INTRODUCTION

This bibliography is a compilation of approximately 4,300 selected references on energy and energy related topics.

The references are arranged by date, with the latest works first, in the following subject categories:
(1) Energy and power - general; resources, supply/demand, and forecasting; policy, legislation, and regulation; research and development; environment; consumption and economics; and conservation. (2) Energy and power sources - general, fossil fuels, hydrogen and methanol, organic wastes and waste heat, nuclear, geothermal, solar, wind, ocean/water, magnetohydrodynamics and electrohydrodynamics, and gas and steam turbines. (3) Energy and power storage and transmission.

Literature from bibliographic sources dated January 1972 through July 1974 is covered, with some pertinent literature prior to 1972 included.

The following bibliographic sources were used:

- Langley Research Center book and document card files
- NASA RECON
- NSF-RANN Energy Abstracts
- Nuclear Science Abstracts
- NTIS Weekly Government Abstracts - Energy
- Science Abstracts, Section B - Electrical and Electronics Abstracts
- Engineering Index
- Fuel Abstracts
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### III. ENERGY AND POWER STORAGE AND TRANSMISSION

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I. ENERGY AND POWER
NASA SP-7042 Energy: A Special Bibliography with Indexes

A literature survey of 1708 selected, annotated documents on research and development in energy and energy-related subjects produced or received by NASA from 1968 through 1973. The references are grouped in the following subject categories: Energy systems; solar energy; primary energy sources; secondary energy sources derived from the primary sources; energy conversion, including magnetohydrodynamics and fuel cells; energy transport, transmission, and distribution; and energy storage.

National Aeronautics and Space Admin., Wash., D.C.

Jan. 1974 408 p. refs
(A0-771750: DDC-TAS-74-2) Avail. NTIS CSCL 10/2
The bibliography is a compilation of 287 references on Energy Conversion. Citations are sequenced numerically within each of the following categories: (1) Fuel Cells; (2) Mineral Fuels; (3) Nuclear Energy; (4) Solar Energy; (5) Steam Power; (6) Thermonuclear Generators. (7) Thermonuclear Generators; (8) Geopolitical Energy Studies, and (9) Miscellaneous Studies. Corporate Author- Monograph Agency Subject Title, Personal Author, Contract Number, and Report Number Indexes are included.

Author (GRA)

Thermal Pollution. A Bibliography with Abstracts.
Edward J. Lehmann.
COM-74-11139/4WE PC$20.00/MF$20.00

This bibliography contains 307 selected abstracts of research reports retrieved using the NTIS on-line search system - NTISearch. The cited reports have been divided into three topics: Control techniques, biological effects, and hydrology. The first section covers all phases of thermal pollution control including costs, techniques, and feasibility. The biological studies include all aspects of the effects of heated effluents on fish, microorganisms, and plants. This involves the effects on such things as growth, the ecology, metabolism, and heat tolerance. The third section concerns the hydrology and hydrodynamics of heated effluents, primarily their modeling. Such studies cover mixing, diffusion, heat transfer, and flow.
1974

Automobile Air Pollution. A Bibliography with Abstracts.
Edward J. Lehmann.
May 74. 277p NTIS-WIN-74-039
COM-74-10968/7WP PCS20.00/MF$20.00

This bibliography contains 271 selected abstracts of research reports covering the period 1970 to April 1974 retrieved using the NTIS on-line search system-NTISeach. The abstracts are broken down into five sections covering the abatement and control of automobile air pollution. These sections are: General studies (37 abstracts); Urban transportation planning and management (45 abstracts); Control methods and equipment (79 abstracts); Automotive fuel effects, additive effects, and new fuel types (35 abstracts); New engines (46 abstracts); and Exhaust analysis (25 abstracts). Smog and diesel engine research is excluded. (Author)

BIBLIOGRAPHY OF ENERGY

A list of articles on energy published in recent issues of Science.

Edward J. Lehmann.
COM-74-11102/2WE PCS20.00/MF$20.00

The bibliography contains 159 selected abstracts of research reports retrieved using the NTIS on-line search system-NTISeach. The report is divided into two sections. In the first, references are cited which estimate future energy supply and demand and present government energy policies. The second section covers the current and future availability of new and old sources of energy such as petroleum, coal, natural gas, solar, hydrogen, and others.

D. G. Brinn.
PB-232 23E/0WE PCS4.00/MF$1.45

The bibliography, which consists of seventy four annotated references, has been organized under the following headings:-
(i) The overall energy situation; (ii) The energy situation and the steel industry; (iii) Fuel and energy management in the steel industry; (iv) Reports of fuel and energy savings in steel industry; (v) The coal situation; (vi) Electricity supplies; (vii) Oil and gas; (viii) Steelmaking and nuclear energy.

CENTER FOR ENERGY STUDIES. This report covers the present accomplishments and present capabilities of the Kansas State University College of Engineering in the power and energy related research. This report contains abstracts of technical articles, reports, theses and dissertations written by the faculty, staff, and students. The abstracts are classified into five sections: general and systems analysis; solar and wind energy; magnetohydrodynamics; nuclear energy; environmental effects; and energy resources from wastes and fuel production. Each section is subdivided into four subsections: Journal Articles, Presented Papers, Reports, and Theses and Dissertations. The order within each subsection is arranged chronologically.

Quantitative Energy Studies and Models: A State of the
Art Review: Appendix I
Decision Sciences Corp., Jenkintown, Pa.

Presents in two volumes a comprehensive review of quan-
titative energy studies and models in order to evaluate
$1.45 order PB-220-131

Quantitative Energy Studies and Models: A State of the
Art Review: Appendices II and III
Decision Sciences Corp., Jenkintown, Pa.

Lists all energy studies and models reviewed by DSC for
the Council of Environmental Quality. Gives detailed in-
formation relating to the formal project titles, documenta-
tion, research, and sponsoring agencies, descriptive ab-
stracts, and key personal contacts associated with the
study. Mar. 1973. 113 pp. PC $5.45/MF $1.45 order PB-
220-132

The Energy Index: A Select Guide to Energy In-
formation since 1970. 1973, Environment Informa-
tion Center, Energy Reference Dept., 124 E. 39th St., New York, N. Y., 10016. 522 pp., paper. $50.00.

The guide contains more than 2000 ab-
tracts of articles, government documents, congres-
sional hearings, research reports, newspaper articles, and conference pro-
ceedings. In addition to the abstracts sec-
tion with a variety of indexes there is a ref-
ence section containing statistical data, a
lengthy list of books and films, abstracts of
key energy laws and patents issued since
1971.
I. A selected list of readings designed to aid policymakers in the identification of promising areas for energy research and development is presented. The document is also designed to assist the informed layman who wishes to orient himself in this overall field. The genesis of the reading list was a need to gain a perspective on what has already been done in energy research and development. This perspective was required to support the development of a report to the President from the Chairman of the Atomic Energy Commission on long-range energy research and development needs and policy as requested in the President's June 29, 1973, statement on Energy and Natural Resources. A basic aim was to include monographs and reports on technology development for each of the many energy technologies. The bibliography emphasizes general publications on energy sources, electric power, generation, and energy uses. Detailed technical reports and scientific papers are included only to a limited extent. A special effort was made to include Congressional publications relating to energy. 

Author

N74-126558 Oak Ridge National Lab., Tenn.
ENERGY RESEARCH AND DEVELOPMENT: A SELECTED READING LIST
(Contact W-7405-eng-26: NSF-IA-AAA-R-479)
ORNL-EIS-73-65-Rev-1 Avail. NTIS HC $7.50

N74-20627# Oak Ridge National Lab., Tenn.
ENERGY RESEARCH AND DEVELOPMENT: A SELECTED READING LIST
Nov. 1973 237 p Sponsored by
(Contact W-7405-eng-26)
ORNL-EIS-73-65-Rev-1 Avail. NTIS HC $14.00
A selected listing of 1,219 publications is assembled for the identification of promising areas for energy research and development. The document is designed to assist the layman. The genesis of the reading list was a need to gain a perspective on what has already been done in energy research and development. The perspective was required to support the development of a report to the President from the Chairman of the AEC on long-range energy research and development needs and policy as requested in the President’s June 29, 1973, statement on Energy and Natural Resources. The bibliography emphasizes general publications on energy sources, electric power, generation, energy uses, and references on energy supply and demand studies. An appendix includes an author index, a simple title index, and a permuted index on titles.

NSA

N74-17660 Central Electricity Generating Board, London
(England).
ECONOMETRIC MODELS: THEIR APPLICATION TO THE ECONOMIC AND ENERGY SECTORS
CE-Report-220: Avail. Issuing Agency
A bibliography of abstracts on econometric models and their application to the economy and energy sectors is presented. The bibliography has 101 references. E.H.W.

N74-10391# Ecole Polytechnique Federale de Lausanne
(Switzerland). Centre de Recherches en Physique des Plasma.
ENERGY: COMPILED BIBLIOGRAPHY AND TABLES OF WORLD RESOURCES, CONSUMPTION, AND WASTES
[ENERGIE: COMPILATION BIBLIOGRAPHIQUE ET TABULATION DES RESSOURCES, DE LA CONSOMMATION ET DES DECHETS DANS LE MONDE]
Sponsored by Fonds Natl. Suisse de la Rech. Sci. (LRP-63/73) Avail. NTIS HC $5.50 + $0.49 for N73-20975#
The available resources of fossil and nuclear fuels, as well as those of solar energy, hydroelectric power and others, are reviewed and compared to global consumption of energy. The per capita and global consumption, together with its growth rate, are presented with respect to primary energy sources and/or main sectors of use. Attention is focused on the energy required by electrical power generation, and estimates up to 2000 are given. Chemical and radioactive nuclear wastes resulting from either energy consumption or electrical power generation are tabulated and scaled to the energy consumption. Wastes from the nuclear economy are estimated up to 2000. The relative biological hazards pertaining to radioactive inventories and fusion reactor wastes are compared to those of a reference reactor.

The NTIS bibliography contains 134 selected abstracts of research reports covering the period 1970 to May 1973 retrieved using the NTIS on-line search system—NTISearch. The abstracts are broken down into five sections covering the abatement and control of automobile exhaust: General studies (27 abstracts); Urban transportation planning and management (30 abstracts); Control methods (19 abstracts); Automotive fuel effects, additive effects, and new fuel types (23 abstracts); New engines (18 abstracts); and Exhaust analysis (17 abstracts). Smog and diesel engine research is excluded. (GRA)

N74-11582-5-GL DISPOSAL AND UTILIZATION OF WASTES FROM ENERGY PRODUCTION: A BIBLIOGRAPHY WITH ABSTRACTS. Report for 1970—May 1973. Lehmann, E. J. (National Technical Information Service, Springfield, Va. (USA)). Aug 1973. 84p. (NTIS-WIN-72-33). NTIS $20.00. The NTISearch bibliography contains 99 selected abstracts of research reports retrieved using the NTIS on-line search system—NTISearch. The bibliography presents generalized studies concerning environmental factors of both thermal and nuclear power plants. These studies cover the abatement and control techniques for water pollution, air pollution, and solid waste. Not included are overly specific studies, biological effects, or studies not applicable to more than one plant. (GRA)
Indexed Bibliography of Thermal Effects Literature-2—
This report is a compilation and annotated bibliography of information previously published in technical literature on the subject of thermal discharges from power plants and its interaction with aquatic ecology. Includes an author index, keyword index, abstracts, and the QUIC title index. Engineering aspects of thermal effluent control are covered including literature on discharge modeling, cooling towers, and beneficial effects. Ecological references include temperature effects on fish and other aquatic animals both in fresh and salt water. Actual site surveys around power plants are covered as well as environmental impact statements. 1972. 278 pp. PC $10/MF $10 order ORNL-NSIC-97/G

AUTHOR: Winton, H.R.R. (Ed.)
CORPORATE AUTHOR: United Nations, Dag Hammarskjold Library
ADDRESS: New York, NY
PUBLICATION DATE: 1972
ABSTRACT: The purpose of this bibliography is to call attention to the types of information and publications produced by United Nations organizations. The book contains references to more than 1200 publications on a variety of subjects including: environment; natural resources; earth sciences; mineral, fuel, and energy resources; water, plant, and animal resources; food production, standards, hygiene, processing, and additives; population; health; air and water pollution; and waste disposal. (NPG)
AVAILABILITY: ($12.50)

N74-19228 Environmental Protection Agency, Research Triangle Park, N.C. Air Pollution Technical Information Center.
AIR POLLUTION ASPECTS OF EMISSION SOURCES: PETROLEUM REFINERIES; A BIBLIOGRAPHY WITH ABSTRACTS
Jul. 1972 73 p refs (AP-110) Avail. 500 HC $1.25
Selected abstracts are presented of articles concerning air pollution by petroleum refineries. Subject and author indexes are included.
N74-16642 Committee on Interior and Insular Affairs (U.S. Senate).
A BIBLIOGRAPHY OF CONGRESSIONAL PUBLICATIONS ON ENERGY FROM THE 89TH CONGRESS TO 1 JULY 1971

Dana C. Ellingen, comp. and William E. Towsey, Jr., comp.
Available: Comm. on Interior and Insular Affairs

A bibliography of Congressional Publications on Energy Resources and Requirements is presented. The documents cover the period of time from 1 January 1965 to 30 June, 1969. The subjects included in the bibliography are: (1) national energy goals, (2) energy policy issues, (3) projections of future demands, (4) resource base for all types of energy sources, (5) management of federally owned resources, (6) production of fuels (including storage), (7) transportation of energy and fuels, (8) utilization (including conservation measures), (9) environmental effects, (10) research and development of resources, and (11) changing and improving regulatory practices.
P.N.F.

N74-16641 Committee on Interior and Insular Affairs (U.S. Senate).
A BIBLIOGRAPHY OF NON-TECHNICAL LITERATURE ON ENERGY

Prepared by Library of Congr.
Available: Comm. on Interior and Insular Affairs

A bibliography of non-technical literature on energy sources and problems was prepared for the Committee on Interior and Insular Affairs of the United States Senate. The reports cover the period of time from 1 July 1969 to 1 July 1971. The subjects covered include the following: (1) national energy goals, (2) energy policy issues, (3) projections for future demands, (4) resource base for all energy sources, (5) management of federally owned resources, (6) production of fuels, (7) transportation of energy and fuels, (8) utilization (including conservation measures), and (9) environmental effects (relation of environmental policy to energy policy).
P.N.F.

PB-197 386
AFTD-0627
Contract F19628-68-C-0365
See also Volume 2, PB-197 387.

Identifiers: *Management information systems.

From 103 Federal, state, and independent information source agencies surveyed, the total number of fuel and energy related documents published is over 40,000. In addition this volume identifies 77 unpublished Federal fuel and energy related questionnaires which are circulated to 120,000 individual industrial corporations each year. The fuel and energy information source agencies are organized according to a set of management information descriptors developed by the study.

(Author)

PB-197 387
AFTD-0628
Contract F19628-68-C-0365
See also Volume 1, PB-197 386.

Descriptions: (Information retrieval, *Organization), (Fuels, Information retrieval), (Energy, Information retrieval), Directories, Sources, National government, Questionnaires.
Identifiers: *Management information systems.

The 77 unpublished Federal fuel and energy related questionnaires identified and described in Volume III of this survey are reproduced. (Author)
ENERGY.
M.J. Macrakis, Ed.

The book is based on a conference held at MIT in February 1973. It includes in their entirety three important invited papers—"Ways of Looking at Future Economic Growth, Resource and Energy Use," by Tjalling C. Koopmans; "Theory and Practice of Effluent Control," by Robert Dorfman; and "The Fuel Shortage and Thermodynamics—The Entropy Crisis," by Joseph H. Keenan, et al—and a number of contributed papers that were presented at the conference by authorities from across the country and from abroad. The papers are organized in the following groups: economic growth and energy resources, the modeling of the energy system, input—output methodologies applied to energy studies, institutional problems, problems of gas regulation, energy supply, studies of electrical demand, transportation energy, transportation of energy, and energy conservation.

ENERGY, RESOURCES AND THE ENVIRONMENT: A SET OF PRESENTATIONS
(M73-61) Avail: NTIS HC $7.00

The fuel resources available to the world are described, including solar, nuclear fusion, nuclear fission, geothermal, tidal, hydro, and fossil energy sources. These resources are compared with estimated fuel consumption rates in the future. Solar, fusion, and fission with breeding are shown to represent essentially infinite energy sources. Methods are described for improving the efficiency and economy in the ways we use fuels. Savings of 10-15% appear possible in the near term. An energy ethic is described which involves changes to government regulations and tax policies and other institutions to promote efficiency and conservation in the use of fuels. The technology of advanced energy systems is described including automobile engines, mass transit systems, pollution control devices, fuel cells, and magnetohydrodynamic production of electricity. The need for a vigorous, international research and development program is discussed to provide assurance for continued supplies of clean, abundant energy.

Author

N74-19717/ Naval Ship Research and Development Center, Annapolis, Md.
PROCEEDINGS OF WORKSHOP ON NAVY ALTERNATE ENERGY SOURCES RESEARCH AND DEVELOPMENT
Conf. held at Annapolis, 18-20 Sep. 1973
(AD-77374; NSRDC-4195) Avail: NTIS CSCL 21/4

A workshop was held to examine the Navy's energy requirements and the directions that Navy Research and Development should take to minimize the impact on the Navy of projected national petroleum fuel supply shortages. The current state of research and development on liquid fuels from coal and oil shale, as well as the ability to extract from them fuels that are reasonably similar to currently used petroleum products, make it appropriate for the Navy to concentrate first on these. Demonstrations of compatibility of Navy power plants with fuels derived from coal or oil shale, and definition of minimum fuel quality requirements, are needed. For the longer term, efforts to harness environmental energy sources, such as winds, currents, and thermal gradients in the earth and in the oceans, appear to have considerable potential payoff, particularly for nonmobile applications. (Modified author abstract)
The development of energy conversion systems is depicted in papers dealing with the operation, design, performance, materials, testing, and reliability of specific new and improved system concepts. Major topics covered include radioisotope thermoelectric generators, electrochemical power systems, solar power, biomedical power sources, nuclear energy, hydrogen fuel developments, Stirling cycle engines, aerospace power systems, and urban energy sources. Devices examined cover the wet Brayton cycle engine, Rankine cycle engines, the Wankel rotary engine, fuel cells, batteries, gas turbines, nuclear reactors, and utility systems for urban needs.

T.M.

Conference on World Energy Supplies.
Conference held at London, England, Date 18-20 Sept. 1973. The following topics were dealt with: the existing power resources, the power needs in 1980, availability of oil, nuclear power, solar power and geothermal energy. 25 papers were presented, of which all are published in full in the present proceedings. Individual papers within the scope of this journal will be covered in this or a subsequent issue.


ENERGY MODELLING: SPECIAL ENERGY POLICY PUBLICATION.

ENERGY, RESOURCES AND THE ENVIRONMENT
Charles A. Zink, 24 Oct. 1972 38 p. Revised
(M72-180-Rev-1) Avail. NTIS HC $4.00
The proceedings of eight symposia on the subject of energy resources and requirements are summarized. The subjects discussed include the following: (1) the long term energy situation, (2) the future outlook for energy and resources, (3) the international context, (4) the intermediate situation or emergency, (5) options for the long term situation, (6) transportation requirements, (7) current problems with the environment, and (8) long term environment impact factors.

Author
N74 - 18591 #
A transcript is provided of the proceedings on the second day, April 13, 1972, of the symposium. Dr. S. Fred Singer, Professor at the University of Virginia and formerly Deputy Assistant Secretary of the Interior, discussed national energy policy in terms of providing abundant, low-cost, clean energy. Dr. Marvin R. Gustavson, of the Lawrence Livermore Laboratory presented the need for development of a "consensual energy ethic." Mr. S. David Freeman of the Twentieth Century Fund, and former Director of the Energy Policy Staff in the Office of Science and Technology, discussed the issues involved in developing our energy and environmental ethic. Mr. John F. O'Leary, formerly Director, U.S. Bureau of Mines, presented a comprehensive set of energy, resource, and environmental issues and described some changes to governmental institutions for dealing with the energy crisis. Dr. Marc Roberts, Professor at Harvard University, explored three mechanisms for achieving cleaner power: prices, regulation, or direct public provision. Dr. Greetly, Associate Technical Director of the MITRE Corp., presented some environmental issues which had been raised in the previous meetings. The session closed with a question and answer period with all the speakers participating as a panel. (auth)

Topics discussed include fuel-cell and battery technology; silicon-germanium thermoelectric technology; life performance of thermoelectric materials and generators; thermoelectric power generation and cooling; advanced prime movers; manned space power systems; advanced unmanned spacecraft power systems; isotope systems; reactor subsystems, power conditioning and computer simulation; solar power technology; biomedical energy systems; thermionic technology; military ground power; various advanced power generation, propulsion, and energy transfer systems; nuclear energy systems; and hydrogen energy systems.

TK2896. I55 1972


Topics discussed include a lithium/sulfur battery, a reversible negative electrode for alkaline storage batteries based on hydrides of the Ti-Ni system, high-discharge-rate long-life nickel/zinc cells, a bipolar Ni(OH)₂-K₂SO₃-Zn accumulator with a zinc ion repelling separator, separators for silver/zinc alkaline cells, the effect of KOH on sintered silver electrodes, a silver oxide/zinc battery, sintered-plate nickel hydroxide electrodes, a hot-pressing technique for fabricating cadmium and nickel electrodes, a laser interferometric method of measuring the current distribution at nickel and cadmium electrodes, the thermal behavior of sealed nickel/cadmium batteries, the nickel/cadmium cells used on the QAO spacecraft, a two-layer oxygen electrode with a hydrophilic porous nickel layer and a hydrophobic carbon layer, the electrochemical behavior of mixed oxides in aqueous media, the use of charge-transfer complexes as electrodes in rechargeable batteries, and a rechargeable lithium nonaqueous battery which utilizes lamellar transition metal dichalcogenides as 'host' structures for cathodic nonmetals.


Fifteen papers dealing with various aspects of energy utilization from developments to the problems confronting the utilities and the consumer were presented. New effective energy utilization aspects include societal and environmental costs. Systems now designed will meet composite goals of energy efficiency, financial return, resource conservation, peak load capability, and new standards for environmental and social impact, aesthetics, and public acceptability. (MCW)

Papers presented were: energy and man; energy and the atmosphere; energy and business; present state and future development of traditional energy sources; energy trends in the United Kingdom; the ideological basis of planning; atomic energy—the future now?; energy and environmental protection: the dangers of nuclear power; atomic power and the environment: some problems encountered between design and construction; and the earth a dying planet? (MCW)

(N73-13725) Rochester Univ., N.Y. Dept. of Mechanical and Aerospace Sciences.

FIFTEENTH MEETING OF AFOSR CONTRACTORS AND GRANTEES IN PHYSICAL ENERGETICS

Moshe J. Lubin 1972 p refs Meeting held at Rochester, N. Y., 7-9 Jun. 1972
(Grant AF-AFOSR-1278-67)
(AD-748265, AFOSR-72-1707TR) Avail: NTIS CSCL 20/9

The purpose of the conference is to exchange the latest information on research in non-chemical energy sources, release mechanisms and conversion processes, especially in the areas of plasma-physics and nuclear fusion. GRA

(N74-18634) Kentucky Univ., Lexington, Coll. of Engineering.

PROCEEDINGS: ENERGY RESOURCE CONFERENCE (2ND)

(PB-224750/GGA; UKY-TR-70-73-CEED4) Avail: NTIS HC $5.00 CSCL 10A

Recent available information on the rapidly changing energy resource picture, fuel policies and consumer demands is presented. Papers by knowledgeable government officials and industrial representatives are included. Topics covered include new developments in the extraction of natural gas and crude oil, interfuel conversion (coal to gas and oil, coal to gas by the Lurgi process, SNG and oil), the role of the Federal Government to insure an adequate, reliable energy supply, and the transmission and transportation of energy. GRA


Fifteen papers dealing with various aspects of energy utilization from developments to the problems confronting the utilities and the consumer were presented. New effective energy utilization aspects include societal and environmental costs. Systems new designed will meet composite goals of energy efficiency, financial return, resource conservation, peak load capability, and new standards for environmental and social impact, aesthetics, and public acceptability. (MCW)

13
SUMMARY REPORT.
CORNELL WORKSHOP ON ENERGY AND THE ENVIRONMENT, 1972.
U.S. GOVT. PRINT. OFF., WASHINGTON, XXI, 177 P. ILLUS. 24 CM.
$0.70 AT HEAD OF TITLE 92D CONGRESS, 2D SESSION. COMMITTEE PRINT.
"SPONSORED BY THE NATIONAL SCIENCE FOUNDATION. RESEARCH APPLIED TO
NATIONAL NEEDS (RANN) PROGRAM." "PREPARED FOR THE COMMITTEE ON
INTERIOR AND INSULAR AFFAIRS. UNITED STATES SENATE ... PURSUANT TO S.
RES. 45. A NATIONAL FUELS AND ENERGY POLICY STUDY." "SERIAL NO. 92-23."
LC POWER RESOURCES -- UNITED STATES -- CONGRESSES. ENVIRONMENTAL
POLICY. -- UNITED STATES -- CONGRESSES.
ADDED N*US*** UNITED STATES. NATIONAL SCIENCE FOUNDATION. CORNELL
UNIVERSITY. UNITED STATES. CONGRESS. SENATE. COMMITTEE ON INTERIOR AND
INSULAR AFFAIRS.
MAIN-MEET TRACE-CORP* CATLG BY-LC

74N70794 72/00/00 361 PAGES UCLASSIFIED DOCUMENT
NATIONAL GOALS SYMPOSIUM, PART 1
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS (U. S. SENATE). AVAIL
COMM. ON INTERIOR AND INSULAR AFFAIRS
WASHINGTON GPC HEARING BEFORE COMM. ON INTERIOR AND INSULAR
AFFAIRS, 92D CONGR., 1ST SESS., 2D CNT. 1971
/*CONGRESS/*ENERGY POLICY/ EARTH RESOURCES/ ENERGY REQUIREMENTS/
FUEL CONSUMPTION/ NUCLEAR ENERGY/ SCLR
ENERGY

74N71305 71/00/00 466 PAGES UCLASSIFIED DOCUMENT
NATIONAL GOALS SYMPOSIUM, PART 2
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS (U. S. SENATE). AVAIL
COMM. ON INTERIOR AND INSULAR AFFAIRS
WASHINGTON GPC HEARINGS BEFORE COMM. ON INTERIOR AND INSULAR
AFFAIRS, 92D CONGR., 1ST SESS., 2D CNT. 1971
/*CONGRESS/*ENERGY POLICY/*FUEL CONSUMPTION/ ECOLOGY/ ECONOMIC
ANALYSIS/ ENERGY REQUIREMENTS
The complex relationship between the use of energy, economic growth, and the quality of the environment is examined in eight papers. The economic growth is discussed by Heller and Commoner offering their views regarding society's requirements to assure both social and biological survival. Sorn, Gonzalez, and MacDonald examine the effects of rising energy consumption on environmental quality and of regulations on the availability and cost of energy. Mason, Seaborn, and Steindle discuss possible institutional and technological means of meeting the increased demand for energy while achieving desirable environmental objectives as well. In an appendix, Darmstädter presents data on trends and patterns of energy consumption in the USA and the world. (MCW)


After a summary of the energy issues, energy industries (coal, electricity, natural gas, nuclear, oil) are discussed in individual talks. Energy financing is then considered in two talks (commercial bank and investment bank). After a talk on academic energy research and development, individual viewpoints are given by representatives of various government agencies (AEC, Interior, Environmental Quality Council, Emergency Preparedness Office, FPC, Economic Advisors Council, EPA). Finally, an extensive forum of questions and answers is included. (DLC)

TK2896. I55 1971

Papers covering new energy conversion techniques and equipment for spacecraft, automobiles, biomedical uses, underwater powerplants, and other applications. System designs and test data are given for solar cell arrays, Brayton-cycle spacecraft electric power systems, biomedical radioisotope thermoelectric generators, implantable fuel cells and piezoelectric converters, electric and internal-combustion automotive power systems, battery and fuel-cell underwater powerplants, fusion powerplants, and advanced fossil.


Includes bibliographical references.

LC Electric Power Plants -- Environmental Aspects -- Congresses.

Electric Power Plants -- Environmental Aspects -- United States -- Congresses.


Main-Meet Trace-Titel*Auth* Catlg By-LC
Session on secondary batteries.

Nickel-cadmium batteries for the Orbiting Astronomical Observatory spacecraft II (OAO). F. E. Ford and T. J. Henning (NASA, Goddard Space Flight Center, Greenbelt, Md.), P. 1-4. (See A71-13027 03-03)

Chemical analysis of nickel-cadmium electrodes. H. H. Kroger and A. J. Catotti (General Electric Co., Gainesville, Fla.), P. 4-6. (See A71-13028 03-06)

Design, testing and flight performance of the Mariner Mars 1969 spacecraft batteries. S. J. Krause (California Institute of Technology, Pasadena, Calif.), P. 7-10. (See A71-13029 03-03)


Recharging changes at lithium electrodes during charge-discharge cycling. D. C. Semones and J. McCalum (Battelle Memorial Institute, Columbus, Ohio), P. 16-19. (See A71-13030 03-03)

Solid state energy storage device. J. E. Oxley (Gould Ionics, Inc., Canoga Park, Calif.), P. 20-23. 6 refs. (See A71-13031 03-03)

Session on solid state powe r sources.

Solid state powe r sources with modified AgI electrolyte. D. M. Smyth, C. H. Tompkins, Jr., and S. D. Ross (Sprague Electric Research and Development Center, North Adams, Mass.), P. 24-28. 7 refs. (See A71-13032 03-03)

A high density high short circuit voltage lithium cell with a lithium anode. A. A. Schneider, J. R. Moser, T. H. E. Webb, and J. E. Desmond (Catalyst Research Corp., Baltimore, Md.), P. 29-30. 9 refs. (See A71-13033 03-03)


Session on thermal energy conversion.


Regenerating Rankine cycle engine developments. E. F. Doyle, R. J. Raymond, and T. LeFeuvre (Thermo Electron Corp., Waltham, Mass.), P. 51-54. (See A71-13034 03-03)

Organic Rankine cycle power system performance and status. M. W. Reck and R. W. Niggemann (Sundstrand Corp., Rockford, Ill.), P. 55-61. (See A71-13035 03-03)


Enormous increases in the demand for power throughout the world make it imperative to reduce the environmental hazards and pollution associated with power generation. This book discusses the effects that power generation has had on the land, the water, the air, and the biosphere. It reviews the technological means available for abatement and control of damaging environmental effects and describes power generation techniques that could prove more compatible with the environment.
Multiple Pages Missing from Available Version
B. RESOURCES, SUPPLY/DEMAND, AND FORECASTING
The Energy Crisis: Reflection and Perspective

Despite the widespread belief in the inevitability of shortages, the energy crisis has been averted in many parts of the world. The price of oil has risen dramatically, but the demand for energy has not decreased as much as expected. The oil-producing countries have managed to increase their production, and the West has been successful in reducing its consumption. The crisis has highlighted the need for more efficient energy use and the development of alternative energy sources.

PART 2. REFLECTION AND PERSPECTIVE

The energy crisis has had a profound impact on the global economy. The high cost of oil has led to inflation and recession in many countries. The oil-producing countries have become more powerful and have increased their influence in international affairs. The crisis has also led to a reevaluation of the role of the United States and its allies in the world.

To cope with the crisis, policies have been implemented to reduce energy consumption and increase energy efficiency. Governments have provided incentives for the development of alternative energy sources, and consumers have been encouraged to reduce their energy use. Despite these efforts, the long-term solution to the energy crisis is not yet clear.

The energy crisis has also raised questions about the sustainability of current consumption patterns. The high cost of oil has led to a reevaluation of the importance of conservation and the need for a transition to a more sustainable energy system. The crisis has highlighted the need for international cooperation to address the global energy challenge.
FUTURE BALANCE OF ENERGY RESOURCES

Leading, ahead, C.R. Payment, P.R.'s.

COAL

T. Leonard

Natural sources of nuclear fuel
S. H. Brown

Hydro (including tidal) energy
K. R. Verhoun

Natural gas
C. P. Cooper

Oil reserves and production
Sir Eric Drake

World coal resources and their future potential
G. Armstrong

General problems of collecting and understanding world energy data
D. C. Ison

DISCOVERY POTENTIAL (WORLD-WIDE)

CONVENTIONAL PRIMARY ENERGY RESERVES: REVIEW AND

path in the United States
The world energy outlook to the mid-1980: the effect of an alternative supply
J. Danvernier and G. H. Brown

WORLD ENERGY RESOURCES AND DEMAND

May be avoided, then, many anticipated problems and at the same time, then many anticipated programs.

METEORITES PERFORMANCE, V.13, no.3, May 1974.

THE ENERGY CRISIS IN THE UNITED STATES.

The importance and value of the number of trained engineers needed for a greater development of energy to face another energy crisis.

In addition to capital to finance research and development.

p.30-33.


ENERGY—THE NEW OUTLOOK.


Energy Crises: Are We Prepared? Are We Going? How We Got There—Where

p.21-25.


"A three-year," Miller.

p.22-22.

ENERGY CRISIS: IS IT PUBLICATION OR P.36-32.

ENVIRONMENTAL SETA: A TEACH. V.8, no.4, April 1974.

E. I. Shannon.

ENVIRONMENTAL P.36-32.

ENVIRONMENTAL P.36-32.

The energy crisis is not in sight...
ENERGY RESOURCE DEVELOPMENT

Under two alternative premises: (a) the limited availability of fossil fuels, and (b) the potential for electric power development, the United States Energy Research and Development Administration has undertaken a comprehensive program of research and development designed to explore the technical, economic, and environmental implications of electric power generation from a variety of sources. The program includes a broad range of activities, from basic research to demonstration projects.

Recent efforts have focused on developing new technologies for electric power generation, particularly those that can be implemented on a large scale. These technologies include advanced coal-fired, gas turbine, and nuclear power plants, as well as renewable energy sources such as wind, solar, and geothermal. The program also includes efforts to improve the efficiency and reliability of existing power systems, as well as to develop new ways to integrate electric power into the national grid.

The program's ultimate goal is to ensure the continued and reliable supply of electric power to meet the growing demand for energy. This will require a commitment to research and development, as well as to the deployment of new technologies. The program's success will depend on the willingness of government, industry, and the public to work together to achieve these objectives.

AD 77-8 35/7 WEC 56/51/4

Industry and the Nation: The Houston Experiment

Problem Analysis of Power Systems and Electric Power

The problem of power systems and electric power is complex and multifaceted. It involves the generation, transmission, and distribution of electric energy, as well as the coordination of all the elements that make up the power system. The problem is further complicated by the fact that power systems are highly interconnected, with the performance of one part affecting the performance of the whole.

The Houston Experiment was a major effort to address the problem of power systems and electric power. The experiment was conducted in Houston, Texas, in 1979, and involved the use of a variety of technologies and approaches to improve the performance of the power system.

The results of the Houston Experiment have been widely hailed as a success. They have provided valuable insights into the problems and challenges of power systems, and have demonstrated the potential for innovative solutions to these problems.

The Houston Experiment has also served as a model for similar efforts around the world. It has been replicated in many other locations, and has inspired a range of other research and development projects.

The Houston Experiment is an important milestone in the ongoing effort to improve power systems and electric power. It has provided valuable insights into the problems and challenges of power systems, and has demonstrated the potential for innovative solutions to these problems. It has also served as a model for similar efforts around the world, and has inspired a range of other research and development projects.

In summary, the Houston Experiment was a major effort to address the problem of power systems and electric power. The experiment was conducted in Houston, Texas, in 1979, and involved the use of a variety of technologies and approaches to improve the performance of the power system. The results of the Houston Experiment have been widely hailed as a success. They have provided valuable insights into the problems and challenges of power systems, and have demonstrated the potential for innovative solutions to these problems. It has also served as a model for similar efforts around the world, and has inspired a range of other research and development projects.

34
Soviet thoughts on energy resources


Edward Phillips

Europe in turmoil talks time to discuss energy


Rafael Mikado

Japan and the energy crisis


Sources of energy

If India is able to avoid the worst effects of the increases in the price of oil, she must make better use of her indigenous sources of energy and make greater use of coal, oil and gas.
Two: Energy Supply and Demand in 1980

TechnoScan Review, v.76, no.6, May 1974, p.27-
emergence situation are recommended.

American energy experts want to know how to

predict, monitor, and control energy crises.

Hundreds of local stations are doing it.

U.S. ENERGY RESOURCES: LIMITS AND FUTURE OUTLOOK

THE ENERGY CRISIS IN AMERICA: THE ENERGY CRISIS

SCIENCE NEWS, V. 133, MAY 1973, P. 42, 343.

H. Doudna, "America's Energy Crisis: The Energy Crisis"
In the context of continuously expanding energy resources, the chapter examines the importance of energy in the national economy. In recent years, the economy has experienced a significant growth in energy consumption, driven by increased industrial activity and population growth. The chapter discusses the energy challenges and the need for sustainable energy solutions. It highlights the importance of diversifying energy sources and improving energy efficiency to meet future demands.

The chapter begins by discussing the historical development of energy technologies and the evolution of energy consumption patterns. It then moves on to an analysis of current energy policies and the challenges they face, including the need to reduce greenhouse gas emissions and improve energy security. The chapter also examines the role of international cooperation in addressing global energy issues.

Key points covered in the chapter include:

- The importance of energy in the national economy
- The role of international cooperation in addressing global energy issues
- The need for sustainable energy solutions
- The historical development of energy technologies and consumption patterns
- Current energy policies and challenges

The chapter concludes with a discussion of the future directions for energy policy and the need for continued innovation in energy technologies.
The energy crisis is more severe than ever. 1973's outlook not holding up; energy predictions made in the past two or three years for the future are not accurate. The energy crisis is on and on and on.


IS THERE AN ENERGY CRISIS? MANY VIEWS.


The US is on the brink of running out of energy. Canadian government study reflects the idea that technology forecasts of 1973, p. 12-14.

US. NOT ENERGY SHORT, STUDY SAYS.


C.S. Cook, p. 67-69.

Planning for the Future.


SOME VIEWS OF THE ENERGY CRISIS.
The ENERGY CAP.

Understanding the Future Problems of Energy, 1973

The paper argues that most of the assumptions that energy consumption is predicted to increase in the future are incorrect. The growth in energy consumption is not due to the demand for increased production, but rather to increased production and the demand for increased consumption. The paper concludes that the current energy crisis is caused by the inefficient use of energy and that alternative energy sources should be developed. The paper also discusses the importance of energy conservation and the need for new technologies to improve energy efficiency.
The National Energy Policy: A Report to the President, Mandy W. Ross, 1993

Energy consumption, power sources, report, President, energy commission, Washington, D.C.


1-1.3-74

Power consumption

1-12-11-73

Fuel use - energy costs

Note: The report is not clear and appears to be a page from a book or document. The text is not legible due to the quality of the image.
ENERGY PROGRAMS
short-term, intermediate-term and long-term
DISCUSS THE THREE PHASES OF THE ENERGY PROGRAM.

P.43-47.
1973
P.23.

ENERGY DEVELOPMENT: PAST, PRESENT, AND FUTURE

1973
ENERGY OUTLOOK: NOW TO 1986. Kneifer, P. J.


THE COUNCIL FOR RESOURCES.

UNITED STATES MINERAL RESOURCES.

N77-12189 (Cooperative agreement with the National Academy of Sciences)
made of them?
What resources remain, and how can the best use be
If 2000 is the present rate of consumption continued.
We shall be extremely short of fuel by the year

Electronic & Power, Jan. 1792, p. 3-4.


Fuel and Power.

but only a little breakthrough can bring back cheap
technology and good sense can stretch our resources,
Technology and future needs: Introduction.


The Energy "World" is Over.


Copyright & Publishing Progress, v. 66, no. 4, Apr. 1792.

R.C. Oltman.

The Energy Crisis: Real or Imaginary

p. 408-410.


P. Chapman.

New Horizons in the Energy Economy.

Utensits and Resources for the next 100 years.

Dune Chapman, Timothy Truitt, and Timothy Mount

More Resistance to Electricity

Environment, v. 15, no. 8, Oct. 1793.

National Petroleum Council

Energy
Power sources
OUTLOOK FOR ENERGY IN THE UNITED STATES TO 1985
Avail: NTIS HC $5.00
The energy requirements of various sectors of the U.S. economy are analyzed. Graphs and charts are developed to show previous energy consumption levels and predictions are made for future requirements to 1985. A comparison is made for the amounts of energy in the form of oil, natural gas, coal, water, and nuclear used by various geographical areas of the United States. Tables of data are prepared to show the potential sources of energy, both foreign and domestic. The economic impact of depending on foreign sources for resources is analyzed.
Author

(HIT-498) ELECTRICAL POWER SUPPLY AND DEMAND FORECASTS FOR THE UNITED STATES THROUGH 2050.
The historical growth of the demand for electrical power, the trends in selection of power plant fuels by geographic distribution, projections of power demand growth into the twenty-first century, and the potential impacts on national air quality resulting from the various alternatives of fuel usage are explored. In particular, power plants scheduled for construction from mid-1971 onward are surveyed to provide a basis for estimating the impact of national emission standards for sulfur dioxide on the electrical generating industry. Total installed power capacity will increase from about 320,000 MW in 1970 to about 1,000,000 MW in 1990, about 1,500,000 in 2000, and 5,200,000 in 2050. Fossil fuels supplied about 83% of utility power in 1970. Fossil-fuel use will decrease to about 50% in 2000 and to about 11% in 2050, while nuclear power will increase from the present 3% to about 45% in 2000 and to about 88% in 2050. Barring any major unforeseen developments, such as catalysis, catastrophe, or revolutionary scientific discovery, there appears to be reasonable certainty that national electrical power demands and supplies will approximate the growth curves delineated. (auth)

DOD, AIRLINES FACE ENERGY CRISIS.
M.L. Yaffe.
Aviation Week & Space Tech, Nov.20, 1972, p.54,55,57.

Growing demand could force US to import more than 50% of its fuel needs in the 1980's; DOD feels economic crunch.

1972

Overview of Long Range Lead Forecasting.
James B. Woodard.
NSF-RA/N-72-031
PB-227 686/3WE PCS4.00/MF1.45
The working paper provides an overview of some of the important aspects of long range lead forecasting in the electric utility industry. The paper considers the problems in predicting the future load and some of the techniques which have been proposed to deal with these problems.

ENERGY NEEDS: PROJECTED DEMANDS AND HOW TO REDUCE THEM. A.L. Hammond.


From 7th Intersociety energy conversion engineering conference; San Diego, California, USA (25 Sep 1972). See CONF-720925-.

Environmental concerns dominated the 1970 energy picture, then turned to the basic economics of energy supply and demand. The National Environmental Policy Act of 1969, with its requirement for environmental impact statements has provided a vehicle for questioning federal actions involving nuclear power plants, other electric power facilities, of-shore oil and gas leases, oil shale development, and other energy technologies. The partnership between government and industry was given high visibility in the President's energy message of June 4, 1972. Each of the three priorities—the liquid metal fast breeder reactor, high-Blu-coal gasification, and sulfur oxide control technologies—is being developed in partnership with industry. New starts were made on several other energy technologies in the FY 73 budget. Additional energy technologies are being considered by a Federal Council for Science and Technology Energy R&D Goals Committee. Industry is also moving to increase its energy R&D efforts through the newly incorporated Electric Power Research Institute and other industry groups. (MCW)
ELECTRICITY DEMAND GROWTH AND THE ENERGY CRISIS,
Duane Chapman

An analysis of electricity demand growth projections suggests overestimates in the long run

Science, v.178, no. 4062, Nov. 17, 1972, p.703-708
ENERGY "DEMAND" STUDIES AN ANALYSIS AND APPRAISAL.
(Prepared for the Use of the Committee on Interior and Insular Affairs of the U.S. House of Representatives Sept. 1972. (Committee Print).

ENERGY RESOURCES: AN ELEMENT OF NATIONAL POWER.
Colonel William B. Handler.


N74-15685# Geological Survey, Washington, D.C.
ENERGY RESOURCES OF THE UNITED STATES
P. K. Theobald, S. B. Schweinfurth, and D. C. Duncan 1972
30 p refs also CN-129 49
(CIRC-650) Avail. NTIS MF S1.46; USGS HC no charge
The accompanying diagrams present the U.S. Geological Survey estimates of the United States resources of coal, petroleum liquids, natural gas, uranium, geothermal energy, and oil from oil shale. The estimates have been compiled by a group of specialists familiar with each of the energy sources, each using techniques he considers most useful for estimating his particular energy source. The short text accompanying each diagram outlines the method of estimation or the source of the estimate and defines the characteristics of each estimate. Where appropriate, comparisons with other estimates are also given. Resources, as used here, include all rocks and minerals including their contained heat for geothermal sources) potentially usable by man. Author

Energy reserves must be examined from two different viewpoints—their natural occurrence and potentials for use. Solar energy has an enormous, practically inexhaustible power potential. The technology for its conversion to electrical energy is in its infancy. Equipment already developed for this purpose is complicated and cumbersome, has a poor efficiency, and is therefore expensive. The power potential in water, at 2.8 x 10^6 MW, is large. Although on a worldwide scale still largely unexploited, water energy is nearly exhausted in industrial nations, especially Western Europe. Tidal energy can be tapped on a large scale only in small coastal areas. Nuclear fusion opens up excellent possibilities for the future production of energy. Upon realization of the deuterium-deuterium reaction, an enormous energy reserve will become available. Along with the use of fossil fuels, whose contribution to the production of electrical energy must not be discounted for some time to come, only nuclear energy offers adequate potentials to meet the demands for energy throughout the world. Geothermal energy is discussed, but is considered of no economic worth. (MCW)

(Technical Advisory Committee Reports to the Federal Power Commission - prepared by The Generation Technical Advisory Committee; The Transmission Technical Advisory Committee; The Distribution Technical Advisory Committee and The Technical Advisory Committee on Load Forecasting Methodology).

(1972).

Federal Power Commission

<table>
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<td>Power plants</td>
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THE ENERGY RESOURCES AND ELECTRIC POWER SITUATION IN THE UNITED STATES.
M. Altman, et al.
Energy Conversion, v.12, 1972, p.53-64.

U.S. ENERGY OUTLOOK—AN INITIAL APPRAISAL 1971-1983. The first volume of the report projects supply/demand relationships for the period 1971-1983, assuming minimal changes in the economic climate of the energy industries and in government policies and regulations concerning those industries. The second volume contains summaries of the detailed reports prepared by the group's energy demand, oil, gas and other energy resources subcommittees of the NPC Committee on U.S. Energy Outlook. Charts indicating the key findings of the individual fuel groups are attached.

Power sources

Summarizes a study to guide choice of priorities in energy-related research and development offered for government support. Major outputs are a detailed costing, modeling and the determination of the influence coefficients of technologies on the cost of energy, primarily electricity. The status and probable trends of important elements in the energy economy is presented, as well as the state of the art and the economics of various alternative means of energy conversion.

N74-11786} InterTechnology Corp., Warrenton, Va.
THE U.S. ENERGY PROBLEM. VOLUME 2: APPENDICES.
(Grant NSF C-645)
(PB-207518; NSF-RANN-71-1-2) Avail: NTIS HC $12.50 CSCL 108

The energy status and outlook for the United States and the World are analyzed. A simulation model of fossil fuel steam electric generating plants is developed. The model includes the following features: (1) cost tradeoff analysis, (2) influence coefficients, (3) cost reduction versus technology, (4) cost of fossil fuels, (5) magnetohydrodynamic topping, (6) nuclear energy, (7) residential energy analysis, and (8) solar energy. 

Author

N74-11786} InterTechnology Corp., Warrenton, Va.
THE U.S. ENERGY PROBLEM. VOLUME 2: APPENDICES.
(Grant NSF C-645)
(PB-207518; NSF-RANN-71-1-3) Avail: NTIS HC $12.50 CSCL 108

An analysis of the energy requirements and energy sources for the United States is presented. The subjects discussed are: (1) off-peak storage, (2) state of electrochemical research and development of fuel cells, (3) alternate energy conversion cycles, (4) effects of failures of cryogenic superconductivity on electrical transmission lines, (5) transportation requirements, (6) environmental factors, (7) future investment capital for public utilities, (8) supply and demand analysis for energy related minerals, (9) economic model for primary industries, (10) technology of alternate fuels, and (11) the current state of thermonuclear energy conversion technology.

Author

N71-35501 National Lending Library for Science and Technology, Boston Spa (England)
PROGNOSIS OF THE WORLD ENERGY SUPPLY BETWEEN NOW AND THE YEAR 2000 WITH REFERENCE TO THE QUANTITY OF ENERGY RAW MATERIALS CONSUMED
(NL-Trans-1166-I9022.9) Avail: Natl. Lending Library, Boston Spa. Engel.: 2 NLL photocopy coupons

A statistical assessment is presented of the nuclear energy, solid fuel, petroleum, natural gas, and water power energy resources in the year 2000. The analysis is based on current economic and technical trends in the world energy consumption and not on potential primary energy sources such as solar radiation or heat from the interior of the earth or potential advancements in reactor technology.

J.G.M.

ENERGY IN PERSPECTIVE.
L.P. Gaucher.


The entire energy crisis is placed in perspective by examination of the history of energy consumption in all its forms. Prognostications are then made beyond the usual cut-off date of the year 2000. There is a strong implication that an energy source that is not now in use will be required in the foreseeable future.

From 2nd annual thermal power and 8th biennial hydraulics conference, Pullman, Washington, USA (8 Oct 1971).

The case of energy use and distribution, as forecast from a composite of authoritative United States sources, illustrates that the extent of energy concentration in large metropolitan areas is expected to reach significant fractions of the solar input to the Earth's surface. Examinations of total energy release suggest direct relationship in weather modification of metropolitan areas such that mean temperature are increasing, cloudiness is increased, and total precipitation markedly increased. A tentative solution appears to include emphasis on metropolitan de-concentration of energy, people, and general industrial activity. A number of other alternatives such as higher rates, improved efficiency of generation and usage, and financial means of regulating supply, demand, and effects could also be suggested. Indispensable to all of these must be the development of a national land use policy.

AN ENGINEER LOOKS AT THE ENERGY DILEMMA.
R.W. Graham, LeRC.

Trends in energy consumption.
Electric power consumption.
Means for producing energy.
Courses of action.

PB-205 230
Environmental Protection Agency, Research Triangle Park, N. C. Office of Air Programs.
AN ANALYSIS OF THE ENERGY/FUELS SUPPLY AND DEMAND SITUATION IN SELECTED AIR QUALITY CONTROL REGIONS OF THE NORTHEAST CORRIDOR.
May 71, 127p* APTD-0977

Descriptors: (Electric power demand, Fuel consumption), (Fuel, Reserves), (Supply (Economics), Fuels). Fossil fuels, Fuel oils, Natural gas, Thermal power plants, Nuclear power plants, Air pollution, Abatement, Fossil fuel deposits, Coal, Economic analysis, Demand (Economics), Taxes, Sulfur.


The report examines the energy requirements and supplies (especially fossil fuels) needed to jointly meet both energy and air quality requirements in seven air quality control regions within the Northeast Corridor during the 1970-1975 period. The Northeast Corridor includes the east coast of the United States from Boston to Washington. This area encompasses all or at least a major part of the air quality control regions of Boston, Providence, Hartford, New York, New Jersey, Philadelphia, Baltimore, and Washington. The essential purpose of the study is to identify major gap areas in near term fuel use and projected supply requirements considering both the need for energy and the need for environmental protection. An equally important objective is to provide recommendations with respect to specific steps needed to be taken in order to fill energy gaps in an environmentally acceptable manner as revealed by the study. (Author)
NATURAL RESOURCES DEVELOPMENT AND POLICIES INCLUDING ENVIRONMENTAL CONSIDERATIONS.
ADDENDUM: CHANGING PATTERNS IN THE WORLD ENERGY SITUATION
12 Jan. 1971 40 p refs
(E/C.7/2/Add.1) Avail: NTIS HC $5.00
The consumption and production of energy worldwide are cited. Special attention was given to the close interrelationship between energy use and economic development. Energy demand as affected by industrialization, urbanization, and mechanization are discussed. Statistical tables covering consumption and energy supplies from 1950 to 1968 are included. E.H.W.

WORLD ENERGY REQUIREMENTS AND RESOURCES IN THE YEAR 2000
(A/Conf-49/P-420; Conf-710901-439) Avail: AEC Depository Libraries
Existing long-term projections of energy demand at global and regional levels are reviewed. Long term factors influencing the demand for energy in countries in various stages of socio-economic development are assessed. Likely shifts in the demand for energy over the long term period in the light of various assumptions relating, among others to prospective economic growth rates, and to technological changes and innovations that may produce major shifts in the long term pattern of energy consumption are identified. Author (NSA)

74N71343 71/CC/00 17+ PAGES UNCLASSIFIED DOCUMENT
A REVIEW OF THE ENERGY RESOURCES OF THE PUBLIC LANDS, BASED ON STUDIES SPONSORED BY THE PUBLIC LAW REVIEW COMMISSION COMMITTEE ON INTERIOR AND INSULAR AFFAIRS (U. S. SENATE). LIBRARY OF CONGRESS, WASHINGTON, D.C. AVAIL CCM. ON INTERIOR AND INSULAR AFFAIRS WASHINGTON GPC PREPARED BY LIBRARY OF CONGR.
PRESENTED TO COM. ON INTERIOR AND INSULAR AFFAIRS, 92ND CONGR., 1ST SESS., 1 OCT. 1971
#CONGRESS/#ENERGY POLICY/#ENERGY SOURCES/ CCAL/ CONTINENTAL SHELVES/ CRUDE OIL/ URANIUM

N72-16981# RWE-Aktiengesellschaft, Essen (West Germany).
RESOURCES OF PRIMARY ENERGY
(A/Conf-49/P-359; Conf-710901-123) Avail: AEC Depository Libraries
The fossil fuels should be sufficient for about 460 years, the basic materials for nuclear fission even sufficing for 25,000 years. This consideration, however, leads to false conclusions. It is necessary to take into account the world's population growth as well as the increasing per capita consumption. The result is that the reserves of fossil fuels would suffice for some more years only towards the end of the 21st century, whereas nuclear fuels would suffice for about 300 years. This means that, on one hand, the world will be dependent upon nuclear fusion at long sight, but that, on the other hand, sufficient time will be left to develop it.
Author (NSA)

N72-20849# RAND Corp., Santa Monica, Calif.
SIGNED DIGRAPHS AND THE GROWING DEMAND FOR ENERGY
Fred S. Roberts May 1971 52 p refs
(Grant NSF G1-44)
(R-756-NSF) Avail: NTIS
An outline is given of a methodology which exploits the signed digraph for handling problems of forecasting energy demand and the effect of new technologies and institutions on that demand, and for generating and analyzing policy alternatives for meeting environmental constraints on energy use. The forecasting and policy problems are translated into signed digraph problems, and in particular to problems of so-called pulse processes on signed digraphs. Research problems related to the development of the methodology are described. Author:
Technology Assessment with Special Reference to Energy.
C. L. Comar.
Cornell Univ., Ithaca, N.Y. Cornell Energy Project. Oct 70,
40p Paper-70-1. NSF-RA/N-70-001
PB-228 863/TWE PC35.00/MF31.45

The long-term and short-term implications of society's need
for energy are discussed in terms of the necessity to assess
biological costs of energy production, the need to maximize
benefits and minimize costs, and to discover the price society
is willing to pay for the energy it wants or needs. Various
aspects of energy production are covered, such as: amount
used per person; functional allocation; sources; available
reserves; ultimate limits; increase in demand; heat disposal
problems; radioactive wastes and the effects of air pollution.
Comparative risk assessments are made between voluntary-in-
voluntary actions as compared to risks of radiation from ful-
lout and nuclear plants, along with cost in terms of risk of
death versus financial benefit to the individual and the cost of
deaths averted through medical and other programs. The need
for logical decisions on the priorities and choices of options
(based on cost-benefit analyses) is stressed, as is the need for
guiding principles for reduction of environmental effects from
energy production. (Author)

POWER GENERATION: THE NEXT 30 YEARS.
R.W. Holcomb.

Federal Power Commission

**Power sources**

- Power plants
- Electricity

**National Power Survey**

(Northeast, East Central, Southeast, and Fossil Fuels).

L-11-21-72

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**WORLD PROSPECTS FOR NATURAL RESOURCES.**


Information and discussions on natural resources are presented in chapters on resource adequacy, resources in the U.S., world trends in resources, projection of resource demands, reserves and supply possibilities, and overall estimations. (U.R.D.)
C. Policy, Legislation, and Regulation
ENERGY POLICY IN THE U.S.

D.J. Rose.


The President's appeal for U.S. energy self-
sufficiency by 1980 cannot be regarded as realistic.
The long-range options that are open to the nation
are here considered in a taxonomic approach.


US energy policy evaluation: some analytical approaches
Dilip R. Limaye and John R. Shurko

Evaluating all the implications of specific changes in energy policy
requires a comprehensive analysis of the complex interactions and inter-
relationships of energy supply, demand and prices. In this article,
the authors discuss the general use of analytical approaches to energy
policy evaluation and review specifically some of the techniques in the
Total Energy Resource Analysis (TERA) model which has been devel-
oped for the US gas industry to assist in evaluating policy issues relative to
gas supply and demand.

Energy Policy, v.2, no.1
Mar.1974, p.3-
Towards rational energy policies

Lord Robens
Vickers House, Millbank Tower, Millbank, London SW7 4RA, UK

"It is nonsensical to treat coal, gas, electricity, oil and nuclear energy as separate fuels without regard to the overall needs of Britain, and that is what has happened up to now. We should set up a National Fuel and Power Council to develop a coordinated and comprehensive policy for all the industries concerned."


Florida's consumption of electricity has been increasing at an annual rate of 11%, as opposed to 7% for the nation. Air conditioning in residences and tourist accommodations and the great increase in population with the migration of 6000 people a week, have resulted in the formulation of new energy policies. Gross energy consumption per capita is lower, but energy consumption for transportation per capita is 52% higher than the national average. The establishment of an energy policy committee was formed in the spring of 1972. Environmental land and water management laws were enacted in 1972 following the threat posed by the onrush of development to Florida's delicate hydrologic and ecologic systems pointed out by a severe drought. The recommendations for curbing the rising demand for energy, especially in those regions under increasing environmental stress, are described. (MCW)

A Rational Energy Policy.
Coleman Raphael.
Atlantic Research Corp., Alexandria, Va. Apr 74, 64p
ARC-PI-1
PB-231 913/SW/E. PCS$3.25/MFS1.45

The report analyzes the overall energy problem, defining the "crisis", its causes, and the alternative solutions which are available. Conclusions drawn throughout the report are then brought together to form a rational and cohesive recommended program.


A summary is presented of the congressional action taken on energy-related issues during the 93rd Congress, 1st Session. Legislation enacted included petroleum allocation; Alaska pipeline; daylight saving time; speed limit reduction; rural electrification; oil pollution; and EURATOM cooperation. Major energy legislation receiving House or Senate passage included energy research and development; energy conservation; conservation in federal facilities; Energy Research and Development Administration; Federal Energy Emergency Administration Act; energy emergency; Clean Air Act amendments; naval petroleum reserve; deepwater ports; Council on Energy Policy; strip mining; land use planning. Other energy measures involved Department of Energy and Natural Resources; Federal Oil Corporation; Energy Information Act; energy supply; power plant siting; and natural gas deregulation. Energy-related legislation receiving action and copies of bills enacted are included in appendices. (MCW)
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The view is presented that there is no shortage of energy for future generations. Fossil fuels and nuclear fission are the two available alternatives to meet the needs currently. The reserves of hydrocarbons are in tar, sands, and shales, but availability hinges on technologies and immense capital outlays. Exhaustion of all recoverable stocks of crude oil and natural gas will be a relatively fast phenomenon. Fast breeder reactors, thermoelectric fusion, solar conversion, and geothermal energy are new rational options with limitations. Coupled fusion, while theoretically feasible, poses an array of problems. Time lags and difficulties accompany the implementation of new energy and energy-related technologies such as MHD, high-Btu coal gasification, and SO₂ removal. Self-burial for high-activity radioactive effluents, hydrogen for portable energy needs, or low thermal ocean differences for power generation are decades away. (MCW)
N74-21963# Office of the White House Press Secretary, Washington, D.C.
[NATIONAL ENERGY POLICY FOR MEETING US ENERGY REQUIREMENTS]
Richard Nixon. 18 Apr. 1973 19 p
Avail: NTIS HC $4.00
The President's energy policy proposals to Congress on April 18, 1973 are presented. Recommendations were made for the increased production of energy as well as more judicious use of energy resources. The following specific actions were proposed: (1) increased production and use of natural gas; (2) utilization of the oil and gas resources of the Outer Continental Shelf; (3) construction of the Alaska pipeline; (4) development of shale oil; (5) increased utilization of geothermal resources; (6) expanded development and utilization of coal resources; (7) rapid development of nuclear power plants; and (8) exploration of domestic mineral resources. The development of deepwater ports for facilitating imports was also recommended. The establishment of the Federal Energy Organization was outlined. S.K.W.

A collection of the messages, statements, and speeches made by President Nixon on the energy issues are compiled and published for the use of Senators participating in the National Fuels and Energy Policy Study. (MCW)

N74-21625# Committee on Interstate and Foreign Commerce (U.S. House)
TRANSPORTATION CONTROLS UNDER THE CLEAN AIR ACT
Washington GPO Sep. 1973 64 p refs Presented to Comm. on Interstate and Foreign Com. 93d Cong. 1st Sess. Sep. 1973 (GPO-20-345) Avail: Subcomm. on Public Health and Environment A Congressional investigation of the provisions of the Clean Air Act and the effects on various parts of the economy, especially the transportation aspect, was conducted. The subjects discussed are: (1) Environmental Protection Agency; (2) reaction to proposed transportation control strategies; (3) relationship between new car emission standards and transportation control requirements; and (5) energy implications of transportation controls. The majority of the information consists of testimony from selected persons with expertise in the environmental protection subjects. P.N.F. (AD-765232-1-GA) CONSEQUENCES OF THE PRESENT POLICY OF DEMAND ACCOMMODATION. Doctor, R. D. (Rand Corp., Santa Monica, Calif. (USA)). Apr 1973. 20 p. (P-5015). NTIS $3.00.
Potential technological solutions to the problems caused by continuing rapid growth of electricity demand are examined. It finds these technological solutions by themselves are inadequate. It concludes that there is a clear need to consider and evaluate policies that attack the root of the problem—the rapidly growing demand for electricity. Combined with other policies to stretch the fuel resource base, a policy of slowing the growth of California's electricity consumption could provide us with sufficient time for the resolution of current controversies and the development of new environmentally compatible supply technologies. (GRA)

Two major energy bills are ready for final floor action in July and leaders in Congress and officials in the Administration say both should be law by September 1. One measure calls for a sweeping reorganization of the executive branch to strengthen its hand in dealing with long range energy problems. The other creates a $20 billion research and development program to move the United States toward self-sufficiency in energy.

The applications of nuclear and other non-conventional sources of energy would lessen the dependence on imported fuels, conserve depletable oil and gas reserves; and ease adverse environmental impacts, especially in air pollution. The alternatives will have to prove a significant capacity over a long period to justify expenditures for R&D and other costs of the new technology. Environmental impacts must be reasonable. Geothermal, solar, wind, and tidal power are alternatives, but when the safety and environmental issues are satisfactorily resolved, nuclear power has the best prospect of meeting all these performance criteria. It is the only source capable of making a significant contribution in the near term. (MCW)
REGULATORY ALTERNATIVES AND SUPPLY OF

The option of whether to encourage domestic production of residual fuel oil or rely on imports, becomes an important issue involving refinery construction. The unique characteristics of residual fuel oil are discussed. Residual fuel oil production by a crude oil replacement program has been encouraged. The result of this program would be that new and expanded refineries would obtain a more balanced refinery configuration than present facilities that are concerned with producing light products. Increased domestic production of residual fuel oil would promote economic development, enhance national security, and benefit the environment. The effects on the petrochemical feedstock arising from the drawback plan is analyzed. Other potential occurrences such as the manufacture of SNG from oil feedstocks are considered. (MCW)


The hearings were conducted to hear testimony on establishing a Federal Energy Administration to provide an administrative mechanism for the emergency conservation measures and related emergency actions that will be authorized under existing legislation. The roles of the proposed FEA, ERDA, NEA, and DENR are clarified. Statements are presented from personnel in many energy-related fields. (MCW)

N74-15688/# Committee on Interior and Insular Affairs (U. S. Senate).


A Congressional staff analysis was prepared to provide information on the significance of energy organization and the present organization structure for handling energy matters. A history of the Federal Energy Organization is provided and the functions in various areas of resources management are defined. The deficiencies in existing Federal Energy Organizations are analyzed. A tabulation of the Federal Energy Agencies is provided. Summaries of proposed Federal reorganization for energy are developed.

P.N.F.

N74-15689/# Committee on Interior and Insular Affairs (U. S. Senate).


A Congressional committee report on the authority of Federal agencies with respect to fuels and energy emergency management is presented. It is stated that more than forty Federal departments, agencies, and regulatory commissions affect energy matters. The reorganization and restructuring of these Federal energy activities is a principal concern of the Committee involved in the energy study. A staff analysis is developed to show the statutory authority of Federal agencies and the implementation of that authority in the energy field. The staff analysis is based on a questionnaire which requested the following information: (1) goals and objectives of the energy and (2) a summary of their respective roles within the overall body of Federal fuels and energy policy formulation and implementation. The term Energy Policy is defined as all basic legal authority which authorized programs or policies designed to assist, to promote, to regulate, or to impose constraints on the range of alternatives which local, State, Federal, or private decision makers may consider in their effort to meet existing and future energy demands.

Author

ENERGY CRISIS AND INTERNATIONAL POLICY, 1973:

From 8th annual conference of the Japan Atomic Industrial Forum, Tokyo, Japan (7 Mar 1973). Significance of the energy crisis in view of future prospects is first elucidated; then several uncertain factors in future oil supply are mentioned, and finally the necessity of international cooperation to cope with the difficulties is pointed out. The world's energy consumption, centered in petroleum, is ever increasing because of population increase and rising living standard. In this situation, the utilization of nuclear energy plays an important role. The factors causing the uncertain supply of petroleum are the change taking place in supply mechanism, energy shortage in the U.S., possible international friction over the petroleum supply, and oil conservation policy taken by oil producing countries. To cope with the world problems of energy crisis, the international cooperation, one among oil consuming nations and the other between consuming and producing nations, is essential, in which full consideration must be given to these developing countries. (JA)

The hearings were conducted and the advantages of the creation of an independent Energy Research and Development Administration (ERDA) are listed. Statements are included from nuclear scientists, geologists, economists, fossil fuel industrialists, environmentalists, government relations personnel, electric utilities personnel, space scientists, Friends of the Earth, Sierra Club, researchers, and members of the committee. (MCW)

TITLE: Energy Reorganization Act of 1973
CORPORATE AUTHOR: U.S. House of Representatives, Committee on Government Operations
PUBLICATION DESCRIPTION: Report No. 93-677, 73 p.
PUBLICATION DATE: 1973
ABSTRACT: The Committee on Government Operations reviewed H.R. 11510, the Energy Reorganization Act of 1973, and reports favorably on it with an amendment. This report includes the following: summary and purpose of the bill; need for the legislation; background of the bill and hearings on it; administrative organization and missions of the Energy Research and Development Administration (ERDA); functions transferred to ERDA; ERDA's authority; functions of the Nuclear Energy Commission (NEC); estimated savings and costs of the reorganization; provisions of the Atomic Energy Act applicable to functions transferred from the AEC and other functions remaining in NEC; and section-by-section analysis of the bill. Appendices contain a list of sponsors of the bill; personal provisions of HB 11510; organizational charts; and the text of the bill as reported by the committee with amendments. Additional views from two Congresses are also included. (MCW)

1973

1973

N74-12581° Auburn Univ., Ala.
NATIONAL ENERGY POLICY
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res. Sep. 1973 12 p. refs (For availability see N74-12674-03-34)
CSCL 05A
The efforts of the U.S. government to cope with the national energy crisis are discussed. The provisions of several legislative actions to implement the actions for energy conservation are examined. Immediate conservation measures and the long range planning for energy resources are reported.

N74-16687© Committee on Interior and Insular Affairs (U.S. Senate);
THE PRESIDENT'S ENERGY MESSAGE AND S. 1870
Avail. Comm. on Interior and Insular Affairs
The message of the President of the United States concerning energy resources which was delivered to the Committee on Interior and Insular Affairs on 1 May, 1973 is presented. The subjects discussed are: (1) The national energy policy, (2) developing domestic energy resources, (3) importing fuels to meet demands, (4) conserving energy, (5) research and development projects for energy sources, and (6) international cooperation. The message prepared the development of legislation to authorize the President to allocate energy and fuels when he determines and declares that extraordinary shortages or dislocations in the distribution of energy and fuels exist or are imminent. The legislation provides for the delegation of authority to the Secretary of the Interior to carry out the provisions of the bill.

ON THE LIMITS OF ENERGY RELEASE AND IMPLICATIONS FOR PRESENT POLICY.
C. Barus.
The U.S. Energy Crisis: The Multinational Oil Corporations and Their Relationship to U.S. Foreign Policy in the Middle East
Army War Coll., Carlisle Barracks, Pa.

Examines the activities of multinational oil corporations, the existing energy crisis, and the interactions relative to changes in the U.S. energy policies and the behavior of the multinationals. Feb. 1973. 56 pp. PC $3/MF $1.45

ORDER AD-760-868

1973

ENERGY: ACTION AND REACTION.
Chemical Engineering, May 28, 1973, p. 56, 58, 60.

President Nixon's energy message finally emerges bringing few surprises and evoking both praise and criticism. Oil and gas policy draw the most attention.

AVAILABILITY: NSF SC $4.00
COMPUTERIZED SIMULATION, JET ENGINE FUELS, MILITARY AIRCRAFT, PROCUREMENT POLICY, CRUDE OIL, INTERNATIONAL RELATIONS C36 NA-22590

Toward a National Policy on Energy Resources and Mineral Plant Foods,
Samuel P. Ellison, Jr.
PB-230 248/7WE PCS4.75/MPS1.45

A report is made on the first of the university conferences concerning what our national policy should be on oil, gas, coal, nuclear, geothermal, solar sources on energy resources and on all varieties of mineral plant foods. Directions on what policy should be taken on educational endeavor are included.

Michael J. Briggs, and Mitchell L. Moss.
University of Southern California, Los Angeles. Sea Grant Program. Dec 73, 108p USC-SG-7-73, NOAA-74030412 COM-74-10721/0WE PCS4.50/MPS1.45

The 'energy crisis' is beginning to affect us all. One way to ease this fuel shortage is to discover more new domestic supplies of oil and gas. Since most new sources will probably be in populated areas, it will be necessary to carefully evaluate the environmental and social costs versus the demand. It is at the local community level where the environmental costs of energy exploration will be most acutely felt; and thus, where opposition to proposals for energy exploration and development, is likely to be most vigorously articulated. In this paper the authors examine the capacity of local governmental units to make decisions dealing with energy exploration. The conflict which emerged from the proposal to undertake oil drilling and exploration in the Pacific Palisades section of Los Angeles provides an ideal opportunity to examine community decision-making in local energy exploration. The various environmental, economic, geological, social, aesthetic, political, and legal aspects of this conflict are examined in detail and suggestions are offered which, hopefully, will increase the effectiveness of the local governmental agency in the future. (Author)
As early as 1952, a Presidential commission realized the need for a government-inspired and -coordinated energy policy, but today, with our energy demands spiraling, our internal resources seriously depleted, and our economy weakened by an adverse balance-of-trade deficit that precludes indefinitely increasing fuel purchases from abroad, what energy policies exist are promulgated by 66 different agencies. A tabulation of the federal agencies that presently administer energy policies and programs is shown. The task is monumental for coordination and augmentation of the federal operating programs and reorganization for energy implementation is proposed. (JOW)

Explicit differences in viewpoints that exist regarding the energy crisis are discussed. There are disagreements as to the nature or even the existence of the problem. There are differences in the types of consequences that are of primary concern. There is no commonly accepted and suitable framework within which to resolve many of the functional issues. The review gives some insight into the variety of primary concerns that motivate those engaged in the energy dialog, another barrier to productive discussion that often goes unrecognized.

The energy policy is a major concern of the Office of Science and Technology. Seven departments of the government involved in research and development in energy are the Atomic Energy Commission, Interior Department, the Environmental Protection Agency, the Commerce Department through the Bureau of Standards, the National Science Foundation, NASA, and the Department of Transportation. A recognized policy involves technological, economic, social, legal, political, environmental, and moral problems. The President's Science and Technology Message to Congress in 1973 is analyzed. Near, medium, and long term challenges are outlined. (MCW)

The proposed Electric Facilities Siting Act of 1973 as recommended in President Nixon's message on the environment on Feb. 17, 1973 and introduced in the 93rd Congress is discussed. Legislative provisions deal with long-range planning, organization of certifying agencies (state and federal), certification procedures, and actual certification authority. Questions and answers on the President's Energy Message to Congress are presented. (JOW)
ENERGY: A STRATEGY OF DIVERSITY.
E.E. David, Jr.

The stakes in the energy crisis and in the longer range future of our US energy supplies are high indeed. But a coalition of forces and policies -- not monolithic technological attack -- is the only appropriate response.

ENERGY AND THE FUTURE: RESEARCH PRIORITIES AND NATIONAL POLICY.
A.L. Hammond.

The energy problems facing the United States are only partially amenable to technological solutions. Not every new energy conversion device nor every exotic energy source needs to be developed. More significant, in the long run, will be new attitudes and policies that take into account finite resources and equitable distribution of the costs of producing energy.
The energy equations
Realities of the energy crisis Chauncey Starr 322
Energy analysis in policy making Dr Malcolm Slessor 323
Battle for an EEC energy policy Dr John Thomas 330

The U. S. policies in the economic, national security, research and development, and environmental areas were formulated prior to the 1973 energy crisis. The establishment of an energy policy that is consistent with other existing national policies will be difficult, when the inconsistencies already existing are considered. Heavily funded breeder reactor development exemplifies the type of inconsistency existing. It is suggested that a reasonable energy policy involves nuclear fission playing a minor role, clean-burning fossil fuels decreasing in importance, and geothermal or solar energy sources becoming dominant. (68 references) (MCW)


ENERGY 1: CLEAR US POLICY REMAINS ELUSIVE GOAL AS WORLD AND DOMESTIC DEMAND FOR FUEL RISES SHARPLY. p.1505-
ENERGY 2: IMMEDIATE PROSPECTS. p.1508-
ENERGY 3: GOVERNMENT REORGANIZATION. p.1517-
ENERGY 4: RESEARCH MANAGEMENT. p.1527-
ENERGY 5: RESEARCH AND DEVELOPMENT. p.1531-
ENERGY 6: WORLDWIDE OIL POLITICS. p.1539-

A discussion of state energy problems and the research required to support the selection of policies designed to solve them. The example chosen is the State of Florida, in which future energy demands may be in conflict with its unique environment, and the basis for the discussion is Rand's past and present energy work for the National Science Foundation and the State of California. Author
ENERGY CRISIS: PRESIDENT SPRINTS TO CATCH UP WITH EVENTS. R. Gillette.

74N71306 72/00/00 669 PAGES UNCLASSIFIED DOCUMENT
FEDERAL LEASING AND DISPOSAL POLICIES
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS (U.S. SENATE). A/VAIL
COMM. ON INTERIOR AND INSULAR AFFAIRS
WASHINGTON GPO HEARING BEFORE COMM. ON INTERIOR AND INSULAR
AFFAIRS, 92ND CONG., 2ND SESS., 15 JULY 1972
/*GOVERNMENTS*/POLICIES/RESOURCES MANAGEMENT/
COAL/ ENERGY REQUIREMENTS/ GEOTHERMAL RESOURCES/ NATURAL GAS/ SHALE
OIL

74N72734 72/00/00 186 PAGES UNCLASSIFIED DOCUMENT
A REVIEW OF ENERGY POLICY ACTIVITY OF THE 92ND CONGRESS, FIRST
SESSION
A/PERRY, H.; B/BEARD, D.; C/BROWN, H. A/(COMP.); B/(COMP.);
C/(COMP.)
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS (U.S. SENATE). LIBRARY
OF CONGRESS, WASHINGTON, D.C. A/VAIL COMM. ON INTERIOR AND INSULAR
AFFAIRS
WASHINGTON GPO PREPARED BY LIBRARY OF CONG.
PRESENTED TO COMM. ON INTERIOR AND INSULAR AFFAIRS, 92ND CONG., 2ND
SESS., 30 DEC. 1971
/*CONGRESS*/DECISION MAKING/ENERGY POLICY/ ENERGY SOURCES/
MANAGEMENT PLANNING/ PROBLEM SOLVING

73N72315 DOS-PUBL-3662 72/08/00 6 PAGES UNCLASSIFIED DOCUMENT
THE INTERNATIONAL IMPLICATIONS OF THE ENERGY SITUATION GENERAL
FOREIGN POLICY SERIES 265
A/IRWIN, J. N., II
STATE DEPT., WASHINGTON, D.C. (OFFICE OF MEDIA SERVICES.)
/*ENERGY SOURCES*/INTERNATIONAL COOPERATION/ ENERGY REQUIREMENTS/
PRODUCTION ENGINEERING
FRESH WHITE HOUSE MOVES TO COPE WITH ENERGY CRISIS.

A new "energy czar"...a new conservation drive. They're the latest White House actions to relieve a summer gasoline problem that is touch and go.

ENERGY SHORTAGE - THE PRESIDENT'S BLUEPRINT FOR MEETING THE NATION'S NEEDS.

WHITE HOUSE ENERGY POLICY: WHO HAS THE POWER?

PRESIDENT NIXON TAKES A FIRM STAND ON ENERGY.

1973

PERSPECTIVES ON POWER AND POLICY. SIMPSON,
The shift to the electrical economy must be the core of a national energy policy, but the formulation of a meaningful policy may not come in time to avert a real energy crisis. The entire electric energy industry must set to develop strategy to meet the future energy demands. Substitutes must be found for gas and oil when possible. Coal is one substitute, electrical power from a nuclear energy base is another. (Auth)

FACING THE ENERGY CHALLENGE. Warren, F. M.
In view of the many dimensions of the energy challenge, it is better to have the widespread interest in what is being done to avert a true energy crisis than have the lack of attention that existed when electricity and other forms of energy were taken for granted. Co-ordination of nationwide energy policies is urgently needed. Confusion and contradictions must be eliminated. (JCW)

ENERGY SECURITY - NEW DIMENSION FOR US POLICY.

N74-19617# Committee on Commerce (U. S. Senate).
COUNCIL ON ENERGY POLICY
Washington GPO 1973 225 p refs. Hearings on S, 70 and
1973
Avail: Comm. on Comm.
Hearings on the establishment of a national energy resources
advisory board are presented. Measures to coordinate energy
policies and improve management of energy resources are
outlined.

S.K.W.
SOME IMPLICATIONS OF POLICIES TO SLOW THE GROWTH OF ELECTRICITY DEMAND IN CALIFORNIA.

Rand Corp. R-990-NEP/CSA
Rand Corp. R-1116-NEP/CSA
NEP 01-44 (For R-1116-NEP/CSAsee CN-129,867)

Energy Highway Plan 1.8 - Resources L-8-29-73

MAN VERSUS HIS INSTITUTIONS
The goals of a rational energy policy encompass: (1) limitation of total energy consumption to those amounts necessary for a quality of life compatible with the carrying capacity of the environment; (2) use of a combination of energy sources for maximum efficiency; (3) minimization of ecological disruption, aesthetic harm, or damage to human and animal health; (4) public policy making procedures to achieve above goals; and (5) elimination of undue special interest propaganda based on one-sided facts.

G.G.

N-129,690 92d Congress, 2d Session Committee on Interior and Insular Affairs

PETROCHEMICALS AND OUR ENERGY POLICIES.
W.C. Brown, Hercules, Inc.
**CALIFORNIA'S ELECTRICITY QUANDARY: 3: SLOWING THE GROWTH RATE**


(Grant NSF G1-44)
(R-1116-NSF/CSC) Avail. NTIS HC $10.00

Results are presented of one part of a broad study effort on the underlying cause of the conflict between energy and the environment—the rapid increase in demand for energy in all its forms and on the implications of this conflict for governmental policymaking. The objectives are: (1) to examine the need for new state policies that would slow the growth of electricity demand; (2) to estimate the potential effectiveness of policies designed to slow the growth rate; and (3) to evaluate the potentially important side effects of slowed electricity growth.

Author

**TOP PRIORITY: DRAWING UP AN ENERGY POLICY.**


Fuel forecasts: high costs, low supply. Congress demands an overall plan.

**AN ENERGY ETHIC**

Marvin R. Gustavson | In Mitre Corp. Symp. on Energy, Resources and the Environment, Vol. 2 | 13 Apr. 1972 | p. 28-67 (For availability see N74-18591 09-34)

The development of a consensual energy ethic is projected that leads to public agreement as to what is fair in respect to the various aspects of source development. Key issues are: Source development—particularly of fossil fuel; energy use—affected by education, advertising, and legislation; (3) nationalism—implied in the national security sense as seen by a citizen of a consuming nation; (4) pollution—as a negative factor in the quality of life; (5) Federal funding—as an element of public support; and (6) fusion reactors—as an example of a possible technological key to abundant energy.

G.G.

**ENERGY DILEMMA.** J.R. Schlesinger.


Relations of public policy with energy production are discussed. The ability of the American society to deal with the energy dilemma is considered. Projections of future energy requirements are reviewed to bring in focus the problems faced by society.
D. RESEARCH AND DEVELOPMENT
energy research: science's last best hope

1974

1974
Physical research on the three-tiered system.
only applicable to residents of the state of New York, and the State of New York has the jurisdiction to enforce compliance with the provisions of the Law. The provisions of this Law may be enforced by the Attorney General or the District Attorney of the State of New York.
The research activity, aimed at enhancing and improving the management of food wastage and waste, was performed in collaboration with a local committee. The research activity involved the development of a new model to enhance the management of food wastage. The model was developed in collaboration with a local committee, and its implementation was expected to improve the efficiency of waste management. The model was tested in a pilot project and showed promising results. The model was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant reduction in food wastage and waste. The model was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The model was also compared to traditional waste management methods, and the results showed that the new model was more effective in reducing waste. The research activity also involved the development of a new software tool to facilitate the implementation of the model. The tool was tested in a pilot project and showed promising results. The tool was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant improvement in the management of waste. The tool was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The tool was also compared to traditional waste management methods, and the results showed that the new tool was more effective in managing waste. The research activity was also used to develop a new policy to address the issue of waste management. The policy was developed in collaboration with a local committee, and its implementation was expected to improve the efficiency of waste management. The policy was tested in a pilot project and showed promising results. The policy was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant reduction in waste. The policy was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The policy was also compared to traditional waste management methods, and the results showed that the new policy was more effective in managing waste. The research activity was also used to develop a new program to address the issue of waste management. The program was developed in collaboration with a local committee, and its implementation was expected to improve the efficiency of waste management. The program was tested in a pilot project and showed promising results. The program was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant reduction in waste. The program was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The program was also compared to traditional waste management methods, and the results showed that the new program was more effective in managing waste. The research activity was also used to develop a new strategy to address the issue of waste management. The strategy was developed in collaboration with a local committee, and its implementation was expected to improve the efficiency of waste management. The strategy was tested in a pilot project and showed promising results. The strategy was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant reduction in waste. The strategy was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The strategy was also compared to traditional waste management methods, and the results showed that the new strategy was more effective in managing waste. The research activity was also used to develop a new approach to address the issue of waste management. The approach was developed in collaboration with a local committee, and its implementation was expected to improve the efficiency of waste management. The approach was tested in a pilot project and showed promising results. The approach was then implemented on a larger scale, and its impact on waste management was evaluated. The results indicated a significant reduction in waste. The approach was further improved based on the feedback received from the pilot project, and its implementation was expected to further enhance the efficiency of waste management. The approach was also compared to traditional waste management methods, and the results showed that the new approach was more effective in managing waste.
March 27, 1975

2d Session, Amendment No. 3 for S-1744, Committee on Commerce, U.S. Senate - 94th Congress,

ENERGY RESEARCH AND DEVELOPMENT

N-179, 94th Congress, 2d Session, Serial No. 96-64

For Vol. 2 see NT3-1979

The following is a partial list of consumer products and economic benefits from the national energy program:

1. Reduction in foreign oil dependency.
2. Increased domestic oil production.
3. Improved energy efficiency.
4. Lower energy costs.
5. Increased energy security.

The following are examples of consumer products and economic benefits from the national energy program:

1. Increased energy efficiency.
2. Lower energy costs.
3. Improved energy security.

The following are examples of consumer products and economic benefits from the national energy program:

1. Increased energy efficiency.
2. Lower energy costs.
3. Improved energy security.

1977 94th Congress, 2d Session, Serial No. 96-64

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1. Increased energy efficiency.
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3. Improved energy security.
The Commission's Role in Electric Power Research

Electric Power Research Institute

The Commission's role in electric power research, as discussed in the 1975 Summer Meeting, is to provide a forum for the exchange of information and to serve as a source of technical expertise in the field of electric power. This role is accomplished through various activities, including the organization of technical conferences, the publication of technical reports, and the fostering of collaborative research projects. The Commission aims to promote the advancement of electric power technology and to contribute to the development of a more efficient and sustainable electric power system.

The Commission is composed of representatives from various fields, including utilities, manufacturers, and researchers. These representatives work together to identify key research priorities and to allocate funds for research projects. The Commission's role is particularly important in the face of rapidly changing technology and increasing demands for improved electric power systems.

In summary, the Commission's role in electric power research is to facilitate the exchange of information, to promote collaborative research efforts, and to contribute to the advancement of technology in the field of electric power.

In the first three categories are assessed:

1. Transportation by airlines. Transportation services for future years is needed to plan about evolution.

2. Transportation by automobile. The dependance on transportation on imported petroleum is projected.

3. Transportation by rail. The petroleum products make the transportation sector vulnerable to higher transportation cost.

4. Transportation by water. Transportation cost to be considered now and in the near future. Remedial actions should be initiated now.

Actions include:

Transportation energy demand projections are given and R&D tasks in

N-THO. 792 92nd Congress, 2nd Session.

Department of Transportation

(Report No. 792) September 1975.

Department of Transportation

NTH-79288

1975
E. ENVIRONMENT
The energy crisis raised a threat to Congress to develop a comprehensive energy policy. The Department of Energy, for example, reported that the government planned to provide a variety of energy sources, including nuclear power, coal, and renewable resources. The government also proposed to increase energy efficiency and conservation efforts. The environmental community was concerned about the potential impact of these proposals on the environment.

ENERGY VS. ENVIRONMENT. A CONFLICT IN CONGRESS.

1985 and 2000:
the picture of the energy
resource provides a basis
of energy and the enviroment
A survey of expert opinion

The future of the energy
resource is uncertain.

To be well...
the environmental
energy but so far all still seems
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develop a comprehensive energy policy. The Department of Energy, for example, reported that the government planned to provide a variety of energy sources, including nuclear power, coal, and renewable resources. The government also proposed to increase energy efficiency and conservation efforts. The environmental community was concerned about the potential impact of these proposals on the environment.

ENERGY VS. ENVIRONMENT. A CONFLICT IN CONGRESS.

1985 and 2000:
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The future of the energy
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Emission characteristics of Propane as
freestream.

Emission of gases and vapors from the
burner of a portable halogen lamp.

1973

Environmental Protection Agency

The purpose of conducting this activity is to
find any adverse effects of this emission
source, and to determine if any action is
necessary to control it.

The emission data will be used to
evaluate the potential impact on the
environment and human health, and to
determine if any regulations need to be
implemented to mitigate these effects.

The emission characteristics of Propane
were found to be:

- Propane concentration was 100 ppm.
- The temperature of the emission was
  700°C.
- The flow rate of the emission was
  0.2 m³/min.

The impact on emissions:

- The impact on human health:
  - No adverse effects were observed.
- The impact on the environment:
  - No adverse effects were observed.

The next steps:

- Conduct additional tests to assess the
  impact of different lamp models.
- Develop guidelines for lamp use to
  minimize emissions.

COM: 41-110 WEVF

End the experiment.

1975

End the experiment.

N.I.-7-24

Compliance with applicable laws.

Environmental Protection Agency

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find any adverse effects of this emission
source, and to determine if any action is
necessary to control it.

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- Develop guidelines for lamp use to
  minimize emissions.
The department's test program under the Energy Conservation and Production Act would like to report the following:

- The program is focusing on energy conservation and production.
- The department is working on developing new technologies and methods.
- The department is collaborating with other government agencies and private companies.
- The program is expected to save energy and reduce costs.

The department welcomes any feedback or suggestions for improvements.

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Energy Conservation and Production Act
Department of Energy
The report is concerned with today's problems in the city.

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F. CONSUMPTION AND ECONOMICS
Energy Report/Study lists industries by energy

The energy used by the U.S. food grade constituents about 17 percent of the national energy budget.

Energy-related energy requirements.

Commodity price, 1977 survey of manufacturers.

The commodity was assessed from the
energy costs as a percentage of value of ship-
business categories are ranked according to

The market demand for certain commodities,

1974

The price (cents) of gasoline, the

FOOD RELATED ENERGY REQUIREMENTS.

And 35 percent represented

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and participate in these activities and
experiences that step to be taken by AF to assist
nonprofit organizations, especially meeting the needs and needs
and priorities of the community. The key activities and
services to be provided are:

- A report to the SBE Board of Directors

ECONOMIC POLICIES AND THE ENVIRONMENT

A. Robert Mercer, March 1974

The Annual Report: March 1974

While the report has been reviewed by several
members of the Board and the Committee, the report is
intended to serve as a tool for discussion and
preparation of future reports. The report is
structured to encourage the reader to think about
the issues presented and to consider the
categories of problems that need to be addressed.

ECONOMICS

Energy Use in the U.S. Food System: A. S. E. B. and C. E. Subcommittees

Science, v.74, no.4734, Apr. 19, 1974

Presented by a panel of experts, the report presents
two different approaches to the energy crisis:

- Economic Security for Import-Export Competitors
- A. S. E. B. and C. E. Subcommittees

ECONOMICS

Energy Use in the U.S. Food System: A. S. E. B. and C. E. Subcommittees

Science, v.74, no.4734, Apr. 19, 1974
Making emergency value for money

W. Short

...
ECONOMIC AND THE PROFESSIONAL INDUSTRY

The importance of the service industries, particularly in the post-war years, has been a major decision in the economic planning of the country. The service industries have been expanding faster than the manufacturing sector. The economies have been focused on the expansion of the service sector, which has been growing at a much faster rate than the manufacturing sector.

However, the service industries are not the only ones that have been expanding. The manufacturing sector has also been growing, but at a slower rate. The service industries have been able to grow because of the increasing demand for services. The manufacturing sector, on the other hand, has been able to grow because of the increasing demand for goods. The two sectors are interdependent, and the growth of one has led to the growth of the other.

The economies of the service industries have been expanding faster than the manufacturing sector. This has led to an increase in the demand for services. The service industries have been able to meet this demand by increasing their production.

In conclusion, the service industries have been expanding faster than the manufacturing sector. This has led to an increase in the demand for services, which the service industries have been able to meet by increasing their production. The service industries have been able to grow because of the increasing demand for services, and the manufacturing sector has been able to grow because of the increasing demand for goods.
Comfortable RAstral Office, Wash. D.C.

At 1:15 to 1:35, a panel of experts convened to discuss and examine the implications of recent developments in technology. The panel, composed of representatives from various fields, including architecture, engineering, and urban planning, gathered to address the challenges posed by the rapid evolution of the built environment. The session aimed to explore strategies for sustainable development and to identify new opportunities for innovation.

The panelists, each an expert in their respective domains, shared insights on how technological advancements are reshaping the way we design and live in our cities. Discussions centered around the integration of green technologies, the importance of sustainable materials, and the role of smart city initiatives in promoting environmental stewardship.

As the session progressed, the panelists engaged in a lively exchange, highlighting the synergies between traditional practices and emerging technologies. The goal was to foster a collaborative approach that embraces both cutting-edge innovations and well-established methodologies, ensuring that future development is as responsible as it is responsive.

The event concluded with a closing remarks by the moderator, emphasizing the need for continued dialogue and proactive planning to navigate the complexities of modern urban life. The attendees were encouraged to remain vigilant and proactive in the face of ongoing changes, recognizing that sustainability is not just a goal but a imperative for the well-being of our communities.
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**Note:** Performance demand is the maximum expected level of performance, while performance supply is the actual level achieved. Imports from base levels refer to the difference between performance demand and performance supply, indicating the need for imports to meet demand.
and development trend in energy consumption for national transportation statistics. A supplement to the summary report.
TITLE: A Study of The Refractories Industry - Its Relationship to The U.S. Economy and Its Energy Needs
AUTHOR: Barr, H.W., Jr.; Lyons, R.F.; Fisher, W.H.; Dockworth, W.F.; McCoy, L.G.
CORPORATE AUTHOR: Battelle, Columbus Laboratories
ADDRESS: 185 King Avenue, Columbus, OH 43201
PUBLICATION DESCRIPTION: 32 p. report
PUBLICATION DATE: 1973, October
SPONSOR: The Refractories Institute, 1102 One Oliver Plaza, Pittsburgh, PA 15222
ABSTRACT: This report discusses the contributions that refractories make to the U.S. economy and the energy resources they require. The analysis shows that the use of refractories will result in a proportional decrease in industrial production. It is concluded that it is in the national interest to permit more increases in energy usage by the refractory industry even when energy resources are being allocated.

(ORN-L-NSF-EP-57) ENERGY USE FOR FOOD IN THE UNITED STATES. Hirst, E. (Oak Ridge National Lab., Tenn. (USA). Oct 1973. Contract W-7405-eng-36. 49p. Dep. NTIS $4.50. The energy used in food-related activities in the United States from agriculture to final consumption is computed for the year 1963 using energy input/output table developed at ORNL and economic input/output data from the Department of Commerce. A total of 100 trillion Btu - 12% of total 1963 energy consumption - was required to grow, process, transport, wholesale, retail, and cook food. This includes 120 million cubic feet, 27% of total electricity use that year. Farming accounted for less than one-third of the energy used for food. Farming and processing together used just over half the total. The remainder was used for transportation, trade, and household functions. Between 1960 and 1970, food-related energy use grew at an estimated 3.3% a year. This growth rate was greater than that for population but less than that for total energy use. On average, 6.4 Btu of primary energy were consumed in delivering one Btu of food energy to final demand. The comparable protein ratio was 840 Btu of primary energy per gram of food protein. (auth)

(1973) ROLE OF ENERGY IN AGRO-INDUSTRIAL DEVELOPMENT. Hammond, R.P. Oak Ridge National Lab., Tenn. (USA). [ad]. Sp. Dep. NTIS $3.00. From fourth international symposium on fresh water from the sea, Mendeberg, F.R. Germany (9 Sep 1972). Experience has shown that both agricultural and industrial sectors of any region must be developed together, and that both are dependent on access to cheap energy, which plays a key role. An agro-industrial complex is an efficient way to provide a balanced input of energy and technology. Such a complex, and the more general concept of an energy center, gains efficiency in capital cost, fuel cost, land use, transport, raw material consumption, and in the use of human resources. The inherently large size of a complex is a disadvantage, but there are several ways in which this problem can be minimized. (auth)

(CAMPUS UTILITY COSTS. Turner, B.O. (Engineering Co., Salt Lake City). Heat, Piping Air Cond., 45: 8, 85-88(Nov 1973). Studies were made at three Utah universities to determine utility consumption at individual buildings. One of the first attempts as an economy move in the metering system is to install meters in the buildings. Meters and recorders were installed to the campus utilities, and used to accumulate the required data on heating, water services, and electric power use. The data can be used to estimate utility consumption and costs for existing buildings not metered, buildings under construction, and future buildings for possible means of energy conservation. (MCW)

POWER GENERATION AT THE TOP 100 ELECTRIC COMPANIES. Owens, K.R. Elect. Light Power (Boston), 51: No. 15, 26-31(Jul 1973). Some large electric power producers made adjustments in 1972 to accommodate the fuel crisis. The wide swings are shown in natural gas, oil, and coal consumption in a table ranking the top 100 power generating companies, with comparisons for 1971, on heat rates and fuel consumption data. Where natural gas could be bought, the consumption - primarily for use in gas turbines - went up considerably. Where the gas could not be bought, the consumption used considerable quantities of oil, the quality of which varied from heavy crude, causing higher maintenance rates. Peak demand and capability for the 100 companies also tabulated. The amount of fossil, hydro, gas turbine, and diesel, and nuclear power generation in each of the top companies is listed. It is concluded that the ultimate answer to the national energy problem, according to the president's message, is expansion and development. The essence of the statistics provided on total energy consumption by the electric companies now shows a stable pattern. (MCW)

(POLLUTION CONTROL ENERGY COSTS. Hirst, E. (Oak Ridge National Lab., Tenn. (USA). 1973. 35p. Dep. NTIS $3.00. From winter meeting of American Society of Mechanical Engineers, Detroit, Michigan, USA (11 Nov 1973). The amounts of energy needed for or saved by operation of several environmental protection strategies are examined. The areas considered include: urban passenger traffic, waste water treatment, solid waste management, air-pollution control, and waste heat dissipation. The energy required to meet the environmental needs discussed - based on the limitations and assumptions in this study - are small relative to total energy use. (auth))

The energy problems of the USA up to 1980 are examined from the vantage point of the Treasury Department and the Oil Policy Committee. The present difficulties arise and what will be the impact of the President's new proposals on further exploration and development for oil production, on refinery construction, and on balance of payments are discussed. The effect of the actions may change the way of life in the developed world, and it could be for the better if this is used as an opportunity to eliminate waste and strive for efficiency in energy use.

J.A.M.
N74-14658# Oak Ridge National Lab., Tenn.
ELECTRIC ENERGY REQUIREMENTS FOR ENVIRONMENTAL PROTECTION
(Conf-730205-4) Avail: NTIS HC $3.00
The amount of electricity needed for (or saved by) operation of several environmental quality strategies is examined. These strategies include: electric mass transit, waste water treatment, solid waste disposal, air pollution control, waste heat dissipation, and electricity conservation. Energy requirements of existing electric mass transit systems are compared with the new BART system, buses, and autos. Electric energy costs, as a function of plant size, are examined for primary/secondary sewage plants. Electricity costs and savings are computed for solid waste disposal, recycle, and use as fuel. Electricity needs for air pollution control at stationary sources and from motor vehicles are evaluated. Electricity needs for use of cooling towers at power plants are reviewed. Finally, potential energy savings which reduce air and thermal pollution levels are examined. The electricity required to meet the needs discussed here, based on the assumptions in this study, are small relative to total kilowatt-hour consumption.
Author (NSA)

N74-20617# Arkansas Univ., Fayetteville, Dept. of Physics.
ENERGY IN THE NEAR TERM
Avail: NTIS HC $6.00
The dependence of the United States on petroleum as a primary energy source is discussed. Data are presented which outline energy consumption and production estimates. Techniques which would reduce energy consumption are outlined. Comparisons are made between energy consumption and employment.
S.K.W.


THE ENERGY COST OF POLLUTION CONTROL 37
Eric Hirst
Better reclamation of waste and improved transportation systems would decrease our energy needs by 3.2 percent; air and water pollution controls and solid waste disposal will increase energy demand by 3.7 percent. The net effect of environmental improvement measures on energy demand will therefore be negligible, despite recent advertising to the contrary.

The residential demand for electricity at a very detailed level of aggregation is examined. An econometric model is developed for the New England region using a cross-section of sixty-seven electric utilities and their service areas as the data base. Both supply price and demand equations are estimated, using the two-stage least squares technique, to account for the simultaneous nature of the systems. Conclusions are presented and policy implications discussed. Suggestions for future work in the field are also presented. (NTIS)}
The time-response method for calculating residential heat loads was experimentally verified using several occupied single-family residences. Calculated and measured heating requirements were compared on an hourly basis and for a 54-day test period. The results of the study demonstrated the applicability of the time-response method for calculating residential heat loads for occupied residences having average quality of construction and lifestyle patterns of the occupants.

Electricity growth: Economic incentives and environmental quality --- consumption and pricing of electricity in United States of America, Wisconsin.

Environmental Energy: Examines amounts of energy needed for air and water pollution control, solid waste disposal, and other environmental protection strategies. 19 pages. (CONF-730205-4, available through AEC/contractor channels or at a later date, from NTIS, U.S. Dept. of Commerce, Springfield, Va. 22151.)
AUTHOR: Junt, J.E.
CORPORATE AUTHOR: Massachusetts Institute of Technology, Energy Laboratory; Massachusetts Institute of Technology, Alfred P. Sloan School of Management
ADDRESS: Cambridge, MA 02139
PUBLICATION DESCRIPTION: 179 p. report
PUBLICATION DATE: 1973, February
SPONSOR: National Science Foundation, BAW Program: Air, water, and Noise
ABSTRACT: The actual 1963 and the projected 1970 and 1980 input-output tables are used to analyze changes in energy consumption between 1963 and 1970 and 1980. The changes are broken down into two components: those caused by technological change and those caused by final demand growth. The analysis is performed by converting the dollar flows of the input-output tables into energy flows in BTU's. Various sectors of the economy are ranked according to energy used for total consumption, consumption per unit of output, and consumption per unit of final demand sale. These rankings are made for coal, oil, natural gas, and electricity consumption. The results indicate that the technology of energy use efficiency has not been improving as rapidly as in the past and that by 1980 technology will actually result in increased energy use caused by greater electricity and natural gas consumption. Policy implications are also discussed. (Auth)
A Study of Process Energy Requirements for U.S. Industries

AUTHORS: Johnson, T.J. (Chairman); Bacon, U.L. (Chairman); Ethorp, M.; Brooks, P.B.; Guss, P.S.; Platek, O.; Ploszczyn; C.C.; Slawson, L.A.; Nettick, B.L.; Rocky, R.L.; White, L.W.

CORPORATE AUTHOR: American Gas Association, Inc., Industrial Sales Promotion Committee, Natural Gas Extension Task Forces

ADDRESS: 605 Third Avenue, New York, N.Y. 10017

PUBLICATION DATE: 90000, 020 p.

PUBLICATION DESCRIPTION: Series of 10 reports. Description... (Ref)

ABSTRACT: The series of ten reports discusses process heat requirements in the following industries: nonferrous metals, cement and lime, paper and pulp, chemical, iron and steel, rubber and plastics, food, textile, and glass. Total energy requirements, present and future, and the technical and economic bases for process heat requirement... (Ref)

A Report on Automobile Fuel Economy.

Environmental Protection Agency, Washington, D.C. Office of Mobile Source Air Pollution Control. Oct 73. 42p PB-229 79B/W859

The results of the Environmental Protection Agencies' analysis of fuel economy data from more than 4,000 cars tested on the Federal Driving Cycle are presented. Vehicle weight is the single most important design parameter affecting fuel economy.


The objectives of the study are to determine: (1) what significant purposes have fuels been used for in the United States; (2) what portion of the nation's energy requirements for the various end uses have been met by each fuel; (3) what has been the rate of growth of consumption in the major end uses of each fuel; (4) what technical efficiency can be expected when each fuel is used for those end uses for which it is suitable; (5) the emphasis of the study was on the residential, commercial, and industrial sectors, the use of electric power has also been incorporated along with the transportation sector, in order to arrive at total energy balance. This report is strictly a factual document, its purpose is to provide the most detailed information practicable on how the nation uses its energy. Author


Report is made of an investigation into the nature of transportation in terms of energy depletion and fuel consumption. Graphic profiles are presented which trace the growth rates of specific modes of passenger and freight transportation from 1955 to 1988. A summary of likely transportation energy demands for the future is also included. J.M.M.


The role of transportation in air pollution and consumption of energy, especially petroleum, is reviewed, with emphasis on the U.S. situation. Both technological and control measures for each problem area are discussed. Technological measures control the automobile, high speed ground transportation modes, and non-petroleum fuels. While control measures such as the use of the more efficient transportation modes, are seen to offer significant benefits. The near future is discussed with respect to the impact of the U.S. Clean Air Act of 1970. Transportation evolution over the next few decades is projected. Author (GRA)
Energy Consumption and Electric Supply Influences.
David C. White.
Massachusetts Inst. of Tech., Cambridge. 3 Nov 72. 13p
NSF-RA/N-73-049
PB-228 261/4/W E PCS.00/MFS1.45

Today's U.S. energy problem is not just based on resources or environmental degradation but is much more fundamental. There appears to be a basic mismatch between the relative short time response of the market place and the much longer time response for changes in supply capability. Much of today's energy crisis is due to this mismatch and no method of dealing with it adequately has yet been developed. In the period being faced today and for the next several decades, with the structure of the energy industry adjusting to the new resource and environmental constraints, there are approaches which will help the supply-demand balance, and these require much more attention to the way energy is used to perform the necessary functions of our industrialized society.

N73-20819f Battelle Columbus Labs., Ohio.
(AD-754824) Avail. NTIS CSCL 21/4

The report documents the results of a brief program to review the magnitude and nature of the energy requirements of the Department of Defense (DoD) and to identify research and development activities or other actions which should be undertaken by the DoD in order to minimize or ameliorate its energy-related problems. Some of the topics include the following: Energy resources (coal, oil, natural gas, uranium, fusion energy, hydrogen energy); Energy consumption and projections for future requirements; Energy problems; and Specific recommendations (Develop domestic sources of substitute liquid petroleum fuel from oil shale and coal, improve the efficiency of piston and turbine engines, develop strategies for military use of hydrogen as an alternate energy source).

RESIDENTIAL ENERGY CONSUMPTION - PHASE I REPORT.
March 1972.

Hittman Associates, Inc. HUD-HAI-1
Department of Housing and Urban Development
Contract (HUD)-H-1634

Energy consumption
Power sources

L-8-9-73


Hittman Associates, Inc. HUD-HAI-3
Department of Housing and Urban Development
Contract (HUD)-H-1651

Energy consumption
Power sources

L-8-9-73

1972

1972

TITLE: Energy Use in Wisconsin - A Survey of Energy Flow in the State of Wisconsin
AUTHOR: Poell, W.K. (Rohnston, Wis.)
CORPORATE AUTHOR: University of Wisconsin-Madison, Institute for Environmental Studies
ADDRESS: Madison, WI 53704
PUBLICATION DATE: 1972, October
SPONSOR: National Science Foundation, NASA Program

ABSTRACT: To have undertaken a comprehensive study of energy usage in Wisconsin, its relationship to the state's present societal and physical characteristics, and its implications for the immediate and long-term future of the state.---The basic framework of our study is the creation of a state energy model. A model can be thought of simply as an ordered set of assumptions about a complex system. In our case, it will consist of a computerized collection of data and information about energy usage in Wisconsin, written in a simple mathematical form so as to simulate our energy system and its relationship to various social, economic and physical characteristics of the state. The model is intended to reveal significant trends, causes, and relationships, and to provide a better basis for understanding their implications for the future.---This first report represents only a preliminary collection of data, intended to provide a better feeling for state energy usage, and to reveal areas of growth and importance. The report covers all types of energy, not just electricity, since it is becoming increasingly clear that we cannot develop energy strategies on a compartmentalized basis. The bulk of the information contained in this first report deals with the physical flow of energy, i.e., types, quantities, and the purposes for which it is used. So data on pollution or other environmental effects are included here, nor is any emphasis given to social and economic data, although these are being compiled later. (Auth. from Introduction)

AVAILABILITY: Wesley K. Poell, Deputy Chief, Nuclear Engineering/Environmental Studies, 1500 Johnson Drive, Madison, WI 53704

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From 7th International Energy Conversion Engineering Conference, San Diego, California, USA (25 Sep 1972). See CONF-720825-.

Energy utilization is defined here as: (i) system utilization, that is, a measure of system performance in supplying the demand of the energy system; (ii) energy productivity, that is, a measure of the effectiveness of the demand sector of the system; i.e., product or service output per unit energy input; and (iii) system constraints, that represent the conditions imposed by the larger energy system. System utilization is developed in detail. An analytical formulation of a general energy system is developed, based upon the fundamental concept of thermodynamic availability. A general energy system is defined in terms of system elements—source energy users and converters. Utilization criteria and effectiveness parameters are defined in terms of the ideal performance of the system in which the reversible transfer of energy is considered ideal. From these criteria and performance parameters it is possible to determine the degree of mismatch between the quality of energy supplied and needed; the impact of cascading energy within the system; the effects of system components, with their associated coefficients and interconnection matrices, on the performance of the general energy system; and the degree of departure of system performance from the ideal. (MCW)


From 7th International Energy Conversion Engineering Conference, San Diego, California, USA (25 Sep 1972). See CONF-720825-.

Energy utilization analysis and criteria are applied to the energy system of an air-electric and gas-electric house to demonstrate the feasibility of this analytical approach on a real system and to gain insight into the character of energy utilization in a house. Data show that the grade level of energy required is, on the average, low, generally being dominated by the low-grade requirements of the heating and hot-water systems. Profiles are developed to demonstrate that these energy requirements are met by having converters taking high-quality energy and producing low-grade hot water and hot air—thus, establishing a mismatch between supply and demand. Basically, two points are established about house energy-system utilization: Firstly, the requirement for low-grade thermal energy is met by taking high-quality energy from outside the system and passing it through low-performance converters. Secondly, the cascading of discharge energy improves system performance by increasing one effectiveness parameter from a value of 0.15 to 0.35 (without cascading) to 0.72 and improving a second from 5.04 to 5.5 relative to an ideal value of 0.333. (MCW)


From 7th International Energy Conversion Engineering Conference, San Diego, California, USA (25 Sep 1972). See CONF-720825-.

The current fuel crisis and rapidly increasing fuel consumption throughout the country has highlighted the need to economize on their use. With this thought in mind, Hillman Associates, Inc. under HUD sponsorship has been studying various means by which energy consumption within single-family, townhouse, and multi-family residences can be reduced without changing the basic life style of the residence. Preliminary results are presented and several potential energy saving concepts are discussed. (auth)
1972


The results and conclusions of a 1971–1972 techno-economic survey of trends in the U.S. electric power industry are presented. These conclusions relate to power generating capacity, the effects of environmental considerations on the construction and operation of new generating plants, fuel economics involving coal, oil, natural gas, and nuclear fuels, required research and development programs, the development of larger capacity generating and transmission systems, the need for a national energy policy, and the effect of the increasing time lag between the ordering and operation of new generating facilities. It is concluded that due to the complicated forces acting, it is not possible to predict now whether supply can meet projected demand over the next decade or so. (LCL)


An overall view is provided of the probable directions in the demand, production, transmission, and distribution of electric power in the U.S. Detailed information is included on: U.S. requirements and generating capacity; the structure of the U.S. electric power industry; factors acting to produce changes, such as economic, environmental considerations, fuel supply, and technological trends; fuel research and development work on power systems; power generation systems and equipment; power plants and supply networks; transmission and distribution; and economics. (LCL)

WORLD ENERGY NEEDS IN RELATION TO ECONOMIC GROWTH AND QUALITY OF LIFE. Felix, F. Energy Int., 9, No. 7, 22-28 (Jul 1972). The latest trends of growth of use of energy and of gross national product were correlated for selected countries of the world and are presented. An elasticity coefficient is determined by a measure of the ratio of the rate at which GNP grows to the rate at which the use of energy increases. With the presentation of the data from the book "World Markets of Tomorrow" by the author, an attempt was made to dispel some of the misconceptions that have been responsible for the recent concern about the perils from exponential growth of consumption of energy in its partnership with economic growth. Other facets of energy that were discussed include growth, productivity, convenience, social betterment, higher quality of the environment, and for survival with recycling, desalting, and synthetic industries to replenish natural resources. (MCW)
CONCENTRATION BY COMPETING RAW FUEL INDUSTRIES IN THE ENERGY MARKET AND ITS IMPACT ON SMALL BUSINESS. VOLUME 2: TENNESSEE VALLEY AREA


Hearings investigated the monopolistic impact of the growing economic concentration in the energy field and the reasons underlying the recent increases in electric rates in the Tennessee Valley Area. Electric rates have increased 25% and coal prices have risen 100% between 1971-72. Findings and recommendations concerning the causes and solutions to the escalating energy costs are included.

K.M.M.

74N71001 71/C0/00 1146 PAGES. UNCLASSIFIED DOCUMENT

CONCENTRATION BY COMPETING RAW FUEL INDUSTRIES IN THE ENERGY MARKET AND ITS IMPACT ON SMALL BUSINESS

SELECT COMMITTEE ON SMALL BUSINESS (U.S. HOUSE). AVAIL. SUBCOMM.

ON SPECIAL SMALL BUSINESS PROBLEMS.

WASHINGTON. GPO. HEARINGS BEFORE SELECT COMM. ON SMALL BUSINESS.

92D CONGR., 1ST SESS. 12-15, 20 AND 22 JULY 1971

/*ENERGY POLICY/*FUELS/*GOVERNMENT/INDUSTRY RELATIONS/COMMERCE/

CONGRESS/EARTH RESOURCES


ENERGY CONSUMPTION AND GROSS NATIONAL PRODUCT IN THE UNITED STATES: AN EXAMINATION OF A RECENT CHANGE IN THE RELATIONSHIP

1971 29 p. refs. Copyright. Avail.: NTIS HC $3.50

The ratio of aggregate energy consumption to Gross National Product (the energy/GNP ratio) underwent a long-term secular decline during the period 1947-1966, following a trend that began in the 1920s. Since 1966, however, the trend has reversed and the ratio has shown an uninterrupted increase. If the trend prior to 1966 had persisted, energy consumption in 1970 would have been lower by an amount greater than the total electric utility consumption of coal in that year. An analysis of the possible reasons for this trend reversal indicates that it cannot be ascribed to any single cause but that a major part of it is apparently the result of: (1) the increasing relative importance of nonenergy uses of the fuels, (2) a tapering off in the year-to-year improvement in thermal efficiency at central power stations, and (3) the increasing relative importance of air conditioning and electric heating. The net result of these factors is a tendency toward a sustained higher growth rate in aggregate energy consumption and a consequent increase in the energy/GNP ratio except in years of high GNP growth rate. Author

N72-32079E RAND Corp., Santa Monica, Calif.

THE EFFECT OF FUEL PRICE INCREASES ON ENERGY INTENSIVENESS OF FREIGHT TRANSPORT


The use of energy for transporting U.S. intercity freight and the effect of higher fuel prices are analyzed. Methods of estimating unit energy consumption are developed and applied to determine average values and trends. Water transport is found to consume an average 800 BTU per ton/mile, rail 750, pipeline 1650, truck 2400, and air cargo 63,000, or 45 times the average for all transport modes in 1968. Only a small shift to air freight, from the present less than 0.2% to 2% of all intercity ton-miles, would double the average unit energy consumption for all freight modes. If present trends continue, this increase will occur by the year 1998. Because of its high fuel consumption, however, air freight growth would tend to be inhibited by higher fuel prices, while surface transport would be little affected. Higher fuel prices may result from shortages, the cost of environmental constraints, new taxes, or other reasons. Author
G. CONSERVATION
ENERGY CONSERVATION: Interim findings and proposals by industry advisers to the Interior Department. Covers short-term prospects for conservation in industry, residential, commercial, transportation and electric utility segments, and outlines areas for future, more detailed investigation. 85 pages. (Energy Conservation in the U.S. Short-Term Potential 1974-1978, available at $3.00 from Director of Information, National Petroleum Council, 1625 K St., N.W., Washington, D.C. 20006.)

Conservation in Industry: C. A. Berg ......................... 264
Energy Conservation at an Industrial Research Center: A. E. Brown and E. B. Berkowitz ......................... 271

ENERGY CONSERVATION IN EXISTING PLANTS.
J.C. Robertson.
Chemical Engineering, v.81, no.2, Jan.21,1974, p.104-111.

Describes many of the ingenious ways of conserving energy.

DESIGNING FOR THE ENERGY CRISIS: EFFICIENCY BY DEGREE.
R.A. Jacobson.

Uncle Sam says that efficiency data soon will be part of the labeling on major appliances intended for use in the home. Cars will have to meet gas-mileage standards. The message is clear: Improve the efficiency of your energy-consuming products or you won't be able to sell them.


Data collected from Los Angeles, San Diego, and San Francisco reveal that controlling outside and return air dampers from an enthalpy standpoint, a tangible energy savings are accomplished over an economizer control system. Developments in electronics have brought forth commercial grade controls with excellent temperature and humidity accuracy and enabled electronically combining the two to get the measurement of the composite energy of air on a continuous basis. The result is enthalpy override control that is economically feasible for small, single-fan systems. (MCW)

CONSERVATION (ENERGY)-A MARKETING DILEMMA, A RESEARCH CHALLENGE.
L.W. Fish.

The design of the all-air system for the United California Bank building in Los Angeles is described. The variable temperature supply combined with variable air volume and a unique double duct approach reduce the shaft and fan room space in the tallest building west of Chicago. Three cooling-only and one heating-cooling combination air handling units feed cold and warm air loops on individual floors. Switching dampers control flow of air from combination air handler to cold and warm loops as required. The fifth air handler, used for heating only, handles load for shaded exposure during cooler or sunny weather when capacity of the three cooling-only units is exceeded. (M'N)


The potential for energy savings and corresponding cost reductions or profit improvements is studied for a twenty-story office building near Los Angeles, Calif., an industrial plant at Lexington, Ky.; and an administration building at La Crosse, Wis. The study evolved from a base design, and energy saving ideas are then evaluated against this base to determine their economic feasibility. For an existing building, the as-installed systems represent the base. The case histories reported are based on studies using TRACE (Trans Air Conditioning Economics), which calculates loads, simulates system and equipment operation, and prepares a detailed economic analysis. (MCW)

HOW MANY MORE MILES PER GALLON?
A. Curtis.

An examination of major improvements that could be made to the conventional piston engine to improve fuel consumption.

DESIGNING THE ENERGY MISER.
R.E. Herzog and R.T. Dann.

The pressure is on wringing every last drop of efficiency out of your product while, of course, holding down costs. High efficiency won't come easily, but there are proven ideas and techniques that may help, and some speculative new concepts that appear promising.

CONSERVING UTILITIES: ENERGY IN NEW CONSTRUCTION.
C.E. Schumacher.

The rising cost of energy makes its conservation important whenever possible. Utilities are a prime target; here are some things you can do.

ENERGY CONSERVATION IN NEW-PLANT DESIGN.
J.B. Fleming, et al.
Chemical Engineering, v. 81, no. 2, Jan. 21, 1974, p. 112-122.
EXXON USA, First Quarter, 1974, v. 8, no. 1.

10 USING ENERGY EFFICIENTLY, by Downs Matthews

We're learning to do more work with less energy so as to conserve fuels in short supply.

Photos by Tracy Borland, Cari Rodman, Bill Epinjgde, and Leo Touche.

CONTROL OF ENERGY DEMAND REDUCES OPERATING COSTS.
B.H. Murphy and R.E. Putman.

A computer controlled system.

THE AIRSHIP CAN MEET THE ENERGY CHALLENGE.
J.G. Vaeth.

THE AIRSHIP can be designed to move cargo pieces weighing a million pounds and more into difficult-to-reach places at energy expenditures matching our resources.

A TECHNICAL BASIS FOR ENERGY CONSERVATION.

With cheap fuel a thing of the past, fuel efficiency looms as a sharp necessity for two crucial reasons: to maintain a competitive industry and to supply the goods and services society deems desirable. Inefficiencies at the point of consumption are a greatly neglected area. The nation's hot-water heaters, for example, waste more fuel than the entire aluminum industry consumes.


The effectiveness of the use of optimum flight profiles as a means of reducing the fuel crisis is studied on the basis of selected performance data for the B-727-200 series aircraft. It is shown that the success of airline fuel conservation programs will depend on the controller and the facility planner. A discussion of a method of measuring fuel savings shows that a descent profile must be applied to existing procedures to determine where these savings can be realized.

V.P.

BUILDINGS OF THE FUTURE WILL SAVE FUEL.

Architects are searching for ways to economize on energy in the new homes and offices they design. Some progress is evident already.
DESIGNING FOR THE ENERGY CRISIS-3: PROCESSES THAT CONSERVE POWER. J.C. Bittenes.


Designers may have to answer for products that require an inordinate amount of energy to manufacture—the future guarantees a lean and more costly energy supply. Manufacturers say that energy may become so valuable that no one will be able to ignore its contribution to the cost of making a product. The problem has only recently been recognized and there is no immediate solution.

The Futurist, v.8, no.1, Feb.1974

The Long-Term Value of the Energy Crisis
By Russell E. Train

The energy crisis could turn out to be one of the best things that ever happened, suggests a leading conservationist who is now the Administrator of the U.S. Environmental Protection Agency. He believes the crisis may lead more people to realize that the earth is not a throwaway commodity and that they must learn a new style of life that emphasizes recycling and the prudent use of resources.

AIRCRAFT FUEL-SAVINGS MEASURES DEBATED.
M.L. Yaffee.
Aviation Wk & Space Tech., Apr.1, 1974, p.49.

ENERGY CONSERVATION BEING PUSHED HARD.
Energy conservation is being practiced in petrochemical industries and teams have been established to plan the programs and projects. Dow Chemical, Du Pont, American Cyanamid, BABB Wyandotte, Union Carbide, Exxon Chemical, and Goodyear are companies reporting energy-reduction programs in power generation, process changes, steam savings, using waste, waste steam sales, furnace and fuel gas savings. (MCW)
A means for evaluating measures for coping with the nation’s energy problems and for achieving fuel efficiency is presented. Correction of inefficiencies at the point of consumption of fuel and electric power offers one of the greatest and yet unexploited opportunities for improving overall fuel efficiency. The report says that in the short-run, improved fuel efficiency offers a means for dealing with fuel shortage without severe economic disruption. In the long-run, with steeply rising fuel prices a virtual certainty, the report declares that improved fuel efficiency is an essential part of maintaining a productive, competitive industry, able to supply the goods and services which society requires.

Energy Conservation, It Benefits All of Us.
Federal Power Commission, Washington, D.C. Feb 74, 13p PB-231 978/8WE PC53.00/MFS1.45

This booklet has been prepared to help provide an understanding of the energy problem, to show why energy conservation is essential, and to indicate the actions individuals and organizations can undertake to conserve electricity and natural gas, which together account for half of the U.S. energy consumption.


Tinted glasses accomplish environmental control by means of selected metallic oxides added in small amounts to the basic sodalime-silicate glass formula. The characteristics of a representative office building in Pittsburgh, Pa. were used to determine the effect of glass on energy consumption. Three architectural glasses were evaluated and it was concluded that glass in exterior walls saves energy during heating or cooling. Calculations were made for ¾-in. clear glass, 1-in. bronze insulating glass, and 1-in. reflective insulating glass. Glass is also a good building material choice in regard to the amount of energy needed for its production. (MCW)


Broadway Plaza in Los Angeles covers 4.5 acres with shopping, office, and hotel facilities within a single structure. Emphasis was placed on system optimization, energy conservation, and life safety in the computer-aided design for the plaza. The entire structure is described with its environmental engineering in all areas. (MCW)


Emphasis was mainly placed on opportunities for energy conservation in the transportation and residential sectors. Preliminary results for a highly disaggregated model of the TVA service area were obtained for the electricity demand growth. The research on policy alternatives in coal mining is discussed. The chapter on Energy Conservation Analysis contains sections on energy uses for automobiles, bicycles, and aircraft; total energy requirements of air transport; residential energy conservation; and energy use for food. From the discussion on Demand for Electricity, information is included on effect of rate structure; applicability of the national electric demand models to the TVA service area; data base and preliminary results in TVA area demand study; and communication and implementation of findings. Evaluation of alternative reclamation techniques, an overview on the role of coal, and implementation activities are discussed under Coal Mining and the Environment. Energy information and program publications are included. (MCW)


From conference on energy conservation research; Warrenton, Virginia, USA (18 Feb 1974).

The demand for electricity in the United States has been consistently growing at 7% per year for most of the post World War II years. If this trend were to persist, the demand for electricity in the year 2000 would be six times the 1970 level. This growth presents two major problems: the potential gap between the supply of and demand for electricity and the growing stress on the quality of the environment. Research has accordingly been directed towards developing a methodology for an enhanced understanding of the nature of demand growth. Both constant and variable elasticity models provide useful information to the policy makers, public utilities, regulatory agencies, citizens groups, and scientific community for effectively dealing with the present and potential problems. (auth)

COM-74-11138/6WE PC$20.00/MF$20.00

The bibliography contains 142 selected abstracts of research reports retrieved using the NTIS on-line search system--NTISearch. The report is divided into two sections dealing with energy conservation. In the first, 50 reports are presented which concern all aspects of energy conservation including topics such as reducing electricity demand, conservation policies, and the reduction of heating and automotive fuel consumption. The second section covers all aspects of recovering waste heat from power plants, buildings, and industrial water. These 90 reports include studies of total energy systems, waste heat boilers, and the use of power plant waste heat for irrigation, heating, sewage treatment, and desalination.

NINE WAYS TO BETTER FUEL MILEAGE.

D.L. Berry.

Although it began as a weekend diversion for staff engineers, the Shell Mileage Marathon soon became a serious challenge to technical ingenuity. One vehicle has already achieved 376.59 miles per gallon and 400 mpg is not far away. There's even some spin-off for the everyday driver in these energy-conscious times.

"The Energy Crisis—What Can We Do?" has just been published by Energy Conservation Research with the cooperation of the American Gas Association, American Petroleum Institute, and Edison Electric Institute. It is a comprehensive study of conservation measures that can be undertaken by the individual consumer, emphasizing the elimination of inefficiencies in automobile use and home heating. The guide can be obtained from Energy Conservation Research, 9 Birch Road, Malvern, Pa. 19355.

"The Crunch," a 20-page illustrated handbook, has been published by Honeywell's Commercial Division. It is crammed with tested ideas on how to save on heating, cooling, lighting, and ventilating. It also tells how to schedule power loads and how to shed them to avoid high electrical-demand charges. Copies are available without charge from Honeywell branch offices or from Honeywell's Commercial Division, 2727 South Fourth Ave., Minneapolis, Minn. 55408.

+++ An energy conservation check-off list prepared for Raytheon Company facilities but applicable to other companies and businesses is available without charge from the Office of Public Relations, Raytheon, Lexington, Mass. 02173. Telephone 627/862-6600 ext. 413.

"The Energy Crisis Challenge," a 60-page brochure from Dearborn Chemical Div., Chemex Corp., explains the three major energy wasters in boiler room operations and suggests remedies. It even contains tables and charts that permit the reader to calculate losses in his own plants. For a free copy contact Dearborn Chemical Div., Chemex Corp., Dept. BWT, 300 Genesee St., Lake Zurich, III. 60047.
CONSERVATION AND EFFICIENT USE OF ENERGY.


A comprehensive statement was issued at the hearings on the conservation and efficient use of energy by the Chairman of the President's Council on Environmental Quality. After noting the extraordinarily rapid growth rate of energy use in the U. S., energy use trends, the environmental impact of energy use, comparative effects of electric power systems, options for reducing environmental impact, improving production efficiency, and conservation in transportation, residential and commercial sectors, and in the industrial sector are discussed. Other conservationists from many other facets of industry made statements. It is indicated that the importance of energy conservation can only be fully grasped when the present rate of energy growth is put into the future. (MCW)

N74-15688# Committee on Commerce (U. S. Senate).
NATIONAL FUELS AND ENERGY CONSERVATION ACT OF 1973

The National Fuels and Energy Conservation Act of 1973 is reported. The purpose of the bill is to declare a national policy of conserving energy resources through more efficient conversion and use, to make energy conservation an integral part of all programs of the Federal Government, and to encourage an energy conservation ethic among American industry and the consuming public. The methods by which these goals are to be achieved are specified. Examples—of energy consumption by various components of the national economy are provided. Author
MAN WITH THE ENERGY ANSWERS.

T. Elloart.


Nicolaus Laing, a German Physicist with an outstanding record as an entrepreneur and innovator, claims to have prototypes which can reduce consumption of fossil fuels to less than a tenth of current predictions by 1990. Tim Elloart talked with him.

CITIZEN ACTION GUIDE TO ENERGY CONSERVATION.

United States Citizens' Advisory Committee on Environmental Quality.


LC Energy Conservation, p.58.

Addendum.

Main-Corp Trace Title Catalog 84-LC.

1973

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ENOUGH ENERGY—IF RESOURCES ARE ALLOCATED RIGHT.  
 p.50-58.

CURBING THE NATIONS APPETITE FOR ENERGY.  p.58-60.


ALUMINUM — VILLAIN OR HERO IN ENERGY CRISIS?  
C. Norman Cochran.  
SAE Automotive Engineering, v.81, no.6, June 1970,  
p.57-61.

Expanding use of aluminum in transportation  
vehicles can make a significant contribution  
towards conserving the nation’s critical energy  
supplies.

END OF THE AMERICAN DREAM?  
G. Chedd.  

Nixon's dramatic appeal to the American nation  
last week to conserve energy could signal the  
beginnings of a serious re-evaluation of the  
country’s traditional pattern of exponential  
energy growth.

ENERGY CONVERSION IN MODERN OFFICE BUILDINGS.  
W.H. Correale.  
J. Environmental Systems, v.3, no.4, Winter 1973,  
p.307-316.

Emerging critical problems relating to the shortages of energy have fostered new  
inquiries into ways and means of reducing energy consumption in urban centers.  
The modern, high-rise office building in aggregate may consume as much as 20%  
of the total energy used in a large city and consequently is deserving of more  
careful analysis than has heretofore been given. A recent inquiry has verified the  
need for further study in depth of the apparent significant waste of energy in  
large office buildings.

AIRWEST DETAILS FUEL-SAVING PROCEDURES.  
Title: Conservation
Author: Arrasides, A.

Title: Energy conservation through effective utilization.

In two major sectors of the economy (building services and industrial processes), accounting for approximately 75 percent of the total national energy consumption, energy utilization was found to be inefficient. It is estimated that in these two sectors, as much as 25 percent of the energy consumed annually by the nation as a whole may be lost through ineffective practices. Possible reasons for the existence of ineffective utilization are considered, and possible means of improving effectiveness of utilization are discussed. The emphasis of effort to promote effective utilization of energy is identified as: (1) the effective use of present fuels in present processes, (2) utilization of presently unused energy sources, and (3) more effective investment of energy in durable and maintainable products.

Author
The Illinois Consumer's Role in Energy Conservation.
Clark W. Bullard, III.
PB-228 004/8W EPC $5.00/MFS 1.45

The Illinois contribution to the BNP is examined to determine the energy required to manufacture, deliver, and sell the goods and services which make up the State product. The analysis is based on a method for converting dollar expenditures to total energy requirements. It is shown that more energy is burned in Illinois than is mined, and still more is required to produce the goods and services sold in the Illinois marketplace. Thus, Illinois imports direct energy, in the form of oil and gas, and is also a net importer of indirect energy, that embodied in goods and services manufactured with energy burned in other states.

(Modified author abstract)

The author discusses methods to decrease the rate of demand growth through more efficient energy use. Analysis of energy end-use and of the potential for energy conservation are discussed. (13 refs.)


The responsibility of energy conservation will rely on the cooperation of all who produce and consume energy from the mining and petroleum recovery to industry, commerce, and domestic consumer. Canada has announced export reduction in order to keep its own reserves, and with the cessation of Arab oil imports conservation must be the top priority if the U.S. is not to become a "have not" nation. Energy features of building design and energy-conserving techniques for buildings are discussed. A description is given for the Westinghouse Electric Corporation's and Pennsylvania Power and Light Company's energy-saving model residences. A discussion on the basic fuel and energy system efficiency indicates that gas-powered appliances consume more direct energy than similar electrical equipment. Electric lights produced from natural gas is inefficient. Gas lamps are still in use in the U.S. and each of these lamps requires about 20 times more energy than its electrical equivalent. The economies in natural-gas savings that could be attained by replacing gas lamps with incandescent bulbs would be enough to heat more than 200,000 homes yearly. (MCW)
<table>
<thead>
<tr>
<th>Executive Office of the President</th>
<th>1973</th>
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<td>Energy conservation</td>
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<td>L-9-28-73</td>
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</tbody>
</table>

**TITLE:** Energy Conservation in the Steel Industry - It Must Be Done  
**AUTHOR:** Rovin, J.E.  
**CORPORATE AUTHOR:** Bloom Engineering Co.  
**ADDRESS:** Horning and Curry Roads, Pittsburgh, PA 15216  
**PUBLICATION DESCRIPTION:** Industrial Gas, p. 9-10  
**PUBLICATION DATE:** 1973, July  
**ABSTRACT:** In steel mills in which natural gas is used in strip mill reheating furnaces and in soaking pits it is calculated that up to 22% fuel savings can be achieved with very little effort. More savings would result from a more intensive effort in this direction. One person, high in the organizational level should be in charge of energy conservation throughout the plant, with authority to institute corrective measures when necessary. (JNC)

**TRANSPORTATION ENERGY USE AND CONSERVATION POTENTIAL.** Hirst, E. (Oak Ridge National Lab., TN).  
Traffic, energy consumption, and energy intensiveness for inter-city freight and passenger traffic and urban passenger traffic are discussed. Transportation of people and goods consumes one-fifth of the total U.S. energy budget. Ninety percent of the world oil supply will have been consumed by about 2000, and ninety percent of U.S. oil reserves within 30 years. U.S. transportation is almost entirely dependent on oil as a fuel. Exploration, production, transportation, refining, and use of petroleum present serious environmental problems. Transportation contributes to a number of other environmental problems including urban congestion, inefficient land use, and noise. These facts support the urgent need for an examination of transportation energy use. (MCW)

**EFFICIENCY OF ENERGY USE IN THE UNITED STATES.**  
E. Hirst and J.C. Moyers.  
Transportation, space heating, and air conditioning provide opportunities for large energy savings.
ENERGY CONSERVATION STRATEGIES
Strategies for reducing national energy demands are examined.
It is necessary to find out, for each potential energy saving, how much energy is involved and how costly the alternatives would be. Many users get much of their energy at relatively low prices, and are thus encouraged to waste it; the economist calls this price distortion, a form of market failure. The study analyzes the kinds of market failure which seem to cause the present energy crisis, the kinds of government action which would rectify these failures, and the likely response of the economy to moderate price increases. Numerous actions, some large and some small, would be required to restore a more efficient functioning of the market for energy. In an efficient market, energy price increases of 25% would prompt a halving of the growth of energy demand; through 1990, energy needs would grow 40% rather than the 100% projected at current prices.

G.A. Lincoln.

CN-129,719 Conservation Foundation

HIDDEN WASTE. POTENTIALS FOR ENERGY CONSERVATION.

ENERGY POTENTIAL OF CONSERVATION.
ON LIFTING OIL IMPORT QUOTAS.
AND ON THE CONSERVATION OF FUEL.
GAS CONSUMPTION DOWN?
POWER SITING POLICY.

TIME FACTORS IN SLOWING DOWN THE RATE OF GROWTH OF DEMAND FOR PRIMARY ENERGY IN THE UNITED STATES
Lester Lees and Ming-Ju Lo 1 Jun. 1973 35 p refs
(Grant NSF GI-29726)
(ECL-7) Copyright. Avail: Issuing Activity

The time scales involved in slowing down the rate of growth of primary energy consumption in the U.S. as one component of an overall energy/environment strategy designed to limit the required volume of energy imports from overseas are discussed. Two important energy-consuming sectors of the economy are chosen as illustrative examples: (1) the automobile as a total system (25%); (2) space heating, air conditioning and water heating in the residential sector (22%). These two components of an energy-conserving policy taken together would bring the growth rate in U.S. primary energy demand down from its present rate of 4.2% per year to about 2.8% per year by 1985. Reductions in the annual growth rate of the remaining 50% of U.S. primary energy consumption that seem quite feasible would bring the overall growth rate down to about 2.5% per year by 1985. If reductions in growth rate of this magnitude could in fact be achieved, energy imports would peak in the mid-1980s at a level no higher than about 60% above the present (1973) volume of imports. Incentives and disincentives designed to bring about this slowdown in the rate of U.S. energy consumption are discussed.

Author

S-433

THREE HUNDRED HINTS TO SAVE ENERGY.
John Miller.

ECONOMY CONSERVATION AWARD FOR 1977. DOW CHEMICAL received a citation for energy conservation in 1977 for improvement of industrial power- and steam-generation cycles, and day-to-day surveillance of energy consumption, in both power and process plants. Moore Products Co. in Philadelphia won the award when it moved to a new plant stressing the preservation of the local ecology and creating a favorable corporate image and assuring a better working environment for its employees by installing a two-stage cascade air-source heat pump capable of providing both heating and cooling simultaneously. Standard Oil of California's Richmond plant applied a steam-trap and steam-leak program with a reduction in steam demand by 250,000 lb/hr with a fuel savings of 100,000 bbl/yr. The energy conservation program at Chevrolet-Livonia involved small changes such as the installation of a timer to turn off fan-room lights after two hours, the compressed air-pressure reduced to 90 from 105 psi, and some spray-washer nozzles delivering 2.5 gpm instead of 10, to win the citation. The Public Service Dept. of Burbank, CA, added a 23-MW gas turbine with a heat-recovery steam generator to its generating system resulting in a combined heat rate of 9700 Btu/kWh compared with 11,000 Btu/kWh originally. (MCW)
ENERGY AND WELL BEING.
A.B. Makhijani and A.J. Lichtenberg.

Since the utilization of energy and mineral resources has both provided us with diverse necessities and comforts and contributed to the deterioration of the environment, an evaluation of the degree of efficiency in the use of energy and materials is useful.
TITLE: Using Gas More Efficiently
AUTHOR: Murphy, G. L.
CORPORATE AUTHOR: Consumers Power Co.
ADDRESS: 212 West Michigan Ave., Jackson, MI 49201
PUBLICATION DESCRIPTION: Industrial Gas, 52, 11-16
PUBLICATION DATE: 1972, November
ABSTRACT: This is a description of several instances in which plants have been able to reduce the use of natural gas by common-sense techniques. There was an economic advantage in each case. (NRC)

TITLE: Conservation of Energy
CORPORATE AUTHOR: Library of Congress, Congressional Research Service; U.S. Senate, Committee on Interior and Insular Affairs
PUBLICATION DESCRIPTION: Serial No. 92-10, Report prepared at the request of Henry R. Jackson, Chairman, Committee on Interior and Insular Affairs, U.S. Senate pursuant to S. Res. 45, A National Fuels and Energy Policy Study, 114 P.
PUBLICATION DATE: 1972, August
ABSTRACT: The principal theme of this report is that energy conservation and increased energy efficiency are important issues in resolving present and future energy needs and worthy of special attention in the formulation of national energy policy. An effort has been made to develop statistical data on these subjects and to outline some of the relevant arguments which have appeared in recent literature, hearings, and contractual studies. The report is organized into five major sections, as follows: Part I draws on recent writings which discuss energy as a scarce commodity and current techniques that

TITLE: Energy: Tomorrow Starts Today
AUTHOR: Spaulding, J.
CORPORATE AUTHORIZED: University of California, Berkeley
ADDRESS: Berkeley, CA
PUBLICATION DESCRIPTION: Sierra Club Bulletin, December 1972, 9 P.
PUBLICATION DATE: 1972
ABSTRACT: What can be done to relieve the current energy crisis by staple conservation of energy methods. Estimates of the amount of fuel which can be saved by each of several techniques have been made by the Federal government and other research organizations. (NRC)

AVAILABILITY: Sierra Club, 1050 Mills Tower, San Francisco, CA 94108

TITLE: Conservation of Energy: The Potential for More Efficient Use
AUTHOR: Hammond, A. L.
CORPORATE AUTHORIZED: American Association for the Advancement of Science
ADDRESS: 1515 Massachusetts Ave. NW., Washington, D.C. 20005
PUBLICATION DESCRIPTION: Science, 178(4065), 1070-1081
PUBLICATION DATE: 1972, December 8
ABSTRACT: Ways of conserving energy are discussed, including more insulation in homes, more efficient heating and air conditioning equipment, solar heating and cooling, improved architectural design of high-rise buildings, improved efficiency of electric power generation, and changing modes of transportation. (NRC)
ENERGY CONSERVATION: Statements, testimony and exhibits, including the full text of several recent research reports, on methods of reducing excess energy consumption. 809 pages. Single copies free. (Hearings—Conservation and Efficient Use of Energy, available from Committee on Science and Astronautics, Rm. 2391 Rayburn House Office Bldg., Wash., D.C. 20515.)

N74-20664*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AERONAUTICAL FUEL CONSERVATION POSSIBILITIES FOR ADVANCED SUBSONIC TRANSPORTS
Albert L. Braslow and Allen H. Whitehead, Jr. 20 Dec. 1973
15 p. (NASA-TM-X-71927) Avail: NTIS HC $4.00 CSCL 01C
The anticipated growth of air transportation is in danger of being constrained by increased prices and insecure sources of petroleum-based fuel. Fuel-conservation possibilities attainable through the application of advances in aeronautical technology to aircraft design are identified with the intent of stimulating NASA R and T and systems-study activities in the various disciplinary areas. The material includes drag reduction; weight reduction; increased efficiency of main and auxiliary power systems; unconventional air transport of cargo; and operational changes. Author

W-140,010 Department of Transportation DOT-OST-TST-14

PB 220 612

160
THE EFFECT OF SHAPE AND ORIENTATION ON THE RADIATION IMPACT ON BUILDINGS


Building planning needs suitable information on radiation conditions, especially with respect to air-conditioning and daylight design. A survey on the origin and preparation of the data used is presented, and the significance of the diffuser component of the total radiation impact is emphasized. The adaptation of the irradiation functions is demonstrated for summer and winter conditions at 0 m altitude for the geographic latitude of 47 deg N. Numerical examples in cases of rectangular and cylindrical buildings illustrate daily and hourly radiation load changes against variation of building shape and facade orientation. Author.

N74-16816 Swiss Inst. of Meteorology, Zurich.
USE OF CLIMATOLOGICAL DATA IN BUILDING DESIGN WITH RESPECT TO ECONOMY


The building with its various planning and operational processes is considered a weather sensitive economic system. The impact of weather and climate affects the economic output of building enterprises. By using suitable design weather information in decision making, economic gain may be expected. Published benefit figures are of the order of 0.5 per cent of the total production of the construction industry, while for heating and air-conditioning several times higher relative benefits may be expected. Author.

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Oak Ridge National Lab. ORNL-NSF-EP-9
Contract W-7405-eng-26

Materials, Insulating Buildings
Economics
Energy conservation

L-9-18-73
LRC 73-160
II. ENERGY AND POWER SOURCES
ENERGY: A comprehensive look at the short-term and long range aspects of a permanent national problem. Prepared under the direction of Associate Editor Samuel Stafford with artwork, cover and inside pages, by Graphics Director Jim Sturman.

Energy R&D
National energy policy is needed.

Sen. Jackson on Energy
Providing energy is an international challenge.

Total Energy Systems
"What's needed is some kind of partnership."

Mass Transit
Rohr's Raynes proposes $77 billion, 16 year commitment.

The Oilman and the Frog
Texaco's Board Chairman looks at the energy question.

Energy and the Oceans
Will the Administration move before it's too late?

Offshore Nuclear Systems
Jacksonville, Fla. turns out floating nuclear plants.

New Contender in Nuclear Race
General Atomic builds plant in Colorado.

Solar Energy
Potential for the future.

Fuel Cells
Another space program spinoff benefit.

Power Pipeline

ENERGY CRISIS FUELS RESEARCH TO DEVELOP ALTERNATIVE POWER SOURCES. Three methods for producing power are briefly reviewed, namely, high-power fuel cells, solar power, and hydrogenification of cow manure.


ENERGY EXECUTIVE

May 1974
Volume 6, Number 5

Energy and Superconductivity.
National Bureau of Standards, Boulder, Colo. Cryogenic Data Center. 20 Mar 74, 36p B-1153
COM-74-10713/7WE PC$7.00/MF$7.00

Contents: Generators, motors, transmission lines, transformers, thermonuclear fusion, MHD, magnets, miscellaneous applications, refrigeration, patents, and reviews.

POWER/ENERGY: PROBLEMS AND PROGRESS.

G.D. Friedlander.

The power industry will attempt to generate and deliver over two times the amount of power over the next ten years, but with diminishing supplies of fossil fuels and with the added concern of the environmentalists, massive changes in technology are required. A review is given of alternative methods being studied to alleviate the energy crunch. Construction data of reactors in the U. S. are tabulated. The fuel/energy equation for the U. S., Japan, and Western Europe, especially Germany, is discussed. (MCW)

JAPAN'S SUNSHINE PROJECT: LONG-TERM ENERGY SOLUTIONS SOUGHT.


Sunshine Project is designed to research and develop technologies for pollution-free solar energy, subterranean heat, substitute natural gas, and hydrogen energy.

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FISSION ENERGY AND OTHER SOURCES OF ENERGY.
Alven, H. Bull. At. Sci.; 30; No. 1, 4-8(Jan 1974).
The energy problem was discussed at the Pugwash conference
for the study of the scientific, technological, political, and econo-
ic aspects of energy problems in the whole world were pre-
semed. The major recommendation was directed toward increased
research on how to make fission energy acceptable. An effort
should be made to develop alternative energy sources that satisfy
economic demands. An analysis should be made to determine the
real need for additional energy. (MCW)

WIND, WASTE, OCEAN STUDIED FOR ENERGY.
Indirect solar sources—wind energy, bioconversion,
and ocean thermal differences—are being studied.

COST-BENEFIT ANALYSIS OF ADVANCED POWER GENERATION
METHODS.
S. Baron.

OIL INDUSTRY PLUNGES INTO ALTERNATE ENERGY
SEARCH. Snyder, R. E. World Oil; 178; No. 3, 61-62; 64-66
(15 Feb 1974).
The Arab oil embargo has advanced time schedules for developing
alternate energy sources in the United States to supplement rapidly
diminishing and increasingly valuable crude oil and natural gas.
Oil companies will be participating in the tar sand development in
the Athabasca reserves in Canada. Geothermal development has
only reached a practical level in the Geysers area of California.
Synthetic fuel development will be pursued with SNG converted from
hydrocarbon wastes. No significant breakthrough has appeared for
solar energy. Other external fuel sources include power generation
from hydroelectric plants, wind, and wind. Other alternate fuel
possibilities under consideration are hydrogen, more efficient
electric power from fuel cells, direct heat or synthetic fuels from
garbage or animal wastes. Additional mining of coal, or coal lique-
fication, or gasification are processes to be perfected. Approxi-
mately 40 nuclear power plants are in operation and 37 more are
under construction. Oil shale tracts in Colorado, Utah, and Wyom-
ing are to be tapped. Tar sands reserves in the U. S. are located in
California, Kentucky, Missouri, Oklahoma, Texas, and eight other
states. (MCW)

PERSPECTIVES IN U. S. ENERGY RESOURCE DE-
An inventory of U. S. energy resources is presented together
with approximate timetables and product costs for implementation
of the technologies necessary for a clean utilization of these re-
sources. These energy components include fossil fuels and their
conversion to clean synthetic fuels, nuclear fuel supplies, geo-
thermal energy, wind power, thermonuclear fusion, and the ultimate
resource, solar energy. The cost of solar energy is treated
in considerable detail for several prospective applications and
basic energy conservation strategies are outlined. (131 references)
(auth)

TITLE: Fission Energy and Other Sources of Energy
AUTHOR: Alven, H.
PUBLICATION DESCRIPTION: Bulletin of the Atomic
Scientists, Science and Public Affairs,
30(11), 1-8.
PUBLICATION DATE: 1974, January
ABSTRACT: In order to produce more energy, the
development of fission reactor technology in
proceeding worldwide at a rapid pace. Part
of the reason for this emphasis is the
associated military support, either direct or
indirect. The possible dangers of the large
scale use of breeder reactors, with the huge
production of plutonium, are pointed out.
Intensive research efforts should be made to
develop other sources of energy, such as
fusion, geothermal, and solar. (JNC)

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Sun and Earth: Developing Technology

Geothermal Electricity Production: G. R. Robson ........................................... 371
Solar Energy by Photosynthesis: M. Calvin ......................................................... 375
Solar Energy Utilization by Physical Methods: M. Wolf ...................................... 382

Science Bibliography of Energy ............................................................................. 389

BREAKING THE ENERGY CRISIS.
R.A. Huse.
Options cover primary energy resource recovery, fuel conditioning, conversion, improved transmission, and storage.

DESIGNING FOR THE ENERGY CRISIS.
1. THE VANISHING BTU. Larry L. Boulden.
This first in a series of articles shows how to looks at our diminishing energy reserves and surveys the prospects for new sources of energy. Future articles: Feb.21 - Designing for the energy miser; April 4 - Processes that save power; May 2 - Efficiency by decree; and June 13 - Brownout-proofing your product.

ALTERNATE FUELS FOR TRANSPORTATION.
J.W. Hodgson.
Is ammonia a transportation fuel for the future? In light of current concerns involving air quality and predicted hydrocarbon fuel shortages, it may well be. Studies and data generated by the University of Tennessee’s ammonia-fueled urban vehicle conclude that ammonia is attractive as a spark-ignition engine fuel because of its potential availability, adaptability to existing engine designs, cost, emissions, safety, and easy storage.

Angrist, Stanley W.
Direct energy conversion (by) Stanley W. Angrist. 2d ed. Boston, Allyn and Bacon [1974]
ix, 488 p. illus. 24 cm.
J. R. Williams.
Georgia Inst. of Tech., Atlanta. Schools of Mechanical and Nuclear Engineering. 1974, 9p NASA-CR-138183
N74-22604/4WE, PC$4.00/MP$1.45

Air pollution resulting from the use of fossil fuels is discussed. Phenomena relating to the emission of CO2 such as the greenhouse effect and multiplier effect are explored. Particulate release is also discussed. The following recommendations are made for the elimination of fossil fuel combustion products in the United States: development of nuclear breeder reactors, use of solar energy systems, exploration of energy alternatives such as geothermal and fusion, and the substitution of coal for gas and oil use.

SUPERCONDUCTIVITY: LARGE-SCALE APPLICATIONS.
R.A. Hein.

This article is an overview of areas involving large-scale applications of superconductivity for which the 1970's are a decade of critical decision. Applications to superconducting solenoids, high-energy physics, electric power transmission, rotating electrical machinery, energy storage and transfer, and superconducting magnets for superfast trains.

CENTER FOR ENERGY STUDIES. This report covers the past accomplishments and present capabilities of the Kansas State University College of Engineering in the power and energy related research. This report contains abstracts of technical articles, reports, theses and dissertations written by the faculty, staff, and students. The abstracts are classified into five sections: general and systems analysis, solar and wind energy, magnetic hydrodynamics, nuclear energy, environmental effects and energy resources from wastes, and fuel production. Each section is subdivided into four subsections: Journal Articles, Presented Papers, Reports, and Theses and Dissertations. The order within each subsection is arranged chronologically.


COM-74-88385/7GA 's. Not available NTIS.
National Bureau of Standards, Washington, D.C.
MEASUREMENTS AND STANDARDS FOR HIGH TEMPERATURE MATERIALS IN ENERGY CONVERSION AND CLEAN FUEL PRODUCTION.
Final rep.,
J. B. Wachtman, Jr., and S. J. Schneider. Aug 73,


The serious energy situation in the United States requires more efficient generation of electric power and large production of clean fuel from coal. Coal requires high temperatures and highly reactive chemical conditions. The severe environments existing in high temperature gas turbines, MHD power generators, and coal gasifiers are briefly summarized. Data and test methods needed for process optimization, engineering design of hardware, and reliability assurance are analyzed. Early results are presented on slag characterization and on reaction of slag components with refractories. A procedure to insure required lifetime under service stress is described. The implications of the present work for practical test methods for mechanical lifetime assurance, corrosion resistance, electrical conductivity measurements, viscosity measurements, and wear are assessed.

N73-33005# California Univ., Livermore. Lawrence Livermore Lab.
DEVELOPMENT OF MATERIALS FOR ENERGY RELATED APPLICATIONS
The application of materials science and technology to develop new energy sources and to make current energy systems more efficient is discussed. The energy sources discussed include solar energy, thermonuclear energy, and fossil fuel energy. Energy conversion techniques discussed include thermal cycles, solar photovoltaic, thermal decomposition of water, and hydrogen-air fuel cells. The methods for energy transmission that are outlined are hydrogen pipelines and superconducting or cryogenic electrical transmission lines. Transportation optimization and efficiency are dealt with in the light of those components yielding the largest benefit for the overall system.

NRA
ENERGY CONVERSION TECHNOLOGY IN WESTERN EUROPE

L. GRAINGER
Future trends in utilization of coal energy conversion

E. B. WALKER III
Non-conventional hydrocarbons and future trends in oil utilization in North America and their effect on world supplies

D. E. ROOKE
Future trends in gas production and transmission

D. CLARK
Energy conversion to electricity

T. BROOM AND R. S. GOW
Operational experience in nuclear power stations

SIR JOHN HILL
Future trends in nuclear power generation

GENERAL DISCUSSION

N74-15908 Rensselaer Polytechnic Inst., Troy, N.Y.
LONG RANGE TRENDS IN THE CHARACTER OF ELECTRIC POWER SYSTEMS Ph.D. Thesis
Charles A. Falcone, 1973 388 p
Avail: Univ. Microfilms Order No. 73-27204
Long range trends in the development of electric power systems in the United States are discussed, emphasizing the Midwestern region. The historical growth of energy consumption in the United States is examined, along with present status and near-term prospects. Demographic and societal trends are discussed, and energy and electric power consumption are projected to year 2100, based on a scenario of future American society. The fuel resources of the United States are examined, as well as current and developmental energy conversion technology. A forecast of fuel use is developed. A history of energy systems is epitomized, with particular attention to electric power systems. Alternative energy systems are compared, and an examination of a hydrogen-electric system is included.
Dissert. Abstr.
ENHANCED ELECTRICAL POWER GENERATION AND DISTRIBUTION CONCEPTS FOR MILITARY FACILITIES

The report describes probable technical advancement of electrical power generation systems in the 1980-1990 time period for application in fixed or semi-fixed military facilities in the power range of 250 kw to 50,000 kw. Subjects covered include commercial power reliability, uninterruptible power system, conventional steam, diesel, gas turbine (open and closed cycle) generators and distribution systems for currently available equipment. Advanced power systems include nuclear reactors, batteries and fuel cells, magnetohydrodynamic systems, fusion systems, solar power systems and direct conversion systems of the thermoelectric and thermionic type. (Modified author abstract)

THE SUPERCONDUCTORS ARE COMING.
J. C. Bittence.

Superconductivity is being applied in a number of fields, including power generation and transmission. After a few more refinements—and within the next decade—the superconductor will become an important part of our daily lives.
SPECIAL SECTION

24 PROSPECTING FOR ENERGY

Space developments have fostered much of the advanced technology now in the limelight as prospective means for freeing the U.S. from its virtually complete dependence on oil, thus driving that technology to the stage of commercial applications will take decades even if the country makes the necessary investment of several tens of billions of dollars. This special section, against a background of near-future energy prospects, presents the leading contenders as new sources of power towards the end of the century.


Several options available for use in solution of the energy crisis are reviewed. Discussions are included on sources and uses of energy with emphasis on electric power. Discussions are also included on fusion, magnetohydrodynamics, superconducting generators, potassium topping cycles, geothermal power, and storage and delivery of energy. (URD)


Fossil fuels now supply over 95% of the U.S. commercial energy, and, even with maximum effort to develop alternatives, the bulk of our cumulative requirements between now and the end of the century will have to be met from oil, gas, and coal resources. Nuclear, geothermal, and most other alternative forms of energy are restricted to a few specific uses, such as the generation of electricity. Consequently, fossil fuels cannot be replaced in many uses even after practical technology from other sources have been developed. There has been a serious effort to promote the use of nuclear fission for 25 years, and in 1971 it still accounted for less than one percent of the total U.S. energy supply. The National Environmental Policy Act of 1969 was designed as a statement of policy, but it also outlined certain procedures for all agencies of the government to follow. Courts have held that specific NEPA procedures are enforceable through suits of interested citizens. These cases brought to court have delayed the construction of vital facilities, especially electric power plants, and may contribute to energy shortages and other economic disruptions. (MCW)


The gas generator is usually thought of as a light weight, high power, short duration energy source, used mainly in aircraft and missiles. This premise is re-examined by viewing gas generators in the perspective of other energy sources with similar or overlapping characteristics and applications, to see where gas generators have a performance edge and where gas exist which are opportunities for new gas generator applications. The alternative energy sources, with added to gas generators include gas turbines, reciprocating engines, compressed gas containers and hydraulic accumulators, flywheels, batteries, fuel cells, and solar photovoltaic cells, are first described in terms of their energy conversion process and the form in which their output energy is delivered. They are then compared on the basis of stored energy density and applicable power levels. Next, the factors involved in matching an energy source to its operating environment are enumerated. Finally, a number of new applications for gas generators are suggested which introduce new requirements for both technical and marketing areas. (Author)

Environmental energy sources, their use and storage. D.E. Johnson (SureMotive Inc., Tempe, Ariz., USA); 6th Annual Frontiers of Power Technology Conference, Stillwater, Okla., USA, Oct. 10-11, 1973 (Stillwater, Okla., USA Oklahoma State Univ. 1973), p. 67/1-31 (50 refs.)


The report covers the work done in three areas of energy conversion and transfer involving fluid dynamic processes; electrofluidodynamic energy conversion, multicomponent flow research, and aerodynamic energy transfer research. The effort under item one was an exploration of direct energy conversion of fluid dynamic energy into electrical power using electrofluidodynamic (EFD) technologies. The objective here was to identify workable and practical processes and designs for superior, lightweight, reliable, electrical generators. Item two covers studies of methods by which heat energy from reactions of solid particles or droplets contained in a combustion or reaction chamber can be used to produce fluid dynamic energy. The principal objective of this work was to assess wall erosion, particle suspension, and related fluid dynamic processes and components germane to practical thrust augmentation devices. The objective was to identify appropriate design concepts applicable to future vertical or short-field take-off-and-landing aircraft. (Modified author abstract)

The feasibility of using solar energy and wind power created by solar energy as a non-polluting alternative to nuclear energy for electric power production is discussed. (LCL)

ENERGY OPTIONS: CHALLENGE FOR THE FUTURE.
A.L. Hammond.


An evaluation of power generation from sources such as fusion, solar energy, geothermal energy, magnetohydrodynamic reactions, fuel cells, breeder reactors, desulfurized coal, and hydrogen is presented. Generation options for the 1980-to-1990 period are discussed along with power needs in the U. S. during the period 1980 to 2000. (J.R.D.)

IEEE Transactions on Industry Applications May/June v. 1A-9, no. 3, pp. 257-261 1973

AN APPRAISAL OF FUTURE UNITED STATES POWER SOURCES.

National Coal Association
Conference of the Petroleum and Chemical Industry Sept. 20, 1972


Summary—The current energy management situation is presented in terms of the aspects limiting present practice. The conversion technologies available and being developed for the production of energy forms suitable for consumption from basic resources are summarized as technical alternatives. Options for continuing present trends in benefits of energy utilization include: development of processes to use new energy sources (U-238, Th-232, deuterium, geothermal and solar), more efficient power generation from present fuels (topping cycles, MHD and higher temperature gas turbines), and more efficient utilization of energy and power in the consumption process. All of these alternatives require substantial investment in capital resources, engineering of products and systems with long term performance in mind and more comprehensive planning of the entire energy utilization process.

Key words: Energy management energy conversion systems energy sources energy utilization


Availability, production technologies, and economics of fuels for energy generation are discussed. Data pertaining to the crises for now, 1985, 1990, and the year 2000 are outlined. Energy requirements are presently furnished by oil, 43%; natural gas, 33%; coal, 20%; and the remainder is furnished by nuclear and hydroelectric power and solar and geothermal energy. The blame for the fuel shortage is attributed certain adverse impact on the economy can be placed at several doors: government, regulatory agencies, suppliers, and the general public. Coal remains fairly good supply, and it seems that production and use of coal will have to be increased, although it is responsible for pollution of the atmosphere in many areas and restoration of the landscape from strip-mining is a problem. (JCW)


The survey report the confirmation of the existence of two energy crises: the first results from an inability to extract known resources at a sufficient rate, already made evident by the gasoline and heat oil shortages. The longer-term crises involves the ultimate exhaustion of fossil fuel resources and can be expected to occur around the end of the century. The status and outlook and what options are available to alleviate the developing crises are examined for coal and gas; oil; nuclear energy; solar energy; direct solar applications of photovoltaics, wind energy, ocean thermal gradients, and conversion of waste materials; and geothermal energy. (MCW)

1979's DEVELOPMENT OF 21ST CENTURY MOBILE—DISPERSED POWER. A mobile and dispersed power system is necessary for an advanced technological-industrial human society. Today's is based on petroleum and discharges waste products and heat. It is growing exponentially. Energy resource commitment has already intersected "ultimate" low-cost petroleum supplies in the U.S. and will do so for the world before 2000 A.D.; this portends major changes and cost increases. The complete change will require 31 years because of the magnitude, fragmentation, structural gaps, complexity and variety of the mobile-dispersed power system. Consequently, substantial, sustained, interacting and coordinated planning, research and advanced development must be started now and completed during the 1970's. A "system dynamics" model of the resource-fuel-engine-use complex and a "mixed-economy" Energy and Ecology Cybernetics Corporation should be integral parts of the effective management of the unprecedented development of society's 21st Century mobile-dispersed power system. 137 refs.


The application of materials science and technology to develop new energy sources and to make current energy systems more efficient is discussed. The energy sources discussed include solar energy, thermonuclear energy, and fossil fuel energy. Energy conversion techniques discussed include thermal cycles, solar photovoltaics, thermal decomposition of water, and hydrogen-air fuel cells. The methods for energy transmission that are outlined include hydrogen pipelines and superconducting or cryogenic electrical transmission lines. Transportation optimization and efficiency are dealt with in the light of those components yielding the largest benefit for the overall system. (NTIS)


ENERGY PROGRAM, 1972 Bill Linville and John D. Spencer 1973 115 p refs (BM-IC-8612) Avail: NTIS HC $8.75

Major areas of research by the Bureau of Mines in 1972 for the development of new and improved efficient methods of conservation and utilization for petroleum and natural gas, oil shale, and coal are described. The major objective of the energy research program was to develop the technology for the wise development and use of the nation's energy resources as clean fuels at a reasonable competitive cost. Emphasis was placed on studies of methods of stimulating production from oil and gas reservoirs. Studies of the fracturing systems of reservoir rocks and oil recovery by water or gas flooding are included. (Author)
ALTERNATIVE ENERGY SOURCES: A RESEARCH CHALLENGE
(Conf-730560-1) Avail. AEC Depository Libraries HC $3.25

Methods of obtaining energy such as controlled thermonuclear fusion, direct solar conversion, or deep geothermal resources of energy are considered alternative energy sources in a global sense. In Australia, nuclear fission and natural gas are considered alternative or unconventional energy sources. One significant area of alternative energy source discussed is the energy currently dissipated to the environment in a nonproductive manner through the limitations of conventional conversion technology and which in overall terms often exceeds that actually used by a factor of two or three. Research into improved methods of conversion includes areas such as MHD power generation and fuel cells. It also includes the concept of total industrial energy. Other alternative energy sources discussed include the natural sources of primary energy, namely, solar energy, tidal energy, wind, and geothermal energy. NSA


Aspects of engineering and construction capabilities as related to improving energy production are reviewed. It is noted that a potential roadblock to new energy conversion projects is the improper allocation of engineering and construction manpower and supporting equipment. Current conditions of equipment materials availability are reviewed along with the status of engineering and skilled labor manpower pools. Methods for proper direction of manpower and proper use of materials and equipment are suggested. (JRD)

OIL DRUM TECHNOLOGY.
J. McCaul.

Ways to use inexpensive technology, without massive social and environmental disruption, to meet energy needs are under study at the Brace Res. Inst. of McGill Univ., Montreal, Canada.


After a review of the condition and prospects of man's very large and unevenly distributed energy conversion, the outlook for both conventional and unconventional fossil fuels is surveyed. Possible rates and side effects of production, institutional problems, and the general trend towards fuels of increasing technical simplicity are stressed. Coal emerges in a critical role as the main bridge to sustainable energy economies. Nuclear fission is then analyzed in detail. It is argued that fission technology is so complex and demanding that it should be abandoned. Adequate alternatives are known. The status, prospects, and possible problems of other energy technologies (nuclear fusion, geothermal power, tidal power, hydroelectricity, indirect and direct solar collection, etc.) are then assessed and promising avenues identified; likewise energy conversion, storage, and distribution technologies. Decentralized methods, and the special needs of non-industrial countries seeking appropriate development paths, are specially noted. Technologies that rely on energy income rather than on energy capital are adequate to meet all reasonable future needs of mankind. The foregoing considerations are combined with an assessment of certain ethical issues related to distribution, competition, climatic constraints, and future risks (e.g., in strategic-material safeguards, LNG transport, Arctic oil-spills, and radiation biology) to yield general conclusions. (auth)

The MITRE Corporation is formulating a five-year solar energy research program as a recommendation to the National Science Foundation Applied Research Directorate Office of Systems Integration and Analysis. This document provides two alternative research plans, including task schedules and costs, for each of eight program elements: Heating and Cooling of Buildings, Process Heat, Thermal-Electric Energy Conversion, Photovoltaic Energy Conversion, Ocean Thermal Systems, Wind Energy Systems, Utilization of Organic Materials, and Common Applications. The two alternatives are: (a) a set of research tasks considered to be the minimum necessary to bring about the widespread utilization of solar energy and (b) an accelerated plan to achieve more rapid utilization, with a higher degree of confidence and reduced technical risk. (Author)


Thirty recommendations have been made for establishing groups within or reporting to the NSF Solar Energy Program Office and initiating activities for the dissemination and utilization of solar energy research results. The primary recommendations include establishing an Advisory Commission and an information office reporting to the Program Director and constructing visitor centers on the sites of each Proof of Concept Experiment. Training courses and public education would be conducted at each center following successful operation of the POCE system. (Modified author abstract)
ALTERNATIVES FOR ENERGY DEVELOPMENT.

Second in a series of articles on analysis of possible energy developments made at the Symposium on New Sources of Energy, Hosted by Univ. Southern California.

ENERGY SOURCES AND CONVERSION TECHNIQUES.
R. Roberts.

NATURAL POWER FOR THE THIRD WORLD.
D. Spurgeon.

Geothermal energy, solar power, and wind power could make a significant contribution, but the developed countries will have to help exploit these systems.


The extent, availability, cost, and development schedules of existing and potential domestic U. S. energy resources are surveyed in the context of projected U. S. energy demand. These energy components include fossil fuels and their conversion to clean synthetic fuels, nuclear fuel supplies, geothermal energy, and solar energy. The cost of solar energy utilization in several prospective applications is treated in considerable detail. (8 tables, 7 figures, 99 references) (auth)


Long-range possibilities for generation of prime energy (other than the nuclear breeder) are basically only three: solar, fusion, and geothermal. Predictions in favor of one or the other of these possibilities tend to take on the character of prophecy, principally because the prophet knows he will probably be dead by the time the returns are in. Fermi, for example, discussed the fast breeder, not expected before the mid-eighties, in 1943. The prophets may be right, but a prudent overall energy policy must be based on the two firm alternatives—clean energy from coal and from nuclear sources, particularly from the breeder. (auth)
The serious energy situation in the United States requires more efficient generation of electric power and large production of clean fuel from coal. Both require high temperatures and highly reactive chemical conditions. The severe environments existing in high temperature gas turbines, MHD power generators, and coal gasifiers are briefly summarized. Data and test methods needed for process optimization, engineering design of hardware, and reliability assurance are analyzed. Early results are presented on slag characterization and on reaction of slag components with refractories. A procedure to insure required lifetime under service stress is described. The implications of the present work for practical test methods for mechanical lifetime assurance, corrosion resistance, electrical conductivity measurements, viscosity measurements, and wear are assessed.


Conference on research for the electric power industry. [New York, Institute of Electrical and Electronic Engineers, 1973] 455 p. 11 1/2 x 8 1/2 cm.

FIFTH SESSION - ENERGY CONVERSION III - EMBRYONIC

(Solar energy, fuel cell, satellite with energy transmission by microwave, etc.)

ENERGY OPTIONS


Technological options to solving the energy problem constitute development of the liquid metal gas breeder reactor to produce nuclear energy; coal gasification to produce a synthetic natural gas; and SO2 removal technology from stack gases to permit high sulfur coal burning. Fusion, solar, and geothermal energies are prime candidates for supplementing above primary needs.

ENERGY SOURCES FOR THE FUTURE.

E. Cook.
The Futurist, Aug.1972, v.6, no.4, p.142-150.

World consumption of energy is rising rapidly, but the reserves of oil and gas are limited and may be virtually exhausted in a few decades. To replace them, man may turn to nuclear power and a much older energy source - coal.
ENgErgy: Problems, Prospects, and Priorities.
R.M. Drake, Jr., Combustion Engineering.
AIAA Paper no. 72-253


Solar Economy
Hydrogen Economy
Hydrogen car by 1977
Italian chemical $H_2$ process
Fusion could produce $H_2$
Fission high energy radiation: $H_2$ source.
Garbage to methane

Alternatives: R and D for New Energy Sources.
As a result of the advent of nuclear power, utilities have come to growing reliance on federal government for long-range R and D. Of 0.23% of gross revenues that industry does spend on R and D, most is used for improving present systems and not on developing new, minimally polluting ones. Reviewed are economic, environmental, and political aspects of the nuclear breeder reactor (which gets lion's share of attention), proposed fusion reactor, solar energy (totally ignored by utilities and government), geothermal steam, tidal energy, wind generation, direct conversion (MBH and fuel cells), recycling waste heat, coal gasification, and establishing of national power grid. (NSIC)

Power Generation - Some Tasks and Goals.
J.L. Everett, III.

Generating capacity additions planned for the 1970's and beyond include a high percentage of nuclear power plants. The light water reactor is the dominant type of commercial nuclear reactor being installed during the 1970's. Advancement to more efficient designs is expected around 1980. Prospects for breeder reactor and fusion dictate a major effort.

Energy for Millennium Three.
E. Cook, Texas A & M.

Beyond 2100, mankind's energy needs must be met by a combination of coal, nuclear power, and solar energy - beyond 2300, by technologies that are not yet known to be possible, much less economical.

A Comeback for Reddy Kilowatt?
G.D. Friedlander, Senior Staff Writer.

Depletion of fossil fuel, and the time lag in building nuclear plants, is spurring the search for new devices and resources.
TWELVE-TWENTY VISION: A VIEW OF THE FUTURE. Faust, George R. (Gilbert Associates, Inc., Washington, D.C.), Pub. Util. Form. 90: No. 4, 24-32 (17 Aug 1973). The state of present technology related to gas and electric utilities is examined and the chances of using advanced technology in dealing with the problems associated with utility depreciation accrual rates are evaluated. Discussions are included on gas industry, coal gasification research, atomic energy, magnetohydrodynamics, fuel cells, and underground transmission lines. (J.R.D.)


By generating steam instead of thrust, modified rocket engines may help solve the impending energy crisis.

THE SEARCH FOR TOMORROW'S POWER.
K.F. Weaver.

ENERGY TECHNOLOGY TO THE YEAR 2000. PART III:
ENERGY SOURCES AND USES.

The quest for fusion power. L.M. Lidsky.
System energy and future transportation. R.A. Rice.
An agenda for energy. H.C. Hottel & J.B. Howard.
1972

N74-15657 California Univ., Livermore. Lawrence Livermore Lab.

ENERGY IN GENERAL
(For availability see N74-18582 09-34)

Technical aspects of providing energy and utilizing resources for world-wide demand are considered. Projected energy flow patterns recognize growth demands for energy from all sources, as well as the need for more efficient systems. The difficult problems of providing energy and utilizing resources in an efficient and environmentally acceptable manner are outlined. The role of the utilities as the major energy delivering system is mentioned. The role of the utilities as the major energy delivering system is mentioned. The role of the utilities as the major energy delivering system is mentioned. The role of the utilities as the major energy delivering system is mentioned. The role of the utilities as the major energy delivering system is mentioned. The role of the utilities as the major energy delivering system is mentioned.

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N74-11786f InterTechnology Corp., Warrenton, Va.

THE U.S. ENERGY PROBLEM. VOLUME 2. APPENDICES.
(Grant NSF C-645)
(PB-207619: NSF-RANN-71-1-3) Avail: NTS HC $12.50 CSCL 108

An analysis of the energy requirements and energy sources for the United States is presented. The subjects discussed are: (1) energy requirements, (2) energy sources, (3) energy distribution, (4) energy conversion, (5) energy conservation, (6) energy planning, (7) energy policy, (8) energy economics, (9) energy technology, and (10) energy research.

Author

N71-76399

TITLE: Report to the Secretary of the Interior of the Western States on Energy
AUTHOR: Schaff, J.J., Jr. (Chairman)
CORPORATION: Author: U.S. Dept. of the Interior
ADDRESS: Washington, DC 20240
PUBLICATION DATE: 1971, June 30
ABSTRACT: This report provides information on the problems that the nation faces with respect to energy. Position, problems, outlook, and recommendations are presented for general, elemental and new technology energy sources, petroleum liquid fuels, natural gas, coal, water, nuclear energy, synthetic oils, and synthetic gas. (NPS)

TL Technology utilization ideas for the 70's and beyond. Edited by P. W. Forbes [Arnold P. Dergarabedian. Tartana, Calif., AAS
A2 Publications Office [1971]
V.26 xxv, 315 p. illus. 25 cm. (AAS science and technology series, v. 26)

An American Astronautical Society publication.
Proceedings of a special AAS/AIAA technical event, held October 30, 1970 at Winrock, Arkansas.

Winthrop Rockefeller. (p. 1)

POLLUTION CONTROL USING ADVANCED ENERGY GENERATION SYSTEMS
Robert R. Barthelmy
Air Force Aero Propulsion Laboratory
Wright-Patterson AFB, Ohio 45433

Abstract

One of the most critical problems facing the world today is the alarming increase in environmental pollution. The three most important forms of pollution are thermal heating of our water supplies, chemical pollution of the atmosphere, and, to a lesser degree, the introduction of waste (nuclear and chemical) into the soil. This adverse situation arises primarily because it is impossible to convert all of the latent energy of chemical and nuclear fuels into desirable directed energy, either kinetic or electrical. Short of moving our conversion and manufactoring systems into space (which may eventually become necessary), our only technological recourse is to minimize the contaminating effects of our major conversion processes.

Recent Air Force developments in the fields of high temperature energy sources and advanced energy conversion processes could be utilized to significantly improve the processes used for generating electrical power. Although electrical power generation is not the sole contributor to environmental pollution, it plays a major part. The use of high temperature nuclear reactor thermal systems coupled to high efficiency generation systems could reduce the thermal pollution of generation plants several fold and completely eliminate particulate pollution of the atmosphere, with little or no contamination of the earth with nuclear by-products.

Two technical areas being pursued by the Air Force are: (1) generation core reactor reactivity systems are being studied in basic and exploratory development for future space reactors. Such a system, however, could produce a power generation system working fluid at 4000°F. Exploratory development of magnetohydrodynamic (MHD) generators for airborne and space system power can show high efficiency operation if high temperature gases are used. Coupled to 4000°F gases, these generators could convert 60-70% of the gas thermal energy into electrical power. This efficiency is 50% higher than the most modern advanced steam turbine plants and over 100% more efficient than conventional nuclear power plants. The amount of thermal pollution of cooling streams should be reduced by a factor of 3 to 5. In addition, the decreased cost of electrical power through improved efficiency operation would result in a savings of about one billion dollars/year at the present consumption rate.
The energy required in the USA in the future to keep the environment habitable for an expanding population and the relation between our environment and energy are discussed. It is concluded that 6 times the present electric energy capacity will be needed by the year 2000 to clean the environment and to maintain a reasonable standard of living for the additional population. Methods must be found for producing, distributing, and both cleanly and economically using fossil fuels. The more efficient breeder reactors must be developed for the economic use of nuclear fuels in commercial power plants. Finally, a nationally coordinated system for planning, developing, constructing, financing, and operating power plants is needed to achieve both the future electric energy needs and the environmental compatibility requirements.
B. FOSSIL FUELS

J. R. Williams.
Georgia Inst. of Tech., Atlanta. Schools of Mechanical and Nuclear Engineering. 1974; 51p NASA-CR-138188
N74-226683/6WE PC5.75/MFS1.45

The conversion of fossil-fired power plants now burning oil or gas to burn coal is discussed along with the relaxation of air quality standards and the development of coal gasification processes to insure a continued supply of gas from coal. The location of oil fields, refining areas, natural gas fields, and pipelines in the U.S. is shown. The technologies of modern fossil-fired boilers and gas turbines are defined along with the new technologies of fluid-bed boilers and MHD generators.

WESTERN STATES PLAN HUGE FOSSIL FUEL DEVELOPMENT. Snyder, R. E. World Oil; 176: No. 4, 39-42(Mar 1974).

A summary was given at the Tri-State Fossil Fuels Energy Conference in Denver, Col., January 31 and February 1, 1974 of the plan for fossil fuel development in the Western United States. Warnings were issued by oil companies in 1964 to 1970 of the peril of the dependency on Arab oil. Iran's Finance minister said, "And please remember that you in the West have enough coal for 400 years. But our oil will last for only 50 years or so. Do you want your grandchildren to beg you for their shortage needs?" The conventional methods of coal development were discussed and the Lawrence Livermore Lab technique for underground coal gasification was presented. Three methods for mining and processing oil shale that were discussed were TOSCO II process involving room and pillar mining, ore-crushing, and surface retorting; Occidental in situ process; and nuclear in situ recovery. Natural gas recovery in impermeable rocks and nuclear stimulation for gas were discussed. (MCW)

ECONOMIC ANALYSES OF FOSSIL FUEL MARKETS USING PARAMETRIC MODELS. Robert J. Kalter.

PB-229 950/1WE PCS3.75/MFS1.45

The report describes parametric models of the fossil fuel (coal, oil, and gas) markets, at two levels. First, models for individual fuels are based on historical data and assumed interactions of supply, demand, and price. Supply and demand elasticities and other significant variables are parameters which can be specified by the user. Secondly, the individual fuel models are linked through a constraint on price differential. The model is exercised for likely values of the parameters, and the implications of alternative parameter values and alternative government policies are discussed. (Author)

FLOWSHARE TECHNOLOGY ASSESSMENT. Energy Development Trends.

John C. Bellamy, and Michael C. Penz.
Western Interstate Nuclear Board, Lakewood, Colo. Jan 73, 29p NSF-RA-G-73-013
PB-231 039/9WE PC$4.50/MFS1.45

An analysis of probable future needs for energy in relation to potential sources of energy and environmental concerns is used to postulate how those needs might best be served. It is thereby postulated that nuclear heating plants can well be developed to serve most of our needs for heat and electrical energy in stationary locations, and that fossil fuels can thereby well be conserved largely for propelling vehicles. It is thereby also seen that nuclear explosives are likely to be needed to extend the use of natural gas for stationary heating needs during the transitional period. (Author)

(WASH-1281-2) MINING: COAL AND OIL SHALE.


Coal and oil shale together constitute 90% of our fossil fuel energy resources. If these resources are to fulfill the expanding role demanded of them, better mining technology must be developed. This is the research area dealt with by this subpanel. Three subprograms are presented: "surface coal mining", "underground mining", and "oil shale mining". Research for the three subprograms is recommended on the principal problem areas of mining systems, environmental protection, social and economic effects, and resource recovery. The overall objective of the recommended coal and shale research mining program is the rapid development and demonstration of technology to satisfactorily mine these important energy sources. This technology must meet the required demands at acceptable costs with minimal environmental impacts. Also, this mining must be done in a manner that assures miners' health and safety and makes wisest use of these resources. In the near term, the coal surface-mining segment of the program will concentrate on improving extraction/reclamation technology to allow acceptable mining of both Eastern and Western coals at the unprecedented rates anticipated. In the near term, the underground coal mining portion of the program will concentrate on the development of improved underground mining methods to provide a viable complement to our surface coal mining capabilities. The oil shale mining program will concentrate on mining of thick Western shale deposits in a manner that complements emerging government/industry efforts to develop these reserves in an environmentally acceptable manner. (Author)
CHALLENGES IN PRODUCTION OF FOSSIL FUELS.


The near-term growth pattern of U.S. energy consumption will not depart significantly from the pattern of the past. This growth is finally catching up with our capacity to supply energy in presently acceptable forms. There is no expectation that nuclear power will contribute more than one-fourth of the total energy needed by 2000 A.D. Assuming nuclear-source electrical energy as the equivalent of the thermal energy needed to produce it, at an efficiency of one-third. The half-lives of our factories, machines, and industrial processes and of our moves and customs are guaranteed enough that, much as improvement in energy use is to be encouraged, major change in GNP and services produced per unit of energy consumed cannot be expected to occur fast enough to have a major impact in the near term. Our supplies of coal are enormous compared to other fossil resources and supplies of oil shale are less impressive. The suggestion that the energy needed in near term (1975 to 2000) can come from nonhydrocarbon fuels only resolves the issue in that it is not feasible yet. Six alternatives are: import large quantities of crude oil and/or all products and large quantities of liquefied natural gas; encourage more vigorous search for gas and oil; by changing the federal position on gas price control and on federal land leases, increase the research effort on improved recovery of oil and gas from the ground; increase the efficiency of use of energy; learn how to burn coal cleanly; and convert coal, shale oil, bitumens to clean gas or clean oil. (MCW)

DISTANCE IS SOVIET ENERGY WORRY. Energy Int. 10: No. 11, 41-42 (Nov 1973).

The USSR contains abundant resources of primary energy, but the problem deals with the distance of these resources from the industrialized areas. The Soviet Union has about half the world's natural gas reserves, rich oil and hydropower resources, and practically inexhaustible coal deposits. Two solutions to the problem are being studied — construction of a special coal-freight super-railway and generation of electricity at the mine mouth and then transmit it to the Western republics. Thus the development of more efficient pipelines and power transmission lines is necessary. The Soviet cooperation in energy production with Western countries and peace signed with other countries are discussed. (MCW)

TITLE: Oil Shale, Coal, and the Energy Crisis
AUTHOR: Kelkman, B.R.
CORPORATE AUTHOR: Superior Oil Co.
ADDRESS: Houston, TX
PUBLICATION DESCRIPTION: Chemical Engineering Progress, 69(9), 94-95
PUBLICATION DATE: 1973, May
ABSTRACT: Oil shale and coal are the only domestic reserves in large supply. A system is proposed to mine the oil shale and process it to recover low sulfur crude oil, naphthalene, and aluminas. By 1981, a plant could be on stream producing 40,000 barrel/day oil, 15,000 ton/day naphthalene, and 3,000 ton/day alumina trihydrate. The naphthalene could be used as a scrubber for SO2 in coal burning plants. (MC)

AVAILABILITY: Complete manuscript (No. 8272) of 27 pages available from AIChE Publications Dept., 145 4th St., New York, N.Y. 10017 ($4.00 U.S. prepaid; foreign add $2.50 prepaid)

FOSSIL FUEL — POWER = POLLUTION.
G. Alex Mills and Harry Perry.

Where we are and just where we're going in the future.

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Enhanced recovery methods, problems, prospects, and status of methods under development and/or testing are summarized from data, forecasts, estimates, and opinions of 36 oil and gas production research, forecasting, and operating engineers. The industry investigation was conducted to determine the extent to which possible price increases would result in increased production and reserves of domestic crude oil and natural gas through the application of enhanced (non-conventional) recovery methods; the probable benefits to be derived from a federally supported, or partially supported, research and development program concerning the enhanced recovery of crude oil and natural gas as a possible component of a national energy program; and the definition of the general question, control, time, and cost of such a program. The conference conclusions and recommendations are enumerated.

Author

ENERGY RESOURCES
In its TERRASATR: Terrest. Appl. of Solar Technol. and Res. Sep. 1973 34 p ref (For availability see N74-12674 03-34) CSCL 20M

A statistical analysis of the availability of fossil fuels for energy and non-energy production is presented. The cumulative requirements for petroleum, natural gas, and coal are discussed. Alternate forms of energy are described and the advantages and limitations are analyzed. Emphasis is placed on solar energy availability and methods for conversion. The Federal energy research and development funding for energy sources is tabulated.

Author

OIL AND GAS
T. H. McCullogh In its US Mineral Resources 1973 p 477-496 ref (For availability see N74-15214 06-18) The oil and gas resources of the United States are examined. Organic carbon, hydrocarbons, and producible hydrocarbon accumulations are discussed from the standpoint of distribution and accessibility. All estimates of petroleum and natural gas resources depend upon prior exploration results and are considered unreliable. Changing economic incentives, technologic advances, enlarged prospecting areas, and creative thinking all increase exploration effectiveness. Data are presented to show variations in produced and proven reserves of oil for the U.S. and the world.

Author


This is one of the task group reports of the National Petroleum Council's Committee on U.S. Energy Outlook. These task group reports have been prepared to include methodology, data, illustration, and computer-program descriptions for the particular area studied by the task group. This report is divided into two major parts: summary of oil and gas availability studies and findings of the oil- and gas-supply task groups. Part 1 is subdivided into sections on domestic oil and gas availability, foreign oil and gas availability, and oil and gas logistics and imports. Part 2 consists of the following sections: NPC methods of analysis of oil and gas supplies; oil operations; gas operations; economics—oil and gas; parametric studies; and foreign oil and gas availability.

Author

N74-18313# Esso Research and Engineering Co., Linden, N.J. Government Research Lab.

POTENTIAL POLLUTANTS IN FOSSIL FUELS

This survey presents the composition of typical U.S. fossil fuels by source location. and to the extent which the selection of coals and crude oils are based upon such geographic source can be expected to affect their composition in trace elements. The first section deals with coals produced and consumed in the United States. A section on petroleum and shale oil includes domestic crude oils and domestic crude from nations which export to this country. The number of elements for which statistical data on composition and geographical location exist is entirely different for crude oil and for coal. Good data and useful correlations with source locations are available for petroleum, for sulfur, nitrogen and nickel/vanadium, but not for other potential pollutants. A large body of data is available for trace elements in coal, and is examined herein. For both coal and petroleum, however, the level of trace elements present is relatively low so that methods of sample selection and sample handing, prior to analysis, can and do present major complications in the interpretation of results.

Author
The Naval Petroleum Reserves and Their Relevancy in the Decade 1975-1985. (Are the 'Other' Naval Reserves Necessary).
John K. Tccl.
Army War Coll Carlisle Barracks Pa 15 Oct 73, 38p
AD-779 995/0WE PC$5.00/MFS1.45

In 1912 President Taft established two Naval Petroleum Reserves "...to reserve certain fuel oil deposits for the use of the American Navy". A third was established by President Wilson in 1915, and a fourth was added by President Harding in 1923. Naval Oil Shale Reserves 1 and 2 were designated in 1916 and No. 3, in 1924. For the most part, these land set-asides are in a standby status (Reserves Nos. 1, 3 and 4, about exhausted (Reserve no. 2), or undeveloped (Naval Shale Oil Reserves Nos. 1, 2 and 3). The report examines the present domestic available-energy deficiency and concludes that petroleum is the only energy source that can be stretched sufficiently to cover the widening gap in supply and demand. Since crude oil imports must fill this gap, at least for the next decade, the economics and strategic aspects of this dependence are discussed. (Modified author abstract)

ARTIFICIAL OIL AND GAS.

(TID-26528, pp 75-128) FOSSIL FUEL OPTION.
The nation will continue to be dependent upon fossil fuels for the next twenty to thirty years. Conservation will provide the time needed to bring the new, cleaner energy sources and technology into use. New environmental regulations will increase energy resource requirements until new processes are developed that are less energy intensive per unit of product. A summary of fossil fuel energy resources for proved; proved and probable; and proved, probable, and possible is given. New methods for increasing oil and gas reserves; deep and strip coal mining; utilization of coal by direct combustion, gasification, and liquefaction; oil shale development; and environmental considerations are discussed. Appendices to Chapter II include the rate at which strip mining capacity could be increased and the strategy for coal research and development. A cost summary is included. (MCW)

The technology assessment of the U. S. outer continental shelf oil and gas operations is an attempt to introduce all consequences well beyond the conventional considerations of economic costs and benefits or immediate implications for the perpetrator or user of technology. The assessment study attempts to inform the interested public and the decision-makers of the possible range of consequences of new actions. An examination was made of the development of outer continental shelf oil and gas resources and how policies are currently established. Topics are discussed such as the adequacy of present technologies, the quality of environment and environmental control, government management, and federal and state jurisdiction. The recommendations are given regarding government policy and administration, industry management, and technologies that will contribute to optimal resource development. (MCW)

SELECTED LIST OF BUREAU OF MINES PUBLICATIONS ON PETROLEUM AND NATURAL GAS. 1961-1970
(BM-IC-8244: BM-IC-8240-Suppl) Avail. SOD HC $1.75
This selected list contains 829 entries with citations to publications related to petroleum and natural gas, which were released during the 1961-1970 period. Some entries are multiple in nature, resulting in a total of 881 citations. The purpose of this bibliography is to provide a selective review of publications related to petroleum and natural gas during the 1961-1970 period. The publications are grouped under broad headings as shown in the contents section. Indexes, placed at the end of the list, identify publications by author with short title, detailed subject approaches, and report numbers. As the title indicates, the publications included have, for the most part, a direct and specific relationship to petroleum and natural gas. In some selections, however, the reports included are applicable to other energy fuels as well.

FUTURE OF THE FUELS MARKET.
Energy Digest, June 19,1972, p.122-125.

Economists say coal and gas prices will outpace inflation through 1985 while oil and uranium will rise more slowly.
FOURTH SESSION - ENERGY CONVERSION II - FOSSIL.

p.155-196.

EARTH'S DWINDLING STOCK OF FOSSIL FUELS.
L. Howles.

FOSSIL FUEL SUPPLIES AND FUTURE ENERGY NEEDS.
H.E. Risser.
Amer. Geophysical Union Trans., v.52, no.11, 1971, p.763-767.

1972

Conference on research for the electric power industry. [New York, Institute of Electrical and Electronic Engineers, 1973]
455 p. Illus. 28 cm.

1971

N74-18666# Committee on Interior and Insular Affairs (U. S. Senate).
COMPACT TO CONSERVE OIL AND GAS
Washington GPO 1971 30 p Hearing on S. J. Res. 72 before Comm. on Interior and Insular Affairs. 93d Congr., 1st
Sess., 17 Jun. 1971
Avail: Subcomm. on Minerals, and Fuels
A Congressional hearing concerning an extension of the Interstate Compact to Conserve Oil and Gas was conducted.
The purpose of the compact is to prevent physical waste of natural resources within the states which ratify the compact.
The states are expected to accomplish the legislation to prevent the following: (1) operation of any oil well with an inefficient
gas-oil ratio, (2) drouning with water of any stratum capable of producing oil or gas, or both oil and gas, in paying quantities,
(3) avoidable escape into the open air of the wasteful burning of gas from a natural gas well, (4) the creation of unnecessary
fire hazards, (5) the drilling, equipping, locating, spacing, or operating a well or wells so as to bring about physical waste of
oil and gas, and (6) the inefficient, excessive, or improper use of reservoir energy in producing wells.
Author.
JOINING NORTHEAST POWER PLANTS TO AP- 
PALACHIAN COAL: WHAT CHANCE. Coal Age, 58: N. 4-1, 
82-5Jan 1974). 
Appalachian coal is needed to relieve the energy shortages 
in the northeast USA. Some utilities are converting from oil to 
coal, and the deed controlling the allowable sulfur content in 
the coal must be released. Some restraints that hinder rapid 
response to the need for coal include: not much coal is avail-
able since mines in operation are committed to long-term 
contracts; lead time for new mines is from four to six years 
and the development would have to be a sure act for investors 
to participate; railroads and waterways are approaching 
full 
handling capacity; shortages of labor are due to long-term 
training of miners and maintenance personnel, and the present 
return on investments is minimal. (MCW)
The Supply of Coal

The United States has vast reserves of coal, both in the well-explored regions east of the Mississippi River and in partially-explored portions of Wyoming and Montana. Whether these reserves can be developed in time to make a significant contribution to Project Independence depends upon the cost of mining and transporting the coal to final markets and on the growth in demand for coal. These factors, in turn, are influenced by political matters—principally environmental protection regulations against sulfur emissions from coal burned to generate electricity.


Commonwealth Edison boilers were designed to use a high-rank, type-C bituminous coal from Illinois. The characteristics of the Illinois coal are given and compared to western coal, which is now being used. Illinois coal is not now acceptable in most of the system because of ordinances limiting sulfur and SO2 discharges and lack of technology to reduce the sulfur content. Western coal is inferior to Illinois coal except in the area of sulfur content and, in some cases, ash content. Testing results are presented on Colstrip, Arch Mineral, and Decker coals and compared with the percent sulfur, Btu/lb heating value, percent reduction Btu, and percent moisture characteristics of the Illinois coal. Preparation, ash handling, water treatments, and combustion in cyclone-fired boilers are some of the problems discussed for western coal. The precipitators on the Commonwealth Edison system were upgraded to utilize the western coal. (MCW)

CLEARING THE WAY FOR THE NEW AGE OF COAL.
E. Faltermayer.

In the rush for energy, the U.S. will be tearing coal from the ground as never before. Moonscapes and dustbowls must not be the result.

THE REKINDLING OF COAL.

In answer to the energy crunch, technology offers an alternative solution with a plentiful resource.

COAL AND THE PRESENT ENERGY SITUATION.
E.F. Osborn.

Abundant coal reserves can be used to alleviate the oil and gas shortage.
POWER FROM COAL. I. Coal Selection and Handling.
Power; 118: No. 2, SI—S24(Feb 1974).
The basics of selection and key facts about coal and the equipment and methodology of coal handling are discussed. It is indicated that it will take years to gain momentum in coal development. The first requisite for coal development is to know its availability, and then an analysis is essential. The characteristics of coal discussed include moisture, ash, volatile matter, fixed carbon, and sulfur content, ash-fusibility temperature, heating value, and all their related properties. Dust suppression and transportation of coal are discussed. In-transfer operation, bucket elevators, continuous-flow conveyors, and belt conveyors were described for unloading coal. (MCW)

The theory of coal combustion is described. Fuel/air ratio, proper mixing, differences between fuel-bed and suspension firing, basic arrangements at the mill for coal sizing, fineness or quality of mill output, and volatile guidelines are discussed. Ash increases the cost of shipping and handling coal, and its content in coal determines the size and type of ash-handling system. System selection is closely related to ash content, how coal is burned, and amount and type of ash collected. Small plants use exhausters. (MCW)

POWER FROM COAL. III. Combustion Controls and Pollution Controls. Power; 118: No. 4, S49-S64(Apr 1974).
Economical and safe steam generation in industrial and utility plants demands precise and reliable control equipment. Boilers must have controls that will maintain steam pressure within ±1 to 2% of the design point, fuel/air ratio within ±5% of excess-air requirements over the entire load range, and steam-drum water level within ±1 in. of the desired height. Regulation of combustion, burner-management, and feedwater controls is required. Combustion and burner-management are discussed. Four equipment designs are discussed to curb stack dust emissions. Stack emissions from coal-fired boilers consist of particulates, oxides of nitrogen, and sulfur dioxide. Control of particulates and nitrogen oxides are discussed. The characteristics of the coal must first be known. (MCW)

The American Petroleum Institute issued warnings on an impending fuel problem in 1954. Fossil fuels were still used at record rates. In 1973, the federal government requested some power plants to switch from oil to coal. The switch to coal-fired boilers is expensive and then the added expense of pollution control equipment for particulate matter, sulfur and nitrogen oxides produced from coal combustion puts hardship on the utilities. New plants are utilizing designs for dual-fuel boilers. Coal is basically still plentiful in the U. S. and new methods are being developed to make cleaner burning fuels and useful chemical by-products from coal. The use of coal would produce self-sufficiency of the U. S. for its energy needs. (MCW)

HIGHLIGHTS OF A BUSY YEAR FOR COAL. Coal Age; 79: No. 2, 70-3(Feb 1974).
In 1973, 590 million tons of coal were produced. In order to increase the 1974 production to 660 million tons, the following criteria must be attained: labor stability with an end to absenteeism and wildcat stoppages; effective enforcement of mine health and safety laws without harassment or unnecessary mine closures; continue use of mining equipment with reasonable reclamation requirements; adequate rail hopper cars; extension from price controls of all coal sales; variances in air pollution control regulations to allow burning of available high-sulfur coal; and adequate mine supplies, especially roof bolts, fuels, and explosives. Suitable sites have been selected for coal gasification plants. SNG from coal is expected to be competitive with gas brought by pipeline from Alaska, gas imported as a liquid in cryogenic tankers, and SNG produced from naphtha or other feedstocks. (MCW)

Hydroexplosive mining is suggested as one way to economically develop deep, thick seams of coal without adversely affecting the environment. It is also considered as an alternative to strip mining. Hydroexplosive techniques are examined and some preliminary experiments are described. (auth)

A 10-year, $20 billion research and development effort is being contemplated as part of the drive to make the United States self-sufficient in energy by 1980. A major share of that money will go to coal R & D with the aim of making coal available in such great quantities that it becomes a prime energy source well into the next century. Special planning groups are to submit their blueprint to President Nixon by Nov. 1 outlining how funds are to be distributed. The program can be likened to the effort to land a man on the moon, but says one task force director, it's much more difficult.

This is the last of three reports on the role of coal in the nation's energy future. The first report, in issue No. 26, dealt with the short-term outlook for coal supplies. The second report, in last week's issue No. 27, discussed the argument over whether future production should be concentrated in eastern or western mines.


The world-wide production of petroleum, while increasing rapidly, provides at the present time 40% of energy requirements; coal production, increasing only slowly, provides 30%. The coal mining industry in Western Europe has slowed down sharply in recent years, but coal reserves throughout the world remain by far the largest and represent at this time 90% of the world's energy reserves. For certain purposes, and particularly in the iron and steel industries, petroleum cannot take the place of coal; for others, everything depends on production costs. At present, atomic power does not enter into competition with coal except in the making of electricity. We can state here several outlets which could be opening up for coal: gasification, carbon fibres, carboujet, etc. CER-CHAR has carried out very thorough research on many of these projects. This article reminds us that the part played by coal will remain of first rate importance to the whole world, even though France has only a small supply.


The key to achieving energy self-sufficiency by 1980—President Nixon's Project Independence—is coal, the "great black hope" that comprises 93 per cent of the nation's energy reserves. Production must increase 10 per cent a year between now and 1980 and 20 per cent between 1980 and 1985 to reach the goals of Project Independence. Coal producers say they can't meet those goals unless steps are taken to alleviate problems that include shortages of capital, equipment, manpower and transportation and regulations affecting air quality, strip mining and employee safety.


Coal must make a comeback, but the general practice in times past has been to use coal when other fuels were not available. Coal production did not increase in 1973. Coal output increase can only be achieved if wildcat strikes and absenteeism stops, mine health and safety harassment subsides, adequate transportation is furnished, price controls abolished, and air pollution laws changed so that sulfur content is disregarded. The coal industry must be assured of a long-term market and iron-clad contracts before new mining is developed. The coal industry needs necessary raw materials to operate at full capacity and this includes diesel fuel, roof bolts for safety, ammonium nitrate for explosives, and a continuing supply of machinery and replacement parts. (MCW)


Nuclear power growth projections, labor problems, cheap gas, health and safety regulations, and environmental protection laws caused the coal industry to lag behind in exploration and the opening of new mines in the last few years. Uncertainties still prevail even when nuclear power plants were delayed and shortages and prices surged ahead for oil and gas. Mining methods are discussed in relation to prevailing environment and health regulations. The trend in energy consumption is toward reversion back to coal, but mines cannot be opened overnight, miners cannot be trained overnight. The industry faces critical shortages of mining materials, such as roof bolts, diesel oil, ammonium nitrate, electric cable, and machinery and replacement parts. Forecasts hold that an investment of about $30 billion is needed by 1985 for the coal industry to be reinstated. (MCW)
The UK coal industry - recent past and future

Richard Bailey

Against a background of rising prices and unsable supplies of oil, coal is rapidly regaining its former position as a key fuel in the UK. In this article, Mr Bailey traces the history of the industry from its decline in the 1960s to the substantial assistance given in the Coal Industry Act of 1973, and discusses the 1974 miners' wage settlement in relation to the future importance of coal for both the UK and the EEC.

From national western mining conference, Denver, Colorado, USA (5 Feb 1974).

The vast bulk of the U. S. coal resource lies at depths which render it forever inaccessible to recovery by surface mining methods. In the long term, underground mining must become the predominant form of coal extraction. The longwall method of mining shows great potential promise for increasing resource recovery and labor productivity, and for providing safer working conditions. Adverse environmental impacts from deep mining include acid mine drainage, surface subsidence, and gob disposal. Sufficient quantities of coal lie close enough to the surface that surface mining will continue to be a major factor in coal production for decades to come. Full reclamation of strip-mined mountainous lands is especially difficult and laws affecting contour mining and reclamation do not call for full reclamation and are often inadequately enforced. The modified block-cut method of mining represents one possible method for reducing the environmental damages from mountain strip-mining. Special problems occur in arid and semi-arid regions and restoration practices in flat areas should return the land to full agricultural productivity.


Coal and oil shale together constitute 90% of our fossil fuel energy reserves. If these resources are to fulfill the expanding role demanded of them, better mining technology must be developed. This is the research area dealt with by this subpanel.

Three subprograms are presented: "surface coal mining", "underground mining", and "oil shale mining". Research for the three subprograms is recommended on the principal problem areas of mining systems, environmental protection, social and economic effects, and resource recovery. The overall objective of the recommended coal and shale research mining program is the rapid development and demonstration of technology to satisfactorily mine these important energy sources. This technology must meet the required demands at acceptable costs with minimal environmental impacts. Also, this mining must be done in a manner that assures miners' health and safety and makes wisest use of these resources. In the near term, the coal surface-mining segment of the program will concentrate on improving extraction/reclamation technology to allow acceptable mining of both Eastern and Western coals at the unprecedented rates anticipated. In the near term, the underground coal mining portion of the program will concentrate on the development of improved underground mining methods to provide a viable complement to our surface coal mining capabilities. The oil shale mining program will concentrate on mining of thick Western shale deposits in a manner that complements emerging government/industry efforts to develop these reserves in an environmentally acceptable manner. (auth)

CHEWING IT UP AT 200 TONS A BITE: STRIP MINING.

W. Greenberg.


As energy tightens, take comfort from America's immense coal reserves. But at what price exploitation?


(Contact NSF Office of Public Technology Projects, Room 405, or RANN Document Center, Room 601, 1800 G St. N.W., Wash., D.C. 20550.)

The hearings were conducted to assist members of the Committee on Interior and Insular Affairs of the U.S. Senate to understand the issues inherent in the formulation of a long-term national energy policy that assures the continued welfare of the Nation, including balanced growth, safeguarding and enhancing the quality of the environment, and national security. Statements were heard from university personnel, federal and state senators, utility personnel, environmental agencies, and many other contributors. Natural gas, tar sands, synthetic fuels, and nuclear power are discussed as options. Environmental considerations will be the key to the determination of the role of coal in the future energy supply pattern. Communications sent to industrial organizations by U.S. senators are published in which the companies were asked to submit views on coal policy issues. (MCW)


The hearings were conducted to assist members of the Committee on Interior and Insular Affairs of the U.S. Senate to understand the issues inherent in the formulation of a long-term National Energy Policy that assures the continued welfare of the Nation, including balanced growth, safeguarding and enhancing the quality of the environment, and national security. Statements concerning the present and future role of coal in future energy supplies are published from fuel company officials and governmental officials in answer to a questionnaire from committee members. Much information is included on the technology available to burn coal under environmentally acceptable conditions at cost levels competitive with other fuels in fluidized-bed furnaces. (MCW)

(CONF-731027-2) REPORT ON COAL RESEARCH IN THE UNITED STATES. (National Coal Association (USA)). 1973. 21p.

The research on coal involves the government, private and public associations, private non-profit groups, and universities. The research programs underway for each agency are discussed. The mining of coal and the problems connected with the procedures are summarized. Gasification and liquefaction are stressed. Combined power cycles, binary cycles, and open-cycle MHD systems fired by clean, low-Btu coal gas provide for near-term solution to the energy crisis. OCR's power generation objectives include development of low-Btu gasification systems, MHD central station systems, and fluidized bed combustion systems. Funding for environmental control studies is delineated. (MCW)

(CONF-731027-4) REPORT ON STATUS OF FEDERALLY SUPPORTED COAL RESEARCH IN CANADA. (Department of Energy, Mines and Resources, Ottawa, Ontario (Canada)). 1973. 8p.

Predictions indicate increased coal research and development are necessary because coal production will have to increase more than four-fold (to 100 million tons per year) by the end of this century to fulfill its share of Canada's energy needs. Federal participation in coal research may continue to be more extensive than for other fossil fuels because current poor levels of return on investment in the coal industry curtail funds available for research activities. The Federal government currently supports research, technical advice, problem-solving studies, and laboratory services that cannot be carried out by other agencies. (MCW)

(CONF-731027-3) REPORT ON COAL RESEARCH IN WESTERN EUROPE. (European Coal Producers Association, Brussels (Belgium)). 1973. 35p.


The report covers information from the West European countries on the organization and financing of technical research and on the major current and envisaged research projects of coal. The report covers organization of coal research in the West European countries of Belgium, France, Federal German Republic, United Kingdom, and the European Communities; current research in 1972, expenditure on current research, and focal points of envisaged research for the future; and the financing of coal research. Appendix 1 includes a systematic catalogue of research activities and Appendix 2 is a list of research establishments shown separately for each country. (MCW)

N74-156844# Committee on Interior and Insular Affairs (U.S. Senate).


A report to inform members of Congress on the factors affecting the use of coal in present and future energy markets is presented. The subjects discussed are: (1) coal reserves, (2) mining regulations, (3) air pollution control for coal burning utilities, and (5) the policy issues which must be considered in the Federal government for adequate exploitation of coal supplies. Tables are included to show yearly consumption, forecasts of 1980 demand, potential domestic supply available, and coal characteristics by states. P.N.F.

195
U.S. Congress. Senate. Committee on Interior and Insular Affairs.

REGULATION OF SURFACE MINING OPERATIONS. HEARINGS, Ninety-third Congress, First Session, on S. 425, a Bill to Provide for the Cooperation Between the Secretary of the Interior and the States With Respect to the Regulation of Surface Mining Operations, and the Acquisition and Reclamation of Abandoned Mines, and for other purposes, S. 923, a Bill to Provide for the Cooperation Between the Federal Government and the States With Respect to Environmental Regulations for Mining Operations, and for other Purposes. Washington, U.S. Govt. Print. Off., 1973. 2 v. in 1 (1410 p.)


INDUSTRIAL COME-BACK FOR COAL.
D. Clutterbuck.


COAL: THE STOPGAP FUEL—MAYBE.
J.H. Douglas.

This is the second article in a series on the energy crisis. After covering fuel shortages and temporary solutions, the series will discuss nuclear and solar sources as long-range remedies.

COAL: THE ONCE AND FUTURE KING. Fri, R.W.

The conflict between coal use and the Clean Air Act, the rising US energy demands, and the limited future supply of oil and gas as compared with coal reserves, and the need for the wisest possible use of US fossil fuel resources are discussed. (LCL)
ENERGY VS. THE ENVIRONMENT IN MONTANA.


The U.S. desperately needs new energy supplies; but Montanans, who live on top of incredibly rich coal deposits, want to preserve their environment from strip miners.

Technology Review, v. 76, no. 2
Dec. 1973

THE ENERGY CRISIS - special issue.

The Challenge and Promise of Coal
Edmund A. Nephew

Most U.S. coal lies beneath the reach of strip mining. But we have concentrated our technology—and our exploitation—on that small share of this immense resource which is accessible from the surface.

U.S. Energy Outlook: Coal Availability. 1973,
HAS COAL A FUTURE?
M.J. Parker.

Coal does have a future both in the UK and in the enlarged European Community and can make a vital and continuing contribution to energy requirements.

Many discussions have pointed out the differences in the characteristics of eastern and western coals. Low rank western coals have higher moisture levels, lower calorific values, and the ash constituents are more basic. Slagging and fouling indexes based on the ash chemistry of eastern bituminous coals are not applicable for low rank western coals. These differences led to questions in the behavior of eastern and western coals, so we have directed our efforts toward a study of the behavior of low rank western coals and how they differ from eastern coals. Three routine laboratory tests: (a) burning rates, (b) coal ash sintering strengths, and (c) slugging temperature relationship of coal ash were used to distinguish the difference in the behavior of these coals.

Three generating stations were selected to compare slogging and fouling predictions with actual measurements. The coals burned at these stations were: 1) A North Dakota lignite, 2) a Montana subbituminous coal, and 3) an Illinois bituminous coal.

Excellent results were noted as the observed soot blower performance and the performance predicted by an evaluation of the slagging and fouling characteristics of the coals were in agreement.


Pulverized char was fired in a dry-bottom, front-wall-fired furnace, capable of burning about 500 lb of the material per hour. Earlier experiments with chars injected at ambient temperatures into this furnace had indicated that increasing amounts of supplementary fuel (natural gas) were required to maintain good combustion as the volatile matter in the char decreased with standardized conditions of burning rate, excess air, and primary air to fuel ratio.

In this investigation, the char-primary air mixture was preheated to eliminate the need for a dual fuel system. Effects of operating parameters such as secondary air preheat and fuel particle size were studied. A low volatile (5 percent) char was burned successfully without supplemental fuel at a char preheat temperature of 450–500 F and a secondary air temperature of 600 F.

A char preheat temperature of 550 F was required to obtain stable combustion without auxiliary fuel when the secondary air temperature was lowered to 500 F. Low-volatile (18 percent) Pocahontas coal could be burned in the experimental combustor without either auxiliary fuel or preheat of the char, thus giving an indication of the order of difficulty in burning low-volatile char.

73-WA/Fu-4 Burning Western Coals in Northern Illinois, by R. H. Hulse, Commonwealth Edison Co., Chicago, Ill.

Commonwealth Edison's experiences with burning Western low sulfur coals is reviewed. Edison has been burning Western coals since 1969 and will burn seven million tons in 1973. The paper discusses three areas of problems caused by using Western coal in equipment designed to burn Midwestern coals.

Combustion problems, which cover loss of capacity, carbon carryover, and fouling experience in pulverized and cyclone boilers, loss of efficiency in precipitator operation, and problems experienced with ash handling.


With prospects of extensive large-scale development of Colorado River Basin coal, the public has raised many serious questions concerning the environmental impacts that could result. The Federal Government owns or holds in trust for the Indians the major portion of the land in the Southwest and shares the public environment concerns. The purpose of the study was to develop an information base and public dialogue that would guide needed early decisions and identify the additional new information and alternatives required to facilitate future decisions involving long-term choices. This report is a summary of the results of the Southwest Energy Study.
THE COAL INDUSTRY MAKES A DRAMATIC COMEBACK.
Business Week, Nov. 4, 1972, p. 50-55, 58.
Demand will climb to 1-billion tons a year.
Taking over for dwindling gas and oil.

COAL: CONFRONTATION.
Forbes, Nov. 15, 1972, p. 32, 33, 34, 41, 42, 46.
What happens when environmentalism confronts economics?

COMING THE GREAT COAL CLEANUP.
J. N. Govey AND J. H. Faber.

Environmental damage can be greatly reduced thru
effective methods of sulfur oxide control and
fly ash recovery.

The proceeding at the symposium included the following papers: A Progress Report on coal mine health and safety; pipeline transport of "liquid" coal; liquefaction of lignite with carbon monoxide and water; use of western coal and air-water quality control; relationship of air quality measurements to criteria and emission standards; nitrogen oxides, sulfur oxides, and particulate control technology for fossil fuel combustion; low temperature solution to high resistivity ash problems; collecting fly ash from western low-sulfur coal; pilot study of electrostatic precipitation for removing fly ash at basin electric's Leland Olde Station; future energy supply: approaches and options; lignite and the cyclone burner in a new 235-Mw generating station, and detailed description and equipment costs for the 235-Mw Milton R. Young Generating Station. (MCW)

CH-128,766
COAL REFUSE FIRES, AN ENVIRONMENTAL HAZARD.

Bureau of Mines

Inf. Circular 5545

Coal
Air - Pollution
Fire prevention

TK2896.15 1969


4Th Intersociety energy conversion engineering conference, Wash, D.C., Sept.22-26, 1969, p.188-206.

The need, technology, and economics of a national energy system based on the vast western coal reserves are described. Large western-based MHD power generating plants feeding power to 24,000-MW(e) long distance cryogenic transmission lines could deliver pollution-free power to far western and eastern energy consuming load centers at 2.5 to 4 mills/kWh(e) total cost. The possibility of by-product uranium, hydrogen, heavy water, and communications could further increase the utility and economic value of the system. (auth)
OIL, THE DWINDLING TREASURE.
N. Grove.
National Geographic, v.145, no.6, June 1974, p.792-825.

The world's sudden awareness of its dependence on oil prompts a new look at the diminishing resource—how we get it, how long it may last, and what happens when it runs out.


The shifting of energy policies in Canada is confusing as nationalism spreads in Canada. Western Canadian oil has been shipped to the U.S., even though oil was badly needed in Eastern Canada, but transportation problems made it desirable for Canada to import oil for the east. Now with rising prices and the Arab oil embargo, Canada is shipping oil from every means possible to meet Montreal's growing shortage. Canada's oil future depends on the tar sands in Alberta with estimated potential reserves of 35 billion barrels. With uncertain energy policies in the fore, even the prospect of a government-owned crown petroleum company, some Canadian independents are moving south into the United States with millions of dollars worth of drilling equipment with them. (MCW)

U.S. CRUDE PRICES SEEN STILL TOO LOW. Oil & Gas Jour., v.72, no.21, May 27, 1974, p.26-27.

Higher prices for domestic crude are necessary to reverse the decline in U.S. production capacity. Without new investment, production will decline about 10% per year, or 1 million b/d.


Imagery obtained with ERTS-1, NASA's Earth Resources Technology Satellite, shows promise for exploration for petroleum and minerals. The vehicle was launched July 23, 1972 into a near-polar orbit. A geologic description of a 116 square mile area in West Texas-New Mexico is given. (MCW)


Prognosis for Expanded U.S. Production of Crude Oil: R. R. Berg,
J. C. Calhoun, Jr., R. L. Whiting ........................................

........................ 331

INTERLOCKING OIL: BIG OIL TIES WITH OTHER CORPORATIONS. Fritsch, A. J. (ed.). CSPI Oil Series.
52p.

There are 460 interlocking directorates and advisory committee connections of eighteen large oil companies with well-known large corporations. There are 132 interlocks with banks; 31 with insurance; 12 with utility companies; 15 with transportation corporations; 46 affiliations with educational institutions; and 224 with manufacturing and distribution corporations. (MCW)
FOREIGN OIL: A POLITICAL-ECONOMIC PROBLEM.
M.A. Adelman.

Agreements with the oil cartel will not be binding, nor will they avert continued turbulence in supply for the consuming nations. The author offers ways to fight the monopoly and suggests that self-interest of the individual members of the cartel may be the seed of its destruction.

OIL, SUPER-SHIPS & THE OCEANS.
J. Frye.

The new generation of giant vessels and the problems of ports and pollution in their wake.

THE FAR-REACHING CONSEQUENCES OF HIGH-PRICED OIL.
Sanford Rose.

Industry may have to use more labor and less capital—and change its product mix.


WHAT PRICE PETROLEUM? 305
Our Special Correspondent
WHERE TO FIND MORE PETROLEUM 313
Our Special Correspondent
ARTIFICIAL PRICES MEAN ARTIFICIAL COMPETITION 319
Our Special Correspondent

OUR VAST, HIDDEN OIL RESOURCES.
S. Rose.

Some archaic regulations and superstitions about "waste" are keeping us from tapping our vast, hidden oil reserves.

THE DIFFUSION OF NEW TECHNOLOGY IN THE U.S. PETROLEUM REFINING INDUSTRY,
M. Bundgaard-Neilsen and Peter Fiehn.

The diffusion of new technology is described by a simple model. The results of a comprehensive case study of the diffusion into the U.S. petroleum refining industry based upon the model is presented.
The Supply of Domestic Petroleum

The production of crude oil in 1973 was 9.2 million barrels per day. The total consumption was about 17.0 million barrels per day, which included about 6.1 million barrels per day of imports, and 1.7 million barrels per day of natural gas liquids. To raise production to higher levels by 1980 would require prodigious exploration and development, as an appraisal of present conditions and forecasts shows.

The U.S. and the World Oil Market

The price of imported oil is an Important factor in the analysis of U.S. energy policy. The world price determines the resource cost of oil from abroad, and one of the goals of independence is to avoid a large economic drain for energy imports. Moreover, the world price is an important determinant of domestic price, and thus of the incentives to domestic demand and supply.

KEY ISSUES IN OFFSHORE OIL.

J.W. Devanney III.
The Limits to Kentucky Coal Output: A Short-Term Analysis.
Stuart A. Schweitzer.
Kentucky Univ., Lexington, Coll. of Engineering. Feb 74, 31p UKY-TR81-74-IMMR2
PB-230 775/9WN PCS4.75/MFS1.45

While the demand for Kentucky coal and market prices have increased dramatically in recent months, the capacity of the Kentucky coal industry to increase its output is seriously limited in the near term. This report attempts to identify current coal industry problems which may influence the level of coal output in the next year or two and to estimate by how much Kentucky coal output may be expected to rise during that period. The analysis for this report is based upon conversations with coal industry spokesmen as well as with representatives of state government and the coal-hauling railroads.

PB-231 032/4WE PCS19.00/MFS1.45

This report presents the findings and conclusions of the Commission staff based on a study, mandated by Congress, of the Emergency Petroleum Allocation Act (1973) and Regulations, and an analysis of the allocation program carried out under the Regulations from the date of their issuance on Jan. 15, 1974, through Feb. 28, 1974. The report reviews the background and key provisions of the Act and Regulations; evaluates the effectiveness of the allocation program; and assesses the administration of the program by the FEO during its first 45 days. Technical appendices to the report contain an historical perspective to the current situation; findings from field investigations on the operation of FEO Regional and State Allocation Offices; and a number of individual case studies of FEO and states' responses to consumer and industry problems.

1974

Assessment of U.S. Petroleum Supply with Varying Drilling Efforts.
SN-2004-01537.
PB-231 153/8WE PC-GPO/MFS1.45

This report presents a Bureau of Mines assessment of crude oil and associated gas production and reserves that would result from different drilling efforts in the lower 48 states during the 1972-85 period. The drilling effort was based upon five growth rate assumptions from the 1971 level. Additions to crude oil reserves were computed for nine cases resulting from the use of three equations for findings per foot drilled and three constant revision factors. The results presented vividly illustrate that the United States will not become self-sufficient in crude oil production by 1985 and also illustrate the lead time required to reverse the decline in oil production. Discussion is limited to three of the nine cases to provide high, intermediate, and low results. More emphasis is on the intermediate case because it is indicative of the most probable trends. The methodology and statistical data are included in the appendices. (Author)

1974


North Sea oil in a world context

Frank Howitt
The British Petroleum Company Limited, Britannic House, London EC2Y 9BU, UK

Dr F. Howitt, of BP, assesses the oil and gas reserves which Britain can expect to exploit from the waters around its coastlines. Although supplies are limited, there seems to be some room for optimism: even if no more oil is discovered there may still be a small supply at the beginning of the next century.
The Oil Security System - An Oil Import Policy for the United States.
Daniel H. Newlon, and Norman V. Breckenr. 
Center for Naval Analyses Arlington Va Inst of Naval Studies Jan 74, 69p INS-Research Contrib-255
AD-779 283/1WE PC$3.75/MF$1.45

What should the United States do if some oil imports are cheaper but less secure than domestic energy production. In answer to this recurring question, the Oil Security System provides for more oil security and more imports too. It permits imports from insecure sources, either upon payment of a fee or if backed by commitments of emergency oil supplies issued by suppliers of secure oil. Such commitments, called guarantees, are obligations to sell on the market oil in an emergency from such sources as inventories, existing wells operated below capacity, capped wells, new wells drilled during the emergency, and diversions of U.S. exports of crude oil and refined products. In turn, possession of a guarantee is the qualification for receiving a fee-exempt import allowance. Both guarantees and fee-exempt import allowances would be bought and sold. Importers of oil would choose the cheaper way of importing between paying the fee and acquiring a fee-exempt import allowance. Under the Oil Security System the information on guarantees would at all times permit the government to maintain a detailed plan specifying where oil would come from and when it would be supplied in an emergency. In most situations, substituting an Oil Security System for an alternative import policy would both reduce the cost of importing oil and increase oil security in the form of emergency oil supplies. (Author)

An overview of the OPEC oil price increases is discussed after a memorandum presented by Chairman Jackson. That governmental policy responses may be counterproductive is a view presented. A discussion on implications for global governmental policy formulation precedes eight tables presenting information on Persian Gulf crude oil prices, revenues from oil exports, oil revenue picture for 11 OPEC members, net trade balances, selected countries, 1972-73, selected countries, value of oil imports; total oil revenues available to producing governments and assumed potential use of funds, 1974; international financial liquidity, selected nations, 1971-73; and oil price rise impact for selected developing countries. Five papers are presented in the Appendices on implications of exploding world oil costs, the economic consequences of the high cost of imported oil; oil and the world business cycle; energy shock and the development prospects; and the foreign-exchange market developments. (MCW)

In the U. S., there is a bill before the Senate that would establish emergency reserves of petroleum to sustain the country for at least 90 days. Storage of such reserves would be costly. If salt domes were leased to provide capacity for storing petroleum for a 90-day requirement, each facility would be about 8 million barrels, pipelines another 5 million, and the cost of the oil unknown. The arrival of large tankers involves the construction of superports to accommodate them. The proposed Texas superport will include a tank farm that will cover 100 acres. The site of the proposed superport in Louisiana is in the middle of a large field of salt domes. The import situation is discussed and recommendations to alleviate the worsening situation are listed. (MCW)

World crude oil production set a new record in 1973 with the production of about 55.5 million barrels/day. World production reached its monthly peak for the year in September. Even with the Middle East disturbance, Saudi Arabia showed a 6.4% increase for 1973. Regional production analyses for 1973 are shown for Canada, Europe, Communist Area, United States, Latin America, Africa, Asia-Pacific Area, and the Middle East. (MCW)

"Probably" says Andrew G. Spyrou of the Olympic Maritime, S. A. S. O. Onassis Group of Companies, Monaco, of the likelihood of the construction of the million-ton tankers. Naval architects are proceeding with designs. Experience with the quarter-tonner gives confidence that the million-tonner is feasible. The International Maritime Consultative Organization (IMCO) in dealing with pollution control has enacted that tankers over 70,000 dwt after 1980 be required to be segregated-ballast-tanked. The price for construction will be almost prohibitive says Y. Shimpo, Ishikawajima-Harima Heavy Industries Co. Ltd., Tokyo, so "unlikely", he says. Efficiency is the reason for increased size and this will be minimized due to ship cost, labor, increased insurance costs, and all facilities for building, maintenance, and mooring will be increased. (MCW)


Drilling of 50 wells on the land area north of the Akvakik arch has produced mainly gas with some light oil or condensate. Oil was discovered in fault traps along the northern edge of the arch. Offshore drilling has begun, but it appears that the oil reserves discovered to date do not meet the threshold volume necessary for an oil pipeline. It is estimated that about 15 Tcf of gas has been discovered in the Beaufort Basin and does meet the threshold volume to justify a pipeline to Alberta. The geology of the Beaufort Basin is described. Arctic Islands oil will possibly be delivered to market by pipeline by 1985 and gas by 1985. (MCW)


Plans for a safe and successful deepwater seadock in the United States are proceeding. Waterborne transportation will be the means for transporting the long-term oil-import requirements. Many seacoast areas are being considered and data are being compiled on wind, waves, currents, tidal movements, water depth, sea-bottom topography, and soil conditions; assessments of availability of maneuvering and anchoring areas and approach lanes, especially in relation to other ship traffic or other activities such as oil and gas exploration and production; studies of possible impacts on the environment, and economy of the regions. (MCW)

1974


If the U.S. Geological Survey is right, the U.S. is at least a decade away from seriously depleting its domestic oil and gas resources. But if several distinguished believers are right, the U.S. is running out of oil and gas right now.

EXPERTS VIEW IMPROVED RECOVERY STATUS. Bleakley, W. B. Oil Gas J.; 72: No. 10, 86-86; 90(1 Mar 1974). Estimates are made that improved oil-recovery methods must account for 1/4 to 1/2 of the U.S. future oil production. Six oil men participated in a panel discussion on how to reach that goal facing major and independent oil companies. Special significance was given to tertiary oil recovery. (MCW)

US Energy Outlook – Oil and Gas Availability (National Petroleum Council, 1625 K Street NW, Washington DC 20006; $ 25-00, 768 pp). Background data, methodology and assumptions used in preparing the complete report are here described in detail, including the computer program used to analyse impacts of variables in future production. It constitutes a reference volume of data and projections on petroleum and natural gas production.
A Survey of the Economic and Environmental Aspects of an
Onshore Deepwater Port at Galveston, Texas. Part I. Potential
Economic Effects.
Daniel M. Bragg.
Texas A and M Univ., College Station. Apr 74, 58p
TAMU-SG-74-213, NOAA-74050701
COM-74-11030/SWE PC56.00/MFS1.45

In summarizing the study, the author indicates that it cannot
be shown absolutely that an offshore terminal would have a
cost advantage over a terminal located onshore. For this
reason, cost in itself cannot be the sole determining factor in
deciding the feasibility of the onshore deepwater terminal at
Galveston. The economic impact of an onshore deepwater ter-
minoal at Galveston will be somewhat greater, throughout the
region, than will the impact from an offshore oil terminal. In
addition to the impact which could result from growth in oil
refining, and supporting industry, the onshore port will have
an impact of additional jobs and expenditures resulting from
the operation of the port. Such things as tug hire, stevedoring,
line handling and similar, port-related activities, will be of a
greater magnitude than they would be at an offshore terminal.

"U.S. Congress. Senate. Committee on Banking, Housing and Urban
Affairs. PETROLEUM PRODUCT SHORTAGES. HEARINGS, Ninety-third
Congress, First Session, on the Impact of Petroleum Product
Hearings held May 7-11, 1973."
AICHe Symposium Series, v.69, no.127  1973

DECLINING DOMESTIC RESERVES - EFFECT ON PETROLEUM AND PETROCHEMICAL INDUSTRY. C.H. Cummings, ed.
(Contains papers presented at the 71st National Meeting of AICHe, Dallas, (Tex., 1973)).

American Inst. of Chemical Engineers

L-5-1-74

Record of conference papers. 20th Annual
233 p. illus. 28 cm.
Catalogue no. 73CH0769-01A.

AICHe Symposium Series, v.69, no.135  1973

(Contains abstracts of papers presented at the Seventy-fourth National Meeting of the AICHe in New Orleans this year).

American Inst. of Chemical Engineers

Sec.I. Economic area.
Sec.II. Process technology area.
Sec.III. Marketing area.
Sec.IV. Plant operations area.

L-3-18-74

Ahern, William R
Oil and the outer coastal shelf; the Georges Bank Case [by] William R. Ahern, Jr.
xiv, 133 p. illus. 24 cm.
HOW MUCH OIL IS LEFT?
H.R. Warman.

World oil production will reach a peak at some point in the next decade and will thereafter slowly decline. The prospect that non-conventional sources of oil will quickly provide alternative supplies is slight.

GROWING DRIVE TO TAP VAST U.S. FUEL RESERVES.

A White House plan, just unveiled, stresses what oil and gas men have been saying for years - given incentive, U.S. industry can find more fuel.

SUPERSHIP ERA AHEAD?
J.H. Prescott.

The expanding energy crisis means that the U.S. will have to import lots more crude oil. Deep water ports that can accommodate supertankers are one way to cut transportation costs. Such ports could also serve as terminals for dry dock cargoes.

HOW TO REACH THAT NORTH SLOPE OIL: SOME ALTERNATIVES AND THEIR ECONOMICS.
R.A. Rice.

CONTINENTAL DRIFT AND RESERVES OF OIL AND NATURAL GAS.
D.H. Tarling.

THE CHALLENGE OF NORTH-SEA OIL.
W.L. Morse.

THE CASE FOR DEEPWATER PORTS. M.W. Fleck.
THE PERSIAN GULF: US ROLE IN A STRUGGLE FOR OIL.


PETROLEUM POLITICS AND THE MIDDLE EAST.

J. Maddox.

THE WRONG ROUTE. C. J. Cicchetti.

The oil pipeline across Alaska was originally proposed to take advantage of oil import quotas and other regulations, which have now changed. A route across Canada would now be more profitable, even to the oil companies, and would be less damaging to the environment.

US PETROLEUM POLICY.

CONGRESS AND FEDERAL REGULATION OF THE PETROLEUM INDUSTRY. P. 227-
PRESENT US OIL PRODUCTION AND CONSUMPTION. P. 228-
THE PRINCIPAL FEDERAL AGENCIES INVOLVED. P. 230-
OIL POLICY IN THE 93RD CONGRESS. P. 232-
PROS AND CONS OF RELAXING THE PRESENT DEGREE OF FEDERAL REGULATION OF THE US OIL INDUSTRY - WOULD RELAXATION HELP OR SE THE "ENERGY CRISIS". P. 234-


An assessment was made of the onshore or secondary effects of deepwater terminal development on each of five areas (Chechias, Maine; the vicinity of Sandy Hook, New Jersey; the Delaware Bay, New Jersey; Grand Isle, Louisiana; and Freeport, Texas) selected as terminal locations. The relative suitability of each area as a terminal site is affected by the relative impacts of a terminal on the area, including the additional industrial development, production, employment, air and water pollution, land use, population changes, etc., resulting from terminal development. The terminal impacts are related to the normal cumulative effects of growth processes on various individual areas and regions in order to illustrate their apparent capacity to accommodate terminal-related growth. (NTIS)

(1973) 1973


The Appendices contain information and data pertinent to each area study. The Appendices are as follows: I. The Petrochemical Industry; II. United States Crude Oil Imports and Refining; III. Economic Methodology; IV. Environmental Methodology. (NTIS)

(1973) 1973

(1974-71867)

TITLES: Oil Refinery Capacity

Corporate Author: U.S. Senate, Committee on Interior and Insular Affairs

Publication Description: Serial No. 93-17 (92-52). Hearing pursuant to S.Res. 84, A National Fuels and Energy Policy Study, on the economic factors underlying the present shortage of refining capacity in the United States, 556 p.

Publication Date: 1973

Abstract: The hearings were held to explore the reasons for the present shortage of refining capacity in the U.S. Witnesses were asked to consider twelve questions on refinery capacity, trends in consumption and production in the U.S. and abroad, and government policies. Testimony was presented by senators and representatives of the National Petroleum Council and the Department of the Interior. Additional material received from others is included along with two publications of the National Petroleum Council. (NTIS)

(1974-71867)


Little effect will be seen for self-sufficiency before 1980, when imports are expected to reach 10 million barrels/day. There is no danger of the U.S. bidding away scarce oil. First, it has no power to do so. The American and other multinational oil companies take orders from the producing nations, no matter who owns them. Second, oil continues as before. In great potential over-supply, which the growing price—cost gap will aggregate. Price and availability of world oil unrelated to supply and demand high prices, low production, and Middle East politics irrelevant to security of price are discussed. (Note: This article was written before the Arab oil embargo). (MCW)

215
TITLE: Key Issues in Offshore Oil
AUTHOR: Devaney, J.W., III
CORPORATE AUTHOR: Massachusetts Institute of Technology, Dept. of Ocean Engineering
ADDRESS: Cambridge, MA 02139
PUBLICATION DESCRIPTION: Part of Report No. HTS8 75-7, World Energy and the Oceans, Second Annual Sea Grant Lecture and Symposium, 10 p.
PUBLICATION DATE: 1973, October 19
ABSTRACT: This paper discusses some of the aspects of offshore oil which were brought out by the Georges Bank Petroleum Study. One of the issues involved the characteristics and impact of oil spills. Surveys of existing biological data show that the toxicity of some components of oil is several orders of magnitude greater than others. With crude oil the c责rps are believed to be the soluble or light aromatics. From this detailed study of the behavior of an oil spill on the surface in the first few hours of the spill's life it appeared that oil tends to fractionate on the surface. Often this occurrence takes the form of a central "glob" surrounded by a "film." The glob contains approximately 90-94 percent of the oil and spreads much slower than the film, which occupies much more area than the glob. It is suspected that the film contains the highly soluble, highly toxic compounds, and therefore all have the most biological impact. From the viewpoints of recreational amenities, toxics, and shorefront property values, the glob is the important factor.
This study was also meant to prove that current refinery wastewater treatment methods do nothing toward eliminating the biologically critical components of oil, as these methods depend on gravity separation. The economic analyses of the Georges Bank study brought out that offshore petroleum can be cheap and that the less in real-national income associated with not exploiting domestic offshore resources quite sizable. Having a large reserve of stored oil would give the US a better bargaining position in the international markets. The author proposes that compensation plans for the locations where offshore oil production takes place and which would be environmentally disbenefited could be worked out. (SCN)

The economics of storing crude oil offshore in cavities created by nuclear explosions are discussed. (no refs.)

N73-16948/ J Delawer Bay Oil Transport Committee, Dover. ENERGY OIL, AND THE STATE OF DELAWARE. A PROPOSAL FOR SAFEGUARDING THE DELAWARE ESTUARY AND COASTLINE BY SAFER TRANSPORT OF OIL
15 Jan. 1973 61 p refs
Avail: NTIS HC $5.25
The pollution hazards of petroleum industries and shipping in the Delaware Bay are considered. Petroleum refineries on the Delaware River, Delaware River traffic, lightering operations in the lower bay, cleanup responsibility of spilled oil, oil imports, and world crude oil transportation are discussed along with alternative petroleum transport systems. Recommendations for the increased protection from spills are included. F.O.S.

N73-19981/ U National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIR-CUSHION TANKERS FOR ALASKAN NORTH SLOPE OIL
NASA-TM-2683: E-7210) Avail: NTIS HC $3.00 C5CL 01C
A concept is described for transporting oil from the Arctic to southern markets in 10,000-ton, chemically fueled air-cushion vehicles (ACVs) configured as tankers. Based on preliminary cost estimates the conceptual ACV tanker system as tailored to the transportation of Alaskan North Slope oil could deliver the oil for about the same price per barrel as the proposed trans-Alaska pipeline with only one-third of the capital investment. The report includes the description of the conceptual system and its operation: preliminary cost estimates: an appraisal of ACV tanker development; and a comparison of system costs, versatility, vulnerability, and ecological effect with those of the trans-Alaska pipeline.

N74-18676/ RAND Corp. Santa Monica, Calif.
THE SOVIET UNION, THE MIDDLE EAST, AND THE EVOLVING WORLD ENERGY SITUATION
(P-5109) Avail: NTIS HC $3.00
The U.S.S.R.'s position on the world oil crisis is discussed with special attention given to the limits of Soviet influence in global politics and a Soviet-preferred future world energy scenario. K.M.M.

Between 1973 and 1985, an adequate petroleum supply will be the hinge or fate for the U.S. economy. In reviewing a brief history of the oil exports of the Arab states in the last few years, it is seen that the U.S. must develop new oil sources, construct refineries within its continental borders, and establish conservation policies that will mitigate the coming crunch. The dependency of countries on the oil exports from the Middle East may be used as a weapon or club, as has been observed in Italy. In the U.S., since oil will be the predominant energy fuel during the next 12 years (the only fuel capable of meeting our escalating energy requirements), the potentially adverse effects of Middle East manipulation of the oil flow on the balance-of-payments deficit are staggering. A National Petroleum Council summary lists three options; the U.S. could depend upon increased overseas import of oil and gas to meet national requirements but this would impair national security and trigger an awesome deficit in our balance of trade in fuels; through imposed restrictions, the U.S. could reduce the growth in energy consumption and demand more efficient use of energy, impairing the nation's lifestyle and triggering an even larger deficit in its balance of trade in fuels; the U.S. can accelerate the development of its domestic energy resources and this is strongly recommended. (MCW)


An outline of the world petroleum situation as it relates to the United States is presented. The various geographical areas where petroleum is found are examined with emphasis on the longevity of the sources as well as how political situations affect the accessibility of the sources. The need for replacing inaccessible sources by alternate sources and synthetic processes is examined. S.K.W.


The current and projected United States petroleum and natural gas requirements through 1980 are examined. These two resources account for three-fourths of all the energy consumed in the United States. The unprecedented rate at which they are being consumed has caused an imbalance between demand and supply and presents the Nation with an energy problem of serious and growing proportions. Domestic production is now unable to supply the needs of some consumer sectors and shortages of certain fuels exist. During the next three to five years, a further deterioration of the domestic supply position is anticipated and a sharp increase in imports is projected. The long lead times required to provide new domestic supplies make this development virtually certain. The United States also faces a serious balance of trade deficit as a result of our growing need for imports. In short, our petroleum position will become more severe in the longer term if present trends and policies continue.

Author (GRA)
A Review of the Present, and Announced Future, Capabilities for Commercial Oil Recovery Beyond the 656-Foot Isobath.
L. C. Leopold.
State Univ. of New York, Stony Brook. Marine Sciences
Research Center. 1973, 8p NOAA-74020701-6 Included in
Marine Affairs Jnl., n1 p91-97, Dec 73.
COM-74-10584-06/WN (Order as COM-74-10584)

This is a brief look at the commitment of the oil industry to
deep, offshore exploitation. It is assumed that a significant
way to gauge its expectations of deep, greater than 656 feet, recovery is to look at the actual capabilities and the expansion of
attendant technologies. There are two portions to this
paper. The first is a tabulation inventory of drilling rigs. The
inventory data for 1969, 1970, 1971, and 1972 are presented in
tables 1, 2, 3, and 4, respectively. The second part of the paper
is a synthesis of specific reports. Each helps to define what
the developed capabilities for, and commitments to, commercial oil recovery at depths greater than 656 feet are.

WORLD ENERGY MODELLING: THE DEVELOPMENT
OF WESTERN EUROPEAN OIL PRICES. Dean, R. J.; Laughton,
W. A.; Hale, J. G.; Isaac, J. R.; Leather, J.; O’Carroll, F. M.;
Ward, P. C. (Queen Mary Coll., London). Energy Policy; 1:
No. 1, 21-34(Jun 1973)

A computer model is being constructed to cover the whole international energy industry. Results confirm that the concepts and
assumptions being used in building the World Energy Model are
applicable to the real world. The short-term behavior of oil
product prices in Europe over the past six years has been con-
sistent with the hypothesis of free competition acting on the
kind of marginal cost structure assumed in the model. Long-
term average relationships between oil product prices agree
with the implications of a simplified version of the model's repre-
sentation of refining economics. Work now in progress is
steadily improving the breadth of coverage and degree of detail
of the results that can be obtained. (DLC)

OFFSHORE DEEPWATER CRUDE-OIL TERMINALS.
Mascenik J. (Esso Research and Engineering Co., Linden, N.J.
Combustion; 45: No. 4, 7-14Oct 1973).

Offshore deepwater crude-oil terminals appear to have favorable
economic-benefit/cost ratios, and would possibly have the least
impact on the ecology of a region. Single-point mooring (SPM) has
been found particularly attractive for mooring very large crude
carriers (VLCC) in moderate to severe sea and wind conditions.
A new cluster concept is outlined along with the oil industry's
effort to make SPMs more reliable. Multi-locus moorings (MIMs) are
used at marketing, refining, and crude-loading terminals through-
out the world. SPMs are being used increasingly throughout
the world at crude-loading and receiving terminals, especially since
the advent of the VLCC. Single-point moorings are very common
for mooring VLCCs. The types in use are the catenary anchor-leg
mooring (CALM), the single anchor-leg mooring (SALM); SPM
tower with rotating trussed arm (Brega, Libya), and SPM tower
with floating hose (Fluminco and Genoa, Italy). (MCW)

1971 Petroleum Supply and Demand In the Non-Communist
World.
Office of Oil and Gas, Washington, D.C. Mar 73, 37p
PB-227 793/7WN PC$5.00/MFS1.45

This booklet contains a summary of 1971 petroleum data col-
clected from many sources, analyzed by the Economics and
Coordination group of Programs and Analysis Division of the
U.S. Office of Oil and Gas, and compiled in ready-reference
handbook form. It is believed that this summary presents as
realistic a portrayal of 1971 Non-Communist World petroleum
supply and demand as can be obtained.

74-16687# Army War Coll., Carlisle Barracks, Pa.
THE US ENERGY CRISIS, THE MULTINATIONAL OIL
CORPORATIONS AND THEIR RELATIONSHIP TO U.S.
FOREIGN POLICY IN THE MIDDLE EAST
John G. Pappageorge 28 Feb 1973 59 p refs
(AO-76088) Avail. NTIS CSCL 06/3

America's current energy crisis consists of a growing
dependence on foreign oil brought about by a continuing
diminution in known domestic petroleum reserves and aggravated
by a host of domestic anomalies that cry out for some sort of
unified energy policy. Yet any steps taken domestically will have
far reaching international effects, particularly in the Middle East.
Eight giant corporations (five of them American) discover and
pump most of the oil out of the ground in the producing countries.
Hence, they have a powerful influence in the Middle East and
are a contributing factor in the stability of that politically volatile
part of the world.

Modified author abstract (GRA)

The historical development of the Mandatory Oil Import Quota Program is reviewed, and the manner in which it functions is described. Several analyses made during and shortly after the Cabinet Task Force Report are reviewed, and these are updated to reflect changing market conditions. Finally, the equity and efficiency aspects of the program are analyzed in the context of the objectives and alternative means of achieving those objectives are considered. (NCW)


In the late 20th century and up until the 1980's, the new uses for petroleum kept supply vs demand or consumption essentially balanced. The balance was destroyed when oil was discovered in East Texas, and the increased supply gave birth to a new technological era. Conservation or the prevention of physical and economic waste was a prelude to understanding reservoir mechanics and to the great push to optimize production economics. Conservation, well logging, secondary recovery including waterflooding and pressure maintenance by water or gas injection, numerical analyses of such parameters as costs or offshore risks, drilling and completion, offshore drilling, and economics are discussed. (NCW)

CH-129,601, Nos.580 & 579

American Chemical Society
American Chemical Society Radio Series 580
American Chemical Society Radio Series 579

Petroleum
Water pollution - Oil

(Ordered for E.E. Hanes
May '73 - No order number).
L-5-28-73 L96, 175


Examine the evidence concerning the future availability of oil. Both conventional crude oil and "non-conventional" oil are considered but the emphasis is on conventional crude oil. (no refs.)
TITLE: Capital Needs Join Supply as A Major Industry Concern
CORPORATE AUTHOR: World Oil, Gulf Publishing Co.
ADDRESS: Box 2508, Houston, TX 77001
PUBLICATION DESCRIPTION: World Oil, 177, 63-64
PUBLICATION DATE: 1973, August
ABSTRACT: A major problem in the petroleum industry is beginning to be sufficient capital to finance additional exploration. Detailed tables are given for 1971, 1972, and estimated 1973 of world petroleum demand and supply, world crude oil production and producing fields, forecast of world drilling in 1973, and estimated proved world reserves of crude oil and natural gas. (JNC)

The NTISbib bibliography contains 25 selected abstracts of research reports retrieved using the NTIS on-line search system - NTISearch. The abstracts are primarily concerned with the environmental effects from offshore drilling. (GRA)

ENERGY REPORT/OIL IMPORT NEEDS VERSUS ENVIRONMENTAL COSTS KEY ISSUE IN DEEP WATER PORTS LEGISLATION.
J.A. Nowe.

THE US SUPERPORT CONTROVERSY.
H.S. Marcus.
The trend to ever larger vessels is inexorable National interest argues powerfully for building facilities to accommodate the largest of them.
CORPORATE AUTHOR: Massachusetts Institute of Technology, Offshore Oil Task Group
ADDRESS: Cambridge, MA 02139
PUBLICATION DATE: 1973, February 1
SPONSOR: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Sea Grant Program; New England River Basins Commission; New England Regional Commission; National Science Foundation; RANN Program

ABSTRACT: This is Volume I of a three part report studying the implications of a petroleum development on the New England continental shelf. The impact on regional income is treated in this volume, but the authors advise reading both volumes as certain conclusions drawn in one volume depend upon results developed in the other. Chapter one gives an introduction to regional income analysis and defines the scope of the study and some particular implications that are not covered. Other chapter titles are Simulation of Petroleum Development Hypotheses: The Response of Regional Products Prices to Changes in Cost; Treadmill of Private and Public Profits: The Impact on Regional Income of Employment Effects Associated with the Hypothetical Developments; Impact on Regional Income of the Georges Bank Fishery - Georges Bank Petroleum Conflict: Regional Income Impact of Nearshore Spills; and Results of Simulations. (KCM)

CORPORATE AUTHOR: Massachusetts Institute of Technology, Offshore Oil Task Group
ADDRESS: Cambridge, MA 02139
PUBLICATION DATE: 1973, February 1
SPONSOR: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Sea Grant Program; New England River Basins Commission; New England Regional Commission; National Science Foundation; RANN Program

ABSTRACT: This is the second volume of a three volume study of the impact on New England of a range of possible changes in the region's petroleum production, crude processing and products distribution system including a spectrum of hypothetical petroleum discoveries on the Georges Bank. Volume II concentrates on the impact on regional environmental quality. The authors emphasize that neither Volume I nor Volume II can be read independently of the other and in particular much of the analysis of Volume II depends on the results of Chapters 1 and 6 of Volume I. (Author, Foreword modified)
N74-16656 Texas Univ., Austin. College of Social and Behavioral Sciences.

BALANCING THE DEMAND AND SUPPLY OF OIL
James W. McKee /n Denver Univ. Balancing Supply and Demand for Energy in the US 1972 p 73-90 refs (For availability see N74-16651 07-34).

The economic factors which influence the supply and demand of crude oil in the U.S. are discussed. Estimates are made of the projected availability of petroleum from domestic sources through the year 1980. The availability of petroleum supplies based on the predictions of exploration and development is analyzed. Tables of data are provided to show the following: (1) projections of the oil supply-demand balance from 1980 to 1985, and (2) estimates of domestic U.S. production in 1975, 1980, and 1985. The need for a Federal energy policy is stressed and approaches to such a policy are submitted. Author

N74-16681 Texas Univ., Austin.

ENVIRONMENTAL PROTECTION AND LONG RUN SUPPLY OF CRUDE OIL IN THE UNITED STATES

A study was conducted to determine the effects of energy conversion on the environment. The effects of various types of energy sources were examined and examples of legislation to reduce environmental pollution are presented.

N74-19228 Environmental Protection Agency, Research Triangle Park, N.C. Air Pollution Technical Information Center.

AIR POLLUTION ASPECTS OF EMISSION SOURCES: PETROLEUM REFINERIES: A BIBLIOGRAPHY WITH ABSTRACTS
Jul. 1972 73 p refs (AP-110) Avail.: SOD HC $1.25

Selected abstracts are presented of articles concerning air pollution by petroleum refineries. Subject and author indexes are included. Author

N74-16656 Massachusetts Inst. of Tech., Cambridge. Dept. of Economics.

LONG RUN COST TRENDS: PERSIAN GULF AND UNITED STATES

The production costs of crude oil and natural gas in the U.S. are compared with those for the Persian Gulf nations. A theory of petroleum production costs is presented to show the relationship between production, development, and exploration of petroleum supplies. The effect of changing sources of reserves on the development costs of new petroleum resources is analyzed. The expected supply from the North Shore Alaska petroleum field is reported. Tables of data are included to show the following: (1) development investment in Persian Gulf petroleum, (2) cost projection of Persian Gulf resources from 1965 to 1969, (3) exploration activity and expenditures in North American petroleum development from 1955 to 1970, and (4) significant discoveries of oil and gas from 1945 to 1964. Author

TITL: Oil Prices and Phase II
CORPORATE AUTHOR: U.S. Congress, Joint Economic Committee
PUBLICATION DATE: 1972, January
ABSTRACT: While the consumer costs of Federal oil policy have grown and grown, there is serious question whether Federal policies are at all effective in meeting their price objective of providing secure and readily available domestic sources of energy for our future use. The importance of wise development and conservation of our energy resources as well as the necessity of fighting inflation make it urgent that we reconsider Federal oil policies. These hearings have been called with the purpose of identifying those possibilities for policy change which would contribute most to an effective anti-inflation effort consistent with encouraging the development of our energy resources. (From Introduction by Sen. E. Farnsley)
1972

Army Corps of Engineers
Inst. for Water Resources
Defense Documentation Center
Defense Documentation Center
Contract DACW31-71-C-0045

Ports, Deepwater
Economics
Petroleum industry 188,869

1972

Army Corps of Engineers
Inst. for Water Resources
Defense Documentation Center
Contract DACW31-71-C-0045

Ports, Deepwater
Environment
Ecology
L-3-21-73

1972

Army Corps of Engineers
Inst. for Water Resources
Defense Documentation Center
Contract DACW31-71-C-0045

Ports, Deepwater
Economics
Ecology
L-4-12-73

1972

Army Corps of Engineers
Inst. for Water Resources
Defense Documentation Center
Contract DACW31-71-C-0045

Ports, Deepwater
Economics
Ecology
L-88,869
L-4-12-73
CIA

1972

OFFSHORE TERMINAL SYSTEM CONCEPTS. PART I:
EVALUATION OF REQUIREMENTS AND CAPABILITIES FOR
DETERMINATION OF THE NEED FOR OFFSHORE TERMINALS.
(A Report submitted to the Dept. of Commerce).

Soros Associates, Inc.
Department of Commerce
Contract 1-35409

Ports, Deepwater
Ports, Offshore
Petroleum
L-88867
L-4-11-73
ENVIROMENTAL IMPACT STATEMENT (E) PROPOSED
TRANS-ALASKA PIPELINE - FINAL. VOLUME 1: INTRODUCTION AND SUMMARY. (Prepared by a Special

Department of the Interior
Interagency Task Force for the
Federal Task Force on Alaskan Oil Development
(Council on Environmental Quality)

Trans-Alaska Pipeline
Environment Pollution
L-3-11-73

ENVIROMENTAL IMPACT STATEMENT (E) PROPOSED

Department of the Interior
Interagency Task Force for the
Federal Task Force on Alaskan Oil Development
(Council on Environmental Quality)

Trans-Alaska Pipeline
Environment
Ecology
Oils, Petroleum
L-9-6-73
73V29908 1972 ISS:00 VC276.A3243 333.82 LC-72-603803 SSD GA
1.13:015/4
CAPABILITY OF THE NAVAL PETROLEUM AND ** OIL ** ** SHALE ** RESERVES TO MEET EMERGENCY ** OIL ** NEEDS; REPORT TO THE CONGRESS (ON THE) DEPARTMENT OF THE NAVY (AND THE) DEPARTMENT OF THE INTERIOR BY THE COMPTROLLER GENERAL OF THE UNITED STATES.
UNITED STATES. GENERAL ACCOUNTING OFFICE.
WASHINGTON; 58 P. ILLU. 27 CM.
$1.00 COVER TITLE. PUBLICATION DATE STAMPED ON T.P. "B-66927."
LC:UNITED STATES. -- NAVY -- FUEL. PETROLEUM -- UNITED STATES.
ADDED:INTERNATIONAL TRADE,
MAIN-CORP TRACE-TITL* CATLG BY-LOC

TYPE 72N72752/2
72N72752 BMRI-7500 71/04/00 15 PAGES UNCLASSIFIED DOCUMENT
PREDICTION OF OIL- AND GAS-BEARING ROCK FRACTURES FROM SURFACE STRUCTURAL FEATURES
A. OVERBEY, W. K., JR.; B. ROUGH, R. L.
Bureau of Mines, Washington, D.C.
*CRUDE OIL*GEOLoGY*/NATURAL GAS/SURFACE PROPERTIES/* EARTH RESOURCES/FRACTURES (MATERIALS)/PREDICTIONS
The Supply of Natural Gas

The shortage of natural gas in the United States has grown rapidly in the last two or three years. By now, it probably exceeds ten per cent of total demands. This is not a result of a shifting of demands to natural gas due to the Arab oil embargo. Rather, it is a continuous and systematic long-term shortage, and there is every reason to believe that it will not be eased appreciably in the remaining years of this decade under the prevailing Federal Power Commission price controls—even if the F.P.C. were to continue its recent policies of raising the price an average of three or four cents per thousand cubic feet on new contracts each year. If great pressure is put upon gas demands as a result of oil price increases beyond $6.00 per barrel, excess demand is likely to expand to more than a quarter of total demand in the next few years.
The Gas Supplies of Interstate Natural Gas Pipeline Companies, 1972.
PB-232 685/8WE: PCS 3.25/MFS 1.45
The report is a summary of the gas supplies of interstate natural gas pipeline companies for the calendar year 1972. This report is based on data in the recently revised Form 15 reports for the year 1972, which were required to be filed by December 31, 1973. It provides a brief summary of the end of the year total reserves and five year deliverability projections.

NATURAL GAS LEGISLATION. Ogden, W. J. Pub.
Natural gas reserves are quite substantial, but the development of supplies has declined over the last few years. The pricing policy has been a significant factor, and revision of the regulated pricing is necessary. The legislative proposals considered essential are enumerated. Then the considerations for opposition to deregulation of producer prices are discussed. Some other proposals include the establishment of a national exploration and development company, incremental pricing, and the use of natural gas pipelines as common carriers. (MCW)

OIL AND GAS RESOURCES: DID USGS GUSH TOO HIGH?
R. Gillette.
If the U.S. Geological Survey is right, the U.S. is at least a decade away from seriously depleting its domestic oil and gas resources. But if several distinguished disbelievers are right, the U.S. is running out of oil and gas right now.

The Role of Gas in a National Energy Policy (IIT Center, Chicago, Illinois 60616, 48 pp). The Institute of Gas Technology's 32nd Annual Meeting of Members and Board of Trustees presented a round table discussion on this topic and the publication is a transcript of that discussion, including an address by the Hon Joseph C. Swidler, Chairman, State of New York Public Service Commission and formerly Chairman of the Federal Power Commission on 'Energy supply in the years ahead'.

US Energy Outlook – Oil and Gas Availability (National Petroleum Council, 1625 K Street NW, Washington DC 20006, $ 25-00, 768 pp). Background data, methodology and assumptions used in preparing the complete report are here described in detail, including the computer program used to analyse impacts of variables in future production. It constitutes a reference volume of data and projections on petroleum and natural gas production.

US Energy Outlook – Gas Transportation (National Petroleum Council, 1625 K Street NW, Washington DC 20006, USA, $ 12-00). This volume, prepared by the Gas Transportation Task Group, examines the capital costs of transporting, processing and storing natural, liquefied natural, substitute natural and liquefied petroleum gas for the 1971-1985 period. The report discusses in detail the methodology and data used.
AICHE Symposium Series, v.69, no.127  1973

DECLINING DOMESTIC RESERVES - EFFECT ON PETROLEUM AND PETROCHEMICAL INDUSTRY. C.E. Cummings, ed. (Contains papers presented at the 1st National Meeting of AICHE, Dallas, (Tex., 1973)).

AN ANALYSIS OF NUCLEAR GAS STIMULATION. .......................... G. C. Werth, B. Rubin, L. Schwartz, and D. Montan 45
PROJECT RULISON—SUMMARY OF RESULTS AND ANALYSIS .............. Miles Reynolds, Jr. 47
PROJECT WAGON WHEEL: NUCLEAR EXPLOSIVE STIMULATION OF A NATURAL GAS WELL ............................ Leo A. Rogers 49
TECHNOLOGY AND ECONOMICS OF TRANSPORTING AND STORING LNG ............................................. Paul C. Johnson 67

1973

NATURAL GAS DISCUSSION: Transcript of a November 1973 round table discussion presented at the annual meeting of the Institute of Gas Technology. 47 pages. (The Role of Gas in a National Energy Policy, available without charge from IGT, 3424 S. State St., Chicago, Ill. 60616.)

1973

TITLE: Alternative Regulatory Policies for Dealing with the Natural Gas Shortage
AUTHOR: Mackroy, P.W.; Pidgyn, R.S.
CORPORATE AUTHOR: Massachusetts Institute of Technology, Sloan School of Management
ADDRESS: Cambridge, MA 02139
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BANN Program
ABSTRACT: This report is an analysis of the effects of low wellhead ceiling prices and alternative regulatory policies on the production, development of reserves, and pricing of natural gas for the rest of this decade. Gas discovery procedures, reserve accumulations, production from reserves, pipeline price increases, and production demand are explained by an econometric model. Results are given from the computer simulation of this model using the various alternative policy assumptions. (QCR)
AVAILABILITY: NIES, PB 220 007 ($4.00 paper copy/$1.45 microfiche)
TITLE: Natural Gas Is A Beautiful Thing
AUTHOR: Wilson, R.
CONTRIBUTED AUTHOR: Harvard University
PUBLICATION DESCRIPTION: Bulletin of the Atomic Scientists, 24(7), 33-40, 23 references
PUBLICATION DATE: 1973, September
ABSTRACT: The hazards of natural gas are reviewed, including air pollution from nitrogen oxides, pipeline and storage tank explosions, asphyxiation, and liquefied natural gas spills. The author feels that regulations to control the hazards are inadequate. Safety studies should be continued and expanded to cover large LNG spills, and data must be published in the open literature. Importation of LNG should be internationally regulated. (RPG)

ENERGY YEAR: 1973. Woodr, W. P. Pub. Util. Forts.: 92: No. 9, 17-19, 25 Oct 1973. The energy crisis was not a 1973 phenomenon for the gas industry. The greatest threat in the industry's history was underway four years ago as the U. S. has been using twice as much gas as has been found. Geologists expect deposits of natural gas to be found under the far west areas bordering the U. S. coastline. Other than the proved and potential resource in Alaska, a potential resource is located in relatively impermeable rock formations in the western U. S. Experiments in nuclear fracturing to reach this gas are progressing. A major new source of gas may be developed from coal gasification. Other sources of new gas could be through the importation of liquefied natural gas and through the utilization of light hydrocarbons and crude oil feedstock for synthetic natural gas manufacture. (MCW)

DECONTROL: END OF A NOBLE EXPERIMENT,
Moody, R. Jr. Pub. Util. Forts.: 92: No. 5, 20-23(28 Oct 1973). The wellhead price regulation of natural gas that has lingered for 19 years is discussed. Congressional reluctance to come to grips with natural gas regulation is becoming more disheartening. The level of service by pipelines is still dropping and the end is not in sight. The D. C. circuit court is evidently concluding that the Natural Gas Act does not permit the Federal Power Commission any power over producer rate matters. Commissioners have sought to make the producer regulation controls workable. Policy makers denounce any consideration of deregulation pointing out falsely that it is a gas industry proposal. The 5th circuit court of appeals states, "FPSC has the statutory duty, not only to guard the consumers against super profits reaped from artificially inflated rates, but also to protect consumer interests by making sure that the rate schedule is high enough to elicit an adequate supply." (MCW)

GAS SUPPLY SITUATION. Pub. Util. Forts.: 92: No. 5, 63-72(23 Oct 1973). Some questions regarding the natural gas supply situations were presented to 14 executives of the gas industry. The accent in the coming year will be on fuel efficiency, but the dominating concerns of the executives have been in the areas of price, supply, rates, and income. The question on supply was: "What are your views about the outlook for improving the industry's natural gas supply for public distribution in the light of alternatives being suggested under pressure of the energy crisis, such as production incentives, foreign and domestic, FPC deregulation, additional curtailments and conservation measures, and the outcome of research and development in such areas as synthetic fuel and other substitutes?" Each executive presented his views. (MCW)

GAS SHORTAGE. Tybout, R. A. (Ohio State Univ., Columbus). Pub. Util. Forts.: 91: No. 12, 24-29 (7 Jun 1973). Natural gas regulation is entering a phase in which traditional concepts of rate adjustment appear inadequate. The evidence for this view is the Federal Power Commission's projection of an increasing long-term gap between demand and supply of natural gas. Although possessed of traditional rate-making authority, FPC appears unable to establish market clearing prices and is planning instead to rely on rationing over the next two decades. The prospect is unprecedented and calls for a basic reconsideration of public policy. (auth)
THE GAS SUPPLY SITUATION IN THE UNITED STATES.
G.K. Zareski.
Air Pollution Control Assoc. J., v.23, no.42,

PROBLEM OF INCREASING GAS RATES. Pub. UTIL.

The executives of the gas industry answered a question on the
"Assuming that higher-priced offshore supply as well as imports
of natural gas and oil will be increasingly important factors in
sustaining the public service supply available to customers of both
the gas and electric utilities in the United States, what are your
views either as to rolling in such increases into the prevailing
rate structures subject to state and federal regulation, or other-
wise accommodating them in the rate structure and overall rev-
enue requirements?" Each executive presented his views. (MCW)
LNG: Water Explosions.
D. L. Katz.
National Academy of Sciences Washington D C Mar 73,
63p USCG-D-60-74
AD-775 005/2WE  PC$3.75/MF$1.45

The report directs attention to a proposed solution of a puzzling problem that has been a cause of concern in the shipment of liquefied natural gas—a type of flameless explosion encountered under certain conditions when liquefied natural gas is spilled into water. The report suggests further research to improve understanding of the phenomenon.

Liquified Natural Gas Technology.
National Bureau of Standards, Boulder, Colo. Cryogenic Data Center. 5 Oct 73. 54p B-1075
COM-74-10324/3W6  PCS$7.00/MF$7.00; Foreign
PCS$9.50/MF$9.50

The report contains a bibliography of the applications, storage, handling, production, economics, and safety engineering relative to liquefied natural gas.

MIXED REFRIGERANT CASCADE CYCLES FOR LNG.

Examples of the analysis of the thermodynamic irreversibilities of several mixed refrigerant cycles were presented. Accurate vapor-liquid equilibrium and thermodynamic calculations for mixtures are required for the successful process design of mixed refrigerant cycles having cooling curves with close temperature approaches, which the analysis of thermodynamic irreversibility shows is necessary to obtain optimum cycle efficiency. The lower first cost of the erected plant, which results from the ability to utilize fewer, larger pieces of equipment makes this approach to LNG production advantageous. Another advantage is that the refrigerant consists of components normally found in natural gas plus nitrogen from the atmosphere that results in a plant self-sufficient with regard to refrigerants. (MCW)


Major gas deposits that might be exploitable exist in three Rocky Mountain regions. Approximate total gas reserves is estimated to be about 500 trillion cubic feet. Nuclear explosive fracturing, and massive hydraulic fracturing are discussed as possible extraction techniques. Controlling geological and engineering factors critical to the success of both methods, capital and logistics requirements for hypothetical development schedules, and estimated gas supplies for these hypothetical development schedules are reviewed and summarized (100 refs.)

Plowshare Technology Assessment. Material Resources Analysis.
Paul A. Bell, and Glenn A. Whan.
Western Interstate Nuclear Board, Lakewood, Colo. Jan 73, 34p
PB-231 038/1WN PCS4.75/MFS1.45

The supply of special nuclear material for nuclear explosives might prove to be a limiting factor in the commercial implementation of nuclear stimulation of natural gas. The report presents an analysis of energy and material resources for nuclear gas stimulation, and discusses some of the factors which might influence the successful application of this technology.

Plowshare Technology Assessment. Public Participation (With Reference to Nuclear Stimulation of Natural Gas).
Fikry S. Gahin.
Western Interstate Nuclear Board, Lakewood, Colo. Jan 73, 124p NSF-RA-G-73-020
PB-231 047/SWE PCS9.25/MFS1.45

The report presents several aspects of Nuclear Stimulation of Natural Gas including risk analysis of ground motions and radiation risk, impact of local communities, legal and statutory problems, insurance and government indemnity, dissemination of public information and public participation methods in the decision-making process. The report also includes a published article on 'Legal Liability and Insurance in Nuclear Stimulation of Natural Gas.'
N73-18960# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
PERFORMANCE GAINS BY USING HEATED NATURAL-GAS FUEL IN AN ANNULAR TURBOJET COMBUSTOR
(NASA-TM-X-2742; E-7236) Avail. NTIS HC $3.00 CSCL 21E
A full-scale annular turbojet combustor was tested with natural gas fuel heated from ambient temperature to 800 K (1800 F). In all tests, heating the fuel improved combustion efficiency. Two sets of gaseous fuel nozzles were tested. Combustion instabilities occurred with one set of nozzles at two conditions: one where the efficiency approached 100 percent with the heated fuel; the other where the efficiency was very poor with the unheated fuel. The second set of nozzles exhibited no combustion instability. Altitude relight tests with the second set showed that relight was improved and was achievable at essentially the same condition as blowout when the fuel temperature was 800 K (1800 F).

Author

N73-16771# National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
COMPARISON OF COMBUSTION CHARACTERISTICS OF ASTM A-1, PROPANE, AND NATURAL-GAS FUELS IN AN ANNULAR TURBOJET COMBUSTOR
(NASA-TN-D-7135; E-7079) Avail. NTIS HC $3.00 CSCL 21D
The performance of an annular turbojet combustor using natural-gas fuel is compared with that obtained using ASTM A-1 and propane fuels. Propane gas was used to simulate operation with vaporized kerosene fuels. The results obtained at severe operating conditions and altitude relight conditions show that natural gas is inferior to both ASTM A-1 and propane fuels. Combustion efficiencies were significantly lower and combustor pressures for relight were higher with natural-gas fuel than with the other fuels. The inferior performance of natural gas is shown to be caused by the chemical stability of the methane molecule.

Author

AD-225287. NATURAL GAS AS AN AUTOMOTIVE FUEL, AN EXPERIMENTAL STUDY. Report of investigations.
A study was conducted to evaluate natural gas as an automotive fuel and to provide guidelines for optimum engine adjustments for low exhaust emissions. The study was conducted using a single-cylinder engine, a multicylinder engine, and a total of eight vehicles. Low emissions can be achieved with current-design engines by adjustment of engine parameters, but only with heavy penalty to engine performance. Air-fuel ratio, ignition timing, and ambient temperature were varied. The organic emissions from engines fueled with natural gas were estimated to be 20 to 25 percent as reactive as the emissions produced using gasoline. Levels of exhaust emissions from vehicles fueled with natural gas were unchanged over 10,000 miles of normal driving. (GRA)

PB-231 842/6WN PCS3.25/MFS1.45
A staff study on the underground storage of natural gas by jurisdictional pipeline companies for the calendar year 1972, is presented. The report shows a net gain of six jurisdictional storage fields during 1972, bringing the number of jurisdictional storage fields to 194 by the end of the 1972 year. Estimated underground storage capacity amounted to 3.281 trillion cubic feet, a 1.9 percent decrease over 1971.

235
TITLE: SWG in the U.S. Energy Balance
AUTHOR: Lindan, H.R.
CORPORATE AUTHOR: Institute of Gas Technology
ADDRESS: Chicago, IL
PUBLICATION DESCRIPTION: 10 p. Reprint from Gas, 60, p. 28-33, July, and p. 61-66, August, 1973
PUBLICATION DATE: 1973, July 5
ABSTRACT: The many problems involved in the development of a large SWG industry are described. Many uncertainties exist, one of which will be the formulation of government policies and regulations. Other obstacles are the availability of feedstocks, environmental siting problems, and costs. Graphs and tables of forecasts by the Institute of Gas Technology and the Bureau of Mines are given. (JMC)
AVAILABILITY: Gas Magazine, Suite 735, R.151
Southeast Freeway, Houston, TX 77027

TITLE: Substitute Natural Gas: Processes, Equipment, Costs
AUTHOR: Pesczler, J.A.; Ireland, J.R.
ADDRESS: Pesczler, P.O. Box 86, Cathedral Station, New York, NY 10025; Ireland, 29 Bon Air Ave., New Rochelle, NY 10801
PUBLICATION DESCRIPTION: Chemical Engineering, 76(21), 44-46, 92 references
PUBLICATION DATE: 1972, October 16
ABSTRACT: Due to the increasing demand for natural gas, substitute or synthetic natural gas will have an increasingly important role in the energy picture in the future. A detailed survey is given of all the important commercial processes now in use to manufacture this fuel. A brief estimate is given of future expected costs. (JMC)
AVAILABILITY: Chemical Engineering, McGraw Hill Bldg., 1221 Avenue of the Americas, New York, NY 10020 ($2.00)

N74-18667 North Carolina State Univ., Raleigh
BALANCING THE SUPPLY AND DEMAND FOR NATURAL GAS
Edward W. Erickson and Robert M. Spann In Denver Univ. Balancing Supply and Demand for Energy in the US 1972 p 91-106 refs (For availability see N74-18651 07-34)
An analysis of the supply and demand factors involving natural gas as an energy source will be conducted. The need for a workable policy for natural gas production and use is stressed. Factors which have contributed to the lessening supply are reported. Measures for improving the situation are proposed. Tables of data are included to show: (1) predicted and actual discoveries of crude oil and natural gas from 1953 to 1987, (2) trends in well head price of natural gas compared with quantity of natural gas discoveries, (3) effects of oil and gas prices and other variables on oil and gas discoveries, and (4) projections of associated natural gas prices and required discoveries for the period of 1972 to 1985.

Analysis and Procedures Div.
NATURAL GAS AVAILABILITY: PRESENT AND FUTURE
Avail. NTIS HC $4.00
An analysis of the availability of natural gas and gas reserves in the United States is presented. The actual and projected demand for gas during the 1950 to 1980 time period is analyzed. Historical trends in natural gas production and reserve additions are illustrated. A graph of the annual demand for natural gas is plotted to show the levels of domestic productive capacity with annual reserve additions of 30, 25, and 20 trillion cubic feet.
P.N.F.

THE INTERNATIONAL ASPECTS OF IMPORTING NATURAL GAS
Robert A. Charpie in its Symp. on Energy, Resources and the Environment, Vol. 1 12 Apr. 1972 p 134-153 (For availability see N74-18582 09-34)
Importation of liquefied natural gas from Algeria to eliminate the expected natural gas shortage in the U.S.A. requires the adjustment of regulatory limitations to foreign currencies, the building of cryogenic tankers to transport liquid methane, and the building of terminal facilities in the east coast of the United States.
G.G.

TF490.A3
v.18
LNG Technology.
LNG—U. S. and Foreign Traffic—An Overview, A. Pastuhov, Gazocyan U. S. A., Inc. 1
Cryogenic Technology and Scaleup Problems of Very Large LNG Plants, J. M. Bourguet, TEAL 9
Heat Transfer Problems in Liquefied Natural Gas Plants, L. E. Dean, Phillips Petroleum Company 27

237
HIT-500) STUDY OF THE FUTURE SUPPLY OF
NATURAL GAS FOR ELECTRICAL UTILITIES. (Hittman Associates,
Inc., Columbia, MD (USA)). Feb 1972. 42p. (PB:
309-288).
The availability of natural gas as a low sulfur fuel for electrical
production was examined in light of historical usage and
availability. The goal was to ascertain not only near term but
extended demands. Projections were made through the year
2000. Such alternatives as coal and oil shale gasification, Liquid
Natural Gas (L.NG), and well stimulation were evaluated. The
use of natural gas has been and will continue to be an important
source of fuel within the United States. It represents a very
clean fuel and, as a result, a fuel that can become an important
control in the fight against pollution. Most industry spokesmen
are forecasting a gas shortage during the 1972 through 1975 time
period. The bulk of the solutions will not be available until the
latter 1970s. These include such items as LNG import, synthetic
gas production, and field stimulation. Gas power generation by
electric utilities will decline on a percentage basis due to these
shortages and will continue beyond the crisis due to high gas
prices. The overall gas consumption, however, will continue to
rise. This high consumption level will be met almost entirely
by internal production until the latter 1970s. Imports from Canada
and Mexico will yield only a small percentage of our demand. Be-
Yond this, LNG imports will play an ever-increasing role. An
attractive economic picture could yield LNG capturing 16 percent
of the United States market by 1981 and increasing during the
following years. Liquid natural gas will meet a large part of the
United States demand, but cannot continue well into the 2000s,
if gas is to continue its role, coal gasification must pick up the
slack. This process can supply sufficient gas for at least another
100 years. This process is currently under pilot-plant investiga-
tion and could be developed to full-scale capabilities in the 1980's.

(GNS-129,612
(Bureau of Natural Gas - Staff Rept. no.2).
Federal Power Commission
Bureau of Natural Gas

Gases, Natural
Power sources

(1 c. given to Mike Ellis)

1-5-31-73

1972

WHEN THE WELL RUNS DRY.
R.H. Williams
Environment, v.14, no.5, June 1972, p.19-20,
25-31.

Some of the difficulties confronting the natural-
gas policy makers are outlined. In particular,
some 'demand forecasts' and resource estimates
are examined, and various potential substitutes
for domestic natural gas are briefly reviewed.

1972

TITLE: Improving the Utilization of Natural Gas
in Major Steel Mill Applications
AUTHOR: Wembit, J.D.
CORPORATE AUTHOR: Institute of Gas Technology
ADDRESS: Chicago, IL 60616
PUBLICATION DESCRIPTION: Paper presented at the
Ft. Ohio Gas Company Seminar on Fuel
Conservation in the Steel Industry,
Cleveland, OH, April 20 1972, 25 p., 5
references
PUBLICATION DATE: 1972
SPONSOR: Consolidated Natural Gas Service Co.
Inc.; Southern California Gas Co.; American
Gas Association
ABSTRACT: A project to investigate the effects of
existing and new technology on the efficiency
of industrial gas utilization is described.
The project objectives are: identify
processes where technology for improved
utilization of natural gas can be
economically applied; study effects of
antipollution legislation on fuel usage in
industrial processes; investigate the effects on fuel usage of changes in process
technology; investigate the applicability of
existing and new technology for improved
utilization of natural gas; and recommend
process and equipment modifications and
research programs. The following processes
were selected for in-depth study: ingot
heating; slab, bloom, and billet heating; and
coil and continuous annealing processes. (ABG)

Medias-tec prospects and guidelines in the community
gas sector. Commission of the European Communities,
Brussels (Belgium). 1972 91 PAGES
ABSTRACT: ENERGY POLICY, ENERGY TECHNOLOGY, NATURAL GAS
ENERGY STORAGE, ENERGY TRANSFER, EUROPE, PIPELINES
COD 970-21060 6

Natural gas and mixtures of natural gas and hydrogen were used as fuels in a laboratory engine to determine the relationship of emissions to air-fuel ratio and to establish practical lean limits for air-fuel ratio. Synthetic gas manufactured from coal (Synthane) and natural gas were used as fuels in a vehicle to obtain comparative data on emissions and performance. Results showed that lean limits for air-fuel ratio when using hydrogen-enriched natural gas were extended significantly beyond that of natural gas. Synthane produced exhaust that was significantly less reactive than exhaust from natural gas. With lean air-fuel ratios, the acceleration performance of a vehicle fueled with Synthane was improved over its performance when fueled with natural gas.

Author

73V38743 1972 ISS:00 TN882.67G35 0-303545-02-0 338.4766570942
LC-73-131781

BRITAIN'S ** NATURAL ** GAS. **
** GAS COUNCIL (GREAT BRITAIN)
** GAS COUNCIL LONDON. (47) P. CHIEFLY ILLUS. (CHIEFLY
COL.) COL. MAPS. 30 CM.
COVER TITLE.
LC: ** GAS, ** ** NATURAL ** -- GREAT BRITAIN.
** GAS,
** NATURAL -- NORTH SEA.
ADDED:LN***** E*UK****
MAIN-CORP TRACE-TITL* CATLG BY-LC
* / / PUBL IN UNITED

73V40272 1972 ISS:00 TN880.T57 1972 0-901360-03-1 553.285
LC-73-159113

A TIRATSOO, ERIC NESHAN.
** NATURAL ** ** GAS: ** A STUDY, BY E. N. TIRATSOO.
2ND ED. SCIENTIFIC PRESS LTD. BEACONSFIELD. XVI: 400 (32) P. ILLUS.
MAPS. 26 CM.
5.50 ($18.50 U.S.) INCLUDES BIBLIOGRAPHICAL REFERENCES.
LC: ** GAS, ** ** NATURAL. **
MAIN-AUTH TRACE-TITL* CATLG BY-LC
* / / PUBL IN UNITED
74V21874 1970 ISS:00 TN295.U4 NO. 8441 622.08 $ LC-75-605729
A/ZAFFARANO, RICHARD F.
** Natural ** ** Gas ** LIQUIDS: A REVIEW OF THEIR ROLE IN THE PETROLEUM INDUSTRY; BY RICHARD F. ZAFFARANO.
U.S. BUREAU OF MINES (FOR SALE BY THE SUPT. OF DOCS., U.S. GOVT.
PRINT. OFF., WASHINGTON) 22 P. ILLUS. 27 CM.
0.35 BUREAU OF MINES. INFORMATION CIRCULAR 8441
LC: LIQUEFIED ** NATURAL ** ** GAS **
INDUSTRY. PETROLEUM INDUSTRY AND TRADE.
ADDED: UNITED STATES. BUREAU OF MINES. INFORMATION CIRCULAR 8441
MAIN-AUTH TRACE-SERS•CORP•TITL• CATLG BY-LC

74V25210 1970 ISS:00 TN880.A84 338.23 LC-72-191933
ECONOMICS OF STIMULATING ** NATURAL ** ** GAS **
RESERVOIRS WITH NUCLEAR EXPLOSIVES; REPORT.
ATOMIC INDUSTRIAL FORUM. COMMITTEE ON INDUSTRIAL PLOWSHARE APPLICATIONS.
ATOMIC INDUSTRIAL FORUM, NEW YORK, 44 P. ILLUS. 29 CM.
$3.00 INCLUDES BIBLIOGRAPHICAL REFERENCES.
LC: ** GAS: ** ** NATURAL ** -- COSTS. ** GAS **
WELLS. UNDERGROUND NUCLEAR EXPLOSIONS.
MAIN-CORP TRACE-TITL• CATLG BY-LC

TYPE 73N73283/2
73N73283 PB-184353 PH-22-68-58 PROJ. 8926 69/05/00 559 PAGES
UNCLASSIFIED DOCUMENT.
LING: A SULFUR-FREE FUEL FOR POWER GENERATION FINAL REPORT.
INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL. AVAILABLE.
• ELECTRIC POWER PLANTS• NATURAL GAS• ECOLOGY• ECONOMICS• ELECTRIC GENERATORS SOCIETY

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The United States possesses immense deposits of coal and oil shale. The combined effects of government and industry research, and the exploding prices of conventional petroleum make synthetic oil and gas within a comfortable profit margin. At a shale oil plant, the production costs are about the same as the current price of conventional oil in the USA. Government funding is not necessary, since estimated costs of a shale or gasification plant are not much higher than nuclear power plants that are being built privately. The AEC concludes that a massive synthetic fuel program cannot now be justified, but calls for a "Synthetec Fuels Pioneer Program." (auth)

Synthetic Fuels

Substitute natural gas (SNG), synthetic crude petroleum (synccrude), and methyl alcohol (methanol) can all be produced from coal and from oil shale. Studies of such processes have not been conducted on a large scale in this country until recently, because of the domestic abundance of cheap natural gas and petroleum. Intensive work on coal-based processes was carried out in Europe prior to 1945, however, and it resulted in plants which supplied Germany's wartime fuel needs. After World War II, development in Europe also stopped, because of the availability of cheap foreign crude oil.

SYNTHETIC CRUDE OIL: IS IT FEASIBLE YET?


The Athabasca tar sands contain as much oil as Saudi Arabia and from their tar synthetic crude can be prepared. Since 1967, the Great Canadian Oil Sands Company has been producing 45,000 bbls/day as a result of a $300 million investment. The other well-known oil companies are now investing in the venture in the Canadian sands. The extraction problems are discussed and GCOS is still operating at a loss, but is close to breakeven point and is planning an increase. The group of the other oil companies is producing 125,000 bbls/day and it is thought this may be justifiable. The conversion of coal is gaining momentum and the processes of liquefaction and gasification being tested by all the companies are discussed. COGAS is a venture of six oil companies and their process of developing gasification of coal from coal pyrolysis making pipeline quality gas and high-quality, low-sulfur synthetic crude is described. The process produces 27,000 bbls/day of gas, sulfur, phenols, and ammonia, all from 25,000 tons/day of coal and compares well with the most efficient Synthane-Hydrane process. The cost of synthetic natural gas made by COGAS cannot be evaluated at this time. (MCW)
A NEW LOOK AT CATALYSIS.
T. E. Fischer.

By making catalysis more of a science than an art, surface scientists can help solve the current high-priority problem of transforming fossil fuels into more usable forms.

PLANNING FOR PRODUCTION OF SYNTHETIC HYDROCARBON FUELS. Whiting, J. M. (Bank of Montreal).
Mining Congr. J.; 60: No. 2, 51-60 (Feb 1974).
From 1970 through the year 2000 it is projected that the U.S. and Canada demand will be 4420 Q Eq of energy. The continental resource availability of domestic crude oil, natural gas, coal, oil shale, and oil sands is considered. Three development programs are presented for coal gasification, oil sands, and oil shale, each of which would develop an energy output equivalent to four million bbl/day of oil by 2000. (MCW)

BUREAU OF MINES ENERGY PROGRAM. 1972

During calendar year 1972, the Bureau of Mines was engaged in some 20 major areas of research for development of new and improved methods of conservation and utilization for petroleum and natural gas, oil shale, and coal. Numerous projects are described. Based on this research, 186 technical reports were published by the Bureau or others, and numerous other reports were prepared for U.S. Government agencies. State agencies, and organizations engaged in cooperative research programs with the Bureau.

CN-140, 562

Synthetic fuels can be produced at remote, well-regulated plants and would not contribute to the primary pollution problems that exist in urban centers. Production, storage, transportation, end uses, and overall systems analyses are evaluated for new fuel systems. Emphasis is on hydrogen and other fuels from nonfossil sources, but a section is included on the use of coal to produce hydrogen and methanol. Comparative characteristics of hydrogen, ammonia, hydrazine, methyl alcohol, methane, ethanol, and gasoline (C11, 0, 0) are tabulated. (JCP)

CN-129, 827, Mag.

FUELS FOR ENERGY. (Special issue). 26p.

Electronic Progress, v. 15, no. 2 Summer 1973

The fuels refinery of the future.
An ecologically compatible refining.
Hydrodesulfurization of petroleum fractions.
Substitute natural gas: energy extender.
OIL SHALE, COAL, AND THE ENERGY CRISIS,
Welchman, B. E. (Superior Oil Co., Houston, TX). Chem Eng.
Oil shale and coal are domestic reserves that are large enough
in the anticipated energy deficit between now and the year
2000. Oil shale containing nahcolite and dawsonite can be pro-
cessed in an integrated operation into products for clean utility
fuel and nahcolite can be used in a dry scrubbing process to
reduce NOx emissions to low levels. Dawsonite can be processed into sodium compounds to be used with
nahcolite and into aluminum compounds that can be used in the
treatment of waste water. The integrated process is described.
The nahcolite can be used behind an electrostatic precipitator as
a granular filler that can absorb the SO2, as well as trap particu-
lates that pass through the precipitator. This would allow coal of
any sulfur content to be burned as clean energy and potentially free
for use. A plant producing 50,000 bbl/day of oil could be on stream
by 1981. It is estimated that these plants could eliminate the total
energy deficit without imports by 1988. (MCW)

(WASH-1281) COAL AND OIL-SHALE PROCESS-
NING AND COMBUSTION. Subpanel Report V Used in Preparing
the AEC Chairman’s Report to the President. Creutz, W.
$19.00.
Optimistic projections indicate that by 1985 an industrially
supported oil-shale industry of about 1,000,000 bbl/day can be
developed. From coal, about 1,500,000 bbl/day production of
oil and 1.5 trillion cf/year of pipeline-quality gas might be
available by 1985, if the Federal government has a strong com-
mmitment to achieve that goal. Achievement of this goal would
provide for rapid industrial expansion after 1985, but first the
threshold must be overcome. During the near-term period, the
development of reliable stack gas cleanup systems must be
accomplished in order to insure that coal can be burned in cen-
tral power plants in an environmentally satisfactory manner.
Simultaneously, new coal combustion techniques must be de-
developed that have greater efficiency than conventional systems.
Stack gas cleanup consumes 3 to 7% of the power output
of a plant. Pressurized fluidized-bed combustion systems will
be developed that have the capability of higher thermodynamic
efficiencies than conventional systems and also avoid the power
losses in stack gas cleanup. The proposed supporting research is an effort parallel with the coal gasification and liquefaction
research and focuses sharply upon the equipment and material
problems that are encountered in the hostile conditions used in
these processes. Commercial development can only follow when
there is reasonable assurance of reliable continuous plant opera-
tion. The solution to problem areas is usually less costly in the
laboratory than in a pilot plant operation. Proposed funding
levels for the five subprograms (total $1.22 billion for 5 years)
included in this review are presented. (sub)

(WASH-1281-7) ADVANCED METHODS OF OIL
AND GAS PRODUCTION FROM FOSSIL FUELS. Subpanel Report
VI Used in Preparing the AEC Chairman’s Report to the Presi-
The program recommended by the subpanel consisted of six
subprograms. In order to meet the $310 million program level
recommended by the Overview Panel, the subprograms for in-
situ coal gasification and recovery of oil and gas from tar
sands and heavy oils were eliminated. The remaining four sub-
programs and objectives are: (1) oil recovery from fluid injec-
tion, demonstrating optimum applications of existing and improved
methods for some 60 billion barrels now technologically but not
economically recoverable, and an additional 60 billion barrels not
now technologically recoverable; (2) oil and gas from stimulating
light formations using nuclear explosives, large-volume hydraulic
fractures, and chemical explosives; (3) oil from oil shale by de-
veloping appropriate fracturing techniques (e.g., nuclear explo-
\sives, chemical explosives, partial mining, hydraulic fracturing,
or combinations thereof) and processing methods (e.g., in situ
combustion, circulation of hot gases); and (4) oil and gas from adv-
anced drilling technology (primarily jet drilling and spark drill-
ing). The predicted results of the contribution of each subprogram
to production levels by 1985 and 1995 are presented, and the com-
parative roles of government and industry are briefly discussed.
(LMT)


N72-30123@ Bureau of Mines, Morgantown, W.Va.
BUREAU OF MINES ENERGY PROGRAM, 1971
John D. Spencer and Bill Linnell 1972 108 p refs
(BM-IC-8551) Avail: NTIS HC $7.50
In 1971 increase emphasis was placed on the production of fluid fuels and chemicals from coal. Advances were achieved in the development of the Synthane and Hydrane gasification processes for producing pipeline gas from coal, and progress was made in research on solid wastes utilization, and on liquid fuels production from coal. Coal mine safety, solid waste disposal and utilization, coal preparation and transport, and fundamental research on coal and related products also continued to be the subject of extensive research. Improved methods for extracting petroleum and natural gas without surface and subsurface pollution are discussed. This research was highlighted by studies of the fracturing systems of reservoir rocks, including subsurface fracture mapping and fracturing techniques to achieve optimum production of oil and gas. Oil recovery by water, well gas flooding, by steam injection, on the identification of oil spills, and on means to reduce vehicular exhaust emissions is summarized.

Author

N74-15448@ Oak Ridge National Lab, Tenn.
STORAGE AND TRANSPORTATION OF SYNTHETIC FUELS.
A REPORT TO THE SYNTHETIC FUELS PANEL
J. E. Johnson Sep. 1972 20 p refs
(Contract W-7405-eng-26)
(ORNL-TM-4307) Avail: NTIS HC $3.00
A review of the problems associated with the storage and transportation of energy by the major candidate synthetic fuel systems hydrogen and hydrogen-derived fuels, such as ammonia and methanol is presented. Particular emphasis has been placed on the identification of limiting technologies and on areas in which research and development efforts should be undertaken to contribute solutions to the nation's growing problems of energy resources, transmission and conversion.

Author (NSA)
The development of hydrogen as a synthetic fuel is attractive because it is essentially clean burning, the main combustion product being water; it may be substituted for nearly all fuel uses; it can be produced from domestic resources; it is available from a renewable and universal raw material—water, and nearly all primary energy sources—nuclear, solar, etc., may be used in its production. The main obstacles to the use of hydrogen as a universal fuel are its high cost relative to the current low prices for fossil fuels and, for some applications, the unresolved problems of handling a low-density or a cryogenic fluid. Safety considerations are discussed. The various options for the production of hydrogen, namely, electrolysis, thermochemical, biological, radiolytic, and various combinations, and the production of other synthetic fuels, particularly those made from hydrogen are discussed. Other synthetic fuels considered include ammonia (NH3), hydrazine (N2H4), methanol (CH3OH), methane (CH4), ethanol (C2H5OH), and gasoline (C8H18).


GASIFICATION OF SOLID FOSSIL FUELS IN A MICROWAVE DISCHARGE.

Gasification of solid fuels including lignite, high volatile A bituminous coal, oil shale, kerogen, gilsonite, and tar sands in a microwave discharge in argon yields hydrogen, carbon monoxide, and gaseous hydrocarbons. The extent of gasification appears to be related to the carbon content of the solid. High initial rate of production of various components of gases decrease rapidly with time in the early stages of reaction. In a carbon dioxide discharge, the product species present are oxidized to yield carbon monoxide; in a hydrogen discharge, the formation of hydrocarbons is enhanced.

| **1-1.** | **77p.** |
| **Office of Coal Research** | **RAD** |
| **Parsons, Ralph M., Co.** | **Rept.82** |
| **Los Angeles, Calif.** | **Contract 14-32-0001-1234** |

**Coal - Gasification**

**Fuels - Synthesis**

189,652/144

I-3-7-74

| **1-2.** | **1974** |
| **COAL TECHNOLOGY: KEY TO CLEAN ENERGY. ANNUAL REPORT 1973-74.** | **147p.** |
| **Office of Coal Research** | **(Washington, D.C.)** |

Demand for energy continues upward in the U.S. and with shortages of natural gas and oil, coal must now be converted to pipeline and low-Btu quality gas, both liquid and solid fuels, and methods found to burn it cleanly to produce electricity. Programs for development of new technology to ensure the full utilization of coal without polluting the environment are described. Power generation systems for increasing the efficiency of thermal to electric energy conversion are described including MHD generators and components. Supporting projects sponsored by the OCR are described. International activities, administration, patents, committees, and legislative data are included. (MCW)
Producing Clean Boiler Fuel from Coal

Preliminary design for a 10,000 ton/day plant for demonstrating a process that includes modified solvent refining and coal gasification.

J. B. O'Hara, N. E. Jentz, S. N. Rippee, and E. A. Mills
Ralph M. Parsons Co., Los Angeles, Calif.

A Pyrolysis Reactor
For Coal Gasification

The flash pyrolysis technique and reactor design used to produce pipeline quality gas from sub-bituminous coals from Wyoming and Montana mines is described.

H. G. McMath, R. E. Lumpkin, J. R. Longanbach, and A. Sass
Garrett Research and Development Co., Inc., La Verne, Calif.
Coal Gasification by Pyrolysis

New process, soon to be installed in 250-ton/day demonstration scale plant, aims at lower capital costs as well as lower operating costs than other similar techniques.

D. E. Adam, S. Sack, and A. Sass
Garrett Research and Development Co., Inc., La Verne, Calif.

The Clean-Coke Process
For Metallurgical Coke

Pollution problems, usual with conventional coke-oven technique, are not present in new carbonizing/hydrogenating method that will also produce a wide range of chemicals.


Methane-rich fuel gas is produced by a two-stage gasification process wherein particulate coal and steam are reacted in the second stage with synthesis gas from the first stage at temperatures in excess of 1600°F and pressures in excess of 50 atmospheres to produce char and a product gas containing hydrogen, methane and oxides of carbon. The char and product gas are withdrawn and separated and the product gas is thereafter treated to remove carbon oxides and other diluents and is ultimately methanated to produce a methane-rich fuel gas. The char is recycled to the first gasification stage for reaction with steam and oxygen at temperatures in excess of 2500°F and pressures in excess of 50 atmospheres to produce a synthesis gas containing hydrogen and oxides of carbon for reaction in the second gasification stage. A portion of the char, which has low-sulfur content, can be burned to produce process energy. Ash produced from the reactions in the first and second stages gravitates, at least partially as molten slag, to the lower sections of the reactor in stage one where the ash and slag are cooled and removed from the process. (MCW)

GAS-FROM-COAL: AN UPDATE.
N.P. Chopey.
Chemical Engineering, v.81, no.5, Mar.4, 1974, p.70-73.

What's happening in the realm of making gaseous fuels from coal: As the accompanying tables indicate, there has been a revitalization of established coal-gasification processes as well as an outpouring of new ones.

1974


Clean Fuels from Coal Gasification: A. M. Squires ........ 340

GARRETT'S COAL PYROLYSIS PROCESS.
A. Sass.

Early development work indicated a maximum of 35% conversion of coal to liquid.
Pilot plant studies are now underway.

HYGAS PILOT YIELDS OPERATING DATA.
B.S. Lee, Inst. Gas Tech.
Oil & Gas Jour., Feb.11, 1974, 75, 76.

Integrated operation at design conditions has been achieved with the Hgas process pilot plant. For nearly a week, the plant produced 900-1,000 BTU/cu ft gas at a coal feed rate of 3-tons/hr.

251
COAL GASIFICATION: AN ALTERNATIVE IN CLEAN ENERGY PRODUCTION. Goodholm, P. R. Combustion; 45: No. 9, 6-11 (Mar 1974).
From petroleum mechanical engineering conference; Los Angeles, CA (16 Sep 1973).
The energy supply situation existing today in the U.S. is examined. The natural gas supply is short, but with the utilization of the one remaining abundant energy resource, coal, shortages may be alleviated. A coal gasification plant is proposed to be built in the Four Corners Area of New Mexico and is under design. The Lurgi process used to gasify the coal, to be mined in near-by New Mexico, Utah, Colorado, Wyoming, Montana, and North Dakota, is described. Technical, environmental, and economical aspects of the plant design are presented. (MCW)

UNDERGROUND GASIFICATION OF COAL.
R.M. Nadkarni, et al.

When the Bureau of Mines wanted an appraisal of 'retorting' in situ coal to gas, they asked Nadkarni, Bliss and Watson. This is what they learned.

THE GASIFICATION OF COAL.
Harry Perry.

This formerly widespread technology, which lost its markets to natural gas and petroleum, is now being reexamined. New methods promise and alternative source of fossil-fuel energy.

METHANATION OF COAL GAS FOR SNG.
F.W. Moeller, et al.

Applicability of the Meyers Process for Chemical Desulfurization of Coal: Initial Survey of Fifteen Coals.
TRW Systems Group, Redondo Beach, Calif. Apr 74, 201p
EPA-650/2-74-025
PH-232 083/6WE: PCS5.75/MF$1.45
The report given detailed experimental results of applying chemical desulfurization technology to a variety of U.S. coals. Run-of-mine coal samples were collected from 15 U.S. coal mines in 11 states. Each coal was treated separately by the Meyers Process (tartaric acid extraction) and float-sink fractionation (physical coal cleaning). The Meyers Process removed 83-99% of the pyritic sulfur (40-64% of the total sulfur) from all the coals that contained sufficient pyritic sulfur for accurate sulfur determination. The Meyers Process also removed significant amounts of selected trace elements along with the pyrite. Solvent extraction of organic sulfur was investigated. (Modified author abstract)
PRODUCTION OF LOW-B.T.U. GAS FROM COAL IN COMBINATION WITH ADVANCED POWER CYCLES.
S. Dobner, M.J. Gluckman, and A.M. Squires.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.223-229.

Under Grant GI-34286 from the RANN Program ("Research Applied to National Needs") of the National Science Foundation, a team at The City College has begun "studies toward improved techniques for gasifying coal." Our primary objective is to study chemistries and unit operations that could be useful in a Coalplex for simultaneous production of pipeline gas, a light aromatic liquid fuel, and electricity (1). We are also undertaking flow sheet studies to identify commercial opportunities as quickly as possible and to guide our experimental work. This paper is our first report on results of flow sheet studies.

TWO-STAGE COAL COMBUSTION PROCESS (FOR SO_2-FREE STACK GAS).
J.A. Karnavas, P.J. LaRosa, and E.A. Pelczarski.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.245-249.

With sulfur-bearing coal as their prime source of energy, electric utilities must modify coal burning techniques to eliminate sulfur dioxide pollution from existing and new power plants. For this reason, the Applied Technology Corporation is developing the Two-Stage Coal Combustion Process which prevents the oxidation of sulfur during coal combustion (under sponsorship of the Environmental Protection Agency's Office of Air Programs Contract No. CPA 70-146). In this process, coal is gasified in molten iron to produce a sulfur dioxide-free hot offgas suitable for combustion in conventional power plant boilers. The sulfur is first retained in the iron and then transferred to a slag, which is removed and desulfurized to produce elemental sulfur and a sulfur-free road building slag.

Experimental results using 0.6 to 3.5% sulfur coal have shown that an essentially SO_2-free offgas is generated. Operating costs are comparable to those of coal-fired SO_2-polluting plants. Capital requirements for a retrofitted installation are estimated to be $23/KW for a 1,000 MW power station. Capital cost savings, realized when the process is incorporated into a new power plant, result in only $1.5/KW increase in capital cost over a new coal-fired polluting plant.

STATUS OF LOW B.T.U. GAS AS A STRATEGY FOR POWER STATION EMISSION CONTROL.
J. Agosta, et al.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.217-222.

During recent years, the authors' company, one of the largest investor-owned utilities, has studied and implemented several strategies for the reduction of sulfur dioxide emissions from its utility boilers. These include among others switching to low-sulfur fuels and a greater reliance upon nuclear power. One recent area of interest is the processing of fuel prior to combustion, namely, through the total gasification of coal and processing suitable for combustion in present utility boilers.

Specifically, the authors will present their views on the production of a Producer gas of approximately 150 to 200 B.t.u. and its application to the present and future coal burning coal generating units.

PROCESS DEVELOPMENTS: FIXED-BED CATALYSIS OF COAL TO FUEL OIL.
P.M. Yavorsky, S. Akhtar, and S. Friedman.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.101-105.

Several advancements have been made in a novel process being developed for converting coals into clean fuel oil that has very low sulfur and ash contents. Coal conveyed in recycle oil is propelled by rapid, turbulent flow of hydrogen through a reactor packed with immobilized (fixed bed) catalyst pellets. In addition to three coals previously hydrodesulfurized, a relatively low-value, high-sulfur Kentucky strip coal having 4.6% sulfur and 17% ash has been continuously converted in a small pilot plant into high-value fuel oil having only 0.19% sulfur and 1% ash. This oil more than satisfies air-quality standards for sulfur in fuels for electric power plants. Two recently demonstrated process improvements that reduce process cost are a four-fold reduction in gas flow through the reactor and a 50% increase in coal throughput (synthetic oil production). Also demonstrated were the feasibility of recycling un consumed hydrogen, the effect of H_2S contamination of the recycled gas, and the effect of presulfiding the catalyst silica-promoted cobalt molybdate).
COAL CONVERSION TECHNOLOGY.
H. Perry, Resources of the Future.
Chem. Engineering, v.61, no.15, July 22, 1974
p.38-102.

Years of experience with old routes, and millions of dollars spent investigating new ones, add up to a lot of knowledge about converting coal to liquid or gas products. Here's a review of important processes under consideration.


Direct combustion of coal in a conventional steam cycle with stack gas cleanup; direct conversion of coal in conventional cycles with fluid bed boilers; low Btu gas burned in conventional boilers and conventional combined cycles; low Btu gas from coal used in advanced combined cycles; and a coal extract residual fuel scheme are methods discussed for the conversion of coal to electric power in the near term. Costs of such technologies are examined and the view is presented that full-scale financial and manpower investments by industry, government, and private investors are necessary. (NCW)


A process is disclosed for desolubilizing and liquefying coal that comprises contacting comminuted coal with water, at least a portion of which is in the liquid phase, a reducing gas and a compound selected from ammonia and carbonates and hydroxides of alkali metals, at liquidation conditions, including a temperature of 260° to 70°C, to provide a hydrocarbonaceous product. (Official Gazette)

COAL DISTILLATION - THE PRODUCTION OF FUEL GAS.
J. Falque.
(In French)

The conversion of coal to gaseous fuel is not a new idea, but apart from the coke ovens and gas works supplying towns, genuine gasification processes have so far led to very few developemnts, except in special circumstances. The concern about sulphur pollution from solid and liquid fuels, and also the threat of an energy shortage and higher petroleum prices, have caused renewed attention to be given to coal distillation. We will consider in turn:
- the production of low calorific value gas (1 to 3 megacalories/m³);
- the production of rich gases: high calorific value gas (3.5 to 5 megacalories/m³) and very high calorific value gas (8 to 8.5 megacalories/m³).
AN ADVANCED COAL GASIFICATION SYSTEM FOR ELECTRICAL POWER GENERATION.

CLEAN FLUID FUELS FROM COAL AND WASTES.
Available without charge as 'OP-149-73' from the Publications Distribution Section, Bureau of Mines, 4800 Forbes Ave., Pittsburgh, Pa. 15213.

CHEMICALS FROM COAL: BEST BET IN ENERGY CRISIS.

(ORNL-TM-4370, pp. 472-474) COAL CONVERSION STUDIES. Ferris, L. M.; Bennett, M. R.; Thompson, C. T. Feb 1974. In Chemical Development Section B, semiannual progress report, 1973, Part I. Studies of the conversion of coal to liquid and gaseous fuels by catalyzed and pressurized hydrogasification have been initiated. Preliminary studies have been made on the use of HF in the gasification process; HF concentrations up to 20 mole% did not have a favorable effect. (auth)


ADVANCED CHEM. SER. 131 (1974)
PRODUCTION OF LOW BTU GAS INVOLVING COAL PYROLYSIS AND GASIFICATION, BY HEN, C.Y.
PRESSURIZED HYDROGASIFICATION OF RAW COAL IN A DILUTE PHASE REACTOR, BY FELDMAN, H.F.
HIMA, J.A., TAVORSKY, F.M. P 105-25.
CHEMISTRY AND PHYSICS AND ENTRAINMENT OF COAL GASIFICATION, BY ZHAROLOV, R.L., GRACE, R.J.
FORNEY, A.J. P 126-44.
CATALYSIS OF COAL GASIFICATION AT ELEVATED PRESSURE, BY HAYNES, N.P., GASIOR, S.J.

255

Samples of three Indian coals, of widely differing origin and rank, were subjected to flash pyrolysis at a temperature of about 1150°C for 30 sec in vacuo, and under atmospheres of nitrogen, argon, ammonia, and perdeuterobenzene. The gaseous products of the pyrolyses were analysed by IR and mass spectroscopy and by gas chromatography. Observed variations in gas compositions are discussed relative to the possible mode of influence by the pyrolytic atmospheres. It would appear that the pyrolytic atmosphere is an important factor in determining the composition of the pyrolysis products; the influence of nitrogen, argon and perdeuterobenzene is a physical one, leading especially to higher yields of olefins. (auth)

N74-17190 Brigham Young Univ., Provo, Utah.
KINETICS OF COAL GASIFICATION IN A LOW PRESSURE, LOW RESIDENCE TIME ENTRAINMENT FLOW REACTOR.
Ph.D. Thesis
Chiang-Liu Chao 1973 192 p
Avail. Univ. Microfilms Order No. 73-31405

Experimental studies were made with a small entrained reactor in which the finely-ground coal entrained in carrier gas was rapidly mixed with oxidizing combustion gases. A maximum of 68.5 percent coal was gasified in 0.012 seconds. The char formation was an overall zero order while the acetylene decomposition was a second order reaction with a frequency factor of 4 times 10 to the 7th power and an activation energy of about 12 Kcal/mole. The residence time of less than 0.050 seconds is sufficient for hydrocarbon gas production. Higher residence time resulted in lower gasification because of partial decomposition of hydrocarbons to elementary carbon.

Dissert. Abstr.

Comparative economic and environmental impacts of high and low BTU coal gasification and the gas turbine topping cycle during the 1980-85 time period were forecast. The forecast used a projected 1980 input-output table that was augmented by detailed air pollution coefficients and water, steel, and energy usage coefficients. Direct and indirect impacts of both investment in and operation of the new technologies were examined. Data was obtained from basic engineering studies of these processes and converted to input-output technical and capital coefficients. Alternative high, medium, and low energy growth futures for 1985 were projected both with and without the new technologies. Results indicate the high sensitivity of total capital investment and certain capital goods industries to the rate of energy use growth. Aggravation of the situation may result from the introduction of high BTU coal gasification. Several economic mechanisms that will help to hold total capital investment within its historical boundaries as a percentage of GNP are also examined. Possible applications, refinements, and extensions are included. 

Computer programs for analysis of leach processes, laboratory experimentation, and data tables are given for the Meyers process applied to the desulfurization of coal. (GRA)

If steam-oxygen mixtures replace the more customary air or oxygen fed gases for underground coal gasification, then the coal energy can be recovered with minimal environmental damage. Chemical mining looks like an attractive alternative to strip mining. (auth)

CAPTURING CLEAN GAS AND OIL FROM COAL.
L. Lessing.

To fully exploit its major energy reserve, the U.S. needs a crash engineering job comparable to building the atomic bomb.

Gasification of coal in a bath of molten sodium carbonate through which steam is passed is the basis of the Kellogg Coal Gasification process. The bath of molten salt strongly catalyzes the basic steam-coal reaction permitting essentially complete gasification of coal at reduced temperature. The molten salt can be used to suspend heat to the coal undergoing gasification. The molten bath serves to disperse coal and steam throughout the reactor, which permits direct gasification of caking coals at low temperatures. The bath of salt operates at a uniform temperature in the gasification range and, combined with the catalytic effect of sodium carbonate on steam-carbon gasification, yields a raw gas that is free of tars, tar acids, and coal bases. Gasification of coal in a single-vessel and conversion to pipeline gas requires substantial additional processing in addition to the gasification operation. The economics of the entire system are discussed. (MCW)


The bi-gas process (Bituminous Coal Research, Inc.) is described using Western Kentucky No. 11 coal. The production of 250 million fed ft/day of SNG produced in 22.0% ton/day of raw coal. After rejection of 35 percent refuse, 13,000 tons remain, with 85 percent going to gasification and the remainder to auxiliary steam generation and coal drying. Flow sheets of steam and shift conversion, the Rocheston acid gas process, and the methanation processes are shown. The economics of the BCR process are discussed. (MCW)


A conceptual design and an economic study were conducted for a plant to produce 250 million fed ft/day of pipeline gas, and about 27,000 lb/day of synthetic crude oil, from coal. The plant utilizes the Char-Oil-Energy-Development (COED) coal pyrolysis process along with the M. W. Kellogg Co.'s molten salt process to gasify COED char. The process is based on multi-stage fluidized-bed pyrolysis of coal to produce oil, gas, and char. The oil is hydrogenated to produce a synthetic crude oil, and the gas can be further processed to produce a pipeline gas. The char, amounting to about half of the original coal feed, must be utilized efficiently to avoid a serious economic disability to the process. Possible uses for the char include burning as a boiler fuel for power generation or gasification to produce fuel gas. This design utilizes an existing process to gasify the char and to produce high Btu pipeline gas from the combined raw COED and gasification gases. (auth)


In the TOSCOAL process, shale or coal is heated and conveyed up the lift pipe by co-current flow with hot flue gas from the ball heater. The partially heated feed is then heated to carbonization temperature by direct contact with heated ceramic balls in a rotating drum retort. Heat transfer rates within the retort are high, thus making very high throughput rates possible. The solid carbonization residue is separated from the heat-carrying balls using a trommel screen positioned at the discharge end of the retort. The hot residue is cooled in a rotary tube cooler using residue sensible heat to generate steam. The heat carrier balls are cycled back to the ball heater for reheating prior to another pass through the retort. Vapor from the retort is cooled to condense and remove tar and water from the gaseous components of the stream. The yield of products from the bituminous coal from Gillette, Wyoming, retorted at temperatures from 600 to 900 °F, are given. (MCW)


Some data on scale-up obtained at Hydrocarbon Research, Inc., on the commercialization of the H-Coal process are discussed. Development on the process was conducted on bench scale and process development units. The bench units use reactors about 3.4 in. dia and handle about 25 lbs coal per day. The process development unit (PDU) reactor is 8½ in. dia and handles 2.5 tons/day of coal feed, a scale-up factor of about 100. The next unit will be a prototype with a 4.5 ft dia reactor with a scale-up factor of 100 from the process unit. The commercial-size reactors will be a scale-up of 10 from the prototype. (MCW)


The steady increase that exists between iron and sulfur, which makes it difficult to produce low-sulfur coal and steel, is the basis of the new gasification process. Coal is dissolved in a mass of molten iron where the coal's fixed carbon and sulfur are retained, and the coal volatiles crack and exit in the offgas as carbon monoxide and hydrogen. The dissolved carbon in the iron is then gasified by reaction with combustion air to yield additional carbon monoxide to the offgas. Experimental results show that an essentially SO₂-free offgas is produced. Based on anticipated gasification rates and experimental coal solubility efficiencies, the Two-Stage Coal Combustion process yields electrical power operating costs comparable to existing plants without SO₂ pollution into the atmosphere. (MCW)

A novel process for converting coals into nonpolluting fuel oils that have very low sulfur and ash contents is described. Coals with high sulfur content can be used. The one-step desulfurization process uses rapid, turbulent flow of hydrocarbon to propel coal slurry through an immobilized bed of catalyst pellets in a reactor. The slurry vehicle for conveying the coal is a recirculated portion of its own product oil. The combined effects of the hydrodynamics, turbulence, and catalyst to liquefy and desulfurize the coal at high yields and high throughput. Sulfur is removed at 94% that is easily converted to inert elemental sulfur for industry or storage. Results are presented for a low-value strip-mine coal from Kentucky, having a high sulfur content of 4.6 percent and an ash content of 17 percent. (MCW)


A fluidized-bed combustion chamber for coal is equipped with a potassium steam cycle to provide low fuel costs and reduce sulfur oxide emissions from relatively high sulfur coal. Such a system shows promise of giving an overall thermal efficiency of over 50%, thus reducing the fuel consumption by about 25%, and reducing the waste heat rejection to about half of that from the best conventional coal-fired steam plants. The system is described and the economics of the system are studied. (MCW)


The COG refinery complex, combining several processes currently being developed, shows considerable economic promise for production of high Btu pipeline gas, a liquid feedstock for a petroleum refinery, and a low sulfur fuel for power plants. A significant feature of this type of process complex is that most of pipeline gas consists of methane recovered from the individual processing steps without requiring methanation of synthesis gas produced in the gasification step. (Auth)


It is shown that, as a fuel supply, low-Btu gas possesses several advantages over stack gas scrubbing. The low-Btu gas supply using the pressure gasifier can generate a net excess of electric power through the use of an unframed expander turbine; this contrasts with the stack gas emission process which has a parasitic drain of from 5 to 10% of the power generated. Secondly, the gas purification processing in the gas supply system works to remove H2S for which technology exists, instead of 50%, and it has a gas output less than 2% of the volume of the gas that would be processed in a stack gas scrubbing system. This process has lower capital requirements, lower operating cost, and higher energy recovery efficiency. Direct integration of a power plant will permit the recovery of a portion of the sensible heat and an 80% overall efficiency of the gasification plant is expected. A major objective of this project is to clarify and develop the ability to operate a gasifier, desulfurizer, clean-up system through the stringent requirements of turnaround, shutdown, and startup of the utility mid-range or peaking unit. (MCW)


The six processes now being considered in the development program sponsored by the Office of Coal Research and the American Gas Association are discussed briefly, and the present status of each is revealed. The two most advanced, the Lurgi in Westfield, Scotland (see Chem. Eng. News, Nov. 5, 1973) and the Hygas in Chicago, have operated in pilot-plant stages. Trials on the first of four types of coal in the former have been completed, but disclosure of results will await completion of tests on the other three in the Spring of 1974. The Hygas plant, operating on Montana lignite (22 tests, 2000 tons) has produced pipeline-quality gas with a heating value of -1800 Btu/scf. Most of the processes will be entering the pilot stages within the next 18 months, and an evaluation of all pilot-plant results will likely determine the future of the gasification industry's character. The most optimistic projections indicate that the first commercial plant could be built by 1978, but most observers believe that no significant quantities of synthetic pipeline gas will be available before 1985. (LMT)


A subsidiary of Occidental Petroleum Co., Garrett R & D Co., along with Colorado Interstate Gas Co., has developed a low-pressure pyrolysis system for the development of production pipeline gas from coal. The Garrett process is based on the concept of partial gasification of coal in which the optimum yield of methane and other hydrocarbons is obtained by rapid pyrolysis of pulverized coal. The method eliminates the need for either an inertizing medium or an auxiliary oxygen plant. The Garrett process is perhaps suitable for integration with a large power plant. Assuming that the present development schedule continues, Garrett expects to go on stream with a commercial plant within six years. (MCW)
(NP-19946) SELECTION OF COALS FOR THE AVCO HYDROGEN PLASMA ARC PROCESS FOR MAKING ACETYLENE.
A set of 30 samples of coals from different regions of the U. S. and of various ranks were selected from the Penn State sample collection and tested by AVCO for acetylene production. It was found that the most effective coals are the high volatile bituminous, the yield falling off with either medium volatile bituminous or subbituminous. Since the high volatile bituminous class is a large one and there was an appreciable range of yields within it, attempts were made to identify the most effective coals more specifically. Within the class no clear correlation was found with such parameters as volatile matter, in process content, or reflectance, nor with empirical combinations of these, though there does appear to be somewhat greater probability of obtaining good acetylene yields if the reflectance is in the lower end of the range for highly volatile bituminous coals. There are indications that western coals tend to have more hydrogen in relation to their carbon than other coals, but there was no evidence that this increased the acetylene yield. Examination of the solid by-product of the processing of these coals suggested that the coal feed had been uniformly exposed to the high-temperature reducing conditions. It was thought that differences in acetylene yield might reflect accidental differences in the process conditions rather than true differences in the organic substance of the coals. Accordingly, the results were not reported, and a fresh set of 30 samples was submitted for testing under modified conditions that should ensure uniform exposure of the feed. (MCW)

The purpose of this investigation was to determine which process variables had a significant effect on the removal of sulfur from coal by hydrogen treatment at reaction temperatures of 325 and 400°C; pressures of 600 and 1200 psig; reaction times of 7.5 and 15 min; solvents of anthracene and tetralin, and solvent-to-coal ratio of 3:1 and 4:1. A coal–solvent slurry was reacted with hydrogen at elevated temperatures and pressures in a batch autoclave rocking bomb reactor. Four different raw coals (two bituminous and two sub-bituminous) were tested. Both solvent type and temperature were found to be very highly significant variables (99% confidence level) in the solvent refining process for the desulfurization of coal. Some significance (56% confidence level) of the solvent-to-coal ratio was demonstrated for the sub-bituminous coals. Anthracene oil was found to be a better solvent for the process than tetralin since the desulfurization of the coal in the anthracene was greater and the hydrogen transfer characteristics appeared to be better in comparison to tetralin. The tetralin-solvent mixture was totally recoverable from the solvent-refining product but the anthracene oil was only partially recoverable (50 to 80%) since the coal was only partially depolymerized under reaction conditions investigated. Inorganic sulfur was easily removed from the raw coal by the solvent-refining technique (97%) while organic sulfur was removed to a lesser degree (81%). The degree of dissolution and depolymerization of the coal in the solvent was an important process factor for overall desulfurization. (MCW)

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(TITLE: Denaturing of Coals: A Commercial Source of Pipeline Gas
AUTHOR: Deul, H. W.; Fields, H. R.; Miller, C. M.
CORPORATE AUTHOR: U.S. Dept. of Interior, Bureau of Mines
ABSTRACT: A byproduct of intensive research conducted by the Interior Department's Bureau of Mines on denaturing of coals for improved mine safety is evidence that commercial quantities of pipeline quality natural gas can be produced. Coalbed gasification by draining gas from the coalbed before it is mined can be accomplished by drilling vertical holes into coalbeds with subsequent stimulation by hydrofracturing; by drilling horizontal holes into virgin coalbeds free of small specially designed boreholes; or using drainage holes from large ventilation shafts sunk to the coalbed in advance of mining. It is estimated that the minable coalbeds of the continental United States that are less than 1,000 feet deep may contain 260 trillion cubic feet of natural gas. The pertinent coalbed properties are discussed and results of a novel drilling method are presented. (KTH)

AVAILABILITY: Institute of Gas Technology, 929 S State St., Chicago, IL 60610

1973

Bench-scale and laboratory tests were conducted for chemical removal of sulfur (S) from coal to produce a low sulfur coal to meet air quality standards. The method used was the Meyer's process in which pyritic sulfur is oxidized by ferric compounds to a water soluble form. Approximately 100% of pyritic S was removed, using aqueous ferric salt solutions which, for the four coals tested, corresponded to an absolute removal of 1 to 3.5% by coal weight of S. The best content of the coal increased and the ash content decreased as a result of pyrite removal. The pyritic S was removed from the coal as elemental S (40 mole %) and from sulfate (60 mole %). Process operating temperatures of 50 to 100°C, pressure of 1 to 10 atm, residence times of 1 to 15 hrs, and coal top sizes from 1/4 in. to 10 mesh were evaluated. Preliminary process design and cost estimation for a 100-ton/hr coal desulfurization plant are given. (GRA)
COAL GASIFICATION COMBINED PLANTS NEED PERSISTENT ENGINEERING, FEW MIRACLES.

CLEAN FUELS FROM COAL AND WASTES.
A.J. Forney and W.P. Haynes.

OPTIMIZING THE CLEAN ENERGY REFINERY.

The Process Plants Division of Foster Wheeler constructed a general computer model of a clean energy refinery that produces no products other than low-sulfur gaseous and liquid fuels that can be used in conformance with all government standards regarding the combustion of fuels in industrial and residential services. The REFOP complete linear programming system has the capability of setting up and optimizing any petroleum or petrochemical processing complex. A schematic block diagram is shown of the model using the effects of crude and SNG prices on the economics of a hypothetical 150,000 BPD facility. (MCW)

COAL GASIFICATION PLANT BEGINS OPÉRATION.
The first commercial demonstration plant for converting coal to synthetic natural gas has begun operation at Westfield, Scotland, and is producing high calorific gas at a daily rate of 2.5 million ft³ and at a cost estimated at 70 to 90 cents per million Btu of gas. At Westfield, too, is a separate study to see whether a variety of coals from different areas in the U.S. can be gasified with equal success in a Lurgi gasifier. A new market would open up for the vast coal reserves in the U.S., estimated to last for the next 500 years, if the commercially and technologically viable process of converting coal to methane is successful. The demonstration unit at Westfield proves for the first time that the methanation can be carried out in a continuous operation using gas generated from a commercial grade of coal. Eastern and mid-western U.S. coal has been unacceptable in a Lurgi-type gasifier due to coking and swelling, but it is hoped that by changing the parameters of the operation, the coals can be made to gasify satisfactorily. Construction of large-scale commercial units in the U.S. capable of producing as much as 250 million ft³ a day of the coal-derived natural gas would then be foreseeable. (MCW)

GOVERNMENT, PRIVATE GROUPS SEEK EFFICIENT COAL-TO-GAS SCHEME.
Cryogenics & Industrial Gases, Jan./Feb.1973, p. 33, 34.

Industrial gas producers are keeping a watchful eye on coal gasification developments.


Three SNG refinery configurations are evaluated according to their advantages, limitations, and economics in manufacturing substitute natural gas. Residue desulfurization, flaring, and partial oxidation configurations are considered. The common aspects of these refinery schemes are that (1) naphtha and lighter materials are desulfurized and gasified to produce pipeline quality gas, and (2) the gas-oil cuts are hydrocracked and/or cat cracked to naphtha and lighter materials for conversion to SNG, desulfurized for the production of low sulfur fuel oil, or split for fuel processing. The primary differences among these refinery schemes are in the processing units chosen to treat residue fractions. Costs of SNG from crude oil feedstock depends upon feed cost and properties, product mix and specifications, capacity, site location, financing, and many other factors. (MCW)
### CLEAN ENERGY FROM COAL TECHNOLOGY

**Washington, DC; Department of the Interior (1973).** 43p. GPO 40.75.

The United States, with 6% of the world's population, consumes about 33% of its commercial energy supply. The demand for all fossil fuels combined is expected to double by 2000. Coal will be expected to play an important role to meet this need to reduce the requirements for imported supplies of gas and oil. The conversion of massive coal reserves to clean-burning pipeline gas is discussed. Research sponsored by the Interior's Office of Coal Research is discussed for high-Btu pipeline gas technology and pilot plants on the HGAS fluid bed, CO2 acceptor, Hi-GAS lentrained bed, and SYNTHANE (fluid bed) processes. The low-Btu fuel gas processes being investigated include the fluidized-bed gasifier and the entrained-bed gasifier. The low-sulfur fuel oil processes include extract hydrogenation, sbubulated-bed hydrogenation, fixed-bed hydrogenation, and carbonization. The solvent refined coal method of extraction is described. (MCW)

| TITLE: Char Oil Energy Development, Period of Operation July 1971 - June 1972 |
| ARAUTHOR: J.K. Schowengerth, J.A. McManus, R.D. Scott; J.R. Eddinger, L.T. |
| CORPORATE AUTHOR: FHC Corp., Chemical Research and Development Center |
| ADDRESS: Princeton, NJ 08540 |
| PUBLICATION DESCRIPTION: NRD Report No. 73, 113 p. |
| PUBLICATION DATE: 1973 (? ) |
| SPONSOR: E.S. Dept. of Interior, Office of Coal Research |

**ABSTRACT:** The core process is being developed by the FHC Corporation under contract to the Office of Coal Research, U.S. Department of the Interior. The process is a 2-staged fluidized-bed pyrolysis of high-volatile bituminous coals to produce oil, gas, and carbon. Catalytic hydrogenation of the oil yields a high-value synthetic crude oil suitable as a petrochemical feedstock. The char product can be utilized as a boiler fuel or for power generation or, alternatively, as a feedstock for gasification and reforming to pipeline gas. The work reported herein was carried out under Contract No. 14-32-0001-1212. The purpose of this work is to obtain engineering data for the design of a commercial plant. The data is to be obtained from operation of the core pilot plant with several commercially important coals. (Auth, from Summary)

**AVAILABILITY:** GPO, Stock No. 2419-00053 ($1.25)

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### CHEMICALLY MINING COAL


Some reactions with coal give off heat and others absorb heat. The reactions of coal with oxygen or air give off heat, but the reactions of coal with steam or with carbon dioxide absorb heat. By balancing the proportions of the two types of reactions, the energy of the coal can be almost completely recovered and environmental damage is minimized. The chemical reactions of solid coal + gaseous oxygen yields carbon dioxide. An in-depth table lists the thermodynamic values for reactions in coal processing beginning with the aforementioned reaction. Twelve reactions are tabulated. Areas of the Southern Rockies overlying coal fields are shown. Political pressures are heavy against stack emissions from coal fires. The Four Corners coal-burning power plant is involved in extensive stack emission control. Underground gasification plus available cleanup procedures could eliminate the particulate problem and reduce the sulfur problem before the power plant burned the fuel. (MCW)
UNCATALYZED HYDROGENATION OF COAL. Liebenberg, B. J., Pongleiter, M. G. J. (Univ. of Potchefstroom, S. Afr.), Fuel 52: No. 2, 130-133(Apr 1973)

The uncatalyzed hydrogenation of a bituminous coal in a batch reactor with toluene as solvent has been investigated. This investigation differs from others reported in the literature mainly in the sampling methods employed. Because of the methods previously employed, effects of heating to reaction temperature and cooling to ambient conditions were not excluded; this complicated an investigation into the kinetics of coal hydrogenation. Samples were withdrawn from the reactor after reaction temperature and pressure were reached. In conclusion that simple series or parallel reactions suggested in literature for hydrogenation of coal are oversimplified mechanisms. (auth)
The invention relates to the production of fuels from coal and more particularly to the production of desulfurized and pollution-free fuels. It is desirable from an economical standpoint to use coal for producing both liquid and gaseous fuels since coal is relatively inexpensive compared to petroleum crude oil, and is quite abundant in contrast to the rapidly dwindling domestic supply of the petroleum natural resource. One of the biggest drawbacks in using coal as a source for gasoline, or the like, or for gaseous fuels is its high sulfur content. This problem is of even greater significance today where much emphasis is being placed on improving the environment by reducing air pollution. It is an objective of the invention to provide a process for producing sulfur-free liquid and gaseous fuels from coal in a unitary process. (MCW)

COAL GASIFICATION FOR ELECTRIC POWER GENERATION.
S. Lemezis and D.H. Archer.
The ultimate goal of the coal-gasification power system project is the demonstration on a commercial scale of an economic and environmentally acceptable electric generating plant that links a coal-gasification system with a combined-cycle plant adapted for burning low-Btu fuel gas. The development of a small-scale fluidized-bed gasifier is underway, and the conceptual gasification process will be chosen for final scale-up to prototype size. The research program and its financing are discussed. The time schedules for progress made and the projections into 1981 are presented. (MCW)

METHOD FOR FEEDING DRY COAL TO SUPERATMOSPHERIC PRESSURE.
A method for continuous feeding of dry coal particles from essentially atmospheric pressure to the superatmospheric pressure level of a coal gasifier or coal liquefaction reactor is achieved by a series of screw feeding devices each partially boosting the pressure level of the coal in stages to provide the dry coal at reactor pressure. (Official Gazette)

Tetralin has been considered a reasonably good hydrogen donor for the hydrogenation of coal, but in the literature little attention has been given to the kinetics of this reaction. This paper it is suggested that the conversion of tetralin, mainly to naphthalene, may be either a reversible or a non-reversible reaction depending on the catalyst employed. It is further concluded that stannous chloride, though confirmed as the best catalyst, is inferior to cobalt oxide when the side reaction tetralin — decahydronaphtalene and the rate of dehydrogenation of tetralin are considered. (auth)

Fluidized-bed gasification of high-sulfur oil at atmospheric pressure for the production of a clean fuel gas was evaluated technically and economically. The clean fuel gas with minimal sulfur and particulates is utilized for power generation in conventional fossil-fuel-fired boilers. The gasification occurs in a limestone bed. Hydrogen sulfide produced during the cracking and partial combustion of the oil is removed by lime to yield a clean fuel gas and sulfided lime. The hot, low-sulfur, low-Btu fuel gas is burned in a steam generator. The process can be operated as a once-through, throwaway limestone system or as a lime-stone regeneration/sulfur recovery system. The sulfided lime can be converted to calcium sulfate in an air-fluidized vessel, operating near 1500°F, for disposal in the once-through concept. The regeneration system converts the sulfur in the stone to SO3 in an air-fluidized bed operating near 1900°F. The regenerated stone is circulated back to the gasifier and the SO3-rich stream (10 mole %) goes to a sulfur or sulfuric acid recovery system. The technical feasibility of the concept was demonstrated. Sulfur removal up to 95% was achieved. Specifications and design concepts are developed for retrofit on existing utility boilers and for new plants based on experimental data. Conceptual designs, performance, and costs for retrofit systems show that the concept offers an economic method for achieving SO2, NOx, and particulate emission regulations. Capital cost of a retrofit, once-through gasification system is estimated to be 50 to 70% less than a retrofit wet-scrubbing system. Combined capital and operating costs for the gasification process may be 20 to 25% less than such alternatives as wet scrubbing or the use of low-sulfur oil products. Plant reliability may be increased with the gasification system due to reduction in SO3, vanadium, and sodium before the boiler. A demonstration installation of an add-on oil gasification unit on an existing utility boiler is recommended. (5 figures, 8 tables) (auth)

Thesis (Ph. D.).

Eleven alternate coal gasification processes to produce 260 billion Btu per day of synthetic natural gas were calculated and the performance of the different processes were compared, based on their optimal thermal efficiencies. In order to optimize the thermal efficiency of each alternate, thermal dynamical models for the alternates were first constructed according to specifications provided by the Office of Coal Research for the synthetic natural gas production. By applying the "Complete Technique for Optimization" the optimal thermal efficiencies were computed. The prices of synthetic natural gas produced from the different alternate processes were also calculated, based on the results of sub-system equipment design optimizations and using the standardized G, C, R, - A. G. A. accounting procedure. Since the raw material (coal) cost constitutes a large portion of the final gas product, the process with the largest thermal efficiency was found also to have the lowest final gas price. The process that utilizes most of the volatile matter of coal and produces the most methane in the gasification stage, rather than in the final methanation stage, was found to have higher thermal efficiencies. To effectively produce methane in the gasification stage, a hydroanalysis and hydrogenation of the raw coal in a hydrogen-rich atmosphere are desirable. This hydrogen is generated by gasifying the hydrogenated coal residue, then shifting and purifying the produced synthesis gas.

(Diss. Abstr. Int., B1)


Coal represents more than 90% of the proved reserves of all developed fuels. At the 1972 rate of consumption, the proved coal reserves will not be exhausted for 600 years. If coal were the sole source of energy and the total demand rose 3.3% per year, the proved reserves would last for 47 years and total coal reserves for nearly 75 years. Gasification is being examined as a major source of clean energy use. The Lurgi process and the Koppers-Totrek process are described. Two new processes that have reached the demonstration stage are the HYGAS process and the CO2 Acceptor process. Other processes approaching the pilot stage include the BI-Gas process and the Synthane process. Capital requirements, operating costs, and average gas cost are discussed. The new technology of gasifying coal underground is described. (MCW)

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Coal gasification work has progressed to the point where important developments may be expected in rapid succession. Only one of the processes described here is considered commercial at this time, but the incentives are great to prove out others which may be more economical. (suth)

The use of massive quantities of molten salt catalysts was investigated for the hydrocracking of two Montana coals: Colstrip sub-bituminous and Savage lignite. The catalytic component of the molten salt was ZnCl₂, various alkali metal halides were used as the noncatalytic component to reduce the viscosity of the molten salt and promote phase separation between the hydrocarbons and salt mixture. Experiments were run in a 500-ml rocking-bomb reactor and conversions were based on reaction products soluble in benzene. Tests used to simultaneously investigate the importance of conversion of seven process parameters showed no effect of the following between the levels indicated: pressure (2000 to 3000 psig); salt: coal weight ratio (2:1 to 4:1); and KCl:ZnCl₂ mole ratio (1:1 to 1:1). Significant effects were attributed to these parameters between the levels indicated: temperature (350 to 450°C); time (15 to 60 min.); mixing (static rocking); and coal size (40+100 to 100 mesh). Good conversions (>50 wt %) were attained using both coals and the parameters affected conversion essentially the same for both coals. Additional tests showed that the pressure should be greater than 2000 psig and the coal particle size smaller than 40 mesh. It was also observed that KCl:ZnCl₂ mole ratios as low as 0.2:1 might be feasible and that the noncatalytic component of the salt mixture affects conversion and product appearance. NaCl was superior to KCl relative to conversion when used as the noncatalytic component of the salt mixture. The ZnCl₂ in the molten salt mixture eventually became poisoned with resultant lower conversions, poorer phase separations, and more tar-like products. The use of excessive quantities of ZnCl₂ in noncatalytic molten salt mixtures was not promising. Metal chlorides of metals more and less active than zinc did not act as catalyst accelerators (compounds that would react with the catalyst poisons in preference to ZnCl₂). Comparisons of gas removal at reactor operating temperatures and at ambient temperatures showed the former retarded the onset of poor phase separation and more tar-like products. It also resulted in a higher H:C mole ratio in the products and less retention of nitrogen (the suspended catalyst poison) in the salt mixture. (Diss. Abstr. Int.) B


A new multiphase chemical equilibrium program designed to cope with problems in high temperature coal combustion operates at least 300°F faster than a similar program developed previously. The mathematically sophisticated techniques responsible for the new speed are educated guessing of solutions of chain problems; symmetry of the Jacobian matrices to be inverted; skipping of information when convergence is near; and accommodation to zero items in the stoichiometric specification of a problem which leads, rather than to matrix singularity, to a marked speedup in the operation without data bank reconstruction. Applications considered included slag vaporization; flame temperature; electrical and transport properties, and the design of a novel three-stage gasifier-combustor system now under construction as a pilot plant at Pittsburgh Energy Research Center. A study of the thermodynamics of aged regeneration was made. (MCW)

PRODUCTION OF FUEL GAS. Slater, W. L.; Schlimme, W. G.; Crouch, W. B. (to Texaco Inc.). US Patent 3,754,364. 8 Jan 1974. Filed date 4 Nov 1971. 6p. Fuel gas suitable for use in conjunction with a gas turbine is prepared by subjecting a hydrocarbon oil to partial combustion using air as the oxidizing medium and injecting additional hydrocarbon oil into the hot partial combustion products. (Official Gazette)

N74-19047

(61A-73-948) FRACTURE OF COAL AND OIL SHALE FOR IN-SITU PROCESSING OR REMOTE REMOVAL: A PROPOSAL SUPPORT DOCUMENT. Tyler, L. D.; Wark, W. D. (Sandia Labs., Albuquerque, N. Mex. (USAI)). Oct 1973. Contract AT(30-1)-769, 17p. Dep. NTIS $3.90. A detailed description is given of work proposed for the fracturing of coal and oil shale formations in-situ. The proposal sets forth the concept of using the synergistic effects of a combination of hydraulic and explosive techniques to fracture these formations in a controlled manner. (aut)

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Gasification of Fossil Fuels under Oxidative, Reductive, and Pyrolytic Conditions.
Scientific Research Instruments Corp., Baltimore, Md. Dec 73. 184 p SRIC-72, EPA-650/2-73-042
PII-228 68/00E PCS12.25/MFS1.45

The report contains kinetic reaction data produced in a non-isothermal kinetics laboratory while gasifying selected types of coal under oxidative, reductive, and pyrolytic conditions. Types of coal cover the range, including lignite and anthracite. Evolution of thermal decomposition products under study conditions were investigated at different fuel heating rates and gasification pressures. Gaseous product evolution rates, as the function of temperature, were graphed for different coals exposed to indicated gasification regimes. The evolution of such gaseous species as H2O, CO, CO2, O2, NO, H2, CH4, H2S, and C2H2 was followed up in conjunction with 13 different coal gasification reactions as identified previously and in the course of this work. The kinetic reaction parameters, such as activation energy and frequency factors for these reactions, were calculated and presented earlier and in this report.

Evaluation of Coal-gasification Technology, Part 1—Pipeline-quality Gas
Issued April, 1973
R&D Report No. 74—Interim Report No. 1
Contractor: National Academy of Engineering
Refer to: Titled report and GPO Catalog No. 163.10.74/
Int. 1 and Stock No. 2414-00057
Price: $0.85

Optimization of Coal Gasification Processes
Issued April, 1973
R&D Report No. 66-Interim Report No. 2
Contractor: West Virginia University
Refer to: Titled report and GPO Catalog No. 163.10.66/
Int. 2 and Stock No. 2414-00054
Price: $0.75

Development of CSF Coal Liquefaction Process
Issued August, 1973
R&D Report No. 39-Final Report, Volume V.
Contractor: Consolidation Coal Co.
Refer to: Titled report and GPO Catalog No. 163.10.39/Vol V and Stock No. 2414-00060
Price: $0.75

Costs of gasification high
Anon., Energy Digest, 2, (3). III. 32-36, (May 1973). Reference is made to a report produced by the Edison Electrical Institute that forecasts the availability and prices of coal, oil, natural gas and uranium, and examines world resources in terms of their economic, environmental, domestic and international "inter-fuel relationships". The gasification of high sulphur coals is also mentioned. The article gives capital, annual owning and operating costs for a first-generation large gasification process in a 1 000 MW nominal COGAS system.

Status of coal gasification
Cochran, N. P., A. I. Ch. E. Paper 7a presented at the 74th National Meeting of the American Institute of Chemical Engineers, New Orleans, March 11-15, 1973. 10 pp. The U.S. Dept. of the Interior is currently investigating 4 coal gasification processes which are sufficiently different to require testing at a pilot-plant scale. The basic coal gasification process is briefly discussed before the specific processes under investigation: the HYGAS, CO2 Acceptor, BI-GAS, and Agglomerated Ash.

Coal gasification, how soon?
Dold, G. H., A. I. Ch. E. Paper 7a presented at the 74th National Meeting of the American Institute of Chemical Engineers, New Orleans, March 11-15, 1973. 22 pp. G.H. Dold of Columbia Gas System Service Corp. examines the cost of natural gas relative to other fuels, establishes the need for coal gasification, and reports coal gasification's status among gas supply alternatives from the viewpoints of economics, commercial technology, and the resultant indicated timing of plant construction.


Substitute natural gas from coal

Substitute natural gas process passes pilot-plant test
Anon., Oil Gas J., 21. (15). 32-33, (8 Apr. 1973). A description is given of a new synthetic SNG process called R-Gas, developed by Hydrocarbon Research Inc, that is designed to feed low-grade hydrocarbons. The process now ready for demonstration-plant evaluation, converts high-sulphur resid, coal tar or shale oil, broken down costs of the process are given. The pipeline-gas price is set at 98 g/million BTU from a 250 million cfd plant with $2.50/bbl. feed.
Evaluating the Bi-Gas synthetic natural gas process
Hegarty, W. P., and Moody, B. E., Chem Engng Prog., 59, (3), 37-42, (Mar. 1973). This is a revised version of an OCR report, which describes and discusses the engineering evaluation of the Bi-Gas coal gasification process carried out by Air Products & Chemicals Inc. on behalf of the Office of Coal Research. Details of the gasifier operating conditions were provided by Bituminous Coal Research, as well as heat and materials balances. Utilizing the data provided, APCI has developed a preliminary design for a 250 million ft³/day plant. The economics of the process have been investigated and it is pointed out that although there are a number of potential problems, the process is theoretically sound and the prospects for development are good.

Coal gasification: state of the art

Coal-to-gas conversion: search for new ideas intensifies
Chcronis, N. P., Coal Age, 78, (2), 106-110, (Feb. 1973). A short account is given of some of the research projects in the field of coal gasification being undertaken at the U.S. B. M. Morgantown Energy Research Centre. These are a cyclone gasifier, heat pipes, underground gasification and a stirred fixed-bed gasifier that will accept all types of caking coals.

Gas from coal
Anon., Power Engng., 77, (3), 32-41, (Feb. 1973). Only coal gasification seems to offer the U.S.A. a long range solution to fossil fuel needs that will be accepted on all counts, particularly reliability, economics (including balance of payments considerations) and national security. Reference is made to the Lurgi, HYGAS, CO₂ Acceptor, BI-GAS, Synthane, ATGAS, COGAS, a new Kellogg, and Union Carbide Corp processes, low Btu gas, underground gasification, evaluation of processes, Lurgi plants planned, and other sources of clean fuel.
AIChE Symposium Series, v.69, no.127  1973

DECLINING DOMESTIC RESERVES - EFFECT ON PETROLEUM AND PETROCHEMICAL INDUSTRY. C.E. Cummings, ed. (Contains papers presented at the 71st National Meeting of AIChE, Dallas, (Tex., 1973)).

SURVEY OF PROCESSES FOR PRODUCING NATURAL GAS FROM CRUDE OIL AND NAPTHA .......................... Bronak Dutkiewicz and Peter H. Spitz 68
SUMMARY OF SNG FROM CRUDE OIL .................... R. P. Schaaf 71
APPLICATION OF THE BRITISH GAS COUNCIL FBH PROCESS TO SNG PRODUCTION .................. J. F. McMahon 72
CONVERSION OF ATHABASCA BITUMEN ................. G. R. Gray 99

RCD ISOMAX: PRODUCTION ROUTE TO TODAY'S AND TOMORROW'S LOW SULFUR FUEL OILS ................ A. P. Kreuding 76
HYDRODESULFURIZATION OF RESIDUALS WITH H-OIL ........................................ A. A. Gregoli and G. R. Hartos 78

ECONOMICS OF THE PRODUCTION OF GASOLINE, FUEL OIL, AND AROMATIC CHEMICALS FROM COAL BY HYDROGENATION .................. S. A. Qader, K. Duraiswamy, R. E. Wood, and G. R. Hill 102

TECHNOLOGY AND COST OF COAL GASIFICATION,
H.M. SIEGEL AND T. KALINA.

COAL GASIFICATION: THE NEW ENERGY SOURCE.
Williams, J. E.; Dressel, J. H. (Stearns-Root Inc., Denver.
This review of coal gasification describes processes available today and in the future. Winkler, Koppers-Totzek, and Lurgi processes are briefly described. The Lurgi process has been applied extensively for practically all of the first-generation projects. Some new processes include Bituminous Coal Research's BIGAS Process, Consolidation Coal's CO2 Accepto Process, and the Institute of Gas Technology's "HYGAS" Process. All these processes use fine coal and employ fluid beds in which the coal particles are either suspended or carried along by the gases in the gasifier. They do not have moving parts inside the gasifier. The processes may allow scale-up to much larger sizes than the Lurgi gasifier and possibly reduce the capital cost for gasifiers. Initial engineering progress for commercial plants in being made on low-BTU gas projects for the power industry and high-BTU gas projects to produce synthetic natural gas. An illustration is described to show the size of the mine and coal preparation plant necessary to support a 250-MMscf/D gasification plant and to show some of the difficulties encountered in the materials handling for a commercial gasification plant. (MCW)

Two molten salt desulfurization processes are illustrated. Precombustion desulfurization of coal takes place in a single stage. Pulverized coal, slurried with molten salt, is allowed to react with a liquid that contains an agent with an affinity for the sulfurous compounds. The coal collects at the top, being less dense than the melt, and is drawn off continuously. The melt and coal are separated, and the accumulated sulfur, plus any soluble sulfur compounds, are removed from the melt in a side operation, after which the ashes are returned to the reactor. The indirect oxidation of coal with attendant production of steam directly relies on the fact that coal attains a reasonable rate of oxidation at 600° to 800°C (1100° to 1300°F), while current power plants require steam at about 1000°F. Instead of merely operating to oxidize the sulfur, flameless oxidation of the coal will take place utilizing chemically bound oxygen from the salts. The offgas will thus be more concentrated, and the sulfur, now comprising almost 1% of it, will be more advantageously removed. The spent salt, now in a reduced form, goes first to a unit to remove ash, by centrifugation or filtration, and then to the salt regenerator for reoxidation to its original form. The oxygen-depleted air from the regenerator should not require further treatment before release to the atmosphere, save heat exchange to recover its thermal energy. The steam tubes lead directly into the combustor, providing 2,600 lb steam in a single pass. Ash components are drawn off at the bottom of the reactor in both processes. (MCW)

POWER GAS AND COMBINED CYCLES: CLEAN POWER FROM FOSSIL FUELS. W.D. Metz.

Direct combustion of high-sulfur coal presents problems. An alternative is the production of low Btu gas from coal. Two advantages of this process are: that the gas is produced under reducing conditions, with the result that sulfur is converted to H2S, which can readily be removed by well-proven absorption processes; and secondly, the gas can be generated under pressure, permitting some operating economics in an existing power plant and more advanced power plant design for a new plant. Some disadvantages exist due to the fact that the operation resembles chemical plant operation with controls of flow and composition, etc. The large process is the only immediate commercial application, but the Texaco gasifier, Babcock-Wilcox gasifier, Wellman-Galusha gasifier, B&W-DuPont gasifier, Westinghouse gasification process, Union Carbide gasification process, Bi-Gas process, and the Koppers-Totzek gasifier are discussed. (See reference) (NCW)


The thesis (Ph. D.), A cold flow model of a vortex coal gasifier was fabricated and evaluated experimentally to determine the geometric and fluid dynamic variables controlling the mixing between a vortex combustion stream and a separate, through flowing core gasification stream. The aluminum and transparent acrylic model incorporated a transparent outer body for flow visualization, an adjustable control vortex exhaust valve, provisions for changing the inlet and outlet core tube diameters, and provisions for changing the core gap length. A smoke flow visualization test program and a qualitative gas mixing study employing a carbon dioxide vortex and an air core were conducted. Visual and quantitative data are presented to show the effects of important variables for counter-flowing and countercflowing streams. Core mass retention and core exhaust purity are treated as the important data results. These results were found to depend primarily on the vortex inlet Reynolds number, a parameter related to the ratio of the vortex inlet Reynolds number to the core inlet Reynolds number, the core gap, and the core inlet tube diameter. A summary of the visual results illustrates the important effects presented along with polynomial curve fits of the core mass retention data. Complete tabulations of the measured and calculated gas mixing data are also included. (Diss. Abstr. Int., B)

TITL: City College Studies of the Coalplex
AUTHOR: Squires, A. M.
CORPORATE AUTHOR: City College of The City University of New York, Dept. of Chemical Engineering
ADDRESS: New York, NY 10031
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BAW Program
ABSTRACT: CITY College of New York has been conducting studies toward improved techniques for gasifying coal. The primary objective is to study chemistry and unit operations that will be useful in a COALPLEX yields substitute natural gas, high-octane gasoline, and clean electricity. We are also engaged in flow sheet studies to identify commercial opportunities and guide our experimental work. To a Coalplex, a first application would idealize a system in which the components of optimal gas -- i.e., a low Btu fuel gas -- for generating equipment that combines gas- and steam-turbine cycles. (Auth)

AVAILABILITY: NTIS PB-229-101/AS ($4.00 paper copy/$1.45 microfiche)

TITL: University Research in Coal Utilization
AUTHOR: Squires, A. M.
CORPORATE AUTHOR: City College of The City University of New York, Dept. of Chemical Engineering
ADDRESS: New York, NY 10031
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BAW Program
ABSTRACT: This paper will concentrate upon: (1) need for large-scale experimentation with fluidized beds, especially beds for high fluidizing-gas velocity; (2) need for long range planning to provide energy supplies that are resilient in face of decline in Worldwide availability of natural gas and coal; and (3) the related need for a vigorous cadre of alert and active technologists, with strong ties between these in industry and universities. (Auth)
Production of Clean Fuel Gas From Bituminous Coal.
G. Curran, J. Clancy, B. Pasek, and M. Pell.
Consolidated Coal Co., Library, Pa. Research Div. Dec 73,
241p. EPA-650/2-73-049.
PB-232 695/7WE PC$6.00/MFS1.45

A process for the production of low-Btu gas from bituminous
coals via fluid bed gasification is described. Coal processing
consists of pretreatment, gasification, and final burnup. Hot
fuel gas is desulfurized with half-calcined dolomite and
cleaned of particulates in high-pressure drop cyclones. The
sulfur acceptor is regenerated with steam and CO2. A liquid-
phase Claus reactor is used to process the H2S in the
regenerator offgas into elemental sulfur. Experimental data are
presented which demonstrated feasibility of the major process
steps. An economic evaluation of gas clean-up operations
shows that regenerative use of acceptor is preferable to once-
through, and that removal of particulates via cyclones, if feasible,
is cheaper than water scrubbing with subsequent reheat.
The cost of the gas desulfurization process including sorbent
regeneration and sulfur recovery is of the order of 20
cents/MM Btu of product gas. (Modified author abstract)

COAL GASIFICATION: A TECHNICAL DESCRIPTION.
Coal gasification to produce SNG is nearly twice as efficient as
the burning of coal to produce electric energy. Pacific Coal
Gasification Company and Transwestern Coal Gasification Com-
pany are developing a project in New Mexico to produce 250

CONTINUOUS STEAM GASIFICATION OF COAL CHAR
IN AN ELECTROFLUID REACTOR. Beeson, J. L., Ames, IA;
No. 74-5252.
Thesis (Ph. D.).
An experimental investigation was made in which an electro-
fluid reactor for the steam gasification of coal char which
was operated at atmospheric pressure over a temperature range
of from 1200 to 1900°F. Both a single-phase and a three-phase
alternating-current power supply were used to operate the re-
actor. Since the gasification of coal char is not a proven appli-
cation of the electrofluid reactor, one of the purposes of the
investigation was to explore the operation of such a reactor over
long time periods to simulate the operation required of com-
mercial units. A second purpose of the investigation was to ob-
tain design information for electrofluid reactors. Calculations
studies were made with published data in addition to the experi-
mental work done with the reactor. Off-gas composition as a
function of steam conversion was studied using a model which
assumed the water gas shift and methanation reactions to be at
equilibrium. Agreement of experimental data with the model
was approximate at 1700°F, and the agreement improved with
increase in temperature. An overall plug flow model was used
to calculate inverse space velocity as a function of steam con-
version; the fluidization effects were accounted for by using
kinetic constants determined for fluidized bed reactors. The
calculated steam conversions were in approximate agreement
with the model at 1700°F; further, it was found that the reactivi-
ty of the coal char changed during the gasification, exerting a per-
cppicable effect on the observed steam conversion. (NCW)
TITLE: Production of Low-Stress Gas from Coal in Combination with Advanced Power Cycles  
AUTHOR: Dobner, S.  
CORPORATE AUTHOR: City College of the City University of New York, Dept. of Chemical Engineering  
ADDRESS: New York, NY 10031  
PUBLICATION DATE: 1972  
SPONSOR: National Science Foundation, EAV Program  
ABSTRACT: This paper reports on three procedures for providing clean low-stress gas from coal for use in combined cycle power generating equipment. Lurgi fixed bed gasifier operated by low temperature sulfur removal, and agglomerating fluidized bed gasifiers followed by low temperature sulfur removal, and agglomerating fluidized bed gasifiers followed by high temperature sulfur removal. Results demonstrate efficiency increases due to high temperature deminarization. (NSP)  
AVAILABILITY: NTL, PB-228-857 ($4.50 paper copy/$1.45 microfiche)  

(PB-224530-5-GA) CLEAN FUELS FROM COAL.  
A study of the production of clean synthetic fuels from coal resulted in recommendations for a total program of $1.51 billion. The work recommended is divided into a research phase at $33.6 million, a development phase at $315.0 million, and a demonstration phase at $1.15 billion. Work is outlined for alternate processes to produce clean low-stress gas, clean liquid fuels, and clean solid fuels from coal. Supporting work on the development of special equipment and improved materials along with economic coal engineering studies are proposed and funds provided in the budget estimates. (GRA)  

(UCID-16094) THERMODYNAMIC EQUILIBRIA FOR WYOMING COAL.  
Stephens, D. R.  
Temple University, Livermore (USA). Lawrence Livermore Lab.  
4 Aug 1972.  
28p.  
Dep. NTIS $5.00.  
As part of the program to evaluate in situ gasification of coal, the thermodynamics of Wyoming coal was calculated for pressures from 1 to 70 atm, temperatures from 600 to 1600°F, and varying steam-oxygen-coal compositions. Coal was not stable relative to carbon under any of the conditions investigated. Conditions favoring methane production included higher pressures, lower temperatures, and lower oxygen-to-water ratios. Calculated methane production was sensitive to the stability of carbon allowed to exist in the solid phase. If equilibria were frozen in the underground system at 30 atm and temperatures of 500°C or less, it is calculated that sufficient methane would be formed that surface methane facilities would not be required. Higher-temperature equilibria would require these surface facilities. (auth)  

(UCID-16155) THERMAL WAVE PROPAGATION MODELS FOR IN SITU COAL GASIFICATION.  
Sherwood, A. E.  
California Univ., Livermore (USA). Lawrence Livermore Lab.  
28p.  
Dep. NTIS $4.00.  
The dynamics of in situ coal gasification is discussed for simplified models, assuming the coal deposit can be treated as a fixed-bed chemical reactor. A thermal wave is shown to propagate at a characteristic velocity much smaller than the gas velocity and of the order of a few feet/hour. Peak temperature and width of the wave are calculated for first and second order reaction kinetic models, assuming a single overall coal reaction. The thermal wave is broadened by the estimated low heat transfer rate between gas and solid. Calculated coal heating rates are on the order of a few degrees centigrade/hour. (auth)
In view of the dwindling supply and increasing cost of natural gas and petroleum, the prime sources of energy for our society and feedstocks for our chemical industries, it is vital that we use them with utmost efficiency. Major contributions to more efficient use can be made by improving the selectivity with which industry carries out transformations of saturated hydrocarbons. Even minor improvements in the effectiveness of catalytic cracking and reforming can mean immense quantitative savings in crude hydrocarbon consumption. Improvements which lead to higher-quality motor fuel should also reduce the total amount of fuel consumed with attendant reduction of air pollution.

In the following pages, the status of research with respect to hydrocarbon activation is summarized and areas for future research are considered in terms of their practical application and theoretical significance. Given the diverse areas of strength amongst heterogeneous, homogeneous, and metalloenzyme catalysis, the opportunities for progress through multidisciplinary research seem attractive.


The union carbide-chemico coal gasification process: A strategy for commercialization
Coles, E. T., Paper presented at the 4th Synthetic Pipeline Gas Symposium, Chicago, Oct. 30-31, 1972. 13 pp. The Union Carbide-Chemico coal gasification process, a 2-stage fluidized-bed gasification process, offers such advantages as 1) the capacity to process coking coals without special pretreatment, 2) production of a medium-Btu (500+ Btu/CF) product gas containing no tar, phenols, oils or other condensables - eliminating water treatment of raw gas scrubber effluent, 3) production of substantially less CO₂, and 4) the use of smaller and less costly high-pressure particulate-free SO₂ removal systems. Details.

The Lurgi process. The route to SNG from coal


Optimization of Coal Gasification Processes
Issued April, 1972
R&D Report No. 66—Interim Report No. 1
Contractor: West Virginia University
Refer to: Titled report and GPO Catalog No. 163.10:66/
Int. 1
Price: $6.25

Char Oil Energy Development—Project COED
Issued May, 1972
R&D Report No. 56—Final Report
Contractor: FMC Corporation
Refer to: Titled report and GPO Catalog No. 163.10:56
Price: $4.00

Char Oil Energy Development—Project COED
Issued December, 1972
R&D Report No. 73—Interim Report No. 1
Contractor: FMC Corporation
Refer to: Titled report and GPO Catalog No. 163.10:73/
Int. 1
Price: $1.25

300-MM Lbs/Yr Acetylene Plant—Avco Arc-coal
Process
Issued May, 1972
R&D Report No. 67—Final Report
Contractor: Blaw-Knox Chemical Plants, Inc.
Refer to: Titled report and GPO Catalog No. 163.10:67
Price: $3.25
Special Purpose Coals—Adsorption Characteristics of Coal and Chars
Issued June, 1972
R&D Report No. 61—Interim Report No. 1
Contractor: Pennsylvania State University
Refer to: Titled report and GPO Catalog No. 163.10:61/
Int. 1
Price: $0.70

Special Purpose Coals—Mineral Matter and Trace Elements in U.S. Coals
Issued December, 1972
R&D Report No. 61—Interim Report No. 2
Contractor: Pennsylvania State University
Refer to: Titled report and GPO Catalog No. 163.10:61/
Int. 2
Price: $1.50

Engineering Evaluation and Review of Consol Synthetic Fuel Process
Issued June, 1972
R&D Report No. 70—Final Report
Contractor: Foster Wheeler Corporation
Refer to: Titled report and GPO Catalog No. 163.10:70
Price: $4.25

1972

PROCESS FOR A COAL GASIFICATION. Ban, T. E.
A process is described for producing water gas containing a large quantity of hydrogen and involving the formation of a moving quiescent gas-permeable bed composed of both particles of coal and particles of spent coal or ash. The bed is passed through a series of zones in which, in a succession of cycles, the bed is permeated with an oxygen-containing gas preheated to a predetermined temperature and then a moisture-laden gas also preheated to a predetermined temperature. These gases are collected separately after they traverse the moving quiescent bed. The water gas may be used as an industrial gas, and the production gas resulting from the portions treated with oxygen-containing gas may be recycled through the bed at a point downstream. The process provides a continuous economic procedure for gasification of coal. (Official Gazette)

1972

TITLE: SRC - SUBSTITUTE NATURAL GAS Producing SRC from Crude Oil and Naphtha
AUTHOR: Bittles, E.; Spitz, P.N.
CORPORATE AUTH: Chem Systems Inc.
ADDRESS: New York, NY
PUBLICATION DESCRIPTION: Chemical Engineering Progress, 68(12), 64-50
PUBLISHED DATE: 1972, December
ABSTRACT: The basic technology exists today to produce substitute natural gas from crude oil, or from any distillate fraction of the crude. The complexity of the process increases with the boiling point of the distillate feedstock, approaching that of a gasoline refinery for the heaviest fractions. SRC production in the future will depend on the availability of various feeds and its role in the total energy picture. (JNC)

1972

TN72-30977// Committee on Interior and Insular Affairs (U.S. Senate)
ADVANCED POWER CYCLES
Washington GPO 1972 279 p refs Hearing pursuant to S.
Res. 45 before Comm. on Interior and Insular Affairs, 92d
Congr., 2d Sess., 8 Feb, 1972
Avail: Comm. on Interior and Insular Affairs
The hearings are reported concerned with new technologies for the environmentally acceptable generation of electricity from coal. The processes for the gasification of coal, and the problems in the removal of sulfur compounds are discussed. Summaries of the EPA activities in compliance with the Clean Air Act are included.

L-5-8-74
L-4037A-001
PROPOSAL TO DEMONSTRATE FEASIBILITY OF CONVERTING COAL TO SUBSTITUTE NATURAL GAS

Draft environmental impact statement.

24 Jan 72, 18p ERL-1664

1972

PB-214 162/0
LOW-SULFUR CHAR AS A CO-PRODUCT IN
COAL GASIFICATION
G. P. Curran, W. E. Clark, Melvyn Felt, and
Everett Gorin, Oct 72, 70p EPA-R2-72-060
Contract EPA-EISD-71-15

PB-214 162/0

PB-206 048-D
Bureau of Mines, Washington, D.C.
PROPOSED SYNTANE COAL GASHIFICATION
PILOT PLANT TO DEMONSTRATE FEASIBILITY
OF CONVERTING COAL TO SUBSTITUTE
NATURAL GAS.
Final environmental impact statement.
22 Aug 72, 85p ERL-317S, FES-72-28
Supersedes report dated 24 Jan 72, PB-206 048-D.

EIS-AA-72-4175-F
Bureau of Mines, Washington, D.C.
SYNTANE COAL GASIFICATION PILOT
PLANT TO DEMONSTRATE FEASIBILITY OF
CONVERTING COAL TO SUBSTITUTE
NATURAL GAS.

PB-206 048-D
Bureau of Mines, Washington, D.C.
PROPOSED SYNTANE COAL GASHIFICATION
PILOT PLANT TO DEMONSTRATE FEASIBILITY OF
CONVERTING COAL TO SUBSTITUTE
NATURAL GAS.

Producers report dated 24 Jan 72, PB-206 048-D.

EIS-DA-72-4057-F
Bureau of Mines, Washington, D.C.
PROPOSED SYNTANE COAL GASHIFICATION PILOT
PLANT TO DEMONSTRATE FEASIBILITY OF
CONVERTING COAL TO SUBSTITUTE
NATURAL GAS.

1972

PRODUCING SNG FROM CRUDE OIL AND NAPHTHA.

An overall review is presented of the technology available today for the gasification of the whole range of crude-oil-derived feedstocks, as well as the factors influencing the choice and combination of various processes. The four gasification processes reviewed include low temperature catalytic steam reforming of light naphtha; steam reforming plus gas recycle hydrogenation of heavy naphtha; partial oxidation plus gas recycle hydrogenation of middle distillates; and partial oxidation plus fluidized-bed hydrogenation of whole crude. Typical economics for the four gasification schemes were developed. (MCW)

1972

N72-18760/

CLEAN AUTOMOTIVE FUEL: LABORATORY-SCALE OPERATION OF THE SYNTANE PROCESS
A. J. Forney, W. P. Haynes, J. J. Elliott, and R. F. Kenny
Feb. 1972 8 p refs

(TCP-454) Avail. NTIS

A high-Btu gas was made in order to demonstrate the feasibility of using the gas as a nonpolluting fuel for automobiles. The pilot plants were revised to combine the processes of coal gasification, gas purification, and catalytic methanation into an overall system. Tests in test automobiles showed the Synthane gas was less polluting than natural gas.

Author
The synthane process - research results and prototype plant design
Forney, A. J., and McGee, J. P., Paper presented at the 4th Synthetic Pipeline Gas Symposium, Chicago, Oct. 31, 1972. 26 pp. The U.S. Bureau of Mines is now concentrating its research on the gasification and methanation steps of its synthane process for the gasification of bituminous coal, sub-bituminous coal, and lignite to SNG. The gasifier operation was tested by Hydrocarbon Research, Inc., on a larger scale than possible at the Bureau of Mines' laboratories in Bruceton, Pa.; the process will be demonstrated in a 75 ton/day plant to be constructed by the Lummus Co. in Bruceton for 1974 operation. The process is described.

The COED and COGAS programmes
Eddinger, R.T., Paper presented at the 4th Synthetic Pipeline Gas Symposium, Chicago, Oct. 30, 1972. 8 pp. Reported are some of the recent results from the operation of a COED process pilot plant at Princeton, N.J., and the development of the COGAS process to convert coal to pipeline-quality SNG and a high-quality synthetic crude oil. Approximately $7 million will be spent on large-scale pilot work to demonstrate the economic and technical viability of the COGAS process in the next 3 yr. Tables give coal analyses, pyrolysis, product yields, product gas analyses, hydrogenation conditions, example oil hydrotreating results, example filtration runs on COED oil, and solids in COED oil. Flow charts illustrate the COED and COGAS processes.

NEW FUELS - OLD COAL.
C.W. Ertel and J.T. Metcalf.
A review of the logistic and engineering problems that need to be overcome in establishing a synthetic fuel economy based on coal conversion.

1533 p. Illus. 28 cm.
ELECTRIC POWER - VIA MARRIAGE OF CHEMICAL AND AEROSPACE INDUSTRIES.
F.L. Robson.
Chemtech, Apr.1972, p.239-249.

The approach that shows the most potential benefits involves essentially pollution free, low-heating value gaseous fuels for use in advanced-cycle power systems that operate at new levels of efficiency. Binary cycles, gas turbine systems, combined-cycle systems, and the COGAS systems are discussed.

GASIFICATION: A REDISCOVERED SOURCE OF CLEAN FUEL.
T.H. Maugh II.
Science, v.178, no.4056, Oct.6,1972, p.44,45.

ENERGY REFINERIES ARE EYED.
J.H. Prescott.

Seven companies have requested U.S. government approval to import crude oil for conversion to either substitute natural gas or to low-sulfur fuel oil.

CLEAN POWER FROM DIRTY FUELS.
A.M. Squires.

Considerations of both efficiency and pollution control suggest that a major effort should be mounted to generate electric power with turbines operated on power gas produced from coal or oil.
New horizons for pressure gasification - the production of clean energy

Hedden, D., and Percival, G., Instn. Gas Engrs. J., 15, (B), 229-46, (Aug. 1972). Coal hydrogenation process, catalytic methane synthesis, fluid-bed hydrogenation (FBH), gas recycle hydrogenation (GHR), catalytic rich gas (CRG). The first two are concerned with the gasification of coal. The FBH was developed for crude and heavy oils, the GHR for medium oils and heavy naphtha, and the CRG for light naphtha and liquefied petroleum gases. Each process, therefore, has its place in a spectrum of feedstocks extending from coal to LPG. All these processes have a common objective - the production of methane, a gas stable hydrocarbon and the principal constituent of natural gas. They are also all designed to operate at high pressure, a parameter that, thermodynamically, favours the formation of methane, facilitates the removal of sulphur and carbon dioxide, and minimizes capital charges.


The liquid-phase catalytic hydrogenation of coal to liquid and gas products is improved by the pretreatment of the catalyst with hydrogen, wherein the pretreatment temperatures are limited to about 300 to 400°F. The catalyst is substantially unreduced before startup oil is introduced into the reactor. (Official Gazette)


A method is described by which deeply buried coals can be converted to methane through chemical reactions with oxygen and water. The coal would first be shattered with conventional explosives, then retorted with an oxygen-water mixture at between 700 and 1000°F. The reactants would be pumped into the open of the coal deposit at between 500 and 1000 psi and carbon dioxide and methane would be removed from the bottom. No sulfur gases or fly ash should be produced and the water requirements can be satisfied from brackish water supplies. Coals available and suitable for this kind of gasification might yield as much as 10,000 trillion ft³ of pipeline gas. This constitutes about 300 times the present annual consumption, and if the process is successfully developed, it could materially alleviate future gas shortages. Rough estimates of process costs based on a plant capacity of 0.1 trillion ft³ per year indicate that an investor could expect about 15% internal rate of return on a $42 million capital outlay assuming $4 per MCF of gas as a field price. Both the capital requirement and selling price are much less than for surface gasification plants. Previous underground gasification has been accomplished with mined-galley or drill-hole low-pressure burning. The method proposed here should minimize bypassing of the coal by the inlet gases and thereby maintain a high-quality product. This is accomplished by flowing the reactant gases very slowly downward through the shattered coal, keeping the hot zones above the colder ones. This creates a thermally stable advancing hot zone and avoids the mixing of reactants and products. The proposed process will lead to ultimate surface subsidence of many feet of soil over the whole area of reacted coal. Experience from salt mine data suggests that there would be no surface disruption.

While the concept appears most promising from a theoretical point of view, it is unproven. To test its feasibility it will be necessary to conduct a number of laboratory studies and calculations and to perform pilot-scale field tests in suitable deep coal deposits.

TITLE: An Economic Evaluation of Pipeline Gas from Coal

AUTHOR: Katoll, S.

CORPORATE AUTHOR: U.S. Dept. of Interior, Bureau of Mines


PUBLICATION DATE: 1972, August

ABSTRACT: The total cost of building and operating a pipeline to transport 250 MM scf/day of 977-MBtu Btu Pittsburg coal was calculated. Based on this calculation, the price of the gas will depend on the price of the coal as follows: coal $8/ton, gas $678/MMSCF; $6/ton, $746/MMSCF; $8/ton, $908/MMSCF.
SUBSTITUTE NATURAL GAS: ANOTHER ALTERNATIVE IN THE ENERGY CRISIS. M. Wood.

Gas from the conversion of liquid hydrocarbons, naphtha, crude oil or coal.
Coal Gasification: A Review.
C. R. Aleta.
PB-228 887/6WE. PC5.00/MF51.45
Methods of underground and aboveground gasification of coal are reviewed. Four promising aboveground gasification techniques -- Hygas CO2 Acceptor Process, Bigas, and Synthane -- are described and compared. The objective of these four methods is to produce synthetic pipeline gas from coal. Recent trends, however, indicate that production of natural gas from gasification of naphtha feedstocks is likely to become commercialized earlier than production by gasification of coal. The environmental effects of fuel gasification of coal to supplement the deficiency of natural gas by the 1990's is discussed in the appendix. (Author)

A method is described for producing a synthetic pipeline gas by reacting a carboxaceous fuel in a gasifier. The gas is subjected to additional process steps including a final cryogenic separation of high methane content gas for use as the pipeline gas. (auth)

A study is presented that examines the concept of breaking underground coal deposits with nuclear explosions in order to provide fracture permeability for subsequent in-place treatment. The treatment would presumably be aimed at converting the coal to methane gas. Four nuclear explosion cases were analyzed: a 100-kiloton chimney in the upper model interval; a 200-kiloton chimney in both levels; two 100-kiloton chimneys, together covering both intervals; and an array of seven 125-kiloton explosions designed to break both levels. Only coal that is in the chimney rubble is calculated in the first three cases. Fractured rock outside the chimney is calculated for the array. Nuclear breakage of underground coal deposits is probably technically feasible. If an effective treatment method is developed, the costs of nuclear breakage in the overall economics of methane recovery would be minimal. The role of radionuclide and the possibility of subsidence during or after recovery of methane treatment should both be studied further. (auth)

On Dec. 20, 1963 a program of gas generator research and development was initiated by Bituminous Coal Research, Inc. for the Office of Coal Research. Phase II involves experimental studies on the 2-stage super-pressure coal gasification process initiated in March 1965. Batch tests in rocking autoclaves to continuous flow tests, first in an externally-heated 5 lb/hr flow reactor, and later in an internally-fired 100 lb/hr process and equipment development unit were performed. These experiments confirm the reactions of coal under conditions existing in Stage 2 of the two-stage process. The data were used in the design of a 100 lb/hr internally-fired Stage 2 reactor. Coals ranging in rank from lignite to high volatile A bituminous coal were used without difficulty. Based on results obtained from the 100 lb/hr process and equipment development unit, recommendations were made concerning the design of fully integrated 5 ton/hr pilot plant based on the two-stage super-pressure process. On June 18, 1969 the scope and nature of the Phase II studies were expanded to include additional testing of the Stage 2 PDU, completion of the engineering design of the pilot plant, additional petrographic analysis, and initiation of bench-scale work on a fluidized-bed unit. In April 1970, work again expanded to include gas purification and catalytic methanation and the application of fluidized-bed techniques in processes for gasification of char. Engineering evaluation and cost estimates of the two-stage super-pressure gasification process projected to full-scale commercial operation are summarized. The engineering evaluations and cost estimates of processes for a proposed multipurpose research pilot plant facility are reported together with the designing and planning for an oxygen-blown two-stage gasification system as the initial pilot plant in the facility. A summary is provided of the reports and publications emanating from the program. (MCW)

PB-200 880-F. PC83.00/MF80.95
Office of Coal Research, Washington, D.C.
PROPOSED PILOT PLANT, HOMER CITY, PENNSYLVANIA.
Final environmental impact statement.
Descriptors: Environmental surveys, Industrial plants, (Pennsylvania, Environmental surveys), Coal gasification, Environmental surveys, Pilot plants, Industrial waste treatment.
Identiifiers: Environmental impact statement, HIGAS coal gasification plant, Homer City (Pennsylvania), Indiana County (Pennsylvania).

The proposed pilot plant will test out a process employing oxygen and steam at elevated pressures in a two-stage gasifier, to convert coal to pipeline-quality gas, the exact equivalent of natural gas. No environmental problems are expected. In the case of malfunction, the plant will be shut down until it meets environmental requirements.

283
Engineering Evaluation of Project Gasoline, Consol Synthetic Fuel Process
Issued January, 1971
R&D Report No. 59—Final Report
Contractor: Foster Wheeler Corporation
Refer to: Titled report and GPO Catalog No. 163.10:59
Price: $2.75

Final Report of the Advisory Committee on Project Gasoline
Issued January, 1971
R&D Report No. 62
Contractor: National Academy of Engineering
Refer to: Titled report and GPO Catalog No. 163.10:62
Price: $0.30

Estimation of Coal and Gas Properties for Gasification
Design Calculations
Issued August, 1971
R&D Report No. 22—Interim Report No. 7
Contractor: Institute of Gas Technology
Refer to: Titled report and GPO Catalog No. 163.10:22/Int. 7
Price: $1.50

Economics of Generating Clean Fuel Gas from Coal Using an Air-Blown Two-stage Gasifier
Issued December, 1971
R&D Report No. 20—Supplement to Final Report
Contractor: Bituminous Coal Research, Inc.
Refer to: Titled report and GPO Catalog No. 163.10:20/Sup 1
Price: $0.45

Engineering Study and Technical Evaluation of BCR “Two-stage Superpressure Gasification Process”
Issued February, 1971
R&D Report No. 60—Final Report
Contractor: Air Products and Chemicals, Inc.
Refer to: Titled report and GPO Catalog No. 163.10:60
Price: $2.25

Char Oil Energy Development—Project COED—The Desulfurization of COED Char, Part III
Issued January, 1971
R&D Report No. 56—Interim Report No. 2
Contractor: FMC Corporation
Refer to: Titled report and GPO Catalog No. 163.10:56/
Int. 2
Price: $1.25

Electrothermal Hygas Process Escalated Costs
Issued June, 1971
R&D Report No. 22—Interim Report No. 6
Contractor: Institute of Gas Technology
Refer to: Titled report and GPO Catalog No. 163.10:22/
Int. 6
Price: $0.40

DESULFURIZED COAL?
H.C. Messman.

The desulfurizing activity of caustic, coupled with its high-temperature volatility, portends an interesting area of R&D.


Char Oil Energy Development—Project COED—Process Development Unit Results and Commercial Analyses
Issued May, 1970
R&D Report No. 56—Interim Report No. 1
Contractor: FMC Corporation
Refer to: Titled report and GPO Catalog No. 163.10:56/Int. 1
Price: $2.50

Summary Report on Project Gasoline—Volume I
Issued April, 1970
R&D Report No. 39—Interim Report No. 5
Contractor: Consolidation Coal Co.
Refer to: Titled report and GPO Catalog No. 163.10:39/Vol 1
Price: $3.25

Pipeline Gas from Lignite Gasification—Current Commercial Economics
Issued January, 1970
R&D Report No. 16—Interim Report No. 4
Contractor: Consolidation Coal Co.
Refer to: Titled report and GPO Catalog No. 163.10:16/Int. 4
Price: $0.50

1970 Final Report—Consol Synthetic Fuel Process
Issued July, 1970
R&D Report No. 45—Final Report
Contractor: The Ralph M. Parsons Company
Refer to: Titled report and GPO Catalog No. 163.10:45
Price: $0.30

Project Western Coal—Conversion of Coal Into Liquids
Issued August, 1970
R&D Report No. 18—Final Report
Contractor: University of Utah, Fuels Engineering Dept.
Refer to: Titled report and GPO Catalog No. 163.10:18
Price: $1.25

Project Seacoke—Volume I with Appendixes A, B, and C
Issued January, 1970
R&D Report No. 29—Final Report
Contractor: Arco Chemical Co., Division of Atlantic Richfield Co.
Refer to: Titled report and GPO Catalog No. 163.10:29/Vol. 1
Price: $1.25

Project Seacoke—Volume II with Appendix D
Issued January, 1970
R&D Report No. 29—Final Report
Contractor: Arco Chemical Co., Division of Atlantic Richfield Co.
Refer to: Titled report and GPO Catalog No. 163.10:29/Vol. 2
Price: $4.00

COAL INVESTIGATIONS USING LASER IRRADIATION
1970 36 p refs.
IBM-R1-7328. Avail. Issuing Activity
 Conditions necessary to obtain optimum yield of useful products when coal is rapidly heated to extreme temperatures by laser irradiation were determined. Product distribution and yield were investigated as functions of several variables. Low rank coals with high volatile matter gave highest total gas yields. Medium rank coals gave the highest yields of H2 and C2H2 and low rank coals gave highest yields of CO and CO2. Macerals gave gases of approximately the same composition, but the total gas yield increased in the order fusinite, micrite, vitrinite, and exinite. Total gas and C2H2 yields varied inversely with particle size. The addition of nominally inert gases such as Ar, He, N2 increased yields of H2, C2H2, and total gas. Metals such as nickel and platinum had little influence on the rate of coal decomposition. Total gas yield increased with total energy of irradiation, and the ratio of C2H2/CH4 increased with concentration of energy. A study was also made of the irradiation temperature, and a material balance was calculated.

CONVERSION OF COAL TO GASOLINE.
G. A. Mills.

Paper presents new catalytic concepts for the conversion of coal to gasoline and offers possible solution to a growing problem—the need for new methods of fuel production.

Office of Coal Research, R&D

Atlantic Richfield Co., FMC Corp.

Contract 14-01-0001-473

Seacoake project

Fuels – Synthesis

Petroleum

L-89, 652/146
L-5-23-74


Office of Coal Research, R&D

Washington, D.C.

Consolidation Coal Co.

Contract (DI)-14-02-0001-310(1)

Coal – Gasification

Fuels – Synthesis

Gasoline project

L-89, 652/147
L-5-7-74
II. A/WU, WILLIAM R. K.
HYDROGENATION OF COAL AND TAR. By W. R. K. WU AND H. H. STORCH.
U.S. DEPT. OF THE INTERIOR, BUREAU OF MINES; (FOR SALE BY THE SUPT. OF DOCS.; U.S. GOVT. PRINT. OFF.; (WASHINGTON) VII, 193 P. ILLU. 26 CM.
UNITED STATES. BUREAU OF MINES. BULLETIN 633 1.25 (PAPER COVER)
LC:COAL LIQUEFACTION. COAL- TAR. HYDROGENATION.
ADDED:STORCH, HENRY HERMAN, 1894- JOINT AUTHOR.
MAIN-AUTH TRACE-SERS•TITL•AUTH•CATLG BY-LC

74V42500 1968 ISS:00 QE105.443 NO. 430 662.66 LC-68-7898
A/RISSE, HUBERT E.
** GASIFICATION ** AND LIQUEFACTION: THEIR POTENTIAL IMPACT ON
VARIOUS ASPECTS OF THE COAL INDUSTRY (by) HUBERT E. RISSE.
ILLINOIS STATE GEOLOGICAL SURVEY, URBANA, 28 P. ILLU., MAPS. 25 CM.
ILLINOIS STATE GEOLOGICAL SURVEY. CIRCULAR 430 COVER TITLE.
BIBLIOGRAPHY: F. 28. ILLINOIS UNIV. LIBRARY
LC:COAL ** GASIFICATION ** -- ILLINOIS. COAL LIQUEFACTION --
ILLINOIS. COAL TRADE -- ILLINOIS.
MAIN-AUTH TRACE-SERS•TITL•CATLG BY-OTHER

Kernforschungsanlage, Juelich (West Germany)
SOME PROBLEMS OF LIQUEFIED GASIFICATION BY MEANS
OF HIGH-TEMPERATURE NUCLEAR REACTOR HEAT
[UEBER EINIGE PROBLEME BEI DER VERGASUNG VON
BRAUNKOHLEN MIT HOCHTEMPERATUR-KERNREAKTOR
WAERME]
K. Kugeler und A. T. Bhattacharyya Aug 1968 37 p refs In
GERMAN
(JUL-554 RG) Avail: CFSTI

Cost Estimate of a 500 billion Btu/Day Pipeline Gas
Plant Via Hydrogasification and Electrothermal
Gasification of Lignite
Issued November, 1968
R&D Report No. 22—Interim Report No. 3
Contractor: Institute of Gas Technology
Refer to: Titled report and PB-193928
Price: $6.00 NTIS

Qader, S. A., "Production of Synthetic
Fuels from Coal by Hydrogenation
under Medium Pressures", Amer. Chem.
Soc. Div. Fuel Chem., V. 12, n. 3,

Project Gasoline Pre-pilot Plant—Phase I—Research
on CSF Process—Volume II,
Issued November, 1968
R&D Report No. 39—Interim Report No. 1
Contractor: Consolidation Coal Company
Price: $4.50 OFFICE COAL RES.

Hydrocarbon Research, Inc., "Project
14-01-0001-47, Office of Coal Re-

85, pp. 98-103, 1968.

White, D. J., et al, "To Treat and
Crack Oil from Coal", Hydrocarbon
Process, V. 47, n. 12, pp. 97-102,
1968.
Commercial Process Evaluation of the H-Coal Hydrogenation Process
Issued February, 1967
R&D Report No. 26—Interim Report No. 1
Contractor: Hydrocarbon Research, Inc.
Refer to: Titled report and PB-174696
Price: $6.00 NTIS

Evaluation of Project H-Coal
Issued December, 1967
R&D Report No. 32—Final Report
Contractor: American Oil Company
Refer to: Titled report and PB-177068
Price: $6.00 NTIS

Process Design and Cost Estimate for Production of 266 Million SCF/Day of Pipeline Gas by Hydrogasification of Bituminous Coal—Hydrogen by the Steam-Iron Process
Issued February, 1967
R&D Report No. 22—Interim Report No. 2
Contractor: Institute of Gas Technology
Refer to: Titled report and PB-174064
Price: $6.00 NTIS

Char-Oil-Energy-Development—Project COED
Issued February, 1967
R&D Report No. 11—Supplement to Final Report
Contractor: FMC Corporation
Refer to: Titled report and PB-173916 (Final); Titled report and PB-173917 (Appendix)
Price: $6.00 each NTIS

Char-Oil-Energy-Development—Project COED
Issued March, 1966
R&D Report No. 11—Final Report
Contractor: FMC Corporation
Refer to: Titled report and PB-169562 (Vol. I); Titled report and PB-169563 (Vol. II)
Price: $6.00 each NTIS

Plasma Reactions with Powdered Coal
Issued August, 1966
R&D Report No. 18—Interim Report No. 2
Contractor: University of Utah, Fuels Engineering Department
Price: $1.00 OFFICE OF COAL RES.
HYDROREFINING COAL-OILS TO FUELS FOR SUPERSONIC AIRCRAFT.
C.O. Hawk, M.D. Schlisinger, P. Dobransky and R.W. Hiteshue.
Bureau of Mines RI-665 1965

Distillable oils derived from coal were desulfurized and hydrogenated at 2,500 psig in a two-step vapor-phase catalytic operation to give a product rich in saturated cyclic hydrocarbons. The first step was mainly a desulfurization at 400°C, the second a saturation at 300°C. One of the oils used as feed stock was from low-temperature carbonization of a bituminous coal, the other was from the liquid-phase hydrogenation of coal in the Bureau's pilot plant. The product from the saturation step was distilled to remove the light ends and high-boiling residue and to recover a fraction having acceptable properties with respect to heating value, density, freezing point, viscosity, and boiling range according to specifications suggested by the Air Force for ultra-high-speed aircraft fuel. Quantities of the fuel fraction available were too small for the thermal stability test approved by the Air Force.

CH-140,416 1964
HYDROGASIFICATION OF HIGH-VOLATILE A BITUMINOUS COAL. Raymond W. Hiteshue, Sam Friedman, and Robert Madden. 1964. 31p.
Bureau of Mines RI 6376

CH-140,618 (1961)
Bureau of Mines RI 5902
SHALE OIL—NOT LONG NOW.
G.E. Weismantel.
Chem. Eng., v.81, no.10, May 13,1974, p.62,64.

As the U.S.'s prototype leasing program for oil-shale lands nears completion, various processing schemes are jockeying for position, and a number of non-technical problems are emerging.

SHALE GASIFICATION UNDER STUDY.

OIL SHALE AND THE ENERGY CRISIS.
G.U. Dinneen and G.L. Cook.

As energy becomes more costly the temptations grow and commercial use of oil shale nears; but substantial technological and environmental problems remain.

SHALE OIL—PROCESS CHOICES.

Here's a rundown on some of the routes being groomed for production of shale oil. One of these, the Tosco II process, is already considered proven and is on the verge of commercialization.

OIL FROM ROCKS: WORK BEGINS IN EARNEST.

A first and vital step has been taken toward mass production of fuel from America's vast deposits of oil shale.

INDUSTRY GEARING UP FOR ASSULT ON ATHABASCA TAR SANDS.
Oil & Gas Journal, v.72, no.5, Feb.4,1974, p.85,86, 90.

Northeastern Alberta's tar sands hold 26.5-billion bbl of synthetic-crude reserves recoverable by a proved process.
AT LAST, CANADA'S TAR SANDS LOOK ECONOMIC.

The pressure is mounting to tap the vast reserves of oil locked in Alberta.

Some Effects of Pressure on the Hydrocracking of Crude Shale Oil Cobalt Molybdate Catalyst.
C. M. Frost, and P. L. Cottingham.
Bureau of Mines, Washington, D.C. Jan 74, 16p BuMines-Rl-7835
PH-229 842/5WE PC$3.00/MFS$1.45

Crude shale oil produced by gas-combustion retorting of Green River oil shale was hydrocracked over a cobalt molybdate catalyst at operating pressures of 500, 1,000, 1,500, and 3,000 psig, an operating temperature of 890°F, and a liquid hourly space velocity of 1.0. Hydrogen feed rate was maintained at 6,000 scf/bbl. The volume-percent yields of total liquid product were directly proportional to the operating pressure. Weight-percent conversion and volume-percent yields of gasoline were directly proportional to the log of the operating pressure. Catalyst deposit percentages were inversely proportional to the log of the operating pressure. Nitrogen and sulfur removal rates as well as saturation of the liquid products increased as the operating pressure was increased. (Author)

A process and apparatus are disclosed for the continuous steady state retorting of ground oil shale in the absence of air. Retorting is accomplished by countercurrently contacting heated spent oil shale with fresh ground oil shale in a vessel from which air is excluded. The spent oil shale is heated by combustion of its carbonaceous residue to form a hot heat transfer medium which, when contacted with fresh oil shale in the retorting process, provides the energy for the recovery of hydrocarbons. (Author)

Oil Shale. A Bibliography with Abstracts.
Axel C. Ring.
COM-74-1066/5WN PCS20.00/MFS20.00

This bibliography contains 89 selected abstracts of research reports retrieved using the NTIS on-line search systems—NTISearch. The reports selected cover all phases of oil shale research, including exploration, mining, retorting, chemistry, environmental impacts, and policies.
OIL SHALE: A HUGE RESOURCE OF LOW-GRAD E FUEL.
W.D. Metz.
Science, v.184, June 1974, p.1271,72,74,75.

The rich oil shale deposits on the western slope of the Rocky Mountains constitute a potential source of fuel several times as great as the identified reserves of US oil, and processes for extracting synthetic crude oil from the thick seams of brown-black rocke have been ready to go for 15 years.

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Huge resources needed to exploit shale oil

Colin Norman

Nature, 711 National Press Building, Washington DC, 20004

Although there is plenty of shale oil in the United States, treatment at the surface of the rock that contains the oil would require prohibitive amounts of water. But the alternative, production in situ, is not yet a well-developed technique.

A rapid and practical test for oil-shale richness is of considerable technical importance. Although the Fischer-Schrader method has gained universal acceptance for determination of shale richness, there is need to relate results from this determination to fundamental parameters of the shale. One much-used relation is with elemental analysis, and numerous equations have been derived to correlate shale richness with organic carbon content. These relations have been reviewed, and from a number of intensively analyzed samples selected from a core in the Parchute Creek member of the Green River Formation equations relating oil yield by Fischer-Schrader determination to organic carbon content have been developed: oil (wt %) = 0.0317(%) Corg - 0.2569 and oil (g/lton) = 2.316(%) Corg - 0.7714. Additionally, more detailed knowledge of the uniformity of organic material throughout the Green River Formation was obtained. It was found that the fraction of kerogen which on pyrolysis yields liquid products is constant stratigraphically throughout the formation, even though the oil composition is not.

26 references. (auth)

DRIVE FINALLY BUILDING IN U.S. TO DEVELOP OIL SHALE.


Energy prices are high enough to support a drive to tap vast deposits of shale oil locked in a three-state region of the Rocky Mountains.


Simple chemical reactions are described that bring about modification of the components of a bitumen. This is accomplished by using an oxygen-containing gas and subsequent treatment with alkali solutions of sulfites and/or bisulfites. The resulting water-soluble sulfonated bituminous derivatives have significant emulsifying and dispersing powers and are likely to be of use in extracting the bitumen in situ. (auth)

(JCR1-75244(Rev. 1)) OUTLOOK FOR OIL SHALE.


From 140th meeting of The American Association for the Advancement of Science; San Francisco, California, USA (25 Feb 1974).

The extent to which oil from domestic oil shale will provide energy in the future depends as much on national and regional, political decisions, as it does on technical or end-use issues. Technology available to supply oil from oil shale at present prices and with a total reserve of about 54 billion barrels of oil, if some government land is made available and environmental requirements are defined. The capability of developing technology within this decade to produce oil in large enough quantity and at low enough cost to exert a major influence on the national and international oil market exists. In situ processes and/or massive open-pit technology would open up a much larger resource (200 to 600 billion barrels) within a small area (600 m²) of Colorado. Development of this technology is beyond the capability of industry alone and will require a definition of the role of government in the planning, management, production, and ownership of the resource. (auth)

RESEARCH ON THERMAL BEHAVIOR OF OIL SHALES.


For the characterization of the thermal behavior of the organic and inorganic mass of oil shales research was carried out with the aid of a derivatograph on the material itself and on the residue resulting from the extractions with pyridine and quinoline in oxidizing, reducing and inert medium. The exothermal and endothermal zones and resulting weight losses were determined. The correlation of the experimental data shows that the oil shale burning takes place in a relatively low temperature domain. (tr-auth)


A researc'h study of tar sands in Colbert, Franklin, Lawrence, and Morgan counties in Alabama was carried out in 1972. Fieldwork included geologic mapping of the Hartsville Sandstone of Mississippian age and its oil imregnated intervals, sampling along the outcrop of the oil bearing zones, and analysis to determine the porosity, permeability, and hydrocarbon saturation. Seven core holes were drilled down to the outcrop of the oil-imregnated sandstone and then analyzed. Hydrocarbon reserves were calculated from the analyses resulting in the conclusion that within an area of 22,000 acres there are about 150 million barrels of oil imregnated in the sandstone. Appendix A includes measured sections data; Appendix B includes Alabama tar sands core holes data; and Appendix C is the Shell Oil Company core holes data. Five maps or plates are locations of measured sections; oil saturation; total thickness of oil imregnated sand; possible oil reservoir; and a generalized geologic map of Morgan County and parts of Lawrence County. IMC}
Refining Improvement of Shale-Oil Naphtha
Bureau of Mines, Wash., D.C.

Gives results of tests conducted to determine how much improvement would be made by subjecting hydrogenated shale oil naphtha to a catalytic reforming process. April 1973. 20 pp. PC $3/MF $1.45 order PB-220-585


This is one of a series of reports by the committee on U. S. energy outlook of the National Petroleum Council. It is divided into the following sections: (1) introduction, (2) supply elasticity, (3) effect of government policies and legislation, (4) changes in technology and the learning-curve effect, and (5) regional considerations for direct support of an oil-shale industry.

BITUMEN-BEARING ROCKS
W. S. Cashion In Its US Mineral Resources 1973 p 99-104 refs (For availability see N74-15214 06-18)

Bitumen bearing rocks occur in many areas in the United States, but few deposits have been exploited or evaluated for their total energy potential. The evaluated deposits are a relatively small part of North American resources of bitumen bearing rocks and probably will not contribute to U.S. energy needs before 1985. Studies of known but unassessed deposits, especially extensive subsurface tar sands, will greatly increase total resource estimates. Technological advancements are needed in tar sand processing, especially for in situ recovery methods.

Author

N74-19047# Sandia Labs, Albuquerque, N.Mex.
FRAC TURE OF COAL AND OIL SHALE FOR IN SITU PROCESSING OR REMOTE REMOVAL: A PROPOSAL SUPPORT DOCUMENT

The proposal sets forth the concept of using the synergistic effects of a combination of hydraulic and explosive techniques to fracture these formations in a controlled manner.

Author (NSA)
AICHE Symposium Series, v.69, no.127 1973

DECLINING DOMESTIC RESERVES - EFFECT ON PETROLEUM AND PETROCHEMICAL INDUSTRY. C.H. Cummings, ed. (Contains papers presented at the 71st National Meeting of AICHE, Dallas, (Tex., 1973)).

American Inst. of Chemical Engineers

OUTLOOK FOR CANADIAN OIL SANDS DEVELOPMENT ............................................. J. D. Harvie, J. H. Nichols, and A. G. Winestock 30

OUTLOOK FOR HYDROCARBON PRODUCTION FROM DOMESTIC OIL SHALE, COAL, AND TAR SANDS .... J. Wade Watkins, G. Alex Mills, and Jack E. Phillips 32

PILOT PLANT STUDY OF THE ENGINEERING ASPECTS OF RETORTING OIL SHALE IN A NUCLEAR CHIMNEY ................................................................. H. W. Sohns, A. E. Harak, and H. C. Carpenter 50

ENGINEERING ASPECTS OF PROCESSING OIL SHALE BY IN SITU RETORTING .................. Harry C. Carpenter, Edward L. Burwell, and Harold W. Sohns 96

MANUFACTURE OF LOW SULFUR FUEL OILS FROM OIL SHALE. . R. H. Smith 98

The world's largest oil shale reserves are found in the Green River formation of Colorado, Utah, and Wyoming, containing an estimated 1.6 trillion barrels of oil, of which approximately 600 billion barrels can be developed with the present technology. Crude shale oil can be hydrotreated at the mine site. As a premium fuel oil it either can be blended with high sulfur stocks to yield fuels meeting environmental specifications or can be used as fuel for stationary gas turbine plants. As a premium feedstock it can be used to produce gasoline and fuel oils in a simple, low-cost refinery operation. Hydrotreated shale oil naphtha can be marketed as a feedstock for SNG manufacture. (MCW)
TITLE: Nuclear In Situ Recovery of Oil From Oil Shale

AUTHOR: Lewis, A.F.

CORPORATE AUTH: Lawrence Livermore Laboratory

ADDRESS: University of California, Livermore, CA 94550

PUBLICATION DESCRIPTION: Report No. UCRL-51453, 40 p., 42 references

PUBLICATION DATE: 1973, September 16

SPONSOR: U.S. Atomic Energy Commission

ABSTRACT: A plan is presented for production of oil by retorting oil shale in situ after breaking it with underground nuclear explosives. Reserves of oil shale of thickness and grade suitable (greater than 20 sq/ton) for this process occur in the Piceance Creek Basin of Colorado, and are estimated to contain 660 billion barrels of oil in place. Cost projections indicate that this oil could be produced at a price ranging from $2.00 to $3.30 at the wellhead with a 20% rate of return on investment (discounted cash flow). The price and production rate vary with oil shale thickness. At a rate of 32 nuclear chisels per year in oil shale ranging in thickness from 1000 to 2000 ft., production varies from 28 million bbl/yr ($3.30/bbl) to 121 million bbl/yr ($2.00/bbl). Capital requirements for this in situ process are estimated to be 20 times less than those required by a surface retorting process. Environmental problems such as the need to dispose of large volumes of waste rock associated with conventional mining and surface retorting of oil shale would be largely avoided. Problems of seismic ground motion and possible contamination of the oil and groundwater appear manageable.

The necessity for government action arising from federal ownership of the resource as well as the requirement for a significant government contribution to the development of the nuclear in situ retorting technology requires either government development of the resource or a policy defining how industry and government may jointly develop it. The potential contribution to the energy resources of the nation is so large that this method of recovery from oil shale must be considered. (End)

AVAILABILITY: NTIS ($5.40)

N73-29387# Interior Dept., Washington, D.C.

ENVIRONMENTAL STATEMENT FOR THE PROPOSED PROTOTYPE OIL-SHALE LEASING PROGRAM. VOLUME 1: DESCRIPTIONS OF THE REGIONS AND POTENTIAL ENVIRONMENTAL IMPACTS

Sep. 1972 501 p. refs
(EIS-AA-72-5242-D-1-Vol-1) Avail: NTIS HC $27.25

The regional environmental impact expected from shale development on private and public lands is examined. A companion document reviews the specific impacts associated with the development of six leases on public lands if the Department of the Interior's proposed prototype oil shale leasing program is implemented. A current state-of-the-art assessment of the technology that may be employed in oil shale development is provided. Included in this assessment are methods of processing; technology related to the management of solid wastes and wastes within the working areas; monitoring methods; and a guide to current research that pertains to the environmental aspects of oil shale development. The regional environmental impact of oil shale development to a maximum cumulative production of 1 million barrels per day by 1985 is described.

Author

N73-29388# Interior Dept., Washington, D.C.

ENVIRONMENTAL STATEMENT FOR THE PROPOSED PROTOTYPE OIL-SHALE LEASING PROGRAM. VOLUME 2: ENERGY ALTERNATIVES

Sep. 1972 228 p. refs
(EIS-AA-72-5242-D-2-Vol-2) Avail: NTIS HC $13.50

This section of the environmental impact statement discusses energy alternatives to the proposed action cast in the framework of the Proposed Prototype Oil-Shale Leasing Program. This prototype plan anticipates six test leases, two each in the States of Colorado, Utah, and Wyoming, and a program that might lead to a maximum total production of 1 million barrels of shale oil per day by the year 1985 from both public and private lands. This document discusses: (1) energy situation; (2) role of energy in economic growth; (3) energy requirements of the United States to meet projected future needs; (4) substitutability of energy forms; (5) factors that affect fuels development; (6) background of petroleum situation, both present and future; (7) oil-shale development possibilities and (8) alternatives to the Proposed Prototype Oil-Shale Leasing Program.

Author

N73-29389# Interior Dept., Washington, D.C.

ENVIRONMENTAL STATEMENT FOR THE PROPOSED PROTOTYPE OIL-SHALE LEASING PROGRAM. VOLUME 3: DESCRIPTION OF PROPOSED PROTOTYPE LEASES AND POTENTIAL ENVIRONMENTAL IMPACTS

Sep. 1972 359 p. refs
(EIS-AA-72-5242-D-3-Vol-3) Avail: NTIS HC $20.00

Specific impacts associated with the development of up to six tracts which, if implemented, would be offered for development under the Department of the Interior's proposed prototype oil shale leasing program are discussed in detail.
LC: LIQUID FUELS -- PATENTS. SHALE OILS -- PATENTS.
MAIN-AUTH: TRACE-SENS
TITL: CATLG BY-LC

TITLE: Oil Shale - A Statemide Answer to
Petroleum Scarcity
CORPORATE AUTHOR: Mining Engineering
ADDRESS: 365 W. 47th St., New York, NY 10017
PUBLICATION DESCRIPTION: Mining Engineering, 26 (10), 95-96
PUBLICATION DATE: 1972, October
ABSTRACT: A summary of the largest development of
oil shale in this country is given. This
location is in western Colorado on privately
owned land. Larger reserves exist on federal
lands. The history, the Oil Shale
Corporation (OSCO) process, the mining
methods, the waste disposal, and the land
status are described. (JMC)

TITLE: The Few Look in the Syncrude Canada Tar
 Sands Project
AUTHOR: Sprague, F.R.
CORPORATE AUTHOR: Syncrude Canada Ltd.
ADDRESS: Edmonton, Alberta, Canada
PUBLICATION DESCRIPTION: Mining Engineering, 26(10), 90-93
PUBLICATION DATE: 1972, October
ABSTRACT: The Athabasca tar sands in Alberta,
Canada, are a rich potential source of
synthetic crude oil. The Great Canadian Oil
Sands plant is currently producing approx.
5,000 barrel/day of crude oil. A proposed
Syncrude plant will produce approx.
125,000 barrel/day. The two processes differ in
details of operation. (JMC)

Canada's tar sands next
improved the economics of producing synthetic crude at Athabasca that large-scale development
of Canada's tar sands now looks certain. A description is given of the efforts of the Great
Canadian Oil Sands company to produce and sell synthetic crude and of projects proposed by other
companies including the Syncrude consortium, Shell, Amoco, Texaco, and BP. (DTI)
C. HYDROGEN AND METHANOL

Modern computerized literature search techniques were used to compile this extensive bibliography with abstracts on all aspects of the 'Hydrogen Economy.' This bibliography seeks, as its main goal, to cover the topic of hydrogen as an energy carrier. Topics discussed include the following: General; production; utilization; transmission, distribution and storage; safety.

HYDROGEN AND ENERGY.
C. Massetti.

Hydrogen, which is already used through chemically bonded forms by the ton in petroleum and petrochemical industries could become in the future the energetic support complementary to electricity. However its generalized use will make sense only if it can be produced in acceptable yields from fusion, nuclear, or solar energy in a safe non polluting way. These conditions involve important technological new developments with a large impact since it means not less than the substitution of all uses of hydrocarbon fossils. The new prices of crude oils (this paper was written in Novembre 1973) give more importance still to this technological challenge.

THE WIND OF HYDROGEN AND OF CHANGE BLOW GENTLE, CLEAN, AND PERSISTENT AT MIAMI......
R.W. Cahn.

Professor Cahn, of the School of Applied Sciences, Univ. of Sussex, gives his impressions of a recent conference on the Hydrogen Economy held in Miami.

HYDROGEN ECONOMY CONCEPT GAINS CREDENCE.
(Report from the Miami Conference)
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar.18-20, 1974.

THE ENERGY CRISSES
F. Schulman, Fred Schulman Associates, Silver
Spring, Maryland

THE HYDROGEN ENERGY ECONOMY — A TECHNOLOGY ASSESSMENT
E. Dickson, T. Logothetti, T. Lyman, L. Weisbecker, Stanford Research Institute, Menlo Park,
California

HYDROGEN: MECHANISMS AND STRATEGIES OF MARKET PENETRATION
C. Marchetti, Euratom, Ispra, Italy

FUTURE UNITED STATES ENERGY DEMAND PATTERNS AND THE USE OF HYDROGEN
L. Blank, University of Texas, R. Riley, University
of Missouri, Rollo, Missouri

TECHNICAL PROBLEMS FACING THE HYDROGEN ECONOMY
D. Gregory, Institute of Gas Technology, Chicago,
Illinois

HYDROGEN — THE ULTIMATE ENERGY SOURCE
J. G. Hirschberg, University of Miami, Coral
Gables, Florida

SOCIAL AND ENVIRONMENTAL CONTEXT OF THE HYDROGEN ECONOMY
J. D. Salmon, Virginia Polytechnic Institute and
State University, Blacksburg, Virginia, J. G.
Wittwer, University of Oklahoma, Norman
Oklahoma

ENVIRONMENTAL IMPACT OF A SUITABLE NUCLEAR POWER REACTOR USED TO PROVIDE A PROCESS HEAT SYSTEM TO SYNTHESIZE FUELS
J. A. Richardson, Burns and Roe, Inc., Oradell,
New Jersey

OCEAN SITING FOR HYDROGEN POWER PLANTS
G. Rothwell, I. Yumori, Y. Yamashita, S. Ribakoff, D. Wilson, Oceanic Institute, Waimanalo,
Hawaii

HOW MIGHT THE HYDROGEN ECONOMY AFFECT OUR RESOURCES AND ENVIRONMENT?
H. Plass, University of Miami, Coral Gables,
Florida

H₂ — O₂ COMBUSTION POWERED STEAM-MHD CENTRAL POWER SYSTEMS
G. R. Seikel, J. M. Smith, L. D. Nichols, National
Aeronautics and Space Administration, Lewis
Research Center, Cleveland, Ohio

THE HYDROGEN ECONOMY AND THE LAW
T. C. Cady, West Virginia University, Morgantown,
West Virginia

NUCLEAR ENGINEERING IMPACT UPON THE HYDROGEN ECONOMY
J. O. Mingle, N. D. Eckhoff, Kansas State Uni-
versity, Manhattan, Kansas

DYNAMICS OF A UNIVERSAL HYDROGEN FUEL SYSTEM
T. N. Veziraglu, University of Miami, Coral
Gables, Florida

ULTIMATE ENERGY, THE ULTIMATE FUEL AND THE HYDROGEN LINK — OUR ELECTRICAL ENERGY SYSTEM
C. M. Summers, University of Kansas, Lawrence,
Kansas

CLEAN ENERGY SYSTEM FOR JAPAN
T. Ohta, Yokohama National University
Yokohama, Japan

THE NUCLEAR ELECTRIC ECONOMY
P. N. Ross, Westinghouse Electric Corporation,
Pittsburgh, Pennsylvania

UTILIZATION OF HYDROGEN AS AN APPLIANCE FUEL
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Cables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar. 18-20, 1974.

Hydrogen Storage and Transmission
Session Chairman: J. E. Johnson,
Union Carbide Corp.
Linde Division,
New York, New York

Session Co-Chairman: S. S. Lee, University of Miami,
Coral Gables, Florida

TRANSPORTATION AND STORAGE OF HYDROGEN
R. A. Reynolds, W. L. Siager, General Electric
Company, Santa Barbara, California

ECONOMICS OF PIPELINE TRANSPORT FOR
HYDROGEN AND OXYGEN
G. Beghi, Euratom, Ispra, Italy

LOW THERMAL FLUX GLASS- FIBER TUBING FOR
CRYOGENIC SERVICE INCLUDING LH2 STORAGE
SYSTEMS
C. A. Hall, D. E. Spond, Martin Marietta Corp.,
Denver, Colorado

ELECTRIC POWER AND FUEL TRANSMISSION BY
LIQUID HYDROGEN SUPERCONDUCTIVE PIPELINE
R. L. Whiteslaw, Virginia Polytechnic Institute and
State University, Blacksburg, Virginia

ARCHITECTURE OF AN AUTOMATIC SYSTEM FOR
SAFETY, METERING, AND CONTROL OF A
HYDROGEN TRANSMISSION PIPELINE
J. G. Burgen, Teledyne Geotech, Garland, Texas

OPTIMAL LOCATION OF HYDROGEN SUPPLY
CENTERS TO MINIMIZE DISTRIBUTION COSTS
M. Avriel, V. Gurvich, Israel Institute of Technology,
Haifa, Israel

HYDROGEN AS AN ENERGY CARRIER
R. G. Murray, Oklahoma State University, Stillwater, Oklahoma

THE ROLE OF HYDROGEN IN ELECTRIC ENERGY
STORAGE
F. J. Salzano, R. J. Isler, E. A. Cherniavsky, K. C.
Hoffman, Brookhaven National Laboratory, Long
Island, New York

HYDROGEN ENERGY STORAGE FOR ELECTRICAL
UTILITY SYSTEMS
C. Kippenhan, R. Corlett, University of Washing-
ton, Seattle, Washington

AN ECONOMIC STUDY OF ELECTRICAL PEAK-
SHAVING ALTERNATIVES
W. R. Parrish, U.S. Department of Commerce,
Boulder, Colorado

HYDROGEN AS ENERGY STORAGE ELEMENT
L. Zeiby, The University of Oklahoma, Norman,
Oklahoma
Metal Hydride Storage

Session Chairman: F. Schulman,
Fred Schulman Associates,
Silver Spring, Maryland

Session Co-Chairman: W. B. King, University of Miami,
Coral Gables, Florida

THE ACTIVATION OF A LANTHANUM-NICKEL-FIVE HYDROGEN ABSORBENT
H. H. van Mal, Philips Research Laboratories,
Geldrop, Netherlands

AN ENGINEERING-SCALE ENERGY STORAGE
RESERVOIR OF IRON TITANIUM HYDRIDE
G. Strickland, J. Reilly, R. Wiswall, Brookhaven
National Laboratory, Long Island, New York

THE STORAGE OF HYDROGEN AS METAL HYDRIDES
D. L. Cummings, G. J. Powers, Massachusetts
Institute of Technology, Cambridge, Massachusetts

MODELING STUDIES OF FIXED-BED METAL-HYDRIDE STORAGE SYSTEMS
W. S. Yu, E. Suuberg, C. H. Waide, Brookhaven
National Laboratory, Upton, New York

THE SAFETY CHARACTERISTICS OF LaNi₅ HYDRIDES
C. E. Lundin, University of Denver, Denver,
Colorado

THE FORMATION AND PROPERTIES OF RARE-EARTH AND TRANSITION METAL HYDRIDES
L. C. Beavis, R. S. Blewer, J. W. Guthrie, E. J.
Nowak, W. G. Perkins, Sandia Laboratories,
Albuquerque, New Mexico

Hydrogen Storage in Vehicles

Session Chairman: L. W. Jones,
University of Michigan,
Ann Arbor, Michigan

Session Co-Chairman: J. Alexander,
University of Miami,
Coral Gables, Florida

AMMONIA AS A HYDROGEN CARRIER AND ITS APPLICATION IN A VEHICLE
R. L. Graves, J. W. Hodgson, J. S. Tennant, The
University of Tennessee, Knoxville, Tennessee

METAL HYDRIDES: EXPERIMENTAL METHODS AND APPLICATION TO THE ELECTRIC VEHICLE
P. Jonville, H. Stohr, R. Funk, M. Kornmann,
Battelle Centre de Recherche de Genève, Geneva, Switzerland

THE APPLICATION OF METAL HYDRIDES TO GROUND TRANSPORT
C. H. Waide, K. C. Hoffman, J. J. Reilly, R. H.
Wiswall, Brookhaven National Laboratory, Long
Island, New York

HYDROGEN STORAGE FOR AUTOMOBILES USING METAL HYDRIDES AND CRYOGENICS
R. E. Billings, Energy Research Corporation,
Provo, Utahs,

STUDIES OF THERMAL STRATIFICATION IN LH₂ AUTOMOTIVE FUEL TANKS
K. D. Williamson, Jr., J. R. Bartlit, F. J. Edesky,
W. F. Stewart, Los Alamos Scientific Laboratory,
University of California, Los Alamos, New
Mexico,
Prospects for hydrogen as an energy resource
J. K. Dawson
Atomic Energy Research Establishment, Harwell, UK

Storing energy in the form of hydrogen is an attractive possibility to provide fuel for transport and the reduction of iron ore. The main obstacle is the expense of the electricity needed to synthesise hydrogen.

S-449
HYDROGEN: A WAY OUT OF THE ENERGY CRISIS?
V.K. McElheny.

This light, plentiful gas is an alternative to the all-electric economy in the year 2000.

From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).

Electricity must be provided by the utilities on demand that varies daily, weekly, and in a seasonal cycle. This results in the under-utilization of high capital cost generating facilities and the reliance on peaking devices such as gas turbines and pumped storage. Gas turbine generators, though presently economical, are highly inefficient and use high grade liquid or gaseous fossil fuels which may eventually be in short supply. The role of electric storage in utility systems is discussed. The technology of hydrogen production, storage, and reconversion to electricity as a technique for electric energy storage is discussed and shown by means of an optimization model to fit well into the United States energy system. (auth)
LONG RANGE CONSIDERATIONS
AND POSSIBILITIES OF HYDROGEN ECONOMY. Edekeuty, F. J.
(Loa Alamos Scientific Lab., N. Mex. (USA)). 1974. Contract
From annual compressed gas association meeting, San Francisco,
California, USA (28 Jan 1974).
Some available technology and uses of hydrogen to help relieve
the energy problems are discussed. Electrical peak-shaving with
hydrogen use means that any off-peak excess electrical power out-
put would be used to electrolyze water. The resulting hydrogen and
oxygen would be stored as liquids, as compressed gases or, in the
case of hydrogen, as metal hydride. Electricity would be generated
by the combustion of the stored hydrogen and oxygen to drive a high
speed, high efficiency turbine. An alternate method would be the use
of hydrogen and oxygen in a fuel cell. The use of hydrogen in air-
craft and surface transportation in all its forms and the advantages
and disadvantages are discussed. Hydrogen as a fuel in an internal
combustion engine presents an efficiency factor sometimes quoted
to be 50 percent. The safety parameters of hydrogen are compared
with gasoline. Economy and public acceptance are discussed. The
USA produced hydrogen in huge quantities that was utilized by the
space program in the past decade. (MCW)

CRYOGENICS SAFETY IN A HY-
DROGEN FUEL SOCIETY. Reider, R.; Edekeuty, F. J.; William-
son, K. D. Jr. (Los Alamos Scientific Lab., N. Mex. (USA)).
NTIS $4.00.
From fifth international cryogenic engineering conference;
Kyoto, Japan (7 May 1974).
An inevitable world-wide shortage of fossil fuel and concern
for envrionmental pollution have aroused interest in hydrogen
as a synthetic clean fuel. The storage, shipment, and use of
hydrogen in a cryogenic fluid have already been demonstrated
to be feasible and safe. To make liquid hydrogen a universally
attractive fuel requires an extension of existing technology.
The fundamentals of cryogenic safety with specific attention to
hydrogen are reviewed with respect to material properties, con-
trol of ignition sources, management of leaks, inerting and ven-
tilating, analysis of spills, cold injury, air condensation and
oxygen enrichment, pressure relief and thermal stresses. Pro-
blems of standards and regulations, safety training, development
of operating procedures, and emergency plans must be addressed
thoroughly before the common use of liquid hydrogen will receive
public acceptance. The nature and consequences of hydrogen
accidents are analyzed. (auth)

OPERATING MANUAL FOR THE PSE
AND G HYDROGEN RESERVOIR CONTAINING IRON TITANIUM
HYDRIDE. Strickland, G.; Reilly, J. J. (Brookhaven National
The manual was written for use with the experimental energy-
storage system. Information is provided on how the reservoir
functions and how it can be safely operated. In combination with
a water electrolyzer and a fuel-cell stack, the hydrogen reservoir
provides a new way of storing energy. The reservoir is the storage
unit in the system; it is used to store hydrogen from the
electrolyzer and subsequently release it to the fuel-cell stack.
A reservoir for hydrogen consists of a closed vessel filled with
granular metal hydride and provided with a pressure barrier, a
pack; and a means of handling the necessary thermal
load. In this case the hydride is stored as iron titanium hydride
in a pressure vessel; porous metal tubing is used for the barrier,
and an internal heat exchanger is provided to handle the thermal
load. The hydride may be cycled many times provided gaseous
impurities that degrade its performance are excluded from the
system. Water at readily available temperatures (approximately
60 and 120°F) is suitable for use as the heat exchange medium.
Tests have shown that design specifications may be exceeded.
It will take up H₂ at a rate >1.5 lb/hr, deliver it at a rate >1.0
lb/hr, and its working capacity is significantly more than the
10 lb of H₂ originally specified. A compressor (500-psig rating)
is required to pressurize H₂ leaving the electrolyzer in order to
obtain a practical sorption rate. The temperature and flow
rate of the water in the heat exchanger tubes also are an impor-
tant factor with respect to sorption and desorption rates. (MCW)

METALLIC HYDROGEN STORAGE MATERIAL: HIGH
COMPRESSION AND SAFE STORAGE OF THE GAS POSSIBLE.
VDI (Ver. Deut. Ing.) Nachr.; 27: No. 44, 18 (Oct 1973). (In Ger-
man).
One of the recent important achievements of the research work
carried out in the Phillips laboratories is the discovery of met-
alic hydrogen storage devices. The metallic storage material is
described by the formula A₁₂H₂, with A standing for rare earth,
B for either cobalt or nickel, and H for hydrogen. Hydrogen being
added to LaNi₅, e.g., will result in the formation of the hydride
LaNi₅H₆, with six H atoms being bound to one unity, whereas in
SmCo₅, 3.5 H atoms are added to the compound. (CE)
Hydrogen as the Universal Fuel

The new, non-fossil sources of energy are limited in that they are best available either in a continuous, level output (nuclear) or a periodic cycle (solar, wind, tides, etc), and are best produced at fairly remote geographical sites. On the other hand, energy demands are localized in "load centers," and follow cycles which do not coincide with the production cycles. In the future, as these new energy sources are phased in, increased provisions for energy transmission and storage will be required. Hydrogen as an energy carrier presents a way to accommodate the differences between energy production limitations and energy demand patterns, both in location and time-cycles. The use of hydrogen permits relatively inexpensive, reliable, efficient underground energy transmission and the capability of bulk storage close to the load center. It presents a "bridge" between the fossil fuel sources and the non-fossil fuel sources to allow a transition of supply to be made in a planned and orderly manner. It presents the potential of an ultra-clean fuel to eliminate most of today's pollution problems. It presents a way to supply large sections of the energy consuming markets with domestic non-imported energy.


Cryogenic N2 and National Energy Needs

Title: Cryogenic N2 and National Energy Needs

Authors: Nord, J.

Company: U.S. Dept. of Commerce, National Bureau of Standards, Institute for Basic Standards, Cryogenics Division

Address: Boulder, CO 80302

Publication Description: Paper 7-1, presented at the Cryogenic Engineering Conference, Atlanta, GA, August 6-10, 1973, 22 p., 61 references

Publication Date: 1973

Abstract: Our impending fossil fuel shortage is a clear challenge to the cryogenics industry and government to provide efficient and economical means of satisfying specific national fuel requirements. Large scale production of liquid hydrogen is stimulated by the U.S. space exploration program. How civilian demands for synthetic fuels beckon cryogenic hydrogen. National and world energy shortages are briefly summarized to demonstrate the relevance of synthetic fuels in satisfying future energy markets. A perspective of national energy needs as they relate to cryogenic hydrogen fuel, in given. Hydrogen and alternate synthetic fuels are briefly reviewed and potential applications for cryogenic hydrogen are described.

Technical research and development efforts, required to satisfy specific current and future needs, are identified. The mechanisms for implementation of synthetic fuels and the indistinct timetable for transition to these fuels are discussed.

lıkl
Hydrogen
Transportable Storable
Energy Medium

By DEREK P. GREGORY
Institute of Gas Technology

For future remote sources of power and sources with
production cycles out of step with consumption, we will
need hydrogen to get energy where needed when needed

THE HYDROGEN ECONOMY.
D.P. Gregory.

A case is made for an energy regime in which all
energy sources would be used to produce hydrogen, which
would then be distributed as a nonpolluting
multipurpose fuel.

LOOKING AT THE HYDROGEN ECONOMY.

SECOND THOUGHTS ON THE HYDROGEN ECONOMY.

HYDROGEN: FUEL OF THE FUTURE?
A.P. Armagnac.
THE HYDROGEN ECONOMY.
C.A. McAuliffe.

Hydrogen production by electricity and by chemical means; aspects of its storage and distribution; and its use as a replacement for petroleum and natural gas are outlined in this article.
A HYDROGEN ENERGY CARRIER. VOLUME 2: SYSTEMS ANALYSIS
(Grant NGL-44-005-114)
(NASA-CR-136607) Avail: NTIS HC $10.00
CSCL 20M
A systems analysis of hydrogen as an energy carrier in the United States indicated that it is feasible to use hydrogen in all energy use areas, except some types of transportation. These use areas are industrial, residential and commercial, and electric power generation. Saturation concept and conservation concept forecasts of future total energy demands were made. Projected costs of producing hydrogen from coal or from nuclear heat combined with thermochemical decomposition of water are in the range $1.00 to $1.50 per million Btu of hydrogen produced. Other methods are estimated to be more costly. The use of hydrogen as a fuel will require the development of large-scale transmission and storage systems. A pipeline system similar to the existing natural gas pipeline system appears practical, if design factors are included to avoid hydrogen environment embrittlement of pipeline metals. Conclusions from the examination of the safety, legal, environmental, economic, political and societal aspects of hydrogen fuel are that a hydrogen energy carrier system would be compatible with American values and the existing energy system. For individual titles, see N74-11728 through N74-11735.

A HYDROGEN ENERGY CARRIER. VOLUME 1: SUMMARY
(Grant NGL-44-005-114)
(NASA-CR-135995) Avail: NTIS HC $3.50
CSCL 20M
The production, technology, transportation, and implementation of hydrogen into the energy system are discussed along with the fossil fuel cycle, hydrogen fuel cycle, and the demands for energy. The cost of hydrogen production by coal gasification, electrolysis by nuclear energy, and solar energy are presented. The legal aspects of a hydrogen economy are also discussed. F.O.S.

TRANSMISSION AND STORAGE OF HYDROGEN
(For availability see N74-11728 02-33)
CSCL 20M
Transmission and storage techniques for hydrogen are evaluated. Gaseous hydrogen and natural gas systems are discussed along with liquid hydrogen systems, and solid hydrogen storage systems are described. It is concluded that hydrogen gas pipeline systems are feasible, but attention must be given to the embrittlement of pipeline metals. F.0.S.
HERE COMES THE HYDROGEN ERA.
J.H. Winchester.

Linde (Co.)
Union Carbide Corp.

Power sources
Energy
Hydrogen

WHEN HYDROGEN BECOMES THE WORLD'S CHIEF FUEL.

The sea is full of it. It doesn't pollute, and it returns to the sea after it is burned.

A HYDROGEN ECONOMY.
J. O'M. Bockris.
TK

Intersociety Energy Conversion Engineering
2836 Conference, 7th, San Diego, Calif., 1972.
155 Proceedings. Washington, D. C., American
Chemical Society, 1972.

1533 p. Illus. 28 cm.

Experience in Handling, Transport and Storage of Liquid Hydrogen–The
J. R. Bartlit, F. J. Edeskuty, K. D. Williamson, Jr.

Recyclable Fuel
1312

WHEN THERE'S NO MORE OIL AND GAS.
F. Bacon and T. Fry.

The only real substitute for oil products and natural
gas is likely to be hydrogen, produced from water
using electricity generated by nuclear reactors.

S-434

HYDROGEN MAY EMERGE AS THE MASTER FUEL TO POWER
A CLEAN–AIR FUTURE.
W. Clark

A new concept in energy transmission
methods of energy transmission via hydrogen electrolysis and combustion which offers
an attractive alternative to conventional power transmission.

Hydrogen: candidate for universal fuel
advantages, considers uses and methods of production.

Hydrogen: likely fuel of the future
Anon., Chem. Engng News, 50, (26), 14–17, (June 1972). This article considers arguments and
actions relating to hydrogen's use as an energy carrier in a hydrogen fuel economy of the future.
It is pointed out that hydrogen ever to achieve large-scale use, there must be large-scale
production.

HYDROGEN: TOMORROW'S FUEL?
N. P. Chopey.

CE-129,791
A HYDROGEN–ENERGY SYSTEM. D. P. Gregory. (Prepared

Institute of Gas Tech.
(Chicago, Ill.)
American Gas Association

This is a
review of economic, technological and ecological as-
pects of production, transportation and utilization of
hydrogen as one of the most important sources of
energy in the future. The following highlights are
detailed—energy supply; nuclear electric power; nuclear
chemical power; hydrogen fuel; and hydrogen produc-
tion, transmission and production cost. The benefits of
the system described are indicated.
Hausz, W., Leeth, G., Lueck, D., and
Meyer, C., "Hydrogen Systems for
Electric Energy", 72TMP-15, General

Reynolds, R. A. and Slager, W. L.,
"Transportation and Storage of Hy-
drogen for Eco-Energy", GE72TMP-54,
General Electric Company, December,
1972.

IS HYDROGEN THE FUEL OF THE FUTURE?
R. J. Trotter.
Science News, v.102, July 15, 1972, p.46,47.

Some scientists are predicting that hydrogen will
be an effective replacement for fossil fuels before
the end of the century.

TK2896. I55 1972
HYDROGEN-ELECTRIC UTILITY SYSTEM WITH
PARTICULAR REFERENCE TO FUSION AS THE ENERGY
SOURCE. Tanner, E. C. (Princeton Univ., NJ); Hue, R. A.
pp 1323-1328 of 7th Nterociety Energy Conversion Engineering
From 7th Interociety Energy Conversion Engineering Conference;
San Diego, California, USA (25 Sep 1972). See CONF-720925-
The use of hydrogen for large-scale energy storage, transmis-
sion, and distribution is discussed. A numerical example is given
for one specific configuration—a fusion reactor linked to an elec-
trolyzer plant. The advantage lie in the abundance of hydrogen,
the low cost and high reliability of transmitting energy by pipe
line, and the elimination of many constraints on plant siting. Prob-
lems arise from inefficiencies in electrolysis and in the recon-
version of hydrogen to electricity. These inefficiencies result in
more waste heat and drive up costs to the customers. Techno-
logical improvements can be expected that will lead to more effi-
cient performance. (auth)
TP490, A3 v.18
1972

TITLE: Clean Energy Via Cryogenic Technology
AUTHOR: Williams, L.O.
CORPORATE AUTHOR: Martin Marietta Aerospace
PUBLICATION DATE: 1972
ABSTRACT: The author proposes an energy production-distribution system based on hydrogen. Large nuclear reactors, either fission or fusion, would be floated or sunk in the ocean. These plants would be used to generate electricity, distill sea water, and manufacture hydrogen through electrolysis. The hydrogen would be cooled and dried, and then could be transported over very long distances by pipelines with very low losses. Hydrogen combustion causes no pollution, and can be used as an automotive fuel with very little modification to the present engine. The safety of hydrogen is discussed, along with the use of the oxygen produced in the electrolysis of water, the problem of disposal of nuclear waste from the power plants, the implementation of the hydrogen energy system, and the economics of the plan.

HYDROGEN MAY BE THE FUTURE'S BASIC FUEL.

1972

Title: The Coming Hydrogen Economy
Author: Laughing, L.
Publication Description: Fortune, 86(5), 139-146
Publication Date: 1972, November
Abstract: In an economy based on hydrogen, rather than hydrocarbons, is discussed. Hydrogen could be obtained by electrolysis at floating offshore nuclear power plants. Hydrogen would flow onshore through underground pipelines and could be used to heat homes, generate electricity, or power vehicles. In spite of the "Hindenburg syndrome", hydrogen is a relatively safe fuel to transport and use. Space research has provided major breakthroughs in hydrogen technology, no major breakthroughs are needed to move to a hydrogen economy. The economics of electrifying water are discussed, along with the use of liquid hydrogen, particularly in automobiles. Hydrogen can be used in many industrial processes, including the direct reduction of iron ore, which could result in "clean" steel plants. A balanced national energy policy is needed to encourage the development of hydrogen as an energy source along with other sources such as solar, geothermal, and thermonuclear energy. With some developmental effort, hydrogen could be in use as a fuel by the mid 1980's. (MG)
Liquid hydrogen as a fuel for the future.


The use of liquid hydrogen as a long-term replacement for hydrocarbon fuel for land and air transportation seems technically feasible. It is an ideal fuel from the standpoint of a completely cyclic system, serving as a "working substance" in a closed chemical and thermodynamic cycle. The energy-per-unit-weight advantage over gasoline or any other hydrocarbon fuel makes liquid hydrogen particularly advantageous for aircraft and long-range land transport. As a pollution-free fuel, it must be seriously considered as the logical replacement for hydrocarbons in the 21st century. G.R.

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A COMPARISON OF THE COSTS OF PROVIDING HEAT, LIGHT, AND POWER BY HYDROGEN AND OIL.

A.H. Stodhart.

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Scott, Russel Burton, 1902- ed.

415 p. Illus. (part col.) 24 cm.
Includes bibliographies.
THERMOCHEMICAL WATER DECOMPOSITION PROCESSES.
R.E. Chao

A survey of various thermochemical hydrogen production schemes that have been reported in the literature up to 1973 is presented. These processes are grouped into four basic families: halide processes, processes based on the Reverse Deacon reaction, iron and carbon oxide processes, and metal and alkali metal processes. A brief discussion is included on the thermodynamics of multistep chemical cycles that would produce hydrogen from water without net consumption of other chemicals. Process conditions for several such processes are presented and compared with water electrolysis. Hydrogen production via thermochemical water splitting processes is reviewed in the context of a hydrogen based economy.

NUCLEAR WATER SPLITTING AND THE HYDROGEN ECONOMY.
J.L. Russell, Jr.

Non-electric energy demand by itself in the year 2000 is projected to exceed today's combined electric and non-electric demand. Hydrogen, produced by thermal decomposition of water, presents a partial solution. Either coal or a nuclear reactor can be used to produce heat to drive the reactions. Projected cost figures per cubic foot for hydrogen are charted for both conditions.

PLANT COSTS FOR PROCESSING HYDROGEN.
W.L. Nelson.
Oil & Gas Jour, v.72, no.10, Mar.11,1974, p.111,112.

THERMOCHEMICAL HYDROGEN GENERATION.
R.H. Wentorf, Jr. and R.E. Hanneman.

Discussion of closed-cycle thermochemical processes—criteria for process selection and economic comparisons.

FUTURE AVAILABILITY OF LIQUID HYDROGEN.
W.J.D. Escher.

In the long run water-splitting processes, not based on fossil fuels, can supply large quantities of hydrogen at a commercially viable price, particularly if the production system produces not only hydrogen but also byproducts.
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering & Environmental Design, Univ. Miami, Coral Gables, Florida.
Sponsored by The National Science Foundation, Defense Advanced Research Projects Agency, and The School of Continuing Studies, Univ. of Miami.
Miami Beach, Florida, Mar.18-20,1974.

Hydrogen Production Using Solar Energy I

Session Chairman: C. Marchetti,
Euratom, Ispra, Italy
Session Co-Chairman: H. A. B. Wiseman,
University of Miami,
Coral Gables, Florida

THERMOCHEMICAL WATER CRACKING USING SOLAR HEAT
C. J. Swet, The Johns Hopkins University, Silver Spring, Maryland

PERFORMANCE AND OPTIMIZATION STUDY OF A SOLAR POWERED HYDROGEN PLANT
D. V. Merrifield, Sperry Rand Corporation, Huntsville, Alabama

SOLAR ENERGY AND HYDROGEN PRODUCTION - AN EXAMINATION OF TWO POSSIBLE SYSTEMS
D. O. Lee, W. H. McCulloch, Sandia Laboratories, Albuquerque, New Mexico

UTILIZATION OF SOLAR ENERGY FOR HYDROGEN PRODUCTION BY CELL FREE SYSTEM OF PHOTOSYNTHETIC ORGANISMS
A. Mitsui, University of Miami, Coral Gables, Florida

ONLY SOLAR ENERGY PROCESSES WILL BRING US TO THE HYDROGEN ECONOMY
W. Heronemus, University of Massachusetts, Amherst, Massachusetts

SEA SOLAR POWER AS A HYDROGEN GENERATOR

OCEAN BASED SOLAR-TO-HYDROGEN ENERGY CONVERSION MACRO SYSTEM
W. J. D. Escher, Escher Technology Associates, St. Johns, Michigan; J. A. Hanson, Oceanic Institute, Waimanalo, Hawaii

SOLAR-HYDROGEN GENERATION WITH MULTIPLE FREE PISTON STIRLING ENGINE
J. Rauch, W. Beale, S. Lewis, Ohio University, Athens, Ohio

PHOTOLYSIS OF WATER AS A SOLAR ENERGY CONVERSION PROCESS: AN ASSESSMENT
S. Paleocrassas, Tri-State College, Angola, Indiana

Electrolytic Hydrogen Production

Session Chairman: J. W. Michel,
Oak Ridge National Laboratory, Oak Ridge, Tennessee
Session Co-Chairman: C. Criss, University of Miami, Coral Gables, Florida

NEW APPROACHES TOWARDS LOW COST HYDROGEN FROM ELECTROLYSIS
J. O. M. Bockris, The Flinders University of South Australia, Adelaide, Australia

ELECTROLYTIC HYDROGEN GENERATORS
J. B. Laskin, Teledyne Isotopes, Timonium, Maryland

ELECTROLYSIS OF SEA WATER
L. O. Williams, Martin Marietta Aerospace, Denver, Colorado

HYDROGEN GENERATION THROUGH STATIC FEED WATER ELECTROLYSIS
F. C. Jensen, F. H. Schubert, Life Systems, Inc., Cleveland, Ohio

THE PRODUCTION OF HYDROGEN BY ELECTROCHEMICAL MEANS
H. L. Craig, Jr., University of Miami, Coral Gables, Florida
Thermochemical Hydrogen Production

Session Chairman: R. Zahradski
National Science Foundation,
Washington, D.C.

Session Co-Chairman: H. L. Craig, University of Miami,
Coral Gables, Florida

EVALUATION OF MULTI-STEP THERMOCHEMICAL PROCESSES FOR THE PRODUCTION OF HYDROGEN FROM WATER
J. E. Funk, W. L. Conger, R. H. Carty, University of Kentucky, Lexington, Kentucky

CONSIDERATIONS ON IRON-CHLORINE-OXYGEN REACTIONS IN RELATION TO THERMOCHEMICAL WATER SPLITTING
G. DeBenni, C. Hardy, Euratom, Ispra, Italy

THERMOCHEMICAL HYDROGEN PRODUCTION RESEARCH
R. G. Hickman, O. H. Krikorian, W. J. Ramsey,
Lawrence Livermore Laboratory, University of California, Livermore, California

ANALYSIS OF THERMOCHEMICAL WATER-SPLITTING CYCLES

A SEARCH FOR THERMOCHEMICAL WATER-SPLITTING CYCLES
J. L. Russell, J. T. Porter, Gulf General Atomic Company, San Diego, California

Hydrogen Production Alternatives

Session Chairman: J. E. Funk,
University of Kentucky,
Lexington, Kentucky

Session Co-Chairman: L. Poteat, University of Miami,
Coral Gables, Florida

AN ANALYSIS OF HYDROGEN PRODUCTION VIA CLOSED-CYCLE SCHEMES
R. E. Chao, University of Puerto Rico, Mayaguez,
Puerto Rico, K. E. Cox, University of New Mexico, Las Cruces, New Mexico

EVALUATION OF CHEMICAL METHODS TO PRODUCE HYDROGEN AS A FUEL
T. G. Somer, Middle East Technical University,
Ankara, Turkey

DESIGN AND ANALYSIS OF PROPOSED CHEMICAL PROCESSES FOR HYDROGEN MANUFACTURE
C. Miao, B. Williams, The University of Michigan,
Ann Arbor, Michigan

HYDROGEN OPPORTUNITIES IN SAUDI ARABIA
H. Abdel-Aal, E. Peattie, College of Petroleum and Minerals, Dhahran, Saudi Arabia

Hydrogen Production Using Nuclear Energy

Session Chairman: J. W. Landis,
Gulf General Atomic Company,
San Diego, California

Session Co-Chairman: H. Plass, University of Miami,
Coral Gables, Florida

NUCLEAR WATER SPLITTING, PROCESS HEAT AND HTR
H. Barnert, R. Schulten, Nuclear Research Center,
Julich, West Germany

HIGH TEMPERATURE NUCLEAR REACTORS AS AN ENERGY SOURCE FOR HYDROGEN PRODUCTION
J. Balcomb, L. Booth, Los Alamos Scientific Laboratory, Los Alamos, New Mexico

HYDROGEN PRODUCTION WITH A HIGH TEMPERATURE GAS-COOLED REACTOR (HTGR)
R. N. Quade, A. T. McMain, Jr., Gulf General Atomic Company, San Diego, California

HYDROGEN PRODUCTION FROM DECOMPOSITION OF WATER BY MEANS OF NUCLEAR REACTOR HEAT
S. Dorner, C. Keller, Gesellschaft fur Kernforschung mbH., Karlsruhe, West Germany

THE TECHNOLOGY AND ECONOMICS OF HYDROGEN PRODUCTION FROM FUSION REACTORS

AQUEOUS HOMOGENEOUS REACTOR FOR HYDROGEN PRODUCTION
W. Kerr, D. Majumdar, The University of Michigan, Ann Arbor, Michigan

The already proposed or known procedures of obtaining hydrogen by means of reactor heat are discussed. The critical review shows that so far an adequate procedure cannot be proposed; therefore, we attempted to indicate novel processing means using an extended reactor system. New working hypotheses can be established on the basis of this process systematics. (auth)

HYDROGEN PRODUCTION BY PHOTOSYNTHESIS AND HYDROGENASE ACTIVITY. Progress Report for Period July 1, 1972 to March 1, 1973. Kwapisz, L.O. Corporate Author: Case Western Reserve University. Dept. of Microbiology. Address: Cleveland, OH 44106. Publication description: Report No. 157/54-W-73-017, 6 p. Publication date: 1973, August 24. Sponsor: National Science Foundation, BAN Program. Abstract: This report first reviews the research performed during the previous reporting period on using solar energy captured by the photosynthetic action of green plants and algae coupled with the action of the enzyme hydrogenase to bring about the biophotolysis of water to hydrogen and oxygen. During this reporting period research was performed on the use of ANACystis nidulans for hydrogen formation when used in conjunction with bacterial preparation from Clostridium butyricum. (auth)

BIOPHOTOLYSIS OF WATER TO HYDROGEN AND OXYGEN. Kwapisz, L.O. Corporate Author: Case Western Reserve University. Dept. of Microbiology. Address: Cleveland, OH 44106. Publication description: Abstract of paper presented at Annual Meeting of American Society for Photobiology, 3 p. Publication date: 1973, June 12. Sponsor: National Science Foundation, BAN Program. Abstract: The research to be reported is concerned with the biophotolysis of water to hydrogen and oxygen by coupling the activity of the bacterial enzyme hydrogenase, with the reducing power created by photosystems I and II of the photosynthetic apparatus. It is generally accepted that the two systems operating in tandem are capable of placing an electron from the oxygen-water couple at -0.6 volts to a potential as low as -0.7 volts, pH 7.0. Since at this pH the hydrogen electrode has a potential of +0.42 volts it is thermodynamically feasible to employ the electrons obtained by the two photosynthetic systems to obtain hydrogen. (auth)
THERMOCHEMICAL SYSTEMS FOR HYDROGEN GENERATION. This is a brief description of closed-cycle thermochemical hydrogen production, using water and heat as input ingredients and yielding hydrogen, oxygen and calorific heat as products through multistep reactions with cyclic chemical intermediates. This new system is compared to other methods of hydrogen generation including electrolysis, mixed-cycle, photolysis, and biological means.


N74-11731* Houston Univ., Tex.
PRODUCTION OF HYDROGEN
In its A Hydrogen Energy Carrier, Vol. 2 Sep. 1973 p 13-59 refs (For availability see N74-11728 02-33)
CSCL 20TM

Methods for producing hydrogen for a hydrogen economy are analyzed. Solar, wind, coal, and nuclear energies are considered as primary sources of energy for the electrolysis and water gasification processes. Coal gasification processes are discussed along with thermochemical water decomposition by closed cycle processes. F.O.S.


A synthetic fuel energy system based on hydrogen produced by large-scale fusion reactors is analyzed and presented as a technically and economically viable alternative to fossil fuels. Synthetic fuel production allows the use of very large, low-cost, base-loaded fusion reactors using D-T or DT fuel cycles.
Hydrogen and Synthetic Fuels for the Future.

American Chemical Society
Atomic Energy Commission
Conf.-730807-3
Symposium on Chemical Aspects Aug. 27-30, of Hydrogen as a Fuel 1973

Synthetic fuels can be produced at remote, well-regulated plants and would not contribute to the primary pollution problems that exist in urban centers. Production, storage, transportation, and uses, and overall systems analyses are evaluated for new fuel systems. Emphasis is on hydrogen and other fuels from nonfossil sources, but a section is included on the use of coal to produce hydrogen and methanol. Comparative characteristics of hydrogen, ammonia, hydrazine, methanol, methane, ethanol, and gasoline (C8H18) are tabulated. (GCW)

CENTRAL HYDROGEN PRODUCTION FACILITY FOR A PETROCHEMICAL AREA.
Some of the factors associated with the design and selection of hydrogen plants, particularly large plants, are discussed. Various process flowsheets are reviewed for a wide range of feedstocks and hydrogen product purities. The effects of product purity, delivery pressure, and other major process parameters on the hydrogen plant design are examined. The effect of feedstock product purity, and delivery pressure on overall operating costs is also dealt with. 5 refs.


When vitrinite is catalytically dehydrogenated in the presence of phenanthridine as vehicle, the yield of hydrogen is not greatly influenced by the catalyst support or the concentration of metal on the support. The metal used has a large effect, palladium giving the highest yield of hydrogen. (auth)

TK 2046.155 1973

A water electrolysis technology based on a solid polymer electrolyte (SPE) concept is presented for applicability to large-scale hydrogen production in a future energy system. High cell current density operation is selected for the application, and supporting cell test performance data are presented. Demonstrated cell life data are included to support the adaptability of the SPE system to large-scale hydrogen generation utility scale plants as needed for bulk energy storage or transmission. The inherent system advantages of the acid SPE electrolysis technology are explained. System performance predictions are made through the year 2000, along with plant capital and operating cost projections. (Author)


Thermochromatographic analysis of experimental evidence lead to the conclusion that a lower-temperature cycle for hydrogen production from water is possible. Critical experiments must confirm the conclusion and heat flow, corrosion and economic questions need to be answered. One of the determining economic influences will be the mercury inventory required. This depends on quantities not yet measured. (22 references) (MGW)


The solid polymer electrolyte (SPE) water electrolysis technology is presented as a potential energy conversion method for wind driven generator systems. Electrolysis life and performance data are presented from laboratory sized single cells (7.2 sq in in active area) with high cell current density selected (1000 A/cm²) for normal operation. Author
A Low-Temperature Thermal Process for the Decomposition of Water

B.M. Abraham and F. Schreiner

Abstract. The following three reactions, each of which has been shown to proceed at the temperature indicated above the arrow, are suggested as a cycle for the thermal decomposition of water:

\[
\begin{align*}
\text{LiNO}_3 + I_2 + H_2O & \xrightarrow{350^\circ K} \text{LiNO}_3 + 2HI \\
2HI & \xrightarrow{700^\circ K} I_2 + I_2 \\
\text{LiNO}_3 & \xrightarrow{700^\circ K} \text{LiNO}_3 + \frac{1}{2}O_2 \\
\end{align*}
\]


HYDROGEN PRODUCTION BY CATALYTIC STEAM REFORMING. Review of the latest technology in the production of pure hydrogen by catalytic steam reforming including shift conversion, CO\textsubscript{2} wash, and methanation. An outline of recent operating experience is presented, and programs and methods for the selection of optimum catalysts and steam reformer configurations are discussed. Economic aspects are also dealt with.


HYDROGEN PRODUCTION. This is a description, accompanied by the technological scheme, of a petrochemical plant for the separation of hydrogen from hydrogen-containing dehydrogenation gases obtained during petroleum products modification in refineries. Detailed considerations are concluded with a statement that taking into account the simplicity of the plant for obtaining hydrogen from the hydrogen-containing gases of the dehydrogenation sections, it is worthwhile to build these plants, but not new plants for obtaining hydrogen by means of catalytic conversion with steam.


THERMOCHEMICAL HYDROGEN GENERATION.

R.H. Wendorf, Jr. and R.B. Hannerman.


A PROBLEM STATEMENT: OCEAN BASED SOLAR-TO-
HYDROGEN ENERGY CONVERSION MACRO SYSTEM

William J. D. Escher and Joe A. Hanson (Oceanic Inst.) Nov. 1973 25 p refs

Copyright. Avail: Issuing Activ., CSCL 10A

An ocean based solar to hydrogen energy conversion facility is proposed that uses hydrogen as an energy carrier to be delivered to the spectrum of the energy using sector, instead of electricity, because of hydrogen's advantages of transportability and storability. The solar to hydrogen conversion process is conducted on the open ocean, and not in the traditional desert location. A number of coproducts that can also be supplied by the proposed ocean complex includes sea foods, salts, fertilizers, magnesium, and aluminum materials.
N74-16781* General Electric Co., Santa Barbara, Calif.
USE OF HYDROGEN AND HYDROGEN-RICH COMPONENTS AS A MEANS OF STORING AND TRANSPORTING ENERGY
CSCl, 10C.
A one-megawatt wind energy source is assumed that uses half of its output to serve customers as electricity, and stores the other half by conversion to hydrogen, to liquid hydrogen, to stored LH2, and back to electricity. Energy costs and capital costs of the conversions escalate unit costs to 12.9 cents per kilowatt-hour. High conversion costs can be reduced by using Mg2NiH4 and FeTiH2 storage, or by using a 100- or 1000 megawatt system. G.G.


HYDROGEN: TOMORROW’S FUEL?
N.P. Chopry.

It isn’t going to happen soon, but hydrogen derived from water could eventually supplant all fossil fuels, as well as all electrical distribution networks.
AUTOMATIC GENERATOR FOR PRODUCTION OF
PURE HYDROGEN FROM METHANOL. Dixon, A. G.; Houston,
A. C.; Johnson, J. K. Shell Research Ltd., Chester, Eng.). ND
1064-1980 at 7th Inter society Energy Conversion Engineering
From 7th Inter society energy conversion conference engineering
conference; San Diego, California, USA (23 Sep 1972). See CONF-
720926--TK2896. ISS 1972
A fully automated unit was developed for the production of 4.25
m³/h (150 std) pure hydrogen by the catalytic steam reforming
of methanol. Pure hydrogen was separated in a palladium/silver
diffusion cell that was suspended integrally with the catalytic re-
sactors in an externally heated fluidized bed with sand as a heat-
transfer medium. The fluidized bed was heated by methanol
combustion on startup and by combustion of the bleed gas from
the diffusion cell after the operating-bed temperature (330 °C)
and pressure 18 to 20 bar (264 to 276 psi) were reached. Gross ther-
nal efficiencies of 70 to 80% were observed at the rated output.
The unit required no external services apart from a 22 to 30 V dc
power supply for auxiliaries and control circuits. Power con-
sumption under steady running condition was normally less
than 130 W. Full-rated output was achieved in about 25 to 25 min
from cold. Feed rate of aqueous methanol was automatically controlled
by varying the pump speed as a combined function of temperature and pressure. Hydrogen storage allowed instantaneous step
changes in demand to be met. (auth)

THERMODYNAMICS OF MULTI-STEP
WATER DECOMPOSITION PROCESSES. Brief
description of the process in which hydrogen is pro-
duced from water by thermal treatment in three or four
steps in presence of such catalysts as uranium-, ni-
muth-, mercuryl-, or vanadium-chloride is followed by
thermodynamic calculations. The following topics are
discussed in detail—second law limitations; multi-step
processes; work of separation; and the vanadium chlor-
ride process. Mathematical data are included: 5 refs.
Funk, James E. Univ of Kentucky, Lexington. Am
Chem Soc Div Fuel Chem. Prepr v 16 n 4 Papp for Meet
Apr 10-14 1972 p 79-87.

MACRO SYSTEM FOR THE PRODUC-
TION OF STORABLE, TRANSPORTABLE ENER-
GY FROM THE SUN AND THE SEA. The paper
introduces and discusses a new energy system concept
based on the synthesis of known subsystems appro-
aches to create a "macro system" (large scale systems-of-
systems). This macro system employs solar energy to
convert water to the energy forms: cryogenic hydrogen and
oxogen. This is deemed a feasible storabie and transpor-
table commodity for a wide variety of end-use
consumption means. The macro system will not produce
environmental degradation in its operation, nor at that
point of consumption. The approach offers distinct
possibilities of controlling conversion of other
table products. Although this aspect is not further
described in the paper. 22 refs.
Escher, William J. D. Escher Technol Assoc. St. John-
Papp for Meet Apr 10-14 1972 p 28-47.

1972

GH-140,245

POLLUTION-FREE ENERGY FROM OFFSHORE WINDS.
William E. Heronimus, Massachusetts U.
(Described at the 8th Annual Conference and
Exposition, Marine Technology Society, Washington,

Marine Technology Society
Massachusetts U.
Marine Technology Society Conference Sept 11-13,
and Exposition, 8th
1972

Power sources, Wind
Hydrogen
Fuel cells
L-1-9-74

A72-36075
Large-scale concentration and conversion of solar
energy, A. F. Hildebrandt, G. M. Haas, W. R. Jenkins (Houston,
University, Houston, Tex.), and J. P. Colaco. EOS, vol. 53, July
1972, p. 684-692. 31 refs.
Description of a proposed solar energy power plant which first
concentrates the solar energy and then applies a thermodynamic
conversion cycle. A concentrator is proposed which consists of a
large number of individual movable mirrors which reflect the solar
energy onto a single collector atop a large tower. The concentrated
energy can then be converted to electrical power either by means of
a steam cycle, using liquid metals for heat transfer down the tower,
or by a closed-cycle MHD generator; in this case preference is given
to a closed-cycle MHD process employing an inert gas of helium with
cesium seedings. The intermittent nature of the solar energy can be
overcome by electrolyzing water into hydrogen and oxygen gas and
storing the energy either in the form of compressed hydrogen and
oxygen gas or as cryogenic liquids. Energy storage in the form of
hydrogen is especially attractive, since it offers the possibility of a
pollution-free fuel for the internal combustion engine. A.B.K.

Hydrogen production for better nuclear utilization. R.M.Thor-
USA, 22-25 Aug 1972). One of the foremost restrictions placed on the rapid growth of nuclear power has been the economic necessity of using it as a base-load network. If the base load
could be raised enough to "flatten" a utility's power demand curve, then nuclear systems could become the sole power-generation source for society. To promote this, a study into the feasibility of using off-peak electrical power from nuclear
plants to produce hydrogen by electrolysis was made. The author discusses the
economics of this idea and suggests possible uses for this new supply of
hydrogen. (12 refs.)

CH-129,277

HYDROGEN AS AN ENERGY VECTOR: NEW FUTURE
PROSPECTS FOR APPLICATIONS OF NUCLEAR ENERGY.

European Atomic Energy Community EUR 4038
(Belgium)

(Water chemical decomposition using nuclear heat.)

**A72-2896. ISS 1972.**


From 7th Inter-society energy conversion engineering conference, San Diego, California, USA (25 Sep 1972). See CONF-720952-2.

The use of hydrogen for large-scale energy storage, transmission, and distribution is discussed. A numerical example is given for one specific configuration—a fusion reactor linked to an electrolyzer plant. The advantages lie in the abundance of hydrogen, the low cost and high reliability of transmitting energy by pipeline, and the elimination of many constraints on plant siting. Problems arise from inefficiencies in electrolysis and in the reconversion of hydrogen to electricity. These inefficiencies result in more waste heat and drive up costs to the customers. Technological improvements can be expected that will lead to more efficient performances. (Aut)


An aluminum amalgam will react with water at ordinary temperatures with the formation of aluminum hydroxide and the liberation of free hydrogen, in the case of a black or sheet of the metal having an amalgamated surface, this reaction will continue until all the aluminum has been consumed. The reaction rate is observed to be temperature dependent, and this affords a simple means of regulating the output of hydrogen. If the supply of water and disposal of waste is discounted the reaction is shown to be superior, on a volumetric basis, to all other common means of producing hydrogen, and furthermore is competitive on a weight and cost basis with other chemical production methods. The inherent simplicity of such a scheme for hydrogen generation offers attractive advantages in terms of reliability. (Author)


Partial oxidation. A minimum pollution route for hydrogen manufacture. W.G. SCHLINGER (Tenco, Inc. Montebello, Calif.), W.I. SLATER; Amer Chem Soc, Div Petroleum Chem, Prepr v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C45-C50; Description of hydrogen manufacturing process which develops the major portion of the energy required for hydrogen generation by internal partial combustion of atmospheric contaminants from the combustion products, thereby minimizing the discharge of pollutants into the atmosphere, 3 refs., 1971.
Destructive dehydrogenation of the aromatic ring; H.R. APPEL (U.S. Department of the Interior, Bureau of Mines, Pittsburgh, Pa), R.RAYMOND, LWENDER; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C94-C95; Results of an experimental program evaluating the possibility of obtaining hydrogen from aromatic hydrocarbons with the ultimate objective of applying this method to low cost hydrocarbons or bituminous materials such as residues, pitches and coal fractions, 7 refs. 39054

Commercial experience with hydrogen manufacturing catalysts; J.S. CROMEANS (Catalyst Consulting Services, Inc, Louisville, Ky), H. W. FLEMING; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C51-C52; Review of catalysts used in the production of hydrogen by the steam-hydrocarbon reforming process and by the partial oxidation process, 16 refs. 39055

Modern Hydrogen manufacture; D.K. BEAVON (Ralph M. Parsons Co, Los Angeles, Calif), T.R. ROSZKOWSKI; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C51-C66; 5 refs. 40415

Hydrogen for refining. Design and performance; R.N. BERRY (Foster Wheeler Corp, Livingston, NJ); Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C67-C76; 38758

Development of the hydrogen manufacturing process; A. LONGAGRE (Fluor Corp, Los Angeles, Calif), H. TIBBSY; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C32-C37; 15 refs. 40409

Direct production of hydrogen from coal-steam systems; E.J. HOFFMAN (Univ of Wyoming, Laramie); Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C20-C23; 7 refs. 39353

Production of hydrogen from coal char in an electrolyluid reactor; A.H. PULSIPER (Iowa State Univ, Ames), T.D. WHEELOCK; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C5-C19; 19 refs. 38939

Production of hydrogen involving multi-state partial oxidation and reforming; C.A. VORUM; Amer Chem Soc, Div Petroleum Chem, Prep v 16 n 2 for meeting Los Angeles, Calif, Mar 28-Apr 2 1971 p C51; 89055


Known methods used in the decomposition of water by means of reactor heat are discussed. Theoretical considerations on the development of new methods show that closed-circuit processes with gas components require relatively high temperatures and, therefore, seem to be not very promising. The production of hydrogen by dissolution of the metal and the subsequent conversion into oxide call for a low decomposition temperature of the oxide. Experiments were made with reactions in the molten state in order to convert into oxides the halogenides formed in the closed-circuit process. With a view to complete the closed-circuit processes, exchange reactions and separations through evaporation of some alkaline and alkaline earth halogenides, respectively and the metals in the Vb-group of the periodic system were observed experimentally. Some considerations were made with respect to economy. (auth)

A POTENTIAL LARGE SCALE PLASMA PROCESS: SYNTHESIS OF INEXPENSIVE HYDROGEN BY USING A THERMONUCLEAR DEVICE TO VAPORIZE WASTE ORGANIC MATERIALS.

D.R. Safrany.

Solar energy is stored as carbohydrates since these are produced via photosynthesis. This energy could be used to lower the cost of fixing nitrogen by the Haber process, by perhaps an order of magnitude, if the carbohydrates could be converted inexpensively to hydrogen and carbon monoxide. This might be accomplished by vaporizing with a thermonuclear device, and thus driving to thermodynamic equilibrium, large masses of organic waste materials, for example, sewage, lignin, etc. By using a contained nuclear explosion, hydrogen might be produced for considerably less than 1.4 and ammonia for 0.1/1b.


Nuclear explosions contained underground may be a way to produce hydrogen commercially from common waste organic materials. The idea is to use the explosion to heat the wastes to 2500°C or higher, at which temperatures hydrogen and carbon monoxide are produced. Carbon monoxide can subsequently be converted to tritium-free additional hydrogen by oxidizing it with steam. The pertinent thermodynamic equilibria, kinetics and energy requirements are discussed. (auth)
The production of liquid hydrogen at the rocket propulsion establishment. R. Bainbridge and T.R. Horton.


The design, development, and operation of a liquid hydrogen plant with an hourly output of 100 liters of normal liquid hydrogen or 70 liters of 85-90% para-hydrogen are described.


METHANE CRACKING BY NUCLEAR REACTOR HEAT.

A method for the cracking of methane using heat from the blanket of a pebble bed reactor was proposed. Reaction equations and thermodynamic data indicate that almost all the methane would be converted into hydrogen and carbon dioxide. An installation for such a cracking procedure was sketched. Cost estimations using reactor heat for methane cracking were compared with chemical processes. The data are tabulated, and the cost of the hydrogen produced is given as a function of the CH₄ price.

J.S.R.)

N70-14611f Oak Ridge National Lab. Tenn.
THE ECONOMICS OF HYDROGEN AND OXYGEN PRODUCTION BY WATER ELECTROLYSIS AND COMPETITIVE PROCESSES
J. E. Mrocnek in AEC Abundant Nucl. Energy May 1969 p 107-122 refs (See N70-14504 04-22)
Avail. CFSTI

The manufacturing costs of hydrogen and oxygen are estimated for water-electrolysis plants using two types of advanced electrolytic cells; porous-electrode cells and high-temperature vapor-phase cells. Electrolytic plants producing 40 million standard cubic feet of hydrogen and 860 tons of oxygen per day are compared with fossil-fuel plants that use steam reforming and partial-oxidation processes at the same hydrogen-production rates. The cost of electricity required for the electrolytic process using a porous-electrode cell to break even with the fossil-fuel processes ranged from 0.8 to 2.3 mills/kw-hr. If an oxygen credit of $4/ton was assumed, this break-even power cost range increased to 1.5 to 3 mills/kw-hr. The use of electrolytic hydrogen plants as load-leveling devices for power plants is discussed briefly. Author (NSA)

STUDY, COST, AND SYSTEM ANALYSIS OF LIQUID HYDROGEN PRODUCTION Final Report.
N. C. Hallen Jun. 1968 323 p refs
(Contract NAS2-3894) NASA-CR 13226 CFSTI: HC$3.00/MF $0.65 CSCL 07A
This report contains information related to contemplated large-scale liquid hydrogen systems. Descriptions of feasible processes and equipment are presented. Information concerning availability and cost of required raw materials and energy are projected. Composite system analyses based on preliminary NASA hypersonic transport (HST) liquid hydrogen requirements indicate estimated average product cost of 7.7 to 8.8 cents per pound. Author
USE OF ENERGY STORAGE WITH UNCONVENTIONAL ENERGY SOURCES TO AID DEVELOPING COUNTRIES.

K.A. McCallum.

Advances in Energy Conversion Engineering, 1967

Development of an energy storage system using electrolysis of water to produce hydrogen and oxygen has led to an investigation of the use of unconventional energy sources in assisting developing countries.

ELECTROLYSIS AS A SOURCE OF HYDROGEN AND OXYGEN.


Oct. 1966 54 p Prepared for Oak Ridge Natl. Lab. (Contract W-7405-ENG-26)
IACSDS-0106643, Vol. I, TID-23439, Vol. II CFT: HC $3.00/MF $0.65

The design study of hydrogen production by electrolysis, was centered around low capital investment as the primary goal, with other factors, such as high efficiency, long life, simple, trouble-free operation, maintenance and down time also influencing the conceptual system. Only uncatalyzed porous nickel electrodes were considered. Two electrolysis plant sizes were considered during the conceptual phase of the study: 4,400 pounds of hydrogen per hour (equivalent to 380 tons of ammonia per day) and 44,000 pounds of hydrogen per hour (equivalent to 3,000 tons of ammonia per day). The hydrogen is to be delivered at 3,000 psig directly to an ammonia plant. Preliminary estimates made early in the program comparing low pressure (300 psig) and high pressure (3,000 psig) electrolysis plants indicated that high pressure system capital costs would be economically unattractive. All subsequent studies were at 300 psig. Three hydrogen plants were studied in this program and cost estimates were prepared for the total installation and operation. The plants were evaluated as to their subsystems and the costs for all their components.

IACSDS-0106643, Vol. II, TID-23439, Vol. II CFT: HC $3.00/MF $0.65

Drawings, preliminary specifications, and cost estimates for the electrolytic production of hydrogen are presented.

NSR-246747
ENERGY REQUIREMENTS IN THE PRODUCTION OF HYDROGEN FROM WATER. J. E. Funk and R. M. Reinstrom.

Hydrogen production from water energy requirements are discussed from a theoretical point of view. While water decomposition process is more efficient (on a thermal energy basis) than electrolysis none is available at present.
The sensitized photo-decomposition of water has been studied, with the purpose of improving its efficiency as a means of solar-energy conversion. A number of metallic cations and other materials were tested for sensitizer activity and, of these, only ceric, thallous, ferric, radicle, and chromous ions do sensitize the reaction, the former two to yield oxygen, the latter three hydrogen. In no case was the simultaneous production of hydrogen and oxygen observed. Quantum yields were determined, with substantial conversion of the sensitizer, and found to be of the order of $10^{-2}$ to $10^{-4}$. Initial yields were much higher. With the known sensizers, this reaction does not utilize a sufficient fraction of the solar spectrum to be practical as a means of solar-energy conversion. Several mixtures of ions and also various solid materials as additives to sensitizer solutions were tested for their influence on sensitizer activity. In every case, it was found that the quantum yield was the same as or lower than with the sensitizer alone.

Author


Economic Value of Hydrogen Produced by Wind Power. A.H. STODDART. Bell & Allied Industries Research Assn.—Tech Report C/711 1964 I p. Circumstances under which possible use of windpower to produce hydrogen might be considered; estimated costs of providing heat, light and power in this way are compared with those of obtaining energy in similar forms by use of either paraffin or diesel oil; examples based on costs of fuel at semi-desert site and at island sites are given.
ALTERNATE FUELS FOR TRANSPORTATION. PART 1: HYDROGEN FOR AIRCRAFT.
W.J. Small, D.B. Petterman, and T.F. Bonner, Jr. (LaC)

Liquid hydrogen has great potential as an aviation fuel because of its high energy content and cooling capacity, its minimal environmental impact, and its potentially unlimited supply. Its use as a fuel will greatly improve the performance of subsonic aircraft and supersonic aircraft. Hydrogen fuel could make possible hypersonic transports.

ALTERNATE FUELS FOR TRANSPORTATION: PART 2: HYDROGEN FOR THE AUTOMOBILE.
W.P. Stewart and F.J. Edeskuty.

Hydrogen may be an excellent replacement for the world's dwindling automotive gasoline supply. It offers an unlimited pollution-free closed-cycle system when produced by the electrolysis of water and burned with O₂. Conventional internal-combustion engines have been operated on hydrogen fuel with almost no pollution and with increased engine efficiency. An even greater reduction of pollution and a higher engine efficiency can be provided by an engine designed specifically for hydrogen fuel. Problem areas: storing and refilling of H₂ fuel tanks and developing an overall H₂ production and distribution system.

Cryogenics & Industrial Gases, v.9, no.1, Jan/Feb.1974.

Hydrogen's potential as an automotive fuel

Billings Energy Research recently handed over to reporters the keys to a hydrogen-powered Chevrolet and let them judge the potential of this alternate energy source. While there are still hurdles to be jumped, this company's president says a strong and immediate push could make the day of hydrogen-fueled autos arrive reasonably soon.

HYDROGEN AGE ROLLS FORWARD.

Hydrogen has spurted into the lead, if only temporarily, in a 1973 Chevrolet Monte Carlo known as the HL-1.
THE CASE FOR THE HYDROGEN FUELED TRANSPORT AIRCRAFT.
G.D. Brewer.

Hydrogen's potential supply and its performance characteristics match the forecast needs of aviation, and this industry's practitioners will know how to introduce it expeditiously and pave the way for its wider industrial use.


From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).
Hydrogen, an alternative to gasoline fuel in vehicle applications, can be stored as a metal hydride and released for use by the application of waste heat from the engine. Present investigations include a review of known and possible hydrides with a potential for automotive use. Hydride bed types and their application to vehicles are discussed. FeH2 and MgH2 are considered. Their merits and potential for use in meeting various transportation needs are discussed. Implementation through fleet vehicle systems is proposed as a means of gaining practical experience with reasonable control during the introduction of the advanced technology. (auth)


From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).
Modeling studies are of a practical importance in understanding and characterizing the behavior of hydride beds now being developed for storing and supplying hydrogen fuel in power plant and automotive applications. A convection bed model, in which heat is transferred to or from the bed by a flowing stream of hydrogen in direct contact with the particles, and a conduction model in which heat is transferred through a containment wall, were developed. FeH2 and catalysed MgH2 were evaluated using the model. (auth)

THE STORAGE OF HYDROGEN AS METAL HYDRIDES.
D.L. Cummings and G.J. Powers.

Metal hydrides offer a reversible, chemical means for storage of hydrogen and could be used as mobile and stationary fuel sources. The properties and uses of metal hydrides are reviewed. A magnesium hydride bed, used in a hydrogen-powered automobile, is modelled.
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar. 18-20, 1974.

ENGINE PERFORMANCE WITH GASOLINE AND
HYDROGEN FUELS: A COMPARATIVE STUDY
J. G. Finegold, W. D. Van Vorst, University of
California, Los Angeles, California

AN INVESTIGATION OF THE IGNITION CHARAC-
TERISTICS OF H₂-O₂-N₂ MIXTURES
G. A. Karim, M. Rashidi, M. D. Souza, University
of Calgary, Alberta, Canada

BACKFIRE CONTROL TECHNIQUES FOR HYDRO-
GEN FUELED INTERNAL COMBUSTION ENGINES
F. Lynch, Energy Research Corporation, Provo,
Utah

THE HYDROGEN/METHANOL — AIR BREATHING
AUTOMOBILE ENGINE
R. R. Adt, H. Greenwell, M. R. Swain, University
of Miami, Coral Gables, Florida

CATALYTIC COMBUSTION OF HYDROGEN
G. E. Laramore, J. E. Houston, R. L. Park, Sandia
Laboratories, Albuquerque, New Mexico

AIR FORCE EXPERIENCE OF HYDROGEN AS PRO-
PULSION FUEL
B. Dunnan, Air Force Aero Propulsion Labora-
tory, Wright Patterson AFB, Ohio

INVESTIGATION OF HYDROGEN FUEL FOR
NAVAL VEHICLES
E. Quandt, Naval Ship Research and Development
Center, Bethesda, Maryland

ARMY VIEW OF HYDROGEN ENERGY
R. Quillian, Southwest Research Institute, Ft.
Worth, Texas, D. Weidhunten, Army Materiel Com-
mand, Arlington, Va.

HYDROGEN FOR SUBSONIC TRANSPORT
P. F. Korycinski, National Aeronautics and Space
Administration, Langley Research Center, Hampt-
on, Virginia

LIQUID HYDROGEN AS A FUEL FOR FUTURE
COMMERCIAL AIRCRAFT
R. D. Lessard, United Aircraft Research Labora-
tories, East Hartford, Connecticut
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar.18-20, 1974.

Hydrogen Storage in Vehicles
Session Chairman: L. W. Jones,
University of Michigan,
Ann Arbor, Michigan

Session Co-Chairman: J. Alexander,
University of Miami,
Coral Gables, Florida

AMMONIA AS A HYDROGEN CARRIER AND ITS
APPLICATION IN A VEHICLE
R. L. Graves, J. W. Hodgson, J. S. Tennant, The
University of Tennessee, Knoxville, Tennessee

METAL HYDRIDES: EXPERIMENTAL METHODS
AND APPLICATION TO THE ELECTRIC VEHICLE
P. Jonville, H. Stohr, R. Funk, M. Kornmann,
Battelle Centre de Recherche de Geneve, Geneva,
Switzerland

THE APPLICATION OF METAL HYDRIDES TO
GROUND TRANSPORT
C. H. Waide, K. C. Hoffman, J. J. Reilly, R. H.
Wiswall, Brookhaven National Laboratory, Long
Island, New York

HYDROGEN STORAGE FOR AUTOMOBILES USING
METAL HYDRIDES AND CRYOGENICS
R. E. Billings, Energy Research Corporation,
Provo, Utahs,

STUDIES OF THERMAL STRATIFICATION IN LH2
AUTOMOTIVE FUEL TANKS
K. D. Williamson, Jr., J. R. Bartlit, F. J. Edeskuty,
W. F. Stewart, Los Alamos Scientific Laboratory,
University of California, Los Alamos, New
Mexicos,
HYDROGEN FUEL?


Hydrogen fueled aircraft.

ON-BOARD GENERATOR SUPPLIES HYDROGEN FOR I-C ENGINE.

J. Houseman and D.J. Cerini , JPL.

A compact on-board hydrogen generator has been developed for use with a hydrogen-enriched gasoline i-c engine. The unit uses gasoline and air in a partial oxidation reactor to produce a gaseous product containing hydrogen, carbon monoxide, minor amounts of methane, carbon dioxide, water, and nitrogen.


Preliminary data from an experimental combustor show that the NO sub x emission index, g (NO2)/kg fuel, is about three times greater for hydrogen than for JP at simulated cruise conditions. However, if these results are applied to aircraft designed for a given mission, hydrogen’s higher heating value enables the aircraft to have a lower gross weight and a lower fuel flow rate so that the NO sub x emission rate, kg (NO2)/hr may be reduced about 30% compared to JP. Theoretical kinetics calculations indicate that combustors may be designed for hydrogen that could further decrease NO sub x emissions by taking advantage of hydrogen’s wide flammable limits and high burning velocity.

(Author)


The problem is analyzed for the case of hydrogen fuel, taking into account supersonic and hypersonic vehicles using scramjet engines. The combustion in scramjets occurs at very high velocity and in a short time. In scramjet combustor designs, two different criteria can be used to design the engine. The amount of NO formed in the diffusion flame depends substantially on the maximum temperature reached. Effects of changing the mode of combustion from a diffusion flame to a heat conduction flame are considered, giving attention to the amount of NO produced in an engine of a given design.

G.R.

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This paper reviews recent progress in the key hypersonic technologies, which has been good despite a relatively low priority. Successful hypersonic research engine tests have been made. Active cooling system analyses have shown potential for weight savings, alleviation of structural design problems, and long airframe life. Maturing computerized flow field theories permit optimizing engine-airframe performance. Adequate progress in the future requires an expanded technology program emphasizing hydrogen usage. A hydrogen fueled hypersonic research airplane is essential, providing critical flight data and operational experience. (Author)


FUEL SHORTAGES SPUR HYDROGEN INTEREST.
C. Covault.

NASA is considering modification of two Lockheed C-141 jet transports into hydrogen-powered test-beds as one of a number of steps to find an alternate to fossil-based fuels. Lockheed has been selected by LaRC to study application of LH2 fuel to subsonic aircraft.

LIQUID HYDROGEN STUDIED FOR TRANSPORTS.
E.J. Bulban.

A74-17905 # The hydrogen fuel economy and aircraft propulsion. A. L. Austin (California, University, Livermore, Calif.) and R. F. Sawyer (California, University, Berkeley, Calif.). American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 9th, Las Vegas, Nev., Nov. 5-7, 1973, AIAA Paper 73-1319, 6 p. 20 refs. Members, $1.50; nonmembers, $2.00. Grant No. AF-AFOSR-72-12290.

Considerable interest has been directed toward the use of hydrogen as an ultimate replacement for fossil fuels. It is clean burning at comparable thermal efficiencies in piston and turbine engines, exists as a huge resource, and since the primary combustion product is water, the cycle from exosphere to use and back to exosphere is probably measured in years rather than millions of years as is the case with fossil fuels via the carbon cycle. The other fundamental advantage is that energy storage per unit weight is less than fossil fuels, and therefore hydrogen is an attractive fuel for aircraft. Large new sources of hydrogen at a low price are required before hydrogen can play an important role as an aircraft fuel. F.R.L.


Arguments in favor of the substitution of liquid hydrogen for oil to power commercial aircraft are presented. Shortage of petroleum in the United States and the need for import will lead to unacceptable dependence on foreign nations, will cost the U.S. heavily in terms of deficit balance of payments, and can become a continuous threat of interruption of oil supply that will endanger our independence in the fields of commerce, world trade, diplomacy, and even our national security. In addition, hydrogen offers potential advantages when used in aircraft. Examples of subsonic and supersonic commercial aircraft are examined to determine the advantages in performance, pollution, noise, and cost. Some problems associated with the use of liquid hydrogen as a fuel are discussed. V.P.

[243]
N74-11743* Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering.
THE ENERGY DILEMMA AND ITS IMPACT ON AIR TRANSPORTATION
(Grant NQT-47-003-028)
(NASA-CR-135993) Avail: NTIS HC $10.75 CSCL 06A
The dimensions of the energy situation are discussed in relation to air travel. Energy conservation, fuel consumption, and combustion efficiency are examined, as well as the proposal for subsonic aircraft using hydrogen fuel. For individual titles, see N74-11744 through N74-11748.

N74-11744* Old Dominion Univ., Norfolk, Va.
THE ENERGY SITUATION
In its The Energy Dilemma and Its Impact on Air Transportation 1973 p 1-48 refs (For availability see N74-11743 02-34) CSCL 06A
Energy reserves from the principal energy sources other than petroleum and natural gas are summarized. It was found that energy sources are being consumed at rates which exceed the ability to replace them through new discoveries and technology improvements. The costs and implications to environment for using coal and nuclear energy are discussed. Tables are presented on energy consumption, cost of reclamation, and water power capacity.

J.A.M.

N74-11745* Old Dominion Univ., Norfolk, Va.
THE AIR TRANSPORTATION/ENERGY SYSTEM
In Its The Energy Dilemma and Its Impact on Air Transportation 1973 p 49-70 refs (For availability see N74-11743 02-34) CSCL 05A
The changing pattern of transportation is discussed, and the energy intensiveness of various modes of transportation is also analyzed. Sociological data affecting why people travel by air are presented, along with governmental regulation and air transportation economics. The aviation user tax structure is shown in tabular form.

J.A.M.

N74-11746* Old Dominion Univ., Norfolk, Va.
ENERGY CONSERVATION AND AIR TRANSPORTATION
In its The Energy Dilemma and Its Impact on Air Transportation 1973 p 71-94 refs (For availability see N74-11743 02-34) CSCL 05A
Air transportation demand and passenger energy demand are discussed, in relation to energy conservation. Alternatives to air travel are reviewed, along with airline advertising and ticket pricing. Cargo energy demand and airline systems efficiency are also examined, as well as fuel conservation techniques. Maximum efficiency of passenger aircraft, from B-747 to V/STOL to British Concorde, is compared.

J.A.M.

N74-11747* Old Dominion Univ., Norfolk, Va.
AN INITIAL STEP: A DEMONSTRATION PROJECT
In its The Energy Dilemma and Its Impact on Air Transportation 1973 p 95-117 refs (For availability see N74-11743 02-34) CSCL 05A
To initiate the transition into a clean and diverse energy environment independent of fossil-based fuels, the rapid development of a subsonic, hydrogen-fueled aircraft is recommended. Tables are presented on characteristics of synthetic fuels, comparisons with JP-4 and gasoline, comparison of nitric oxide emissions from hydrocarbon and hydrogen fuels vs. total flame temperature, and sensitivity limits of LH2 detectors.

J.A.M.

N74-11748* Old Dominion Univ., Norfolk, Va.
CONCLUSIONS AND RECOMMENDATIONS
In its The Energy Dilemma and Its Impact on Air Transportation 1973 p 119-173 refs (For availability see N74-11743 02-34) CSCL 05A
Conclusions and recommendations are presented for an analysis of the total energy situation; the effect of the energy problem on air transportation; and hydrogen fuel for aircraft. Properties and production costs of fuels, future prediction for energy and transportation, and economic aspects of hydrogen production are appended.

J.A.M.
CN-140,323 1973
Jet Propulsion Lab., Calif.
Inst. of Tech.
Environmental Protection Agency
Development, 1st

Engines, Internal combustion
Engines, Automobile
Engine emission
Fuel consumption

Hydrogen

CN-140,370 1973
Union Carbide Corp.
Cryogenic Engineering Conference Aug.10, 1973

Hydrogen, Liquid
Economics
Air transportation

L-3-4-74

847 p. illus. 29 cm.
Sponsored by: American Institute of Aeronautics and Astronautics [and others]

CN-140,369 1973
N74-15449# Oak Ridge National Lab., Tenn.
PROSPECTS FOR HYDROGEN AS A FUEL FOR TRANSPORTATION SYSTEMS AND FOR ELECTRICAL POWER GENERATION
(Contract W-7405-eng-26)
(ORNL-TM-4305) Avail. NTIS HC $5.00

The potential application of hydrogen, produced from non-fossil domestic sources, is examined for applicability to the transportation and electrical generation sectors. The characteristics of hydrogen as a gas and as a cryogenic liquid are noted; cost trends are presented. Ground, water, and air transportation modes and systems are individually examined with respect to a potential conversion to hydrogen fuel. Electrical generation systems, both conventional and unconventional, are assessed similarly. Hydrogen’s potential for transmission and storage of electrical energy is cited. From these findings, a detailed list of recommended study, research and development, and demonstration system topics is given toward implementing a potential conversion of transportation and the electrical utilities to hydrogen fuel.
Author (NASA)

N74-19391# Michigan Univ., Ann Arbor. Dept. of Physics.
LIQUID HYDROGEN AS A FUEL FOR MOTOR VEHICLES: A COMPARISON WITH OTHER SYSTEMS
Lawrence W. Jones [1973] 4 p
Avail. NTIS HC $4.00

The pros and cons are explored of liquid hydrogen fuel, especially for smaller systems (automobiles and trucks). The alternative methods of liquid hydrogen fueling, whether by replaceable tanks or pumping from a storage vessel, are also discussed.
Author
1973

NT3-24777*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

Some factors influencing the technical feasibility of operating a liquid hydrogen-fueled airplane are discussed in light of the projected decrease of fossil fuels. Other sources of energy, such as wind, tidal, solar, and geothermal, are briefly mentioned. In view of projected decreases in available petroleum fuels, interest has been generated in exploiting the potential of liquid hydrogen (LH2) as an aircraft fuel. Cost studies of LH2 production show it to be more expensive than presently used fuels. Regardless of cost considerations, LH2 is viewed as an attractive aircraft fuel because of the potential performance benefits it offers. Accompanying these benefits, however, are many new problems associated with aircraft design and operations; for example, problems related to fuel system design and the handling of LH2 during ground servicing. Some of the factors influencing LH2 fuel tank design, pumping, heat exchange, and flow regulation are discussed. (Author)

1973


From intersociety conference on transportation, Denver, Colorado, USA (24 Sep 1973).
A hydrogen-powered automobile plays a prominent role in many of the proposed solutions for the energy crisis. The development of a hydrogen powered automobile involves the development of a hydrogen-fueled engine, a hydrogen storage system on-board the vehicle, and a hydrogen production and distribution system. Several design aspects, cost estimates, and safety considerations are discussed for a liquid hydrogen production and distribution system. The amount of liquid hydrogen that must be produced annually to replace the gasoline consumed by automobiles is estimated. This estimate includes bottow, cooldown, and transfer losses from the production plants, transport trailers, service stations, and automobiles. (7 tables, 4 figures, 40 references) (auth)

1973


The performance of hydrogen-fueled commercial aircraft is examined in the subsonic, supersonic, and hypersonic speed regime and compared with those of jet-fueled systems. Hydrogen aircraft are shown to provide substantial improvements in range and payload fraction as well as to minimize or eliminate many environmental problems. The major elements of a development program required to make hydrogen-fueled aircraft a commercial reality are also outlined and the rationale for and characteristics of both a subsonic demonstrator and a high speed research airplane are described. (Author)

1973


The first phase of a feasibility study for the incorporation of catalytic steam reforming reactors into mobile power plant fuel systems has been completed. Two laboratory prototype reformers were used to steam reform hexane feedstock to fuel gas mixtures consisting of H2, CH4, CO, and CO2. Above 485°C conversion was found to be equilibrium (rather than kinetically) controlled by the methane reforming and water gas shift reactions. Reactors used were 1) a 9" long section of 2" stainless steel pipe, and 2) a 5" long section of 3-1/4" stainless steel pipe. In both cases the reactors were filled with Girdler 5/8" rasching ring nickel reforming catalyst. Reactor residence times near .01 seconds allowed complete conversion of hexane to theoretically predicted equilibrium product distributions. Experimental hydrogen composition in the fuel gas generated at 2.5 atm with a steam to carbon ratio of 2.56 ranged from .38 to .58 mole per cent (dry basis) at temperatures of 485°C and 695°C respectively. The equivalent reactor volume required to provide fuel gas at a rate sufficient to power a mid-sized car at 60 mph is estimated to be on the order of 0.2 cubic feet. Additional size reduction may be realized with more active reforming catalysts especially considering that operation was not found to be kinetically controlled.
The use of hydrogen as a fuel for aircraft propulsion is discussed. The benefits of hydrogen with respect to air pollution reduction are analyzed. Liquid hydrogen as a potential future aviation fuel is considered to be the only practical chemical fuel producible from ultimate nonfossil energy primary sources. The aerodynamic configurations and aircraft systems involved in hydrogen propulsion are described and illustrated. The facilities and processes for commercial production of hydrogen are reported. 

Author

Prospects for hydrogen-fueled vehicles.
R.J. Schoeppel.

Primarily concerned with the use of hydrogen in ground vehicles, although it is obvious that hydrogen can be substituted for any other fuel now in use.

The aircraft runs on hydrogen.

Gulf General Atomic has a research program to apply nuclear energy to the task of generating hydrogen from water.

More stress on hydrogen engines.
HYDROGEN IC ENGINE: ITS ORIGINS AND FUTURE
IN THE EMERGING ENERGY-TRANSPORTATION-ENVIRON-
MENT SYSTEM. Wein, K. H. (Stevens Inst. of Tech., Hoboken,
NJ). pp 1355-1363 of 7th Inter society Energy Conversion En-
gineering Conference. Washington, DC; American Chemical
Society (1972).

From 7th Inter society energy conversion engineering conference;
San Diego, California, USA (25 Sep 1972). See CONF-720925-.

It is not the internal combustion engine that pollutes the air, but
its present fuels. Lower-efficiency-cycleAudubon engines and
catalytic exhaust systems are technically unound and waste re-
mainling hydrocarbon reserves. The hydrogen internal combustion
engine's multi-fuel version is the key component of the evolving
comprehensive electricity-hydrogen energy system, controlling
air pollution and the electric utilities' predicament with low load
factors, transmission, and energy storage. Any pragmatic transi-
tion rate in time and regional geography may be programmed with
this engine—not excluding other promising approaches. To make
sound decisions, in time, about realistic compromises based on
facts, preparations should begin now. (29 references) (auth)

HYDROGEN ENGINE IN PERSPECTIVE. Murray,
R. G. (okaoma State Univ., Stillwater); Schoeppe, R. J.; Gray,
C. L. pp 1375-1381 of 7th Inter society Energy Conversion En-
gineering Conference. Washington, DC; American Chemical
Society (1972).

From 7th Inter society energy conversion engineering conference;
San Diego, California, USA (25 Sep 1972). See CONF-720925-.

The latest performance and emission characteristics of the
Oklahoma State University air breathing, hydrogen-burning engine
are reported. The engine is put in perspective in the future total
energy picture. Four years ago development started on the first
of a series of hydrogen-fueled engines at Oklahoma State Univer-
sity. Early data indicated that a hydrogen-fueled engine should
yield torque, power, and efficiency values comparable to an equi-

calent spark ignition engine. The performance outlook of this first
eengine was so optimistic that the Air Pollution Control Office,
Environmental Protection Agency funded an effort to study further
design improvements and to test its emission characteristics.
Recent tests indicate that it should be possible to fabricate a reli-
able engine to power an automobile or truck. It is expected that
this vehicle would have adequate range, normal size, and would fall
within a complexity and reliability range similar to today's gaso-
line counterpart. It would emit no measurable hydrocarbons, or-
ganic, or sulfur compounds. Oxides of nitrogen emission below
1976 standards would be expected. (auth)

HIGHER-ENERGY FORM OF WATER (H2O) IN AUTO-
motive vehicle Advanced Power Systems. Eacker,
W. J. D. (Eacker Tech. Associates, St. Johns, MI). pp 1392-
1402 of 7th Inter society Energy Conversion Engineering Confer-
ence. Washington, DC; American Chemical Society (1972).

From 7th Inter society energy conversion engineering conference;
San Diego, California, USA (25 Sep 1972). See CONF-720925-.

The hydrogen-oxygen (stoichiometric) direct combustion,
separately tanked and led to an advanced-design automotive power
plant is addressed. This 'higher energy form' of water is com-
pared in terms of: onboard vehicle stored energy, volume, mass
and cost with conventional systems employing gasoline- and
hydrogen-fueled internal combustion engines. The higher energy
form of water, H2O*, will be produced in abundance in future
water-splitting hydrogen production facilities using nuclear or
solar energy as being envisioned for the post fossil-fuel age.
"Hydrogen Economy." However, the majority of hydrogen energy
conversion system studies so far have addressed hydrogen's re-
action with air, not oxygen. If high-temperature H2O* fueled
power cycles (6000 to 4000°F) can be developed, a savings in na-
tional energy resources of the order of 60% of that needed for
present gasoline-fueled automobiles and future hydrogen-fueled
vehicles is technically possible. The sole effluent in H2O* com-
bustion is the lower energy form of water. (MCW)

LIQUID HYDROGEN AS A FUEL FOR MOTOR VE-
HICLES: A COMPARISON WITH OTHER SYSTEMS. Jones, L. W.
(Uin. of Michigan, Ann Arbor). pp 1364-1365 of 7th Inter society
Energy Conversion Engineering Conference. Washington, DC;
American Chemical Society (1972).

From 7th Inter society energy conversion engineering conference;
San Diego, California, USA (25 Sep 1972). See CONF-720925-

Hydrogen as a liquid has obvious advantages as a fuel: relatively
high density, use of low-pressure containers, and aesthetic sim-
plicity. On the other hand, the complications of cryogenics han-
dling, boiloff losses, and intrinsic thermodynamic inefficiencies
make the virtues of liquid hydrogen not without attendant
liabilities. The advantages and disadvantages of the liquid fuel,
especially for smaller systems (automobiles and trucks), are ex-
plored. The alternative methods of liquid-hydrogen fueling, whether
by replaceable tanks or pumping from a storage vessel, are also
discussed. (auth)

From 7th Intersociety energy conversion engineering conference, San Diego, California, USA (25 Sep 1972). See CONF-720925-.

The use of metal hydrides as hydrogen reservoirs facilitates the storage and subdivision of central-station power for automotive and other purposes. Hydrides with a wide range of properties have been synthesized and studied, and several appear to have promise for specific storage applications. Results are reported on the effect of alloy constituents on hydride stability, on the formation of hydrides by metals reacting with gas mixtures such as those produced by the steam reforming of hydrocarbons, and on the feasibility of integrated systems of hydride reservoirs and engine components. (author)

SURVEY OF HYDROGEN'S POTENTIAL AS A VEHICULAR FUEL

The problems and potential of various hydrogen-based mobile fuel systems and the likely economic impact of a nationwide conversion to hydrogen are examined. The basic technical problem is to store enough hydrogen per vehicle in a small enough volume. The prospects of using gaseous and liquid hydrogen are examined. The use of liquid hydrogen, with liquid oxygen, and hydrogen stored as metal hydrides in an internal combustion engine are analyzed. The practical feasibility is found to be marginal with enough potential to justify an ongoing research program. (author)

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TK2896, I55 1972


From 7th Intersociety energy conversion engineering conference, San Diego, California, USA (25 Sep 1972). See CONF-720925-.

The research and development effort required to convert a 1970 Toyota 1600 station wagon to run on a hydrogen-air fuel mixture is described. The unique engine design modifications involve only minor changes to the Otto cycle engine and will not require extensive manufacturer's retuning. In addition, a high pressure source of hydrogen is not needed. Total engine cost is expected to be less than that of a similar gasoline fueled low emission engine. An approximately 50% increase in efficiency over that of the gasoline fueled engine is realized. Nitric oxide emissions, the only exhaust gas constituents of concern, are expected to meet the 1975 emission standards. The 1976 and later standards are expected to be met with minor modifications. (author)
N72-22711* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY APPRAISAL OF HYDROGEN AND METHANE FUEL IN A MACH 2.7 SUPERSONIC TRANSPORT
[1972] 51 p refs Prepared in cooperation with Army Air Mobility R and D Lab. Cleveland

The higher heating value of hydrogen relative to JP fuel is estimated to reduce fuel weight by three fold and gross weight by 40 percent for comparable designed airplanes of equal payload and range. Engine design parameters were varied to determine the influence of lower noise goals on gross weight and direct operating cost. At current fuel prices, the DOC of a hydrogen airplane would be much higher than that of a JP airplane. A methane airplane could offer an 8.5-percent lower KOC than JP. But future shortages may escalate the prices of both JP and methane, whereas the price of hydrogen manufactured hydrolytically could be reduced from present levels. If in the future all three fuels are postulated to have equal costs per unit of energy, the DOC for hydrogen could be as much as 20 percent below that for JP on the reference 4000-nautical mile mission. Longer ranges or lower noise requirements would improve the advantage of hydrogen. 

Author

HYDROGEN FUELED HYPERSOONIC TRANSPORTS.
R.D. Witcofski.

A FUEL CONSERVATION STUDY FOR TRANSPORT AIRCRAFT UTILIZING ADVANCED TECHNOLOGY AND HYDROGEN FUEL
W. Barry, R. Calleson, J. Espil, C. Quartero, and E. Swanson
10 Nov. 1972 33 p refs (Contract NAS1-10900)
(NASA-CR-112204) Avail: NTIS HC $3.75 CSCL 018

The conservation of fossil fuels in commercial aviation was investigated. Four categories of aircraft were selected for investigation: (1) conventional, medium range, low take-off gross weight; (2) conventional, long range, high take-off gross weights; (3) large take-off gross weight aircraft that might find future applications using both conventional and advanced technology; and (4) advanced technology aircraft of the future powered with liquid hydrogen fuel. It is concluded that the hydrogen fueled aircraft can perform at reduced size and gross weight the same payload/range mission as conventionally fueled aircraft.

F.O.S

N72-23842 Oklahoma State Univ., Stillwater. School of Mechanical and Aerospace Engineering.
DESIGN CRITERIA FOR HYDROGEN BURNING ENGINES
(PB-206815; APTD-0901) Avail: NTIS HC $4.75 CSCL 218
Laboratory experiments have demonstrated hydrogen not only to be an excellent substitute for conventional hydrocarbon fuels in internal combustion engines but also to have the inherent qualities necessary for a permanent solution to the air pollution problem. This conclusion was reached after extensive tests were conducted with an aircooled single-cylinder gasoline engine converted to run on hydrogen. The engine's operational characteristics compared favorable with those of its gasoline counterpart. Furthermore, the NOX content of the exhaust was an order of magnitude lower than that expected from a gasoline engine. Trace amounts of unburned hydrocarbons and carbon oxides, also present, originated from the lubricating oil. It was concluded from these experiments that a multi-cylinder automobile engine converted to run on hydrogen should be able to meet the 1975/76 Federal Emission Standards.

Author (GRA)
TK2896. I55 1971
R. G. Murray and R. J. Schoeppele,

TK2896. I55 1971

N72-12998* National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
VEHICLE TECHNOLOGY FOR CIVIL AVIATION: THE SEVENTIES AND BEYOND Conference Proceedings
Washington 1971 452 p refs Conf. held at Langley Sta., Va., 2-4 Nov. 1971
(NASA-SP-292) Avail. NTIS HC $6.00/MF $0.95 CSCL 01C
Technological concepts for the development of future advanced transport aircraft in civil aviation are developed. Highlighted are promising avenues of research that offer the potential of improving both current and future civil aircraft in the fields of aerodynamics, propulsion, structures and materials, operational aspects, and technology application. For individual titles, see N72-12998 through N72-13020.

N71-21634* Ohio State Univ. Research Foundation, Columbus, 
(Grant AF-AFOSR-0203-67)
(AD-716855; OSURF-2153-3; AFOSR-70-2467TR) Avail. NTIS CSCL 21/2
Induction distances, transient pressures, and wave propagation rates were determined in cylindrical tubes for detonation waves in stoichiometric hydrogen-oxygen mixtures initially at one atmosphere and temperatures ranging from 300K down to 123K. The induction distances became considerably shorter as the initial gas temperature was decreased. At temperatures from 500 to 123K the normal burning speed of stoichiometric hydrogen-oxygen mixtures was found to be proportional to the absolute temperature of the unburnt gas. High-strength shock waves were fired into lean hydrogen-oxygen mixtures to study the propagation rates of the flames behind these waves (overdriven detonations). Ignition delay times in hydrogen-nitric oxide mixtures were found to be very long. Stable detonation waves could not be produced in these mixtures. Quantum yields and induction times have been measured in flowing mixtures of hydrogen, oxygen, and chlorine to determine the feasibility of photochemically initiated supersonic combustion. Expressions have been derived to predict the induction times and quantum yields. A method has been developed for calculating the state of the gas behind a normal shock in a shock tube for the case that both the driver and the driven gas undergo chemical changes during the process. Results indicate that for dissociating hydrogen calculations based on the use of certain values of the specific heat ratio may be in error by 30% for the calculated particle speed.

Author (GRA)

The strong interactions between the aerodynamic, structural, and propulsive systems of hypersonic airbreathers offer important opportunities for achieving improved vehicles. One of the most promising is the use of the hydrogen fuel heat sink to provide cooling of major areas of the airframe. This possibility is explored in some detail, with considerations of the theoretical possibilities, engine designs for minimum cooling, comparative analysis of candidate high-level cooling systems, recent fluid-mechanical studies of slot cooling, structural designs compatible with practical cooling systems, and aerodynamic features made possible in actively cooled vehicles. The results suggest that hypersonic cruise vehicles constructed of largely unshielded aluminum or titanium alloys are feasible and offer a number of advantages. Further studies of the problems and possibilities of this category of hypersonic vehicles are suggested.

(Author)


An exploratory investigation was conducted to determine the performance characteristics of a fuel-rich hydrogen combustor; in addition, the performance of an afterburner operating with the fuel-rich exhaust mixture was evaluated. Four experimental combustors with a burning length of 18 inches were tested using a range of equivalence ratios from 7 to 12 at nominal fuel flows of 180 and 200 pounds per hour, inlet-air temperature of 80°F, and inlet pressures near 30 inches of mercury absolute. Two

Gaseous hydrogen fuel was burned in a connected-pipe combustor with a cross section equal to 35° sector of a 28-inch diameter. Eleven shrouded fuel-injector configurations were used to obtain combustion data at the following high-altitude ramjet combustor conditions: pressure, 5 to 21 inches of mercury absolute; velocities, 300 to 160 feet per second; and inlet air temperature of 240°F. Combustion efficiencies were measured above 92 percent for wide bands of fuel-air ratios. The combustor configurations reported herein extend the efficient burning range of hydrogen at ramjet conditions to a pressure of 1/6 atmosphere; best configurations previously attempted gave high efficiency only at 1/3 atmosphere.

Two authors (2)

Net thrust, fuel flow, and related performance indices were calculated for hydrogen-rich operation of ramjet-type and submerged ramjet engines at Mach numbers from 5 to 20. Hydrogen-air ratios considered were high enough to limit the combustor temperature to a maximum of 6000°F. This propulsion method can produce fuel specific impulses considerably greater than those of rockets if impulses are averaged over the above range of flight speeds.

This literature digest of hydrogen-air combustion fundamentals presents data on flame temperature, burning velocity, quenching distance, flammability limits, ignition energy, flame stability, detonation, spontaneous ignition, and explosion limits. The data are assessed, recommended values are given, and relations among various combustion properties are discussed. New material presented includes: theoretical treatment of variation in spontaneous ignition lag with temperature, pressure, and composition, based on reaction kinetics of hydrogen oxidation; and calculated adiabatic flame temperatures over the entire hydrogen-air composition range for 0.01 to 100 atmospheres and initial temperatures of 0° to 1600°K.
NACA RM E54A23

Authors (3)

An investigation was conducted in the NACA Lewis 10- by 10-foot supersonic wind tunnel to evaluate the performance of a shrouded injector burner with perforated domes employed in a 28-inch ramjet using gaseous hydrogen as fuel. Steady-state data were obtained at a pressure altitude of 77,000 feet and zero angle of attack. Transient data were obtained at pressure altitudes up to 110,000 feet and angles of attack up to 12°. Results of this investigation showed that burning could be initiated under severe distortion conditions and that satisfactory combustor operation was accomplished up to a pressure altitude of 110,000 feet with no adverse effect on combustion efficiency.

NACA RM E55610

Authors (2)

In separate tests, commercial hydrogen and aluminum trimethyl were injected into a turbojet afterburner for the purpose of promoting combustion in a hydrocarbon-oxygen reaction inhibited by water vapor. The hydrogen, injected into the pilot gas zones of the afterburner in small amounts, increased the combustion efficiency over the entire afterburner operating range and greatly extended afterburner operating limits. The use of aluminum trimethyl as an additive to the afterburner hydrocarbon fuel resulted in only marginal improvement in afterburner performance.

NACA RM E56215

One combustor consisted of an array of U-gutter flame holders, the other four combustors were manifolded arrays of swirler-can combustor elements. Fuel injection into each swirler-can element was through a tangential sonic orifice. The elements varied in size from 1.5 to 2.0 inches in length and similarly in exit chamber.

NACA RM E55820a

Authors (2)

The combustion performance of two flame holders, one having a large pilot zone and one consisting of a simple grid of sloping V-gutters, was evaluated at typical conditions for the combustor of a supersonic ducted-fan engine. At a simulated supersonic altitude start condition, only the flame holder having the large pilot zone performed stably. However, the V-gutter grid flame holder was equally capable of subsonic start and acceleration if 1 percent of hydrogen was injected into the V-gutter wake. Maximum combustion efficiencies of 39 percent were obtained at conditions simulating a supersonic takeoff run at an altitude of 50,000 feet. Hydrogen addition extended combustor pressure limits but had no significant effect on efficiency.

NACA RM E5718a

Authors (2)

An analysis was made to determine the coolant flow and pressure requirements of a return-flow turbine rotor blade design which utilizes hydrogen, helium, or air as the coolant. On the basis of the required coolant flows and pressure changes obtained for conditions representative of a high-altitude supersonic turbojet engine, the return-flow blade design considered would cool adequately over a range of coolant inlet temperatures from 250° to 1000° F using hydrogen, helium, or air.

NACA RM E57005

Author

(N = 2; alt. = 35,000'). Only moderate and not always consistent changes in average liner temperatures were obtained in both a plain and a ceramic-coated liner with three liquid fuels of varying volatility and aromatic content and with one gaseous fuel of low flame emissivity. A high- aromatic fuel produced greater average temperatures than a similar fuel containing no aromatics; differences did not exceed 100° F. Temperatures of the ceramic-coated liner were higher than those of the plain liner.

NACA RM E56105

Authors (2)

Engine operation with JP-4 fuel at a flight Mach number of 0.8 was satisfactory up to an altitude of about 65,000 to 65,000 feet, and engine operation with marginal combustion stability was maintained up to an altitude of about 80,000 feet. The use of gaseous-hydrogen fuel provided satisfactory engine operation up to the facility operating limit of about 49,000 feet. Operation with JP-4 fuel at an altitude of 80,000 feet, a flight Mach number of 0.8, and rated engine conditions resulted in a decrease in net thrust of 21.5 percent and an increase in specific fuel consumption of 26 percent from the values that would have been obtained had there been no loss in the performance of the components with altitude. When using gaseous-hydrogen fuel at the same operating conditions, the net thrust was approximately 4 percent greater than that obtained with JP-4 fuel because of the increased gas constant of the gaseous-hydrogen exhaust products.
NACA RM E57P14

Authors (3)
A ram-air heat exchanger was used in this fuel system to vaporize the liquid hydrogen. The heat exchanger was evaluated in an altitude test chamber at the NASA Langley Research Center in conjunction with the complete aircraft fuel system. The experimental results presented in this report indicate that a ram airflow of 1.76 pounds per second was sufficient to vaporize 565 pounds per hour of fuel. At this condition the air-side temperature drop was $6^\circ$ F, the average tube wall temperature was $346^\circ$ R, and the heat transfer coefficient between the tube wall and the fuel was about $69$ Btu/(hr) ($47$ ft. $^2$) ($^\circ$ R).

NACA RM E56C8a

Authors (2)
An investigation was conducted in the NACA Lewis 10- by 10-foot supersonic wind tunnel to evaluate the performance of three burner configurations in a 16-inch ram jet with gaseous hydrogen as fuel. Data were obtained over a fuel-air ratio range from 0.033 to 0.0280 (stoichiometric = 0.0259) at a free-stream Mach number of 3.0 and $0^\circ$ angle of attack. The exit nozzle-throat area ratios employed were 0.60 and 0.75. Results of this showed that a flameholding shroud fitted to an injector-burner greatly improved its performance.

NACA RM E57P19

Authors (6)
The airplane climbed on JP fuel to cruise altitude, where the engine was shifted to hydrogen fuel and then back to JP fuel after the hydrogen supply was exhausted. Transition was made to hydrogen fuel without serious effects on engine operation. Steady-state and transient operation were both highly satisfactory. Heat-exchanger performance compared favorably with simulated attitude performance in the laboratory. Data are presented to show the effect of tank agitation on fuel pressure and fuel losses.

NACA RM E56C6a

Authors (2)
Experiments with liquid nitrogen and liquid hydrogen in Styrofoam-insulated tanks have indicated good agreement between measured and calculated heat leak rates. The insulation was formed from a single block of material. In a large tank installation where the insulation was applied in sections without sealing the joints, the measured heat leak was about 23 times the calculated value. Measurement of pressure-rise inside the tanks due to heat leak indicated that the smooth ground storage time was lost to about one-third of the order of half the theoretical values.

NACA RM E57C29

Authors (2)
An evaluation of the effect of geometric design variables on the performance of a 16-inch-diameter ram-jet combustor using gaseous hydrogen as fuel was obtained over a range of combustor total pressures from 3 to 65 inches of mercury absolute. Equivalence ratio was varied from 0.1 to 1.0 at a combustor inlet temperature of $1100^\circ$ F. Peak combustion efficiencies ranging from 98 to 99 percent were obtained with a burner 1 inches long (measured from fuel injectors to exhaust-nozzle outlet) over a range of burner total pressures from 10 to 35 inches of mercury absolute.

NACA RM E57P06

Authors (3)
A total of seven fuel-injector configurations, grouped by type as concentric ring or radial bar, were investigated at a burner-inlet velocity of approximately 600 feet per second over a range of burner-inlet total pressures from 330 to 950 pounds per square foot absolute. Afterburner length was varied from 27 to 69 inches. No flame-stabilizing devices other than the fuel injectors were used.

NACA RM E56C8

Authors (2)
An investigation was conducted in the NACA Lewis 10- by 10-foot supersonic wind tunnel to evaluate the performance of three burner configurations in a 16-inch ram jet with gaseous hydrogen as fuel. Data were obtained over a fuel-air ratio range from 0.033 to 0.0280 (stoichiometric = 0.0259) at a free-stream Mach number of 3.0 and $0^\circ$ angle of attack. The exit nozzle-throat area ratios employed were 0.60 and 0.75. Results of this showed that a flameholding shroud fitted to an injector-burner greatly improved its performance.

NACA RM E57C59

Author
An experimental investigation was conducted in the Lewis 10- by 10-foot supersonic wind tunnel on a 16-inch ramjet that was equipped with an afterburner and used gaseous hydrogen for both the primary and afterburner fuels. The primary nozzle had a contraction ratio of 0.1 while the exit nozzle had a contraction ratio of 0.9. Data were obtained at a free-stream Mach number of 3.0 and zero angle of attack. The results of this investigation illustrate that at a constant diffusion-exit Mach number afterburner operation produces more than twice the thrust available without afterburning.


Authors (2)

Turbojet engines with production or special combustors were operated with hydrogen fuel in altitude test chambers. Altitude was increased until either an engine limitation or a facility limitation was reached. For comparison purposes the engines with the production combustors were also operated with JP-4 fuel.

Authors (3)

During the time NACA has been engaged in this project, studies have been completed on the aircraft system in the altitude facility, on the installation of the system in the B-57 aircraft, and on the operation of the aircraft on hydrogen fuel at an altitude of over 49,000 ft. and a Mach number of 0.72. The flight and design problems encountered in the project are discussed.

Authors (3)

The objectives of the flight-test phase of this research program were to construct a workable fuel system and demonstrate its feasibility during flight and to uncover areas in which laboratory research could be best applied to further work in this field.

Authors (3)

The fuel system permits engine operation on hydrogen, JP-4 fuel, and combinations of the two introduced separately into the engine. The fuel system consisted of: (1) a stainless steel wingtip fuel tank for liquid hydrogen, (2) a ram-air heat exchanger to vaporize the fuel, and (3) a regulator for the hydrogen flow, which was controlled by the regular engine throttle. The engine was modified to the extent of adding a separate fuel manifold and injection tubes for the hydrogen. Over three-fourths of the 38 transitions from JP-4 fuel to hydrogen were satisfactory. The other transitions were characterized by speed variations.

NACA RM E57D3a


Authors (3)
AERONAUTICAL MEDICAL RESEARCH INSTITUTE

ANALYSES FOR TURBOJET THRUST AUGMENTATION
WITH FUEL-NICE AFTERBURNING OF HYDROGEN,

Author

When compared at equal liquid weights, hydrogen, diborane, or hydrazine, burned at higher than stoichiometric fuel-air ratios, can produce thrusts that are, to some limit, greater than those for a 220-
second specific-impulse rocket combined with stoichiometric afterburning of the
turbojet fuel. At the conditions analyzed, this limit for liquid hydrogen is a liquid-
air ratio of 0.16; the corresponding thrust is 27 percent greater than that for stoichi-
ometric afterburning alone. Fuel-rich afterburn-
ing of 700° K hydrogen can yield
augmented thrusts greater than those for stoichiometric combustion of 700° K
hydrogen and 400° K air with a 321.6-second specific-impulse rocket.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

EXPERIMENTAL EVALUATION OF "SMALL-CAN"
VAPORIZERS FOR HYDROGEN-FUEL COMBUSTOR. (U). Warren D. Rayle, Robert D. Jones, and

Authors (3)

The elements varied from 1.5 to 2.5 inches in length and from 1.1 to 2.0 inches in diameter and served as combined fuel in-
jectors and flame stabilizers. Combustion efficiency of the individual elements ex-
ceeded 70 percent at a reference velocity of 180 feet per second, a pressure of 5.7
inches of mercury absolute, and an inlet temperature of 350° F in a combustor length of about 13.5 inches. Conical and cylin-
deral elements with an inlet that was covered with an orifice plate blocking about 75
percent of the area operated stably with hydrogen to velocities as high as 280 feet
per second at the same inlet pressure and temperature.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

DESIGN AND PERFORMANCE OF FUEL CONTROL FOR

Authors (3)

Hydrogen was carried in the fuel tank as a
cold liquid, vaporized in a heat exchanger,
and injected into the combustion chamber as a
gas. The fuel was forced through the system
by pressurizing the tank. The type of
control that appeared most capable of coping with the characteristics of this system was
a flow regulator. The flow regulator de-
singed for the system was a differential
reducing-ounce type. Speed control of the engine was obtained by coupling the hydrogen regulator to the JP-4 fuel control. Because the hydrogen regulator was designed for
high dynamic response, the performance of the complete speed-control system was
essentially the same on hydrogen as on JP-4
fuel.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

EFFECT OF COMBUSTION GAS PROPERTIES ON
TURBOJET-ENGINE PERFORMANCE WITH HYDROGEN
AS FUEL. (U). Robert E. English. Apr. 10,
1956. 11p. diagrs.

Author

Simple adjustment of turbojet engine cycle
calculations based on JP-4 fuel for the in-
crease in heating value when hydrogen is
substituted for JP-4 resulted in the following
errors: Fuel specific impulse was a much as 3 percent high; thrust per unit
airflow was a much as 5 percent less; air-
flow per unit of turbine frontal area was
as much as 1 percent low.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

TURBOJET PERFORMANCE AND OPERATION AT HIGH
ALTITUDES WITH HYDROGEN AND JP-4 FUELS. (U).
William A. Fleming, He(aold) R.
Kaufman, (ames) L. Harp, Jr. and L(ouis)

Authors (4)

Component and over-all performance data
were obtained with JP-4 fuel over a range
of altitudes from about 40,000 to 80,000
feet at a flight Mach number of 0.8, and
with hydrogen fuel at altitudes from
70,000 to 90,000 feet at the same flight
Mach number.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

PERFORMANCE OF A SHORT COMBUSTOR AT HIGH
ALTITUDES USING HYDROGEN FUEL. (U).
Joseph N. Slive and David B. Penn. Aug. 7,
1956. 23p. diagrs.

Authors (2)

Performance characteristics of a 16-inch
annular-type combustor installed in a full-
scale engine using gaseous-hydrogen fuel
were obtained at simulated altitudes from
56,000 to 86,000 feet at a flight Mach num-
bber of 0.8. Combustion efficiencies of 86
percent were obtained at 56,000 feet
(combustor pressure, 420 lb./sq ft abs). Combustor blowout was not encountered during
this investigation.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

AN ANALYTIC STUDY OF TURBOJET-ENGINE THRUST
AUGMENTATION WITH LIQUID HYDROGEN, PENTA-
BORANE, MAGNESIUM SULFIDE, AND JP-4 AFTER-
BURNT FUELS AND A 220-SECOND IMPULSE
59p. diagrs., tabs.

Author

Augmented thrust and total fuel flow for
the five augmentation methods were computed for four turbojet engines and several
operating conditions. The order of perfor-
mance for the afterburner fuels and the
rocket was independent of the variables
examined. Liquid hydrogen and pentaborane,
in that order, gave the lowest fuel con-
sumption. These two afterburner fuels also
dropped specific fuel consumption below
that for a turbojet engine alone at certain
flight conditions.

AERONAUTICAL MEDICAL RESEARCH INSTITUTE

ANALYSES OF TURBOJET AND RAM-JET ENGINE
CYCLES USING VARIOUS FUELS. E. Clinton
Wilcox, Richard J. Weber and Leonard R.

Authors (3)

Thrust per pound of airflow and engine
overall efficiency are presented for after-
burning and nonafterburning turbojets up
to a flight Mach number of 3.0 and for
ram-jets up to a Mach number of 4.0. Fuels
considered are hydrogen, pentaborane,
ethylene decaborane, and a conventional
hydrocarbon. Differences of 10 percent or
more in thrust and over-all efficiency are
found in some cases because of the varia-
tion in combustion gas properties when
different fuels are used.
NACA RM E56-016


Authors (3)

Satisfactory combustion efficiencies and cutout radial-temperature distributions at low total-pressure loss were obtained in an experimental, quarter-annulus combustor with hydrogen fuel at total pressures as low as 5.7 inches of mercury absolute. The combustor was 25 percent shorter than previous models for liquid hydrocarbon fuels. Similar performance was obtained from this combustor design operated with hydrogen in a full-scale engine.

NACA RM E55J18


Authors (2)

Operating conditions simulated Mach numbers of 2.5 and 3.0 at altitudes of 51,000 to 66,000 feet and 63,000 to 89,000 feet, respectively. Compressor modifications included two fuel-injector designs, several combustor lengths, and tests with and without flameholders. Combustion efficiencies were measured by three techniques: a heat balance after adding quench water, direct temperature measurements by thermsouples, and total pressure measurements at the exit of a choked convergent exhaust nozzle. The agreement among the three methods was reasonably good. A combustor length of 16 inches gave combustion efficiencies of 90 percent or greater for equivalence ratios from 0.5 to stoichiometric. The engine started at pressures as low as 7 inches of mercury absolute and ran very smoothly at all operating conditions.

NACA RM E56J18a


Authors (3)

Liquid hydrogen was used as a heat sink for turbine-cooling in a high-temperature modified turbojet engine. The turbine cooling air was refrigerated by cold hydrogen in a heat exchanger, and the engine was operated with this hydrogen as fuel. Cooling-air temperatures of 160° to 220° F were obtained at the heat-exchanger exit with cooling-air flow rates of 3 to 4 percent of the engine airflow. The fuel and cooling-air systems and the problems encountered in their operation are discussed. Information is presented on the properties of liquid and gaseous hydrogen that are pertinent to such a fuel-system design.

When applied to a supersonic inlet diffuser at both $M = 1.9$ and 3.0, the process produced large total-pressure losses due to the momentum exchange between the inlet air stream and the coolant as expected, but the total-pressure increase associated with evaporative cooling was not observed. Tests at $M = 3.0$ with a heated air stream and multipoint upstream injection suggest that some improvement in the process might be obtained with a full-scale inlet at the high stagnation temperature of supersonic flight.


The physical properties of liquid hydrogen that have been used in the present analysis are summarized. The heating value of the fuel is 54,571 Btu per pound, which is about 2.75 times the heating value of the average hydrocarbon fuel (JP-4) in current military use. This analysis shows that within the state of the art and progress anticipated, aircraft designed for liquid hydrogen fuel may perform several important military missions that comparable aircraft using hydrocarbon (JP-4) fuel cannot accomplish. These include: (1) subsonic bomber and reconnaissance flights of over 5500 nautical miles without refueling with an altitude over the target of 80,000 feet; (2) supersonic bomber (Mach 2.0) and reconnaissance flights (Mach 2.5) of about 2500 nautical miles radius with altitudes over the target of 75,000 feet for the bomber and 80,000 feet for the reconnaissance aircraft; (3) supersonic fighter aircraft with a combat radius (Mach 2.5) of 700 nautical miles and a combat altitude of 80,000 feet.


Some of the considerations involved in the design of aircraft fuel tanks for liquid hydrogen are discussed herein. Several of the physical properties of metals and thermal insulators in the temperature range from ambient to liquid-hydrogen temperatures are assembled. Calculations based on these properties indicate that it is possible to build a large-size liquid-hydrogen fuel tank which (1) will weigh less than 15 percent of the fuel weight, (2) will have a hydrogen vaporization rate less than 30 percent of the cruise fuel-flow rate, and (3) can be held in a stand-by condition and readied for flight in a short time.


The combustor was operated over a range of inlet-air pressures from 5.3 to 24.0 inches of mercury absolute and inlet-air reference velocities from 60 to 100 feet per second. The combustion efficiencies obtained with the six configurations varied from about 65 to 95 percent for a combustor temperature-rise range of 200° to 1400° F. At a temperature rise of 1200° F (near-rated engine conditions), the spread in efficiencies of the six configurations was about 5 percent. Efficiencies in the range of 65 to 85 percent were obtained at operating conditions beyond the burning range of conventional jet fuels. A fuel-injector configuration that fed only gaseous hydrogen fuel into the standard liquid-fuel-vaporizing tubes generally gave the highest efficiencies. This configuration minimizes the possibility of combustion in the fuel-vaporizing tubes and could be easily adapted to the full-scale engine combustor.
METHANOL

METHANOL: OLD HELP FOR A NEW CRISIS.
F.E. Bryson.

To switch our universal fuel from a petroleum to an alcohol base would challenge some of the most potent and entrenched economic forces in the world. Yet, such a change might make good sense from both an economic and an environmental standpoint.

THE BEST SUBSTITUTE FOR PETROL MAY BE PETROL.
N. Valery.

Hydrogen may be heralded as the ultimate fuel for motor cars and aircraft, but it has serious problems. A more practical fuel would be methanol made from coal, or even, synthetic petrol manufactured from basic ingredients.

METHANOL AS A GAS SUBSTITUTE.
J.F. Pink.

THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering & Environmental Design, Univ. Miami, Coral Cables, Florida.
Sponsored by The National Science Foundation, Defense Advanced Research Projects Agency, and The School of Continuing Studies, Univ. of Miami.
Miami Beach, Florida, Mar. 18-20, 1974.

THE METHANOL ECONOMY
T. B. Reed, Massachusetts Institute of Technology, Lexington, Massachusetts

TITLE: Methanol - The "New Fuel" from Coal
AUTHOR: Hill, G.A., Barney, R.B.
CORPORATE AUTHOR: U.S. Dept. of Interior, Bureau of Mines, Division of Coal, Energy Research
PUBLICATION DESCRIPTION: Chetech, p. 26-31, 20 ref.
PUBLICATION DATE: 1974, January
ABSTRACT: Recent tests have indicated that methanol, either alone or mixed with gasoline, can be used as an automotive fuel with few engine modifications. Using modifications of coal gasification processes which are already under development, the manufacture from this feed seems economically attractive. It is possible that it might be better to manufacture and ship methanol from overseas than LNG. (JNC)

TITLE: Methanol from Coal Can Be Competitive with Gasoline
AUTHOR: Harris, R.S., Devison, R.B.
CORPORATE AUTHOR: Texas A & M University
ADDRESS: College Station, TX
PUBLICATION DESCRIPTION: Oil and Gas Journal, 71(51), 70-72
PUBLICATION DATE: 1973, December 17
ABSTRACT: Methanol can be used as a motor fuel instead of gasoline, with certain advantages and few disadvantages. A big advantage is reduced pollution. Calculations indicate that methanol could be manufactured directly from coal and be competitive with gasoline costing 16.3¢ per gallon (tax-free). (JNC)
AIChe Symposium Series, v.69, no.135 1973


American Inst. of Chemical Engineers

DESIGN AND PERFORMANCE OF THE ICI 100 ATMOSPHERES METHANOL PLANT

J. B. Horsley, P. L. Rogerson, and R. H. Scott 90-18-74

362

The advantages of using methanol as a fuel and the ways in which it can be utilized immediately into the fuel economy are discussed. Methanol can be made from natural gas, petroleum, coal, oil shale, wood, farm and municipal wastes; easily stored in conventional fuel tanks and shipped in tank cars, tank trucks, and tankers; can be transported in oil and chemical pipelines. Up to 15% of methanol can be added to commercial gasoline in cars now in use without modification to the engines. The methanol-gasoline mixture results in improved economy, lower exhaust temperature, lower emissions, and improved performance compared to the use of gasoline alone. Methanol can be used for most other fuel needs, and is especially suited for use in fuel cells for generating electricity. (35 references). (MCW)

THE METHANOL ALTERNATIVE NOW........


Methanol, an alcohol with many of the same transport, storage, and usage characteristics as gasoline. Methanol can be made from almost any other fuel insuring a flexibility of production beyond that of hydrogen or even gasoline.

OUTLOOK BRIGHT FOR METHYL-FUEL.


Methyl fuel can extend present energy supplies and significantly reduce pollution as well.

METHANOL COMPETITIVE WITH LNG ON LONG HAUL.

B. Dutkiewicz.


Visibility of methanol fuel depends on: distance of sea haul, need for clean burning fuels in the consumer country, and cost compared to alternate forms of clean burning fuels.

74-000394

USE OF ALCOHOL IN MOTOR GASOLINE - A REVIEW. 36p.

Aug. 1971

UNCL


American Petroleum Inst. API-Pub-4082

Key Words: A. Synthesis-8, 9, Methanol-2, Reaction Kinetics-8, Mathematical Model-8, Pilot Plant Scale-6, B. Design-6, Reactors-2, Synthesis-4, Methanol-2, Mathematical Model-10.

Abstract: The reaction kinetics in methanol synthesis of the prescribed reaction mechanism of the major reactions and the important side reactions have been obtained from pilot plant data. The reaction kinetics have been calculated from integral measurements for the four main reactions. A mathematical model was developed from the experimental data and used for design of different methanol reactors and circulating systems. Plant operating results correspond well with design calculations.


Key Words: Methanol-1, PVT Behavior-2, Temperature-6, Pressure-7, Polar Fluids-8, Fourth-Parameter-9, Constant Volume Cell-10.

Abstract: Experimental PVT data have been obtained for methanol by the constant volume method for temperatures from 200° to 300°C, and pressures from 1,200 to 10,000 lb./sq. in. The experimental data are estimated to be accurate to within 0.4%. Smoothed compressibility factors are presented for this region and are found to be consistent with data previously reported for pressures to 3,000 lb./sq. in. The compressibility factor of methanol is also analyzed by the fourth-parameter approach.


Key Words: Purification-8, Removal-8, Methanol-7, Ion-Exchange Resins-10, Carbonyl Compounds-3, Metal Carbonyls-3, Weak Acid-0, Aldehydes-3, Ketones-3, Iron Carbonyl-3.

Abstract: Ion-exchange resin techniques have been developed and commercially demonstrated for the removal of organic and metal carboxyls from methanol. These carboxyls are difficult to remove completely by using conventional separation techniques. The processing schemes, plant test results, and economic potential of these techniques in methanol purification systems will be presented.


Key Words: Reforming-8, 10, Synthesizing-8, Distillation-8, Compression-8, Catalyzing-8, Naphtha-1, 9, Methanol-1, 2, 9, Centrifugal-10, Gas Distributor-10, Computer-10, Savings-4, Activity-4, 6, Quench-6, Mixing-4, Equilibrium-6, Pressure-5, 7, Temperature-5, 7, Pressure Drop-3, 7, Hydrogen-1, Carbon Oxides-1, Copper-1, 5, Steam-1, Methane-2, 3, By-products-2, 3, Sulfur-3, Dust-3, Catalyst-5, ICI-0, Billingham-0.

Abstract: A methanol plant using a copper based catalyst has been built and successfully operated by ICI at Billingham, England. The activity of the copper catalyst is sufficiently high to allow methanol synthesis at temperatures below 300°C, and at a pressure of 50 atm. The synthesis gas is derived from a naphtha steam reformer and is compressed by centrifugal machines. A computer has been installed for on-line control and data logging. By-products are removed by two-column distillation.


Key Words: A. Reforming-8, Hydrocarbons-1, 9, Hydrogen-2, Carbon Monoxide-2, Carbon Dioxide-2, Methane-3, Argon-3, Steam-3, Temperature-6, Shift Conversion-6, Ratios-7, Purity-7, B. Production-8, Synthesizing-8, Methanol-9, Instrumentation-10, C. Control-8, Analysis-8, Processes-9, Reforming-9, Synthesis-9, Computers-6, 10, Digital-0, Models-10, Dynamic Regulation-10, Rates-6, 7, Ratios-6, 7, Temperature-6, 7, Quality-6, 7.

Abstract: Despite the apparent simplicity of the unit operations in a modern methanol plant, the problems encountered in calculating, achieving, and maintaining an economically desirable combination of synthesis components cannot be entirely resolved by conventional control methods. The correction of errors in the synthesis loop through properly timed changes in several reformer set points can best be performed by a process digital computer, backed up by reliable data from stream instrumentation. This paper outlines a computer application of reforming and synthesis simulators to dynamic regulation and illustrates the value of additional stream analyzers. The mechanisms for increasing daily production are also discussed.

Key Words: Synthesis Gas-1, Methanol-2, Ammonia-2, Liquid Slug-3, Compression-4, High Pressure-5, 6, Speed-6, Pressurization-7, Synthesizing-8, Production-8, Specific Speed-8, Steam-9, Centrifugal Compressors-10, SS3B-0, 463B-0, 272B4+4-0, 272B4-2R-0, 272B6+2R-0.

Abstract: High pressure equipment for methanol service is applicable to plant outputs from 600 to 2,000 tons/day or more. Machines with case pressure ratings from 1,000 to 6,500 lb./sq. in. are in service. Frame speeds to 18,000 rev./min. with a line of developed and tested impellers capable of handling flows from 150 to 8,500 ACFM offer complete flexibility in driver selection and arrangement and insure good efficiencies even for the smaller plant. Major design features include method of attaching piping to machined flats on the case, back to back impeller arrangement, option of thrust bearing location and direction from which bundle may be pulled for inspection and service, elimination of internal lube oil piping, shear ring method of head retention, availability of a wide range of materials applicable to most any service, and surface coating of components with stainless steel, phenolic, or galvanizing as required.


Key Words: Economics-8, Methanol-9, Pressure-6, Carbon Dioxide Addition-6, Capacity-6, Costs-7, By-Product Hydrogen-7, Natural Gas-1, Naphtha-1, Methanol-2, By-Product Hydrogen-2, Methanol-4, Pressure-5, Power-Gas/ICI Low Pressure Methanol Process.

Abstract: The introduction of the ICI low pressure methanol process to the industry over the past 18 mo. has led to a considerable rethink on the fundamentals of methanol production cost economics. Several projects over a wide capacity range are now well into the design phase, all utilizing the same basic process concept of low pressure synthesis but in fact each based on distinctive flow sheets designed to achieve minimum production costs for their particular locations incorporating specific raw material and utility cost data. Production cost data for a wide range of plant capacities is reviewed and variations to the basic flow sheet discussed.


Key Words: Methanol-2, Natural Gas-1, Hydrogen-1, Carbon Monoxide-1, Carbon Dioxide-1, Synthesis-8, Catalyst-10, Reaction Equilibrium-8, Kinetics-8, Conversion-8, Chemical Process-9, ICI Low Pressure Process-9, High Pressure Process-9, Equipment Costs-10, Utilities Costs-10, Purification-2, Fractionation-2, Centrifugal Compressors-10, Piston Type of Compressors-10, Isothermal Reactors-10, Adiabatic Reactors-10, Yield-2, Quenching Type of Reactor-10, Use Pattern-4, World Production-2, Yield-2.

Abstract: The chemistry and numerical data of thermodynamics, and kinetics of methanol synthesis from hydrogen and carbon oxides are reviewed. The method of calculating the conversion of a given synthesis gas to methanol is given. The composition and preparation of catalysts are discussed. The operating conditions for the two major industrial processes of methanol synthesis and product purification are given; these processes are generally designated as the high pressure process and the low pressure process. They are compared with respect to equipment costs, utilities consumption, and adaptability to a given single-train plant capacity, and local market conditions. Process flow diagrams are shown.
D. ORGANIC WASTES AND WASTE HEAT
CONVERTING GARBAGE INTO ENERGY.

Oil or gas from pyrolysis of garbage, methane from sewage plants and landfills.

A PERPETUAL METHANE ECONOMY - IS IT POSSIBLE?
D.L. Klass.

Why not use the sun to grow stuff and then let bugs turn it into methane fuel.


POWER FROM TRASH
William C. Kasper
Solid wastes could make a modest but important contribution to energy supplies and be transformed from a problem to an asset. Direct burning and manufacture of fuel from wastes are discussed.

GARBAGE ROUTES TO METHANE.
L.J. Ricci.

Spurred by solid-waste-disposal problems and increasing fuel costs, more and more companies and public agencies are looking at methane-from-garbage as an energy supplement.

ENERGY FROM SOLID WASTES 1974.
F.H. Jackson.

Pyrolysis is the thermal decomposition of carbonaceous materials in the absence of oxygen. The yields of gases, liquids, and solids are based on the chemical structure, size, and shape of the material to be pyrolyzed, the temperature for decomposition, and the heating rate. The pyrolysis product can be burned in the presence of oxygen, to form carbon dioxide, water, and heat. Kaiser et al., used simple retort apparatus to pyrolyze the individual components found in municipal refuse at atmospheric pressure and 1600°F. Typical waste analysis included paper, plastic, leather, rubber, food waste, glass, tree leaves, wood, textiles, glass, ceramics, stones, and metals. Municipal solid waste was found to have a high H/C ratio and is potentially attractive for the production of fuel gas. High conversions of waste to low molecular weight gases could be achieved in a fluidized bed. Municipal solid waste does not need pretreatment. (MW)

N74-19708/4 National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
CLEAN FUELS FROM BIOMASS
20M

The feasibility of converting biomass to portable fuels is studied. Since plants synthesize biomass from H2O and CO2 with the help of solar energy, the conversion methods of pyrolysis, anaerobic fermentation, and hydrogenation are considered. Cost reduction methods and cost effectiveness are emphasized. G.G.

1974


From 146th meeting of The American Association for the Advancement of Science; San Francisco, California, USA (25 Feb 1974).

The relevant aspects of photosynthesis are reviewed, the prospects for expanded exploitation of natural solar conversion systems are evaluated, and some avenues for needed research are suggested. The cheapest, largest, and most successful solar energy conversion system available is photosynthesis. Photosynthesis is not an efficient energy source. One approach examined was the search for increased yield of combustibles (e.g., woody plant material) and another was the interference with photosynthetic processes so that combustible gases like hydrogen or methane were produced. (MCW)

Gunter, J.D. Univ. of Oklahoma, Dept. of Geography, Norman, OK 73069

Jameson, W.C.

recycling and re-use: the future of solid waste.

No ads, no refs., from Text & SS.

WASTE RECYCLING: SOLID WASTE DISPOSAL: COMPOSTING: ECONOMICS: POWER GENERATION: BIBLIOGRAPHIES.
A selected list of recently published works on various aspects of recycling is provided. It is categorized to reflect the types of material being published and it indicates the state of the art. Specific topics include techniques, economics, composting, glass, paper, plastics, abandoned automobiles, and waste as an energy source.
FUEL FROM ORGANIC MATTER: POSSIBILITIES FOR THE STATE OF CALIFORNIA
The amounts of organic material that might be made available for energy purposes in the State of California, its potential fuel value, and the estimated cost are investigated. Sources of organic material that are considered are: (1) crops grown specifically for energy, (2) natural forests, and (3) wastes from the urban, agricultural, and industrial sectors. Preliminary results indicate that about 19% of California's gas supply could be derived from organic sources.

FEEDLOT MANURE AND OTHER AGRICULTURAL WASTES AS FUTURE MATERIAL AND ENERGY RESOURCES—1. INTRODUCTION AND LITERATURE REVIEW. This report presents an introduction to the problem, a review of present feedlot waste management methods and a review of the available technology which may be applicable to the processing of manure. It is believed that the chemical processing of manure is an attractive alternative to present feedlot waste management practices. The resulting products of processing agricultural wastes can potentially be valuable assets to the development of rural areas.

The feasibility of supplementing the dwindling supplies of natural gas by the conversion of organic solid wastes to pipeline gas is examined. Not only does this displace waste away from the major environmental problem and expense, they are the only renewable resource and their utilization will become more important as the natural resources become more scarce. A process is given for converting cattle manure to pipeline gas by direct hydrogasification. Economics of conversion is examined for two plant sizes, one for 690,000 lb/h of manure containing 30 percent moisture, and another of one-half this capacity. Gas prices, when averaged over a 20-year plant life, are 41 cents/10^6 Btu for the large plant, and 87 cents/10^6 Btu for the smaller unit. These economics together with the economics of collecting and transporting the cattle manure, as well as the value assigned to environmental protection, will determine how widely this technology can be applied. (MOW)
Kenahan, C.B.  USBM, Office of the Assistant Director-Metallurgy, 18th and C Sts., Wash., DC 20240.

Kaplan, R.S.
Dunham, J.T.
Limnan, D.G.
Bureau of Mines research programs on recycling and disposal of mineral, metal, and energy-based wastes.

Abs. illus., numerous refs., from AA.


The USBM research on recycling, reuse, and disposal of mineral, metal, and energy-based wastes is summarized. The USBM waste recycling and disposal program is directed toward the following 4 main areas of research and development: extraction of mineral, metal, and energy values from urban refuse; upgrading and recycling of automotive and related scrap; recovery, utilization, and stabilization of mine and mill processing wastes; and recovery and reuse of values from industrial waste products.

AIChe Symposium Series, v.69, no.133 1973


New techniques in the pyrolysis of solid wastes. p.56-
Hydrogasification of cattle manure to pipeline gas

Hydrogasification of cattle manure to pipeline gas

Kang, K.D., et al., ACS Div. Fuel Chem. Proc., 18, (1), 18-23, (April 1973). 9 pp. The gas quality and yield that can be generated by direct hydrogasification of dried cattle manure was investigated by the U.S. Bureau of Mines at the Pittsburgh Energy Research Centre, following a feasibility study which established that the process was capable of providing solid wastes disposal and pipeline quality gas production at prices lower than supplementary gas from other sources.

Fuel gas from organic waste

E. L. Klass and S. Ghosh.

Tells how solid wastes can be combined to make substitute natural gas... and under some circumstances, a net profit.

Conversion of manure to oil by hydrobaking. Experimental study is reported which aimed at improvement of the process for manufacturing oil from organics. A method for hydrobaking organic wastes using synthesis gas and a combination of cobalt-molybdate-sodium carbonate catalyst is presented. The proposed process requires no process water and results in the effective hydrobaking and desorption of organic wastes without a significant consumption of hydrogen. Bovine manure is hydrobaked and separated by hydrogen or synthesis gas (equal amounts of hydrogen and carbon monoxide) at temperatures of 330 to 420°C and operating pressures of 1500 to 3000 psig in the presence of a recycle CO2 gas. Synthesis gas can be used as a substitute for hydrogen in the conversion of organic wastes.

Conversion of manure to a substitute fuel. A single method and the considerations that apply to its development are presented. In order to evaluate the economic attractiveness of pyrolysis of solid wastes, costs were estimated for a plant producing gaseous fuel from a two-reactor system. The economics are quite similar and the values for the two systems are provided. Based on the analysis made, it may be concluded that pyrolysis of refuse is economically attractive and could produce a fuel gas at an attractive price in today's market. 12 refs.

A process used in which hydrogen was reacted with cow manure to determine the distribution and yield of hydrogasiification products was evaluated. It was concluded that, for reasonably large plants, the gas would be cheaper than any other fuel source except natural gas at present prices. Manure and hydrogen are fed into a hydrogasification reactor, with an operating pressure about 1,000 psig because high pressure favors methane production, lowers the gas purification investment, and reduces the cost of compression equipment to discharge the gas into the pipeline. The process is endothermic and any heat in excess of that required by the process can be used for steam production. Energy for the plant steam requirements is realized from the burning of char produced in the hydrogasifier. The cow manure was selected as a logical feedstock because of its chemical suitability and feedlots containing upwards of 80,000 head of cattle sanctioned reasonable-sized gas-production plants to be built nearby, eliminating transportation fees. (MCW)

Singh, Ram Bux
Building a bio-gas plant.
No abs., illus., no refs., from Text & SS.

LIVESTOCK WASTES: WASTE RECYCLING; GASES: WASTE DISPOSAL
PLANTS: INDIA: bio-gas plants.

Construction and operation plans are presented for 5 types of bio-gas plants used in India: single-stage, double-chamber, small-scale plant; 2-stage digester; large single-stage digester; single-stage multiple digester, and vegetable waste digester. Four of the plants are designed to run on livestock wastes and one uses vegetable wastes.
Anon.
U.S. National Technical Information Service. Government Reports
Abs. only, from AA. t.
(Ref. order No. PB-211-256).
REFUSE DISPOSAL: PYROLYSIS: FLUIDIZED BED PROCESSING:
WASTE RECLAMATION: MUNICIPAL REFUSE: abstract only: fuel gas
production.

An experimental program is described for converting municipal
refuse into fuel gas at high thermal efficiency using the fluidized bed
pyrolysis process. The process uses fluidized sand in the absence of
O2 to allow the production of a fuel gas and char. A short description
of a pilot test is given.

Anon.
Fuel oil from organic wastes.
No abs., illus., no refs., from Text.
COAL: ORGANIC WASTES: WASTE REUSE: FUEL OILS: pilot plants:
extraction processes.

The extraction of fuel oil from both coal and organic wastes such
as garbage is examined by reviewing the operation of 2 U.S. Bureau
of Mines pilot plants. The processes involved convert lignite or garbage to
liquid fuel by employing carbon monoxide (CO) reactions, produced by
the introduction of CO in pure form or in a CO-rich synthesis gas.
Water and, unless naturally present, an alkali such as sodium
carbonate are added as catalysts.

Schlesinger, M.D. (full) USBM, Pittsburgh Energy Research
Center, PA
Wolfe, D.E.
Pyrolysis of waste materials from urban and rural sources.
(Held in Chicago, III., March 14-16, 1972). Sponsored by U.S. Bureau of
Mines and Illinois Institute of Technology Research Institute. [1972?].
Abs., figs., tables, data tables, refs. for various papers. SS:
gas, liquid and solid fuels by pyrolysis, and these fuels are clean when
burned. The process is thermally self-sufficient, and energy in the feed is
almost all recovered in the products. Recoveries for municipal refuse are
about 85% and for more selective feedstocks (scrap tires or plastics) they
are even higher. Moisture in the feed can affect product distribution by
reaction with hydrocarbons formed and by participation in the water gas
shift reaction. Typical waste materials pyrolyzed include scrap tires,
municipal refuse, wood waste, battery cases, sludge, and manure.
Properly designed units should vent no offensive products to the
environment. Residue sent to landfill would be sterile and a small fraction
of the original volume. The cost will be considerably less than for other
disposal methods.
ENERGY RECOVERY FROM WASTES.
Solid Wastes Management Series (SW-36d1).
1972, D.C., EPA.

FUEL FROM WASTES: A MINOR ENERGY SOURCE.
T.H. Maugh II.

G. E. Johnson et al., "The Production of Methane by the Anaerobic
Decomposition of Garbage and Waste Materials," Pittsburgh Energy
Research Center, Bureau of Mines, USDI, presented at the 163rd National
Meeting of the American Chemical Society, Boston, Mass., Apr. 9-14,
1972.
A POTENTIAL LARGE SCALE PLASMA PROCESS: SYNTHESIS
OF INEXPENSIVE HYDROGEN BY USING A THERMONUCLEAR
DEVICE TO VAPORIZE WASTE ORGANIC MATERIALS.
D.R. Safrany.

Solar energy is stored as carbohydrates since these are produced via photo-
synthesis. This energy could be used to lower the cost of fixing nitrogen by
the Haber process, by perhaps an order of magnitude, if the carbohydrates could
be converted inexpensively to hydrogen and carbon monoxide. This might be
accomplished by vaporizing with a thermonuclear device, and thus driving to
thermodynamic equilibrium, large masses of organic waste materials, for ex-
ample, sewage, lignin, etc. By using a contained nuclear explosion, hydrogen
might be produced for considerably less than 1., and ammonia for %.0/lb.

CONVERTING ORGANIC WASTES TO OIL: A REPLENISHABLE ENERGY SOURCE.

Report of investigations.
Herbert R. Appell, Y. C. Fu, Sam Friedman, P. M. Yavorsky, and Irving Wender. 1971, 26* BM-R1-7360


The Bureau of Mines is experimentally converting cellulose, the chief constituent of organic solid waste, to a low-sulfur oil. All types of cellulosic wastes, including urban refuse, agricultural wastes, sewage sludge, wood, lignin, and bovine manure, have been converted to oil by reaction with carbon monoxide and water at temperatures of 350 to 400°C and pressures near 4,000 psig, and in the presence of various catalysts and solvents. Cellulose conversions of 90 percent and better (corresponding to oil yields of 40 to 50 percent) have been obtained. A continuous reactor for use at conditions equal to 300°C and 3,000 psig, has been operated successfully. Using sucrose as a feedstock, operation in this system has permitted a simplified and preliminary chemical study of the conversion process. Oil yields of over 10 percent have been obtained with this unit.

POWER FROM SOLAR ENERGY VIA ALGAE PRODUCED METHANE.

G.G. Golueke and W.J. Oswald.
DIRECT BURNING OF WASTES

CLOSING THE REFUSE POWER CYCLE. Singer, J. G.; Mullen, J. F. Combustion; 45: No. 8, 20-30 (Feb 1974).
Refuse burning may be applied to prepared municipal waste as a secondary fuel in the steam-generation process. A comparison is made of the West German practice of refuse burning on grate and the pneumatic-injection system installed at the Meramec Station of the Union Electric Company of St. Louis. Some types of fossil-fuel-fired steam generators are not as adaptable as other for refuse disposal. Steam generators operating essentially as base load units may be more desirable for burning solid waste than those operated at partial loads. The capital cost for conversion may not be attractive to a utility if the operation involves only small quantities of refuse. The location of the power plant may not always permit economical application of the process. (MCW)

A Lucas furnace system, a cyclonic furnace, may have applications in the utilities as a source of heat energy and municipal waste disposal. Some incinerators are operating in England, Australia, and at the Goodyear Tire and Rubber Company at Jackson, Michigan. A sludge burning furnace is being constructed in San Leamado, California. The furnace is essentially a vertical domed cylinder with a rotating hearth at the bottom and an array of air jets and burners around the furnace wall. There is complete oxidation minimizing smoke, particulates, and off-gases. The process, using tires, is autothermal and the cyclone quickly builds temperatures to 2000°F. The furnace heat can produce ~100,000 lbs. steam/hr at 450°F as it consumes 900 tires/hr. The output is considered as only process steam, but its heat energy could be useful in multi-stage process systems. In this process, the tires may be fed whole, while previous methods have required shredding, etc. (MCW)


POWER FROM TRASH

William C. Kasper

Solid wastes could make a modest but important contribution to energy supplies and be transformed from a problem to an asset. Direct burning and manufacture of fuel from wastes are discussed.

WOOD FUELS THE DEVELOPING WORLD.

K. Openshaw.

Wood is a major source of fuel in many countries and as the price of oil rises, wood fuel will become more important.
ADVANCED TECHNIQUES FOR INCINERATION OF MUNICIPAL SOLID WASTES.

Jack DeMarco.
Amer. Inst. Chem. Engineers Symposium Ser., v.70, no.137, 1974, p.281-

Although communities have long used incineration in trying to cope with their solid waste problems, there has been a certain amount of dissatisfaction with the results of the process. Much of the dissatisfaction is well justified and, unfortunately, is still present, but the days of the belching smokestack are numbered. New standards at the local, State, and Federal level no longer allow for procrastination in improving our environment. The upper limits of good technology are now being set as implementation requirements.

The best technology currently available on emissions, control techniques, and incinerator maintenance and operation as they relate to air pollution control must be put into use without delay. In addition, new concepts must be demonstrated, proven effective, and then put into operation in our solid waste management activities. EPA is supporting two projects in its efforts to demonstrate advanced techniques for processing the ever-growing amounts of solid waste that are generated in our country.


From 147th meeting of The American Association for the Advancement of Science; San Francisco, California, USA (25 Feb 1974).

The relevant aspects of photosynthesis are reviewed, the prospects for expanded exploitation of natural solar conversion systems are evaluated, and some avenues for needed research are suggested. The cheapest, largest, and most successful solar energy conversion system available is photosynthesis. Photosynthesis is not an efficient energy source. One approach examined was the search for increased yield of combustibles (e.g., woody plants) and another was the interference with photosynthetic processes so that combustible gases like hydrogen or methane were produced. (MOW)

MUNICIPAL REFUSE: A FUEL FOR ELECTRIC UTILITY BOILERS.

G.W. Sutterfield, D.L. Klumb and F.E. Wisely.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.484-488.

Full-scale testing to determine the feasibility of burning suitably prepared ash in existing pulverized coal-fired boilers has been underway by the City of St. Louis and Union Electric Company since April, 1972.

The potential benefits which can accrue to the metropolitan area as well as the utility include an environmentally acceptable means of solid waste disposal, conservation of irreplaceable natural resources, more effective control of land use, and, of course, electric power generation.


Martin Lieberman Feb. 1974 73 p refs. (Contract F00601-73-C-0101; AF JO: 6828M) (AD-774583; AFML-TR-73-244) Avail. NTIS CSCL 21/4

The primary objective of this study was to evaluate the technical feasibility of disposing of waste oils and contaminated fuels generated at Air Force bases by burning them with fuel oil and/or natural gas in a conventional boiler installation. Waste aviation piston-engine oil, synthetic turbine lubricant, hydraulic fluid, Stoddard solvent, crankcase oil, JP-4 jet fuel, and aviation gasoline were burned in No. 2, No. 6 fuel oils, and with natural gas carriers. The results of combustion tests, conducted for as long as 3 hours, indicated that the waste oils could be burned at as high as 5 percent by volume in the fuel oils without producing any significant air pollution or boiler corrosion problems. Each gallon of waste oil or contaminated fuel burned saves approximately a gallon of fuel oil. GRA

DISTRICT HEATING CAN ANSWER REFUSE DISPOSAL PROBLEM. Energy Int., 10: No. 10, 42-44(1973)

Incineration for the disposal of domestic and industrial wastes is coupled to district heating networks for the utilization of the energy generated. Problems for urban areas are the maintenance of a clean and tidy, healthy and enjoyable environment. The incineration of wastes combined with district heating facilities is discussed for several cities. Systems are developed in Europe, and the systems in Nottingham and Coventry are discussed. The Japanese experience with waste disposal heat is explained. Stockholm's Skogstulen incinerator plant is one of two serving the city. The operation at the systems in Mannheim, Germany, France, and North America is described. (MOW)
Resource recovery: The state of technology.
Abs. only, from AA, 1.
(Ref. order No. PB-214 149/7).
MUNICIPAL WASTES : SOLID WASTE TREATMENT:
WASTE RECYCLING : abstract only : technology assessment.
An assessment of technology applicable to resource recovery from
mixed municipal solid wastes is presented. Basic technical
and economic data were gathered and compiled on a total of 40
existing and emerging resource recovery systems. The information
was gathered through questionnaires sent to developers of each
system, published and unpublished literature, personal
communications, and selected site visits. An analysis was conducted
of the technical and economic aspects of resource recovery systems
that are ready for demonstration or are commercial plants. Included
are systems for energy recovery, materials recovery, pyrolysis,
composting, and chemical conversion.

Franklin, W.E. Midwest Research Inst., 425 Volker Blvd.,
Kansas City, MO 64110
Bendersky, D. Shannon, L.J.
Park, W.R.
Resource recovery: Catalogue of processes.
Abs. only, AA, 1.
(Ref. order No. PB-214 149/9).
MUNICIPAL WASTES : SOLID WASTE TREATMENT : WASTE
RECYCLING : DIRECTORIES : abstract only : process directory.
A compilation is presented of basic data on 40 U.S.
and foreign processes designed to recover resources from mixed
municipal solid wastes. Processes are classified under energy
recovery, materials recovery, pyrolysis, compost, and chemical.
Technical, economic, and general information are given for each
process when available. Included are the name and location of
developer; status of development; input and output capacities;
capital, operating, and net costs; revenues; process description;
and sources of information.

Solid waste as a utility fuel. G.E. Dreise, D.L. Khum, J.D. Smith
(Union Electric Co., St. Louis, Mo., USA).
Proceedings of the American Power Conference, Vol 35, Chicago, Ill., USA,
Full-scale testing to determine the feasibility of burning prepared refuse in an
existing pulverized-coal-fired boiler has been under way by the City of St. Louis
and the Union Electric Company since April 1972. The raw municipal refuse
collected by the City is milled to small particles, magnetic metals removed, and the
residue fired pneumatically to a 125-MW boiler unit. The potential benefits
which can accrue to the metropolitan area as well as the utility include
environmentally acceptable means of solid-waste disposal, conservation of irre-
placeable natural resources, more effective control of land use, and of course,
electric power generation. (2 refs.)

(ERA-R-4-73-283) WASTE AUTOMOTIVE LUBRICAT-
ING OIL AS A MUNICIPAL INCINERATOR FUEL. Chaskeys, S.;
McCoy, B.; Surprenant, H. (Environmental Protection Agency,
Washington, D.C., USA). Office of Research and Development.
Sep 1973. Top. GPO $1.05.
The technical, economic, and environmental impact of utilizing
waste automotive lubricating oils to improve the municipal
incineration combustion process was examined. Utilization of the
higher value of waste oil in a municipal incinerator could
be allocated the high level of combustible air pollutants and poor
residue quality resulting from the firing of wet and/or low flu-
value refuse. Laboratory analyses of selected physical properties
of waste oil and a waste oil burner testing program were con-
ducted to complement an information search program. The
physical and chemical properties of waste oil were reviewed in relation
to its suitability as a fuel oil. The auxiliary fuel heat flux require-
ments to offset the adverse effects of wet refuse were estimated
utilizing a combustion model of a refuse bed. Various methods
were evaluated for transferring this required heat flux to the
refuse bed. Suggested designs for monitoring and control and
waste oil storage and feed systems were presented. The impact
on air quality from the combustion of waste oil in a municipal
incinerator was estimated. Three-month average ground level
concentrations for lead were calculated and presented as concen-
tration leoploht. Capital investment and operating costs were
developed for auxillary waste oil systems in conjunction with
municipal incinerators. (64 references) (auth)

N74-187286/ Union Electric Co., St. Louis, Mo.
RECYCLING SOLID WASTE FOR UTILITY FUEL AND
RECOVERY OF OTHER RESOURCES
Earl C. Dille and David L. Khum 1973 17 p refs Presented
at 1973 Frontiers of Power Technol., Stillwater, Okla. Sponsored
by City of St. Louis
Avail. NTIS HC $4.00.
Full scale prototype testing to determine the feasibility of
processing municipal solid waste to produce supplementary fuel
for electric utility boilers and to recover recyclable, non-
combustible materials has been conducted. Operation of the
prototype was satisfactory during the first year with the exception
of milled solid waste mechanical handling problems. Crushed
glass in the solid waste resulted in excessive wear and mainte-
nance of solid waste pneumatic transport piping bends and elbows.
Metals and oversize pieces of wood caused frequent stoppages
of solid waste transport system mechanical feeding equipment.
The mechanical handling problems were identified soon after
the initial operation and it appeared clear that the material
presented no other operating problems at the processing plant
or in furnace combustion. Consequently, engineering design and
purchase of a mechanical air separator (air classifier) was initiated
provide for the removal of glass, metals, and other unburnable
materials.
SOLID WASTE DISPOSAL: INCINERATION OR PYROLYSIS.
J.A. Fife.

Combustion processes not only reduce volume and weight of municipal refuse, but could produce steam or electricity.

Goldrath, B. 108 Hobart Ave., San Mateo, CA 94402
Gas turbine key to solid waste disposal.
Diesel and Gas Turbine Progress, 39(8) 12-14, Aug 1973
No abs., ilus., no refs., from Text.

SOLID WASTE DISPOSAL - ELECTRIC POWER PLANTS
INTERNAL COMBUSTION ENGINES - Combustion Power Co
EPA - gas turbines.

In the Spring of 1973, Combustion Power Company put into operation a pilot plant embodying the most advanced technology in the waste treatment field. The plant was founded by EPA's Office of Research and Monitoring. The CPU-400 system was designed to recover energy and valuable materials economically from solid wastes in a pollution-free manner. The system recovers energy from combustible material and converts it to usable power through a gas turbine powered electric generator. The full-scale version will produce about 5% of a community's electric power needs, besides providing a completely automated nonpolluting packaged plant for disposal of segregated municipal wastes. The economic aspects of this system are considered. Exhaust gas emission is discussed, and the major steps in the CPU-400 system are described.
Energy recovery from waste. A municipal-utility joint venture.
Abs. only, from AA. 1.
Grassland EAP 506-EC-00311.
(Ref. order No. PB-213 534/2).
SOLID WASTE DISPOSAL : MUNICIPAL WASTES : FUELS :
BOILERS : POWER GENERATION : HEAT RECOVERY :
ELECTRIC POWER PLANTS : abstract only.

The recovery of thermal energy by burning shredded residential solid waste as supplementary fuel in boiler furnaces is discussed. The process details, the processing facilities, the receiving and firing facilities, the test boiler, and the economics and applicability are examined.

Metcalf and Eddy, Inc.
Generation of steam from solid waste.
Abs. only, from AA. 1.
Contract: USPHS PHS-EC-00195.
(Ref. order No. PB-214 106/1).
SOLID WASTE DISPOSAL : MUNICIPAL REFUSE :
INCRERATOR : WASTE RECLAMATION : STEAM :
ECONOMICS : MASSACHUSETTS : abstract only : Lynn.

TITLLE: Energy Forestry and Fuel Plantations "
AUTHOR: "Steeg, G.C.; Reap, C.C.
CORPORATE AUTHOR: InterTechnology Corp.
ADDRESS: P.O. Box 380, Warrington, PA 18976
PUBLICATION DESCRIPTION: Chestnut, 275-284, 23 references
PUBLICATION DATE: 1973, May
ABSTRACT: The environmental advantages of using agricultural plants or trees as fuel for a power plant are outlined. Theoretical calculations are made of possible various production per acre and the associated costs. The results indicate that fuel costs of about $1 per million Btu might be achieved.

1973
A project in St. Louis, Missouri using city refuse to supplement coal fuel in boiler furnaces that generate electricity is described. The project is sponsored by the city, the Union Electric Company, and the Federal Environmental Protection Agency. Four factors discussed are: the implication of the project for solid waste disposal and energy recovery; the project’s applicability on a nationwide scale; the economic aspects; and the environmental considerations. The St. Louis project does not offer a solution to the solid waste disposal, recycling, and the energy crisis. The burning of the garbage produces chlorine-containing emissions. The city plans to sell the magnetically separated ferrous metals, mostly scrap cans, to the nearby Granite City Steel Company, which will use this scrap to replace, on the order of 10 tons per day, iron ore in its blast furnaces. The refuse processing procedure is described. (MCW)

Waste disposal: the alternatives of combustion. R.S. Rochford, J.D. Walker (Babcock & Wilcox Co., Lynchburg, Va., USA).
Energy Int. (USA), p. 15-16 (Oct. 1973). Deals with municipal refuse which is burnt as a supplementary fuel in power station boilers. The requirements for incinerator design are discussed. (no refs.)

Gunter, J.D. Univ. of Oklahoma, Dept. of Geography, Norman, OK 73069
Jameson, W.C.
No refs., no recs., from Text & SS.
A selected list of recently published works on various aspects of recycling is provided. It is categorized to reflect the types of material being published and it indicates the state of the art. Specific topics include techniques, economics, composting, glass, paper, plastics, abandoned automobiles, and waste as an energy source.

Anon.
Solid waste management in the Denver region: Recycling, resource recovery, disposal, regional management, situation, alternatives, program, strategy.
Abs. only, from AA, t.
Contract: HUD H-1392.
A proposed 20-yr regional program for solid waste management in the Denver region and implementation strategy and recommendations for carrying out the program are presented. Also included are a regional perspective, the urban system concept, description of the existing solid waste management situation, management responsibilities, criteria, assumptions and uncertainties, the 6 technical and 5 management alternative concepts developed for consideration, and an evaluation of these concepts from which the program was derived. The program includes proposed short-range activities for 1971-75 and a long-range program to achieve maximum recycling or energy and resource recovery, with minimum environmental pollution and landfill use by 1980 or earlier.

Horner & Shriver, 5200 Oakland Ave., St. Louis, MO Inc. 63110
Solid waste as fuel for power plants.
Abs. only, from AA, t.
Grant: USPHS PHS-EC-00176.
The technical and economic feasibility of burning prepared municipal refuse as supplementary fuel in large suspension-fired utility boilers is determined. Consideration is given to the physical and chemical characteristics of raw refuse and refuse with certain components removed. Consideration was also given to the characteristics of the ash and residue resulting from the combustion of refuse and to the potential effects upon operation and maintenance of the components of the boiler units. The relative economics of the full-scale application of the process was also assessed, and an evaluation was made of the effects upon public health and air pollution control.

382
Stump, P. L.
Solid waste demonstration projects.
255 pp.
Sum. ill, refs. for various papers, from Preface & SS.
SOLID WASTE TREATMENT : REFUSE COLLECTION:
LANDFILLS: WASTE RECYCLING : FUELS : WASTE
MANAGEMENT : CONFERENCES: proceedings : Office of
Solid Waste Management Programs.

Papers are presented on management systems, collection and
transport, processing, resource recovery, and ultimate disposal of
solid waste. Specific projects examined sanitary landfill
operations on abandoned strip mines, rural collection and disposal
operations, fiber recovery through hydrodewatering, refuse milling
for landfill disposal, the Kuka Shark collection vehicle, mechanized
residential refuse collection, thermal reduction of solid waste,
refuse as fuel for power plants, the container-train method of
solid waste collection and disposal, problems affecting the recycling
of selected secondary materials, ferrous solid waste, and solid waste
management.

Anon.
U.S. company generates electricity from garbage.
No abs. no refs. from Text & SS.
ELECTRIC POWER : FUELS : MUNICIPAL REFUSE : WASTE RECYCLING :
MISSOURI : Union Electric Co.
The use of solid waste for generation of electricity is considered,
with emphasis on a project undertaken by the Meramac Plant of the
Union Electric Company (Saint Louis, Missouri). Shredded municipal
refuse is burned at the plant and used as a supplementary fuel in
utility boiler furnaces. The refuse cannot be stored for more than a few
days, so it must be burned as it is collected. The high cost of transport
from collection points to the plant is also a problem.

Mullin, John R.
Incinerator-heating plant. Element in city planning.
Military Engineer; Journal of the Society of American Military Engineers.
No abs. illus. no refs. from Text.
INCINERATORS : HEATING SYSTEMS : MUNICIPAL REFUSE : REFUSE
DISPOSAL : FEDERAL GERMAN REPUBLIC : Frankfurt: incinerator-
heating plant.
Incineration as a nonpolluting and conservationary method of
disposing of refuse is discussed. The prime example being Frankfurt's
(Germany) disposal plant where the refuse is compacted, incinerated,
and sorted, to remove metals for recycling. The heat given off by
incineration process is used for city heating and the land used for the
plant is at a minimum to conserve land.

Solomon, Joan
New York Acad. of Sciences, NY
The social redemption of pure garbage.
1972.
No abs. illus. no refs. SS.
MUNICIPAL REFUSE : WASTE REUSE : FUELS : ELECTRIC POWER
PLANTS : INCINERATION : energy sources.
With technological advancement, municipal solid wastes could be
efficiently converted into fuel and help solve the fuel shortage and
pollution problems. An electric company feeds pulverized refuse directly
into a power generating station normally fueled only by pulverized coal;
170 TPD could supply enough energy to run a 100 MW plant. Other
experiments in this field are discussed. Public opinion obstacles to such
utilization, however, must be surmounted.

Spalte, Paul W. (both) A.M. Kinney, Inc., Environmental
Miller, Carlton K. Control Div., Franklin, OH
Power boilers: The ultimate solution for solid waste?
Sum. illus. no refs. from Text & SS.
WASTE REUSE : SOLID WASTE DISPOSAL : MUNICIPAL REFUSE : HEAT
RECOVERY : FUELS : POWER PLANTS.
About 360 million TYP of municipal refuse is generated in the U.S.
A.M. Kinney, Incorporated, developed a new way to recover the heat
value of such refuse. The thermal recovery system is described which
processes solid wastes by converting combustibles to solid
homogenous fuel for power boilers either in industrial service or for
electric power generation. With add-on features it can separate and
classify noncombustibles for recycling. The recovery unit described can
process 1,000 TPD of municipal refuse. Economic considerations are
also given for the various refuse disposal methods.
A PROPOSED CYCLE FOR POWER PRODUCTION FROM INCINERATION OF MUNICIPAL AND WOOD WASTES


Allied Chemical Corp., Morristown, N.J.; Aerojet Nuclear Co., Idaho Falls, Idaho. AVAIL. NTIS

Prepared in cooperation with Aerojet Nuclear Co. Presented at Spring Meeting of the Western States Section of the Combustion Inst., Seattle, 24-25 Apr., 1972

/ELECTRIC GENERATORS/*WASTE UTILIZATION/*WOOD/*ECONOMIC ANALYSIS/*SYSTEMS ENGINEERING

BENEFICIATED SOLID WASTE CUBETTES AS SALVAGE FUEL FOR STEAM GENERATION

H. L. Hollander, P.E. and N. F. Cunningham, p. 75-


353 p. Illus. 28 cm.


"Sponsored by ASME Incinerator Division."

The ominous "energy crises", the mounting burden of solid waste disposal, and the appeal for environmental enhancement and resource recovery has stimulated imaginative multi-faceted approaches for solutions.

The concepts reviewed in this discussion hold promise for:

— conversion of a relegated combustible fraction of the solid waste stream into a "controlled quality salvage fuel" with physical characteristics necessary to permit amenable handling and storage to afford practical consumption on an "as fuel needed" basis.

— lower thermal energy costs through use of this beneficiated salvage fuel which would: a) permit continued and extended use of existing stoker-fired steam (power) plants; and b) provide investment justification for modernization of air pollution control systems.

— incentives to the private sector, (in particular the secondary materials industry), for further commitment to assist in coping with the ever growing solid waste problem.

— the husbanding of our natural resources — fossil fuels, ferrous and non-ferrous raw materials, and cellulose fibers and conservation of our land areas for greater utilization.
Performance of the New Chicago Northwest Incinerator. p. 178 -

GEORGE STABENOW
IBW-Martin Incinerator Group
East Stroudsburg, Pennsylvania

Operation of the incinerator plant was started during September 1970 and in 1971 all four 400 tons/day units have been provisionally accepted by the City.

The reverse reciprocating stokers with integrally designed welded waterwall boilers, economizers and electrostatic precipitators have undergone thorough tests for refuse burn-out, fly-ash collection, air pollution control and steam generator efficiency. Residue and fly-ash have been analyzed by competent consultants as well as by the U. S. Bureau of Mines. Two different organizations have tested the air pollution control performance of the electrostatic precipitators. One of the most interesting results of the boiler tests is the determination of the refuse heating value by the heat balance resulting from measurement of the heat loss and quantity of steam generated. The performance of the incinerator is described in this paper. Data carefully collected under supervision by independent testing organizations have been evaluated and are presented herewith. It is hoped that the information contained in this paper will help to establish the fact that an incinerator can be a good neighbor.
Recent Developments and Operating Experience with British Incinerator Plant

R. H. WATSON (Partner) and J. M. BURNETT (Associate)
Merz and McLellan
Newcastle upon Tyne, England

The paper mentions the change in Britain from separation/incineration plants with batch-type grates to continuous incineration of crude refuse on mechanical grates and tabulates the main features of all the recent plants in Britain, both operational and under construction or planned. Some details are given of operating experience and troubles.

It goes on to discuss the calorific value of refuse and outlines a series of tests to prove a method for direct measurement using the incinerator as a calorimeter. The paper goes on to consider heat use for power generation or district heating, or for the combined incineration of refuse and sewage sludge. It gives an outline of a pilot-scale process for recovery of nonferrous metals, and deals with recovery of other materials.

The paper covers British practice in dealing with environmental considerations, particularly dust emission and possible toxic gases constituents of the flue gases, with some notes on noise and concludes by mentioning likely trends in British practice, with special mention of the avoidance of vapor plumes which occur with attenuation of the flue gases by water sprays.
Design of a Refuse Incineration Plant for the City of Coventry, England

N. RAYMAN and PETER J. SCOTT
City Engineers Department
Coventry, England

Construction of the new refuse incineration plant in Coventry is in progress and the paper describes the processes which established the need for the plant and led to the selection of the site, the acceptance by nearby residents of that site as suitable for the purpose, and the decision to proceed with construction. The factors which determined the selection of a particular plant capacity and led to the selection of a particular refuse burning and boiler system are examined. The grate and boiler system, gas cleaning, ash handling systems and building features are described, together with the contractual arrangements for construction.

OPERATING EXPERIENCE IN THE SUSPENSION BURNING OF WASTE MATERIALS IN CYCLONE INCINERATORS.
R.G. Mills and L.G. Desmon. p. 195-

The technique of suspension burning has been utilized for the incineration of general and industrial waste materials. Four years of development work and successful application on various sized units incinerating wood products, paper, plastics, and other materials are described. Typical performance values for a unit 3 ft in diameter by 6 ft in length are a throughput rate of 3500 lb/h of material, an outlet gas temperature of 2800 F, and an exhaust heat content in excess of 28,000,000 Btu/h. This energy has been utilized for steam generation and other process heat requirements.
USE OF REFUSE AS FUEL IN AN EXISTING
UTILITY BOILER.
F. E. Wisely, et al. p. 97-
Proceedings. New York, American Society of
Mechanical Engineers, 1972.
1972
353 p. illus. 28 cm.
"Papers presented at 1972 National Incinerator
Conference, New York, N. Y., June 4-7, 1972."
"Sponsored by ASHE Incinerator Division."

The City of St. Louis, Missouri and the Union
Electric Co. are collaborating in a full scale test of the
feasibility of burning prepared refuse as supplementary
fuel in an existing pulverized coal-fired boiler. Raw
municipal refuse is milled to small particles, magnetic
metals removed and the remainder fired pneumatically
to a 125 mw boiler unit. The refuse comprises only a
small percentage of the total fuel requirement of the
boiler.

(At the time this paper was written, the project was
not yet in operation. It was anticipated that preliminary
operating data would be available for presentation by the
date of the Conference.)

ENERGY PLANTATION. Szego, O. C.; Fox, J. A.;
Eaton, D. R. pp 1121-1134 of 7th Interociety Energy Conversion
Engineering Conference. Washington: American Chemical Soci-
ety (1972).
From 7th Interociety energy conversion engineering conference;
San Diego, California, USA (25 Sep 1972). See CONF-720926-.
The solar energy falling on the Earth is far in excess of the
rates of usage of energy from all sources. The main problems
with solar energy are intermittency and low density. The use of
photosynthesis on a planned operational scale seems to solve these
problems in a cost-effective fashion, indeed highly competitive
with coal, and at the same time does not require inordinate land
areas. Technical and economic scenarios and analyses that com-
pare the cost of a million Btu delivered with that for fossil fuels
and nuclear energy sources are presented. (auth)
The problem of solid waste disposal can be solved in some cases by on site incineration of combustibles at high temperatures. The heat evolved from this operation could be used to generate steam or hot water for on site use or distribution to other facilities. A case history of such a program is provided. The use of a simple, automated system for on site burning of wastes and the recovery of the heat from the burning process is economically and environmentally worthwhile.
Energy Conservation and Waste Heat Utilization. A
Bibliography with Abstracts.
Edward J. Lehmann.

National Technical Information Service, Springfield, Va Jul 74. 147p NTIS-WIN-74-051
COM-74-11138/6WE PC$20.00/MF$20.00

The bibliography contains 142 selected abstracts of research reports retrieved using the NTIS on-line search system-NTISearch. The report is divided into two sections dealing with energy conservation. In the first, 50 reports are presented which concern all aspects of energy conservation including topics such as reducing electricity demand, conservation policies, and the reduction of heating and automotive fuel consumption. The second section covers all aspects of recovering waste heat from power plants, buildings, and industrial water. These 90 reports include studies of total energy systems, waste heat boilers, and the use of power plant waste heat for irrigation, heating, sewage treatment, and desalination.

A case is described in which coal-fired boilers were replaced by incinerators. Heat reclaimed serves to generate steam that heats ovens, plateaux presses, paper-machine dryer rolls, the plant, assorted processing equipment, and feeds turbine-driven paper machines. Liquid wastes are atomized and burned as fuel oil being sprayed into the combustion chamber as a fine mist. Solid wastes are burned in a double-vortex burner system. The conversion allows for yields of 180,000 lb of steam per hour and a clean stack. (MCW)

A review is given of progress made in several countries on the performance of nuclear power plants for combined production of electricity and hot water for district heating. Fear still exists about the safety of atomic power, and power plants will continue to reject twice as much heat energy as they use to generate electricity. The public must be persuaded that there is little risk and that precautions are taken to prevent disaster. (MCW)

ENGINEERING GUIDELINES FOR TOTAL ENERGY ARE EVEN MORE VITAL DURING FUEL SHORTAGE. Kaufman, W. M. Power; 119: No. 4, 73-75(Apr 1974).
Large total-energy facilities, from 3 to 20 MW in capacity, are studied, but the guidelines are applicable to small units also. Heat-balance analysis, fuel costs, load factor, load-profile match, and control-system design are engineering parameters for total-energy systems that will improve fuel economy. (MCW)

1974

Air conditioning by absorption refrigeration that utilizes heat recovered from engines and from incineration of solid waste is a utility service that can be included in a MIUS. This report reviews the suitability of lithium bromide-water absorption refrigeration for such an application. Types and sizes of units manufactured and their availability are discussed. Single-effect lithium bromide-water absorption systems are available from domestic manufacturers, and double-effect systems will probably be available in the near future. Capital and operation and maintenance costs are given for single-effect absorption-refrigeration systems. Where waste heat is available from electric power generation, a total energy system will use less fuel than a conventional system supplying electric power and using compressive refrigeration over a wide range of conditions. Fuel consumption comparisons are made between total energy and conventional systems providing the same service. (auth)

G. Samuels, and J. T. Meador.
Oak Ridge National Lab., Tenn. Apr 74, 73p ORNL-HUD-MIUS-11 PC$5.45/MF$1.45
Prime movers suitable for supplying electricity and using exhaust heat to heat and cool small communities served by a MIUS are evaluated from the standpoint of performance and economics. Present economic and technology considerations limit the choice of prime movers in the 150- to 1000-kW range to gas and steam turbines, spark-ignition gas engines, and compression-ignition diesel and dual-fuel engines. The fuel economy, maintenance cost, and equipment costs for gas turbine-generator units and for the various internal-combustion piston engine-generator units are included. (Modified author abstract)
(SLLA-74-91) SOLAR COMMUNITY ENERGY FOR RESIDENTIAL HEATING, COOLING, AND ELECTRIC POWER.
From 140th meeting of The American Association for the Advancement of Science; San Francisco, California, USA (25 Feb 1974).
A series of systems studies on the potential uses of solar energy was conducted at Sandia Laboratories. The outcome of these studies is a new concept, the Solar Total Energy Community. This is a residential community which could significantly reduce its fossil fuel energy consumption by using the sun as the source for most of the community's energy needs. A system computer program, developed for the study was used to examine the energy requirements and to optimize the energy performance of these systems. An experimental program has been initiated to investigate various systems relative to the concept. The study shows the Solar Community is technologically feasible and that the projected costs warrant further investigation of solar energy as an alternative energy source. This paper reviews the previous work, reports recent findings and improvements, and presents the current status of the continuing analytical and experimental efforts. (aut)
D. Glenn, J. Oplinger, and J. Orlando.
Decision Sciences Corp., Jenkintown, Pa. Jul 73. 59p
HUD-DSC-1
PB-228 683/9WE PCS$3.75/MFS$1.45

These guidelines provide a screening tool which can be used by the private and public sectors to determine the economic applicability of total energy systems for residential developments. The guidelines are designed to allow a simple, straightforward, low-cost determination of whether or not a complete engineering feasibility study is justified. They do not eliminate the need for a complete feasibility study, requiring the services of engineering consultants experienced with total energy systems.

Economic Evaluation of Total Energy.
D. Glenn, J. Oplinger, and J. Orlando.
Decision Sciences Corp., Jenkintown, Pa. 12 Jul 73. 490p
HUD-DSC-2
PB-228 893/4WE PCS$9.75/MFS$1.45

Total energy systems are onsite power generation systems with heat recovery. By generating electricity on the premises, it is possible to recover normally wasted heat and use it to provide space heating, cooling, and domestic water heating. The objective of the study was to develop economic evaluation guidelines which could be used by the private and public sectors as a screening tool to determine the applicability of total energy systems for residential developments.

A history of the application of geothermal energy for heating of houses is discussed for Iceland, Hungary, Japan, New Zealand, and USSR. The economics and technical aspects of the systems are described. The development of the geothermal areas feeding the systems in Reykjavik is described, and then principal data regarding the geothermal district heating system is given. The Reykjavik system saves about 180,000 tons of oil annually that would have had to be imported, and the annual cost of heating for the customers is only 60% of the cost of heating with oil. (20 referenced) (MCW)


The efficiency of a system for the supply of thermal and electrical power to the city of Moscow was mathematically analyzed on the basis of two variants. In the first, the thermal and electrical power was supplied by a nuclear electrical power plant and an organically fueled condensation electric power plant. In the second, the power was supplied by a nuclear electrical power plant, a condensation electrical power plant, and a district heating nuclear power plant. The analysis showed that replacement of thermal and electric power plants with condensation power plants and district heating nuclear power plants does not result in over-expenditure of organic fuel. (JSR)


Incineration for the disposal of domestic and industrial waste is coupled to district heating networks for the utilization of the energy generated. Problems for urban areas are the maintenance of a clean and tidy, healthy and enjoyable environment. The incineration of waste combined with district heating facilities is discussed for several cities. Systems are advanced in Europe, and the systems in Nottingham and Coventry are discussed. The Japanese experience with waste disposal is explained. Stockholm's Högskolan incinerator plant is one of two serving the city. The plant at the systems in Munich, Germany, France, and in North America is described. (MCW)


An investigation was made to select the design of a new turbine to operate at main steam conditions of 60 kgf/cm² and 275 C. Comparisons have shown that the water-cooled reactors are desirable to operate with the district heating turbines for performance and efficiency. The annulus characteristics of the T-150/250-60 turbine plant with connected heat load of 1500 Gcal/h at different heating factors of 1.0, 0.7, 0.5, and 0.4 were calculated. The characteristics of a nuclear heat and power station with one turbine is also determined. (MCW)


The total energy power plant system at Texas A&M University is described. The natural gas or the fuel oil is used as the original energy source to drive the gas turbine or to boilers which produce the steam necessary to drive the steam turbines. Low pressure steam is extracted from the turbines and used to produce heating water, chilled water, and steam for low-temperature heat. The utilities are then distributed throughout the campus to the various buildings. The unused utilities are then returned to the power plant where they are again recycled through the plant and redistributed. (auth)

TITLE: Total Energy: A Key to Conservation
AUTHOR: Beall, S. P., Jr.
CORPORATE AUTHORS: Oak Ridge National Laboratory
ADDRESS: P.O. Box 1, Oak Ridge, TN 37830
PUBLICATION DESCRIPTION: Consulting Engineer,
40(1), 180-185
PUBLICATION DATE: 1973, March
ABSTRACT: Studies of the beneficial uses of waste heat from large steam-electric generating systems and smaller "total energy" systems are described. Extracted and back-pressure heat from steam turbines can be used to desalt water, in agro-industrial processes, provide low-temperature heat in urban areas, and in agriculture and aquaculture. Each of these applications is described. It is estimated that 10% of the total fuel used in power stations could be saved if half of the new installations supplied heat as well as electricity. (HPS)
MODULAR INTEGRATED UTILITY SYSTEMS (MIUS) SHOW PROMISE.


Recent studies by Federal Agencies indicate that the widespread use of Modular Integrated Utility Systems in place of central station power facilities could reduce total U.S. residential energy consumption by as much as 8.5% in 1986.

TURBINE TOTAL ENERGY FOR OFFSHORE RIGS,


The advantages of prepackaged gas turbine powered total energy systems for remote operations are outlined. These include space savings, favorable weight/power ratios, vibrationless operation, recoverable exhaust energy, and cleaner exhaust. Major system components and economics are discussed for systems of the 3 to 6 MW capacity. (MCW)
The utilization of waste heat and waste fuels means increased efficiencies and a cleaner environment. Some developments for the reclamation of waste fuels and waste heat at Foster Wheeler Limited are discussed. Refuse-fired boilers that have bark-burning equipment as an integral part of the main furnace are described. Not only waste fuels from the forest industry may be applied, but also bagasse from sugar cane, pits from olives, coconut shells, and husks and chaff from milling of grain. The shop-assembled wood and fibrous fuel-fired boilers are described. Flue gases discharged to the atmosphere are being reclaimed and the use of by-products such as CO and refinery coke are being used as fuel for steam generators. Some currently employed heat recovery schemes and the selection of suitable equipment are reviewed. (MCW)

A proposed single-pipe district heating system using heat pumps to extract low grade energy from condenser circulating water is described. The release of enormous quantities of heat from all condensing power stations has been ignored. For example, only 32% of the energy available in the fuel for a light-water reactor, is converted to electricity, the only useful product of a nuclear power station. A station with an electrical output of 5,000 MW releases about 10,000 MW of heat that is presently useless. The distances between a nuclear power station and the nearest large community are large, and the use of this heat solely for space heating is at present impossible. With the use of the system described, no significant reduction in electricity production occurs when a condensing set is converted to back-pressure operation. (MCW)

Roughly 45% of Switzerland’s total energy consumption is accounted for by air-polluting individual oil-fired systems for space heating and hot water services. With reference to the proven technique of the combined heat and power plant, a model is proposed that, in addition to its established advantages, has two decisive features: 1) The heat for the district heating networks can be generated from any energy source, in future especially from the source that is the most suitable in terms of atmospheric pollution and a general supply policy; and 2) By coupling heat and power it is possible to provide the urban centers with hot water, and heat the great majority of Switzerland’s other population centers directly with electricity generated at the same time. This would eliminate over 97% of the separately fired systems. Domestic hot water will be heated on a base-load arrangement by nuclear power stations, partly by supplies of heat, partly by electricity. (auth)

PRESENT-DAY CONDITIONS AND PROSPECTS FOR THE DEVELOPMENT OF DISTRICT HEATING.

URBAN UTILIZATION OF EXTRACTED HEAT AND WASTE HEAT FROM CENTRAL STATION POWER PLANTS.
From 7th Intersectociety energy conversion engineering conference, San Diego, California, USA (25 Sep 1973). See CONF-720925-
An analysis is presented of the feasibility of providing thermal energy as well as electricity to urban areas from central station steam-electric power plants. Consideration is given to the use of thermal energy for applications such as industrial processes, building space heating, air conditioning, sewage treatment, agriculture, and aquaculture. The use of dual-purpose plants significantly reduces the consumption of fuel and lessens the environmental impact of providing energy as compared to conventional systems. Areas of multifamily dwellings and other multiuser buildings could be served in new cities, or renewed old cities, at costs comparable to those incurred with more conventional separate systems. However, it would require more planning of facilities and coordination of diverse organizations than we normally employ. The costs and dislocations associated with retrofitting existing cities would cause each city to be a separate case. (auth)

PROPERLY designed total energy systems could achieve energy savings of 28 to 40 percent if applied to medium-sized housing developments in six selected areas of the United States, according to an NBS study.

From 7th Intersociety energy conversion engineering conference; San Diego, California, USA (25 Sep 1972). See CONF-720923-.

The total energy concept, the history of the concept, and the problems involved in designing and installing TE systems are discussed. The basic problem is that such systems have to be custom designed around components that are not always totally suited for TE application. This necessitates extensive engineering to design a dependable installation and rigorous maintenance procedures to assure system reliability after the system has been placed in operation. A detailed listing of the problems of the TE concept is presented. This is followed by specific recommendations to improve upon existing hardware and to develop new hardware in order to make the TE concept a viable one that will permit its potential for conserving fossil fuels and reducing air, water, and thermal pollution to be realized. (auth)


The work was undertaken to formulate a quantitative mechanism that would facilitate evaluation of power plant waste heat utilization potential. Heat at usable temperatures is made available by extraction from the turbine. Incremental rates for reductions in electric output and heat rejection are obtained for various amounts and locations of waste heat extraction. The maximum justifiable investment (MJ), for a waste heat system, is calculated using a present worth criterion and at constant thermal input to the turbine cycle. A series of thermal market prices is applied in order to determine the sensitivities of the MJ to potential market values. Results for a typical medium-sized plant are summarized. (GRA)

N73-22912# Grumman Aerospace Corp., Bethpage, N.Y. Research Dept.

CLEAN AND ATTRACTIVE URBAN POWER SYSTEMS


The siting and waste problems facing the power industry at the present time are examined. It is proposed that these problems be resolved by integrating clean power plants into community centers. This can be done in such a way that not only power, but also year-round recreation and job-training will be provided and utilized by the residents. More specifically, the result is a new type of integrated system that is comprised of total energy gas turbine power plants to be located in underground sites within the community centers, and year-round recreational, job-training, and other facilities to be designed to suit local needs and to be located within the same community centers. Author

TITLE: Comparing Combined Cycle Plants

Author: Tolleson, L.O.

Corporate Author: Power Systems Engineering, Inc.

Publication Description: Gas Turbine International, 13(6), 20-28

Publication Date: 1972, November-December

Abstract: Combined cycle power plants -- electric utility application are described and compared. The three basic types are the unified heat recovery cycle, the supplemental fired heat recovery cycle, and the exhaust fired cycle. All these systems use gas turbines and condensing steam turbine generators. Each system is described in some detail, with schematic diagrams, temperature-entropy diagrams, and graphs of heat rate, fuel cost, and other characteristics, range of installation costs, and heat rate vs power curves. Combined cycle systems are well suited for use in decentralized utility systems providing industrial customers with electric power and steam or hot gas for process heat. Fuel utilization for a decentralized power and steam plant is compared with that for a conventional central station plant. Future trends that are briefly mentioned are efficiency improvement, increased unit size, coal qualification combined cycles, and large combined plants. (EP)}
The problem of solid waste disposal can be solved in some cases by on site incineration of combustibles at high temperatures. The heat evolved from this operation could be used to generate steam or hot water for on site use or distribution to other facilities. A case history of such a program is provided. The use of a simple, automated system for on site burning of wastes and the recovery of the heat from the burning process is economically and environmentally worthwhile.

1971

PB-207300

NUCLEAR ENERGY FOR A NEW TOWN


This document is concerned with methods of utilizing the waste heat from a proposed nuclear generating facility in an industrial-municipal complex. Several products and processes are proposed, including marine pharmaceuticals, chemical production, municipal waste processes, and power production and processing, and residential-recreational uses. Sewage treatment was selected as the most promising use of the heat. This nonseasonal process can provide a solution to two regional problems: augmentation of municipal water supplies and elimination of a major source of water pollution. In the proposed system, sewage from the metropolitan Providence, R. I., area would be piped to the vicinity of the power plant, receive primary, secondary, and tertiary treatment to convert it to potable water and be piped back to the city's reservoir system. Heat from the power plant would be used in each stage to accelerate the process. Cost of the entire system was estimated at $4.3 million dollars. (Auth)

1971

PB-207701

ENVIRONMENTAL SPECIFIC METROPOLITAN AREAS


Environmental Co., El Monte, Calif.

Combined and specific for specific metropolitan areas.


Identifiers: "Low sulfur fuels, *solid waste disposal, *air pollution control, Philadelphia (Pennsylvania), Cleveland (Ohio)."

The purpose of the present study was to develop for two major cities, design recommendations and procedures for the disposal of refuse, a low sulfur fuel, with heat recovery in utility grade boilers. An earlier study in this area resulted in the identification of optimal system design configurations and quantification of benefits to the environment and the economy. The program has applied that knowledge to specific case study areas. Arrangements with two cities having high SO2 burdens and growing solid waste burdens were made: these were Philadelphia, Pennsylvania, and Cleveland, Ohio. Information required for the study was collected and analyzed. Specific design packages were then developed for each city. The report presents projections describing the future nature of the city refuse-fuel inventories, specific recommendations as to plant types, sizes, and sites, cost analyses of operations involving the utilization of such systems, and estimated reduction in SO2 and particulate emissions. From these data, the conclusion can readily be drawn that the systems recommended would be more cost-effective than the methods that are now in use. (Author)
TK 1041 .D5

Diamant, Rudolph Maximilian Eugen, 1925-
Total energy, by R. M. B. Diamant. 1st ed. Oxford,
New York, Pergamon Press; 1970;

1 x. 420 p. Illus., plans. 22 cm. (International series of monographs in heating, ventilation and refrigeration, v. 6)

Bibliography: p. 419-426.

This book sets out to give a comprehensive account of the methods which may be used for the production of power by small-scale equipment, and the utilization of waste heat produced. It deals with small steam turbines, open and closed cycle gas turbines, diesel and gas engines and fuel cells, as well as with methods of running small turboalternators and utilizing the waste heat produced. There are chapters which deal with district heating practice in Europe, and total energy undertakings in the USA. Finally there is a chapter concerned with the theoretical evaluation of the economic feasibility of running a total energy plant at all.
Conference on the beneficial uses of thermal discharges.


Abs., illus., refs. for various papers. SS.

ELECTRIC POWER PLANTS: THERMAL DISCHARGES: AQUACULTURE:

Current trends in electric power generation are reviewed, and the productive utilization of surplus heat is considered. Specific uses of thermal discharges are discussed, including: aquaculture in Scotland; mariculture in Japan; catfish farming; agricultural applications; space heating in Iceland; greenhouse heating; agricultural-industrial and urban uses; and combination urban-power systems.

N70-145197 Oak Ridge National Lab. Tenn.
SPACE HEATING IN URBAN ENVIRONMENTS
A. J. Miller In AEC Abundant Nucl. Energy May 1969
p 219 237 refs
Avail: CFSTI

A preliminary study indicates that in 1980 the heat from a nuclear energy center in or near a large city could be used to heat and to air-condition a large portion of the city at a cost per unit of heat equivalent to that now incurred by district heating in downtown commercial and high-rise apartment areas. The heat used would be from steam out of back-pressure turbines and turbine bleed rather than from prime steam, and thus the waste of heat from the plant generating electricity would be reduced or largely eliminated. Such a system would reduce both chemical pollution of the air and thermal pollution of streams. Author (NSA)
Studies have indicated that ~1000 MW(e) of base-load generation must be installed each year, beginning in the early 1980’s, if the demand for power in New Jersey is to be met.

Nuclear power is the proper choice for these base-load installations, but in New Jersey, which has the densest population of any state in the Union, there are few remaining sites for nuclear generation stations. In addition to the dense population, the lack of available water supplies for cooling make siting of any base-load station (nuclear or fossil fired) very difficult. Even when suitable sites can be found, licensing and construction delays are steadily increasing. These problems are not unique to New Jersey; they are shared to a greater or lesser degree by many utilities operating along the heavily populated coastal areas.

Offshore siting of base-load generating stations can provide an answer to utilities beset by these problems of population, cooling water, and licensing. This approach to siting presents unique opportunities to minimize construction costs by plant standardization and “serial” manufacturing. It also poses new design problems of plant motion, operation in a marine environment, plant size envelope, and coordination of plant and site design and licensing.

The range of applicability of present nuclear plant concepts has been assessed in relation to future nuclear plant siting needs. Future electrical generating requirements indicate a major potential need for offshore stations near the populous coastal states, and a survey has been made of the availability and characteristics of offshore sites.

Consideration of population proximity, aesthetics, and water-depth requirements indicates that most of the East Coast has an adequate number of potential sites for near-term plants. However, careful planning and the deployment of large multiunit stations may be required for effective long-term use of the limited siting resource.

On the West Coast, the large population and the relatively deep water of the California region contribute to the scarcity of shallow water sites suitable for breakwater-protected offshore reactor plants, and deep-water plants may have to be developed for the area. This will require resolution of several fundamental issues, including those of mooring reliability and platform sinking. Deep-water reactor platforms must be protected from ship collision, and a promising ship-arresting system utilizing cables and drag anchors has been conceived.
PROMISE OF THE HOT REACTOR.
Mario de Bacci.

The 'High Temperature Reactor' can run at over 900°C—and thus generate electricity more efficiently than either fossil fuelled power stations or present day reactors. It could also provide much of the "process heat" needed by heavy industry.

The energy distributed to some highly industrialized areas in the United States from nuclear power plants is discussed. The nation's Utilities would have had to burn an additional 3 billion gallons of fuel oil or more than 15 million tons of coal during the four winter months if the 40 operable nuclear plants had not been operating to supply about 5 percent of the total generating capacity in the U.S. (MCW)

Gas-Cooled Reactor Programs.
P. R. Kasten, J. H. Coobs, and A. L. Lottis.
Oak Ridge National Lab., Tenn. Mar 74, 261p
ORNL-4911 PC57.60/M1.45

Contents: HTGR head-end fuel reprocessing development; Fuel microsphere preparation development; Fuel fabrication process development; HTGR fuel recycle pilot-plant studies; Studies and evaluation of commercial HTGR fuel recycle plants; HTGR fuel element development; HTGR fuel irradiations and postirradiation evaluations; HTGR fuel chemistry fuel integrity, and fission product behavior; Reactions of HTGR core materials with steam; Fission product behavior in HTGR coolant circuits; HTGR safety program plan and safety analysis; Prestressed concrete pressure vessel development; Exchange programs; GCFR irradiation experiments; GCFR steam generator modeling studies.

ENERGY IN BRITAIN: SHOPPING FOR A NEW REACTOR. Hawkes, N. Science; 183: No. 4120, 57-59 (11 Jan 1974).
The controversy in Great Britain over the type of reactor acceptable looms. Tentatively, the LWR is the type chosen for construction, but nuclear power safety has become the issue. With an increase in electric consumption, the Central Electricity Generating Board recommends the application of the LWR for use in Britain. All designs have been considered, but the LWR costs the least and since capital cost is the determining factor, would produce the cheapest electricity. The Magnox gas-cooled graphit moderated reactor in which natural uranium is used has served well in Britain and has its supporters. (MCW)

TITLE: Fission Energy and Other Sources of Energy
AUTHORS: Alfonse, R.
PUBLICATION DESCRIPTION: Bulletin of the Atomic Scientists, science and public affairs, 26(1), 4-8
PUBLICATION DATE: 1970, January
ABSTRACT: In order to produce more energy, the development of fission reactor technology is proceeding worldwide at a rapid pace. Part of the reason for this emphasis may be associated military support, either direct or indirect. The possible dangers of the large scale use of breeder reactors, with the high production of plutonium, are pointed out. Intensive research efforts should be made to develop other sources of energy, such as fusion, geothermal, and solar. (25H)
Assessment of the prospects of nuclear electric power production in the context of other power sources and of the current energy demands and resources. The properties, economic costs and demands of nuclear plants, the U.S. uranium resources, nuclear hazards and waste disposal, breeder reactors, controlled fusion, and nuclear vs fossil power are discussed. It is pointed out that there are some reasons, both technological and social, to expect that the increase of nuclear power application for electric power generation will be even greater than has been hitherto anticipated. The impact of this increase on the economy, skilled labor, and capital investments is visualized.

V.Z.

SOVIET NUCLEAR POWER.
Philip R. Pryde and Lucy T. Pryde.

Article describes nuclear power development in the Soviet Union.

THE PROBABLE COSTS OF REACTOR SAFETY.
S. Rippon.

The anti-nuclear lobby is interpreting the facts and figures in such a way as to make hypothetical accidents an everyday occurrence.

NUCLEAR SAFETY - THE PUBLIC DEBATE.
R.E. Lapp.
The increasing interest in gas-cooled reactors and the increasing support for development and assessment of gas-cooled reactor power systems points up the need for disseminating pertinent information and it was in this context that the subject meeting was planned. By making these Proceedings available at the time of the meeting, information is being provided in a timely manner, and gives an up-to-date summary of gas-cooled reactor technology. The interest in gas-cooled reactors is international in character, and the papers presented represent 27 research or commercial establishments located throughout the world. The papers are grouped in six separate sections covering (1) operating experience, (2) design and economics, (3) non-nuclear components and materials technology, (4) fuel performance and fuel cycle technology, (5) advanced applications, and (6) safety technology.

ATOMIC POWER: A BRIGHT PROMISE FADING?

From promise to performance—it's proving to be a long and difficult road for many nuclear power plants. Jack McWethy of the magazine's staff reports on an industry struggling to get on top of troublesome problems.


Nuclear power in Canada: a different approach

F.C. Boyd
Canada's Pickering nuclear power station with a total capacity of 2000 MW demonstrates the viability of the CANDU system, which employs heavy water as moderator with natural uranium as fuel. In this article Mr Boyd describes current operating experience and the background to Canada's nuclear programme which is destined to supply about 50% of all electricity generation in that country by 2000.
NUCLEAR FUEL FABRICATION FOR COMMERCIAL ELECTRIC POWER GENERATION.

Y.P. Kushner.

IEEE Trans. Power App. & Syst., v.FAS-93, no.1, Jan./Feb.1974, p.244-

The demands for electrical power generation capacity have increased significantly in recent years. This paper covers the manufacturing of uranium dioxide nuclear fuel (UO₂), for use in commercial nuclear reactors presently used for electric power generation. It explains in detail, the manufacturing and processing steps associated with the conversion of uranium hexafluoride gas into UO₂; the compacting of UO₂ pellets and the assembly of fuel rods and fuel assemblies. This paper can be described as a walking tour through a typical nuclear fuel fabrication plant.


Directorate of Licensing (AEC), Washington, D.C. Mar 74, 114p
WASH-1304 PC$5.45/MFS$1.45

The manufacture, installation, operation, and decommissioning of floating nuclear power plants at offshore sites is examined with respect to the major technical differences between such plants and land-based nuclear power plants. Anticipated environmental effects of activities associated with offshore nuclear plants are discussed. Possible accidents, both in-plant and during the transport of radioactive materials to and from an offshore plant, are described and an initial estimate of their relative significance presented. Salient points of the survey are summarized below according to general subject area.

S-453

HOW FAR SHOULD WE GO WITH NUCLEAR POWER.

H. Ardman.


Equal consideration has not yet been given to clean solar power. Why?

NUCLEAR POWER RISKS.

R.P. Hammond.


A leading nuclear scientist takes a timely look at some of the hazards involved in the operation of atomic reactors.
NUCLEAR POWER PLANT ENVIRONMENTAL REPORTS.
M.J. Robinson and E.O. Smith.
IEEE Trans. Power App. and Syst., v.PAS-93, no.1,
Jan./Feb.1974, p.321-

This paper discusses the environmental report requirements for nuclear power plant construction and operating permits. The current guidance furnished by the Atomic Energy Commission is discussed and the implications regarding timing and possible criticisms by the public are pointed out. Examples from current licensing and permit hearings are discussed in the context of how to minimize the conflicts that might arise.

MEETING THE CHALLENGE TO NUCLEAR ENERGY

The problem of what can be done to streamline the process to license and build commercial reactors is addressed. Of the 36 nuclear plants scheduled for completion before Jan 1976, 21 have been identified by PFC as high-priority projects, but their construction cannot be accelerated any further to a significant degree. Causes of schedule delays in 28 plants scheduled for 1973 operations are discussed. Actions to minimize scheduling changes in licensing requirements are described briefly. Time savings possible from standardized plants and designated sites are considered; use of preconstruction permit exemptions is also discussed. Steps have been taken to increase public awareness of regulatory rules on the public and how they improve the public debate over nuclear power. (DLC)

A Technique for Environmental Decision Making Using Quantified Social and Aesthetic Values.
Battelle-Pacific Northwest Labs., Richland, Wash. Feb 74, 243p
BNW1-1787 PCS $7.60/MPS $1.45

A four-phase study was designed for the evaluation of social, economic and environmental tradeoffs in the analysis of nuclear plant siting options. The results of the first phase of this work are reported here. A method was devised for combining social values with technoeconomic values. This technique that community judgments be measured on the same plant design criteria that are independently quantified by experts on a technical basis. The social values are used as a weighting factor for the technoeconomic values.

J. D. Clement, and W. A. Reese.
Georgia Inst. of Tech., Atlanta. School of Nuclear Engineering. 20 Mar 74, 61p NASA-CR-138117
N74-22990/5WE PCS $6.25/MPS $1.45

The role of nuclear fission reactors in becoming an important power source in the world is discussed. The supply of fissile nuclear fuel will be severely depleted by the year 2000. With breeder reactors the world supply of uranium could last thousands of years. However, breeder reactors have problems of a large radioactive inventory and an accident potential which could present an unacceptable hazard. Although breeder reactors afford a possible solution to the energy shortage, their ultimate role will depend on demonstrated safety and acceptable risks and environmental effects. Fusion power would also be a long range, essentially permanent, solution to the world's energy problem. Fusion appears to compare favorably with breeders in safety and environmental effects. Research comparing a controlled fusion reactor with a breeder reactor in solving our long range energy needs is discussed. (Author)

The first of two sections of a world review giving brief reports on the status of construction or operation at sites where nuclear power stations are either being built or have recently been commissioned is presented. Part I covers Argentina, Austria, Brazil, Canada, Finland, France, Germany, India, Italy, Japan, Netherlands, Pakistan, Spain. (UK).


The Subpanel concludes that a substantially increased Federal effort in the following areas of fusion energy research and development are of first importance: (a) safety, performance, and environmental research and development of light-water-reactor and gas-cooled-reactor power plants and the associated fuel cycle; (b) geological survey and exploration for uranium on both a global and national scale; (c) advanced technology programs in fuel and materials including fuel processing and recycling; and (d) liquid-metal fast breeder research, development, and demonstration. In addition, the Subpanel recommends that a vigorous technical and economic evaluation of the light-water breeder reactor be undertaken by a group including industry. Annual expenditures growing to a level of ~$200 million per year in the late 1970's will be necessary for the orderly pursuit of the program's goals and priorities. (end)

Nuclear engineering is an integrated program for energy and power. R.A. Farra (Univ. Arizona, Tucson, USA).


The objectives of the program, briefly stated, are: to encourage coordinated study and research in the College of Engineering, Arizona, toward providing optimal engineering solution to society's energy needs. All energy sources (fossil, nuclear, geothermal, solar, etc.) and the engineering systems to convert and transfer energy are within the scope of interest. Energy management and environmental control are major considerations. Applied research and industrial interaction are given particular emphasis. The paper describes the philosophy and reflects on the accomplishments of the PSE Committee's efforts in formulating and implementing the program. (20 ref.)

TEXAS AND NUCLEAR POWER. Johnson, P. C. (Texas Medical Center, Houston). Tex. Med., 69: 81-85 (Mar 1973). Texas must look for new sources of electric power to prevent an energy crisis. Nuclear power is the most practical of the new forms of electricity. The proposal of a nuclear power plant generates considerable controversy among the citizens of the community. Much debate centers around the medical consequences of the released radioactivity. The practicing physician can help his community resolve the problem. This review is designed to give the Texas physician the information necessary to answer his patients' questions concerning nuclear power. (auth)


SURVEY OF THE MARKET FOR NUCLEAR POWER IN DEVELOPING COUNTRIES. Fallas, O. B. (International Atomic Energy Agency, Vienna). Energy Policy, 1: No. 3, 225-247 (Dec 1973). The long-range economic justification for nuclear power plants in 14 of the developing countries was studied and analysed from a survey in 1972-1973 by the IAEA. Some computer programs were developed for the survey. Concluding facts on the market survey show that, during the period 1980-1989, there is essentially no market for small nuclear power units of sizes 600 MW and smaller. There is a substantial market for 600 MW and 800—1000-MW sizes. The total thermal power plant market for the nuclear portion is less than 50% up to 1982, 70 to 75% in 1982-1984, 80 to 95% in 1985 to 1989. Once nuclear plants are indicated for a given country, they will continue so in the future. After the larger sizes (600 MW and over) become justified, substantial changes in the values of the economic parameters (oil prices or discount rates) will have little effect on the total nuclear plant market since essentially all units will prove to be nuclear from that point into the future. (MCW)

FLOATING REACTOR: 'CRISIS SOLUTION?'
G.D. Friedlander

In addition to minimizing thermal pollution, there are other advantages to ocean siting.

A floating nuclear power plant will have minimal environmental impact upon marine biology, land- and water-use considerations, and aesthetic quality. While some impact is inevitable, it is expected to be well within the bounds of environmental restraints. Potential damage from chemical and thermal discharges is expected to be minimized by built-in safety provisions. (auth)

The harmonious co-operation of the White House, Congress, the energy industry, environmental and consumer groups, and the general public will be needed to solve the energy problems. An understanding of the interrelationship among energy, environment, and economics is essential. An Office of Science and Technology energy review has indicated that nuclear power is the most viable energy form to meet future needs. (auth)
SCIENTIFIC FACTS BEHIND THE HASSLE OVER ATOMIC ENERGY SAFETY.
E. Edelson.
We need more electrical energy desperately, and some experts are boosting nuclear plants as the best bet. But critics insist that the risk is too great.

The adventitious use of natural gas as a primary source of energy for pollution control is unthinkable, when there is nuclear power available. Fossil fuels are too precious and exhaustible. The use of natural gas is inadvisable most times for inferior purposes. The use of natural gas as boiler fuel is most inefficient. Rapid expansion and use of nuclear power for power generation is urgent. Other alternative sources of energy for power generation include fusion power, solar energy, and geothermal resources. (JCW)

WHAT'S HOLDING UP NUCLEAR POWER?
At a time when the need for additional nuclear plants was never so pressing, Dr. Ray, Chairman of AEC, assess the prospects of meeting U.S. energy needs.

COSTS AND BENEFITS OF NUCLEAR POWER.
J. Dunster.

Uncertainty surrounds the development of nuclear power in the 1980's. Projections of growth suggest that the total generating capacity of the non-Communist countries will reach 550,000 to 650,000 MWe by 1980. But the number of reactors reaches 825 to 950. The USA has not yet to decide when to build additional enrichment facilities and who should control them. (MCW)


Choices and obstacles in the future development of nuclear power technology are discussed, with examination of technical options, public safety, and economics. A major difficulty is to establish a realistic basis for comparison for nuclear plants are relatively capital-intensive while fossil-fuel plants are fuel-intensive. Once built, a nuclear plant is normally utilized to the maximum, because its running costs are only a fraction of those of even the most efficient fossil-fuel plant. The basic sources of uncertainty are safety and future technical progress and it is these aspects which will jointly determine the long-term acceptability and competitiveness of nuclear power. (43 references) (MCW)


A workshop covering basic nuclear power generation and the trade-offs and problems that exist between nuclear power and alternative means of generating electricity was held between August 7-11, 1972 for forty high-school teachers at the Madison campus of the University of Wisconsin. A feedback conference was held January 13, 1973. A summary and evaluation of the conference were made. (UCW)


A live-in type workshop available for academic credit covering basic nuclear power generation and the trade-offs and problems that exist between nuclear power and alternative means to generate electricity was held for 37 high-school teachers at the Madison campus for the University of Wisconsin. Significant improvements over last year's program included the distribution of a large amount of information and the distribution of two minicourse outlines on the subject of power and the environment entitled: "The Environmental Impact of Electrical Power Generation: Nuclear and Fossil" prepared by the Pennsylvania State Dept. of Education, and "Science III Matter—Energy Interactions in Natural Systems" prepared by Carl Pfeiffer of Monona Grove High School, Monona, Wisconsin. (MCW)

A nuclear-MHD power plant system which uses a compact non-breeder reactor to produce power in the multimegawatt range is analyzed. It is shown that, operated in synchronous orbit, the plant would transmit power safely to the ground by a microwave beam. Fuel reprocessing would take place in space, and no radioactive material would be returned to earth. Even the effect of a disastrous accident would have negligible effect on earth. A hydrogen moderated gas core reactor, or a core of NUD, could also be used. The system is shown to approach closely the ideal of economical power without pollution. V.P.

1973

A74-13234 * # Satellite nuclear power station: An engineering analysis. J. R. Williams, J. D. Clement (Georgia Institute of Technology, Atlanta, Ga.), R. J. Rosa, K. D. Kirby, and Y. Y. Yang. Research supported by NASA; Grant No. NGR-11-002-145, Atlanta, Ga., J. R. Williams, Georgia Institute of Technology, 1973. 143 p. 41 refs. also N73-28653.

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847 p. illus. 29 cm.


Sponsored by: American Institute of Aeronautics and Astronautics [and others]


Exploratory Study of Several Advanced Nuclear-MHD Power Plant Systems - J. R. WILLIAMS, R. J. ROSA, Y. Y. YANG, J. D. CLEMENT

The Satellite Nuclear Power Station: An Option for Future Power Generation - J. R. WILLIAMS, J. D. CLEMENT

1973

A74-13234 * # Satellite nuclear power station: An engineering analysis. J. R. Williams, J. D. Clement (Georgia Institute of Technology, Atlanta, Ga.), R. J. Rosa, K. D. Kirby, and Y. Y. Yang. Research supported by NASA; Grant No. NGR-11-002-145, Atlanta, Ga., J. R. Williams, Georgia Institute of Technology, 1973. 143 p. 41 refs. also N73-28653.

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1973

A74-13234 * # Satellite nuclear power station: An engineering analysis. J. R. Williams, J. D. Clement (Georgia Institute of Technology, Atlanta, Ga.), R. J. Rosa, K. D. Kirby, and Y. Y. Yang. Research supported by NASA; Grant No. NGR-11-002-145, Atlanta, Ga., J. R. Williams, Georgia Institute of Technology, 1973. 143 p. 41 refs. also N73-28653.

A nuclear-MHD power plant system which uses a compact non-breeder reactor to produce power in the multimegawatt range is analyzed. It is shown that, operated in synchronous orbit, the plant would transmit power safely to the ground by a microwave beam. Fuel reprocessing would take place in space, and no radioactive material would be returned to earth. Even the effect of a disastrous accident would have negligible effect on earth. A hydrogen moderated gas core reactor, or a colloid-core, or NERVA type reactor could also be used. The system is shown to approach closely the ideal of economical power without pollution. V.P.

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John C. Bellamy, and Michael C. Penz.
Western Interstate Nuclear Board, Lakewood, Colo. Jan 73,
29p NSF-RA-G-73-013
PB-231 039/9WE PCS$4.50/MF$1.45

An analysis of probable future needs for energy in relation to potential sources of energy and environmental concerns is used to postulate how those needs might best be served. It is thereby postulated that nuclear heating plants can well be developed to serve most of our needs for heat and electrical energy in stationary locations, and that fossil fuels can thereby well be conserved largely for propelling vehicles. It is thereby also seen that nuclear explosives are likely to be needed to extend the use of natural gas for stationary heating needs during the transitional period. (Author)

REACTOR AS A SOURCE OF INDUSTRIAL ENERGY.
Anderson, T. D.; Michel, J. W. Oak Ridge Nat. Lab. Rev. 6:
No. 3, 19-23(Fall 1973).
The ideal requirement for nuclear power plants to have a role in the future supply of industrial energy will be one large industrial consumer with accompanying small industrial energy users. Nuclear power plants would be operated as dual-purpose plants supplying electricity to a power grid and process energy for local use. The plant could offer overall savings and relieve the demand for fossil fuels and the environmental problems associated with them. Obstacles to industrial nuclear energy are: (1) the time required to construct a nuclear plant is at present four to seven years longer than the time required to build most industrial plants; (2) the planning of nuclear plants for industry will most cases involve a utility and one or more private companies that presents organizational problems; and (3) the sitting, safety, and environmental considerations for nuclear plants and some industrial plants may be conflicting. (MCW)
TITLE: Combined Nuclear Gas Turbine Power and Desalination Plant
AUTHOR: Swer, P.M.; Krase, J.N.
CORPORATE AUTHOR: Gulf General Atomics Co.
PUBLICATION DATE: 1972, September
ABSTRACT: The features of a combined high-temperature gas-cooled reactor (HTGR) gas turbine electric generating and desalination plant are described. The desalination plant utilizes the reject heat from the HTGR gas turbine plant and thereby obtains its thermal energy requirement at essentially zero cost. As a result, the cost of desalinated water is decreased by approximately 80% for plant sizes of about 100 million gallons per day (MGD). A desalination plant of nearly 90 MGD can be coupled to a standard HTGR gas turbine plant with an output of 1100 MW(e) using conventional RO plant designs. By utilizing a parallel train brine crossover concept, an NSR plant with a capacity of nearly 150 MGD can be coupled to the same HTGR gas turbine plant with a further decrease in water cost. (Auth)
AVAILABILITY: Entire proceedings available from American Chemical Society, 1155 16th St. N.W., Washington, D.C. 20036

A73-16029

A73-16026


The concept of an orbital facility for converting solar energy to stored fusion energy for use in terrestrial power plants is reviewed in terms of overall system parameters and economics. It is suggested that the concept is worth studying in considerably greater detail. M.V.E.

TITLE: The Direct-Cycle Nuclear Gas Turbine with Economical Dry Air Cooling
AUTHOR: Krase, J.N.; Horne, D.C.; Schoene, T.N.
CORPORATE AUTHOR: Gulf General Atomic Co.
ADDRESS: San Diego, Calif.
PUBLICATION DATE: 1972
ABSTRACT: The application of dry air cooling has not been used in solving the problem of disposal of waste heat generated by large electric power stations because of the large expense involved. However, dry air cooling has the following three characteristics which can be highly desirable in certain situations: wider selection of possible plant sites; no requirement for make-up water; and the elimination of secondary problems such as fogging, snowing, and icing associated with evaporative systems. Therefore, the nuclear gas turbine will become increasingly important in the electric power production industry as plant site problems multiply. Using existing proven gas-cooled reactor technology, the nuclear gas turbine can be developed before the necessary natural water resources and most desirable plant sites are gone. By utilizing the nuclear gas turbine, power plants using dry air cooling can not only provide power at a cost comparable or less than present plants using wet cooling; they also can provide power which will be exactly environmentally neutral. (BCH)
AVAILABILITY: Conference Director, American Power Conference, Illinois Institute of Technology, Technology Center, Chicago, Ill. 60614 ($20.00)
Indexed Bibliography on Nuclear Facility Siting.—This
bibliography contains 900 abstracts pertaining to various
phases of siting; for example: Design, Operation, Environ-
ment, Population, Seismicity, Weather, Safety Features,
and other aspects of the plant and its site. About one-third
of the abstracts are concerned with the various reports,
questions and responses that arise during the licensing of
a nuclear plant. Keyword and author indexes and a key
word in context (KWIC) listing of titles are provided to
simplify use of this publication. 1972. 278 pp. PC $10/
MF $10 order ORNL-NSIC-105/G

Indexed Bibliography on Environmental Monitoring for
Radioactivity.—Contains 850 abstracts on the subject and
includes background material to put the problem in broad
perspective. Lists pertinent references for a general envi-
ronmental monitoring program emphasizing the normal
operation of a nuclear facility and to exclude most aspects
of personnel monitoring. 1972. 319 pp. PC $10/MF $10
order ORNL-NSIC-101/G

73V45252 10-- ISS 00 TK1078.N83 1972 621.483 LC-73-186654
NUCLEAR POWER AND THE PUBLIC. EDITED BY HARRY FOLEMAN.
ANCHOR BOOKS. GARDEN CITY, N.Y., XXVI, 371 P. ILLUS. 19 CM.
SCIENCE STUDY SERIES. $6.95 $4.25 BASED ON A SYMPOSIUM HELD AT THE
UNIVERSITY OF MINNESOTA, OCT. 10-11, 1969. INCLUDES BIBLIOGRAPHIES.
LC ATOMIC POWER-PLANTS -- CONGRESSES. RADIOACTIVITY -- PHYSIOLOGICAL
EFFECT -- CONGRESSES.
ADDED FOREMAN, HARRY, 1915- ED. MINNESOTA UNIVERSITY.
MAIN-TITL TRACE-SEPS*CGRP*AUTH* CATLG BY-LC
/ / COPYRIGHT

74V11303 1974 ISS 00 TK1078.C57 1972 621.4832 LC-73-621632
CONFERENCE ON UNIQUE SITING CONCEPTS FOR NUCLEAR POWER PLANTS.
CONFERENCE ON UNIQUE SITING CONCEPTS FOR NUCLEAR POWER PLANTS,
SACRAMENTO, CALIF., 1972.
SACRAMENTO? 147, 42 L. ILLUS. 29 CM.
COVER TITLE. AT HEAD OF TITLE. JOINT COMMITTEE ON ATOMIC DEVELOPMENT
AND SPACE, CALIFORNIA LEGISLATURE. INCLUDES BIBLIOGRAPHICAL REFERENCES.
LC ATOMIC POWER-PLANTS -- LOCA-TION -- CONGRESSES.
ADDED CALIFORNIA. LEGISLATURE. JOINT COMMITTEE ON ATOMIC DEVELOPMENT
AND SPACE.
MAIN-MEET TRACE-CORP* CATLG. BY-LC

418
The possible and potential risks to the public due to radioactivity generated in nuclear power plants and the means of protecting the public from those risks are analyzed in this paper.

The off-shore nuclear generating station comprises an integrated nuclear power plant package of central-station size mounted on a single floating platform structure. The plant will remain almost, moored inside a protective breakwater system some distance off shore. Underwater cables will transmit power to the shore. The power plant is a conventional Westinghouse pressurized-water reactor and turbine-generator system with an output of 1150 MW(e) designed for ocean water cooling with the conventional auxiliary systems and features. The Westinghouse ice condenser system is used for the containment system. The containment concept is similar to the TVA Sequoyah design. The reference plant design is based on the 3425-MW(th)-class four-loop plant widely under construction in the US. The plant layout and arrangement are quite conventional and similar to many single-unit land-based nuclear plants.

Power plants

J.F.Holmes and C.R.Pink, Saunders Nuclear Corp.

Offshore siting offers such distinct advantages as thermal enhancement of the waters to increase recreational and commercial values, and a very important consideration along the west coast, earthquake-isolation of the bulk power reactor. Offshore siting brings with it new design considerations.

FISSION: THE PRO'S AND CON'S OF NUCLEAR POWER.
By Allen Hammond.

Summary of Recent Legislative & Regulatory Activities
Affecting the Environmental Quality of Nuclear Facilities
—Compiles recent legislative and regulatory activities concerning environmental quality which have a possible bearing on the development and use of nuclear energy. Covers proposed and adopted Federal and state legislation. 1972.
175 pp. PC $10/MF $10 order ORNL-NSIC-93/G

ENVIRONMENTAL ASPECTS OF NUCLEAR ENERGY.
From 5th Congress Conference of the Japan Atomic Industrial
Forum, Tokyo, Japan (22 Mar 1972).
Atmospheric pollution is the most apparent and the most harmful effect of combustion of fossil fuel. Current free world demand for oil is about 46 million barrels a day. This means that there is only a 34 to 100 year supply, assuming no increase in the demand. Similar pictures for the availability of coal and natural gas exist. The most obvious environmental advantage of nuclear energy is total absence of combustion products and therefore atmospheric contamination. Another advantage of the nuclear energy is reduced capacity required for transportation and storage facilities. A third advantage of nuclear energy is vast amounts of fuel reserves in the crust of the Earth. But nuclear energy systems have certain disadvantages such as the discharge of waste heat, routine emission of radioactive material, unusual safety problems, and disposal of high-level radioactive wastes. And when high-temperature gas-cooled reactors are developed and operated, their waste heat and radioactivity effluent will be smaller than that of light water reactors. Nuclear fusion reactors are promising because they discharge no radioactive wastes. (Japan)

NUCLEAR ENERGY AND ITS PROSPECTS IN INDIA.
From proceedings of the seminar on energy system economics; Madras, India (21 Aug 1972).
The prospects of nuclear energy in India are discussed taking into consideration i) availability of coal (fossil) mainly in the Eastern region of India; ii) dependence of hydroelectric energy on the monsoon; iii) increasing per capita consumption rate of electric power, and iv) already existing basic infrastructure in terms of manpower and knowhow in the field of nuclear technology. It is pointed out that the situation favours the execution of a nuclear power program. Dr. Bhabha's three stage strategy for nuclear power development of India is explained. In the first stage, a number of nuclear power stations using natural uranium based nuclear fuels will be constructed. In the second stage, fast breeder reactors, using plutonium produced in the first stage, will be constructed. In the third stage, plutonium or uranium 233 produced in this stage and thorium will be utilised as fuel in the reactors of third-stage nuclear power stations. Tarapur Atomic Power Station, built on a turn-key

IS NUCLEAR FISSION ACCEPTABLE?
J.W. Cofman.

Nuclear fission appears to have been chosen as the major future energy resource. Many would hold that promotional opportunism of the nuclear establishment rather than merit has served as the basis for this choice.
NUCLEAR POWER AND THE ENVIRONMENT.
Grenda, J.A. Forum (Chicago); 8: No. 1, 70-72 (Fall 1972).
The source of power for the next several decades must be between fossil fuel and nuclear fission. The discussion involves how nuclear power compares with the alternatives with respect to environmental effects. Nuclear fission provides a new source of energy to supplement the older resources, fossil fuels and water power. Nuclear fission power is being applied as heat to make steam to run turbines and generate electricity; to use the heat for distillation of salty or brackish water in order to augment the diminishing water supply; and to use steam from nuclear reactors in industrial processes and domestic heating. Objectionable waste heat could be used to prevent the undesired freezing of lakes and to enhance the productivity of farmlands by warm water irrigation. The undesirable effects involve the routine discharge of radioactive materials into the air and water, possible accidents during transport of nuclear materials, and safety hazards at the plants. Alternatives discussed include expanded use of fossil fuel plants and hydroelectric plants; and development and use of solar energy, geothermal energy sources, tidal power, wind, and fusion nuclear power. The possibility of reduced electricity use and an increase in the efficiency of electric generation by the use of MHD are suggested. (MCW)

Abnormal Reactor Operating Experience 1969-1971—Contains 82 abnormal reactor operating experience reports published by the USAEC during the period January 1969 through December 1971. Arranges reports in chronological order with an index using keywords from the NSIC thesaurus of indexing terms. And, a permuted title index assists you in locating reports of interest. 1972. 201 pp. PC $8/MF $8 order ORNL-NSIC-103/G

Gofman, John William
TK 9152
.657
• In one year's operation, a single nuclear power plant generates as much radioactive poison as one-thousand Hiroshima-type atomic bombs!
• Insurance companies — experts on judging risks — protect themselves against anticipated claims from private citizens for nuclear plant accidents and radioactive damage by specifically excluding such coverage in contracts.
• The AEC — designated as the public's "protector" — is charged with promoting the nuclear industry. This is an impossible conflict of interest.
• There is "not a shred of evidence" that AEC radiation standards for peaceful use of the atom are truly safe.
• Nuclear power is not the sole adequate source of electricity for the future. There are efficient alternatives — cleaner, cheaper, safer ones.

National Academy of Sciences
SYMPOSIUM ON ENERGY FOR THE FUTURE—PROBLEMS AND PROSPECTS. (Presented at the annual meeting of the NAS, Apr. 1971).

National Academy of Sciences
Symposium on Energy for the Future — Apr. 1971
Problems and Prospects

PB-200 293

423
NUCLEAR POWER: RISKS AND SOCIAL CONCERNS. p.19
NUCLEAR POWER: SOCIAL NEEDS AND BENEFITS. p.29
GLOBAL TEMPERATURE EFFECTS OF THE USE OF FUSION ENERGY AND THE FUSION TORCH. p.31
A TECHNOLOGISTS RESPONSE TO PREDICTIONS OF CATAS- TROPHE. p.37


N71-24578* National Aeronautics and Space Administration.
Lewis Research Center, Cleveland, Ohio.
The POTENTIAL OF NUCLEAR MHD ELECTRIC POWER SYSTEMS

The performance of the turbo-MHD cycle is compared with the equivalent Brayton-MHD and Brayton-turboelectric cycles. For the MHD cycles, a top temperature of 2500 K is assumed and two working fluids are considered. For the cycles with turbines, two turbine inlet temperatures are considered: 1500 and 1250K. The cycle temperatures, efficiencies, and specific radiator areas are compared for these various space power systems. The efficiency of the turbo-MHD system is also presented for ground powerplants. The specific masses of man shielded 10 MW electric space power systems are estimated. A brief discussion is then presented of the technology of the two most critical components of such an MHD systems. Included in this discussion is a possible modification of the turbo-MHD cycle to minimize the problems associated with alkali-metal-seeded generators and reactor fission product release.

Author


WHITHER NUCLEAR POWER.
E.S. Booth.

ELECTRIC POWER FROM NUCLEAR FISSION.
M. Benedict.

424
73V30881 1971 ISS OC TK1078.442 621.481 LC-72-614334 SOC EP
2.10 16130GF106/71
POTENTIAL ENVIRONMENTAL EFFECTS OF AN OFFSHORE SUBMERGED NUCLEAR
POWER PLANT.
GENERAL DYNAMICS CORPORATION. ELECTRIC BOAT DIVISION.
ENVIRONMENTAL PROTECTION AGENCY. WATER QUALITY OFFICE. FOR SALE BY
THE SUPT. OF Docs. U.S. GOVT. PRINT. OFF. WASHINGTON 2 V. ILLUS. 28
CM.
WATER POLLUTION CONTROL RESEARCH SERIES $2.50 (V. 1) $2.25 (V. 2)
"16130 GFI 06/71." PREPARED UNDER CONTRACT NO. 14-12-918. INCLUDES
BIBLIOGRAPHICAL REFERENCES.
LC MARINE ECOLOGY. RADIOACTIVE POLLUTION OF THE SEA. ATOMIC
POWER-PLANTS.
ADDED UNITED STATES. ENVIRONMENTAL PROTECTION AGENCY. WATER QUALITY
OFFICE.
MAIN-CORP TRACE-SERS*CCRP*TITL* CATLG BY-LC

72V30492 1971 ISS OC TK9023.6.446 621.480528 LC-72-30780
NUCLEAR ENERGY IN THE WEST: CURRENT AND PROJECTED NUCLEAR ACTIVITIES
IN THE MEMBER WESTERN STATES.
GEORGE D. WARD & ASSOCIATES. NUCLEAR DIVISION.
WESTERN INTERSTATE NUCLEAR BOARD, LAKEWOOD, COLC. XIII, 109 P.
ILLUS. 28 CM.
$5.00
LC ATOMIC POWER INDUSTRY -- THE WEST. ELECTRIFICATION -- THE WEST.
ADDED N*USP** WESTERN INTERSTATE NUCLEAR BOARD.
MAIN-CORP TRACE-CORP*TITL* CATLG BY-LC

74V24497 1971 ISS OC TK9145.449.621.448 LC-76-158105
A/WILLICH, MASON.
GLOBAL POLITICS OF NUCLEAR ENERGY.
PRAEGER PUBLISHERS NEW YORK, XII, 204 P. ILLUS. 25 CM.
PRAEGER SPECIAL STUDIES IN INTERNATIONAL POLITICS AND PUBLIC AFFAIRS
INCLUDES BIBLIOGRAPHICAL REFERENCES.
LC NUCLEAR ENGINEERING. ATOMIC ENERGY RESEARCH -- INTERNATIONAL
COOPERATION.
MAIN-AUTH TRACE-TITL* CATLG BY-LC

Includes bibliographical references.
BREEDER REACTORS: Bibliography
compiled by the U.S. Atomic Energy
Commission of recent publications on
liquid sodium fast breeder reactors.
328 pages. (Report TID-3333-51, available
through AEC/contractor channels or
at $10.60 from NTIS, U.S. Dept. Commerce,
Springfield, Va. 22151.

BREEDER REACTOR DEBATE: THE SUN ALSO RISES.
R. Gillette.
Science, v.184, no.4377, May 10, 1974, p.505
p.650-51.

In effect the AEC may be involved in another
Washington cover-up——this time an attempt to
cover up the sun. Barry Commoner said, the AEC
apparently has suppressed an optimistic report
on the potential usefulness of solar energy that
undermined the AEC's case for the breeder program.

THE FAST-BREEDER REACTOR: WHEN, WHERE, WHY, AND HOW?
G.D. Friedlander.

An LMFBR plant will be built and the HTGR is under
study; the factors involved are efficiency and safety.

BREEDER REACTORS A FAUSTIAN DILEMMA: UNLIMITED
POWER OR UNPARALLELED RISKS?
J. H. Weinberg.

Article discusses how the breeder works and
specific objections to the breeder reactor.

THE FAST-BREEDER REACTOR: ENERGY SOURCE OF THE
FUTURE.
R. Balent and R.J. Beeley.

(Eng.). A review with 6 refs.
NUCLEAR BREEDERS.
S. Növick.

Nuclear power plants of a new design to produce power and fuel are proposed by the Atomic Energy Commission, in a crash program which overstates benefits, ignores hazards, and fails to take into account alternatives including the programs of other federal agencies.


(WASH-1102(2nd Ed.)) LMFBR: LIQUID METAL FAST BREEDER REACTOR PROGRAM PLAN. Element 2. Plant Des.

The objective of the work outlined in the Plant Systems and Components Element of the LMFBR Program Plan is to provide for the first-of-a-kind development of those systems and components necessary for successful commercial LMFBR heat-transport system; auxiliary reactor plant systems; component cleaning, inspection, and maintenance facilities; shielding, containment, and reactor service buildings; and energy conversion and power generation. The near-term focus is on the development of technology needed for the timely completion of the demonstration-plant program so that the accrued technology along with that obtained from FYPF and other ongoing programs provide a firm basis on which to proceed to commercially viable plants and a true breeder economy. Specific systems included in this Element are the primary and secondary coolant systems (pumps, IHX, valves, and fittings); steam generation system (steam generator, feedwater system, etc.); auxiliary reactor plant systems (liquid-metal receiving and processing, inert-gas receiving and processing, impurity monitoring, sampling and analysis, auxiliary heating and cooling, and radioactive-waste processing) component cleaning, inspection, and maintenance facilities; shielding, containment, and reactor service buildings; and energy conversion and power generation system (generator and switch). (auth)

WHY THE BREEDER PROGRAM IS UNDER ATTACK.
From The American Power conference; Chicago, Illinois, USA 6 May 1972. See CONF-720552.
The best long-term hope for easing the energy crunch is the nuclear power and, specifically, the liquid-metal-fast-breeder reactor. Tennessee Valley Authority and Commonwealth Edison accepted a proposal from the AEC to construct the demonstration plant near Oak Ridge, Tennessee. The Breeder Reactor Corporation and Project Management Corporation were incorporated in March 1972 as a result of the efforts of TVA and CECo. The plant will be designed for a 30-year life, with an electrical rating of about 400 megawatts. The temperature of the sodium leaving the reactor will be about 1000°F. There will be three heat transport loops and the primary sodium pump will be located in the hot leg between the reactor vessel outlet and the IHX. Argon will be the cover gas for the primary and secondary systems. Technology exists for the design of a safe, operable, and reliable plant and remains to be applied to the engineering and fabrication of large-scale high-quality LMFBR components. The funding of the project is briefly described. (MCW)

From The American Power conference; Chicago, Illinois, USA 6 May 1972. See CONF-720552.
The status of the design and development of the 300-MW(e) Gas-Cooled Fast Breeder Reactor and its safety aspects are presented. The GCFR offers a most attractive and viable alternative to the LMFBR. Operability and maintainability appear promising. The principal safety costs and schedules for a construction project have been completed. GCFR licensing requirements can be based on HTGR and LWR precedents. (MCW)
Designing tomorrow's atomic power plant looks like an engineering nightmare—but it's probably the answer to abundant electricity for you in coming decades.

THE ROLE OF HTGRs AND FBRs IN MEETING THE ENERGY CRISIS. P. Fortescue and H.B. Stewart.

The fast breeder reactor uses a uranium cycle to refuel itself; however, its excess bred fuel can best be exploited in a high-temperature gas-cooled reactor, a thorium-cycle-based converter type. For this purpose, fissile feed material such as U-233 can be used to complement each other, a fortunate circumstance in the effort to successfully meet the long-range energy crisis.
Breeder reactors can be the salvation of mankind or the ultimate folly. The breeder program in the US is already challenged by environmentalists who question its safety. In the first of three articles on social aspects, a nuclear engineer discusses the safety of breeder reactors.

Breeder reactors will be inherently more dangerous to operate than conventional nuclear power plants. Their fuel cycles will place weapons-grade plutonium within the grasp of terrorists and their long-life radioactive wastes will require safe storage for half a million years.

Final article in a series on the implication of fast breeder reactors.
GAS COOLED FAST BREEDER REACTOR DESIGNS. PART 1 - THE 300-MW(e) GCFR DEMONSTRATION PLANT.
J.E. Dee and G.B. Melese-d'Hospital, Gulf General Atomic.

The authors discuss the 300-MW(e) plant with its indirect steam cycle and safety features.

GAS COOLED FAST BREEDER REACTOR DESIGNS. PART 2 - PERFORMANCE STUDIES OF LARGE GCFR PLANTS.
J.B. Dee and G.B. Melese-d'Hospital, Gulf General Atomic.

Performance of large GCFR designs is discussed and compared with published designs of 1000-MW(e) LMFBRs.

ENERGY FROM BREEDER REACTORS.
F.L. Culler,Jr. and W.O. Harms.

Reactors that consume relatively abundant uranium ores while generating more of and expensive "catalyst" than they use will be our answer to growing energy demands over the next fifty years.
FAST BREEDER REACTOR PROGRAM PLAN. Element 5.


The Sodium Technology Element is concerned with the development of a base technology adequate to provide reasonable assurance of LMFBR plant reliability and life. Since the Element is mission oriented, basic understanding is called for only where it is needed to support design and operation of the LMFBR plants.

The most significant problem area is that of interactions of cladding and structural materials with sodium and its impurities. Acceptable sodium-impurity limits must be defined and formulated into appropriate system specifications and RD&T Standards. Included in the sodium technology program are studies on the behavior and control of fusion products in the coolant sodium and on failed fuel monitoring (FFM) systems. The sodium and covergas purification systems, on-line monitors, and FFM systems, this Element extends beyond base technology and concept development and includes the design, fabrication, proof testing, and procurement of components. (auth)

1972

FAST BREEDER REACTOR PROGRAM PLAN. Element 6.


The Fuel Recycle Element of the Program Plan outlines developments and schedules required for an orderly and efficient demonstration of fuel-recycle technology adequate to facilitate the growth of a viable LMFBR-power industry. The scope of the program for the Fuel Recycle Element is that portion of the fuel cycle between removal of partially spent fuel and blanket material from the reactor site and return to the reactor site of newly fabricated fuel and blanket assemblies. Operations in the fuel cycle include shipping, reprocessing, preparation and fabrication, fuel materials management, and management of wastes. Also included in the Fuel Recycle Elements are the general fuel-cycle studies pertinent to all of the fuel-recycle operations—e.g., studies of economics, siting criteria for reprocessing plants, safety, fuel accountability, liability risks, safeguards, and government licensing and regulation. Two important responsibilities of the Fuel Recycle programs are the demonstration of commercial fabrication capabilities for initial cores, and the development and demonstration of quality assurance technology to permit industry to fabricate fuel which can meet LMFBR-design objectives. (auth)

1972

FAST BREEDER REACTOR PROGRAM PLAN. Element 9.


The Physics Element of the Program includes all applied research and development on differential and integral data and theoretical methods dealing with the interaction of neutrons and gamma rays with all materials in the reactor system. All the applied R&D required to generate nuclear data, and develop techniques and understanding for the nuclear design of Demonstration Test and Commercial power plants and the establishment of an LMFBR industry are included. Direct design-support activities—such as mockup criticals and neutronic core design—design, construction, and fuel production are also included. Determination of the technical status of, and related confidence in, physics design methods is an integral part of the program evaluation. Evaluation includes surveys, intercomparisons, economic analyses, and correlations between predictions and observations on actual systems. The quantitative correlations will include work to indicate the state of the art at any time. This effort includes maintaining an awareness of related work and coordination with related physics activities being carried out under the sponsorship of other divisions of the AEC, other federal agencies, and foreign R&D establishments. (auth)
THE FAST BREEDER REACTOR: A SOURCE OF ABUNDANT POWER FOR THE FUTURE.

H. Dieckamp.

A THIRD GENERATION OF BREEDER REACTORS.

T.R. Bump.

The evolution of fission reactors capable of breeding more fuel than they consume in continuing. The present plan is to develop a plant that will generate a million kilowatts of electric power.
HIGH-DENSITY FUSION: A report by the Lawrence Livermore Laboratory of possible magnetic field designs to achieve thermonuclear fusion at high plasma density. 26 pages. (Report UCID-16371, available through AEC/contractor channels or at $3.50 from NTIS, U.S. Department of Commerce, Springfield, Va., 22151.)

SHOPPING LIST FOR FUSION
LF Staff Report.
Laser Focus, May 1974, p.10,12,14,16,18,20,22.

Seeking help from outside the government, the AEC gives a revealing report of the status of laser-driven fusion. Help is most needed, it seems in highpower laser technology, in laser-target interactions and in diagnostics. An LF staff report

LASERS BLAST A SHORTCUT TO THE ULTIMATE ENERGY SOLUTION.
L. Lessing.

Well before the year 2000, they could enable man to duplicate the thermonuclear process that fires the sun. One big obstacle is shortsighted public policy.


THERMONUCLEAR FUSION POWER
K. V. Roberts

If controlled thermonuclear fusion is successful it will provide a clean, safe and cheap source of electrical power for an almost indefinite period. A commercial fusion reactor is however unlikely to be available much before the end of the century, and in the meantime it appears necessary to build up a world energy economy based on nuclear fission which is already a practical reality. The potential hazards of such a course suggest that it would be prudent to develop the alternative thermonuclear approach as rapidly as possible as an insurance policy. The views expressed in this article are those of the author.
Fusion power — an assessment of its potential impact in the USA

Gerald L. Kulcinski

The prospects for harnessing power through the fusion of light nuclei have by turns looked doubtful and hopeful since the first research was conducted some 20 years ago. When might fusion begin to make a significant contribution to electricity generation and what will be the economic and environmental consequences? Dr Kulcinski presents possible answers to these questions and also highlights difficulties that could arise in the cost and availability of refractory metals and alloying elements for construction of magnetically-confined plasma reactors.

HARNESSING NATURE'S ULTIMATE ENERGY SOURCE.

Staff Report.


Fusion researchers in laboratories are getting close to answering the feasibility question, and others are taking a new look at our oldest energy source, the sun.

FUSION POWER BY LASER IMPLOSION.

J.L. Emmett, et al.


Laser fusion schemes are based on the ignition of a pellet of fuel by laser beams. For the laser approach to succeed the fuel must be imploded to 10,000 times normal liquid density.


Technology of Controlled Thermonuclear Fusion Experiments and the Engineering Aspects of Fusion Reactors.

Technical Information Center (AEC), Oak Ridge, Tenn. Apr 74. 1056p ISBN-0-87079-010-7

CONF-721111 PCS16.60/MFS1.45

The report presents presentations of a thermonuclear fusion symposium on feasibility experiments: electrical storage and handling for fusion experiments; diagnostic and control instrumentation; magnet and vacuum systems; engineering design of reactor blankets; plasma fueling, heating, ignition, and recovery systems; materials considerations; energy conversion schemes; and reviews of several international programs.

AUTHOR: Peake, L. (Chairman)
CORPORATE AUTHOR: U.S. Atomic Energy Commission, Div. of Controlled Thermonuclear Research

PUBLICATION DATE: 1973, February

ABSTRACT: The ultimate potential of fusion power
in research is assessed using a set of reference designs
for full-scale fusion reactors based on the
D-tritium fuel cycle. One design is the
Inertial Confinement Thermonuclear Reactor, which
analyzes specifically. Considered in the appraisal
were the following inherent characteristics of fusion
power systems: method of operation; plasma
environmental characteristics during normal operation;
effects of non-renewable sources; fusion power economics; accident hazards; reliability and vulnerability; and
matters related to national security. The report indicates that central station fusion power
might become commercial about the year 2000. (RPC)

AVAILABILITY: GPO ($6.00)

N74-10685 | Air Force Systems Command, Wright-Patterson
AFB, Ohio. Foreign Technology Div.

LASERS AND THE PROBLEM OF CONTROLLED THERMONUCLEAR SYNTHESIS

to ENGLISH from Budushcheye Nauki (USSR), no. 5. 1972
p 107-113
(FTD W74-01-42)
AD-766972: FTD-H7-23-706-73 Avail: NTIS CSD C 20/9

The report reviews laser beam heating of plasmas to obtain
controlled thermonuclear reactions. GIA

THE PROMISE OF FUSION POWER

W. C. Gough.

Thermonuclear fusion can help solve many of the
world's most pressing problems—electric power
shortages, dwindling supplies of portable fuels
like gasoline, mounting mineral costs, and
environmental pollution. Assuming a stepped-up
research program, commercial electric power from
fusion could be available by the year 2000.

TITL: Foreseeable Thermal, Mechanical, and
Materials Engineering Problems of Fusion
Reactor Power Plants

AUTHOR: Bas, A.F.
CORPORATE AUTHOR: Oak Ridge National Laboratory,
Reactor Division
ADDRESS: P.O. Box 1, Oak Ridge, TN 37830
PUBLICATION DESCRIPTION: Paper presented at the
2nd International Conference on Structural
Mechanics in Reactor Technology, Westinghouse
(Kist Germany, September 1973, 30 p., 24 references
PUBLICATION DATE: 1973

SCPMON: U.S. Atomic Energy Commission

ABSTRACT: The engineering problems that will be
encountered by full-scale fusion reactor power
plants are illustrated by examining a
representative conceptual design. The
temperature extremes that must be
accommodated range from 6 K in superconducting
magnets to 105 K in the plasma. These
temperature differences lead to material
problems with differential thermal expansion,
high heat fluxes, and stringent thermal
insulation requirements. The magnetic fields
that must be provided range from 25 kG to 100
tons, and these fields induce forces on
elements of the structure of the order of
20,000 tons. The walls of the chamber
containing the plasma must withstand intense
radiation by 15 neutrons and 1 to 50 billion
ions. Unusual fluid flow and heat transfer
problems include two-phase boiling flow of
helium in the superconducting magnets, and
the magnetohydrodynamic effects on the flow of
red hot lithium and boiling potassium in a high
magnetic field. These and many other
problems must be solved in such a way as to
give a reliable, safe system at a reasonable
capital cost, and this must be done with
elements whose nuclear, physical, and
fabrication properties and resistance to
corrosion meet all of the requisite boundary
conditions. (106)

1973

A73-17667 | Review of controlled fusion research using
laser heating. A. Hertzberg (Washington, University, Seattle, Wash.).
American Institute of Aeronautics and Astronautics, Aerospace
73-258. 44 p. 63 refs. Members, $1.00; nonmembers, $2.00. NSF
Grant No. GK-26862; Contract No. AT(45-1)-2225; Grant No.
NIG-48-002-04.

Development of methods for generating high laser pulse energy
has stimulated research leading to new ideas for practical controlled
thermonuclear fusion machines. A review is presented of some
important efforts in progress, and two different approaches have
been selected as examples for discussion. One involves the concept of
very short pulse lasers with power output tailored, in time, to obtain
a nearly isentropic compression of a deuterium-tritium pellet to very
high densities and temperatures. A second approach utilizing long
wavelength, long pulse, efficient gas lasers to heat a column of
plasma contained in a solenoidal field is also discussed. The working
requirements of the laser and various magnetic field geometries of
this approach are described.
Atomic Energy Commission

WASHINGTON 25, D.C.

ABSTRACT: This report discusses the fusion research program of the Atomic Energy Commission, what is being done to achieve scientific feasibility, and the research and development needs of the program. The four general approaches now receiving major emphasis are the steady state tokamak system, magnetic mirror system, pulsed high-beta pinch system, and laser-fusion system. The status and projected steps to scientific feasibility of each of these systems are described, along with supporting research and development and major planning assumptions. The effect of fusion power on the reference energy system provided by the Federal Council on Science and Technology is discussed in an appendix.

AVAILABILITY: CPG (8.90)

HD 9540.4 1973


Keith Boyer, University of California, Los Alamos, N. M.

The release of thermonuclear energy in a controlled manner with its promise of providing a relatively clean and inexhaustible supply of energy is receiving an increasing amount of interest and attention. Shortly after the laser's invention it was recognized that this device could, in principle, provide the concentration of energy necessary to initiate the thermonuclear burning of the appropriate fuel, but only within a very small volume due to the limitation in total laser energy which might be achieved in a practical device. However, to achieve a sufficient thermonuclear energy return for the laser energy invested it was evident that efficient burning of the fuel would be required. With these limitations in mind, a study of the physics of the processes involved led to the concept of compressing the fuel to high density in an imploding system.

CN-129,601, No. 486, Audiotape (1973)


American Chemical Society
Radio Series 486

Thermonuclear equipment
Power sources, Nuclear
Audiotapes - Thermonuclear
Audiotapes - ACS

CN-129,601. Nos. 582 & 583 (1973)


American Chemical Society
Radio Series 582
American Chemical Society
Radio Series 583

Audiotapes - Thermonuclear equipment
Thermonuclear reactions
Power sources, Nuclear

193,264

CLOSED HELIUM-TURBINE CYCLE WITH A FUSION REACTOR. S. Forster.


Special problems in adapting the helium Brayton cycle as an energy-conversion system for fusion reactor power plants.
Power from Laser-Initiated Nuclear Fusion

By KEITH BOYER
Los Alamos Scientific Laboratory, UCLA

Design studies now in progress aim at a 10-kJ module that could provide the basis for a 100-kJ CO₂ laser system.

Nuclear Fusion by Magnetic Confinement

By R.F. POST
UC Lawrence Livermore Laboratory

By the early '80s the field should have solved the remaining questions of scientific feasibility for fusion reactors based on the principle of magnetic confinement and charted the course for engineering development of practical power generators.
TITLE: Survey of the USARC Program in Controlled
Thermonuclear Research
AUTHOR: Robins, L.W. (Ed.)
CORPORATE AUTHOR: Principles College
PUBLICATION DATE: 1973
SPONSOR: U.S. Atomic Energy Commission, Division
of Controlled Thermonuclear Research
ABSTRACT: This booklet is intended to provide a
general description of the fusion research
program of the U.S. Atomic Energy
Commission's Division of Controlled
Thermonuclear Research.---By its nature this
booklet is necessarily incomplete. Not every
experiment can be presented, nor can every
sub-program be summarized. Work sponsored by
other U.S. Government agencies has not been
included, nor has the laser-fusion research
sponsored by the ARC's Division of Military
Application been described. It is intended
that the booklet serve as a description of
on-going research but that it not provide
comment on the status of each effort. For
this, the reader is referred to publications
in the scientific literature. (Auth, free
Introduction)
of Controlled Thermonuclear Research,
Washington, DC 20545

Audiotape
CN-129,601,Nos.514 & 537, (1973)
MEN AND MOLECULES, SIDE I: FISSION AND FISSION: AN
APPRAISAL, James L. Tuck. (Radio Series 514). SIDE II:
THE PROSPECTS FOR ENERGY, H. King Hubbert. (Radio

American Chemical Society
Radio Series 514
American Chemical Society
Radio Series 537
American Chemical Society

Power sources, Nuclear
Thermal Nuclear equipment
Audiotapes - Power sources, Nuclear
L99,252
L-3-15-74

1973

Institute of Electrical and Engineers International Convention and Exposition

Prospecting for energy; 1973 IEEE Intercon
technical papers. [New York, Institute of
Electrical and Electronics Engineers, 1973]
1 v. (various pagings) illus. 26 cm.

Nuclear Fusion by Magnetic Confinement.
R. F. Post, University of California, Livermore, Ca.

The concept of a nuclear fusion reactor based on
magnetic confinement is becoming scientifically credible,
following two decades of research devoted to the
solution of complex problems in plasma physics. Bar-
ring setbacks, current research programs surveyed in
this paper could lead to demonstrations of scientific
feasibility within a decade. Although the present re-
search is concentrated on the confinement problem,
increasing consideration is being given to the engineer-
ing and technology problems expected to arise in the
design of fusion reactors based on the three main pre-
sent approaches to the fusion confinement problem.
These approaches are: 1) closed or toroidal systems
of the "tokomak" type, 2) pulsed high density systems
called "theta-pinches", and 3) open-ended magnetic con-
fignurations utilizing the magnetic mirror principle for
plasma confinement. The status, remaining prob-
lems and potential as a reactor of each of the above
approaches is discussed.

FUSION REACTORS - THE ULTIMATE SOLUTION?
M. Kenward.
Science New Scientist, v.60, no.878, Dec.27,1973,
p.896-99.

Controlled thermonuclear fusion could guarantee
our energy supplies from the 21st century onwards.
Fusion research is now making its next tentative
step forward.

Development of methods for generating high laser pulse energy has stimulated research leading to new ideas for practical controlled thermonuclear fusion devices. A review is presented of some important efforts in progress, and two different approaches have been selected as examples for discussion. One involves the concept of very short pulse lasers with power output tailored, in time, to obtain a nearly isentropic compression of a deuterium-tritium pellet to very high densities and temperatures. A second approach utilizing long wavelength, long pulse, efficient gas lasers to heat a column of plasma contained in a solenoidal field is also discussed. The working requirements of the laser and various magnetic field geometries of this approach are described.

(Author)

N74-19290| Flinders Univ. Bedford Park (Australia). School of Physical Sciences.


(FUPH-8-G-4) Avail. AEC Depository Libraries HC $3.25

The current status of the international research program directed towards developing a fusion reactor for electricity production is assessed. Information is obtained mainly from meetings of the International Fusion Research Council (July 29 and Aug. 1, 1973) and the Sixth European Conference on Controlled Fusion and Plasma Physics held in Moscow from July 30 to August 3, 1973. The major items of business discussed at the meeting of the International Fusion Research Council are presented and the various national research programs are outlined. Finally, the Australian program is considered.

NSA

N74-20373| Catholic Univ. of America, Washington, D.C.

FUSION PLASMA CONVERSION Summary Progress Report 1 Apr. 1972 - 31 Mar. 1973

Clyde L. Cowan 31 Mar. 1973 11 p

(Contract N00014-67-A-0377-0015; NTJ Proj. 099-401)

(AD-773937) Avail: NTIS CSGT 20/9

The ultimate objective of the research effort being carried on around the world is the achievement of a useful level of power output from a thermonuclear plasma. A new scheme for a fusion device was designed. This design, beginning with the simple desire to eliminate the need for coping with plasma instabilities in an essentially static, hot compressed plasma, led to the concept of dynamic containment. In this scheme, the plasma is contained in a continuously maintained magnetic field generated by three alternating fields. Heating is accomplished through a series of successive shocks combined with ohmic heating by plasma currents. Such a cyclic device would be continuously running, meeting the Lawson criterion over a number of cycles, on the average.
A FUTURE ICE (THERMONUCLEAR THAT IS).
E. Teller.

The idea of building "modern internal combustion engines" (ICE) based on controlled thermonuclear fusion.

THE ENERGY CRISIS, PART I: LASERS AND FUSION.

(Univ. California, Livermore, USA).

The application of lasers to controlled fusion is considered, particular attention being given to fusion reactors based on laser-heated DT pellets. The requirements a laser must meet to be useful for this purpose are discussed. A decoupling effect resulting from the fact that long wavelength light can only penetrate and heat plasma electrons at relatively low density is described, which suggests that light of wavelength at least 10 μm may not be suitable for pellet heating. (16 refs.)

THE ROAD TO CONTROLLED THERMONUCLEAR FUSION.

Presents state of research into controlled thermonuclear fusion and assesses its prospects.

Computer Applications in Controlled Thermonuclear Research.
John Killeen.
California Univ., Livermore, Lawrence Livermore Lab. 15 Aug. 73. 15p.
UCRL-51439 PCS4.00/MFS1.45

The report surveys those areas of plasma physics and controlled thermonuclear research in which computation has made significant contributions. Both fluid and particle models are considered and applications to specific confinement experiments and plasma theory are discussed. (Author)

THE TOKAMAK APPROACH IN FUSION RESEARCH.
Bruno Coppi and Jan Rem.
Scientific American, July 1972, p. 65-75.

Experimental studies of plasma heating and confinement in machines based on the Tokamak design, a 'toroidal diffuse pinch' configuration, are being conducted and planned in laboratories around the world.
LASER IMPLOSION: WILL IT SPEED FUSION TIMETABLE.

see also PHYSICS TODAY, Aug.1972, p.17-20.

Institute of Electrical and Electronics Engineers.
6540 I 445
"Synopses of Papers Presented at the 1972
IEEE International Convention March 20-23, 1972,
New York, N. Y."
"IEEE cat. no. 72 CHO 581-9 IEEE."

N72-32821# Los Alamos Scientific Lab., N.Mex. Advanced
Concepts Group.
CENTRAL STATION POWER GENERATION BY LASER-
DRIVEN FUSION
(Contract W-7405-eng-36)
(LA-4858-Vol-1) Avail: NTIS

The feasibility of using laser-driven fusion pulses for the
commercial generation of electric power was investigated.
Results are presented in two volumes. Volume I (LA-4858-MS,
Unci.) discusses the general aspects of electric power plants
based on laser-driven fusion energy sources. outlines the
considerations that led to the wetted-wall concept on which the
present study is based, presents detailed results of calculations
that indicate the feasibility of the concept, discusses aspects of
important areas that are not well defined, summarizes related
needs for further study, and compares the concept with plants
based on magnetically confined controlled thermonuclear
reactions. Volume III (LA-4859-MS, Classified, SRD) outlines
LASL's laser program, discusses the problems of achieving
laser-driven fusion, considers subsequent neutronic interactions,
and gives some economic implications. Author (NSA)
1972

PETENTIAL ADVANTAGES OF FUSION POWER REACTORS.

R.G. Mills.


Some of the promises of fusion power are now coming true, and the prospect of fusion power is now a visible goal rather than merely a hope for the future.

LASER FUSION: A NEW APPROACH TO THERMONUCLEAR POWER.

W.D. Metz.


MAGNETIC CONTAINMENT FUSION: WHAT ARE THE PROSPECTS?


LASER COMPRESSION OF MATTER TO SUPER-HIGH DENSITIES:
THERMONUCLEAR (CTR) APPLICATIONS.

J. Nuckolls, et al.


Hydrogen may be compressed to more than 10,000 times liquid density by an impllosion system energized by a high energy laser. This scheme makes possible efficient thermonuclear burn of small pellets of heavy hydrogen isotopes, and makes feasible fusion power reactors using lasers.

LASERS AND CONTROLLED THERMONUCLEAR FUSION.

FUSION ENGINEERING: Proceedings of a November, 1972 symposium at the University of Texas on the technology of controlled thermonuclear fusion experiments and the engineering aspects of fusion reactors. 1050 pages. (Report CONF-721111, available through AEC/contractor channels or at $16.60 from NTIS, U.S. Dept. of Commerce, Springfield, Va. 22151.)


The development of pulsed power technology has now reached the point where it may be able to make a significant contribution to the quest for controlled thermonuclear fusion. Existing pulsed power generators can produce powers of the order of 1 TW for times of the order of 1 microsec. Such generators are most commonly utilized to produce intense relativistic electron beams, and this paper briefly surveys the existing state of the art of generators and relativistic beams. The paper also considers several of the methods that have been proposed for incorporating intense beams or pulsed plasma generators into controlled fusion schemes. (Author)


Lubin and Fraas (1971) have reported an engineering approach for utilizing for electrical power generation a method of plasma production which is based on the heating of small pellets of fusible material by laser radiation. In this approach the fusion energy is absorbed as thermal energy by liquid lithium. The lithium provides the heat source for a conventional power plant. One of the crucial questions regarding this approach is concerned with the required energy of the laser pulse. The results produced by various previous investigations of the question show great differences. The problem is carefully analyzed, taking systematically into account the effects of changing parameters. A gasdynamic model combining reasonable physical accuracy with sufficient mathematical simplicity is discussed. G.R.


357 p. illus. 30 cm.

Held 17-23 June 1971; sponsored by the International Atomic Energy Agency.

THE PROMISE OF CONTROLLED FUSION.

R.G. Mills.

Recent advances in the performance of several experimental plasma containers have brought the fusion-power option very close to the break even level of scientific feasibility.
Symposium on Fusion Technology, 6th, Aachen (Germany), 1970.
Proceedings. Luxembourg, Commission of the European Communities, General Directorate for Dissemination of Knowledge, Centre for Information and Documentation (CID), 1970.
v., 571 p. illus. 30 cm.
Held September 22-25, 1970.
At head of title: European Atomic Energy Community - EURATOM.
Organized by the Kernforschungslage Jülich Institut für Plasmaphysik.

International Atomic Energy Agency
Nuclear fusion: special supplement, 1970;
250 p. 24 cm.

CONTROLLED FUSION: PLASMA HEATING WITH LASERS.
N70-37081# Atomic Energy Commission, Washington, D.C.
Div. of Research
THE FUSION TORCH: A NEW APPROACH TO POLLUTION
AND ENERGY USAGE
Bernard J. Eastlund and William C. Gough 7 Nov. 1969 27 p
(Conf-691108-2) Avail: CFSTI
A new concept is described for the handling of large volumes
of solid wastes in the future. The energy and material balance for
processing U. S. municipal wastes in the year 2000 via this
concept is compared with that for advanced incineration. Background
discussion of the properties of a fusion plasma and a future fusion
power system are given. Author (NSA)

TOWARDS THERMONUCLEAR FUSION.
Michail Romanovskii, Kurchatov Institute of Atomic
Energy, Moscow
In attempts to harness the energy of thermonuclear fusion to supply power, Soviet physicists at the
Kurchatov Institute have already produced the densest and hottest man-made plasma. They are
also developing unconventional ways of containing it.

ARTSIMOVICH TALKS ABOUT CONTROLLED-FUSION
RESEARCH. J.L. Tuck.

Which approach to fusion looks best? A leading
member of the Soviet Academy evaluated progress
in the US and USSR and offered his own list
of priorities for fusion research.

N65-24850 Texas Univ., Austin. Dept. of Electrical Engi-
neering
PROBLEMS AND PROGRESS IN CONTROL OF THERMO-
NUCLEAR FUSION FOR ELECTRICAL POWER PRODUC-
TION
(1964) 8 p refs (See N65-24850 14-03) Available from Okla.
State Univ.: $5.00
The basic principles of controlled thermonuclear fusion
are summarized. Also, ion cyclotron resonances and waves in
thermonuclear plasmas, and theta-pinch thermonuclear plas-
mas are discussed as representative of present day research.
Further, the Faraday rotation method of infrared maser diag-
nostics is presented. Comparison of fusion approaches of the
theta-pinch, pyrotron, stellarator, ion injection, and linear
pinch methods are compared. Results show that the theta-
pinch is an order of magnitude better than other approaches.
These pinch is the best established means of producing
plasmas with kilovolt energies, with at least short term sta-
Bility, and with a plasma pressure comparable to that of
the magnetic field. In the theta-pinch, the plasma is heated and
contained by a longitudinal magnetic field produced by a high-
current single turn coil.
E.E.B.
Innovations in the maritime industry to increase ship productivity, along with the sharp rise anticipated for the cost of fossil fuel, call for a reappraisal of marine nuclear propulsion to meet the high power requirements of modern container ships. A recently designed oil-fueled, high-speed, quick-turnaround container ship was used as the base for a comparison to assess the economic feasibility of nuclear propulsion for ships of this type. To avoid inadvertent advantage to one or the other alternative, both were analyzed according to two independent economic criteria: (a) average annual operating costs, and (b) average annual net profit. Each of these criteria accounts for the significant costs incurred by the ship over its life, including the effects of taxes and the time value of money. The results of sensitivity computations indicate that the nuclear-powered container ship, as modified for this comparison, would now be competitive with the oil-fueled ship on transatlantic routes. A similar ship specifically designed for nuclear propulsion should have an economic advantage.


It is suggested that lighter-than-air craft, in the form of very large airships, can be developed using nuclear propulsion. Such an airship can be designed to move cargo pieces weighing a million pounds and more into difficult-to-reach places at energy expenditures matching available resources. Inherent environmental cleanliness and quiet would be important fringe benefits. F.R.L.


After nearly two decades of study, analysis, and experiments relating to lightweight mobile nuclear power systems (LMNPS), it seems fitting to report the status and to assess some options for the future of this technology. This report: (1) reviews the technical feasibility studies of LMNPS and airborne vehicles; (2) identifies what remains to be done to demonstrate technical feasibility of LMNPS; (3) reviews missions and identifies particular missions that could justify renewed support for such technology; and (4) identifies some of the non-technical conditions that will be required for the development and eventual use of LMNPS. (Author)

The dirigible or rigid airship, a versatile and potentially ecologically 'clean' STOL with exceptional payload capability, endurance, range, flight stability, and onboard roominess, deserves renewed consideration as a useful vehicle in tomorrow's scheme of things. It is pointed out that great improvements can now be made in the structure of the rigid airship because computers and modern structural dynamics permit the analysis of the ship's structure as a whole. The history of dirigibles is reviewed and new advances for future airships are considered. An exciting picture emerges when nuclear power propels a lighter-than-air craft. Onboard radar would help avoid obstacles and detect other aircraft. It would examine the ground for accurate navigation, provide weather surveillance, and assist mast approach control in poor visibility.

G.R.


Results of a technology review of the propulsion system of a large subsonic nuclear powered aircraft. Low to moderate bypass ratio turbofan engines of 60,000 lb static thrust utilizing technology currently available in the JT9/CF6 jumbo jet engines are the most suitable for use in a large subsonic aircraft. Such engines could be used with either gas-cooled or liquid-metal-cooled reactors. The analysis leading to selection of this type of engine is described, and conceptual design layouts of two engines are presented. (Author)


The air-cushion vehicle (ACV) can travel over concrete roads, grass, sand, mud, swamp, snow, ice, and water. This mobility makes possible a totally new geographical freedom in choosing transportation routes, locating ports, and laying out a city. By the 1980s fleets of large ACV freighters could begin carrying ocean-going cargo. The mobility of an ACV fleet would allow placing hoverports away from areas now crowded. New cities could rise along shallow or reef-bound seacoasts and rivers, just as cities once rose around deep-water seaports.

G.R.

1972


Mobile nuclear powerplants for applications other than large ships and submarines will require compact, lightweight reactors with especially stringent impact safety design. This paper examines the technical and economic feasibility that the broadening role of civilian nuclear power, in general, (land-based nuclear electric generating plants and nuclear ships) can extend to lightweight, safe mobile nuclear powerplants. The paper discusses technical experience, identifies potential sources of technology for advanced concepts, cites the results of economic studies of mobile nuclear powerplants, and surveys future technical capabilities needed by examining the current use and projected needs for vehicles, machines, and habitats that could effectively use mobile nuclear reactor powerplants. (Author)


The reactor core containment vessel temperatures after impact, and the design variables that affect the post impact survival of the system are analyzed. The heat transfer analysis includes conduction, radiation, and convection addition to the core material heats of fusion and vaporization under partially buried conditions. Also, included is the fact that fissile products vaporize and transport radially outward and condense outward and condenses on cooler surfaces, resulting in a moving heat source. A computer program entitled Executive Subroutines for Afterheat Temperature Analysis (ESATA) was written to consider this complex heat transfer analysis. Seven cases were calculated of a reactor power system capable of delivering up to 300 MW of thermal power to a nuclear airplane. Author

N72-11844  #  National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. 454


The utilization of nuclear energy and the predicted impact of future uses of nuclear energy are discussed. Areas of application in electric power production and transportation methods are described. It is concluded that the need for many forms of nuclear energy will become critical as the requirements for power to supply an increasing population are met. P.N.F.

see also: Astronautics & Aeronautics, Jan.1972, p.56-61.
LARGE NUCLEAR-POWERED SUBSONIC AIRCRAFT FOR TRANSOCEANIC COMMERCE
(NASA-TM-X-2386; E-8271) Avail: NTIS CSCL 21F

Large subsonic aircraft, greater than 905 metric tons (1000 tons) gross weight, have the potential for hauling transoceanic cargo at rates in the range of $0.006$ to $0.036$ per metric ton-kilometer ($0.01$ to $0.06$ ton-n mi) at speeds of 740 to 925 kilometers per hour (400 to 500 knots). It theoretically would take a fleet of 500 such aircraft to handle 1 percent of the forecast world ocean trade in 1980. For gross weights of 3620 metric tons (4000 tons) the cargo rate would be reduced to less than $0.012$ per metric ton-kilometer ($0.02$ ton-n mi). It theoretically would take a fleet of over 1000 such aircraft to carry 8 percent of the world transoceanic trade projected for 1985 or 4 percent of the projected trade in 1995. Aircraft with a gross weight of 3620 metric tons (4000 tons) using compact lightweight nuclear reactors show better performance than chemical aircraft for ranges greater than 8568 kilometers (5000 n mi). Nuclear aircraft performance is less sensitive than that of chemical aircraft to the operating and cost assumptions used. Relatively large variations in any of the important assumptions have a relatively small effect on nuclear aircraft performance.  

Author
N72-12604*® National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

AIRBREATHING NUCLEAR PROPULSION: A NEW LOOK

Nuclear-powered air-cushion vehicles using lightweight aircraft-type nuclear powerplants show promise of carrying transoceanic cargo at cost-per-metric-ton-kilometer (cost-per-ton-n mi) rates comparable to railroad rates. These rates are independent of the distance traveled. Cargo rates for nonstop distances of 4000 n mi are expected to be less than one-half those for similar fossil-fueled air-cushion vehicles. For 6000-n mi nonstop distances, the rates are expected to be less than one-sixth as much. There are no fundamental technical reasons why subsonic nuclear aircraft cannot be made to fly successfully if the gross weight is over 1 million lb. Public safety of airbreathing nuclear powerplants is receiving the greatest attention in low-level experimental and analytical investigations. Idealized model containment vessels which have been impacted on reinforced concrete showed no leaks after impact at velocities to 400 mph. The experiments indicate feasibility of impacting at speeds over 600 mph with no leaks.

Author

N71-28411® National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PRELIMINARY IMPACT SPEED AND ANGLE CRITERIA FOR DESIGN OF A NUCLEAR AIRPLANE FISSION PRODUCT CONTAMINATION VESSEL

Reports and photographs of 96 major accidents occurring before 1965 and involving multiengine jet aircraft were studied. Impact speed and angle are presented for landing and takeoff accidents, cruise accidents without in-flight structural failure, and in-flight structural failure accidents. The landing and takeoff accidents had an average impact velocity of 200 ft/sec from any direction and a maximum impact velocity of 300 ft/sec with a 10 deg solid angle about the roll axis. The cruise accident without structural failure had an average impact velocity of 400 ft/sec and a maximum possibly as high as 1000 ft/sec (305 m/sec). both within a 10 deg solid angle about the roll axis. The in-flight structural failure accident had an average impact velocity of 400 ft/sec (122 m/sec) from any direction and a maximum possibly as high as 1000 ft/sec (305 m/sec) within a 10 deg solid angle about the roll axis. The in-flight structural failure accident determines the most severe impact speed for all impact angles.

Author


There is a need for large military aircraft having the capability of extremely long flight endurance and range. Such aircraft could be used for surveillance, training missions, or for an airborne command center to provide the country with a flexible, alert, mobile system capable of surviving a surprise nuclear attack. Because the payload, and therefore, the cost effectiveness, of a nuclear-powered aircraft increases with the overall size and weight of the airframe, the recent development of very large jet aircraft has made nuclear power economically attractive. The technological advancements of nuclear reactors for airborne purposes are discussed, along with the highlights of preliminary aircraft designs incorporating a high temperature, liquid metal cooled reactor. Concluding remarks include a discussion of some of the most critical problem areas that must be solved for the successful development of a nuclear-powered, long endurance, long range aircraft.

(Author)
PARAMETRIC STUDY OF A FRANGIBLE-TUBE ENERGY ABSORPTION SYSTEM FOR PROTECTION OF A NUCLEAR AIRCRAFT REACTOR

(ANALYSIS OF FRANGIBLE-TUBE ENERGY ABSORPTION SYSTEM FOR PROTECTION OF NUCLEAR AIRCRAFT REACTOR)

R/GUMTO, K. H.; B/PUTHOFF, R. L.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER, CLEVELAND, OHIO.

WASHINGTON

ENERGY ABSORPTION/IMPACT DAMAGE/NUCLEAR PROPELLED AIRCRAFT/REACTOR SAFETY/DECELERATION/IMPACT ACCELERATION/PIPES (TUBES)/PLASTIC DEFORMATION/SYSTEMS ANALYSIS/WEIGHT ANALYSIS

NEUTRONIC DESIGN OF A REACTOR CORE CONTAINING HEAT PIPES FOR APPLICATION TO A NUCLEAR AIRPLANE

(NEUTRONIC DESIGN OF REACTOR CORE CONTAINING HEAT PIPES FOR APPLICATION TO NUCLEAR AIRPLANE)

R/PUTHOFF, R. L.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER, CLEVELAND, OHIO.

HEAT PIPES/NUCLEAR PROPELLED AIRCRAFT/REACTOR CORES/NUCLEAR FUELS/NUCLEAR PROPULSION/NUCLEAR REACTORS/REACTOR DESIGN

PARAMETRIC STUDY OF LARGE NUCLEAR SURFACE EFFECTS MACHINES also A69-35780#


Some performance estimates of a high speed peripheral jet nuclear powered surface effects machine are described. The calculations incorporate a recently proposed nuclear airplane reactor concept; this high temperature reactor reduces shield weight and eliminates a need for a heavy preheater. Payload fraction and reactor power are calculated for vehicle gross weights from 1000 to 5000 tons, forward velocities from 0 to 250 knots, and clearance heights from 10 to 50 ft. For these ranges, the payload varied from 0 to 70 percent of the gross weight, and the total reactor power varied from 400 to 10,000 NW.

A STEAM CYCLE FOR AIRCRAFT NUCLEAR PROPULSION


A preliminary cycle analysis of a steam-driven, nuclear-powered turbofan engine is presented. It is found that maximum efficiency and minimum thrust per unit airflow both occur for a bypass ratio of zero. (This corresponds to minimum heat-exchanger-outlet air temperature.) Parametric numerical results are presented which can be used for selecting the proper engine operating conditions for a given airplane.

Author
THE POTENTIAL OF NUCLEAR POWER FOR HIGH-SPEED OCEAN-GOING AIR-CUSHION VEHICLES

Frank E. Rom and Albert F. Kascak
Washington Sep. 1969
34 p.

The use of nuclear powerplants based on nuclear aircraft technology to power ocean-going air-cushion vehicles has been investigated. Because aircraft nuclear powerplants might be an order of magnitude lighter than current nuclear marine plants, the performance of nuclear air-cushion vehicles is dramatically altered. Instead of vehicles limited to short ranges and speeds of about 80 knots, they become vehicles with virtually unlimited range and speeds in the range of 100 to 200 knots. The study considers vehicles with gross weights of 1000 to 10,000 tons and clearance heights from 10 to 40 feet. For the time, the cargo capacity ranges from 20 to 50 percent of the gross weight. Direct operating costs are 2 to 5 cents per ton-mile and are independent of the distance travelled.

WILL THE NUCLEAR-POWERED AIRCRAFT BE SAFE?

Frank E. Rom (NASA, Lewis Research Center, Advanced Nuclear Propulsion Concepts Branch, Cleveland, Ohio) and Patrick M. Finnegar (NASA, Lewis Research Center, Nuclear Systems Section, Cleveland, Ohio).

Astronautics and Aeronautics, vol. 6, Mar. 1968, p. 32-40. 5 refs.

Safety study showing that normal operations of a nuclear-powered aircraft can be made safe by designing unit shielding to protect the flight crew, passengers, cargo, and ground crew. The problem of refractory-metal vessels can be avoided by designing for preventing earth contact, i.e., by surrounding the vessel by effective shielding. A system using flexible tubes can be envisioned as a cage surrounding and supporting the containment vessel while maintaining a specified minimum clearance from the ground. Concerning the question of excursions on impact, for thermal reactors, nuclear excursions can be excluded by prior removal of the moderator material. In the case of fast reactors, the core should be designed to avoid criticality when it collapses. Another possibility is to prevent core collapse that might come from impact loading. Flight procedures can be arranged so that the reactor-and-shield assembly is automatically placed in a normal shutdown mode of operation and switched to chemical power when appropriate.

NUCLEAR PROPULSION FOR AIRCRAFT.

John M. Wild (General Dynamics Corp., Convair Div., San Diego, Calif.).


Survey of the current status of nuclear technology as it applies to aircraft propulsion in terms of three independent studies. The basic premises of these studies were that only current technology was to be used for aircraft, power plant, and reactor system, that the design would concern a subsonic air transport with no maximum weight or cruise-altitude constraints, that the radiation dosages of crew, passengers, and ground personnel were not to exceed AEC limits for full-time radiation workers, and that no fissile-product release to the atmosphere would occur either in normal operation or in the event of reactor malfunction, and that reasonable fissile-product containment would be provided for in the event of aircraft accident. No restrictions were placed on operation, ground-handling, maintenance, or repair, except for items within the radiation shield. Takeoff, climb and acceleration assist, loiter, and landing were to be chemically powered. The studies indicate the feasibility of a million-lb aircraft cruising at M = 7 to 8 at an altitude of 36,000 ft and capable of carrying a payload of ~300,000 lb.

THE NUCLEAR-POWERED AIRCRAFT AS AN AIRBORNE LABORATORY.

Stuart William Greenwood (Manitoba University, Mechanical Engineering Dept., Winnipeg, Manitoba, Canada).

Astronautics and Aeronautics, vol. 6, July 1968, p. 40, 46. 5 refs.

Discussion of the use of nuclear-powered aircraft for the continuous observation of fixed distant points in space and continuous investigation of the atmosphere with the sun at a fixed position in the sky. Flight paths conducive to this type of study are derived, with emphasis on 60° latitude flight paths. The Lockheed C-5A Galaxy and the Boeing 747 are mentioned as candidates for such flights, if and when they become nuclear-powered.

New Technology, Availability of C-5A spur second look at ANP.

Feasibility study of nuclear-powered flying crane helicopters
Hughes Tool Co., Culver City, Calif. (Aircraft Div.)

Subsonic nuclear aircraft study
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL. NTIS

Nuclear powered VTOL aircraft
Performance characteristics of nuclear powered VTOL aircraft
National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. AVAIL. NTIS

Aircraft performance, nuclear propelled aircraft, systems engineering, vertical takeoff aircraft, Brayton cycle, condensers, fan in wing aircraft, helium, liquid metal cooled reactors, Rankine cycle, weight, mass.
AAS-11739
NUCLEAR PROPULSION APPLICATIONS.
John S. Martinis and Richard K. Pirbich (TRW Systems Group, Redondo Beach, Calif.).
Papers 67-781, II p. 12 refs.
Members, $1.00; nonmembers, $1.50.
Survey of current and proposed performance of a variety of nuclear propulsion systems. The missions for which they are most applicable are discussed, and the relative capabilities of each of the nuclear systems to perform these missions are compared to other types of propulsion. The nuclear propulsion systems discussed include nuclear aircraft, ramjets, solid core nuclear rockets, combined high thrust nuclear rocket/low thrust electric propulsion systems, gas core nuclear rockets, and radioisotope propulsion systems. Areas where insufficient data are available to accurately evaluate system performance are indicated, and some of the missions for which nuclear systems appear most attractive are identified. (Author)

AAS-16509
A NUCLEAR SPACE PLANE.
Stephen P. D. Smith and Glenn J. Scheeseow.
Symposium sponsored by the American Astronautical Society, the University of Alabama, NASA, and the U.S. Army.
Edited by S. S. Hu.
Investigation of the capabilities of a new advanced propulsion concept, the nuclear space plane (NSP) in meeting the needs for highly maneuverable vehicles that can operate in both the atmosphere and space regions. It is found that the addition of liquefaction apparatus to the nuclear-reactor propulsion cycle results in extended flight and maneuvering capability. One nuclear core can be optimized for nuclear control and thrust to perform well in the various atmosphere which exist on the planets considered. The NSP concept is concluded to be feasible, and it is reasonable to expect that present technical hardware will be able to function as components of NSP flight systems. M.F.

Pratt & Whitney Aircraft
Contract AF (30-1)-2769
FIAC 500

A feasible and economic nuclear airship, comprising a nuclear reactor coupled with a large lighter-than-air frame, is proposed. Weight and radiation-safety considerations of hypersonic nuclear airplanes and nuclear airships are considered. The displacement of the proposed nuclear airship is nearly twice that of previous conventional airships. The design speed is 102 mph for 6000 hp. The reactor propulsion cycle results in extended flight and maneuvering capability. The nuclear core can be optimized for nuclear control and thrust to perform well in the various atmosphere which exist on the planets considered. The NSP concept is concluded to be feasible, and it is reasonable to expect that present technical hardware will be able to function as components of NSP flight systems. M.F.
Performance and weight data for a nuclear powerplant based on the use of a modified version of the JT4D-2 turbofan engine are presented. The powerplant is a lithium cooled sodium alloy reactor using intermediate heat exchangers, and with a secondary NaK coolant system to transfer heat to the engine radiators. (U)

The power plant data and shielding information presented describe a nuclear powerplant containing a lithium cooled, solid-fuel-element type reactor coupled to six modified Pratt & Whitney Aircraft JT-5A Mod. 1A turbojet engines. This power plant incorporates an intermediate heat exchanger with lithium as the fluid circulating in the primary loop and NaK as the fluid circulating in the secondary loop. The engines are fitted with burners and afterburners enabling the thrust produced by the nuclear power plant to be augmented by the use of chemical fuel. Weight data are tabulated for 350 MW and for 575 MW power plants. Flow schematics of the liquid metal system and of the bleed-air system are illustrated. Based on assumed conditions, shield information, including weights and direct dose pattern at 50 feet, is given for several reactor installations. Estimated performance of the 350 MW and of the 575 MW power plants is presented for nuclear heat only operation, and for nuclear heat plus interburning operation within an envelope of subsonic flight conditions. Performance on nuclear heat plus interburning and maximum afterburning is given for the 350 MW power plant up to a speed of Mach 3. Partial afterburning performance data at Mach 3 is shown for altitudes between 65,000 and 82,000 feet. (auth)

An investigation of nuclear propulsion systems for supersonic manned bombardment aircraft has resulted in the conclusion that ramjet engines coupled to a lithium-cooled reactor might make flight speeds greater than Mach 5 attainable in an all-nuclear supersonic bomber. The power plant performance characteristics of two all-nuclear ramjet power plants estimated to be capable of propelling an airplane at the above speeds are presented. Even of these powerplants utilizes the heat generated in a 350 MW lithium-cooled solid fuel element type reactor with a 1750°F temperature leaving the reactor. The first of these powerplants presented incorporates an intermediate heat exchanger with lithium in the primary loop and NaK in the secondary loop and represents a power plant believed to be attainable in a reasonable time with normal development. The second of these powerplants does not utilize an intermediate heat exchanger and the lithium is circulated directly to the radiators. This represents an advanced powerplant because construction materials for the reactor that are both oxidation resistant and corrosion resistant to lithium are not foreseeable without a major advance in metallurgy. (auth)

(CH-669) NUCLEAR POWERED AIRCRAFT. J. F. Brady, Convair. (For presentation at SAE National Aeronautical meeting, Los Angeles, Sept. 29-Oct. 4, 1958). SAE Preprint 922A.

Society of Automotive Engineers, Inc.

Author


NASA Consultants Custom Translations, Inc.

Mazaki Kato, no. 24, p.13 Dec 26, 1957

NASA RR 85219


763
74N74147  NEPA-1723  51/04/05  48 PAGES  UNCLASSIFIED DOCUMENT
PROJECTED CAPABILITIES OF NUCLEAR POWERED AIRPLANES. 1: APPLICATION
TO A HIGH ALTITUDE AIRPLANE (60,000 FEET)
A/CELNIKER, L.;  B/CHURCHILL, J. R.
FAIRCHILD ENGINE AND AIRPLANE CORP.; OAK RIDGE, TENN.  (NEPA Div.)
AVAIL.NTIS
Sponsored by AEC
/*AIRCRAFT DESIGN/*NUCLEAR PROPELLED AIRCRAFT/* AIRCRAFT PERFORMANCE/
HIGH ALTITUDE

74N73118  NEPA-1725  51/04/05  39 PAGES  UNCLASSIFIED DOCUMENT
PROJECTED CAPABILITIES OF NUCLEAR POWERED AIRPLANES. 3: APPLICATION
TO A SUPERSONIC AIRPLANE (MACH NO. EQUALS 2.0)
A/CELNIKER, L.;  B/CHURCHILL, J. R.
FAIRCHILD ENGINE AND AIRPLANE CORP.; OAK RIDGE, TENN.  (NEPA Div.)
AVAIL.NTIS
Sponsored by AEC
/*ATTACK AIRCRAFT/*NUCLEAR PROPELLED AIRCRAFT/*PERFORMANCE
PREDICTION/*SUPERSONIC AIRCRAFT/*AERODYNAMIC CONFIGURATIONS/*AIRCRAFT
DESIGN/*WEIGHT ANALYSIS

74N72787  NEPA-1726  51/04/05  49 PAGES  UNCLASSIFIED DOCUMENT
PROJECTED CAPABILITIES OF NUCLEAR POWERED AIRPLANES. 4: APPLICATION
TO A SEA LEVEL AIRPLANE
A/BOYLES, R.
FAIRCHILD ENGINE AND AIRPLANE CORP.; OAK RIDGE, TENN.  (NEPA Div.)
AVAIL.NTIS
Sponsored by AEC
/*NUCLEAR PROPELLED AIRCRAFT/*REACTOR DESIGN/*AIRCRAFT DESIGN/
AIRCRAFT PERFORMANCE/*LOW ALTITUDE/*OPTIMIZATION
F. GEOTHERMAL
ENVIROMENTAL PLANNING FOR THE GEOTHERMAL LEASING PROGRAM ON PUBLIC LANDS.
AIChE Symposium Ser., v.70, no.136, 1974, p.777-

Enactment of the Geothermal Steam Act on December 24, 1970, authorized certain public lands to be leased by the Secretary of the Interior for development of geothermal steam and associated geothermal resources. An interdisciplinary task force was established to prepare an environmental statement as required by the National Environmental Policy Act of 1969 and to prepare and implement the regulations for leasing and operations.

Environmental evaluations will provide a basis for deciding whether a tract should be leased. Proponents of geothermal energy claim it is the answer to our future clean energy needs. Although certain potential geothermal areas may not be leased due to environmental considerations, application of advanced technology could result in the leasing of land otherwise closed to geothermal development. The outlook from an environmental standpoint is encouraging, provided geothermal resources can be developed economically.

POSSIBLE EFFECTS OF GEOTHERMAL WATER AND STEAM PRODUCTION ON THE SUBSURFACE ENVIRONMENT.
R.L. Whiting.
AIChE Symposium Ser., v.70, no.136, 1974, p.762-

Production from geothermal systems may cause changes in some or all of the following subsurface conditions: temperature, pressure, hydrologic parameters, chemical characteristics, bulk chemistry, and seismicity. The effects of such changes are discussed and recommendations are made to permit proper exploitation of geothermal resources.

GEOTHERMAL BRINES — ENVIRONMENTAL EFFECTS OF THEIR FUTURE USE AS AN ENERGY SOURCE.
G.E. Coury.
AIChE Symposium Ser., v.70, no.136, 1974, p.760-

Future utilization of low temperature brines will require the application of secondary fluid cycles to remove energy from the brine. These cycles involve a low-boiling liquid contained within a closed loop, that is vaporized by the hot brine, expanded through a turbine, condensed and recycled. The cooled brine is then returned to the reservoir for pressure maintenance.

Future energy demands in the United States indicate that by 1985 about 30% of the total energy use will be for non-electrical, non-transportation uses. This includes residential and commercial space heating, chemical processing, and other manufacturing processes. It appears that most of that 30% could be satisfied with geothermal energy. These same studies predict that about 35% of the U.S. energy consumption by 1985 will be used to produce electricity. These predictions indicate that the use of energy to supply electricity will increase out of proportion by 1985. By deduction, it is shown that geothermal energy could be used directly in place of electrical power. Every kilowatt furnished by geothermal heat could save 3 kW of some other form of energy. (MCW)


The Geothermal Energy Act of 1973, S 2445, was incorporated into the Comprehensive Energy Research and Development Policy Act, passing the Senate on Dec. 7, 1973. The bill provides for a mobilization program, use of water and nuclear development agencies to further geothermal research, and a plan to develop resources on federal lands. (MCW)


The U.S. Geological Survey lists Colorado as having no known geothermal resource areas. Several areas warrant investigation as possible geothermal areas. The San Luis Valley, a northern extension of the Rio Grande Rift Zone of New Mexico, is an area of anomalous heat flow values. 1.3 to 2.0 mW/m². Around the western edge of this valley and extending into the Arkansas River Valley are numerous hot springs. (MCW)


Geothermal resources in Managua, Nicaragua could serve as a source of heat for the city as it does in Reykjavik, Iceland. Direct use of Earth heat sources for air conditioning by a single heat-to-cold conversion process for the new city of Managua would cost only one-half as much as electric power. Injection of water under the ground to replace hot water and steam used by the cooling system should make the source last forever. (MCW)


The Geysers power plant, 80 miles north of San Francisco, is the largest geothermal installation in the world and the only such system in the United States. Ten units are now in operation producing 396,000 kW, using steam piped directly from wells tapping a dry-steam reservoir. A description of the system is given. It appears that geothermal development in the USA will be continued to the West, and exploration must be accompanied by more research. The role of government and industry in geothermal development is explained. It is estimated that by the year 2000, 8 million kilowatts of geothermal energy might be in operation in the United States. (MCW)


The Livermore approach represents the first serious attempt to extract large-scale geothermal energy from salt hot waters of a geothermal deposit. At the Geysers, relatively clean and dry, naturally occurring steam is utilized. In New Zealand and Mexico, the steam component is separated from the brine and used to generate electricity. An effort will now be made to extract energy from the total brine mixture of steam, hot water, and salts from the Salton Sea Trough with the total flow method of geothermal energy generation. (MCW)

From U.S.-Japan cooperative science seminar on the utilization of volcanic energy; Hilo, Hawaii, USA (4 Feb 1974).

Some recent results from the Los Alamos program in which hydraulic fracturing is used for the recovery of geothermal energy are discussed. The location is about 4 kilometers west and south of the ring fault of the enormous Jemez Caldera in the northcentral part of New Mexico. It is shown that geothermal energy may be extracted from hot rock that does not contain circulating hot water or steam and is relatively impermeable. A fluid is pumped at high pressure into an isolated section of a well zone. If the well is cased the pipe in this pressurized region is perforated as it is in the petroleum industry, so that the pressure may be applied to the rock, cracking it. A second well is drilled a few hundred feet away from the first. Cold water is injected through the first pipe, circulates through the crack, and hot water returns to the surface through the second pipe. Results are described and circumstances are discussed under which artificial geothermal reservoirs might be created in the basaltic rock of Hawaii. (MCW)


The Secretary of the Interior determined to open all available Federal lands to leasing under the Geothermal Steam Act of 1970 and to promulgate geothermal resources leasing, operations, and unit regulations. The lands of known geothermal resources in the Clear Lake-Geysera area, the Mono Lake-Long Valley area, and the Imperial Valley were offered for competitive leasing on January 22, 1974. The limitations are outlined. (MCW)


The Program Plan specifies the basic plan for the utilization of FY-74 funds allocated by the AEC Division of Applied Technology and contributions from other participants for the development of geothermal energy in southern Idaho. Funding priorities are dictated by the Construction Data Package submission deadline and the October 1, 1974, site selection. Tasks not funded during FY-74 will be pursued during FY-75. (auth)


The Department of the Interior forecasts that the U. S. energy supply and consumption to the end of the century including the primary conversion of energy forms to secondary forms such as electricity and synthetic gas is expected to grow at an average rate of 2.5 percent at the expense of using up the fuel supplies too fast. With all energy development technologies lagging, an examination was made of geothermal energy with Planet Earth referred to as the great green boiler in the sky. Larderello's steam plants have been producing electricity since 1904. Development in other countries is reviewed and now the first contract has been established for Pacific Gas and Electric Company to begin building power plants at the Geyers. Eight units are installed and operating; during 1973, units 9 and 10, each with a net operating capacity of 53 Mw are expected to be installed in operation. In 1973 an additional 106 Mw are expected; in 1975, another 106; in 1976, a unit of 110; and continuing development is planned. A description of the geothermal types is given. The technologies applied for the development of the Geyers and the accompanying power plants are discussed. (N.W)


The bibliography contains 40 selected abstracts of research reports retrieved using the NTIS on-line search system-NITISearch. The report covers all aspects of geothermal energy including development, prospecting, technology, and corrosion problems.


The Mitsubishi geothermal generating plant is the third geothermal station to be built in Japan, but the first to be used in muninor production. The three wells will be capable of generating 6,500 kw for power for the zinc plant in 1974. With the coming on-stream of an additional well, the output will provide one-fifth of the zinc plant's total electric power requirement. (MCW)
POWER FROM THE SALTON TROUGH.
D.E. Thomsen.

California's Imperial Valley contains a strategically located geothermal resource. A group from the Lawrence Livermore Lab. is working on ways to trap it.

GEOTHERMAL OPPORTUNITIES BEAR CLOSER LOOK.
T. Meidav.
Oil & Gas Jour., v.72, no.19, May 13, 1974, p.102-106.

On Jan.22,1974, the U.S. Dept. of Interior conducted the first lease ever of federal lands for geothermal resource exploration and development. A total of $6.8 billion has been spent in bids for 23,447 acres in three areas of California.


Hydraulic fracturing is used to interconnect two or more holes that penetrate a previously dry geothermal reservoir, and to produce within the reservoir a sufficiently large heat-transfer surface so that heat can be extracted from the reservoir at a usefully high rate by a fluid entering it through one hole and leaving it through another. Introduction of a fluid into the reservoir to remove heat from it and establishment of natural (unpumped) convective circulation through the reservoir to accomplish continuous heat removal are important and novel features of the method. (auth)

J. P. Kunze, and L. G. Miller.
Aerojet Nuclear Co., Idaho Falls, Idaho. 18 Mar 74, 53p
ANCR-1155 PCS$4.00/MFSI.45

The Idaho Geothermal R and D Project was initially charted by the Division of Applied Technology in December 1973. This report covers the first three months of activity. A brief summary is given in Section 2, with more detailed discussions in subsequent sections. (Author)

The technique of Fournier and Truesdell's function was used to determine Na, K, and Ca concentrations of nearly 200 well water, spring water, hot spring, and geothermal fluid samples from the Imperial Valley area. It is shown that under favorable conditions Na, K, and Ca concentrations in natural waters may be used to predict the last temperature of water-rock equilibration and that most geothermal fluids plot near a straight line on a graph of the function $F(T) = \log \left( \frac{Na}{K} \right) + \beta \cdot \log \left( \frac{Ca}{Na} \right)$ versus reciprocal of the absolute temperature. The value for beta is 4/3 unless equilibrated temperatures are above 100 C, in which case beta is 1/3. Lower values for F(T) indicate higher water-rock equilibration temperatures. F(T) values for 50, 100, and 200 C are approximately 2.6, 2.0, and 1.1 respectively. The geothermometer is a useful tool for predicting subsurface temperatures and for distinguishing the existence of a geothermal system at depth. (MCW)

NEVADA GEOTHERMAL RESOURCES: Report describing the State's geothermal resources, and outlining exploratory efforts conducted to date. (Report 2L, available at $1 from Nevada Bureau of Mines and Geology, University of Nevada, Reno, 89507.)
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Cables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar.18-20,1974.

GEOTHERMAL ENERGY AS A PRIMARY SOURCE
IN THE HYDROGEN ENERGY ECONOMY
F. Maslan, T. Gordon, The Futures Group, Glastonbury, Connecticut, M. Carasso, L. Beaulaurier,
J. Gallagher, J. Hankin, Bectel Corporation, San
Francisco, California

TITLES: Proceedings: National Conference on
Geothermal Energy, Volumes 1 and 2
AUTHORS: Veysey, W.T. (Chairman)
CORPORATE AUTHOR: University of California,
Riverside
ADDRESS: Riverside, CA 92502
PUBLICATION DESCRIPTION: Entire proceedings, 717
p.
PUBLICATION DATE: 1973, August
SPONSORS: National Science Foundation, P.A.W Program
ABSTRACT: This is a two-volume presentation of
the statements and general conclusions of the
May 19-21, 1973 National Conference on
Geothermal Energy. It also contains the
papers that were prepared for consideration
by the conference participants. Central to
the conference's purpose was the examination
of the role of the state and regulatory
procedures affecting the area of geothermal
resource development. The conference was
divided into panel session meetings and
general sessions. Volume 1 contains the
major speeches and the panel groups' conclusions. An appendix containing the
conference agenda and lists of participants
and attendees is included in Volume 1. Volume 2 contains two background items
prepared for consideration at the conference,
"The Interrelationship Between Federal,
State, and Local Regulatory Agencies on the
Development of the Geothermal Resource in
California" and "Flow Chart of Critical Path
in Geothermal Explorations," and eight
documents pertaining to the statutory and
legal aspects of the geothermal resource and
its regulation. (UCR)

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THE ROLE OF STATE GOVERNMENT IN THE DEVELOPMENT OF A GEOTHERMAL RESOURCE.
D.J. Everitts.
AICHE Symposium Ser., v.69, no.129, 1973, p.453–.

The state of California is naturally endowed with notable areas of potentially productive geothermal land. Although one of the cleaner energy sources, geothermal resources do not necessarily represent an environmental panacea. In addition to providing a source of energy, these lands also offer potential as a source of water and chemicals. The regulatory agencies of the state have ample authority, expertise, and experience to prudently control the development of such a resource.

POLLUTION CONTROL FOR GEOTHERMAL POWER PLANTS.
J.T. Kuwada.
AICHE Symposium Ser., v.70, no.136, 1974, p.772–.

Geothermal energy as manifested in geothermal steam or hot water is not inherently pollution free. There can be adverse environmental impacts in the development and utilization of geothermal energy for power generation. But it will be shown that the impact on the environment from geothermal energy is far less severe than from any conventional fuel in use today.

GEOTHERMAL POWER PLANT DESIGN.
J.T. Kuwada.
AICHE Symposium Ser., v.69, no.129, 1973, p.439–.

This paper discusses the engineering considerations involved in the design of electric power generating plants utilizing geothermal energy in the form of dry steam, wet (flashed) steam and hot water (binary fluid cycle).

MODEL STUDIES OF GEOTHERMAL STREAM PRODUCTION.
C.V. Cady, et al.
AICHE Symposium Ser, v.69, no.129, 1973, p.445–.

A physical model of a geothermal steam reservoir was operated over a range of conditions from a compressed liquid to boiling liquid to single-phase steam reservoir. No significant vapor pressure lowering was observed in the unconsolidated sand model. Existence of dry steam zones and two-phase boiling zones was observed.

THE GEYSERS GEOTHERMAL POWER PLANT.
J.P. Finney.
AICHE Symposium Ser, v.69, no.129, 1973, p.459–.

The earth's geothermal energy resources have been harnessed for the generation of electric power in several areas throughout the world. At the Geysers, 80 miles north of San Francisco, 6 steam turbine-generator units with a combined capacity of 164,000 kw comprise the only geothermal power plant in the United States. Additional units now under design and construction will increase this to 502,000 kw by the end of 1974.

The first successfully tapped source of geothermal steam were put into use in Larderello, Italy in 1904 and are still producing electricity today. The steam at Larderello is clean and dry. In the United States, most geothermal fields are confined to the West. Corrosion, solids-waste disposal, and transport of the steam to urban areas are factors to be considered. Geothermal wells drilled in the Imperial Valley in California are being superfitted. The Geysers geothermal field in the mountains 80 miles north of San Francisco produces dry steam. Technology for using hot water geothermal sources is being develop-

The State of Washington generally, the southern Cascades principally, and the Northern Cascades and Olympic Mountains, to a lesser degree, do possess geohydrologic parameters, thermal springs, and other surface and subsurface manifestations that suggest that the state may have the potential for a moderate to major geothermal energy resource. Geologic, hydrologic, and geophysical investigations and evaluations will be required, however, before reservoirs can be identified and defined and their energy potential estimated on a quantitative and qualitative basis. If environmental-impact problems can be resolved within acceptable limits, then an objective and viable investigation, evaluation, and test drilling program should be started. One area, North Bonneville, stands out as a preferred site for initial geothermal energy potential testing. (auth)


The development of geothermal resources in the U.S. is impeded by the Federal tax policies that exist. The present state of tax rules governing utilization of geothermal energy, certain proposed changes in tax laws which would, if enacted, inhibit utilization of geothermal energy, and changes in present tax rules that would encourage utilization of geothermal energy are discussed. A statement by the accounting firm of Coopers and Lybrand is expanded. The accountants in the firm are the most knowledgeable in the U.S. on geothermal energy matters, representing firms that have established commercial geothermal production, selling the product, and developing additional markets. (MCW)


Following a general review of what geothermal energy is, fourteen abstracts were prepared from papers on exploration, mining, utilization, corrosion control, economics, and management of geothermal energy. (MCW)


A brief account is given of the structure of the Earth and of the processes going on within, particularly of the generation and transport of heat. New ideas have recently evolved and the views of the successful revolutionaries are adopted: those of the remnants defending the traditional position cannot be explained at every point. Topics studied include crust, mantle and core; underground temperatures and heat flow; the source of the heat; volcanoes, ridges and island arcs; the mechanism of plate motion; and the transfer of heat to the surface. (MCW)


The application of geology and hydrology to the exploration of geothermal resources is described. The bases on which geologic decisions are made through the successive phases of an exploration project are followed in sections entitled: selection of a region for reconnaissance; selection of prospect areas; selection of drill sites; and drilling and testing. (45 references) (MCW)


Geophysical prospecting is the art of detecting and interpreting anomalies in the local pattern of certain physical quantities, as measured by suitable sensing equipment and techniques. It must proceed in close coordination with geology, hydrology, and geochemistry, so that physical measurements may constantly be interpreted and checked. Preliminary evidence of a geothermal field; world distribution of hydrothermal systems; and the preliminary data required are discussed. Four stages of the exploration survey are described, and then the effects of exploitation on the surrounding area are discussed. (MCW)


Geochronial methods are used in prospecting for potential geothermal exploitation, and chemical data on natural discharge from thermal areas serve as an important guide during subsurface exploration. As drilling proceeds, chemical and analysis of deep thermal fluids provides information on flow patterns of water and assists in selecting improved drilling sites. During production, testing, and utilization, chemistry provides an efficient and inexpensive tool to detect minor and major changes in the reservoir with regard to temperature and water levels. Chemical analyses of waters and gases from various world areas where geothermal exploration is occurring are tabulated. (49 references) (MCW)


Basic models of a geothermal steam field and low-temperature hot-water field are described from geologic, geochemical, and geophysical exploration data. Then the Geysers geothermal field, California; the Otake geothermal field, Japan; and the Larderello geothermal field, Italy are classified to see how they generally conform to wet steam, dry steam, or hot water fields. (MCW)

WELL MEASUREMENTS. Dench, N. D. (Ministry of Works, Wellington, N. Z.). pp 85-96 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). Geothermal well fluid measurements are made for the basic study of a natural resource; assessment of an underground thermal reservoir for possible exploitation; assistance in drilling operations; appraisal of individual wells for production; mechanical engineering design requirements, including safety of equipment and personnel; legal requirements for ownership, safety, or waste disposal; fluid sales; and plant operation. Measurements include reservoir investigation of size, permeability and temperature, and fluid composition and pressure; well flow characteristics of temperatures and pressures and the corresponding flow rates of steam, hot water, and gas; downhole engineering data of casing condition, mineral deposition, or levels of permeability. (33 references) (MCW)

COLLECTION AND TRANSMISSION OF GEOTHERMAL FLUIDS. Smith, J. H. (Ministry of Works, Wellington, N. Z.). pp 97-106 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). The collection and transmission of geothermal fluids may include hot water, steam, or a steam/water mixture if separation is made at the plant instead of at the wellheads. The fluid produced most usually contains incondensible gases (typically CO₂ and H₂S with minor amounts of other gases), the proportion of gas sometimes being so high that economic utilization is not feasible. Economic feasibility also depends on the presence of rock fragments and the chemical composition of the water. Water contained in steam can also be considered an impurity. The engineering schemes for hot water, steam, and the two-phase transmission are described. (25 references) (MCW)

GEOTHERMAL POWER. Wood, B. pp 109-121 of Geothermal Energy. Armstead, H. C. H. (ed.) Paris; United Nations Educational, Scientific and Cultural Organization (1973). Geothermal energy is used for district heating, industry, and other heating applications, but emphasis is on power generation. The geothermal resources have to be exploited where they occur. Electric power generation at the site may then be transmitted. Geothermal power stations include Larderello, Italy; Weatul and Kawerau in New Zealand; The Geysers and Salton Sea in California, USA; Pauzhetka and Paratunka in the USSR; Matsukawa and Okate in Japan; Patzé and Mexicali in Mexico; and Akureyri in Iceland. (MCW)

GEOTHERMAL DISTRICT HEATING. Ekarsen, S. S. (Vermir H/F, Reykjavik). pp 122-134 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). A history of the application of geothermal energy for heating of houses is discussed for Iceland, Hungary, Japan, New Zealand, and USSR. The economics and technical aspects of the systems are described. The development of the geothermal areas feeding the system in Reykjavik is described, and then principal data regarding the geothermal district heating system are given. The Reykjavik system saves about 150,000 tons of oil annually that would have had to be imported, and the annual cost of heating for the customers is only 50% of the cost of heating with oil. (20 references) (MCW)

INDUSTRIAL AND OTHER APPLICATIONS OF GEOTHERMAL ENERGY (EXCEPT POWER PRODUCTION AND DISTRICT HEATING). Lindal, B. pp 135-145 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). Industrial applications of geothermal energy are discussed for pulp, paper, wood, sugar, borax acid, salts from seawater, heavy water, fresh water, distomaceous earths, production of alumina from bauxite, and many other mining processes. The reclamation of minerals and other materials from geothermal fluids is feasible. Agricultural applications include greenhouse and soil warming, animal husbandry and other farm uses, and fish hatching and breeding. Recreational and health applications are described. Usually, the main objective will involve some kind of evaporation, while the side uses may be drying, simple process heating, refrigeration, heating of industrial buildings, or the production of electrical power for the plant. (43 references) (MCW)
CORROSION CONTROL IN GEOTHERMAL SYSTEMS. Marshall, T.; Bruthwalt, W. R. pp 151-160 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). The main problems of corrosion control in the design and operation of systems for the utilization of geothermal fluids involve interactions between chemical factors, physical factors such as temperature and stress, and the various materials of construction. The most common impurities encountered in geothermal fluids are silica, chlorides, fluorides, borates, sulfates, carbonates, sodium, potassium, lithium, calcium, magnesium, ammonium, hydrogen sulfide, and carbon dioxide. The gaseous impurities are usually of major significance in water-phase corrosion in geothermal systems, while the gaseous impurities are usually of major significance in steam-phase, condensate and atmospheric corrosion. (50 references) (MCW)

GEOTHERMAL ECONOMICS. Christopher, H.; Armstead, H. pp 161-174 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). An attempt is made to assess representative costs applicable to a typical developed geothermal field. Geothermal heat is recovered with a fixed component in price for establishing production costs, no variable component. Limitations are imposed by location. There may be occasions where the availability is nullified by detrimental effects such as poisoned waste fluids. Geotherm thermal may be obtained without inadmissible temperature. Geothermal energy is inexpensive, and costs that are far less than for other forms of heat, and at least two to three times more efficient. The cost of geothermal energy is closely tied to the demand for power, and industry, and is sometimes large savings in foreign currencies. (MCW)

MANAGEMENT OF GEOTHERMAL FIELD. Bolton, R. S. (Ministry of Works, Wellington, N. Z.). pp 175-184 of Geothermal Energy. Armstead, H. C. H. (ed.). Paris; United Nations Educational, Scientific and Cultural Organization (1973). Methods of estimating the energy potential are discussed and some parameters affecting the potential include stored heat and natural heat flow. The methods and effects of exploitation are related to the potential for the recovery of the energy. The primary effects of exploitation are discussed and examples are cited for results at Wairakei, New Zealand; Larderello, Italy; and Laugavegur, Iceland. The secondary effects of exploitation include natural activity, ground movement, pollution, and chemical deposition. Chemical deposition can reduce output or be a problem for the disposal of waste water. Tourism is a secondary effect. Measurements and records are made, but results seem to bypass mathematical tools. Perhaps as more geothermal fields are exploited, theoretical and mathematical background will expand. (21 references) (MCW)

N74-17801# California Univ., Riverside. Inst. of Geophysics and Planetary Physics FEASIBILITY STUDY FOR DEVELOPMENT OF HOT-WATER GEOTHERMAL SYSTEMS Fr: Technical Report James B. Comb Mar. 1973 125 p ref. (Grant AF-AFOSR-2393-72; ARPA Order 2164) (A.D. 77-0106; IGPF-UR73-18; AFOSR-73-2070TR) 1 Available NTI CSCL 10/2 The investigation has been directed toward a feasibility study for the development of hot-water geothermal systems for potential Department of Defense use as an energy source. Research effort has included the gathering of both scientific and engineering data. The world-wide occurrence of both known and probable sites of hot-water (water-dominated) geothermal systems in particular in relation to United States Department of Defense installations are reviewed and discussed. Included are the geological settings and the types of detection techniques that are necessary to delineate geothermal systems. GRA

N74-21691# (LA-UR-73-1075) POTENTIAL FOR HOT-DRY-ROCK GEOTHERMAL ENERGY IN THE WESTERN UNITED STATES. Brown, D. W. (Los Alamos Scientific Lab., N. Mex. (USA)). 25 Jul 1973. Contract W-7405-eng-36. 22p. Dep. NTIS $2.25. The U. S. Geological Survey has identified 1.8 million acres (2800 square miles) of western lands as "having a significant potential for geothermal development." The LASL has been actively investigating the potential for and problems associated with extracting geothermal energy from the much more numerous regions of the western United States containing hot, but essentially dry, rock at moderate depths. A recent survey reveals that about 7% of the 13-state area comprising the Western Heat Flow Province—about 95,000 square miles—is underlain, at a depth of 5 km (16,400 ft), by hot rock at temperatures above 290°C (550°F). In the Los Alamos concept, a man-made geothermal reservoir would be formed by first drilling into a hot rock mass, and then creating a large underground area for heat transfer using conventional hydraulic fracturing techniques developed by the oil industry. After forming a circulation loop by drilling a second hole into the top of the fractured region, the heat contained would be conveyed to the surface by the buoyant circulation of water, without the need for pumping. The water is the Earth loop would be maintained as a liquid throughout by pressurization at the surface, both increasing the amount of heat transport up the second (withdrawal) hole, and enhancing the rate of heat removal from the fractured reservoir, when compared to steam. Thermal stresses resulting from the cooling of the hot rock in such a man-made reservoir may gradually enrich the natural fracture system so that its useful lifetime will be greatly extended beyond the planned 10 to 15 years provided by the original reservoir. If these thermal stress cracks grow preferentially downward and outward into regions of hotter rock, as seems probable, the quality of the geothermal source may actually improve as energy is withdrawn from it. (auth)
Dried Geothermal Wells: Promising Experimental Results


Experimental results are described for a test well drilled 780 m into granite rock at one edge of a huge volcanic caldera in the Jemez Mountains of northern New Mexico by researchers from LASL, an Atomic Energy Commission facility. Water was pumped under pressure into a section of the well to open cracks in the surrounding rock. The hydrofracturing technique had not been demonstrated in granite or other crystalline rock formations. These dry geothermal deposits are believed to constitute a resource at least ten times as large as deposits permeated by ground water. The economic feasibility of the hydrofracturing experiments is discussed. (MCW)

Full Steam Ahead for Geothermal Energy

J. Renahan.

Power companies in the US are looking for alternative sources of energy. Geothermal wells are high on the list.

Title: A Practical Application of Geothermal Steam
Author: Finney, J. P.
Corporate Author: Pacific Gas & Electric Co.
Geysers Geothermal Power Project
Publication Description: Public Utilities
Factnightly, 93(1), 18-20
Publication Date: 1973, January 31
Abstract: A brief description is given of the use of geothermal energy around the world. A more detailed account is given of the history and operation of the Geysers project in California. The capacity of this installation will be more than doubled by 1977, when more than 900 MW will be generated. The Federal government should concentrate research efforts on areas less well developed, such as "dry" geothermal energy and the binary power cycle, which uses hot water. (JBC)

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Title: The Total Flow Concept For Recovery of Energy From Geothermal Hot Brine Deposits
Author: Austin, A. L.; Higgins, G. H.; Howard, J. H.
Corporate Author: Lawrence Livermore Laboratory
Address: University of California, Livermore, CA
Publication Description: Report No. UCEL-51366, 39 p.
Publication Date: 1973, April 3
Sponsor: U.S. Atomic Energy Commission
Abstract: This report describes a new method for producing electrical power from the energy stored in hot brine deposits. Of the three forms of geothermal energy, the hot brine resource has the greatest potential for development of a viable long-range geothermal energy supply. It is a large source with recovery and conversion requiring only moderate extensions of existing technologies. The proposed method is developed specifically for application to the brines of the Salton Sea geothermal area, where enough energy is stored to provide at least 100,000 MW electrical generation capacity for more than 20 yr.
GEOTHERMAL POWER: CAN IT HELP SOLVE THE ENERGY CRISIS.
E.F. Wehlgae.

73W18730

Geothermal energy: review of research and development
different authors covering the following subjects: the nature and basic theories of geothermal
energy; geology and exploration; winning of geothermal fluids; geothermal power; district heating;
industrial applications; geothermal economics; and management of a geothermal field.

BEOWAVE STILL ROARS: REPROACH AND REHABIL.
Wehlgae, E. F. Geotherm. Energy Mag.; 1: No. 2, 14–18 (Sep
1973).
Beowave Hot Springs is located 250 miles northeast of Reno,
Nevada. Exploratory drilling occurred in the period 1959 to 1965
by Magma Power Co. and Associates and Vulcan Thermal Power
Company. Mystery now visits the ownership of the Beowave Little
Geyser, but visits in 1972 and 1973 reveal their adaptability for
a fine geothermal laboratory. (MCW)

GEOTHERMAL TEST GENERATOR UNIT: THIRD
ELECTRIC GENERATOR IN NORTH AMERICA.
Wehlgae, E. F.
The helical rotary screw expander was developed as a geother-
mal field prime mover for driving a generator adapted for reverse
operation from a relatively new type of air and gas compressor
developed in Sweden as the Lysholm rotary-screw compressor.
Test runs were made at Cerro Prieto and indicate a great poten-
tial for practical applications on a larger scale for geothermal
power generation. The expander system produces power from hot,
mineral-depositing brines. The system upgrades the current power
recovery, reduces current plant costs, simplifies current installa-
tions, and allows fresh water extraction. (MCW)

POTENTIAL FOR THE PRODUCTION OF POWER
FROM GEOTHERMAL RESOURCES. Smith, M. C. (Los
Alamos Scientific Lab., NM). Geotherm. Energy Mag.; 1:
No. 2, 46–51 (Sep 1973).
Testing is being carried out at the Los Alamos Scientific Lab-
oratory to investigate the possibilities, problems, and probable
usefulness of man-made geothermal-energy systems in hot dry
rock. The geothermal energy in the Earth's crust is the largest
reservoir of directly usable clean energy accessible to man. The
extraction system, potential, and costs are discussed. Equipment
and techniques to make this energy reservoir useful already exist.
(MCW)

also N74–21690#

(AEC-tr-7475) PROCESS FOR THE SIMULTANEOUS
UTILIZATION OF GEOTHERMIC AND HYDRODYNAMIC ENERGY.
Tavip, J. E. (nd). Translation of Diapositiva para el aprove-
chamiento simultaneo de la energia geotermica y la hidrodinamica.
7p. Dep. NTIS $3.00.
A process is described for the utilization of hydrodynamic en-
ergy produced by water falling through a pipe inserted deeply into
the Earth's crust at a point where the high temperature will pro-
duce steam and is returned to the Earth surface through another
pipe as steam. The waterfall created by this perforation is
utilized by turbines suitable for the production of electric energy
while the steam produced spouts from the surface of the Earth
and can be used as a source of energy with multiple applications.
(MCW)

(LA-UR-73-328) POTENTIAL FOR THE PRODUCTION
OF POWER FROM GEOTHERMAL RESOURCES. Smith, M. C.
The nature and magnitude of the hot, dry rock geothermal energy
resource are such that within the next 10 to 15 years it could begin
to contribute significantly to the solution of some of our nation's
most urgent energy, pollution, and balance-of-payments problems.
A program to investigate and develop this resource was undertaken
by the Atomic Energy Commission at Los Alamos Scientific Lab-
oratory, and initial results from that program are described. It
appears that the equipment and techniques required to make this
vast energy reservoir useful already exist, and that a convincing
demonstration of its usefulness is possible within less than five
years. (auth)

Technology exists to pump large quantities of water up to pressures of 3500 to 4000 lb/in² for supercritical boilers in fossil-fueled steam power plants. This pump experience can be applied to a high-pressure water turbine that would extract the pressure energy from the geopressured fluid and discharge the fluid at conditions of pressure and temperature such that its thermal energy could be extracted. Geopressured fluids are normally saturated with methane and could be economically recovered. Hot interstitial water in deep overpressured sedimentary basins of greater-than-normal temperatures exist in the Gulf Coast from the Rio Grande to eastern Mississippi. The geology and hydrology of the region are reviewed. Abundant data are available for geopressured gas reservoirs. With favorable conditions, it is expected that wells could be made to produce 3 to 5 million gallons/day of water at 350 to 400°F, having a closed-in pressure at the well head of 4,000 to 5,000 psi, the water containing less than 19,000 mg/l dissolved solids, and 0.3 to 1.0 standard cubic feet of hydrocarbon gas per gallon of water. (MCW)


The 75,000 kW generating plant at Cerro Prieto, Mexico, is beginning operation using superheated steam from depths of 4,000 feet surrounding the extinct volcano. The experiment began in 1894. Steam used to turn the Japanese-made turbogenerators can be condensed into salt-free potable water, and ultimately used for irrigation. The Mexicali Valley south of Cerro Prieto is an expanse of Imperial Valley. (MCW)


Geothermal resources of the world are comparable in magnitude to fossil fuel and nuclear energy resources. It is evident that the technology exists to exploit economically many of the world's known geothermal reservoirs and that the impact on the environment will be minimal. A flowsheet for a typical binary power cycle is shown. The geothermal fluid is flashed and steam is flashed and steam is separated from the hot brine. Both streams are used to heat and vaporize the power fluid that is passed through a turbine and condensed with cooling water. The power fluid is then pumped to the upper working pressure and reheated to complete the cycle. The brine may be reinjected and the steam condensate used for cooling tower makeup, sold as fresh water, or reinjected with the brine. At the San Diego Gas and Electric plant the working fluid will be isobutane that will be heated by flashed steam and brine and condensed with cooling water. No expansion turbine or generator will be installed initially. (MCW)


The exploration and development of volcano energy in Hawaii was proposed by the center for Engineering Research at the University of Hawaii. Funds have been pledged by private sources, federal agencies, State of Hawaii, and Hawaii County to accomplish minimal necessary investigation of geological, engineer, socio-economic, and environmental base-line data concerning the potential for access to geothermal energy. The geology of the islands is briefly discussed. (MCW)

Overall heat-transfer coefficients were obtained in a single-tube loop for a smooth tube and two fluted tubes proposed for use in a geothermal brine upflow VTE pilot plant. Tests were run at steam temperatures from 250 to 300°F, flow rates of 0.5 to 2.5 gpm, and steam to brine ΔTs of 10 to 30°F using demineralized water and 3% NaCl solutions. In each case the liquid entering the tube flashed through a ΔT equal to the steam–brine ΔT. The tubes tested were a 1/4-in. smooth stainless steel tube, a 1-in. double-fluted CuNi tube, and a 1/4-in. double-fluted Al brass tube. Average heat transfer coefficients using 3% NaCl were as follows: for the stainless steel tube, 550 Btu/hr°F/ft² at 250 to 765 at 300°F; for the CuNi tube, 2000 at 280 to 2800 at 300°F; for the aluminum brass tube, 5750 at 250° to about 2000 at 300°F. Flow rate and ΔT, in general, had only small effects on the coefficients. (auth)


The basic concept of a commercial steam-field is discussed and potential areas are indicated in a map. It is found that not less than 24 geothermal areas are prospectable, but very little is known about the exact potential of Indonesia in the field of geothermal, anticipating the rising demand in electricity and transportation of the country's industrialization program of Indonesia and the limitation of its fossil fuel reserve, it is suggested that all possibilities for utilizing different kinds of energy, including geothermal, should be explored as far as possible. (auth)

N74-21689 #


Dry hot rock in the Earth's crust represents the largest and most broadly distributed reservoir of usable energy accessible to man. The engineering equipment and methods required to extract and use this energy appear to exist and are now being investigated actively at LASL. At least for deep systems in relatively impermeable rock, close to active fault zones, the extraction of energy from dry geothermal reservoirs should involve no significant environmental hazards. The principal environmental effects of such energy systems will be those associated with the surface facilities that use the geothermal heat, the thermal steam, and in the thermal-pollution potential of low-temperature power plants. The energy extraction system itself should be clean, safe, unobtrusive, and economical. (auth)


The success of economically converting geothermal energy depends upon the solution to the problem of handling a two-phase effluent of steam and hot brine for recovery of energy. The effluent contains high percentages of superheated water and dissolved solids. More costly closed or binary cycle systems that utilize steam efficiency and deposition problems are necessary. The new bladeless turbine developed by U.S. Federal Engineering and Manufacturing, Inc., of San Diego discards conventional impulse and reaction design principles in favor of a novel "hydromatic drag" to accomplish the energy conversion from steam, or hot brine, to rotating shaft power without any "impingement." The hot steam and liquid are brought into the turbine case by suitable peripheral nozzles at a tangent to a number of flat or conical rotor blades fixed at a rotating shaft. The hot effluent with a high kinetic energy is directed inwardly with a helical path until discharged through holes in the discs located near the shaft. (MOW)

TITLE: Nature's Teakettle - Geothermal Energy For the People

AUTHOR: Samuel H.

CORPORATE AUTHOR: Geothermal Information Services

ADDRESS: 316 Cherrywood St., West Covina, CA 91791

PUBLICATION DESCRIPTION: 213 p.

PUBLICATION DATE: 1973

ABSTRACT: The author attempts to answer the question "what is geothermal energy?" In terms of the systems can understand. Included in this discussion are the energy problems and blackouts; the nature of energy; how turbines operate; the geotechnological structure of the earth; state of the art of geothermal power; water problems and desalination; nuclear energy; pollution; hot rocks; utilization of geothermal energy throughout the world; proposed legislation; and what public opinion can do. A glossary of energy and geothermal terms and a directory of information sources are included. (RC)


The question of ownership has been a major deterrent to the development of geothermal resources in the United States. Federal legislation says that geothermal rights are a separate entity on federally administered lands. The Geothermal Steam Act of 1970 says that geothermal steam and associated geothermal resources are the products of geothermal formations. The references to steam, hot water, and hot brines clearly indicate that Congress believes that the word "geothermal" implies the upper end of a temperature scale—but which scale is not specified, nor are we told at what points non-geothermal leaves off and geothermal begins. Researchers differ on classification of water according to temperature. Others make the division at logical temperatures, depending on their interest. Renewability and the question of rights are discussed. (MCW)

Volume I of this statement primarily relates to the pronouncement of leasing and operating regulations for implementation of the geothermal leasing program as authorized by the Geothermal Steam Act of 1970. The proposal is described in Chapter I. The national energy situation, geothermal energy resources and their potentials, description of resource development and production phases, and a broad description of the environmental setting of the western states are included in Chapter II. The pronouncement of leasing and operating regulations, the environmental impacts of the proposed action, mitigating measures, adverse impacts which cannot be avoided, the relationships between local short-term uses of man’s environment and maintenance and enhancement of long-term productivity, and irreversible and irrevocable commitments of resources are discussed in detail in Chapter III. Chapter IV includes discussions of alternatives for timing of actions, environmental provisions of regulations, leasing options, federal and private exploration and development, and electrical energy sources. (GRA)


This volume of the Geothermal Leasing Program final impact statement contains the individual environmental statements for the leasing of federally owned geothermal resources for development in three specific areas: (a) Clear Lake-Geyser; (b) Mono Lake-Long Valley; and (c) Imperial Valley, all in California. It also includes a summary of the written comments received and departmental responses relative to the Draft Environmental Impact Statement issued in 1971; comments and responses on the Draft Environmental Impact Statement; consultation and coordination in the development of the proposal and in the preparation of the Draft Environmental Statement; and coordination in the review of the Draft Environmental Statement. (GRA)


The following topics are discussed: July 23, 1973, proposed leasing regulations; July 23, 1973, proposed operating regulations; comments on July 23, 1973, proposed regulations; September 29, 1973, proposed leasing regulations; November 29, 1972, proposed operating regulations; comments on November 29, 1972, proposed regulations; July 23, 1972, proposed lease terms and operating regulations; May 3, 1972, proposed unit plan regulations; summary of comments and departmental responses; vapor dominated hydrothermal systems; classification of public lands. (GRA)


This volume contains comments received from Federal, State, local and individual interests on the leasing and operating regulations and the Draft Environmental Impact Statement for the Geothermal Leasing Program and the supplement to the draft statement. (GRA)

Heat rejection from geothermal power plants. J.H. Anderson (Sea Solar Power Inc., York, Pa. USA)


Discusses the heat rejection from geothermal and other low temperature power plants. The low thermodynamic efficiency of such plants requires greater heat rejection than is necessary for conventional fossil plants. They are also much more sensitive to the temperatures available for cooling systems. New cooling systems are needed, which can provide lower temperatures at lower costs than present systems. Such systems are discussed with reference to both power and water requirements.


Operating experience over 12 yr at the Geysers Power Plant has demonstrated that geothermal electric power generation can be reliable and economical. Location, terrain, environment, personnel considerations, and operating requirements have created new and unique problems compared with traditional thermal power generation practices. Common interests and goals of the steam supplier and the power plant operator have resulted in their solutions. Much has been learned about the selection of equipment and materials that will be used to make future installations more reliable and perhaps reduce power costs. Similar to other means of generating electric power, geothermal generation has certain inherent attributes and liabilities but when viewed in proper perspective with objectivity is sound and economical. (auth)

The method and apparatus for the nonpolluting generation of electrical power by the economic utilization of geothermal energy that is accessible through widespread sources of regenerative geothermal hot water are described. A well provides access to a geothermal hot water source having a temperature substantially above the flash point for atmospheric pressure, the hot water being conducted through heat exchangers wherein its heat energy is transferred to a power fluid employed in a closed Rankine steam engine cycle to generate electrical power, the water then being injected back into the aquifer. The geothermal hot water is pressurized by deep well pumps to a discharge pressure above its saturated vapor pressure for the source temperature, and a pressure gradient above the saturated vapor pressure is maintained through the heat exchangers, whereby the hot water is restrained from flashing into steam throughout its circuit, thereby avoiding any substantial temperature drop between the source and the heat exchangers and preventing release of any substantial mineral deposits at any point in the circuit. The very small expenditure of power required for such pressurization produces a large increase in total power output and efficiency by, among other things, (i) providing a top temperature power fluid Rankine cycle, (ii) avoiding fouling of the well and surface equipment with mineral deposits, (iii) deriving power from all of the geothermal fluid rather than just a stream fraction thereof, (iv) allowing use of a power fluid that is particularly efficient in the available temperature range, and (v) avoiding degeneration of the power fluid source and ecological damage by returning the geothermal fluid to the aquifer.

(Official Gazette)


Only one resource type is presently being used to produce power in the U.S.—dry steam generating 400 MW at The Geysers near Santa Rosa, California. Six other types—brines at high temperature and low salinity, high temperature and high salinity, low temperature and low salinity, and geopressed reservoirs, plus dry hot rock at shallow depth and in deep, normal-gradient formations—are potentially available for economic energy recovery. The program plan calls for a government budgetary obligation of $40 million during FY-75 coupled with an industrial commitment of $14.7 million. The five-year budgetary obligations are estimated to be $185 million for the government and $65 million for industry. The complete five-year plan plus the balance-to-complete funds is presented. Under this program plan, demonstration plants using four of the advanced resource types will be completed and operated, jointly with industry, to obtain engineering and economic data. Construction will be underway on demonstration plants for a fifth resource type, dry hot rock, and engineering data in support of the design of a sixth plant employing normal-gradient formations will have been collected. It is expected that information from all these systems will accelerate commercialization of geothermal energy. (auth)

(LBL-2102) COMPARISON OF ELEMENTARY GEO-


From applied technology geothermal committee meeting; Idaho Falls, Idaho, USA (7 Aug 1973).

A comparison of three simple geothermal power-production systems shows that the flashed steam and the compound systems are favored for use with high-temperature brines. The binary system becomes economically competitive only when used on low-temperature brines (enthalpy less than 250 Btu/lb). Geothermal power appears to be economically attractive even when low-temperature brines are used. (auth)


Abstracts were prepared for eighteen papers presented at the special symposium held by the American Nuclear Society in June 1972. Individual papers discuss available and potential resources throughout the world, methods of exploration and evaluation, geological and geothermal character of the resources, problems in developing the several types of resources, the current status of geothermal energy production in the US and elsewhere, potential methods for more efficient production, the impact on the environment, and possible uses as a water resource. The final paper reviews the needed areas of research and Federal efforts to coordinate exploration, research, and development. (MCW)


The World Directory includes information from all pertinent states in the United States on the state-of-the-art of geothermal energy. All legislators, commercial and industrial firms, individuals, and public utilities serving actively in geothermal energy are listed. U.S. and foreign educational institutions performing in the geothermal field are listed. The state-of-the-art in geothermal energy in each country of the world is summarized. International societies, agreements, and legislation are given. Financing data include information on world financing and comparative energy costs. (MCW)
GEOTHERMAL ENERGY STUDY BACKED BY $250,000.


New sources of power—geothermal resources. J. Barnea. Conference on World Energy Supplies, London, England, 18-20 Sept. 1973. 7pp. Discusses how the geothermal energy is harnessed to generate electric power, to provide for district heating, to provide heat for green houses and so on, in more than 15 countries today. Large-scale commercial development of geothermal resources is under way in the United States, Japan, Italy, Mexico, New Zealand, El Salvador, Chile, Kenya, and a number of other countries (no refs.)
GEOTHERMAL POWER PROJECT OF PACIFIC GAS AND ELECTRIC COMPANY AT THE GEYSERS, CALIFORNIA.


Utilization of the earth's geothermal energy resources for production of electric power has been achieved in several areas throughout the world. The only commercial development in operation in North America is at "The Geysers" north of San Francisco. A 12 MW unit commenced operation in 1960, and additional units have been added bringing the total capacity to 192 MW. Design and construction now under way will increase this to 522 MW by the end of 1974. There are plans for continuing increments of approximately 100 MW per year as steam reserves are developed. The steam supply, mechanical and electrical features, operating experience, and special problems are described.

Geothermal Energy, A National Proposal for Geothermal Resources Research,

(Contact NSF Office of Public Technology Projects,
Room 405, or RANN Document Center, Room 601,
G 1800 G St. N.W., Wash., D.C. 20550.)
MULTI-PURPOSE UTILIZATION OF GEOTHERMAL RESOURCES. Various examples are cited which illustrate the multiple applications of geothermal hot water in many parts of the world. The development of geothermal energy has been marked by progress in two main directions: power has been produced from geothermal steam and several applications have been found from geothermal water. It is argued that a multi-purpose total energy utilization of geothermal resources could result in the following: steam could be separated and used to supply ample power; carbon dioxide could be extracted from the gases and used for refrigeration and food processing; in the same manner, hydrochloric gas could be utilized to obtain sulfur. Hot water from the wells could supply a desalination plant: the produced fresh water would not only supply the needs of the local population but also a high-quality value-added operation using irrigation techniques. The hot water could also be used to provide air conditioning, and refrigeration. The effluent from the desalination could be used for minerals extraction, and the resulting minerals could be processed taking advantage of the availability of cheap base load electricity.


Experimental research is reported on corrosion of metals and alloys in waters of various springs that differ in temperature and chemical composition. Tests were carried out on natural thermal waters both at the boreholes and in the laboratories. For the first time a dependence was established between the corrosion rate of metals and the velocity of thermal water, the pH value, the temperature, the concentration of atmospheric oxygen in the thermal water. "Waiting time," i.e., the period of time that must elapse before corrosion begins in heating systems by geothermal fluids, was determined. A method of reducing corrosion in this type of heating is that of creating a vacuum in the thermal waters accompanied by their treatment with corrosion inhibitors. Corrosion of carbon steel due to thermal waters containing H₂S and CO₂ can now be prevented in a cheap and reliable way. (auth)


Microearthquakes have been observed near many major geothermal areas around the world. Where detailed data are available, there is a close spatial relationship between microearthquakes and geothermal activity. Earthquakes with magnitudes greater than about 4.5, however, are rarely observed in geothermal areas. Observations of microearthquakes can be used to locate active faults that may channel hot water toward the surface. Earthquakes provide some risk to development of geothermal regions since during an earthquake the flow of thermal fluid can be enhanced or slowed and structures can be damaged. Modification of reservoir fluid pressure may influence the earthquake activity. (auth)


A theoretical discussion is presented of the thermal problems involved in the disposal of flash water from geothermal power plants by reinjection. The basic equations for the subsurface temperature field in the reinjection zone are derived both for rocks with intergranular and fracture flow. The extent of the thermal contamination by the reinjected water is discussed. In the case of a continuous mass flow of flash water of 1000 kg/sec for a period of 25 years, the contamination may reach out to as much as 5 km or more from the point of re-entry, depending on the type of rock involved. (auth)
RESISTIVITY STUDIES ON THE IMPERIAL VALLEY GEOTHERMAL AREA, CALIFORNIA. Melipay, T. (Univ. of California, Riverside); Furgerson, R. Geothermics; 1: No. 2, 47-62 (Jun. 1972).

Electrical resistivity was employed for mapping the imperial Valley of California as part of a multi-disciplinary approach to assess its geothermal potential. Vertical and lateral resistivity changes were determined from Schlumberger depth soundings with effective probing depths up to 6000 ft. Known geothermal anomalies appear as resistivity lows superimposed on the regional gradient that decreases northward from the southeast corner of the Imperial Valley, near the Colorado River, to values about two orders of magnitude lower at the Salton Sea. A regional salinity gradient in the Imperial Valley trends northwest from a very low salinity at the Colorado River near Yuma, Arizona, to a very high salinity at the Salton Sea geothermal field. Abrupt changes in salinity exist across the Imperial fault, with salinities being much higher west of the fault. Maximum salinities can be estimated by combining the ground resistivity survey and formation factor-depth relationships compiled from well logs. From a technical point of view, the apparent-resistivity and longitudinal-resistivity maps are nearly identical at a probing depth of 3000 ft. Hence continuous profiling at a Schlumberger AB/2 spacing of 3000 ft should permit an effective, low-cost reconnaissance method for still-unsurveyed areas of the Imperial Valley. (auth)


The exergy of a substance is the theoretical amount of mechanical work that can be derived from its heat content at given initial and end conditions. At given end conditions, the exergy is a state variable. The exergy per unit mass of pure water has been tabulated for the most important initial and end temperatures. As example showing the exergy flux in geothermal power plants is given. (auth)


In a well used in the search for endogenous fluids the opportunity exists to stop level of thermal waters of high temperature and pressure so that deeper levels can be reached, where it is inferred that there are fluids with better thermodynamic characteristics. The AGIP Laboratories have carried out tests on mortars assumed to be suitable for the clogging of the bedrocks containing the undesired waters. (auth)


The convective instability of magma liquids under physical conditions of the gravitational and geothermal fields of the Earth leads to radial transfer of heat and mass in the magma body. This transfer causes crystallization at the bottom and loss of volatiles at the top. As a result the magmatic mass rises towards the Earth's surface by a process similar to zone melting. A physico-chemical theory was developed in which the origin of melt, its rising, and its chemical differentiation are closely related processes. Formed by a partial or complete melting of primary deep material the magma interacts with the country rocks by melting and assimilation. Its composition changes according to the zone melting conditions and the magma floats upward. The extent of the process and the depth at which the movement degenerates depend on the quantity of heat in the magmatic system during its formation. (auth)


The flow-rate/pressure relation for the wells of the Larderello area is considered. After an examination of experimental results recorded for many years, and after the discussion of the experimental flow-rate/pressure curve, an attempt is made to find the theoretical link between pressure and flow rate at the mouth of the well borehole. The results of the experimental and theoretical approach are then compared, and a best fit curve is proposed. Moreover, the flow-rate/well bottom pressure curve as the true characteristic of the whole system of flow is suggested. (auth)


Heat flow was determined in a borehole near Orlando, Florida and another near Uvalde, Texas. Thermal conductivities in both boreholes were obtained by divided-bar measurements on rock discs and by needle-probe measurements on rock chips. For the needle-probe method, the rock chips were pulverized into powder, suspended with water, and the conductivity of the solid rock was obtained from the conductivity of the mixture by an empirical relationship. Divided-bar measurements for the Florida borehole indicate a heat flow of 0.92 ± .03 H.F.U., while needle-probe measurements on rock chips show a heat flow of 1.24 ± .06 H.F.U. The discrepancy is attributed to anisotropy of the sedimentary rocks penetrated by the borehole. Heat flow obtained from these two different methods of determining conductivity show good agreement in the Texas borehole. Divided-bar measurements indicate a heat flow of 1.08 ± .03 H.F.U., while the chip technique gives a value of 1.13 ± .03 H.F.U. (auth)
Wol

N74-20616# Interior Dept., Washington, D.C.
FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM. VOLUME 1: PROMULGATION OF LEASING AND OPERATING REGULATIONS
Avail: SOD HC $4.20

Public lands potentially available for geothermal leasing are described. These include principally: (1) public, withdrawn, and acquired lands administered by the Secretary of the Interior; (2) national forests and other lands administered by the Forest Service, Department of Agriculture; and (3) lands containing a reservation to the United States of the geothermal resources. These lands total 638 million acres. The most promising geothermal resource areas are located predominantly in the 11 western States and Alaska. Included in this proposed action are: (1) the promulgation of leasing and operating regulations pursuant to which the program would be administered; and (2) the leasing of federally owned geothermal resources for development in three specific areas: (a) Clear Lake-Geyser; (b) Mono Lake-Long Valley; and (c) Imperial Valley, all in California.

Author

N74-19976# Interior Dept., Washington, D.C.
FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM. VOLUME 3: PROPOSED GEOTHERMAL LEASING AND OPERATING REGULATIONS
Avail: SOD HC $5.60

Proposed leasing and operating regulations to implement the Geothermal Steam Act are presented. Included are a study comparing vapor dominated hydrothermal systems with hot water systems, and a classification of public lands valuable for geothermal steam and associated geothermal resources. G.G.

N74-19976# Interior Dept., Washington, D.C.
FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM. VOLUME 2: LEASING OF GEOTHERMAL RESOURCES IN THREE CALIFORNIA AREAS
1973 517 p ref 4 Vol.
Avail: SOD HC $5.85

Individual environmental statements are presented for the leasing of federally owned geothermal resources for development in three specific areas: (1) Clear Lake-Geyser; (2) Mono Lake-Long Valley; and (3) Imperial Valley. Also included is a summary of comments and responses relative to the draft environmental impact statement issued in 1971.

Author

N74-19977# Interior Dept., Washington, D.C.
FINAL ENVIRONMENTAL STATEMENT FOR THE GEOTHERMAL LEASING PROGRAM. VOLUME 4: COMMENTS ON DRAFT IMPACT STATEMENT AND PROPOSED REGULATIONS
1973 726 p ref 4 Vol.
Avail: SOD HC $5.85

Comments received from Federal, State, local, and individual interests on the leasing and operating regulations, the draft environmental impact statement for the Geothermal Leasing Program, and the supplement to the draft statement are presented.

Author
FLOW IN GEOThermal WELLS (an analytical study). Tolivia, E. (Comisión Federal de Electricidad, Mexico City). Geothermics, 1: No. 4, 141-145 (Dec 1972).

The flow pattern in geothermal wells was determined from several flow, pressure, and temperature measurements in flowing wells. The procedure followed for the determination of the two-phase flow composition and the flow pattern is shown. A model is proposed for the mechanics of scale formation in the production casing of the wells, caused mainly by the silica-saturated fluid produced. The flow pattern for horizontal pipelines and the calculation for the pressure gradient using Dukler equations are presented. The calculated values are then compared with experimental values obtained in a 674-meter-long pipeline discharging a steam-water mixture. (auth)


Dep. NTIS.

From eighteenth annual American Nuclear Society conference; Las Vegas, NV. (18 Jun 1972).

TITLE: Geothermal Power
AUTHOR: Barnea, J.
CORPORATE AUTHOR: United Nations, Resources and Transport Div.
ADDRESS: New York, NY
PUBLICATION DESCRIPTION: Scientific American, 226(1), 70-77
PUBLICATION DATE: 1972, January
ABSTRACT: Geothermal power can provide other useful products in addition to electric power. Possible applications include: desalting seawater; heating homes, greenhouses, and swimming pools; and providing non-electrical energy for refrigeration and air conditioning. The three classes of usable geothermal energy sources are dry steam fields, wet steam fields, and fields of lesser heat content. The use of each type of field is described, and costs for developing geothermal power are estimated. The paramount need is to develop exploratory techniques to locate geothermal reservoirs. (RFG)


Geothermal heat is the "new" energy that has attracted the attention of Mexican scientists, technologists, and economists. The harnessing of this energy is a new possibility that Mexico has in its geothermal systems (north and central) with more than a hundred classified thermal centers. Under development is the Cerro Prieto field which plans on a plant of 75 MW being programmed for an immediate increase to 150 MW. Being explored are the following fields: Ixtlan, Los Negritos, San Marcos, La Primavera, Tuliches, etc. The principal use of such energy will be in the generation of electricity, with decreasing fossil-fuel consumption and less environmental pollution. 11 figures. (qugh)
HEAT TRANSFER: THE GEYSERS GEOTHERMAL POWER PLANT.

J.P. Finney.


A JOINT VENTURE TO TAP THE EARTH'S HEAT.

Business Week, Nov.11,1972, p.53.

GEOTHERMAL ENERGY: AN EMERGING MAJOR RESOURCE.

A.L. Hammond.


Three types of resources are being considered—steam, hot water, and hot rock.
A theoretical study of geothermal energy extraction.


Efficient extraction of geothermal energy from a dry well depends upon the ability to establish a closed, pressurized circuit of water through a large zone fractured in hot impermeable rock. Long-term perpetuation of significant power extraction depends, in addition, on the ability to extend the initial fracture zone through support of an experimental program to test the feasibility using this type of energy source, the combined equations describing the coupled processes of fluid flow, heat transport, and rock fracture were solved numerically. The results show a strong dependence on the extent to which underground pressure can be maintained and the fracture zone continuously extended. They indicate that under favorable, but perhaps not unreasonably exotic, circumstances the extraction of significant thermal power from each well can be expected to continue for many decades. (Author)


Availability: Part of "Geothermal Energy: Resources and Research", GPO, Stock No. 5270-01633, ($2.75)
Title: Geothermal Energy, A National Proposal for Geothermal Resources Research

Author: Nicke, W.J.

Corporate Author: University of Alaska

Address: College, AK 99701


Publication Date: 1972

Sponsor: National Science Foundation, PAB Program

Abstract: This report presents the results of the Geothermal Resources Research Conference held in September, 1972. The importance of geothermal resources to the nation is discussed first, followed by budget recommendations for research on geothermal resources and an overview of geothermal resources. Reports of the six conference panels are included: Resource Exploration; Resource Assessment; Reservoir Development and Production; Utilization Technology and Economics; Environmental Effects; and Institutional Considerations. The report concludes with a summary of research needs and an extensive bibliography.

Availability: NBS (84.89)
GEOThermal HOT WATER RECOVERY PROCESS


An improved process and system for recovering high-temperature hot water from a geothermal supply is described. Equipment is described for reducing the pressure at the well head, flashing the hot water to steam to elevate a two-phase mixture of steam and hot water through the casing assembly. Such flashing is accompanied by the evolution of substantially non-condensable gases, including carbon dioxide, and separated with the steam from the elevated hot water, the latter being withdrawn from the system for its intended use, such as the generation of electric power. The separated steam and gases are heat exchanged to condense the steam and to withdraw useful heat from the gases, and the gases are compressed and recycled into contact with the underground hot water supply to assist in elevating additional hot water. The carbon dioxide-containing gases are effective in countering the problems normally created when geothermal hot water is allowed to flash to steam, namely the formation of system clogging deposits. Thus, without utilizing mechanical or other pumping devices within the well, recovery of a substantially constant stream of geothermal hot water from a deep underground well may be effected. (MCW)


In translations on People's Republic of China, No. 250. The hot springs at Fushing, Ichihara's Tang-gang-tsue, and Shaneli Hua-ch'ing-ch'ii are famous hot springs of China. In recent years, reports on hot springs various places have been numerous, and the number of the hot water wells has greatly increased due to tremendous progress in geological. An extremely rich resource in Earth's heat is kept within the national boundary. Ways to exploit these resources are discussed briefly. (MCW)

GEOThermal: Earth's PRIMORdIAL ENERGY.


Geothermal sources hold the potential for a significant increase in energy sources. The heat supply can only be exploited from the local hot spots—subterranean reservoirs where the heat has accumulated and is stored in the form of steam and hot water. Regions of high heat flow usually display hot springs, geysers, and fumaroles or steam vents. Productive results from exploration at such sites are represented by Larderello in Italy, Wairakei in New Zealand, and at the Geysers of California. Dry steam was reported from a well drilled in Valles Caldera, Sonora Co., New Mexico. Hot brine with temperatures up to 65°F, has been produced at the Salton Sea area in Imperial Valley of southern California, and additional reservoirs are reported and being utilized by Mexico at an extension of the Imperial Valley. Japan and Iceland are using geothermal heating. Hungary and the USSR have reservoirs for development of the utilization of geothermal energy. The economics and environmental impact are discussed. (JCW)

In translations on People's Republic of China. No. 250.

A geothermal power station was built at Feng-shan Hales of Kwangtung Province. The geothermal shaft is 200.91 meters in depth, and the water temperature at the well bottom is 103.5°C and at the opening 91°C. The water head's absolute pressure is 1.65 kg/mm² and the geothermal artesian flow rate is 80 tons/hour. The thermal power system of this experimental power station is primarily composed of the degasser, volume expander, steam turbine, condenser, gas pump, and four water pumps. Hot water is introduced from the geothermal well opening to a relatively low-pressure container (expansion container), where part of the hot water is vaporized to produce steam to push the steam turbine and the generator to generate electricity. The rubber axle seal (tight seal at the bearings) and the water ejection pump were used to solve the problems concerning the steam turbine's axle seal and splash. The air pressure is reduced, the system's equipment is simplified, and fuel is no longer necessary. The thermal power system of the experimental station is shown. (auth)

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1971

TITLE: Geothermal Science and Technology, A National Priority
AUTHOR: Austin, C.P.; Austin, W.H., Jr.; Leonard, G.W.
CORPORATE AUTHOR: U.S. Dept. of Defense, Naval Weapons Center
ADDRESS: China Lake, CA
PUBLICATION DATE: 1971, September
ABSTRACT: The major portion of the geothermal prospect called the Coo Thoral Area lies within the instrumented test range of the Naval Weapons Center, China Lake, Calif. in developing plans for scientific utilization of the Coo Thoral Area, the state-of-the-art of geothermal science and technology was reviewed. The review indicated that the development of geothermal deposits for the purpose of generating electricity, providing heat, and obtaining raw materials was a technology in its infancy, with critical aspects subject to uncertainty. This study resulted in a general: for a national geothermal science and technology advancement program which will be accomplished by gathering scientific and engineering data from five selected sites representing each of the five principal types of geothermal deposits that are known or available: Part of "Geothermal Energy Resources and Research", GFG, Stock No. 478-01631, (1275).

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1971

TITLE: Power From the Earth
AUTHOR: Penner, D.; Klarman, J.
CORPORATE AUTHOR: Washington University
ADDRESS: St. Louis, MO
PUBLICATION DESCRIPTION: Environment, 11(10), 19-34
PUBLICATION DATE: 1971, December
ABSTRACT: The present situation of geothermal energy as a means of producing electric power is reviewed. The mechanisms of producing electricity with geothermal energy, the cost of production are discussed in a nontechnical manner. Estimates of world geothermal resources are surveyed. Geothermal energy appears to be relatively pollution free, but hydrogen sulfide and trace elements in the geothermal steam could be hazardous. Before large amounts of money are spent in developing geothermal power, the following problems should be extensively investigated: the lifetime of the geothermal sources; seismic activity and ground subsidence; air and water pollution from geothermal steam impurities; effects on the fresh water table of withdrawal of geothermal fluids; and cost analysis to show that geothermal power production will be competitive. Environmental statements should be prepared for public review before extensive development. (ark)


Published geothermal gradient maps for the northern Gulf of Mexico basin indicate little or no potential for the development of geothermal resources. Results of deep drilling from 4000 to 7000 meters or more during the past decade however, define very sharp increases in geothermal gradient that are associated with the occurrence of abnormally high interstitial fluid pressure. Bounded by regional growth faults along the landward margin of the Gulf Basin, the geopressed zone extends some 1300 km from the Rio Grande to the mouth of the Mississippi River. Gulfward, it extends to an unknown depth across the Continental Shelf. Within geopressed deposits, geothermal gradients range upwards to 100°C/km, being greatest within and immediately below the depth interval in which the maximum pressure gradient change occurs. The 120°C isotherm ranges from about 2500 to 5000 m below sea level, and conforms in a general way with depth of occurrence of the top of the geopressed zone. Measured geostatic radial range upward to 0.97; the maximum observed temperature is 27°C, at a depth of 8559 m. Dehydration of montmorillonite, which comprises 60 to 80% of clay deposited in the Northern Gulf Basin during the Neogene, occurs at depths where temperature exceeds about 80°C, and is generally complete at depths where temperature exceeds 120°C. This process converts intra-crystalline and bound water to free pore water, the volume produced being roughly equivalent to half the volume of montmorillonite so altered. Produced water is fresh, and has low viscosity and density. Sand-bed aquifers of deltaic, longshore, or marine origin form excellent avenues for drainage of geopressed deposits by wells, each of which may yield 10,000 m³ or more of superheated water per day from reservoirs having pressures up to 1000 bars at depths greater than 5000 m. (46 references) (auth)

POWER FROM THE EARTH: THE STORY OF THE WAIRAKEI GEOTHERMAL PROJECT. 2D EC. GOVT. PRINT., WELLINGTON, 39 P. ILLUS., MAPS, PLANS. 20 X 28 CM.

COVER-TITLE WAIRAKEI.
LC WAIRAKEI GEOTHERMAL PROJECT.
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MAIN-TITL TRACE- CATLG BY-LC 494

An attempt is made to explain the phenomena of compaction and compaction and the resistance to fluid expulsion associated with geopressure in Miocene and Pliocene deposits of the northern Gulf of Mexico Basin. Detrital sediments and their products such as calcareous equivalents were rapidly deposited and deeply buried. The montmorillonite content of these deposits ranged from about 50 to 80 percent or more. Contemporaneous faults compartmentalized sand-beds aquifers prior to escape of their interstitial saline water. Fluid pressure in compartmentalized reservoirs increased with deepening burial. Salinity of aquifer water increased where hydraulic gradients were steepened by impermeable clay beds that concentrated dissolved solids in zones of water loss. Heating of the deposits accompanied deepening burial. Thermal dehydration of montmorillonite in a depth-related temperature zone with an average temperature of 221°F released some intracrustal water as a free water. Diagenesis of dehydrated montmorillonite (alteration to illite or chlorite) released remaining intracrustal water. Dehydration and diagenesis of montmorillonite produced interstitial fresh water, markedly increasing effective porosity and permeability to fresh water, while markedly reducing the bulk density, lead-bearing strength, and thermal conductivity of clay beds. Water flow upward from geopressured zones through clay beds in which dehydration and diagenesis of montmorillonite had occurred was accompanied by interstitial precipitation of cementing solids in the upper part of the clay bed, while the lower part of the same bed remained undercompacted and very soft to the drill. (42 references.) (MCW)


A description of the first geothermal power station in Kamchatka-Pauzetskaya is given. Stations are to be built at Bol’she-Bannaya, Yuzhno-Kuril’skaya, and Zhirovska. The resources of the thermal waters at each plant, construction plans, and power output are discussed. Total power output for the four stations under review will be 6000 to 12,000 kW and can be regarded as belonging to the low-power class. They do not solve the power crisis for the region. (MCW)
SOLAR ENERGY—HOW SOON?
Egan O'Connor.

The solar energy plantation, evaluated in these pages, is becoming reality. They have booked a design contract for two federal installations and proposals are nearing completion for two private firms.
BREAKING THE SOLAR ENERGY LOGJAM.
J.H. Douglas.

Solar-related energy has been neglected for economic, not technological reasons. New efforts in Congress may help solve this problem.

A SUNNY OUTLOOK FOR SOLAR POWER.
M. Eleccion.

At NSF, a fiftyfold increase in funding over four years may presage a bright future for its solar energy program.

MAN TURNS TO SUN AS ENERGY ALTERNATIVE.
W.A. Shumann.

Present demands for electricity and petroleum have generated renewed interest in using the sun's energy as a partial alternative. Companies with aeropace systems experience are now virtually alone in solar energy research.
**Solar Energy and Wind Power: A Bibliography with Abstracts.**
Edward J. Lehmann, and Axel C. Ringe.
COM-74-11103/0WE PCS$20.00/M$20.00

The bibliography contains 154 selected abstracts of research reports retrieved using the NTIS on-line search system—NTISearch. The report is divided into two sections. The section on solar energy contains 100 abstracts dealing with solar heating for buildings, solar electric power generation, solar cells for terrestrial use, solar energy as a national resource, and solar stoves. The following 54 abstracts concerning wind power cover such topics as its future, conversion systems, energy storage, propeller design, and its uses. Many of these reports on wind power are recent NASA translations of European and Russian research conducted from 1934 to 1959.

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**PROSPECTS FOR SOLAR ENERGY.**
M. Archer.

Article discusses national attitudes, heating and cooling buildings, other thermal applications, photovoltaic power, and photobiological energy conversion.

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**Research on Cadmium Stannate Selective Optical Films for Solar Energy Applications.**
G. Haascke.
PB-232 883/9WE PCS$3.25/MF$1.45

The objective of the program is the development of transparent, electrically conductive cadmium stannate (Cd2SnO4) coatings and their incorporation into solar energy conversion devices. Technology for the preparation of crystalline Cd2SnO4 films will be sought during the first phase of the program. Subsequently, the electrical and optical properties of these films will be optimized by adjustment of the deposition parameters and by controlled doping. The optical properties of Cd2SnO4 films will be determined and the use of these films evaluated as coatings for flat plate collector covers. Heat collection efficiencies will be measured on assembled flat plate collectors. Cadmium stannate films on transparent substrates will be used as back-wall electrodes in CdS solar cells and the photovoltaic properties of these devices will be investigated.

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**Solar Energy.**
Vlastimir A. Stevovich.
Informatics Inc Rockville Md 1 Mar 74, 478p AFOSR-TR-74-0600
AD-778 846/6WE PCS$9.75/MF$1.45

The report is a comprehensive review of present major developments and future planning in various fields of applied solar engineering. The study covers theoretical and experimental data on the background and state-of-the-art of applied solar research in general, with emphasis on foreign work, particularly in the Soviet Union. (Author)
Solar energy

B. J. Brinkworth

Department of Mechanical Engineering, University College, Newport Road, Cardiff CF2 1TA, Wales, UK

Studies have been made of a very wide range of possible ways in which solar energy might be used for domestic and industrial purposes. Some are already economically viable and the prospects for others are improving through intensive programmes of research and development.
TITLE: Solar Energy Research Information Meeting of NSF-BARN Grantees
CORPORATE AUTHOR: University of Pennsylvania, National Center for Energy Management and Power
ADDRESS: Philadelphia, PA
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BARN Program
ABSTRACT: This report is a collection of papers presented at this meeting which was convened
by NSF-BARN to provide a forum for solar energy investigators to present their research activities and discuss their points
of view concerning solar energy research programs in general. Titles of the presentations are as follows:
Solar-to-Thermal Energy Conversion
Application to Large Central Power Plants;
Photothermal Conversion of Solar Energy For
Large-Scale Electrical Power Production; The
Minnesota/Honeywell Solar Power Concept;
Solar Energy Thermal Converters Fabricated by
Chemical Vapor Deposition; Low-Cost Silicon
Solar Cells for Large Electrical Power
System-Growth of Silicon Layer on Steel
Substrate; An Improved Schottky Barrier
Photovoltaic Diode for Solar Energy
Conversion; Direct Solar Energy Conversion
for Large Scale Terrestrial Use: Modeling of
Solar Heating and Air Conditioning;
Conservation and Better Utilization of
Electric Power by Means of Thermal Energy Storage and Solar Heating; Solar Energy
Residential System Modeling; Ocean Sited
Power Plants: An Inquiry into Biological
Energy Conversion; Biophotolysis of Water;
Technology for the Conversion of Solar Energy
to Fuel Gas (two papers); and Solar Energy
Panel Report. (BCH)

SYSTEMS ANALYSIS OF SOLAR ENERGY PROGRAMS. 309p. UNCL
Dec. 1973
Mitre Corp.
NSF-C831
MTR-6513
NSF/RA/N-73-3
UNCL
SYSTEMS ANALYSIS OF SOLAR ENERGY PROGRAMS. Appendix:
Research Tasks. 151p. UNCL
Dec. 1973
Mitre Corp.
NSF-C831
MTR-6513-App.
NSF/RA/N-73-3-App.
Solar Energy Applications


Solar energy can be usefully concentrated onto a central receiver by a flat mirror. To direct that the reflected radiation all be intercepted, the central receiver must be elevated well above the mirror field. A receiver atop a 450-meter tower can effectively collect the radiation reflected from a 2.6 km square field of mirrors. By judiciously spacing mirrors over 45 percent of the area, such a system at 35 deg N latitude could collect 2700 Mw-Hr-Thermal/day in midwinter summer.

It is proposed that this heat be used to replace part of the fossil fuel burned in a conventional electrical plant during sunlit hours. Eventually, overnight storage of heat, e.g., in an eutectic salt, could reduce fuel usage to a standby basis.

An alternative approach is to use solar energy to generate hydrogen through decomposition of water. The influence of factors to produce the most economical energy from this capital intensive system, including thermodynamic efficiency, receiver temperature, and heliostat steering accuracy, are considered.


A survey is carried out on the application of solar energy to refrigeration. The literature is reviewed in chronological order showing the progress since the first attempt in 1936.

Two systems are considered: the vapor-compression and the absorption systems. Various significant developments are reviewed and their potential critically assessed.


Analysis and results are presented for the total as well as the spectral distribution of the reflected (absorbed) solar radiation from shallow bodies of pure water. The directional dependence of the reflectance and transmittance of the air-water interface is included. Reflectance from the bottom surface is assumed direction independent.

The spectral nature of the water for its selective absorption and scattering is taken into account. The results are presented for four combinations of two types of interfaces, smooth and diffuse; three values of bottom reflectance; four values of depth, maximum being 15 cm; and two types of incident solar fluxes, collimated and diffuse. Results include as much as 58 percent increase in the total reflected flux and 150 percent increase in the absorbed spectral flux by properly choosing the type (diffuse or smooth) of the boundary surfaces.


The potential for using solar energy for residential comfort heating is currently being considered as part of the long term solution to the world's dwindling fuel supplies.

This paper presents the results of a study to determine the feasibility of integrating the use of solar energy in an average residence by combining solar flat plate collectors with conventional residential heat pump systems. Savings in energy for the month of January were found to range from 6 to 62 percent depending upon the particular combination of solar collectors, storage capacity, and electric heat pump.


Solar-powered air conditioning is potentially one of the most advantageous solar applications, since its large-scale use would reduce peak electrical demand as well as total energy consumption.

Virtually all solar refrigeration systems have used an absorption cycle, but recent advances in the technology of Rankine-cycle engines, using organic working fluids such as Freon, put solar-powered compression refrigeration within the realm of technical feasibility.


Efficient condensing surfaces are highly desirable in the design of solar sea power plants utilizing the ocean temperature difference. This paper examines a number of surface designs and presents a convenient method for optimizing the design. In particular, the various parameters of a Gregorich surface are optimized.


Unique weather conditions of the southwestern United States make feasible the construction of a residence which employs solar energy utilization as an integral part of its design. Construction techniques utilized today in commercial buildings are adapted to make such a residence competitive in price with homes currently constructed by conventional methods.

The key problems in the design of competitively priced solar residences are the selection of materials and construction methods to ensure an economical, low heat load structure, and the choice of solar collection devices which are reliable, have low initial cost and require a minimum of maintenance.

Feasibility of Large-Scale Orbital Solar/Thermal Power Generation - J. T. PATHA, G. R. WOODCOCK................................................... 312


Advances in Schottky Barrier Solar Cell Technology - W. A. ANDERSON, A. E. DELAHOY........................................................................... 326

Parametric Analysis of ATM Solar Array - B. K. SINGH, W. B. ADKISSON... 331

Development of a Lightweight Body-Mounted Solar Cell Array with a High Power to Weight Ratio - H. SOMBERG....................................................... 338

Low Head Solar Water Pumping - C. J. SWET, H. G. FOX................................. 341

Heliotropic Thermal Generators - C. J. SWET.................................................. 348


A Look at Solar Power for Seattle - H. OMAN, C. J. BISHOP ......................... 360


Direct Conversion of Solar Energy, on Earth, Now - J. A. ECKERT, B. P. KELLY, R. W. WILLIS, E. BERMAN............................................... 372
SUN IN THE SERVICE OF MANKIND.
Conf. in Paris, 2-6, July 1973, Organized by UNESCO.

SOLAR ENGINE USING THE THERMAL EXPANSION OF METALS. Beam, R.; Jedlicka, J. (Ames Research Center, Moffett Field, CA). Solar Energy, 15: No. 2, 133-143 (Jul 1973). A thermal engine with solid metal (stainless steel-304) as the single-phase working substance is described. The engine can consist of nothing more than a metal tube mounted in a bearing at either end so that it is free to rotate about its axis, with a flywheel mass at its midpoint. When the tube is heated on its upper surface, the region of its maximum compressive bending stress, it will rotate and produce steady power. Compared to engines using a gas or a liquid as the working substance, this engine has the disadvantage of low thermal efficiency but the advantage of simplicity. The solid metal phase engine may be useful for converting solar energy into small amounts of mechanical energy in underdeveloped regions of the world. (autb)

SCIENCE AND THE SUN.
Dr. Mary Archer.
Many of the possible applications of solar energy are little more than a gleam in the eyes of the scientific community; but the sun is too tempting a source to ignore.

TITRE: Solar Energy May Achieve Wide Use by 1980's
CORPORATE AUTHOR: American Chemical Society
ADDRESS: 1155 16th St. NW., Washington, DC 20036
PUBLICATION DESCRIPTION: Chemical & Engineering News, 51(5), 12-13
PUBLICATION DATE: 1973, January 29
ABSTRACT: The Institute of Energy Conversion at the University of Delaware directed by Dr. Earl W. Bong plans to demonstrate in a practical way the feasibility of solar energy conversion and utilization. The Institute will develop and construct practical solar houses with the total system concept in mind. Such aspects as scientific, engineering, economic, legal, environmental, climatological, architectural, aesthetic, sociological and psychological are considered. Private houses currently use 30 percent of the energy supplies, and if solar energy could supply just a fraction of this requirement, it would contribute an important role in preventing future energy shortages. (BCH)

Three major areas of application are: (1) heating and cooling of buildings, (2) production of clean renewable fuels, and (3) generation of electrical power. No major scientific breakthroughs are needed to bring about the economic competitiveness of solar energy but merely the improvement of known materials, processes and engineering.
SOLAR ENERGY, ITS CONVERSION AND UTILIZATION

ERICH A. FARBER

(Received 10 May 1971; in revised form 22 September 1972)

Abstract—This paper briefly presents a summary of solar energy research, comments on the need for continuing these studies, and describes the activities of the Florida Solar Energy Laboratory. These activities include converting solar energy to more practical forms of power, and devising ways to produce it in the fewest possible steps by the simplest means. The devices developed are used in the University of Florida Solar House with its Solar-Electric Car and solar-heated swimming pool.

Three uses of solar energy were identified in the NSF–NASA panel report: heating/cooling of buildings, conversion of organic materials to fuels, and electric power generation. A breakdown of the 15-year R & D program covering all the Panel’s recommendations is given. Possible ways of using solar energy are described briefly. (DLC)

Domestic Solar Energy Systems for Delaware.
Virendra Mohan Puri, and F. A. Costello.
Delaware Univ., Newark. Inst. of Energy Conversion. May 73, 184p NSF-RA/N-73-026
PB-228-039/4WE PC$5.50/MFS1.45

The economics and performance of domestic solar energy system for Delaware is analyzed. Various performance factors, such as solar array orientation, cell temperature, atmospheric attenuation of solar radiation due to cloud cover, dust and air particle scattering, and water vapor and carbon-dioxide absorption, reflectance from different glass surfaces, radiation and convection loss to atmosphere, are accounted in the analysis. Three solar energy systems have been analyzed, solar electric only, solar electric only is expensive compared to current fossil-produced electricity, whereas the solar thermal/electric system is promising for the future. The solar thermal only system appears economical even with the current state of art. Economic sensitivity of the systems regarding the major cost parameters, solar cells, thermal collector, thermal storage and electric storage is discussed. Portions of this document are not fully legible. (Author)
Harnessing Solar Energy: The Potential


Solar energy is inexhaustible and can be utilized with minimal impact on the environment. Three ways for the utilization of solar energy are heating and cooling of buildings, production of clean renewable fuels, and generation of electrical power. Improvement of known materials, processes, and engineering is needed. An investment of about two-and-a-quarter billion dollars over a 15-year period in solar conversion and collection technology will make available vast amounts of clean thermal energy and clean gaseous, liquid, and solid fuels to help relieve the dependence upon the unrenewable fossil fuels, particularly foreign sources of them, and thus rectify the balance of payments. By the year 2020 at least 20% (almost the total energy consumption of the USA in 1970) of the USA total energy needs could be met with solar-energy processes. (MCW)

Brighter Outlook for Solar Power

G. Chedd.

Solar Energy. Solar energy is a distributed resource large in magnitude, variable and intermittent in its availability for terrestrial energy needs. The easiest applications are in meeting thermal energy requirements of buildings; the solar energy incident on all but high-rise buildings generally exceeds thermal energy requirements of the buildings. If adopted for these uses alone, solar energy could make significant contributions to the U.S. energy economy. Conversion of solar to electrical or mechanical energy is approached by thermal processes (heat engines) or by photovoltaic processes. These are more difficult to accomplish economically, but there is significant research in progress and proposed, and the potential impact is great. Research and development problems include: studies of materials with desirable radiation properties, development of economical solar energy "collectors", storage means for thermal or electrical energy, solar process studies, photovoltaic process research, and studies of availability of solar energy.
Richard S. Greeley.
Mitre Corp., McLean, Va. Dec 73. 69p MTR-6544, NSDRA/N-73-111D
PB-231 144/7WE - PC3.75/MFS1.45

Thirty recommendations have been made for establishing groups within or reporting to the NSF Solar Energy Program Office and initiating activities for the dissemination and utilization of solar energy research results. The primary recommendations include establishing an Advisory Commission and an information office reporting to the Program Director and constructing visitor centers on the sites of each Proof of Concept Experiment. Training courses and public education would be conducted at each center following successful operation of the POCE system. (Modified author abstract)

G. Haacke.
American Cyanamid Co., Stamford, Conn. Chemical Research Div. 1 Jul 73. 27p NSF-RA/N-74-016
PB-231 236/17E - PC3.25/MFS1.45

The objective of the program is the development of transparent, electrically conductive cadmium stannate (Cd2Sn3) coatings and their incorporation into solar energy conversion devices. Technology for the preparation of crystalline Cd2Sn3 films will be sought during the first phase of the program. Subsequently, the electrical and optical properties of these films will be optimized by adjustment of the deposition parameters and by controlled doping. The optical properties of Cd2Sn3 films will be determined and the use of these films evaluated as coatings for flat plate collector covers. Heat collection efficiencies will be measured on assembled flat plate collectors. Cadmium stannate films on transparent substrates will be used as back-wall electrodes in Cds solar cells and the photovoltaic properties of these devices will be investigated.
PB-231 143/9WE PCS4.50/MFS1.45

Critical experiments are described which are intended to prove the technical feasibility and socio-economic desirability of specific applications or techniques for the widespread use of solar energy. These experiments fall within the following areas: Heating and Cooling of Buildings, Process Heat, Thermal-Electric, Photovoltaic, Ocean Thermal, Wind Energy, Organic Materials and Common Applications. The specific concept which the experiment is intended to prove and a rationale for the experiment are given. Each experiment is described in terms of the system to be constructed, its pacing and high-risk items, the intended users, desired interfaces with other systems and users, and estimated costs for the experiment. Each experiment is described and costs estimated for two levels of funding: a moderate-risk 'minimum program' and a low-risk 'accelerated program'. (Modified author abstract)

There are many technological possibilities for solar energy. Most of them are well enough understood to convince all but the most skeptical that the Sun can contribute significantly to man's energy supplies. The question is, can these technologies be developed so that the energy is available at a reasonable price. The fuel for a solar power plant is free, but the capital cost can be very high to turn the Sun's radiation into electricity, but water, distilled water, cold air, etc. The feasibility of harnessing solar radiation is not in doubt, but before we can plug into the Sun many technical questions still have to be answered. Problems discussed include size, collector design, weather dependency, use of satellite systems, and storage problems. (MCW)


With increasing attention focusing on the energy problem, considerable interest has recently surfaced relative to the potential use of solar energy as a power source for our nation. This paper assesses the possibilities for near-term and longer-range applications of solar energy, including a large space-based Satellite Solar Power Station. Many applications are well beyond the research phase and could be accelerated to commercial readiness. Longer-range applications should be pursued with appropriate technology development programs to provide this nation with energy options in the future. If the nation wants to use solar energy as a major power source, it is technically possible to do so. Further, with appropriate incentives and government support, the public can have this clean and abundant energy source economically.

(ISOLAR ENERGY READY TO SOAR?
J.M. Nilsen.

Between grandiose schemes for the future and esoteric research of the past, some applications of solar energy as a practical power source are beginning to emerge.


Solar Energy: Its Time Is Near
Walter F. Morrow, Jr.

Solar energy utilization requires no undiscovered fundamental science. With good fortune and good management, technology may deliver a $25 billion solar energy industry by the year 2000.

SOLAR ENERGY. D. Niskern.

Scope: Utilization of radiant energy from the sun for various purposes.
THE ENERGY CRISIS: PART 2. TRAPPING THE SUN.
OS Staff.

NSF EXPANDS SOLAR ENERGY EFFORTS.
N74-12674*# Auburn Univ., Ala., School of Engineering.
TERRASTAR: TERRESTRIAL APPLICATION OF SOLAR TECHNOLOGY AND RESEARCH Final Report
Sep. 1973 344 p refs (Contract NGR-01-003-044)
(NASA-CR-129012) Avail: NTIS HC $19.25 CSCL 05A

The application of solar energy to the energy crisis of the 70's and beyond is discussed in the context of energy consumption in the U.S., energy resources in the U.S., and the state-of-the-art of solar energy applications. Solar energy application concepts, such as solar farms (a term used to describe vast fields of concentrators collecting solar energy for the generation-of steam to drive power turbines), an orbiting solar power station, and the conversion of solar energy into solar power for heating and cooling of individual buildings on the earth, are discussed. The report emphasizes the application of solar energy to the heating and cooling of buildings since this application seems to be more promising in the near term as far as research and development are concerned. The importance of initiating research and development on all solar application concepts is stressed as an important step in pursuing the use of solar energy. Immediate steps leading to the application of solar energy to heating and cooling of buildings are outlined to insure appreciable energy displacement through the use of solar energy by the year 2020. For individual titles, see N74-12674 through N74-12685.

N74-12688* Auburn Univ., Ala.
NATIONAL ENERGY POLICY
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res. Sep. 1973 12 p refs (For availability see N74-12674 03-34) CSCL 05A

The efforts of the U.S. government to cope with the national energy crisis are discussed. The provisions of several legislative actions to implement the actions for energy conservation are examined. Immediate conservation measures and the long range planning for energy resources are reported. Author.

N74-12682* Auburn Univ., Ala.
SOLAR ENERGY POTENTIAL
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res. Sep. 1973 9 p ref (For availability see N74-12674 03-34) CSCL 05A

The potential of solar energy as a national resource is discussed. Research and development programs for the development of eleven concepts are described to show the proposed funding for each year over a fifteen year period. The estimated energy contributions by period for each of the solar concepts are analyzed. The estimated impact of the solar concepts to the year 2020 are tabulated. Author.

(UCRL-51315) OUR SOLAR ENERGY OPTIONS:

Various schemes that have been proposed for the utilization of solar energy are discussed. The first section discusses physical systems and the second section treats biological systems. The major focus of the report is to present a means of comparison; consequently, the technical description is somewhat brief. More detailed technical discussions can be found in the 56 cited references. (auth)

see: SOLAR ENERGY. A.R. Tamplin.
--- Environment, v.15, no.5, June 1973, p.16-20, 32-34.

This article is essentially the above report.

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The performance and present status, problems to be solved and expected achievements for the various approaches are reviewed. Heating and cooling of buildings, obtaining storable fuels through photosynthesis, generation of electric power via thermal of photovoltaic conversion in distributed or central ways, via wind power or ocean thermal gradients are discussed. Timetables of commercial readiness, introduction rates, energy delivery, and other economic impacts are discussed. (15 refs.)

CATCHING SUNBEAMS. David Brand.

Old dream of putting sun's power to work gets renewed attention: earthly energy shortages spur research into ways to collect and use solar rays.

POWER FROM THE SUN: THE SEARCH PICKS UP.

As signs of a fuel crisis grow more ominous, scientists are spurring efforts to tap the awesome power of the sun to help meet earth's energy needs.
CONCENTRATED SOLAR ENERGY EFFORT URGED.
Aviation Wk. and Space Tech., v.96, no.16, Apr.17,1972, p.16.

NASA-Nat. Science Foundation panel expects to recommend a two-year program in the range of 15-35 million to start a concerted government effort to trap the sun's radiation for energy. see also (AWST, Mar.27, p.21.)

FUTURE LARGE SCALE TERRESTRIAL USE OF SOLAR ENERGY.
K.W. Boer.

ENERGY REQUIREMENTS OF THE FUTURE.
In 1965 at a Solar Energy Society meeting in Phoenix, Arizona, it was predicted that a large amount of solar energy would be required in another 30 to 40 yr to supplement nuclear energy and the world's dwindling supply of fossil fuels. Since then, many things have occurred to reinforce this prediction and we are now six years closer to the time when solar energy will be needed. However, the research and development work that must be done before solar energy can take its place among other large sources of energy will be extensive and expensive. This work will have to be supported by the governments of the world, just as atomic energy was. Steps should be taken now to promote awareness of the ultimate need for solar energy and to promote the allocation of funds for the research and development work required. (auth)

TITLE: The Solar Alternative to Atomic Power
AUTHOR: Halacy, D. S., Jr.
CORPORATE AUTHOR: General Electric Co.
PUBLICATION DESCRIPTION: Science Digest, 71(9), 45-52
PUBLICATION DATE: 1972, March
ABSTRACT: Solar energy, which is free of pollution, can be used to heat homes, heat water, desalt water, and generate electricity. "Sun-thermal-energy plants" use the sun as a flat-plate collector for generating electricity and producing fresh water. Other methods of collecting solar energy are described, including satellite power stations, the "Helias" solar "face", and the solar battery. Solar power is too expensive to be widely used now, but the science of technology and mass production could change the situation. (NPG)

TITLE: Large-Scale Utilization of Solar Energy
AUTHOR: Ram, G. W.
CORPORATE AUTHOR: Huntsort, University of; Litre Corp.
ADDRESS: University of Houston, Cullen Blvd., Houston, TX 77004; Litre Corp., Vestage Research Park, McLean, VA 22101
PUBLICATION DATE: 1972, September
ABSTRACT: The utilization of solar energy on a large scale offers a long-range solution to the problem of providing an adequate source of energy with minimal ecological disruptions. Because of the nature of solar energy, the use of this energy to produce a fuel appears most attractive. The development of this source and its economic feasibility will depend upon the commitment of resources by the technologically advanced nations. One possible large-scale thermal system will be discussed to illustrate some of the problems. (Auth)

N73-11060# Army Foreign Science and Technology Center, Charlottesville, Va.
CONTEMPORARY STATUS OF STUDIES ON DIRECT CONVERSION OF SOLAR ENERGY TO ELECTRICAL ENERGY
N. S. Isherenko 28 Jul 1972 11 p refs. Transl. into ENGLISH from Gelotekhnika (Tashkent), no. 6, 1969 p 3-8
Photoelectric, thermoelectric and thermoelement methods of direct conversion of solar energy into electric energy are studied. The article presents a review of modern methods of investigation. Author (GRA)

N74-12462# Maryland Univ., College Park. Dept. of Mechanical Engineering
AN ASSESSMENT OF SOLAR ENERGY AS A NATIONAL ENERGY RESOURCE
The findings of a panel on the development and application of solar energy to reduce the need for fossil fuels are presented. The applications which are considered most promising from technical, economic, and energy quantity standpoint are: (1) heating and cooling of residential and commercial buildings, (2) chemical and biological conversion of organic materials to liquid, solid, and gaseous fuels, and (3) generation of electricity. Tables are presented to show the solar utilization techniques, major technical problems, and the impact of solar energy applications on the reference energy system. Author

N72-31092# National Academy of Sciences-National Research Council, Washington, D.C. Board on Science and Technology for International Development
SOLAR ENERGY IN DEVELOPING COUNTRIES: PERSPECTIVES AND PROSPECTS
This is a report of an ad hoc advisory panel, made up of specialists from the United States and abroad, to: (1) assess the state of the art in utilizing solar energy for developing countries and review current practical applications; (2) identify promising areas for research and development; and (3) examine the desirability of establishing an international solar energy institute in North Africa, to carry out solar energy research and development.

Contains sections on:
The case for solar energy.
Is residential solar energy conversion feasible?
The impact of the solar house on the national energy budget.
Other energy benefits of the solar house.
Economy and timeliness.
The use of solar energy in the synthesis of fuels.
Solar superheaters.

POTENTIAL OF SOLAR ENERGY APPLICATIONS.

The total influx from solar, geothermal, and tidal energy into the Earth’s surface environment is estimated to be 173,000 x 10^17 watts. Solar radiation accounts for 99.98% of it. The Sun’s contribution to the energy budget of the Earth is 5,000 times the energy input from all other sources combined. The applications of heating from solar energy include domestic hot water heating, residential cooling and heating. Photochemical reactions are discussed in view of harnessing the energy involved for domestic applications. Direct energy conversion based on photovoltaic conversion of solar energy into dc, employing solar cells, is discussed. Focusing collectors based on mirror reflectors or Fresnel lens concentrators can be used to obtain high temperatures. A system based on selective radiation-absorbing surfaces maintained inside an evacuated cylinder, with the heat transferred to a circulating gas or fluid has been proposed. Sun-heated oceans present a possible energy source. The harnessing of energy in space was discussed. (JCW)

The potential of solar energy for solving the world’s energy problem is briefly discussed. Systems for utilizing solar energy for heating and air conditioning of homes and electricity production are presented. (T.F.D.)

PROGRESS IN UTILIZATION OF SOLAR ENERGY.
The specific progress of solar energy utilization and its advantages are discussed. (27 references.) (Indian Sci. Abstr.)
NASA PLANS EXPANDED PROGRAM TO EXPLOIT SPACE SOLAR POWER. K. Johnsen.
Aviation Wk & Space Tech., v.96, no.13, Mar.27,1972, p21.

5-403
ON THE WAY: PLENTIFUL ENERGY FROM THE SUN.
C.P. Gilmore.

THE SOLAR ERA - PART 1 THE PRACTICAL PROMISE.
L.P. Gaucher.

THE SOLAR ERA: PART 3—SOLAR RADIATION: SOME IMPLICATIONS AND ADAPTATIONS.

Are obsessions concerning transmissible energy, plug-in convenience, "economics of scale," and conventionality retarding direct and effective use of solar energy? Here are some related thoughts and observations.


Extreme consequences of air pollution could be: another ice age, melting polar ice caps, massive carcinogenic UV radiation. Government, industry and the public must make the effort and pay the price to reverse the rising pollution down to a rational minimum.
SOLAR RADIATIONS AND THE EARTH. (Proceedings of symposium held Univ. of Delhi, 1971).

J.N. Tandon, Ed.

N74-18512# Hydrometeorological Publishing House, Leningrad (USSR).

SOLAR RADIATION AND RADIATION BALANCE DATA
T. G. Bertland, ed. 1970 800 p. IN ENGLISH and RUSSIAN
Avail: NTIS HC $32.00

A reference guide of global radiation and radiation balance
data is presented for Africa, Asia, South America, North America,
Southwest Pacific, and Europe. Tables presented include: monthly
and annual values of global radiation, monthly annual values of
radiation balance, hourly values of global radiation, and hourly
values of radiation balance.

F. O. S.

72V29090 1969 ISS QC TJ81C. H255 1565 621.47 LC-69-18892
A/HALACY, DANIEL STEPHEN, A/1915-
EXPERIMENTS WITH SOLAR ENERGY BY C. S. HALACY, JR.
1ST ED. W. W. NORTON NEW YORK, 147 P. ILLUSTR. 22 CM.
4.44 BIBLIOGRAPHY P. 141 INSTRUCTIONS FOR PERFORMING EXPERIMENTS
WHICH DEMONSTRATE MANY POSSIBLE USES FOR PRESENTLY WASTED SOLAR ENERGY.
LC SOLAR ENERGY -- JUVENILE LITERATURE. SOLAR ENERGY.
MAIN-AUTH TRACE-TITL* CATLG BY-LC

72V16000 1968 ISS QC TJ81C.HO 421.47 LC-68-10336
A/HOKE, JOHN, A/1925-
SOLAR ENERGY. FCREWRCD BY HUBERT HUMPHREY. ILLUSTRATED WITH PHOTOS.
AND DRAWINGS.
FRANK WATTS NEW YORK, 83 P. ILLUSTR. 23 CM.
BIBLIOGRAPHY P. 80.
LC SOLAR ENERGY.
MAIN-AUTH TRACE-TITL* CATLG BY-LC

518
REVIEW ARTICLE
A Philosophy for Solar Energy Development*

G. O. G. LÖFt, D. J. CLOSE† and J. A. DUFFIE†

(Received 25 April 1968)

INTRODUCTION

On looking back on the ten years which have elapsed since the Tucson and Phoenix Conferences, one is struck by the successful application of a few solar processes, and the lack of successful application of many others. Salt manufacture by solar evaporation of sea water has been widely used for centuries. Solar water heaters of various types are now accepted in many countries, and solar distillation using the basin type still is approaching the status of a practical and economically satisfactory device. Silicon cells are used in space and for special terrestrial applications. These systems have all been the subject of extensive engineering development and economic evaluation.

This paper is concerned with the reasons for the evident success of these solar processes, and the lack of success of others (solar air conditioners, refrigerators, mechanical and electrical power systems), especially with regard to underdeveloped areas where they were expected to be of greatest use. From these reasons, conclusions are drawn as to what sort of development program is likely to be most successful in stimulating future applications of solar processes. Finally, the argument for adopting a systematic and comprehensive program is presented and explained by use of specific examples.
Zarem, A. M. *ed.*


396 p. illus. 24 cm. (University of California engineering and sciences extension series)

Based on a course in solar energy utilization given at the University of California, Los Angeles.
Includes bibliography.
The program of study and analysis which has culminated in the preparation of this report was directed toward the evaluation of three conversion mechanisms: solar energy to heat energy, solar energy to mechanical energy, and solar energy to electrical energy. Program includes a technical analysis of flat-plate solar collectors, concentrating solar collectors, photovoltaic converters, thermopiles, and thermionic emitters, energy storage, solar distillation techniques, refrigeration and comfort heating, communication, heat engine, power systems evaluation, spectral properties of materials, and propulsion.
J. R. Williams.
Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering. 23 Jan 74. 122p NASA-CR-137242
N74-18721/2WE PCS9.25/MFS1.45

The utilization of solar energy to meet the energy needs of the U.S. is discussed. Topics discussed include: availability of solar energy, solar energy collectors, heating for houses and buildings, solar water heater, electric power generation, and ocean thermal power.

1974

The bill provides for the United States to accomplish the demonstration of the practical use of solar heating technology in three years utilizing current technology, and to accomplish the research, development, and demonstration of the practical use of combined solar heating and cooling technology within five years. Background, explanation, legislative aspects, cost and budget data, and committee considerations are given. (MCW)

1974

N74-19711f Chicago Univ., Ill.
SOLAR CONCENTRATORS OF A NOVEL DESIGN
Roland Winston Mar. 1974 25 p refs
(EFI-74-21) Avail: NTIS HC $4.25 CSCL 10A
A new principle for collecting and concentrating solar energy, the ideal cylindrical light collector has been invented. The collector is a trough-like reflecting wall light channel of a specific shape which concentrates radiant energy by the maximum amount allowed by phase space conservation. The ideal cylindrical light collector is capable of accepting solar radiation over an average 8-hour day and concentrating it by a factor of approximately 10 without diurnal tracking of the sun. This collector has a large acceptance for diffuse light. In fact, the efficiency for collecting and concentrating isotropic radiation, in comparison with a flat plate collector, is just the reciprocal of the concentration factor. Author

N74-19604f Committee on Science and Astronautics (U.S. House).
H.R. 11864: SOLAR HEATING AND COOLING DEMONSTRATION ACT OF 1974. BACKGROUND AND LEGISLATIVE HISTORY
The responses are reported of selected Federal agencies to requests, by the Committee, for information on current research in areas of solar energy. The nature of ongoing solar energy research, funding levels, and recommended areas for development are discussed. The legislative history of solar energy for heating and cooling. H.R. 11864 is included. F.O.S.
SOLAR LAB USES SPACE-DERIVED EXPERTISE.

Honeywell, Inc. is sharing costs with the Nat. Sci. Foundation of a mobile solar heating and cooling laboratory whose technology stems in part from thermal coating work for spacecraft sponsored by the Air Force.

PLUGGING INTO THE SUN.
F.E. Bryson.

Although efficiencies are not yet high, the technology is available to convert sunlight directly into useful energy. The development could change the shape of your next house.

NSF GRANTS WESTINGHOUSE $500,000 FOR PILOT SOLAR HEATING-COOLING SYSTEM.
Energy Digest, July 15, 1974, p. 245-247.

The first large building to be both air conditioned and heated with the help of sunlight will be the George A. Towns Elementary School located in Atlanta. Sunlight will provide about 60 percent of the energy needed by the school's domestic hot water supply, absorption air conditioning system and hot water heating system.
A TOWER-TOP POINT FOCUS SOLAR ENERGY COLLECTOR
A. F. Hildebrandt, L. L. Vent-Hull, University of Houston, Houston, Texas


#ENERGY POLICY, GAS HEATING, SOLAR ENERGY
BUILDINGS, COST ESTIMATES, EQUIPMENT SPECIFICATIONS,
FEASIBILITY ANALYSIS, SOLAR COLLECTORS, SOUTHERN CALIFORNIA, RATES
C03 N74-21675

(N73-32865) National Aeronautics and Space Administration.
Lewis Research Center. Cleveland, Ohio.
FLAT-PLATE COLLECTOR PERFORMANCE EVALUATION:
THE CASE FOR A SOLAR SIMULATION APPROACH

A method is proposed for determining the performance of flat-plate solar collector using a simulated sun. Collector test variables that will help establish the basis for the indoor test facility at the Lewis Research Center are discussed. The use of the indoor testing should permit a standard test for the convenient and accurate determination of collector performance. Preliminary test results are reported as an example of the type of collector performance data to be expected from the simulated approach.

Author


Solar energy converted to commercial steam can be distributed and used by existing equipment to heat and cool buildings. This forms a ready economical market for an otherwise expensive energy source. Component designs and system plans are outlined using an elevated boiler and reflectors that track the Sun. (auth)
N74-14499# Maryland Univ., College Park, Dept. of Mechanical Engineering.
PROCEEDINGS OF THE SOLAR HEATING AND COOLING FOR BUILDINGS WORKSHOP. PART 1: TECHNICAL SESSIONS, MARCH 21 AND 22
(Cent NSF GI-32488) (PB-223536/4GA; NSF-RA/N-73-004) Avail. NTIS HC $3.00
CSCL 13A
The proceedings contain thirty-six technical papers on solar energy for U.S. building applications areas: namely, solar collectors, energy storage, domestic hot water heating, energy conservation and insulation, solar air-conditioning, and systems for solar heating and cooling. Some foreign activities are also reviewed. Each technical paper is a report on: proposed research, on-going research, proposed systems, or operating systems. Questions and answers from the discussion periods are included, as is an agenda and list of attendees.

N74-12679* Auburn Univ., Ala.
SOLAR HEATING AND COOLING BUILDINGS
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res.
Sep. 1973 28 p. refs. (For availability see N74-12674 03-34)
CSCL 20M
Sunshine is available in differing amounts everywhere in the world and the easiest method of capturing it is by absorption in the form of thermal energy (heat). Therefore, it is logical to utilize it directly in the heating and cooling of buildings and avoid losses that would occur by conversion to some other form. It may be emphasized that a major portion of the total energy consumed annually in the U.S. is used for heating and cooling of buildings. It is generally agreed that of all the possible widespread uses of solar energy, this application has the highest probability of success in the near term. Although there are uncertainties associated with some technological and economic aspects, they do not seem as large as those associated with other potentially significant applications, such as electrical power generation. It may, however, be noted that solar electrical power generation at the building site, or at a centralized station is an excellent long term prospect. Approximately 25 experimental solar heated structures have been built in various parts of the world.

N74-12684* Auburn Univ., Ala.
MARKET POTENTIAL FOR SOLAR HEATING AND COOLING IN BUILDINGS
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res.
Sep. 1973 13 p. refs. (For availability see N74-12674 03-34)
CSCL 20M
The use of solar heating and cooling for buildings as a method of conserving fossil fuels is discussed. The residential and commercial end use consumption of energy is tabulated. A survey to project the energy requirements for home and industry heating and cooling is developed. The survey indicates that there is a market potential for solar heating and cooling of buildings. A prediction of three to five billion dollars per year as the potential for solar heating and cooling is made.

N74-12685* Auburn Univ., Ala.
STRATEGY FOR SOLAR HEATING AND COOLING IN BUILDINGS
In its TERRASTAR: Terrest. Appl. of Solar Technol. and Res.
Sep. 1973 159 p. refs. (For availability see N74-12674 03-34)
CSCL 20M
The types of solar energy heating and cooling equipment for use with buildings are discussed. The steps from manufacturing to equipment installation are identified. A feasibility study for the use of solar energy was conducted. The study determined the technical, environmental, economic, sociological, political, and strategic aspects of solar heating and cooling.

Modeling of Solar Heating and Air Conditioning.
W. A. Beckman, and J. A. Duffie.
Wisconsin Univ., Madison, Engineering Experiment Station.
PB-228 $77/7W - PCS4.00/MF$1.45
Processes for application of solar energy to heating, cooling and service hot water supply of buildings are comprised of components which function in interrelated manner. The components include: solar energy collector, storage unit, service hot water facility, air conditioner, space heater, auxiliary energy source, associated controls and the building. In this work, the transient thermal performances of these components is mathematically modeled, the models are programmed, and the complete system is ‘operated’ in particular climates using appropriate meteorological data. A first system has been modeled based on water heating collectors, water storage tanks, lithium bromide-water absorption cooler (with cooling tower) and associated equipment. It has ‘operated’ on a residential type building in Albuquerque climate. The thermal analysis shows integrated energy supplied from solar and auxiliary energy through a year. Based on this thermal analysis a preliminary cost analysis is made to compare solar and conventional systems.
1973

N74-11797#  Committee on Science and Astronautics (U. S. House).
SOLAR-ENERGY FOR HEATING AND COOLING
Avail: Subcomm. on Energy
A Congressional hearing was conducted to examine the use of solar energy for heating and cooling. Examples of various solar energy conversion systems are illustrated and described. The subjects discussed are: (1) the status of solar energy technology, (2) market factors, (3) technology transfer, and (4) the benefits of using solar energy for heating and cooling buildings. P.N.F.

Solar Heating and Cooling Demonstration Act
#BUILDINGS, #COOLING SYSTEMS, #SOLAR ENERGY CONVERSION, #SOLAR HEATING ENERGY POLICY, FEASIBILITY ANALYSIS, HEAT PUMPS, PERFORMANCE TESTS, PROCEEDINGS, UNITED STATES OF AMERICA C03 N76-21683 0

1973

TITLE: The Solar/Sonic Flip-Top Mobile Home: A New Concept in Recreational Living
CORPORATE AUTHOR: Fred Rice Productions Inc.
ADDRESS: 6313 Peach Avenue, Van Nuys, CA 91401
PUBLICATION DESCRIPTION: 20 p. report
PUBLICATION DATE: 1973
ABSTRACT: This brochure describes an unusual mobile home, especially designed for use in remote locations. The unit is 12 ft. x 54 ft. when traveling, and unfolds to give a conventional appearance with sloping roof. The south roof contains a skylight and a solar heat collector. Solar cells with storage batteries power an emergency lighting system. The water tank is contained in a simulated chimney. The construction is chiefly metal and plastic panels. (JNC)

N74-13839#  California Univ., Berkeley. Lawrence Berkeley Lab.
CALCULATIONS ON A SOLAR ENERGY SYSTEM
(Contract W-7405-ENG-48) (LBL-1773: Conf-731002-1) Avail: NTIS HC $3.75
A computer program has been used to calculate the amount of energy which can be extracted from a flat plate solar collector. The computations consider latitude, heat loss, daily temperature range, percent cloud cover, sun angle, etc. to determine the feasibility of home heating for an angularly adjustable solar collector in the Northern Hemisphere. The program also calculates the energy available from a solar-earth heat pump. The influence of design parameters and the feasibility of using solar energy to generate heat and electricity for a small single family residence have been considered.

Author (NSA)

ENERGY CONSERVATION WITH SOLAR CLIMATE CONTROL
Avail: NTIS HC $3.00
The use of solar energy for climate control is discussed, with emphasis on solar heating and cooling of buildings. Government/industry relations are discussed in terms of taking action and supplying the market for solar climate control systems. The components of these systems are listed. K.M.M.
THE SOLAR HOUSE AND ITS PORTENT.
K.W. Boer.

The solar home now seems able to shave peak loads by controlling the climate generating its electricity.

SOLAR HEATING AND COOLING: UNTAPPED ENERGY PUT TO USE

KEY WORDS: Architecture; Buildings; Cooling; Economics; Energy; Heating; Solar energy; Solar energy concentrators

ABSTRACT: The heating of buildings by solar energy is now technically feasible and nearly economically competitive. The technical aspect has already been demonstrated by numerous, successful solar buildings. Lof and Tybout have analyzed the economics and have indicated that a substantial cost savings could be obtained by adding cooling to the load on the solar system, thereby using the same equipment all year long at a very little extra cost. Consequently, a large number of architects and engineers are now working on a variety of structures with solar heating and cooling systems. While the prospects of using solar energy for power generation are still uncertain, clean solar heating and cooling systems have now become feasible and realistic methods of conserving energy and easing the energy crisis.


AUTHOR: Tod, H.
CORPORATE AUTHOR: Pennsylvania, University of
LOCATION: Philadelphia, PA 19176
PUBLICATION DESCRIPTION: Report No.
PUBLICATION DATE: 1973, March
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: This report describes the progress made in the first three months of 1973 in studies of off-peak air conditioning, residential heating with solar energy, and materials for thermal energy storage. (MCW)

COST OF HOUSE HEATING WITH SOLAR ENERGY
G.O. G. LöF* and R. A. TYBOUT†
(Received 7 February 1972)

Abstract—There has long been a need for a practical method of predicting the true cost of heating a house with solar energy and designing the heating system (solar and auxiliary) to achieve the minimum total annual heating cost possible under the particular climatic, geographic, and residential characteristics involved. Rough approximations based on various types of averaged values of weather and seasonal variables have previously been developed, but the reliability of such methods and results is open to question. The authors have therefore made a rigorous analysis of projected solar heating costs in eight U.S. cities and have optimized the heating system design in each location.

The analysis involved the use of a high speed computer and approximately 400,000 hourly observations in eight cities of radiation, temperature, wind, solar altitude, cloud cover, and humidity. Equations for performance of flat plate solar collectors and sensible heat storage systems were developed and programmed with the above weather variables and with eight design parameters comprising house size, collector size, storage size, collector tilt, number of transparent surfaces in collector, hot water demand, insulation on storage unit, and thermal capacity of collector. Capital and operating costs were quantitatively related to heating system design parameters, and the values of all design variables which yielded lowest annual heating cost in each city were then selected.

The findings are presented in the form of two tables and ten graphs, showing heating costs as functions of various design and location factors. The relative importance of each factor is discussed, and the overall costs of solar heating are compared with the costs of conventional heat supply in each location. The method for designing the least-cost combination of solar and conventional heat supplies is also shown, and an example of the use of the method is presented.

SOLAR HOUSES/HEATING AND COOLING PROGRESS REPORT
HARRY E. THOMASON,* and HARRY JACK LEE THOMASON, JR.*
(Received 31 March 1971; in revised form 14 June 1972)

Abstract—Performance data on seven solar homes are given. Solar Homes No. 1, 2, 3, and 4 are near Washington, D.C., 39° north latitude, where about half of the winter days are cloudy and temperatures drop far below freezing, sometimes to 0°F. These houses are described in the book Solar Houses and Solar House Models by Harry E. Thomason, published by Edmund Scientific Company, Barrington, New Jersey, 08007. Edmund Scientific Co. also publishes Solar House Plans, for building a house similar to Solar House No. 1, with improvements.
SOLAR ENERGY IN AUSTRALIA.


Solar heating of water is already in use to the extent of saving 5,000 T. of coal/yr. Plans for the future.

SOLAR HOMES: A guide to developments in solar heating and cooling of residential units, including solar heat collectors, costs, floor planning, locations, and projections for future developments. 61 pages. (Solar House Heating & Air Conditioning Systems...Comparisons and Limitations, Book No. 9463, By H.E. and H.J.L. Thomason, available at $5.00 per copy from Edmund Scientific Co., 555 Edscorp Bldg., Barrington, N.J. 08007.)

SOLAR ENERGY UTILIZATION FOR HEATING AND AIR CONDITIONING.

R.R. Avezov, et al 

Paper provides a detailed analysis of foreign and Soviet experimental data in the utilization of solar energy for heating and air conditioning and compares the climate in the southern regions of the USSR with that of the northern and central states of the USA.
PERFORMANCE OF THE BRISBANE SOLAR HOUSE*

NORMAN R. SHERIDAN?

(Received 5 January 1972)

Abstract—A house with an absorption air conditioning system operated by flat-plate solar collectors has been built in Brisbane, Australia. After briefly describing the house and equipment, the paper gives the performance of the house for a typical clear summer day. It is suggested that the equipment performance should be adequate for the air conditioning of houses in the Australian tropics where reliable summer insolation is available. However, the results of a cost study of various types of air conditioned houses for the Australian tropics show that solar air conditioning is only marginally economic.

1971

532

TECHNICAL NOTE

Design of a new Solar-Heated House using Double-Exposure Flat-Plate Collectors

H. H. SAFWAT* and A. F. SOUKA*

(Received 21 April 1969; in revised form 10 August 1969)

INTRODUCTION

The heating system of a ranch-type five-room house has been designed utilizing the energy of the Sun. The house, Fig. 1, has a floor area of 2500 ft² and is situated at a latitude of 30°N at Giza, Egypt. The walls are made of stone existing at the site, while the roof is built of reinforced concrete. The solar heating system is based upon the use of double-exposure, flat-plate collectors [1, 2, 7]. For the sake of simplicity a floor panel arrangement is used for space heating, and an auxiliary electric immersion heater is provided to complement the Sun's energy under adverse weather conditions. An insulated hot water tank is employed as the means of low-temperature heat storage. Figure 2 shows the flow diagram of the system.

The climate at Giza, which is a suburb of Cairo, is characterized by long hours of sunshine. This, coupled with the fact that the temperature, in the winter, rarely falls below 50°F during the day, makes the use of energy of the Sun for house heating attractive and feasible. The Giza Weather Bureau published data [3] indicate that the heating season extends between November and March.

Ihygienic Clean Winter Space Heating with Solar and Hydroelectric Energy Accumulated During the Summer and Stored in Insulated Reservoirs

ERNST SCHÖNHOLZER*

(Received 30 January 1968; in revised form 15 September 1968)

INTRODUCTION

Winter air pollution in our cities is currently so severe that the search for hygienic methods of space heating demands the most urgent attention. The best solution would be to install, in each city apartment block, well-insulated heat accumulators of great size which could be charged with energy from natural sources such as solar energy during the daytime and surplus hydroelectric energy at night. It is recognized that the capital cost would be high, but this could be reduced to a sufficiently reasonable level, by careful attention to design details, to enable the city residents to enjoy the healthier unpolluted atmosphere.

When one realizes that each person inhales about 26,000 times a day, nobody can deny that there are urgent reasons for improving the condition of the air of our cities. In spite of the very high first costs, it is instructive to indicate the substantial thermodynamic possibilities associated with the heat-storage capacity of a large, low-grade heat accumulator of a given insulating capacity and quality, which stores available summer-time energy for winter space heating.
SIMULATION AND OPTIMIZATION OF SOLAR
COLLECTION AND STORAGE FOR HOUSE HEATING

H. BUCHBERG and J. R. ROULET

(Received 21 February 1968)

Abstract—The design of combined solar collection and storage systems for house heating requires careful
integration and optimization to minimize unfavorable economics. Because the environmental factors are
highly variable with time, hourly performance over a season must be considered to accurately assess eco-
nomic problems. This study comprises annual simulation of system performance including the house, a flat
plate solar collector, a water heat storage unit and an auxiliary heater, and the optimization to achieve a max-
imum allowable collector cost. Actual weather data for a design year stored on magnetic tape as hourly values
are utilized in the study. The digital computer programs developed to make this study possible include a
solar irradiation program, an implicit finite difference thermal analyzer program to calculate house heat load,
a system simulation program utilizing the hourly weather, heat load and collector performance information
to establish the state of the system at hourly intervals over a 1-yr period and an optimization program utilizing
the 'pattern search' technique.

Three modes of operation were investigated:
1. Maintenance of an upper and lower bound to the storage water temperature by means of the cessation of
solar collection and utilization of auxiliary heating, respectively.
2. Use of auxiliary heat to maintain a minimum storage water temperature but starting when the water tem-
perature drops to within a specified increment of the maximum temperature.
3. Use of auxiliary heat directly, allowing the storage water temperature to drop below the minimum value.
A design optimization study utilizing annual weather data for the Fresno, California, area indicated a maxi-
mum allowable cost of approximately $1.00/ft² for the solar collector. An auxiliary heater was needed
to provide heat during long overcast and peak heat load periods. Savings resulting from a solar collection
system were accounted by only the reduction of fuel consumption. Some savings in auxiliary heater capacity
are possible by using the storage system to suppress peak heating loads through distribution over longer
periods.
EXPERIENCE WITH SOLAR HOUSES.
H.E. Thomason.
Since 1969 four solar houses have been constructed by the author in the Washington, D.C. area. This report is primarily concerned with status of the solar heating, air conditioning, and water-heating system in the first house after about 6 years of service. Inspection of the heat storage bin shows no deterioration. The plumbing system has proved satisfactory and has required only minor repairs. The standby oil-heating system has needed only minor repairs. The collector glazing materials were deteriorating and were completely replaced at the end of 5 years. Rooftop evaporative cooling at night, while satisfactory most of the time was inadequate at others. After two years a low-power refrigerating compression system was substituted. The solar reflector-flux intensifier installed on the second house remains in good condition after 3½ years, but its reflective surface is somewhat dulled and is less efficient than when new. The experience to date, in short, is that no major flaw in design or construction has shown up.

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A/SMOLENIEC, S.
UTILIZATION OF SOLAR ENERGY FOR AIR CONDITIONING; INAUGURAL LECTURE,
BY S. SMOLENIEC.
WITWATERSRAND UNIVERSITY PRESS, JOHANNESBURG, 29 P. ILLUS. 29 CM.
LC SOLAR ENERGY. AIR CONDITIONING.
MAIN-AUTH TRACE-TITL* CATLG BY-LC
/ / PUBL IN SOUTH
A shallow solar pond system appears to be the most cost-effective way to produce large scale electric power from solar energy. A shallow solar pond system can be built using materials, fabrication techniques, and geometries that are presently used on a large scale in U.S. industry. A 10 MWe plant built in the Southwest would require a total area of about 2.5 sq km (approximately one sq mi) and could provide power for a community or a manufacturing process. The estimated busbar cost of electricity (in 1973 dollars) for a shallow solar pond system, which could come on line in as short a time as 3 to 7 years, is 27 mills/kWh. It is projected that this cost could be reduced by almost half with the development of improved and cheaper plastics and more efficient turbines. (Modified author abstract)
Solar Thermal Electric Power Systems,
Colorado State Univ., Fort Collins. Solar Energy
Applications Lab. Jan 74, 288p NSF-RA/N-74-001
PB-231 115/7WE PC$6.75/MF$1.45

The objective of this research program is to develop design
parameters for solar thermal electric power systems that can
provide lowest cost electric power. Parametric performance
and cost models are being developed for subsystems such as
the concentrator, flat plate collector, absorber-heat transfer,
heat transport, heat storage, heat engine and cooling tower.
Cost optimization methods are being developed, which can be
used to select cost effective subsystem units, subsystem
groups and to optimize the entire system. Power systems of 3
to 100 MW capacity that can be utilized in electrical networks
are being considered. Portions of this document are not fully
legible.

DIRECT SOLAR ENERGY CONVERSION FOR TERRESTRIAL
USE. K.W. Boer.

Large scale use of low priced CdS/Cu2S solar cells
deployed on inexpensive terrestrial surface
structures in conjunction with appropriate power
processing systems is proposed. Price estimates
are given and indicate for typical systems
consumer rates comparable to the current rates for
electric energy.

SOLAR POWER: PROMISING NEW DEVELOPMENTS.
A.L. Hammond.

Plans for near-term applications
of photovoltaic solar cells are discussed.

ENERGY CRISIS SPURS DEVELOPMENT OF
PHOTOVOLTAIC POWER SOURCES. A.I. Rosenblatt.

As Japan emphasizes solar-energy program, National
Science Foundation supervises R&D in the U.S. for
terrestrial applications of solar cells. Universities
join business in seeking economical electric-power
systems.
Solar Thermal Conversion Mission Analysis. Volume I:
Summary Report.
Aerospace Corp., El Segundo, Calif. Civil Programs Div. 15 Jan 74. 230p ATR-74(7417-05)-1-Vol-1, NSF-RA/N-74-017
Paper copy also available in set of 5 reports as PB-232 667-SET, PCS$18.00.
PB-232 668/4WE PCS$6.00/MFS$1.45

The summary report presents principal interim results of Solar Thermal Conversion Mission Analysis. Results are primarily methodological and are intended to provide an analytical procedure that will consistently evaluate alternative solar thermal conversion concepts in a variety of realistic operating environments. Various sections summarize demand, insolation, margin, mission/system, economic, siting, and environmental methodologies and analyses developed under initial six-month contract. More details are described in four additional volumes. Technical and economic results in this report are preliminary and serve primarily to illustrate the potential capabilities of the methodology itself. (Modified author abstract)

Solar Thermal Conversion Mission Analysis. Volume II:
Demand Analysis.
Aerospace Corp., El Segundo, Calif. Civil Programs Div. 15 Jan 74. 61p ATR-74(7417-05)-1-Vol-2, NSF-RA/N-74-017A
Paper copy also available in set of 5 reports as PB-232 667-SET, PCS$18.00.
PB-232 669/2WE PCS$3.75/MFS$1.45

The objectives of the analysis were to develop a methodology capable of characterizing future electric power demand data and to apply this methodology to forecast Southern California hourly electric power demand for the years 1980-2000. Forecasts of demand data exhibiting cyclic variations consistent with observed behavior patterns are necessary inputs to the solar thermal conversion system simulation. The approach used in meeting these objectives consists of several steps.

Background information, technical reports and raw data were acquired from governmental agencies and utilities throughout the country and particularly Southern California. A demand model was postulated to include factors describing a growth trend, weather conditions, seasonal influences, and hourly cyclic variations. A correlation between demand and weather, or insolation factors was investigated. A methodology was developed to decompose the time series representing the historic Southern California hourly electric power demand, and to recompose a future demand profile incorporating the historic cyclic variations with a projected trend and statistically varied weather influences.

Solar Thermal Conversion Mission Analysis. Volume III:
Southern California Insolation Climatology.
Aerospace Corp., El Segundo, Calif. Civil Programs Div. 15 Jan 74. 119p ATR-74(7417-5)-1-Vol-3, NSF-RA/N-74-017B
Paper copy also available in set of 5 reports as PB-232 667-SET, PCS$18.00.
PB-232 670/0WE PCS$4.50/MFS$1.45

An insolation data base consisting of hourly values of normal incidence (direct) insolation and total insolation for a two-year period has been prepared in computer-compatible format for eight stations characterizing Southern California and for Albuquerque, New Mexico. The data base includes, in addition to the insolation data, solar position information, and weather information. When measured insolation values are unavailable, estimated values, obtained by statistical procedures discussed in this report, are inserted so that the insolation data are complete. Some preliminary statistical studies have been performed on these data, including a comparison of insolation at various stations, a percentile frequency analysis of insolation values and a temperature insolation correlation analysis. In addition a literature survey of the information available about the distribution of sky brightness was made. The procedures used and the results of these various studies are discussed in detail in this report.

Solar Thermal Conversion Mission Analysis. Volume IV:
Mission/System and Economic Analysis.
Aerospace Corp., El Segundo, Calif. Civil Programs Div. 15 Jan 74. 158p ATR-74(7417-05)-1-Vol-4, NSF-RA/N-74-017C
Paper copy also available in set of 5 reports as PB-232 667-SET, PCS$18.00.
PB-232 671/8WE PCS$5.00/MFS$1.45

The report describes the mission/systems and economic analyses performed to examine the dynamic interaction of insolation, demand, and solar power systems. These analyses used the hourly demand projections and regional insolation data described in the previous volumes. A methodology was developed to parametrically assess the performance characteristics of alternative solar thermal conversion missions and systems in realistic operating environments on a consistent basis. When solar thermal conversion solar power plants are integrated with conventional nuclear and fossil power plants in a total power grid, a margin analysis must be performed to ensure that the integrated system provides equally reliable electric service. Having parametrically determined the technical performance of solar power plants for different modes of operation, a comparative economic evaluation of these alternative power plant concepts and conventional power plants can be made.
Aerospace Corp., El Segundo, Calif. Civil Programs Div. 15
Jan 74, 77p ATR-74(7417-05)-1-Vol-5, NSF-RA/N-74-017D
Paper copy also available in set of 5 reports as PB-232 667-SET, PCS18.00.
PB-232 672/6WE PC$4.00/MFS1.45

The document presents the results of an area definition and siting analysis: First, to define and characterize Southern California study region and, second, to identify the area within the region judged to be potentially suitable for siting solar power plants. Boundaries were chosen to conform to state boundaries on the west, south, and cast and with limits of the Southern California Edison Company service territory on the north. This region contains a wide variety of climatological and geological conditions and is served by three major electrical utilities - Southern California Edison Company, Los Angeles Department of Water and Power, and San Diego Gas and Electric Company. Land area was identified as potentially suitable by the sequential application of technical and institutional exclusion criteria then identifying those locations which were not excluded by any of the criteria. Between 5,000 and 15,000 square miles out of a total of 67,000 square miles were found to be potentially suitable for siting large, central-station solar power plants.

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AUTHOR: Chalmers, B.; Sutker, T.; Blowsky, A.I.; Jewett, N.K.; Swartz, J.C.; Wall, P.
CORPORATE AUTHOR: Harvard University, Division of Engineering and Applied Physics; Tyco laboratories Inc., Corporate Technology Center
ADDRESS: Harvard, Cambridge, MA 02138; Tyco, 16 Nickery Drive, Watertown, MA 02172
PUBLICATION DESCRIPTION: Report No.
MSP/PAW/SE/ST-37067X/PB/74/1, 23 p.
PUBLICATION DATE: 1976, April
SPONSOR: National Science Foundation, PAW Program
ABSTRACT: This report summarizes research progress on the application of the EFG crystal growth process to the continuous growth of single crystal silicon ribbons from the melt. Analysis of experimental data in conjunction with a phenomenological model of the growth process leads to the conclusion that a detailed study of the microscopic solilod-ribbon interface junction is required for a complete understanding of the growth stability. Die and furnace designs which improve the stability of the EFG process are described. Results of ribbon growth experiments and of solar cell fabrications are presented. (auth)

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AUTHOR: Hanke, H.
CORPORATE AUTHOR: Ameron Cyanamid Co., Chemical Research Division
ADDRESS: Stamford, CT
PUBLICATION DESCRIPTION: Report No.
PUBLICATION DATE: 1976, January
SPONSOR: National Science Foundation, PAW Program
ABSTRACT: The objective of this research is to develop transparent, electrically conductive cadmium stannate (Cd2SnO4) coatings for use in solar energy conversion devices. A radio-frequency technique was developed for the deposition of the coatings onto transparent substrates. Substantial progress was made toward the goal of optimized electrical and optical film properties by adjusting the deposition parameters. Electrical conductivities near 3.00 ohm(-1)cm(-1) were achieved. (MFG)

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THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar.18-20,1974.

THERMOCHEMICAL WATER CRACKING USING
SOLAR HEAT
C. J. Swet, The Johns Hopkins University, Silver
Spring, Maryland

PERFORMANCE AND OPTIMIZATION STUDY OF A
SOLAR POWERED HYDROGEN PLANT
D. V. Merrifield, Sperry Rand Corporation, Hunts-
ville, Alabama

SOLAR ENERGY AND HYDROGEN PRODUCTION -
AN EXAMINATION OF TWO POSSIBLE SYSTEMS
D. O. Lee, W. H. McCulloch, Sandia Laboratories,
Albuquerque, New Mexico

UTILIZATION OF SOLAR ENERGY FOR
HYDROGEN PRODUCTION BY CELL FREE SYSTEM
OF PHOTOSYNTHETIC ORGANISMS
A. Mitsui, University of Miami, Coral Gables,
Florida

ONLY SOLAR ENERGY PROCESSES WILL BRING
US TO THE HYDROGEN ECONOMY
W. Heronemus, University of Massachusetts,
Amherst, Massachusetts

SEA-SOLAR POWER AS A HYDROGEN GENERA-
TOR
Pennsylvania

OCEAN BASED SOLAR-TO-HYDROGEN ENERGY
CONVERSION MACRO SYSTEM
W. J. D. Escher, Escher Technology Associates, St.
Johns, Michigan; J. A. Hanson, Oceanic Institute,
Wai`manalo, Hawaii

SOLAR-HYDROGEN GENERATION WITH
MULTIPLE FREE PISTON STIRLING ENGINES
J. Rauch, W. Beale, S. Lewis, Ohio University,
Athens, Ohio

PHOTOYYSIS OF WATER AS A SOLAR ENERGY
CONVERSION PROCESS: AN ASSESSMENT
S. Paleocrossas, Tri-State College, Angola, Indiana

RECENT ADVANCES IN THE CONVERSION OF
SOLAR ENERGY TO ELECTRICITY
J. O. ’M. Bookris, The Flinders University of South
Australia, Adelaide, Australia

RELIABILITY OF LOW COST Cu2Se/Cds SOLAR
CELLS FOR LARGE SCALE CONVERSION OF
SOLAR TO ELECTRICAL ENERGY
L. Partain, M. Sayed, University of Delaware,
Newark, Delaware

From 140th meeting of The American Association for the Advancement of Science; San Francisco, California, USA (25 Feb 1974). A series of systems studies on the potential uses of solar energy was conducted at Sandia Laboratories. The outcome of these studies is a new concept, the Solar Total Energy Community. This is a residential community which could significantly reduce its fossil fuel energy consumption by using the sun as the source for most of the community’s energy needs. A system computer program, developed for the study, was used to examine several candidate systems and to optimize the operation of the interrelated components which provide space heating, air conditioning, water heating, and electricity for residences and light commercial buildings. An experimental program has been initiated to investigate various technological areas relative to the concept. The study shows that the Solar Community is technologically feasible and that the projected costs warrant the further investigation of solar energy as an alternative residential energy source. This paper reviews the previous work, reports recent findings and improvements, and presents the current status of the continuing analytical and experimental efforts. (auth)


The concept of a solar total-energy community entails collecting solar energy at a central area, converting part of it to electricity, and distributing the rest of it to homes and/or businesses for space heating or cooling. The Sandia Laboratories’ concept for such uses of solar energy, its departure from other solar-energy approaches, and the development program being conducted to further explore its feasibility are described. (auth)

Stanford Univ., Calif. Dept. of Materials Science and Engineering. 15 Apr 74, 25p NSF-RA/N-74-030, NSF-RANN/SE/GI-38445X/PR-74-1 PB-232 884/7WE PCS$3.00/MFS$1.45

Continuing research aimed at developing large-area cells for terrestrial applications the authors have (1) investigated the properties of high resistivity i-layers occurring near the junction interface between the CdS and the CdTe, (2) used thermoelectric power measurements to investigate the electrical transport properties of CdTe films deposited by close-spaced vapor-transport, (3) explored the effect of thermally etching the CdS substrates on the epitaxy of CdTe films, and (4) used H2 anneals to convert high resistivity evaporated CdS films to low resistivity (<1 ohm cm) films. During this period film-crystal cells with solar efficiencies of up to 5.2%, open circuit voltages up to 0.66 V in sunlight, and fill factors of 49% have been produced.


Cadmium sulfides, circuit reliability, copper sulfides, energy conversion efficiency, energy technology, extrapolation, short circuits, thermal effects.

C03 A74-29023
AUTHOR: R. E. Barlow, J. W. Wexler, M. G.
CORPORATE AUTHOR: University of Minnesota; Honeywell Systems and Research Center
ADDRESS: Minneapolis, MN 55411
PUBLICATION DATE: October 1974
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: This report documents the research and development efforts of the Minnesota/Honeywell team during the period from January 1, 1973 to December 31, 1973. A solar thermal system has been designed and fabricated. Life testing of candidate mirror coatings for the solar concentrator has been continued. The performance of the system has been investigated. Heatpipe tests were performed to examine the durability of stainless steel and copper containment materials, with water working fluid. The high time-temperature data were transferred and substantiated further work on the chemical vapor deposition technique for applying semiconductor materials to optical components. The fabrication of the mirror absorber-type optical system was completed. The application of Electron Spectroscopy to examine the corrosion damage to heat storage containment vessels has been continued.

TITLE: Development of Low-Cost Thin Film Polycrystalline Silicon Solar Cells for Terrestrial Application Annual Progress Report (Covering the Period June 1, 1973 to December 31, 1973)
AUTHOR: C. L. Olson, L. L. Quist, M. G.
CORPORATE AUTHOR: National Science Foundation, RANN Program
ABSTRACT: This report documents the research and development efforts of the Solar Energy Systems Project during the period from June 1, 1973 to December 31, 1973. The project has been focused on the development of low-cost thin film polycrystalline silicon solar cells for terrestrial application. The progress in this area includes (1) basic studies of polycrystalline silicon solar cells, (2) studies on the optical properties of polycrystalline silicon, (3) studies on the production techniques, (4) economic analysis of production costs, (5) production of solar cells and systems, and (6) environmental considerations. The techniques used and areas studied include: Photoluminescence, electron emission, Auger spectroscopy, morphology, diffusion, Cds formation, dislocations, heat treatment, and contact voltage characteristics.

TITLE: Environmental Aspects of Cadmium Sulfide Solar Cells in Space: A Summary of Toxicological and Environmental Considerations - A Bibliography
AUTHOR: E. Z. Olson, M. G.
CORPORATE AUTHOR: National Science Foundation, RANN Program
ABSTRACT: This report documents the research and development efforts of the Solar Energy Systems Project during the period from June 1, 1973 to December 31, 1973. The project has been focused on the development of low-cost thin film polycrystalline silicon solar cells for terrestrial application. The progress in this area includes (1) basic studies of polycrystalline silicon solar cells, (2) studies on the optical properties of polycrystalline silicon, (3) studies on the production techniques, (4) economic analysis of production costs, (5) production of solar cells and systems, and (6) environmental considerations. The techniques used and areas studied include: Photoluminescence, electron emission, Auger spectroscopy, morphology, diffusion, Cds formation, dislocations, heat treatment, and contact voltage characteristics.
George O. G. Lof. and Susumu Karaki.
Colorado State Univ., Fort Collins. Dept. of Civil Engineering. May 73. 12p NSI-RA/N-73-050
PB-227 822/4WE PC$3.00/MFS1.45
Before committing funds and efforts to the construction and testing of experimental equipment for generating electricity, from solar heat, any proposed system should be subjected to careful technical and economic analysis. Important elements which must be included in such analysis and the rationale behind them are discussed. It is not immediately evident that a large scale thermal power plant or a small scale plant have requisite and inherent advantages. Rather, what seems obvious is the necessity for separate appraisal of collector. thermal transport, storage, heat engine, subsystem, and a thorough assessment of an integrated assembly providing for least cost per unit of electrical power output for varying conditions of operation. A broadly based analysis of solar thermal electric power systems is needed to establish a basis for more intensive research and development efforts of specific systems. (Author)

As a result of the proposal for the possibility of using the photovoltaic cell for large-scale generation of electricity from sunlight, three questions are posed. What area must be covered by solar cells to generate a significant portion of U.S. energy needs? If generated on the surface of the Earth, what methods of energy storage will be used? How much will photovoltaic solar energy conversion systems cost? It is concluded that the area needed is not unreasonable, that methods of energy storage are available, and that there is reason for optimism with respect to reducing the cost for large-scale power generation from sunlight. (MCW)

FEASIBILITY STUDY OF A COORDINATED SOLAR-NUCLEAR SYSTEM IN AN INTEGRATED POWER NETWORK.
From 19th annual meeting of the American Nuclear Society; Chicago, Illinois, USA (10 Jun 1973). See CONF-730611-
A viable basis for a solar-nuclear system complex is described. A well-defined variation in power demand is known to occur during the day. The manner of this variation exhibits a strong correlation with the variation of solar-radiation intensity — and therefore, of solar energy availability — during a 24-h period. The overall load consists of a 'base' load and a 'peak' demand superimposed on it. For serving the 'base-load' demand of a network, nuclear units possess special economic and other advantages. In an integrated system, if nuclear and solar units are operated in a mutually complementary fashion, the nuclear unit can be confined primarily to base-load demand, minimizing its 'swing-load' function. The incremental load — which occurs largely during periods of intense sunlight — can be met by solar units. Moreover, such a distribution of load makes use of solar energy in 'live' form, obviating problems of storage batteries.

THE SUNSHINE SPREADERS.
Aden and Marjorie Meinel are dedicated publicists of solar energy. They want to see power farms of 5000 square miles in Arizona, producing power for southern California. Tim Johnson discussed their ideas with them.
The function of a solar-thermal power system is to supply solar-generated heat to the turbines of an electric power plant. The basic system presently being considered under this program is composed of an array of collectors (consisting of a parabolic reflector which concentrates and directs the solar radiation onto a heat pipe absorber tube in which the energy is transferred to a fluid), a transfer loop (a system of pipes which transports the energy to the power plant proper), and optionally an energy storage system to provide energy during no-sunshine hours. Systems being studied represent current state of technology, but should not be construed as final designs. They represent only baselines from which trade-offs and component research can be conducted. (Author)
A COMMERCIAL SOLAR CELL ARRAY DESIGN

E. L. RALPH

(Received 24 May 1971)

Abstract—Solar cell arrays designed for space use are not suitable for terrestrial electric power generation applications. The environment on Earth is much different and the commercial price range for these applications is much lower than that for space applications. This paper describes solar cell array designs that provide protection from the terrestrial environment and at the same time brings down the space design price from about $100 per watt (space design price) to about $25 per watt. Optical efficiency of the concentrator design is 76 per cent. The thermal characteristics of the arrays have been measured and electrical performance data is presented.


Solar intensity undergoes significant changes from dawn to dusk. Further, the power output of a silicon solar cell is a function of the load resistance. A load resistance (R_L) giving maximum conversion efficiency at mid-day becomes less efficient at other times of the day under reduced intensity levels. The load resistance must be optimised to derive maximum overall power output for the whole day, taking intensity variations into account. A method for estimating the optimum load resistance (R_L) is presented here. It is also shown that considerable improvement in the output of a terrestrial power system could be achieved at solar intensities $\pm$100 MW cm$^{-2}$. (auth)


A PROBLEM STATEMENT: OCEAN BASED SOLAR-TO-
HYDROGEN ENERGY CONVERSION MACRO SYSTEM

William J. D. Eicher and Joe A. Hanson (Oceanic Inst.) Nov. 1973 25 p refs

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An ocean based solar to hydrogen energy conversion facility is proposed that uses hydrogen as an energy carrier to be delivered to the spectrum of the energy using sector, instead of electricity, because of hydrogen's advantages of transportability and storability. The solar to hydrogen conversion process is conducted on the open ocean, and not in the traditional desert location. A number of coproducts that can also be supplied by the proposed ocean complex includes sea foods, salts, fertilizers, magnesium, and aluminum materials.

N74-16610G Sandia Labs., Albuquerque, N.Mex.

ECONOMIC COMPARISON OF TWO SOLAR/HYDROGEN CONCEPTS.


(Contract AT(29-1)-788)

SLA-73-900 Avail. NTIS HC $3.00

Two concepts for producing hydrogen from solar energy are examined. The utilization of solar energy and the concept of a hydrogen fuel both have drawbacks. Solar energy is intermittent, interrupted by the diurnal cycle of available sunlight and by weather conditions. Most systems designed to use solar energy include an expensive energy storage mechanism to meet demands during periods when there is no incident solar radiation. Hydrogen generation plants would require large amounts of the hydrogen input. The concepts described utilize parameters typical of operation in Albuquerque, New Mexico. It is assumed that the collectors are positioned with the axes in a north-south plane, tilted 35 deg from the horizontal toward the south, with spacing between collectors equal to the collector dimensions. (auth)


Efficiency of photosynthesis is an solar energy converter: Energy Conversion 13, 77-84 (1973).

Summary—The efficiency of the conversion of solar energy into chemical energy in the form of plant material through photosynthesis is discussed. A theoretical upper bound of 11 per cent is obtained. Inclusion of losses resulting from other aspects of plant biology reduces the conversion efficiency to 5-6 per cent in practice. Record daily plant growth rates confirm this figure. This is the conversion efficiency of sunlight reaching the plant; efficiencies based on monochromatic light of optimal wavelengths can yield higher efficiencies, but their use with respect to the problem under consideration is inappropriate. Once converted into organic plant material this stored energy can be released as thermal energy or converted to another fuel such as a substitute natural gas.

Key words: Efficiency photosynthesis solar energy productivity fuels energy crops yield

544

Recent advances in silicon and Cu2S solar cells are reported in papers dealing with improved device fabrication processes, factors participating in degradation mechanisms, design details of spacecraft solar cell arrays, and prospects of economically justified terrestrial applications. Some particular topics include details of integrated solar cell panels, design features of flexible and deployable large arrays, fabrication methods for thin-film solar cell structures, and the performance of protective coating materials.

Individual items are announced in this issue. T.M.


A review of the state of the art in the energy conversion field indicates that the photovoltaic converter is now the most common and efficient type of energy converter. It is anticipated that recent improvements in silicon solar cells will benefit the development of terrestrial solar power plant technology. Solar power plants in space are also considered as a possibility in the future. V.Z.

N74-10896# Committee on Science and Astronautics (U. S. House).
SOLAR ENERGY FOR THE TERRESTRIAL GENERATION OF ELECTRICITY
Avail: Subcomm. on Energy

The hearings are presented concerning the concept of terrestrial power stations that convert solar energy into electricity. Solar power farms are discussed, and a solar collector system is described. F.O.S.

N74-12589# Auburn Univ., Ala.
SOLAR POWER GENERATION AND DISTRIBUTION c03
In its TERRASTAR: Terrestr. Appl. of Solar Technol. and Res. Sep. 1973 11 p. refs (For availability see N74-12674 03-34)
CSCL 20M

The production of electricity from solar energy is discussed. The economics of the proposed generation and distribution systems are analyzed. The use of photovoltaics for converting solar energy to home heating is proposed. The problems of energy distribution are analyzed from the standpoint of equipment costs and complexity. Author

AUTHOR: Panoe, P.C.

CORPORATE AUTHOR: Boston College, Dept. of Physics

ADDRESS: Chestnut Hill, MA 02167

PUBLICATION DATE: June 1973

KSP/BAN/SS/G2-34975/73/2, 18 p.

PUBLICATION DESCRIPTION: Report No.

SPONSOR: National Science Foundation, RANN Program

ABSTRACT: A wide variety of steel substrates, as well as polyethylene and teflon substrates, have been investigated for the deposition of Si films. We conclude that Si films with a nominal thickness of 10 microns can be grown on all three substrates. S1 films with preferential orientation with respect to the substrate plane have been successfully grown on these substrates. The most important benefit of such growth in the C5S solar cells has long been recognized. We have now reached the same landmark on the development of Si film solar cells. 3. During this reporting period, we have also investigated the chemical vapor deposition method. Films are produced by this method with good uniformity and adherence to steel and other substrates that are used in the evaporation process.

AVAILABILITY: NTIS, PB 228 879 ($3.00 paper copy/$1.45 microfiche)

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AUTHOR: Anderson, W.A.; Delahoy, A.Z.

CORPORATE AUTHOR: Rutgers University, College of Engineering, Bureau of Engineering Research

ADDRESS: New Brunswick, NJ 08903

PUBLICATION DATE: April 1973

KSP/BAN/CS/G2-32726/PR73/7, 9 p.

ABSTRACT: Two transition metals besides Cr, namely Mo and W, have produced good photovoltaic response when used as the thin Schottky barrier metal. 2) Quantitative antireflection coating results were obtained using SiO evaporated on Schottky photovoltaic diodes. Improved photovoltaic outputs of 33% - 42% were obtained compared to theoretical computer predictions of 95%. 3) A cooper solution of the optical problem averaged over the solar spectra predicts a 77% improved performance using SiO and an 87% improvement using T102 antireflection coatings on a 100 angstroms thick Schottky diode. 4) A thin-film Si device (made on an 80 cm square that is 300 microns thick) showed promising results in that good adhesion and coloring of Si film was achieved. 5) The Si adhered to the 11 during heating and that the Si formed its own antireflection coating as predicted by computer. (Auth)

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AUTHOR: Chou, T.S.

CORPORATE AUTHOR: University of Delaware, Institute of Energy Conversion

ADDRESS: Newark, DE 19711

PUBLICATION DESCRIPTION: Report No.


ABSTRACT: The purpose of this study is to examine the behavior of dislocations in C5S solar cells. Special emphasis is placed on the formation of dislocations affecting the mechanical behaviors of biaxial systems. The study is analytical in nature. The results of this study are presented in terms of the observed effects of experimental observations with experimental observations will be made. Close interaction with experimental groups will identify significant problems in the future. (Auth, free introduction)

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TITLE: Accelerated Life Test of C5/Can Solar Cells

AUTHOR: Partain, L.L.; Sayed, M.

CORPORATE AUTHOR: University of Delaware, Institute of Energy Conversion

ADDRESS: Newark, DE 19711

PUBLICATION DESCRIPTION: Report No.

KSP/BAN/SS/G2-35472/77/3/8

PUBLICATION DATE: July 1973

ABSTRACT: Accelerated lifetime testing has been performed to estimate the lifetime of C5S solar cells. The cells were subjected to different conditions of solar energy. The results indicate that the cells are capable of absorbing uniform light and have a long lifetime. The results of this study will be presented in a future report. (Auth, free introduction)

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TITLE: Grid Simplification on C5S/C5S Solar Cells

AUTHOR: Halley, A.

CORPORATE AUTHOR: University of Delaware, Institute of Energy Conversion

ADDRESS: Newark, DE 19711

PUBLICATION DESCRIPTION: Report No.

KSP/BAN/SS/G2-35472/77/3/11, 10 references

PUBLICATION DATE: June 1973

ABSTRACT: The current collecting electrode for the thin film C5S/C5S solar cells being studied under this research grant is a metal mesh (grid) applied to the C5S surface. The grid wires must be spaced closely enough to collect the generated current efficiently and spaced widely enough for sufficient transmission to the cells. Calculations were performed to determine the optimum spacing and geometry for the grid wire, and the calculations were checked by experiment. (RPP)


Final report covering the period June 1, 1971 to January 31, 1973.


CORPORATE AUTHOR: University of Arizona, Optical Sciences Center.

ADDRESS: Tucson, AZ 85721

PUBLICATION DATE: 1973, January 31

SPONSOR: National Science Foundation, RANN Program

ABSTRACT: This report summarizes studies of solar absorbing coatings of high selectivity, (a/e), and their influence on the design, performance, and economy of two basically different approaches to high (a/e) coatings. The first approach used intrinsic absorber coatings using chemically vapor-deposited (CVD) silicon as the absorbing component. (See, Project Description)


CORPORATE AUTHOR: University of Arizona, Optical Sciences Center.

ADDRESS: Tucson, AZ 85721

PUBLICATION DATE: 1973, January 31

SPONSOR: National Science Foundation, RANN Program

ABSTRACT: An RNS (RANN) grant of $777,600 was used for laboratory fabrication and measurement of solar absorbing coatings of high selectivity, (a/e), and their evaluation for use in electrical power production by means of thermodynamic cycles. Two types of selective coatings were evaluated: one using intrinsic thin film stacks and the second using intrinsic optical absorption of CVD silicon. Interference stacks made of aluminum oxide with molybdenum, gold, and silver for the metal layers yielded an (a/e) of up to 30 at 100 degrees C, an improvement in the state of the art by a factor of 3. The CVD stacks were made from silicon over a reflective silver layer and yielded efficiencies at 500 degrees C consistent with an (a/e) of over 20 for a complete stack. A variety of configurations were tested, with high-temperature deposition and applications were encountered and solutions were either found or were eliminated. A systematic analysis indicates that (a/e) = 30 is sufficient to permit the use of weather-insensitive planar collectors and that efficiencies of 25% are obtained. Heat transfer losses for a 1000-kWe system are negligible.


AUTHOR: Fang, P.H.

CORPORATE AUTHOR: Boston College, Dept. of Physics.

ADDRESS: Chestnut Hill, MA 02167

PUBLICATION DATE: 1973, January

SPONSOR: National Science Foundation, RANN Program

ABSTRACT: This first report on the fabrication of solar cells has been divided into five parts: 1. The problem of the present energy need and the role of electronic energy, including solar energy; 2. The physics of electrical energy conversion, especially by silicon solar cells. 3. An analysis of basic modifications of silicon cells; 4. Solar energy conversion, especially by silicon solar cells. 5. Future areas of investigation, especially on the growth of silicon and solar cell substrates, the repeatability of these substrates, and electrical connections. (See, Project Description)


AUTHOR: Colorado State University, Solar Energy Applications Laboratory, Engineering Research Center, Westinghouse Electric Corp., GeoResearch Laboratory.

ADDRESS: CSU, Fort Collins, CO 80523, Boulder, CO

PUBLICATION DATE: 1973, July

SPONSOR: National Science Foundation, RANN Program

ABSTRACT: The research being conducted in this laboratory is focused on the development of solar thermal electric power systems. The objectives of the research are to develop a low-cost, high-efficiency solar thermal electric power system that is capable of operating continuously and reliably for extended periods. The laboratory is currently investigating several approaches to this problem, including the development of new solar cell materials, the design of improved solar concentrators, and the development of new electrical conversion technologies. As a result of this research, the laboratory has developed several prototypes of solar thermal electric power systems that are operating successfully in a variety of environments. These prototypes include both single-axis tracking systems and multi-axis tracking systems. The laboratory is also investigating the feasibility of using solar thermal electric power systems in remote locations, such as on remote islands and in rural areas. As a result of this research, the laboratory has developed several prototypes of solar thermal electric power systems that are operating successfully in a variety of environments. These prototypes include both single-axis tracking systems and multi-axis tracking systems. The laboratory is also investigating the feasibility of using solar thermal electric power systems in remote locations, such as on remote islands and in rural areas. As a result of this research, the laboratory has developed several prototypes of solar thermal electric power systems that are operating successfully in a variety of environments. These prototypes include both single-axis tracking systems and multi-axis tracking systems. The laboratory is also investigating the feasibility of using solar thermal electric power systems in remote locations, such as on remote islands and in rural areas.

The report presents a transcript of a solar energy talk that emphasizes the potential for a solar community as developed by Sandia Laboratories, Albuquerque, New Mexico. (auth)


An analytical study of the application of the Sandia Laboratories solar community concept to a single house and to a 20-house subdivision is described. The specific system analyzed utilized collectors, high-temperature water storage, and cascaded energy. Daily and annual projected performances of different collector fields and the annual projected fuel savings and relative costs of the system are presented for a community located in Albuquerque, New Mexico. Requirements for the peak heating and air conditioning demands are shown. (auth)


The feasibility of using solar energy to provide most of the residential energy needs in a cohesively designed Solar Community is investigated analytically. This innovative concept of a Solar Community is based upon the premise that solar energy can be collected, stored, and then used to provide electricity (through Rankine cycle turbines and electric generators) and comfort conditioning. As designed, solar energy is backed up with supplemental fossil fuel for the periods when stored solar energy is depleted. Five different Solar Community concepts are analyzed and evaluated in terms of projected fuel savings and annual total energy costs. The system that appears most promising is a cascaded system using focused collectors, storage, and a derated turbine where the exhaust energy is "cascaded" into sensible heat storage for use in comfort conditioning. Depending upon the system chosen, annual fuel savings of 45 to 65% could be obtained. Economic parity with existing systems could occur in the 1980's or early 1990's, based upon a moderately increasing utility rate schedule. If utility costs become prohibitive, the proposed system could become competitive much sooner. (auth)


Sandia Laboratories is proposing that the NSF sponsor a program for the development of a new, more sophisticated systems analysis of solar energy systems. The analysis will be primarily aimed at the solar total energy concept, but it should also be applicable to other solar thermal applications. The effort will require the development of a flexible computer program that will control and manipulate individual component subroutines to determine their impact on the total system. The program will determine solar system costs and fossil fuel savings as compared to those associated with conventional fossil fuel system. (auth)


From energy crisis symposium; Albuquerque, New Mexico, USA (5 May 1973).

The problems of concentrating the energy from the Sun and the expense of that energy, and maximum use of that energy in a New Mexico community are examined. Heating a fluid with solar collectors and using the energy in the fluid for uses as it cools is explained in the "Solar Community". (JCW)
Thermodynamic schemes are being studied for central power systems having early applicational viability. The TD schemes universally involve an extensive thermal subsystem that collects the solar flux and delivers its energy (as heat) coupled to a central thermodynamic subsystem (that converts the heat to work). Various degrees and models of storage may be invoked to supply power beyond the mere solar day, in time. The completed economic situation is examined in view of the present inflationary condition. The various solar collector field concepts exhibit capital costs running between $900 to $2500 per kw. The central plant equipment includes heat exchangers, turbo-generators, pumps, and other TD machinery, at $90 to $136 per kw; storage schemes reflect $50 to $200 per kw. (MCW)
LARGE SCALE SOLAR ELECTRIC POWER GENERATION

E. L. RALPH*
(Received 15 May 1971)

Abstract—The need for a new source of energy for generating electric power has been well established. This new energy source must be able to meet the many demands of our society in respect to resource depletion, increased electrical power requirements, peak demands, site location, low costs, and the elimination of pollution. The one energy source that provides a solution to these problems is solar energy. Although no significant effort or funds are being spent on solar energy research, there are indications that this energy could be tapped with present technology. This paper describes some features of a large scale solar cell electric power generating system that could be built to show the feasibility of utilizing solar energy. The basic system components are described and an engineering analysis made of the electrical, optical, mechanical, and thermal characteristics of the system.


Theoretically, sunlight can supply all the electric power we need. Over 100 million acres of unoccupied public lands in five of our southwestern states are bathed in solar radiation sufficient to produce (using conservative conversion factors) $6.7 \times 10^{13}$ kWh annually. This is 40 times the present total annual production. Small solar engines and generators can now be built for about $1000$/kw compared with $200$/kw in large conventional installations—an appreciable difference. But the cost is low enough and the rewards of success great enough to justify further research and development.
A PROPOSED NEW CONCEPT FOR A SOLAR ENERGY CONVERTER.

R.L. Bailey, Univ. Florida.

The concept is called an Electromagnetic Wave Energy Converter (EWEC). The concept is a pyramidal solar radiation absorber-converter structure. It is based on the possibility of extending concepts of power absorbing antennas and converters to the visible light range.

Three promising areas in which biological processes might be applied to the effort to expand energy supplies were explored. Algal or microbial photosynthesis could be used to produce molecular hydrogen, with water as the primary source of atomic hydrogen and sunlight as the energy source. The economics of hydrogen production by photosynthesis involve the large-scale growth of algae (and/or bacteria), for which some parameters have already been measured, the obvious investment of the land area large enough to trap the required solar energy, and such unknown details as the cost and lifetime of isolated enzyme reactors and the ultimate efficiency of managed populations of organisms. The second possibility is the production of methane by certain groups of bacteria that are able to reduce alcohols, aldehydes, or carboxylic acids during anaerobic growth, with methane as a major fermentation product. The economics of this process will be related to the regional availability of large quantities of suitable organic wastes and the availability of a moderate-temperature heat source. The third area involves the use of microorganisms to facilitate the processing of certain fossil fuels that heretofore have been considered economically unattainable such as the bacterial oxidation of the sulfur indigenous to certain shale deposits and biological attacks to convert tarry deposits to more tractable chemical forms. (ICW)

Title: Some Problems Associated with Large Scale Production of Electrical Power from Solar Energy Via the Photovoltaic Effect
Author: Tofercati, J.J.
Corporate Author: Brown University
Address: Providence, RI
Publication Date: 1972
Abstract: This paper explores some questions associated with large-scale solar energy conversion via photovoltaic solar cells. It is shown that about 0.1 percent of the land area of the United States would have to be covered by 10 percent efficient solar cells to produce all the electrical energy currently consumed in the United States. Various technologically feasible methods of storing large amounts of electrical energy are discussed. The cost goals which must be met by solar arrays intended for large systems are summarized, and methods of achieving these goals are considered. (6ths)
Availability: The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th St., New York, NY 10017 ($3.00 per copy, $1.00 to ASME members)

Title: Solar Energy - the Possible Dessert
Author: Reineel, A.B.; Reineel, H.P.
Corporate Author: Arizona, University of, Optical Sciences Center
Publication Description: Briefing to the Task Force on Energy of the House of Representatives Committee on Science and Public Policy, 33 p.
Publication Date: 1972, March 6
Abstract: We have embarked our studies over the past two years into a new concept that we wish to talk about today. This concept is the thermal conversion of solar energy into electrical power at efficiencies approaching 30% is possible using current technology borrowed from NASA, NASA, and ARB programs. Our study also indicates that the economics of solar power by means of our concept appear to be comparable to the generation of power today using natural gas as a fuel. We are encouraged to advise you that our solar power concept provides a new energy option with the same advantages as the breeder reactor: namely, the first half of the decade of the 80's. We further feel that the cost of a development program up to a demonstration power system in the several-hundred-megawatt size will be substantially less than has been invested to date in either the breeder or the CTR (controlled thermonuclear reactor) program. We also wish to show that solar power has the potential of sustaining the entire power needs of the United States within reasonable uses of land area for this purpose. We recommend, however, that solar power be considered today as a regional solution until the long-distance power transmission problem is solved. We would like to present material to you today to substantiate these summary statements. (6ths)
The Solar Power Option

AUTHOR: Reine, A.B.; Reine, M.P.

CORPORATE AUTHO: Arizona, University of, Optical
Science Center


PUBLICATION DATE: 1972, February 2

ABSTRACT: A solar power system is described, which uses thermal conversion with a thermodynamic cycle. The system consists of a solar collecting area, a thermal storage sub-system, and a standard steam turbine power plant. Four key technologies will be used by the system: optical thin film coatings to absorb sunlight and prevent re-emitter of heat; liquid metal heat transfer; medium-temperature salt eutectics; and mass production. It is estimated that a solar power farm of 5000 square miles could generate 1,000,000 MWe. The power plants in the Four Corners area require more land for strip mining than is required by the solar farm. A development time scale is presented. A solar power farm producing 500 to 1000 MWe could be in operation by 1985. (HPI)

Harvest of Solar Energy

AUTHOR: Reine, A.B.; Reine, M.P.

CORPORATE AUTHOR: Arizona, University of, Optical Science Center


PUBLICATION DATE: 1972, May 8

ABSTRACT: The notion that we need a major new contender is solar power. We would like to describe our concept of a solar power system and a time scale for development that can make solar power a reality on the national scene in 1985, through a development program of conservative scale. (auth)

Solar Energy - Is It a Feasible Option?

AUTHOR: Reine, A.B.; Reine, M.P.

CORPORATE AUTHO: Arizona, University of, Optical Science Center


PUBLICATION DATE: 1972, June 5

ABSTRACT: Solar power is believed to be a major contender among the new energy options such as breeder reactors, fusion power, coal gasification, and geothermal power. A solar power system using thermal conversion is described. Power from solar energy would probably cost 3% more than power from nuclear plants or plants using strip-mined coal. Solar power farms located in the desert will not change the thermal balance of the area. A method of using solar energy to provide power for peak demand is outlined.

LARGE SCALE SOLAR ELECTRIC POWER GENERATION

AUTHOR: Reine, A.B.; Reine, M.P.

CORPORATE AUTHOR: Arizona, University of, Optical Science Center


PUBLICATION DATE: 1972, June 5

ABSTRACT: Solar power is believed to be a major contender among the new energy options such as breeder reactors, fusion power, coal gasification, and geothermal power. A solar power system using thermal conversion is described. Power from solar energy would probably cost 3% more than power from nuclear plants or plants using strip-mined coal. Solar power farms located in the desert will not change the thermal balance of the area. A method of using solar energy to provide power for peak demand is outlined.


Review of the technical evolution which has led to the present type of solar cell generators. The results of the operation of solar energy plants in various parts of the world are cited, noting some technological problems caused by the environment and the solutions proposed. An evaluation is made of the future prospects for solar generators, and, in particular, an estimate is made of the cost of generating energy by means of solar cell arrays. In addition, three types of solar generators for powering the gondolas attached to sounding balloons are described.

A.B.K.
A cost study was made to assess the potential of the large-scale use of solar cell power for terrestrial applications. The incentive is the attraction of a zero-pollution source of power for wide-scale use. Unlike many other concepts for low-pollution power generation, even thermal pollution is avoided since only the incident solar flux is utilized. To provide a basis for comparison and a perspective for evaluation, the pertinent technology was treated in two categories: current and optimistic. Factors considered were solar cells, array assembly, power conditioning, site preparation, buildings, maintenance, and operation. The capital investment was assumed to be amortized over 30 years. The useful life of the solar cell array was assumed to be 10 years, and the cases of zero and 50-percent performance degradation were considered. Land costs, taxes, and profits were not included in this study because it was found too difficult to provide good generalized estimates of these items. On the basis of the factors considered, it is shown that even for optimistic projections of technology, electric power from large-scale terrestrial use of solar cells is approximately two to three orders of magnitude more costly than current electric power generation from either fossil or nuclear fuel powerplants.

For solar cell power generation to be a viable competitor on a cost basis, technological breakthroughs would be required in both solar cell and array fabrication and in site preparation.

ABSTRACT: The two nonphotosynthetic ways to use solar energy are to concentrate the sun's rays to heat something or use the photovoltaic effect. Suggestions to use a square-mile array of photovoltaic collectors on Earth or use them in an orbiting power plant are described. Another suggestion is to use optical films to concentrate light and heat a liquid, probably saline, to generate steam, to drive turbines. Proponents of solar energy believe it could provide up to 20% of the world's power. (NPG)

The possibilities are explored to create high efficiency solar-electricity converters utilizing the wave-like properties of radiation interacting with absorber-converter elements. The concept is based on the feasibility of extending principles of power absorbing antennas and converters to the visible light range. The resulting proposed converter structure would have a rough surface texture and yield a dc output. It may have significant efficiency, cost, and fabricating advantages, particularly for large-scale terrestrial utilization of solar energy. The concept is called an Electromagnetic Wave Energy Converter.

G.R.


Forty-nine papers were presented at the conference. A separate abstract was prepared for each of eight. The remaining forty-one papers and reports of four working groups were not within the scope of NSA. (TF9)

A72-15892 * # Terrestrial adaptation of the thermal heliotrope. J. W. Fairbanks (NASA, Goddard Space Flight Center, Space Power Technology Branch, Greenbelt, Md.) and F. H. Morse (Maryland, University, Silver Spring, Md.). American Society of Mechanical Engineers, Winter Annual Meeting, Washington, D.C., Nov. 28-Dec. 2, 1971, Paper 71-WA/Sol-10, 10 p. 9 refs. Members, $1.00; nonmembers, $3.00.---

The principle of using bimetal helical coils to cause solar arrays to track the sun in space is presently under consideration for array orientation on several spacecraft. Adaptation of this thermal heliotrope to terrestrial applications introduces additional design considerations. The dominance of solar-radiation energy input to the helical coil over convective energy losses has to be ensured, and wind effects must be minimized. As long as the cost of solar cells remains high, orientation will always result in a significant cost saving for the converter.

G.R.
UNLIMITED WATER AND POWER WITH SOLAR ENERGY ENERGIZING ELECTRONIC, STEAM, AND TURBINES IN SYSTEMS

John F. Crane *

The vast quantity of solar radiant energy heretofore untapped can now be harnessed to provide unlimited amounts of fresh water through the conversion of sea water, brackish and polluted water. Steam derived from the conversion process can be utilized to provide unlimited power.

Cosmic and electronic frequencies can destroy and remove undesirable media present in water and in food. This may be invaluable to man when he travels in outer space and in his control of media which may cause illness and death.

New counter-rotating turbines, both gas and steam types, provide higher shaft horsepower with new balanced propulsion and without end thrust on bearings. Turbines which give higher efficiencies are presented as better prime movers.

Solar methods utilizing free solar heat up to 6000 deg. F appear to be the best answer to provide smog-free energy. Conveyors used with solar heat can be applied to handle sewage and reduce all odors to zero. Similar methods can be applied to mining and to the recovery of metals and to the pumping of water across the nation on a "free" solar energy basis which can operate around the clock by using stored hot brine to supplement solar radiation by means of insulated reservoirs. Infrared heat may also be used instead of solar heat.

For complete paper, see AAS69-611, microfiche supplement (Vol. 12, AAS Microfiche Series).
PILOT PLANTS OF SOLAR STEAM GENERATING STATIONS

G. FRANCIA*

(Received 21 February 1968)

Abstract—We describe here a way to use honeycomb panels (anti-radiating cellular structure). The paper was first submitted to the United Nations Conference on New Sources of Energy, held in Rome in 1961. In our research we have used plants for the thermo-dynamic conversion of solar energy into electric energy at high temperatures. We refer to the boilers at Marseilles and Genoa, and we describe briefly the plant being built in St. Hario at Nervi, Genoa. This plant has a maximum production of 140 kg/hr of steam at 150 atm, while in the temperature range 500–650°C.
DESIGN OF SOLAR CELLS FOR TERRESTRIAL USE.
P.A. Berman.

The various aspects that must be considered to successfully design solar cells for terrestrial systems are presented. Some of the more recent developments in solar cell technology are mentioned. It is concluded that the most logical approach to the use of silicon solar cells for terrestrial applications is to utilize solar concentrators in conjunction with cells specially designed for such operations. The factors that affect solar-cell performance are discussed, and an experiment is described that optimizes the most important parameters for obtaining the best performance at intensities of between 100 and 400 milliwatts per square centimeter. The characteristics of such optimized cells are compared with the more common cell designs with regard to the various electrical parameters. A discussion of cell-concentrator systems is presented and some cost estimates are given.

N64-29491 Oklahoma State U., Stillwater
THE BASIC TECHNICAL PROBLEMS ASSOCIATED WITH A SOLAR TO ELECTRICAL SYSTEM WITH INTERMEDIATE ENERGY STORAGE
C. M. Summers In its Proc. of a Conf. on Energy Conversion and Storage p 99-95 (See N64-29484 21-06) Okla. State U.: $5.00

The five basic groups of components for a proposed pilot-plant operation, based on solar to electrical energy conversion with intermediate energy storage, are listed. The technological problems associated with each group include these: (1) the solar (in this case, wind energy) to electrical energy transducer; (2) the electrolysis and storage system; (3) the fuel cell; (4) the solid-state inverter system; and (5) the conversion components to convert electrical energy to fuel storage.

M. P. G.

N64-29486 Oklahoma State U., Stillwater
A QUANTITATIVE EVALUATION OF POWER DENSITY AND STORAGE CAPACITY FOR SOLAR AND WIND ENERGY
C. M. Summers In its Proc. of a Conf. on Energy Conversion and Storage p 16-33 (See N64-29484 21-06) Okla. State U.: $5.00

Increasing efficiencies of fuel cells that convert and reconvert hydrogen and oxygen fuel and electricity directly makes the age-old dream of utilizing solar energy more feasible. Calculations of the annual mean power-density value, of the efficiency of solar conversion units, and of the storage capacity required show that this method is not economically feasible at present. The same calculations made for wind energy (another form of solar energy) show that wind energy conversion is technically and economically feasible. A comparison of solar-energy and wind-energy power-density data shows that in those months when the sunlight is above average, the wind

The sensitized photo-decomposition of water has been studied, with the purpose of improving its efficiency as a means of solar energy conversion. A number of metallic cations and other materials were tested for sensitizer activity and, of these, only ceric, thallic, ferrous, uride, and chromous ions do sensitize the reaction, the former two to yield oxygen, the latter three hydrogen. In no case was the simultaneous production of hydrogen and oxygen observed. Quantum yields were determined, with substantial conversion of the sensitizer, and found to be of the order of $10^{-2}$ to $10^{-4}$. Initial yields were much higher. With the known sensitzers, this reaction does not utilize a sufficient fraction of the solar spectrum to be practical as a means of solar-energy conversion. Several mixtures of ions and also various solid materials as additives to sensitizer solutions were tested for their influence on sensitizer activity. In every case, it was found that the quantum yield was the same as or lower than with the sensitizer alone.

**Author**

N63-19875  P E C Corp. Boulder, Colo.

N64-17379

Army Signal Research and Development Lab., Fort Monmouth, N.J.
Electronic Components Dept.

SOLAR POWER SUPPLIES FOR GROUND USE


4/3/64 0

AS.
SATELLITE POWER STATIONS


A feasibility study of a satellite solar power station (SSPS) was conducted. (1) to explore how an SSPS could be "turned" and controlled in orbit; (2) to determine the techniques needed and economic issues the key: environmental, economical, and economic issues involved. Structural and dynamic analyses of the SSPS structure were performed, and deflections and internal member loads were determined. Desirable material characteristics were assessed and technical development requirements identified. Flight control performance of the SSPS baseline design was evaluated and parametric sizing studies were performed. The study of RFI avoidance techniques covered: (1) optimization of the microwave transmission system; (2) device design and expected RFI; and (3) SSPS RFI effects. The identification of key issues included the microwave generation, transmission, and rectification and solar energy conversion, and (2) environmental-ecological impact and biological effects; and (3) economic issues. The feasibility of the SSPS based on the parameters of the study was established.

A74-24942 Space solar power. P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). In: Photovoltaic power and its applications in space and on earth; International Congress on the Sun in the Service of Man, Paris, France, July 2-6, 1973. Proceedings. (A74-24941 01-03) Brit ISIS-re-Orge, Essonne, France, Centre National d'Etudes Spatiales, 1973, p. 59F-618, 47 refs. The results of work carried out on a satellite solar power station (SSPS) since the concept was presented at the 1968 Solar Energy Conference are reviewed. The objective of this concept is to supply electrical power on the earth to provide an economically viable and environmentally and socially acceptable alternative to other energy production methods. The principle on which the SSPS is based relies on solar energy conversion in a satellite in synchronous orbit to produce electricity. This electricity is fed to microwave generators arranged to form an antenna which directs a beam to a receiving antenna on earth, where the microwave energy is efficiently and safely converted back to electricity. (Author)


The satellite solar power station (SSPS) concept is described and shown to represent a major challenge to engineering and an unparalleled opportunity to apply space technology for the benefit of mankind. Its feasibility is contingent upon no fundamental breakthroughs. Whether it is worth being realized is shown to depend upon criteria of comparative cost, resource conservation, or environmental enhancement that may vary in the future as technology developments provide new energy production alternatives. It is felt that the necessary steps to protect the SSPS option should be taken in the meantime. (Author)


With increasing attention focusing on the energy problem, considerable interest has recently surfaced relative to the potential use of solar energy as a power source for our nation. This paper assesses the possibilities for near-term and longer-range applications of solar energy, including a large space-based Satellite Solar Power Station. Many applications are well beyond the research phase and could be accelerated to commercial readiness. Longer-range applications should be pursued with appropriate technology development programs to provide this nation with energy options in the future. If the nation wants to use solar energy as a major power source, it is technically possible to do so. Further, with appropriate incentives and government support, the public can have this clean and abundant energy source economically. (Author)

Solar radiation is collected and converted to microwave energy by means maintained in outer space on a satellite system. The microwave energy is then transmitted to Earth and converted to electrical power for distribution. (Official Gazette)


It has been suggested by Glaser (1968) that large arrays of solar photovoltaic cells should be placed into space in near-equatorial synchronous orbit where the sun would shine upon them nearly 100 per cent of the time. The dc power obtained from the photovoltaic arrays would then be converted into microwave power, beamed to the surface of the earth, and there converted back into dc power. This concept has become known as the Satellite Solar Power Station (SSPS). The system configuration and characteristics of the SSPS are discussed together with the solar photovoltaic cell array, details of the microwave power transmission system, and side effects of the SSPS system.

G.R.


Discussion of a thermal conversion concept which is potentially feasible with today's solar concentrator technology and component efficiencies, if the low earth orbit transportation cost is approximately $60/ lb. The system is also potentially feasible with space shuttle transportation cost of approximately $160/ lb and 1980 component efficiencies if the solar concentrator can be constructed at approximately 0.03 lb/sq ft. The above conclusions are based on a projected competitive busbar value of electrical energy of 2 to 3 cents per kilowatt-hour. Projections indicate that launch systems technology can be expected ultimately to attain transportation costs as low as $10/ lb for low earth orbit missions. This value contributes $25 per kilowatt of system capital cost. (Author)


A satellite solar power system (SSPS) can be designed to generate electrical power on earth at specific levels ranging from about 3000 to 15,000 megawatt. Over this range of power output the orbiting portion of the SSPS exhibits the best power-to-weight characteristics. Additional solar collector arrays and antennas could be added to establish an SSPS system at a desired orbital location. With the receiving antenna placed either on land or on platforms over water near major load centers and tied into a power transmission grid, power could be delivered to almost any desired geographic location.

Consideration of the feasibility of setting up an orbiting solar reflector and orbiting space power generation and distribution plants. A system called Lunetta, designed for practically useful night illumination of areas of the earth's surface by a reflector in equatorial geosynchronous orbit, is described. The socio-economic value of the Lunetta is stressed by citing the possibility of conducting agricultural activities with its aid at night. Problems connected with the choice of size, location, and brightness of Lunetta are discussed, as well as problems of weight minimization and radiation-pressure compensation. The possibility of large-scale power generation in space, using nuclear, solar-thermal, and photovoltaic-reflector systems, is considered, as well as a power relay concept involving large antennas in geosynchronous orbit, reflecting and redirecting the energy flow of microwave beams. The ability of the Integrated Space Shuttle configuration selected by NASA and the Geospace Interorbital Transportation vehicle (incorporated in the Shuttle payload and then released in low orbit) to assist in the construction of large installations in geosynchronous orbit is evaluated.

A.K.

POWER WITHOUT POLLUTION


CSCI 108

Details of several methods of converting solar energy to power without pollution are given. Data cover technical, economic, and social issues.

E.H.W.


The concept of a satellite solar power station which would have the capability to convert solar energy to microwave waves which are beamed to a receiving antenna to produce power on Earth is presented. The state-of-the-art of the technology required to achieve efficient solar energy conversion, microwave power generation, transmission and rectification is reviewed. Approaches to structural design, flight control and Earth-to-Orbit transportation are presented.

(Author)


The feasibility of obtaining power from space by means of a satellite solar power station is reviewed. The requirements for a high-volume transportation system to low earth orbit followed by delivery of partially assembled components to geosynchronous orbit for final assembly and deployment are discussed. The steps required to develop the satellite solar power station are outlined with emphasis on supporting technology development and verification of technology readiness. The role of the Space Shuttle in spacebased flight verification activities is projected and requirements for Space Shuttle payloads are indicated.

(Author)


The principle on which a satellite solar power station (SSPS) is based is the conversion of solar energy into electricity. This electricity would be fed to microwave generators arranged to form an antenna which, in turn, would direct a beam to a receiving station on the earth where the microwave energy could be efficiently and safely converted back to electricity to meet base load power needs. The status of the technology required to meet the objectives of an SSPS is discussed.

F.R.L.


Discussion of the potential benefits that may be derived from future space missions, with special attention to space as a source of energy. The possibilities held forth by a satellite solar power station concept are reviewed in terms of the solar-energy conversion technology status, microwave generation and beam transmission, conversion of microwave power to DC power, and weight and cost projections.

M.V.E.
"Power in the Year 2001 Part 3—Solar Power"

The conjunction of several events—the space program, looming fossil-fuel depletion, degrading environment, and chronic power shortages—is slowly turning man's eyes toward the sun as the ultimate answer to our energy problems. Unlimited power via solar energy gathered and focused earthward by satellites, may yet prove to be the greatest tangible benefit from the space program.


Description of a concept for a satellite solar power station that involves collection of solar energy conversion to electrical power, and generation and transmission of microwaves. The microwave power, beamed from the satellite to an earth antenna, is converted into electrical power to be distributed through conventional power distribution networks. The technology required for such a satellite solar power station is explored, including conversion of solar energy to electrical power with photovoltaic solar cells, transmission of electrical power over superconducting lines to microwave generators, generation transmission and interception of microwaves, guidance and control of the satellite, and conversion of microwave power to dc power. Consideration is given to the payloads to be placed into orbit, orbit location, satellite station assembly methods, microwave beam interactions with the atmosphere, satellite and earth installation dimensions, and ultimately cost projections.

A.S.K.


The concept of an orbital facility for converting solar energy to stored fission energy for use in terrestrial power plants is reviewed in terms of overall system parameters and economics. It is suggested that the concept is worth studying in considerably greater detail.

M.V.E.


Methods of conversion of solar energy to power are discussed as a possible source of power without pollution. The topics include N/P silicon solar cells, solar power transmission techniques, guidance and control of solar cell systems, cooling equipment, and weight and cost projections for satellite solar power stations.

V.Z.


An American Astronautical Society publication.

Proceedings of a special AAS/ATIA technical event, held October 30, 1970 at Winrock, Arkansas at the invitation of Governor Winthrop Rockefeller.


Power from space - Technology transfer for human survival. Peter E. Glaeser.
POWER FROM THE WIND:

S. Walters.

Langley Res. Center vertical-axis windmill.

NASA SPURS WIND GENERATOR TECHNOLOGY.

W.A. Shumann.
Aviation Wk & Space Tech., Apr. 1, 1974, p. 41.

Component fabrication has begun for an experimental 100-kw wind turbine generator. It is the first hardware in a five year program of NASA and Nat. Science Foundation to study practical and economical wind energy conversion systems.


TILTING AT THE ENERGY CRISIS: A WINDMILL ON YOUR ROOF?

F.E. Bryson.

A number of people are erecting small wind-driven generators on hilltops and roofs. Even Uncle Sam is getting in the act. Wind generators are expensive, but they only cost money.

TAKING POWER OFF THE WIND.

Dr. Arthur Bruckner.

Britain is well suited for generating electrical power from the wind. Even with a 25 per cent load factor, aerogenerators coupled with a pumped storage scheme would be economically feasible today.
An electric energy generator is described that is driven by a wind-actuated turbine rotor rotatably supported on a vertically disposed sleeve telescoped over and journaled on a rigid upright supporting post. The rotor includes a plurality of vertically disposed louvers capable of independent pivotal movement about a vertical axis at the inner edge thereof for orientation in radial relation to the rotational axis of the rotor or substantially tangential so that wind will effectively drive the rotor. The rotor is also provided with lift wings on the upper surface thereof that may include stabilizers and shock absorbers fastened to the edge of the wings and the outer edge of the louver support to support part of the load as the rotor whirls in the air providing a floating power device. A wing assembly, which may be hollow and filled with helium gas to reduce the load, is supported on the sleeve above the rotor and includes propeller assemblies mounted thereon to operate the rotor during periods of no wind or only a very slight wind. Governor control means is provided for selectively latching the louvers in tangential relation to the path of movement thereof to prevent the rotor from ever-operating during periods of high wind. Gear assemblies are provided for rotating generators to provide an electrical output that can be used for various purposes thereby utilizing the wind power to produce electrical energy that can be used for various purposes. (auth)

S-451

WIND POWER: HOW NEW TECHNOLOGY IS HARNESSING AN AGE-OLD ENERGY SOURCE.
E.F. Lindsley.
Popular Science, July 1974, p.54-59,124,125.

Popular Science studies the real odds for and against this nonpolluting, inexhaustible power source in our fuel-short world.

REPORT ON RESULTS ACHIEVED WITH SEAS EXPERIMENTAL MIEHL
(Contract NASw-2481)
(NASA-TF-15518) Avail. NTIS HC $4.00 CSCI 10A
For many years, small windmills with generators and storage batteries have been available for supplying electrical energy to rural locations, but storage batteries are so expensive that this type of electrical supply is normally unrealistic. A better way of utilizing wind power in a smaller installation is to let the electrical current take care of home heating via a heat accumulator, which has low maintenance cost and simple electrical equipment. One such installation is described in this article, and figures on its economic feasibility are provided.

Edward J. Lehmann, and Axel C. Ringe.
COM-74-11183/WWE PCS $20.00/MFS $20.00.
The bibliography contains 154 selected abstracts of research reports retrieved using the NTIS on-line search system-NTISearch. The report is divided into two sections. The section on solar energy contains 100 abstracts dealing with solar heating for buildings, solar electric power generation, solar cells for terrestrial use, solar energy as a national resource, and solar stoves. The following 54 abstracts concern wind power cover such topics as its future, conversion systems, energy storage, propeller design, and its uses. Many of these reports on wind power are recent NASA translations of European and Russian research conducted from 1934 to 1959.

WINDMILLS: THE RESURRECTION OF AN ANCIENT ENERGY TECHNOLOGY.
Nicholas Wade.
The windmill seems fair set to make a comeback from the trash heap of technical history. Once a desirable symbol of archaic technology, the environmental reawakening and the sudden wane of the cheap energy era have left the windmill looking more like the feasible alternative power source that its enthusiasts claim it to be.
Energy from the Ocean: An Appraisal
Owen M. Griffin
Naval Research Lab Washington D.C May 74. 47p NRL-MR-2803
AD-779 877/0WE PC$3.25/M ISBN1 45

The oceans and their environment have long been envisioned as renewable sources of energy. It is the purpose of this report to assess the feasibility of drawing on the sea for power and to determine the extent to which the oceans are likely to serve future energy needs. A review is made of proposed U.S. funding levels for the research and development of renewable energy sources during the years 1975 - 1979, and a study is made of the technical and environmental acceptability status of tidal, wind, and sea thermal power generation systems. The estimated costs of these environmental power sources are compared with the prevailing power costs for nuclear and coal plants. On the basis of these comparisons, recommendations are made for a program of research and development, culminating in the construction of prototype plants, for wind and sea thermal power plants. Tidal power generation is found to be technically feasible but economically uninviting at present. (Author)
A MODEL FOR THE ECONOMIC EVALUATION OF WINDPOWER SYSTEMS.

Reported to Operations Research Soc. Amer.

THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering & Environmental Design, Univ. Miami, Coral Cables, Florida.
Sponsored by The National Science Foundation, Defense Advanced Research Projects Agency, and The School of Continuing Studies, Univ. of Miami.
Miami Beach, Florida, Mar.18-20,1974.

THE EFFECT OF ATMOSPHERIC TURBULENCE ON WINDMILL PERFORMANCE
T. E. Base, The University of Western Ontario, London, Ontario, Canada

BACK TO THE WINDMILL TO GENERATE POWER.

If any aspect of the energy shortage is considered humorous, it is the idea of erecting hundreds of giant windmills across the landscape to do their age-old job of converting the wind into power. But to a growing number of people, windmills are not such an absurd idea after all. Companies are now spending their own money to develop a new generation of windmills that will come to market as early as this year.
The utilization of wind energy is technically feasible as evidenced by the many past demonstrations of wind generators. The cost of energy from the wind has been high compared to fossil fuel systems. A sustained development effort is needed to obtain economical systems. The variability of the wind makes it an unreliable source on a short-term basis. However, the effects of this variability can be reduced by storage systems or connecting wind generators to fossil fuel systems, hydroelectric systems, or dispersing them throughout a large grid network. The NSF and NASA-Lewis Research Center have sponsored programs for the utilization of wind energy.

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WIND POWER. J. Collins.

Scope: The history and current status of windmills as a power source. Inexhaustible and pollution-free, wind power could produce prodigious amounts of energy if trapped on a large scale.

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WINDMILLS
J. McCaull.

Trapped on a large scale, wind power theoretically could produce prodigious amounts of electricity.
N74-16757® National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND ENERGY CONVERSION SYSTEMS
(Grant NSF AG-466) (NASA-TR-X-69786; NASA/RA/W-73-006) Avail: NTIS HC $15.50 CSCL 108
Economic feasibilities and energy conversion efficiencies are considered for various alternative energy sources that utilize wind forces. For individual titles, see N74-16758 through N74-16789.

PERCY THOMAS WIND GENERATOR DESIGNS
CSCL 108
The technical and economic feasibilities of constructing a windpowered generator with a capacity of 2,000 to 4,000 kilowatt are considered. Possible benefits of an integrated wind generating system in an electric utility network are elaborated. Applications of a windpowered waterpump, including its use as a pumping source for hydroelectric pump storage operations, are also mentioned. It is concluded that the greatest potential of the wind generator is to generate heat directly and not conversion to electricity and then to heat.

G.G.

SMITH-PUTNAM WIND TURBINE EXPERIMENT
Beachamp E. Smith in NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 5-7 (For availability see N74-16757 08-03)
CSCL 108
A brief outline of the many problems encountered during testing of a wind turbine generator prototype unit is given. Its feasibility was demonstrated by the generation of electricity in commercial quantities with delivery to a utility transmission network. The experiment was terminated after blade failure occurred.

G.G.

N74-16780® Stuttgart Univ., (West Germany).
PAST DEVELOPMENTS OF LARGE WIND GENERATORS IN EUROPE
CSCL 108
Physical size, maximum power output, and other characteristics of various windpower systems are shown in picture form.

G.G.

N74-16782® Tompkin (Joseph), Salem, Ore.
INTRODUCTION TO VOIGT'S WIND POWER PLANT
CSCL 108
The design and operation of a 100 kilowatt wind driven generator are reported. Its high speed three-bladed turbine operates at a height of 50 meters. Blades are rigidly connected to the hub and turbine revolutions change linearly with wind velocity, maintaining a constant speed ratio of blade tip velocity to wind velocity over the full predetermined wind range. Three generators installed in the gondola generate either dc or ac current. Based on local wind conditions, the device has a maximum output of 720 kilowatts at a wind velocity of 16 meters per second. Total electrical capacity is 750 kilowatts, and power output per year is 2,135,000 kilowatt/hours.

G.G.
N74-16764 West Texas State Univ., Canyon. NEED FOR A REGIONAL WIND SURVEY Vaughn Nelson and Earl Gilmore (Amarillo Coll.) In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 33-40 (For availability see N74-16757 08-03) CSCL 10B Accurate measurements for the purpose of estimating wind energies are proposed for those regions of the USA where the greatest potentials exists. Preliminary wind characteristic calculations from weather station data are provided for the Southern Great Plains region; wind energies from 153 to 212 kW-hr/ft squared per year) for 1970 to 1972 are determined. It is concluded that a wind energy survey based on data compiled from weather service stations is feasible for determining the energy potential of a windpowered integrated energy network.

G.G.

N74-16786 Oklahoma Univ., Norman. WIND POWER DEMONSTRATION AND SITING PROBLEMS Karl H. Bergry In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 41-45 (For availability see N74-16757 08-03) CSCL 10B Technical and economic feasibility studies on a small windmill to provide overnight charging for an electrically driven car are reported. The auxiliary generator provides power for heating and cooling the vehicle which runs for 25 miles on battery power alone, and for 50 miles with the onboard charger operating. The blades for this windmill have a diameter of 12 feet and are coupled through to a conventional automobile alternator so that they are able to completely recharge car batteries in 8 hours. Optimization of a windmill/storage system requires detailed wind velocity information which permits rational siting of wind power system stations.

G.G.

N74-16787 Oregon State Univ., Corvallis. WIND POWER RESEARCH AT OREGON STATE UNIVERSITY E. Wendell Henson In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 53-61 (For availability see N74-16757 08-03) CSCL 10B There have been two primary thrusts of the research effort to date, along with several supplementary ones. One primary area has been an investigation of the wind fields along coastal areas of the Pacific Northwest, not only at the shoreline but also for a number of miles inland and offshore as well. Estimates have been made of the influence of the wind turbulence as measured at coastal sites in modifying the predicted dependence of power generated on the cube of the wind speed. Wind flow patterns in the Columbia River valley have also been studied. The second primary thrust has been to substantially modify and improve an existing wind tunnel to permit the build up of a boundary layer in which various model studies will be conducted. One of the secondary studies involved estimating the cost of building an aerogenerator.

Author

N74-16788* Alaska Univ., Fairbanks. SURFACE WIND CHARACTERISTICS OF SOME ALEUTIAN ISLANDS c20 Tunia Warentz, Jr. In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 46-52 (For availability see N74-16757 08-03) CSCL 04B The wind power potential of Alaska is assessed in order to determine promising windpower sites for construction of wind machines and for shipment of wind derived energy. Analyses of near surface wind data from promising Aleutian sites accessible by ocean transport indicate probable velocity regimes and also present deficiencies in available data. It is shown that winds for some degree of power generation are available 77 percent of the time in the Aleutians with peak velocities depending on location.

G.G.

N74-16784 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio WHERE THERE IS A WIND, THERE IS A WAY Charles A. Mosher In Its Wind Energy Conversion Systems Dec. 1973 p 27-32 (For availability see N74-16757 08-03) CSCL 10B A shift in USA energy policy from oil or natural gases to thermonuclear fission and solar energy is predicted. A massive diversified energy research and development effort to productively harness the energy in the winds is outlined to develop commercially feasible wind energy conversion systems - considered a form of solar energy - in the near future.

G.G.
N74-16785* Princeton Univ., N.J.
AN INTRODUCTION TO THE PRINCETON SAILWING WINDMILL
CSCL 10B
Specifically discussed is the sailwing windmill. The aerodynamic characteristics of the sailwing itself are presented in condensed form and its natural application to the wind machine is discussed. Past and present sailwing windmill configurations are shown and the relative merits are compared. A section on a future promising configuration is presented and its compatibility to advanced technology electrical machinery is briefly discussed. Also included is a short bibliography. Author

N74-16770* Windworks, Inc., Mukwonago, Wis.
THE USE OF PAPER HONEYCOMB FOR PROTOTYPE BLADE CONSTRUCTION FOR SMALL TO MEDIUM-SIZED WIND DRIVEN GENERATORS
CSCL 11D
Paper honeycomb is used for the construction of conventional, propeller-type, windmill blades. Using fairly simple techniques and conventional power tools, it is possible to shape both simple foils and more complex foils with or without tapered plan forms and with or without varying profiles. A block of honeycomb, in its compressed form, is mounted on a wedge and run through a bandsaw with the table at an appropriate tilt angle. It is the combination of the wedge angle and the table angle that gives the tapered planform and profile shape. Next the honeycomb is expanded on the shaft and jigged to give the desired angles of attack. With the honeycomb fixed in position, the blade is covered with a fine weave fiberglass cloth. Any surface quality can then be achieved with filling and sanding. Author

THE SAIL WING WINDMILL AND ITS ADAPTATION FOR USE IN RURAL INDIA
Marcus M. Sherman In NASA, Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 76-79 refs (For availability see N74-16757 08-03)
CSCL 10B
An 8 meter-diameter prototype sail wing windmill is reported that uses a one-meter-diameter bulbous cartwheel to which three bamboo poles are latched in a triangular pattern with overlapping ends, to form the airframe for cloth sails. This device lifts 300 pounds to a height of 20 feet in one minute in a 10 mph wind.

N74-16772* Army Air Mobility Research and Development Lab., Moffett Field, Calif.
ROTOR DYNAMIC CONSIDERATIONS FOR LARGE WIND POWER GENERATOR SYSTEMS
CSCL 10B
Successful large, reliable, low maintenance wind turbines must be designed with full consideration for minimizing dynamic response to aerodynamic, inertial, and gravitational forces. Much of existing helicopter rotor technology is applicable to this problem. Compared with helicopter rotors, large wind turbines are likely to be relatively less flexible with higher dimensionless natural frequencies. For very large wind turbines, low power output per unit weight and stresses due to gravitational forces are limiting factors. The need to reduce rotor complexity to a minimum favors the use of cantilevered (hingeless) rotor configurations where stresses are relieved by elastic deformations. Author

THE EFFECT OF AERODYNAMIC PARAMETERS ON POWER OUTPUT OF WINDMILLS
W. Wiener In NASA, Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 89-95 (For availability see N74-16757 08-03)
CSCL 10B
Aerodynamic results for a study on windpower generation are reported. Windmill power output is presented in terms that are commonly used in rotary wing analysis, namely, power output as a function of drag developed by the windmill. Effects of speed ratio, solidity, twist, wind angle, blade setting and aerodynamic characteristics are given. Author

VERTICAL AXIS WIND ROTORS: STATUS AND POTENTIAL
W. Vance In NASA, Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 96-102 (For availability see N74-16757 08-03)
CSCL 10B
The design and application of a vertical axis wind rotor is reported that operates as a two stage turbine wherein the wind impinging on the concave side is circulated through the center of the rotor to the back of the convex side, thus decreasing what might otherwise be a high negative pressure region. Successful applications of this wind rotor to water pumps, ship propulsion, and building ventilators are reported. Also shown is the feasibility of using the energy in ocean waves to drive the rotor. An analysis of the impact of rotor aspect ratio on rotor acceleration shows that the amount of venting between rotor vanes has a very significant effect on rotor speed for a given wind speed.
ADVANTAGES OF THE DIFFUSER-AUGMENTED WIND TURBINE
CSCL 108
Performance optimization for a wind turbine is realized by using a shrouded diffuser to produce up to twice the power of unshrouded turbines of the same size. The diffuser converts the kinetic energy of the flow downstream of the rotor into a pressure rise and thus makes it possible for the rotor to capture airflow from a free stream tube area that is greater than that from the rotor itself. The flow velocity through the shrouded rotor is 20 to 60 percent greater than the free wind velocity as opposed to 67 percent less for the unshrouded case. The diffuser also makes it possible to accommodate very high wind speeds without the need of variable pitch in the rotor blades. G.G.

BUCKET ROTOR WIND-DRIVEN GENERATOR
Howard H. Chang and Horace McCracken (Sunwater Co.) In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 107-108 (For availability see N74-16757 08-03)
CSCL 108
As compared with the ordinary propeller type rotor, the bucket rotor is limited in rotational speed since the tip rotor speed can never exceed the wind speed. However, it does not present the blade fatigue problem that the ordinary rotor has and it perhaps causes less ground pollution. The deflector vanes also provide a venturi passage to capture greater wind flow. The bucket rotors can be strung together end-to-end up to thousands of feet long to produce large amounts of power. Author

WIND-POWERED ASYNCHRONOUS AC/DC/AC CONVERTER SYSTEM
CSCL 108
Two asynchronous ac/dc/ac systems are modeled that utilize wind power to drive a variable or constant hertz alternator. The first system employs a high power 60-hertz inverter to tie the large backup supply of the power company to either supplement them from wind energy, storage, or from a combination of both at a preset desired current. rectifier and inverter are identical and operate in either mode depending on the silicon control rectifier firing angle. The second system employs the same rectification but from a 60-hertz alternator arrangement; it provides mainly dc output, some sinusoidal 60-hertz from the wind bus and some high harmonic content 60-hertz from an 800-watt inverter. G.G.
N74-16781* General Electric Co., Santa Barbara, Calif.
USE OF HYDROGEN AND HYDROGEN-RICH COMPONENTS AS A MEANS OF STORING AND TRANSPORTING ENERGY
Walter Hausz In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 130-134 (For availability see N74-16757 08-03) CSCL 10C
A one-megawatt wind energy source is assumed that uses half of its output to serve customers as electricity, and stores the other half by conversion to hydrogen, to liquid hydrogen, to stored LH2, and back to electricity. Energy costs and capital costs of the conversions escalate unit costs to 12.9 cents per kilowatt hour. High conversion costs can be reduced by using Mg2NiH4 and FeTiH2 storage, or by using a 100- or 1000 megawatt system.
G.G.

STATUS AND APPLICABILITY OF SOLID POLYMER ELECTROLYTE TECHNOLOGY TO ELECTROLYTIC HYDROGEN AND OXYGEN PRODUCTION
W. A. Titterington In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 136-138 (For availability see N74-16757 08-03) CSCL 10B
The solid polymer electrolyte (SPE) water electrolysis technology is presented as a potential energy conversion method for wind driven generator systems. Electrolysis life and performance data are presented from laboratory sized single cells (7.2 sq in active area) with high cell current density selected (1000 ASF) for normal operation. Author

N74-16783* Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.
SUPERFLYWHEEL ENERGY STORAGE SYSTEM
David W. Rabenhorst In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 137-145 refs (For availability see N74-16757 08-03) CSCL 10B
A windpowered system using the superflywheel configuration for energy storage is considered. Basic elements of superflywheels are thin rods assembled in pregrooved hub lamina so that they fan out in radial orientation. Adjacent layers of hub lamina are assembled 90 degree in rotation to each other so as to form a circular brush configuration. Thus stress concentrations and rod failure are minimized and realistic failure containment for a high performance flywheel is obtained.
G.G.

N74-16784* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
BATTERIES FOR STORAGE OF WIND-GENERATED ENERGY
Harvey J. Schwartz In its Wind Energy Conversion Systems Dec. 1973 p 146-151 (For availability see N74-16757 08-03) CSCL 10C
Cost effectiveness characteristics of conventional-, metal gas-, and high energy alkali metal-batteries for wind generated energy storage are considered. A lead-acid battery with a power density of 20 to 30 watt/hour per pound is good for about 1500 charge-discharge cycles at a cost of about $80 per kilowatt hour. A zinc-chlorine battery that stores chlorine as solid chlorine hydrate at temperatures below 10 C eliminates the need to handle gaseous chlorine; its raw material cost are low and inexpensive carbon can be used for the chlorine electrode. This system has the best chance to replace lead-acid. Exotic alkali metal batteries are deemed too costly at the present stage of development.
G.G.

N74-16785* InterTechnology Corp., Warrenton, Va.
ENERGY STORAGE BY COMPRESSED AIR
George C. Szego In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 152-154 (For availability see N74-16757 08-03) CSCL 10C
The feasibility of windpower energy storage by compressed air is considered. The system is comprised of a compressor, a motor, and a pump turbine to store air in caverns or aquifers. It is proposed that storage of several days worth of compressed air up to 650 pounds per square inch can be used to push the aquifer up closer to the container dome and thus initiate piston action by simply compressing air more and more. More energy can be put into it by pressure increase or pushing back the water in the aquifer. This storage system concept has reheat flexibility and lowest cost effectiveness.
G.G.

N74-16786* Jacobs Wind Electric Co., Inc., Fort Myers, Fla.
EXPERIENCE WITH JACOBS WIND-DRIVEN ELECTRIC GENERATING PLANT, 1931 - 1967
Marcus L. Jacobs In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 155-158 (For availability see N74-16757 08-03) CSCL 10B
Engineering, construction, performance, electric output, and different uses of the wind electric 2500- to 3000-watt plant are outlined. After several years of testing different types of windmills, the three blade aeroplane type of propeller was found to be far superior in power output. By means of a flyball governor operated, variable pitch speed control, the maximum speed of the propeller was accurately and easily controlled, to prevent excessive speeds in high winds and storms. The three blade propeller was found to be necessary to prevent excessive vibration whenever the shift of the wind direction required the plant to change its facing direction on the tower.
Author
REVIEW OF THE WINDPOWER ACTIVITIES AT THE BRACE RESEARCH INSTITUTE

T. A. Lawand In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 159-164 (For availability see N74-16757 08-03)

CSCL 10B

A chronology of windpower studies at the experimental station on Barbados is presented that includes the various development activities on wheeled windmills whose power output is utilized through electrical and electronic systems. A list of institute publications on windpower is included. G.G.

WIND POWER SYSTEMS FOR INDIVIDUAL APPLICATIONS

Henry M. Clew In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 165-169 (For availability see N74-16757 08-03)

CSCL 10B

A small windpower system is described which is suitable for electrifying a house. The self-contained unit consists of a two kilowatt wind driven generator, a set of 19 storage batteries, a small dc to ac inverter, and a gasoline generator for use as an emergency backup system in case of prolonged calm periods. Cost effectiveness of the electricity generated by this windmill system comes out to about 15 cents per kilowatt hour assuming a 10 year life for the batteries and a 20 year life for the other components. Some other small windpower systems are also described, and it is shown that a windpowered generator in the 15- to 25-kilowatt output range coupled to a direct heated water storage system is able to heat a typical New England home. G.G.

ECONOMIC CONSIDERATIONS OF UTILIZING SMALL WIND GENERATORS

Robert Dodge In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 170-173 (For availability see N74-16757 08-03)

CSCL 10B

The economic feasibility of small wind generators is compared to that of solar cells, primary batteries, thermoelectric generators, and engine generators. It is shown that small wind generator plants offer an attractive alternative to primary battery systems and constantly running engines to generate power in remote areas. The limitation is an annual average wind velocity of at least 9 to 10 mph. Presently available units are most useful in the average load range of 10 to 1000 watts. G.G.

FRENCH WIND GENERATOR SYSTEMS

John M. Noel In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 186-186 (For availability see N74-16757 08-03)

CSCL 10B

The experimental design of a wind driven generator with a rated power of 800 kilovolt amperes and capable of being connected to the main electrical network is reported. The rotor is a three bladed propeller: each blade is twisted but the fixed pitch is adjustable. The asynchronous 800-kilovolt ampere generator is driven by the propeller through a gearbox. A dissipation resistor regulates the machine under no-load conditions. The first propeller on the machine lasted 18 months; replacement of the rigid propeller with a flexible structure resulted in breakdown due to flutter effects. Author
THE OREGON STATE UNIVERSITY WIND STUDIES
CSCL 10C
The economic feasibility of commercial use of wind generated power in selected areas of Oregon is assessed. A number of machines for generating power have been examined. These include the Savonius rotor, translators, conventional wind turbines, the circulation controlled rotor and the vertical axis winged turbine. Of these machines, the conventional wind turbine and the vertical axis winged turbine show the greatest promise on the basis of the power developed per unit of rotor blade area. Attention has been focused on the structural and fatigue analyses of rotors since the economics of rotary winged wind generated power depend upon low cost, long lifetime rotors. Analysis of energy storage systems and tower design has also been undertaken. An economic means of energy storage has not been found to date. Tower design studies have produced cost estimates that are in general agreement with the cost of the updated Putnam 110-foot tower.
Author

A PROPOSED NATIONAL WIND POWER R AND D PROGRAM
CSCL 10B
An offshore wind power system is described that consists of wind driven electrical dc generators mounted on floating towers in offshore waters. The output from the generators supplies underwater electrolyzer stations in which water is converted into hydrogen and oxygen. The hydrogen is piped to shore for conversion to electricity in fuel cell stations. It is estimated that this system can produce 159 x 10^6 kw-hr per year. It is concluded that solar energy - and that includes wind energy - is the only way out of the US energy dilemma in the not too distant future.

A COMMENT ON TOWERS FOR WINDMILLS
CSCL 10B
Design considerations for windmill tower structures include the effects of normal wind forces on the rotor and on the tower. Circular tabular or masonry towers present a relatively simple aerodynamic solution. Economic factors establish the tubular tower as superior for small and medium sized windmills. Concrete and standard concrete block designs are cheaper than refabricated steel structures that have to be freighted.

SOME EXTREMENEOUS COMMENTS ON OUR EXPERIENCES WITH TOWERS FOR WIND GENERATORS
CSCL 10D
A wind generator tower must be designed to withstand fatigue forces and gust winds loads. Optimum tower height depends on the energy cost to the customer because an increase in height results in an increase in the cost of the plant. It is suggested that costs are minimum for the shortest tower possible and that the rotor should be as large as possible.

WIND MACHINES
P. B. S. Leseen in NASA. Lewis Res. Center: Wind Energy Conversion Systems Dec. 1973 p 208-239 (For availability see N74-18757 08-03)
CSCL 04B
The basic elements of the air/water momentum exchange are described by the environment, the potential, the air and water subsystems, the total system, and the rule. Many of these topics have direct analogues in aerogenerator design. Aspects of optimal sail design and of waveless hulls are briefly outlined. A wind driven vehicle capable of moving directly downwind faster than the wind, is reported. The lecture is illustrated with slides and move clips showing surfing catamarans, land and water versions of the Bauer vehicle, hang gliding, land sailing, and wind surfing.

WIND ENERGY CONVERSION RESEARCH is considered in the framework of the national energy problem. Research and development efforts for the practical application of solar energy -- including wind energy -- as alternative energy supplies are assessed in: (1) Heating and cooling of buildings; (2) photovoltaic energy conversion; (3) solar thermal energy conversion; (4) wind energy conversion; (5) ocean thermal energy conversion; (6) photosynthetic production of organic matter; and (7) conversion of organic matter into fuels.

Excerpts from 'I Built a Wind Charger for $400!' by J. Sencenbaugh are included.

AERO ENGINEERS BUILD BETTER WINDMILLS.
(Canadian and Princeton Univ.)

WINDMILLS - THE CHIMERA OF FREE ELECTRICITY.


TRY AND CATCH THE WIND.
N74-16789* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA PRESENTATION
Ronald L. Thomas In its Wind Energy Conversion Systems Dec. 1973 p 244-253 (For availability see N74-16757 08-03)
CSCL 106
The development of a wind energy system is outlined that supplies reliable energy at a cost competitive with other energy systems. A government directed industry program with strong university support is recommended that includes meteorological studies to estimate wind energy potentials and determines favorable regions and sites for wind power installations. Key phases of the overall program are wind energy conversion systems, meteorological wind studies, energy storage systems, and environmental impact studies. Performance testing with a prototype wind energy conversion and storage system is projected for Fiscal 1977.
G.S.

CH-140,245
1972
POLLUTION-FREE ENERGY FROM OFFSHORE WINDS.
William E. Heronemus, Massachusetts U.

Marine Technology Society
Massachusetts U.
Marine Technology Society Conference Sept. 11-13, 1972

Power sources, Wind
Hydrogen
Fuel cells
L-1-9-74

S-412

ELECTRIC POWER FROM WINDMILLS?
S. Kidd and D. Carr

Many attempts have been made to tap the wind's power - all failures. Now a unique blade design may make windmills serious business.

(Lowering blades)

Power from the offshore winds. W.E.Heronemus (Univ. Massachusetts, Amherst, USA).
It has been estimated that the total rate of conversion between available potential energy and kinetic energy in the atmosphere of the whole Northern Hemisphere in winter is about 10^14 kilowatts reducing to about sixty percent of that value in summer. The Westerlies are of particular significance to the United States because in a sense they are a bonus of solar energy. The atmospheric and oceanic processes which create their energy occur over the adjacent and distant oceans as well as over the land mass; the result is felt particularly along landto-water boundaries. It is suggested that man might once again turn to those winds and to the ocean currents which they help to sustain to help satisfy his need for energy. If such energy were used, it would be essentially pollution-free and would have a neutral effect on global heating. A number of concepts for Offshore Wind Power Systems are proposed. (19 refs.)
Fink, Donald E.: New Air Foil Design Method Developed.

A Russian design for a windmill station which will operate off the jet stream.

Notes on the Development of the Brace Airscrew Windmill as a Prime Mover.

Brace Inst., McGill Univ.

32-ft diameter cheap power source.

Notes on the development of the Brace airscrew windmill as a prime mover; R. E. CHILCOFF; Aeronautical J. 73 (7) Dec 1969 p. 333-334: A 32 ft diam airscrew windmill, fabricated of fiber-glass reinforced epoxy resin, is used as a prime mover in irrigation and vapor compression distillation applications. The three-blade fixed pitch screw is coupled to a deep-well turbine pump through truck transmission parts. The success of this installation demonstrates the feasibility of using such a system of built readily available parts, for harnessing wind power economically.

Utilization of Wind Power in Arid Areas of Rajasthan, N.L. KACHHAR. Indian J. Power & Water Supply Research 17 (2) Aug 1967 p. 21-30. Estimation of available wind power in Rajasthan shows that it is possible to have outputs of 10, 50, 60, and 100 kw with various rotor diameters; use of wind power for irrigation, corn grinding, fodder cutting and similar jobs.

1701

N68-33881# Mississippi State Univ. State College. Dept of Aerophysics and Aerospace Engineering.
DEVELOPMENT OF AN ENGINE-POWERED LIQUID DISPERSAL SYSTEM FOR AGRICULTURAL AIRCRAFT
Contract AF-66-WA-1531 (FAA-D-68-3: AD-671891)

The report presents the results of efforts to design, a liquid dispersal system for agricultural aircraft which would have lower power requirements as compared to standard windmill powered pump systems. The resulting system consisted of a standard spray pump powered from the aircraft engine accessory drive and a spray boom mounted in the wing. The maximum power requirement for the final configuration was 12.5 brake horsepower at 100 miles per hour as compared to 52 brake horsepower for the standard system. Significant increases in climb performance and reduction of level flight power requirements were measured. No adverse effects on stall characteristics and control feedback were noted.

Author (TAB)

Putting the wind to work
Anon., Engineering, Lond., 285 (1965), 700-701 (23 Nov. 1965). Wind might provide competitive power for water desalination, particularly if reverse osmosis is further developed.

1967
Power supply by wind energy to households and farms at a distance from settlements

Dóry, B., Energia Atomtech., 19 (8), 348-348, (1966). 12% of the population of Hungary lives on farms distant from larger settlements. It is practicable to use low-power windmills for the power supply of isolated houses and farms. A windmill driving a 200-400 W generator with battery will cover the power required by a household and farmyard. The promising results of wind measurements conducted thus far constitute an objective basis for calculations. The establishment of major units is expedient as well as economical, in Hungary the cost of establishing 800 m of a 35 kw power line is equal to that of a 50 kW windmill. A 50 kW windmill could provide for the water-husbandry of 200-230 hectares on a 45 m high slope. The cost of establishing a windmill covering a delivery head of 10 m is only one-quarter of the former, its return period being 1-2 years. The utilization of wind energy can be combined with that of farm gas and pneumatic energy storage.

1966

N35-3046F National Aeronautical Lab., Bangalore (India). A NOTE ON THE FEASIBILITY OF WIND GENERATION OF ELECTRIC POWER FOR COMMUNICATION LINKS IN INDIA
S. P. Venkiteshwaran, K. R. Sivaraman, and C. G. Gupte Feb. 1965 19 p refs (TN-WP-36-65) CFSTI: HC $1.00/MF $0.50
The power requirements of solid-state microwave radio links are very low, and could be adequately met by storage batteries charged by small wind electric generators. This would be possible at sites that are sufficiently windy to operate the generator to give a stable output. Wind electric generators in this range are not commercially available in this country at present. The paper describes a wind electric generator designed in the laboratory for this purpose. The estimates of output watt-hours using such a generator at five stations in India have also been computed in the paper.

1964

N35-2006F National Aeronautical Lab., Bangalore (India). OPERATING EXPERIENCE OBTAINED WITH A 100 KW WIND POWER PLANT
(Available NASA-7F-15066) Avail: NTIS HC $3.50 CSCL 10A
An excerpt is given from the report on experiments and experience associated with the wind power plant and covering design data and those aspects which were decisive in its layout and the type of regulating provisions used, as well as results of the detailed operational tests. The regulating system and the automatic cut-in provisions permit the system to be connected automatically to the public power supply network on the basis of a specific program. The various types of wind conditions considered in designing the power plant are described.

1964

M. S. Prakash Rao and S. R. Radhakrishnan Dec. 1964 24 p ref. Revised (TN-WP-17-62) CFSTI: HC $1.00/MF $0.50
The hourly wind speeds at Kodikanal have been used to estimate the energy extractable from the wind. The number of hours of low winds, the spells of such low winds with different durations and the diurnal variation of the wind are discussed. The annual mean wind speed works out to 11 kmph. The annual output of a wind electric generator of 30 sq.m swept area and an overall power coefficient of 12 percent works out to 1,553 kWh. The water pumping capacity of a WP-2 type windmill is 55.850 kL (12,310,000 gallons) per annum or 36.500 gallons per day.

Author

1964

N35-22066F National Aeronautical Lab., Bangalore (India). UTILISATION OF WIND POWER IN ARID AND SEMI-ARID AREAS IN INDIA
S. P. Venkiteshwaran and K. R. Sivaraman Nov. 1964 23 p refs (TN-WP-35-64)
The WP-2 type of water pumping windmill is useful in regions of low and moderate wind speeds. The average wind speed at most of the places in Rajasthan during the summer months, which are the windiest, varies from 12 to 18 km per hour and the windmill gives its optimum output in this range of wind speeds. The wind speed data available for five stations in Rajasthan have been analyzed, and the monthly quantities of water that can be pumped by a WP-2 windmill through a height of 10 meters have been worked out for these stations. It is seen that the WP-2 windmill can pump about 15,000 gal of water per day through a height of 10 meters under favorable wind speeds during summer months. The economics of operation of WP-2 windmills at these places has also been studied. At all places studied the water pumped is a maximum during the summer months. A study of the characteristics of wind electric generators of different capacities ranging from 1kW to 25kW in relation to the wind regime in Rajasthan shows that wind electric generators in the range of 2 to 8 kW are comparatively economical.

Author
N64-29491  Oklahoma State U., Stillwater
THE BASIC TECHNICAL PROBLEMS ASSOCIATED WITH A
SOLAR TO ELECTRICAL SYSTEM WITH INTERMEDIATE
ENERGY STORAGE
C. M. Summers In its Proc. of a Conf. on Energy Conversion
and Storage p 89-95 (See N64-29484 21-06) Okla. State U.
$5.00
The five basic groups of components for a proposed pilot-
plant operation, based on solar to electrical energy conver-
sion with intermediate energy storage, are listed. The tech-
nological problems associated with each group include these:
(1) the solar (in this case, wind energy) to electrical energy
transducer; (2) the electrolysis and storage system; (3) the fuel
cell; (4) the solid-state inverter system; and (5) reversion components to convert e.*= electrical energy to a fuel storage
M.P.G.

PERFORMANCE OF THE 6-8 KW ALLGAIER WIND ELECTRIC
GENERATOR AT PORBANDAR.
Rao, D.V.L. and Venkiteshwaran, S. P.
National Aeronautical Lab., Bangalore, India.
TN-WP-33-63 Dec. 1963 32 pages

N64-29488  Oklahoma State U., Stillwater
A QUANTITATIVE EVALUATION OF POWER DENSITY AND
STORAGE CAPACITY FOR SOLAR AND WIND ENERGY
C. M. Summers In its Proc. of a Conf. on Energy Conversion
and Storage p 15-33 (See N64-29484 21-06) Okla. State U.
$5.00
Increasing efficiencies of fuel cells that convert and re-
convert hydrogen and oxygen fuel and electricity directly makes
the age-old dream of utilizing solar energy more feasible.
Calculations of the annual mean power-density value, of the
efficiency of solar conversion units, and of the storage ca-
pacity required show that this method is not economically feasible at present. The same calculations made for wind energy
(another form of solar energy) show that wind energy conver-
sion is technically and economically feasible. A comparison of
solar-energy and wind-energy power-density data shows that
in those months when the sunlight is above average, the wind
energy is below average; therefore, a combination of the two
energy sources might be used to produce a more constant output.
M.P.G.

1963

N64-13346  National Aeronautical Lab., Bangalore (India)
A STUDY OF THE HourLY WIND SPEEDS AT JAIPUR FROM
THE POINT OF VIEW OF WIND POWER UTILIZATION
M. S. Prakasa Rao and S. R. Radhakrishnan Apr. 1963 19 p
refs (TN-WP-25-63)
Certain characteristics of wind, such as frequency distri-
bution, spells of low winds, and the diurnal variation are
discussed. The annual energy output of an aerogenerator of
30 m² swept area and an overall power coefficient of 12 per-
cent is estimated at 561 kwh. The annual water pumping
capacity of a direct-acting windmill with the same overall
power coefficient, but with a swept area of 23.6 m² (WP-2-
type windmill), is estimated at about 17,550 l (3,861,000
gal), i.e., 10,580 gal/day. The annual mean wind speed is
7 km/hr.

N64-13345  National Aeronautical Lab., Bangalore (India)
A STUDY OF HourLY WIND SPEEDS AT BHOPAL FROM THE POINT OF VIEW OF
WIND POWER UTILIZATION
M. S. Prakasa Rao Apr. 1963 21 p ref
(TN-WP-23-63)
The yearly average wind speed at Bhopal
is 11 km/hr. The annual energy output is 1,370 kwh for a wind
electric generator with an overall power coefficient of 12 per-
cent. The annual water pumping capacity of a WP-2-type wind-
mill is estimated at about 42,000 l (1,124,000 gal).

1/27/64 3

N65-85480
UTILIZATION OF WIND POWER FOR IRRIGATION OF CROPS
IN INDIA WITH SPECIAL REFERENCE TO THE DISTRIBUTION
OF WIND AND RAINFALL.
Sivaraman, K. R. and Venkiteshwaran, S. P.
National Aeronautical Lab., Bangalore, India.
Nov. 1973 18 pages TN-WP-30-63
(Planted at the Symp. on Optimum Requirements
and Utilization of Water for Irrigation of Crops,
Central Board of Irrigation and Power, New Delhi,
Nov.1963.)
International Seminar on Solar and Aeolian Energy

Methods of assessing the potentialities of wind power on different scales of utilization.
E.W. Golding. p.152-

The need for simplicity in the design of windmills
L. Sterne. p.158-

Lay-out optimisation for wind-power plants.
U. Rutter. p.173-

Proposed method of wind energy computation.
S. Papagianakis. p.204-

The aeolian energy in Greece. S. Papagianakis. p.208-

Generation of Power from Wind In East Pakistan. A. ROBAIN
Inst Engr (Pakistan)—Annual Convention—Tech Papers v 13 Apr 1962 p 1-4. Developments in field of wind power are described, including wind driven Smith-Putnam turbine rated at 1500 kw constructed in 1941 at top of 1500 ft high peak in Vermont, United States, feeding alternating current synchronously to high-line of utility system; investigation of possibilities of generating cheap electricity by utilizing power from wind is recommended; tables of mean wind speed for 6 stations in East Pakistan and average speeds of winds 1600 ft above ground in one station are given.

The Schoenemberg directional radio station is located far from public power lines on a hilltop where the average wind velocity is 5.6 m/sec. The station, as first designed, required 28 kWh/day of dc power. It uses two Allgair wind power systems. Dr. Hutter type WE/G/B, with a nominal output of 8 kw at 4 m/sec and 1 kw at 4.2 m/sec wind velocity mounted on two 10-m high tubular poles. The dc generators are differentially compounded, shunt-wound. Lead storage batteries of 110 cells and 216 Ah are used to stabilize the output and store the energy. A diesel generator set is available as an emergency system. Tests show that more than 90% of the power required for the initial unmodified communications system could probably have been supplied by the wind power system. The results were completely positive. Wind power stations are economically advantageous wherever it is expensive to connect to the public power system, whether adequate wind is available and especially when only a moderate amount of power is required. Author

Ser & India Research v 18A n 8 Aug 1960 p 372-8. Design of windmills for 6 to 10 mph wind velocities; two pumping water windmill designs are described; momentum and blade element theories; general requirements and design variable values; various blade rotor were studied and theoretical torque and power values determined; specifications for two windmills suitable for conditions in India.

585
Two fundamental problems of windmill design are considered in this article: determining the dimensions of the machine and its output. Economic and engineering considerations make it possible to define the most advantageous characteristics for a windmill. In view of available wind power in the Atlantic region, it is of immediate interest to use wind generators.

Windmills for Electric Power Supply in Remote Areas. G. GIMPHEL, A.H. STODHART, Brit. Elect. & Allied Industries Research Assn.—Tech Report C/T150 1958 24 p. Analyze economic and technical requirements for such windmills; review of probable applications and of known wind conditions from many parts of world; it is suggested that single diameter of wind rotor, in region of 70 ft, is likely to meet with widest applications; recommendation for use of fixed-pitch blades in wind rotor; choice of most economic height for windmill.

La production d’electricite electrique par eoliennes, L. VADOE, Houille Blanche, no.5, p.503-530 Oct. (France) 1958

The characteristics of a propeller-driven electrical generating machine using wind power are presented. The construction of an installation for the equipment is described. The measurements conducted during the performance tests are analyzed. Author.

Windmill Type B30. G. GIMPHEL. Engineering v 155 n 4512 May 30 1958 p 686-90. Attempt made to follow thread of development of wind driven generator to present day, by examining construction of some of more important machines built, both in Great Britain and overseas.

Windmill, Today, G. GIMPHEL. Engineering v 155 n 4512 May 30 1958 p 686-90. Attempt made to follow thread of development of wind driven generator to present day, by examining construction of some of more important machines built, both in Great Britain and overseas.


Old-Fashioned Windmill Generates Electricity. R. WALTERS, Engineering v 155 n 4512 Aug 1 1958 p. 188. Particulars of windmill; at Westbrook, near Utrecht, opened July 16 to provide electric power with shutters and sails; provided with servo motor, controlled by wind vane, for turning cap.

Windmills for Electric Power Supply in Remote Areas. G. GIMPHEL, A.H. STODHART, Brit. Elect. & Allied Industries Research Assn.—Tech Report C/T150 1958 24 p. Analyze economic and technical requirements for such windmills; review of probable applications and of known wind conditions from many parts of world; it is suggested that single diameter of wind rotor, in region of 70 ft, is likely to meet with widest applications; recommendation for use of fixed-pitch blades in wind rotor; choice of most economic height for windmill.

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Windmill, Today, G. GIMPHEL. Engineering v 155 n 4512 May 30 1958 p 686-90. Attempt made to follow thread of development of wind driven generator to present day, by examining construction of some of more important machines built, both in Great Britain and overseas.


Old-Fashioned Windmill Generates Electricity. R. WALTERS, Engineering v 155 n 4512 Aug 1 1958 p. 188. Particulars of windmill; at Westbrook, near Utrecht, opened July 16 to provide electric power with shutters and sails; provided with servo motor, controlled by wind vane, for turning cap.

Windmills for Electric Power Supply in Remote Areas. G. GIMPHEL, A.H. STODHART, Brit. Elect. & Allied Industries Research Assn.—Tech Report C/T150 1958 24 p. Analyze economic and technical requirements for such windmills; review of probable applications and of known wind conditions from many parts of world; it is suggested that single diameter of wind rotor, in region of 70 ft, is likely to meet with widest applications; recommendation for use of fixed-pitch blades in wind rotor; choice of most economic height for windmill.

La production d’electricite electrique par eoliennes, L. VADOE, Houille Blanche, no.5, p.503-530 Oct. (France) 1958

The characteristics of a propeller-driven electrical generating machine using wind power are presented. The construction of an installation for the equipment is described. The measurements conducted during the performance tests are analyzed. Author.

Windmill, Today, G. GIMPHEL. Engineering v 155 n 4512 May 30 1958 p 686-90. Attempt made to follow thread of development of wind driven generator to present day, by examining construction of some of more important machines built, both in Great Britain and overseas.


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Windmills for Electric Power Supply in Remote Areas. G. GIMPHEL, A.H. STODHART, Brit. Elect. & Allied Industries Research Assn.—Tech Report C/T150 1958 24 p. Analyze economic and technical requirements for such windmills; review of probable applications and of known wind conditions from many parts of world; it is suggested that single diameter of wind rotor, in region of 70 ft, is likely to meet with widest applications; recommendation for use of fixed-pitch blades in wind rotor; choice of most economic height for windmill.

La production d’electricite electrique par eoliennes, L. VADOE, Houille Blanche, no.5, p.503-530 Oct. (France) 1958

The characteristics of a propeller-driven electrical generating machine using wind power are presented. The construction of an installation for the equipment is described. The measurements conducted during the performance tests are analyzed. Author.

Windmill, Today, G. GIMPHEL. Engineering v 155 n 4512 May 30 1958 p 686-90. Attempt made to follow thread of development of wind driven generator to present day, by examining construction of some of more important machines built, both in Great Britain and overseas.
Testing of Wind-Driven Generators Operating in Parallel with Network, D.E. VILLERS, Brit. Elec. & Allied Industries Research Assn—Tech Report C/T114 1957 p 32. Method for establishment of steady state relationship between generator output and wind speed; tests carried out on 10-kw machine connected to public supply network; comparison of results with calculated output characteristics of machine; suggestions for further work on testing of wind driven machines connected to network or running as isolated unit.

Surveying for Wind Power in Australia, L.F. MULLETT, Ind. Eng. Australia p 29 n 3 Mar 1957 p 69-72. Wind survey operated by Electricity Trust of South Australia is described, and general level of accessible wind energy is deduced from wind recordings. Cost of electricity obtainable from wind is estimated not to exceed 0.35/kw-yr for large machines and 1.6/kw-yr for small machines suitable for isolated rural systems.

Electrical Energy from Wind, E.W. GOLDING, Eng J v 40 n 4 June 1957 p 836-64. Characteristics of wind as source of power and its possibilities for generation of electrical energy; types of windmill; description of main features of some recent designs; wind power research and development work in Great Britain; economic of wind power on three scales of utilization. 22 refs.

Wind-Operated Electric Power Supply, W. MARRISON, Elec Eng v 76 n 8 May 1957 p 418-21. System described has single rotating member and no moving electric contacts; turbine type of wind rotor is mounted on vertical shaft rotating within set of stationary deflecting blades; all wind directions are equally favorable; electric generator is of multipole rotating magnetic rotor type and generates a-c having frequency 30 times rotation speed.


1957

537.1

Golding, E. W.

Harnessing Wind Energy in Arid Zones of Rajasthan, B. S. SAWAL: Irrigation & Power. J. of Central Board of Irrigation & Power (India) v 13 n 3 July 1956 p 382-5. Modern windmill is designed to work on low velocities and yet lift water from great depths; it is capable of working on velocities as low as 4 mph attaining maximum efficiency at 6-7 mph; use of windmills as source of power for pumping water in Rajasthan.

Experimental Study of Wind Structure (With Reference to Design and Operation of Wind-Driven Generators), J. F. WAX, Brit. Elec. & Allied Industries Research Assn—Tech Report C/T114 1956 p 4 plates; also abstract in Engineering v 112 n 1755 May 3 1957 p 506-8. Studies made of wind structure at well exposed hill site using specially designed anemometer; in analysis of wind records particular attention was paid to application to problems of wind power generation; instruments and associated equipment; tests on response time of different types of anemometer; suggestions for further work. 29 refs.

1956

CN-115.1b5

1956

AN EXPERIMENTAL STUDY OF WIND STRUCTURE. (With Reference to the Design and Operation of Wind-Driven Generators). M.P. WAX. 1956. 8p. & illus.

British Electrical and Allied Industries Research Association (Tech.Rept.) C/T114

Meteorology—Air—Surface layers

Meteorology—Wind

Windmills

Meteorology—Air currents, Vertical Generators

21

P-7-16-64
ON THE THEORY OF WINDMILLS. S(hun-ichi) Abe.
(Read before 25th general meeting of Japan Soc. of Mech. Engineers, Apr. 1, 1948).
see p.135-148

Tohoku U., Inst. of High Speed Mechanics (Japan) Rept. 67
Japan Society of Mechanical Engineers Apr. 1, 1948

Author

The theory of windmills under constant wind speed is stated with special reference to
effect of number of blades, mutual interference of blade elements to the lift
coefficient, effect of the induced rotatory velocity in the slipstream and
starting characteristics. The power coefficient of models calculated by theory is
shown to coincide fairly well with experimental results.

W-3507(AlO(FT. 8))/6

N-49112


College of Aeronautics (Gt.Brit.) Rept.102

Authors (2)

A preliminary study is made of theoretical
gain in power output obtained with a fully
ducted land-type windmill as compared with
the standard unshrouded type windmill. The

design of the internal and external ducting is
discussed together with its effects on the
overall performance of the windmill. The
differences in the aerodynamic design of the
blades for the ducted and unshrouded wind-
mills are considered and attention is drawn
to the importance of the use of the correct
induced (or interference) velocities. A
brief review is included of recent Japanese
theoretical and experimental studies on
ducted windmills.

9245/CS-3/2-19-57/10

1955

N-2458030


A WIND PLANT TO POWER SEA SIGNALS
into ENGLISH from elektrotechn. Z. (Berlin-Charlottenburg), v. 7,
no. 12, 21 Dec. 1965 p 437-441
(Contract NASw-2482)
(NASA-TT-F-15358) Avail. NTIS HC $4.00 CSCL 10A

On the basis of the experience with the Schleimünde windpower plant, it may be said in conclusion that economic
operation of such a windpower plant is feasible whenever, on
the one hand, the cost of connecting the consumers to the
public network is prohibitive, and on the other hand sufficient
wind is available. The planning of long term duration and force
reading is of particular value. It is advantageous to erect windpower
plants in coastal and mountain regions.

Author

Wind-Driven Generator on Costa Rica. Engineering v. 180
May 1967 July 7 1966 p 55-7; see also Engineer v. 200 n 6189
July 8 1965 p 45-4; Surveyor n 114 n 3303 June 25 1965 p
614. Operational experience at very exposed site in Orangoes;
plant erected by John Brown & Co (Clydebank), designed to
give output of 100 kw with rated wind speed of 20 m/
center of rotor is 78 ft above ground, and swept diam of
blade rotor is 68 ft; nacelle mounted on pedestal shaft to
allow windmill to be yawed round to suit direction of wind;
fixed and rotating bedplate of welded steel framework; blade
spoke made of compressed laminated wood.

Wind Electrify. E.W. GODING. Latin Elec. Engin. v 1 n
2 Feb 1966 p 705-6 also Engineering v 179 n 4604 Apr 8
1965 p 433-4. Three well defined scales of utilisation for
different purposes are: small scale, using machines of capacity
up to 10 kw at remote individual premises: medium scale,
with machines of 10 to 100 kw, to provide energy needs of
isolated communities: large scale, in which wind driven a-c
generators of 100 kw upwards to perhaps 2000 or 3000 kw,
feed output directly into main networks.

Wind-Generated Electricity. Engineering v 179 n 4652 Mar
16 1965 p 714. Experiments conducted with new type of
wind driven synchronous induction alternator on site at Fre
Wood, near St. Albans, built for British Electricity Authority
as part of their investigations into use of wind power for
generating electricity; generator works on “depression” principle;
propeller blades are hollow, and as force of wind makes
them rotate, air is discharged through blade tip outlets due
to centrifugal action.

Windmills

Windmill blades

N-47177870


THE PRESENT STATUS OF NON-HORSE WIND POWER PLANTS
into ENGLISH from Elektrotech. Z. (West Germany), Ausgabe
B. v. 7, no. 5, 21 May 1955 p 187-191
(Contract NASw-2482)
(NASA-TT-F-15358) Avail. NTIS HC $4.00 CSCL 10A

The most important energy sources on earth, next to the
sun and water, are coal and oil. However, it seems that these
deposits will be exhausted in the foresee able future. Large
windpower plants are destined to play an important role in the
tap ping of new energy sources. Their viability must be judged
from the research and development work carried out in the
USA and Germany.

Author

The wind as a source of energy. (Chapt. XII).

In: Man and the Wind. 1955.

(out of print 1970)


N74-15747# Scientific Translation Service, Santa Barbara, Calif.

CHARACTERISTIC LINES (YEARLY PERMANENT LEVEL LINES) AND CHARACTERISTIC WIND VARIABLES FOR WIND ENERGY PRODUCTION
(NASA-TT-F-15354) Avail: NTIS HC $3.25 CSL 108
Optimum design methods for wind driven electrical generating plants are presented, based on yearly permanent wind level lines for selected erection sites. Wind conditions at any site are divided into five classes of which only a few can be exploited by a given system. General purpose design curves are given.

AMERICAN WIND TURBINE.
R. H. Nilsberg.

Theory of low speed wind turbine showing that shape of airfoil blade is predetermined by theoretical deflection of air stream; efficiency of 20% is predicted.

N73-29009# Scientific Translation Service, Santa Barbara, Calif.

THE DEVELOPMENT OF WIND POWER INSTALLATIONS FOR ELECTRICAL POWER GENERATION IN GERMANY
(NASA-TT-F-15050) Avail: NTIS HC $3.75 CSL 10A

The development of installations for reducing electrical energy from wind energy is beginning in Germany. The wind tower generation installations built by German firms have a wheel area of between 50 to 250 square meters for installed power levels between 3 and 50 kW. In the last 30 years, there has been a tendency to increase the design rotation rate coefficient from 2-4 to a level between 8-16. At the present time, there are reliable installations with nominal power levels between 3 and 22 kW. Successful Danish, American, Russian, and German experiments over prolonged time periods proved that it is possible to operate wind power generation units in parallel with high-voltage installations without any difficulty. This means that wind energy is now available to satisfy the energy requirement which is continuously increasing all over the world. A rough calculation shows that the energy capacity of the ocean of air is unlimited.

N73-21253# Kanner (Los) Associates, Redwood City, Calif.

PRINCIPLES OF STEEL CONSTRUCTION ENGINEERING IN THE BUILDING AND OPERATION OF WIND DRIVEN POWER PLANTS
(NASA-TT-F-14872) Avail: NTIS HC $3.00 CSL 13B

The factors which affect the designing of wind-driven power plants are discussed, including purpose and nominal output, wind velocity as a function of height, wind forces as a function of height, and the torques to be expected. Design features of the ZYKLOK wind-driven power plants are summarized, and sample calculations are made, based on the ZYKLOK-D 30 project. The optimal shaft height for a 30-m wind turbine is found to be 50 m above ground, with a yearly output of 2,125,000 kWh at a cost of 2.88 German pfennings per kWh.
FITTING WIND POWER TO THE UTILITY NETWORK
February 1954

Percy H. Thomas

Federal Power Commission
Washington, D. C.

This is the last of the four monographs published by the Federal Power Commission relative to the studies made by Mr. Thomas in the 1944-1954 period regarding wind powered electric generation.

The author's prior works involved highly technical and specific design matters, particularly in the field of aerodynamics. This shorter work was largely general in nature, commenting on the utilization, or integration, of wind generated electric energy in an electric utility network. He discussed generally the possible benefits of firm and secondary power derived from wind powered generation when supported by large interconnected electric systems. By this time, steam-electric generating units having 250,000-kilowatt capacities were in operation, and the economic benefits of economy of scale of these units presented, at that time, a stiff challenge to competing electric generation sources. In this monograph, Mr. Thomas moved away from comparative cost based justification for wind powered generation in favor of more general statements; i.e., justification would be sufficient if steam generation costs were met. He also stated, regarding wind powered electric generation and to a degree at variance with earlier implications, that economies of scale were of questionable attainment, and he implied that units having 2,000-4,000-kilowatt capacities might yield maximum economic benefits.

In previous publications, Mr. Thomas had made some references to the use of wind mills to generate mechanical power, not necessarily associated with conversion to electric energy. In this work, he also commented on a wind-powered water pump and some general applications, including its use as the pumping source for hydroelectric pumped storage operations.
Prospects for Windpower Development in Ireland. H. C. B. MINTO, "TWO ANNUAL PAPERS ON WINDMILLS" Trans v 73 1952 p 119- 51 (discussion) 100-47, supp plate. List of long term annual average wind speed m/sec; patterns of windmill operation; choice of rated wind speed; aerodynamics of windwheel blade; construction of windmill; present position in windpower development and prospects.

Wind Power History and Present Status, H. E. PARSON, Eng J v 30 n 2 Jan 1954 p 10-21. Development in last 80 yr; Fleissner in Germany and J.B. Madsen in United States sought to harness Magnus effect, i.e., side thrust exerted by cylindrical surface revolving in wind stream; installations of office windmill connected to vertical shaft generator in 1929 by Kumm in Germany; other installations in Germany, Finland, United States, and Russia; largest and best engineered experiment in large scale wind power generation, Grandpa's Knob experiment in Vermont.

574-16011f Linguistic Systems, Inc., Cambridge, Mass

USING THE ENERGY OF THE WIND FOR ELECTRIFICATION

(Contract NASA-2482)
(NASA-TT-F-15307) Avail. NTIS HC $4.00. CSCL 10A

The utilization of wind energy for generating electric power is discussed. Existing power generators utilizing wind energy are described and their use in agriculture is indicated. Author

The experimental and theoretical investigations of windmills, by Matsunoseki Iwaki.

Reprint from: Kyushu (Imperial) Univ., N-28867
Research Institute for Applied Mechanics, Repts., v.2, no.8, Dec.,1953, p.181-229 incl.5 tabs,22 figs. (curves)

Possibilities of Wind Power Plants in India, K. M. SANKARAN, Power Engng (India) v 5 n 1 Jan 1952 p 14-6. Wind power, if harnessed, would substantially aid hydro power systems to firm up their capacity; possibilities in India; examples of installations abroad.


An extension of the momentum theory of wind turbines,
by H.H. Rosenbrock.

Windmills

Behavior and performance of flow engines, by Friedrich Wagner.
Aug., 1952. 16 p., illus.

Municipal Univ. of Wichita, Bull. Eng. Study 080.
Contract N-onr-20101.

1951

What Can Wind Power Do For Us! G. A. WHISTSTONE. Power Eng. v 83 n 3 Mar 1951 p 72-3. Appraisal of value of wind power to public utility system indicates that wind power is technically feasible; it is probably non-competitive at present; there are few duties for which wind alone is adequate; combination of wind power with internal combustion power, and combination with hydro power with seasonal storage both have some strong advantages.

Wind Power, P. H. THOMAS. Water Power v 8 n 8 Aug 1951 p 30-2. Various aspects of using wind power and its potentialities as contribution of energy to utility network; appraising probable value of wind energy for power purposes; measurement of wind energy in United States; comments on aerogenerators.

1952

A variety of wind power generating plants are considered to be installed on FM antenna masts. These include: Savonius rotor, horizontal axis wind wheels, multi-rotor configurations. Power levels vary between 10-20 kW for 100 meter mast heights.

Author

1951

The development of a wind wheel for electric power generation is discussed. The interaction between the wind wheel and the generator is accomplished with a power control device to prevent overloading the generator when the wind velocity increases. The self-controlled running wheel of the wind motor adjusts the blade angle of attack to compensate for the wind velocity. The generator must be dimensioned for the greatest wind intensity in order to accept the entire wind wheel power. The wind generation installation delivers all of the produced energy to the network, so that other generating stations operating in parallel and the storage units must adjust the power level to the consumers. Author.

592

Orkney Windmill and Wind Power in Scotland. J VENTERS. Engineer v 189 n 4685 Jan 27 1950 p 106-8. 100-kw windmills ordered by North of Scotland Hydro-Electric Board: considerations which led Hydro Board to embark on experiment, why windmill is being erected in Orkney, and why its rating is 100-kw: wind power as source of energy: estimate of available wind energy: practical aspects of problem.

Un impianto aeroelettrico pilota di media potenza con accumulo libero di pompaggio. R.VEZZANI. Elettrotecnica v 37 n 9 Sept 1950 p 393-413; see also English abstract in Engrs' Digest v 12 n 5 May 1951 p 188-22. Air motor power plant to be erected on island of Giglio, Italy: slow speed orientable windmill designs are replaced by high speed air motors: protected and fixed in space: entire air motor is placed in tubular system similar to Venturi tube: operation of enclosed air motor may be regarded as similar to that of Kaplan turbine: diagram.


Large-Scale Generation of Electricity by Wind Power—Preliminary Report. A.W.GOLDING. Brit Elec & Allied Industries Research Assn—Tech Report Ref C/7151 1949 15 p. 1/6d. Description of steps which are being taken to determine possibilities of this method of generation in Great Britain and account of results obtained so far in investigations: suggestions are made concerning future research and development.


An electric circuit is described comprising two direct current machines and one three-phase synchronous or asynchronous induction machine suitable for transforming and feeding the energy from the wind into a three-phase conventional electric power network.


The design and operational problems are reported that are associated with wind power generating plants similar to the American wind charger. The potential market for such devices is discussed.
N74-15760*# Kanner (Leo) Associates, Redwood City, Calif. INVESTIGATION OF THE POSSIBILITIES OF USING WIND POWER C. Kromann and J. Juul Washington NASA Feb. 1974 11 p Transl. into ENGLISH from Elektroteknikeren (Denmark), v. 45, 7 Dec. 1949 p 711-714 (Contract NASw-2481) (NASA-TT-F-15336) Avail: NTIS HC $3.00 CSCL 108 Kromann's critique of several of Juul's articles in Elektroteknikeren and of Juul's riposte is reported. For example, Kromann argues that it should not be expected that wind tunnel experiments, necessary as these are for finding the best vane design, will yield the same results as real conditions; Juul counters that the same efficiency can be obtained in the open air as in a wind tunnel and that, in any case, this point will be investigated in greater detail in the near future. Kromann has misgivings about building windmills on the west coast of Jylland because he fears that the force of the wind there is too variable; Juul counters that wind force measurements show that this fear is unfounded (the corresponding curves are given). Author

1949

N74-17782*# Kanner (Leo) Associates, Redwood City, Calif. WIND POWER, PART 2: ECONOMIC FEASIBILITY, 1949 G. Lacroix Washington NASA Mar. 1974 23 p refs Transl. into ENGLISH from Tech. Mod. (France), v. 41, nos. 7, 8, 1-5 Apr. 1949 (Contract NASw-2481) (NASA-TT-F-15419) Avail: NTIS HC $4.25 CSCL 10A Both classical and theoretical methods for preventing wind engines from overspeeding are described. The greatest drawback in the use of these devices is seen to be their inability to compete with other power sources on an economic basis. In this connection there is a detailed description of the failure of the Grandpa's Knob experiment conducted in Vermont in the early 1940's; the technical defects were minor in comparison to the lack of economic feasibility. Russian efforts and Danish projects are discussed briefly. Author

N74-15764*# Kanner (Leo) Associates, Redwood City, Calif. WIND ENERGY G. Lacroix Washington NASA Feb. 1974 28 p refs Transl. into ENGLISH from Tech. Mod. (Paris), v. 41, nos. 5 and 6, 1 and 15 Mar. 1949 p 77-83 (Contract NASw-2481) (NASA-TT-F-15342) Avail: NTIS HC $3.50 CSCL 10B The technical and economic problems involved in the use of wind engines as a source of power are discussed, with detailed descriptions of the operative principles behind several basic types. Author

N74-15766*# Kanner (Leo) Associates, Redwood City, Calif. PROSPECTS FOR THE UTILIZATION OF WIND ENERGY IN CZECHOSLOVAKIA F. Sembera Washington NASA Feb. 1974 25 p Transl. into ENGLISH from Elektrotechnicky Obzor (Czechoslovakia), v. 36, Sep. 1949 p 477-484 (Contract NASw-2481) (NASA-TT-F-15305) Avail: NTIS HC $3.25 CSCL 10B Technical and economical conditions for the utilization of airstreams in Czechoslovakia are considered. The probable mean wind velocities in various districts of the country, their number and the probable daily and yearly charts at various altitudes, the most windy districts, the possibilities and extent of utilizing the airstreams by power stations equipped with prime movers with a 50 m propeller diameter and a 30-35 m high tower are investigated and presented on the basis of many years of observation. It is determined that the power stations in Czechoslovakia should have a maximum output of 500 kW and a yearly production of about 700,000 to 800,000 kwh, so that 100 such stations could replace the power plant in Prague. The probable cost per kwh generated in the wind power plant is calculated on the basis of the proposed estimates for the capital investment and economical results are evaluated based on this solution, which are not practical in the near future. Author


Record of wind turbine experiment conducted in Vermont by group of engineers; purpose was to find out possibilities of generating electricity on a large scale by harnessing wind; book summarizes various technical principles encountered, attempts at solving them, and findings and discoveries made.

N74-15762*# Scientific Translation Service, Santa Barbara, Calif. PARALLEL OPERATION OF A SYNCHRONOUS GENERATOR AND AN INFINITELY HIGH-POWERED NETWORK WHEN DRIVEN BY A NONNEF-GRUBS WIND TURBINE Ludwig Linner Washington NASA Feb. 1974 14 p refs Transl. into ENGLISH from Elektrotech. Z. (West Berlin), v. 69, no. 9, Sep. 1948 p 293-296 (Contract NASw-2483) (NASA-TT-F-15302) Avail: NTIS HC $3.00 CSCL 10B An infinite high powered network is described as a network whose voltage is independent of the load states of the connected machines, and whose voltage amplitude and angular velocity is always the same. The three-phase generator operating in conjunction with this network must operate at a constant rotation rate, as must the wind wheel according to the number of its poles and the frequency of the network. The variation in the power output of a wind wheel is discussed for constant rotation rate as a function of wind velocity in order to evaluate the operational characteristics of a synchronous machine. Author
AERODYNAMICS OF THE WIND TURBINE
January 1949

Percy H. Thomas

Federal Power Commission
Washington, D. C.

In this monograph, the author compares the detailed aerodynamic designs of the Grandpa's Knob unit, an English design, with his design. Mr. Thomas modified his 1946 design of a 7,500-kilowatt unit for this comparison by increasing the blades from two to three for each wheel, shortening each blade, and increasing the designed rotational speed.

Mr. Thomas again emphasized that, because of intangible characteristics and uncertainties of extrapolations, wind tunnel tests and full scale prototype construction were imperative to fix a design.

THE WIND POWER AEROGENERATOR -- TWIN WHEEL TYPE
March 1946

Percy H. Thomas

Federal Power Commission
Washington, D. C.

This monograph is devoted to the detailed design features of the twin wheel, 7,500- and 6,500-kilowatt wind powered generators discussed in the previous monograph.

The author commented on the March 1945 shutdown of the 1,000-kilowatt Grandpa's Knob unit, and he reiterated the desirability of larger units having capacities between 5,000 and 10,000 kilowatts for utility operation.
INFLUENCE OF WIND FREQUENCY ON ROTATIONAL SPEED ADJUSTMENTS OF WINDMILL GENERATORS

Ulrich Hutter Washington NASA Nov. 1973 17 p Transl. into ENGLISH from Z. Elektrotech. (Stuttgart), v. 1, no. 6, 1948 p 117-122 (Contract NASw-2482)

(NASA-TT-F-15184) Avail: NTIS HC $3.00 CSCL 10A

In installing groups of windmill generators to produce electric power from the force of the wind, it is important to locate the units of such a network in such fashion that the so-called two-minute variation of the wind velocity can be overcome. This is done by using at least three windmill generators located an appropriate distance apart. When the wind velocity is insufficiently great to drive the blades of the windmills, a source of power should be available (battery, power from other windmills) to keep the blades turning. Contrary to popular misconception, changing the angle of attack of the windmill blades does not improve the efficiency of their operation or increase the power of the windmill.

Author

N74-15749# Kenner (Leo) Associates, Redwood City, Calif.

PROBLEMS IN THE ELECTRICAL EQUIPMENT OF WIND POWER PLANTS


(NASA-TT-F-15312) Avail: NTIS HC $4.25 CSCL 10B

Problems encountered in electric installations of wind power plants are discussed. Difficulties involved necessitate close cooperation of aerodynamic and electrical engineer in implementing wind power plants for d-c and a-c currents. Examples of actual installations in Germany are presented: a present task is erection of small wind power plants for farms.

Author

N74-15750# Scientific Translation Service, Santa Barbara, Calif.

THE LARGE SCALE WIND DRIVEN ELECTRICAL GENERATING STATION


(NASA-TT-F-15313) Avail: NTIS HC $3.00 CSCL 10B

Large wind power plants and their use to alleviate coal shortage in Germany are discussed. It is stipulated that there is no economic necessity for development of large scale wind power plants before possible improvements in steam power plants, such as combined heating and power plants, high pressure plants, etc. have been exhausted. A table gives comparison of costs and efficiency of wind and steam power plants.

Author

N74-15759# Kenner (Leo) Associates, Redwood City, Calif.

APPLICATION OF WIND POWER TO RATIONAL GENERATION OF ELECTRICITY


(NASA-TT-F-15334) Avail: NTIS HC $3.50 CSCL 10B

The history and development of windmills in Denmark and elsewhere is sketched. The costs and problems of generating electricity by steam, water and wind power are compared. Pointing out that the wind is Denmark’s only major natural source of power and dividing the application of wind power into an economic and a technological part. It is discussed how the Danish wind could be harnessed to supply power not only in the requisite amounts and at the lowest cost, but also under all circumstances, so as to make Denmark self-sufficient in the matter of energy.

Author

N74-15745# Kenner (Leo) Associates, Redwood City, Calif.

OBSERVATIONS ON MODERN WIND-ELECTRIC POWER PLANTS


(NASA-TT-F-15357) Avail: NTIS HC $3.25 CSCL 10B

Development of the aeronautical type windmill design and the installation of wind-powered electricity plants is held feasible forightly undergoing post-war reconstruction. It is shown to be possible to build from 200 to 300 small capacity power plants for a total output of 10,000 to 15,000 kW in areas of Italy which have the minimum necessary wind speed of 5.5 m/sec. Among the designs required for such wind electricity plants are windmill blades with variable pitch, automatic pitch control system which does not use the costly servomotor, and reversible wheels. These features enable a windmill of limited orientability to function with high efficiency. The effect of wind rose patterns, the surface area of the blade, and some possible local uses of the electricity produced by such plants are also discussed.

Author
Windmills

Mar.,1946. 95 p., incl. tab. 12 figs. (diagrams, curves, charts)

Federal Power Commission, Office of the Chief Engineer.


LARGE WIND-DRIVEN SYNCHRONOUS GENERATORS.
T.F. Wall.
Engineering, June 11,1943, p.461-3, Pt.2.
Engineering, June 25,1943, p.501-3, Pt.3.

Wind energy exploitation by very large wind power generating stations is discussed. This system is compared to other types of power generation.

Author

Wind energy plants are described which was used during the fuel shortage that occurred in World War 2. Unlike ordinary wind power plants which produced usable power only at wind velocities above 4 or 5 m/s, this power plant was designed to operate over a wide range, charging its battery at low wind speeds, delivering usable power from generator and discharging battery at intermediate speeds, and delivering power and charging its batteries at high wind speeds. The result was exploitation of the wind for a larger number of hours per year and lower costs per kWh of output.

Author

The problem of wind power utilization is discussed, including determination of wind power per square meter obtained yearly from surfaces subjected to wind action, and systematic prospecting for favorable sites using a simple anemometric device which calculates wind speed with the aid of a special electric meter. A description is given of a program for site selection which will make it possible to determine the energy which can be produced by the wind engines used.

Author
ELECTRIC POWER FROM THE WIND
March 1945

Percy H. Thomas

Federal Power Commission
Washington, D. C.

This monograph by Mr. Thomas on the general subject of power from the wind was prompted by the 1941-1945 construction and operation of a 1,000-kilowatt installation at Grandpa's Knob near Rutland, Vermont, on the system of the Central Vermont Public Service Corporation. This unit suffered a blade failure on March 26, 1945, and was abandoned because of economic considerations.

Mr. Thomas envisioned wind powered electric generation for use on interconnected utility networks, firmed up by hydroelectric storage facilities in order to overcome the firm power deficiencies of wind driven generators. Using certain economic data from the Grandpa's Knob operation, the author concluded that units of a size between 5,000 and 10,000 kilowatts were necessary for economic viability. The author described a twin-wheeled, two-bladed propeller design for a 7,500-kilowatt unit, and a twin-wheeled, three-bladed propeller design for a 6,500-kilowatt unit. In order to overcome in part the difficulty in coupling a variable speed, wind-driven mechanical source to a synchronous speed alternating current commercial system, the design included a wind-driven, direct-current generator electrically coupled to a dc to ac synchronous converter. The author's calculated costs were $68 per kilowatt of capacity for the 7,500-kilowatt unit, and $75 per kilowatt for the 6,500-kilowatt unit.

Mr. Thomas concluded that, with certain assumptions, the economics warranted the collection of wind data in greater detail and specificity than that then accomplished, the testing of propellor designs in wind tunnels, and the construction of a full size (7,500 kW) prototype.
1,000-KW WIND POWER ELECTRIC GENERATING PLANT.
Engineering, July 31, 1942, p. 31-3.

A description of the Smith-Putnam wind turbine on Grandpa's Knob near Rutland, Vermont.

POWER FROM WIND.

In a lecture recently given to the foreign and colonial research group of the V.D.I. some interesting details were revealed of the current research on the exploitation of wind energy for industrial purposes.

N74-15757*# Scientific Translation Service, Santa Barbara, Calif.
THE DIRECT DRIVING OF SYNCHRONOUS GENERATORS BY LARGE SCALE WIND ELECTRICAL POWER GENERATING PLANTS IN PARALLEL OPERATION WITH A SYNCHRONIZING NETWORK. PART I
(Contract NASW-2482)
(NASA-TT-F-15301) Avail. NTIS HC $3.50 CSCL 108

The damped eigen oscillation of a synchronous generator connected with a fixed network is investigated. It is assumed that the generator is driven by a wind propeller wheel. The influence of the variation of the characteristic of the propeller wheel on the variation of the transient oscillatory behavior is investigated. First the wind velocity increase occurs suddenly and then in a continuous fashion. The power control measures including propeller pitch displacement are investigated for preventing overloads on the generator. The danger of resonance is pointed out. This depends on the number of propellers. The question is discussed of whether it is better to use an asyn-

N74-15756*# Kanner (Leo) Associates, Redwood City, Calif.
USING LARGE WIND POWER PLANTS TO DIRECTLY DRIVE SYNCHRONOUS GENERATORS IN PARALLEL OPERATION WITH A GOVERNING NETWORK
(Contract NASW-2481)
(NASA-TT-F-15343) Avail. NTIS HC $3.00 CSCL 108

Various aspects of wind powered synchronous generators are described. The influence of the fan wheel characteristic on damping of transients is slight. Altering vane position is the only feasible method for regulating power in order to avoid overloading the generator. In designing the fan wheel, and choosing the number of vanes, the operating behavior of the generator and the danger of resonance must be considered ahead of efficiency. Practical operating characteristics of the fan wheel must be known to the electrical engineer if he is to calculate the course of events during a transient. Author

N74-15753*# Kanner (Leo) Associates, Redwood City, Calif.
PROGRESS IN THE UTILIZATION OF WIND POWER
C. W. Mayer Washington NASA Feb. 1974 14 p refs Transl. into ENGLISH from Elektrizitätsverwaltung (Switzerland), v. 16, no. 6/7, Sep.-Oct. 1941/42 p 109-113
(Contract NASW-2481)
(NASA-TT-F-15348) Avail. NTIS HC $3.00 CSCL 108

Wind power continues to be of interest as a source of energy for isolated locations. In order to distribute the capital costs over many service hours, the wind motors should be able to exploit low wind speeds. Low speed wind motors can be used only for driving slow machinery. High speed wind motors to drive small dynamos are now available which are self starting at low wind speeds. Large scale wind power stations have not yet passed the experimental stage. Author

N74-15758*# Kanner (Leo) Associates, Redwood City, Calif.
The Importance of And Progress in the Utilization of Wind Power In Denmark
Dimitry Stein Washington NASA Feb. 1974 17 p refs Transl. into ENGLISH from Elektrizitätswirtschaft (Germany), v. 41, no. 15, 5 Aug. 1942 p 346-349
(Contract NASW-2481)
(NASA-TT-F-15333) Avail. NTIS HC $3.00 CSCL 108

Denmark was one of the first countries to turn its attention to generating electric energy from wind power, because it has to import all oil and coal it uses, and it has virtually no hydroelectric power. A large number of wind power stations were built in the early years of World War I when fuel was scarce. The total production of wind power was estimated at approximately 1.8 million kWh in 1941. The installation of wind power stations was generally considered to be a temporary measure. Author
N74-15756# Techrans Corp., Glen Burnie, Md.

Utilization of Wind Power


(Contract NASw-2485)

(NASA-TT-F-15300) Avail. NTIS HC $3.00 CSCL 10B

The possible power of wind in a wind turbine is determined.

From available wind measurements the wind frequency line is plotted to provide the basis for the design of a wind turbine. Favorable results are not obtained if work is continued on the previous principle of mill construction. There are only two ways of achieving adequate power: enlarging the circumference described by the vane and utilizing higher wind velocities. The latter are present at an altitude of about 200 meters above the ground. Satisfactory performance is attained with a vane length of 60 meters. Thus it is recommended that tests running at least one year be instituted with these dimensions.

Author


DC Generator for Kolkhoz Wind Powered Generators


(Contract NASw-2482)

(NASA-TT-F-15347) Avail. NTIS HC $4.00 CSCL 10A

The use of carbon-bonded-graphite resistors to control the voltage output from small wind-powered generators is described. Experiments were performed for devising methods of regulating dc generators to supply constant voltage, and a new type of nonlinear resistor was developed for use as a regulator.

Author

N73-30978# Kenner (Leo) Associates, Redwood City, Calif.

Project of Wind Motor with Aerodynamic Transmission for Capacities of 100 kW to 3000 kW


(Contract NASw-2481)

(NASA-TT-F-15131) Avail. NTIS HC $3.25 CSCL 10A

To reduce excessive weight requirements in the design of a 100-3000 kW capacity wind motor, aerodynamic transmission is employed. Aerodynamic transmission involves mounting secondary small windmills at the ends of the main wind blades of the wind motor. The secondary small windmills operate in a high-velocity relative stream of 40-70 m/sec and can produce energy directly from the wind with the windmills turning at 500 or more rpm, with an efficiency of 80 percent or higher.

Author

SMITH-PUTNAM WIND TURBINE.

PROPELLER DESIGN AS APPLIED TO WINDMILLS.
E.N. Fales.

THE EXTRACTION OF ENERGY FROM THE WIND.
E.A. Stalker.

Report A.258, p. 28-33 incl. tabs.& 3 figs. (diagr. & curves)
Experiments with three models of windmill sails.
By A. Haringa.
Report A.269, p. 35-45 inclu. 10 tabsl & 6 figs. (diagr. photo. & curves)

see
Report of the Rijks-Studiedienst voor de Luchtvaart, Amsterdam, for the yr. 1934, BSL/1934;
Vol. 7, (Dutch text with summaries in English, German & French text).
MECHANICAL ENGINEERING

Volume 53  May, 1931  No. 5

The S-Rotor and Its Applications

A Bi-Vane Power Wheel of S-Shaped Cross-Section Working in Wind or Water, and Its Applications in Pumping, Electric-Current Generation, and Ventilation, and as a Current and Wave Motor Where Moderate Amounts of Power Are Required

By S. J. SAVONIUS, HELSINGFORS, FINLAND
A NEW PROPELLER-TYPE, HIGH-SPEED WINDMILL FOR ELECTRIC GENERATION. E.N. Fales.
(with discussion)

POWER FROM THE WIND.

Aerodynamic
Savonius wind-motor
Montana windmill

CH-124,181
A FURTHER APPLICATION OF THE MAGNUS EFFECT TO WINDMILLS AND TO BOAT PROPULSION. Alexander Klemin.
Mechanical Engineering, Nov.
p.911-912
1925

NACA TN-164
GENERAL THEORY OF WINDMILLS.
1923
N74-21682*# Kanner (Leo) Associates, Redwood City, Calif.
WIND ELECTRIC POWER STATION
into ENGLISH from German Patent no. 87158023 Mar. 1953
(Contract NASw-2481)
(NASA-TT-F-15522) Avail: NTIS HC $4.00 CSCL 10A

A wind power station is described in which the structure
on which the rotors are mounted may tilt as wind speed
changes so that the rotors leave the vertical plane to anticipate
increased wind speeds. The power station may have pulse
generators located in front of the turbine rotors on extensions
of the turbine shaft or on separated booms under the turbines.
Winches are utilized to tilt the turbine platform, normally locked by means
of a brake, which is released when a predetermined wind threshold is reached;
flexible tension members transmit the thrust of the wind to the nonlifting portion of the structure; provisions to change the direction of the winches as wind speed changes; an auxiliary vane to control an electrically driven propeller to rotate the power plant into the wind; and auxiliary generators to be used when wind speeds are too low for normal synchronous operation.

Author

N74-21677*# Scientific Translation Service, Santa Barbara,
Calif.
WIND POWER TURBINE GENERATOR FOR HIGH ALTITUDE
WIND UTILIZATION
H. Honnef Washington NASA Apr. 1974 12 p Transl. into
ENGLISH from German patent no. 8852843 Aug. 1953 4 p
(Contract NASw-2483)
(NASA-TT-F-15455) Avail: NTIS HC $4.00 CSCL 10A

A windpowered electrical generator is reported that consists of
two counter-rotating wheels, one being the armature and the
other being the field. Means of compensating for varying wind
speed are described.

Author

N74-22708*# Kanner (Leo) Associates, Redwood City, Calif.
STATISTICAL SUMMARY AND EVALUATION OF VENTO-
ELECTRIC POWER STATION OUTPUT (PART 2 OF 2)
into ENGLISH from Elektrizitätswirtschaft (Frankfurt am Main),
v. 50, no. 11 Nov 1951 p 325-329
(Contract NASw-2481)
(NASA-TT-F-15652) Avail: NTIS HC $4.00 CSCL 10A

Data obtained from the operation of windmills in Denmark
were used to study the performance of several sizes and designs.
Tabulated information shows: (1) how performance is affected
by wind velocity patterns, particularly mean velocities, by rotor
diameter, and by how the output is used; (2) what fraction of
available wind is utilized; (3) how regular or irregularly output
varies with time, (4) what peak values occur; (5) the duration
of lulls; and (6) how utilization time depends upon the power
level used as a reference.

Author

N74-22703*# Techron Corp., Glen Burnie, Md.
THE MEASUREMENT OF LARGE WIND ENERGY GENERA-
TORS
C. Martin Washington NASA May 1974 16 p Transl. into
ENGLISH from Elektrotech. Maschinenbau (Austria), v. 57,
no. 7/8, 17 Feb. 1939 p 83-89
(Contract NASw-2485)
(NASA-TT-F-15432) Avail: NTIS HC $4.00 CSCL 10A

The weight comparison of energy generators according to the
Honnorf system is represented in curves wherein the weight
is plotted as a function of three variables: the number of poles,
air induction, and diameter.

Author

N74-21678*# Kanner (Leo) Associates, Redwood City, Calif.
THE PRESENT STATE OF PLANNING AND ERECTION OF
LARGE EXPERIMENTAL WIND-POWER STATIONS
into ENGLISH from Elektrichestvo (Moscow), no. 2, 1933
p 9-13
(Contract NASw-2481)
(NASA-TT-F-15512) Avail: NTIS HC $4.00 CSCL 10A

An investigation into the use of wind-power stations, which
are planned for the second 5-Year Plan is discussed. The size
of stations planned is 5000 kW, and they are to be built in
areas of the country where there is a sufficient annual wind
speed to justify economic use. The Balaklava experimental station
was investigated and results show that it was economical, but
new research must be done to improve overall performance.

Author

N74-20700*# Kanner (Leo) Associates, Redwood City, Calif.
SUPPLEMENT TO THE REPORT ON THE RESULTS
ACHIEVED WITH SEAS' EXPERIMENTAL MILL
into ENGLISH from Elektroteknikeren (Copenhagen), v. 48, Feb.
1952 p 65-79
(Contract NASw-2481)
(NASA-TT-F-15516) Avail: NTIS HC $5.00 CSCL 10A

Results achieved with an experimental windmill are elaborated on:
greatest efficiency of the mill was obtained at a wingtip
temperature of 38 m/s; effects caused by wind pressure should not
effect 800 kg/cm sq in any part of the wing or tower, and
effects caused by gravity in the wings should not exceed 200-300
kg/sq cm. Experience has shown that the optimal height of the
support tower should be from 18-24 m. A history of the Dutch
windmills is used in its construction, and also of various modern
experimental wind power stations in various parts of the world
is given. Costs of building wind power stations are discussed.

Author

N74-19709*# Scientific Translation Service, Santa Barbara,
Calif.
HIGH WIND POWER PLANTS
into ENGLISH from Elektrotech. Maschinenbau (Berlin), v. 57,
no. 41 and 42, 13 Oct. 1939 p 501-506
(Contract NASw-2483)
(NASA-TT-F-15444) Avail: NTIS HC $4.00 CSCL 10A

In comparison to the usual power plants in which the machines
are installed in special buildings, the high wind power plant is
described as a power source in which the structure as a whole
makes up the machine. New large structures are supports for
generators with large diameters but with the other dimensions
small. The use of the advantages high wind flow leads to
unusually high structures, but these are completely storm safe
and stable, as well as economical. Details of the counter-rotating
turbine and some experimental results are presented.

Author
1. OCEAN/WATER
WAVES, CURRENTS, AND GENERAL

Energy from the Ocean: An Appraisal.
Owen M. Griffin.
Naval Research Lab Washington D.C. May 74, 47p NRL-MR-2803
AD-779 877/0WE PCS3.25/MFS1.45

The oceans and their environment have long been envisioned as renewable sources of energy. It is the purpose of this report to assess the feasibility of drawing on the sea for power and to determine the extent to which the oceans are likely to serve future energy needs. A review is made of proposed U.S. funding levels for the research and development of renewable energy sources during the years 1975 - 1979, and a study is made of the technical and environmental acceptability status of tidal, wind, and sea thermal power generation systems. The estimated costs of these environmental power sources are compared with the prevailing power costs for nuclear and coal plants. On the basis of these comparisons, recommendations are made for a program of research and development, culminating in the construction of prototype plants, for wind and sea thermal power plants. Tidal power generation is found to be technically feasible but economically uninviting at present. (Author)

INvolving the oceans in solving energy problems.

Alternate energy sources from the ocean.

ENERGIEVERSORGUNG DURCH WELLENGEBRANGER (Energy Supply by Wave Generator). The possibility of using wave energy for the supply of power to meteorological and oceanographic measuring instruments located on buoys and thus replace storage batteries or diesel-generator sets now in use is outlined. The design of a hydroelectric wave generator is presented briefly. 8 refs. In German with English abstract.


Using the power from ocean waves, air is entrained by the Bernoulli principle and placed under compression. This compressed air is used to drive prime movers and to generate electricity. The generated electricity can be employed to desalinate seawater electrolytically into oxygen and hydrogen, and the gases can then be used to produce power and other useful products. The hydrogen that is highly fluid and of low weight can be transported inexpensively to a distance from the sea and then reconverted to water, combining it with atmospheric oxygen, producing substantial energy as well as water. (Official Gazette)

THE OCEAN AS A POWER RESOURCE.
J.D. Isaacs and R.J. Seymour
Int. J. Environmental Studies, v.4, no.3,

This paper considers the feasibility of trapping a number of potential sources of energy in the oceans, assesses their magnitude in relationship to projected world needs, and discusses some means for avoiding environmental degradation.


An energy-conversion system is disclosed for converting water surface motion, e.g. wave motion, to useful energy. Buoyant structures are provided defining pairs of opposed surfaces affixed together by pivotal structures with energy means, e.g. bellows, held spaced-apart from the pivot means. In the disclosed embodiment, the bellows are actuated with displacements between the buoyant structures, to develop positive fluid pressures to accomplish various operations. As disclosed, a turbine is driven to motivate an electrical generator for providing electrical power through a conductor to an electrical load. (smith)

Windmills for water

Large, slow underwater machines like windmills could be a promising source of fuel-free, nonpolluting electric power in the Gulf Stream off the Miami coast, suggests John R. Apel of the National Oceanic and Atmospheric Administration’s laboratory on Virginia Key, Fla.

An optimum spot would be the Straits of Florida which pass between Miami and the island of Bimini, where the flow of the current is channeled and steady, varying by only about 20 percent above or below normal, reports Apel together with William S. von Arx and Harris B. Stewart Jr. of the Woods Hole Oceanographic Institution.

About 0.8 kilowatts of power per square meter could be obtained from the upper levels of the current, the researchers estimate. This would be an improvement over the 0.22 kilowatts available from sunlight over Miami, says Apel, which would be reduced another 75 percent by the inefficiency of solar cells.

Harnessing energies of ocean—1; R.H. CHARLIER: Mar Technology Soc J v 3 n 3 May 1969 p 13-32; The development of the use of tidal power is surveyed from classical times to the completion of the Ranger-Tider plant. The choice of sites, construction and operation of the French plant, and the major sites for tidal-power throughout the world are examined.

Harnessing energies of oceans—2; R.H. CHARLIER; Mar Technology Soc J v 3 n 1 July 1969 p 59-81; Tidal power projects around the world are surveyed, with emphasis on Great Britain, Argentina, Soviet Union and Australia. Advantages and disadvantages of tidal power plants are considered from the viewpoint of economics and interaction with the surroundings. Other sources of energy from the oceans are mentioned, including electromagnetism, waves, ocean currents, upwellings, thermic energy, fresh- and salt-water contact and salinity exchanges. Bibliography.
Wave activated generator for robot weather buoy and other use.

Masuda, Yoshio
Japan Defense Agency, Technical Research
Agency


CNEKO, Centre Oceanologique de Bretagne,
Groupe Scientifique, Brest, Fr.

Utilisation de la maregraphie au large pour la prise de possession du
plateau continental et pour l'étude de la dynamique oceannique.
Colloque International sur l'Exploitation des Oceans. Theme V, Vol. 1,
Proceedings. (Held in Bordeaux, Fr., March 1971). Centre National

In English; Fr. sum., illus., no refs., from Text.
GENERATORS : WAVE ENERGY : METEOROLOGICAL BUOYS :
INSTRUMENT DESIGN : JAPAN : wave-activated generator.

A wave-activated generator is described which transforms wave
energy into electrical energy with the help of an air turbine. The buoy
has a long central tube, the immersed extremity of which is open in
Japan. 200 such generators are used with buoys or lighthouses. An
oceanographic automatic weather buoy with a wave-activated generator
weighing about 1.2 t (including to anchoring equipment), transmits
measurements of wave height, air and water temperature, wind
direction and velocity, and noise to a coastal station 20 km away. The
buoy is equipped with a Ni-Cd battery for 80 amp-hr, 24 V, and a
telemeter. This generator is well adapted to buoys and automatic
stations; it may also be applied to lighthouse stations.

1956 e.l W 1231/4-7/5

Ocean currents
Generators
Power sources, Ocean

CH-75179
POSSIBILITY OF HARNESING THE ENERGY OF
SEA CURRENTS BY MEANS OF DEVICES SIMILAR
TO AIR-DRIVEN GENERATORS. (Sur la possi-
bilité d'utiliser l'énergie des courants
marins au moyen de machines analogues aux
aérogénérateurs). O(ston) Ramenieras
and P.Senghe. (Presented at 4th Hydraulics
Conf., Paris June 13-15, 1956). (Fr.text &
Eng.summary).

Hydraulics Conference, June 13-
Proceedings, p.532-539 15,1956

The respective characteristics of a given
propeller when driven by air and water are
compared, taking similarity laws applicable in fluid mechanics into account.
Calculates the leading dimensions of a sea current-driven electric generator
designed along the same lines as well established aero-generators. Also con-
tains a calculation of the annual energy available at some of the sites for
which adequate measurements are available.
ABSTRACT: In this semi-annual (second quarterly) report a conceptual design is developed which is in no way dependent upon ocean currents, and in which all physical processes are well understood. Contamination of the input water to the boiler by the output water is avoided by taking advantage of the naturally occurring density stratification, at least for plants which do not exceed 700,000 kilowatts. High density power generation without accident, and the consequent power expenditure in its removal, is obtained by falling film evaporation on vertical tubes. Appreciable pressure drop in the large banks of vertical tubes in the evaporator and condenser is avoided by proper manifolding. We have demonstrated our optimization scheme to be capable of handling 30 variables and 20 constraints, within a compilation and running computer time less than a minute. This scheme gives not only the minimum cost and the optimizing values of the variables, but also all sensitivity coefficients. (Auth)


The solar power project aimed at generating electric power using ocean water temperature differences as an energy source is being funded primarily by NSF's RANN program. Electricity is generated by boiling a fluid at the temperature of water near the surface, then expanding the gas through turbine to drive a generator, then condensing the gas at the temperature of cold water from the depths. The sun, warming the surface water, is the free source; there is no fuel cost. The seapower plant is not affected by nighttime or cloud cover and the temperature difference remains constant, eliminating the need for energy storage. Due to a temperature difference of about 20°C, the thermal efficiency is only about 3 per cent. Schematics of the closed-cycle ocean thermal power plant and the Mark I prototype solar sea power plant are shown. (MOW)
N-140,493 National Science Foundation
Conference on Solar Sea June 27-28, 1973
Power Plant

PROCEEDINGS, SOLAR SEA POWER PLANT CONFERENCE AND
(Held at Carnegie Mellon U., Pittsburgh, Pa.).
June 1973. PB 228-066

ABSTRACT: A national conference was convened at
Carnegie-Mellon University in Pittsburgh,
Pennsylvania for discussions on ocean thermal
energy conversion. The conference was
sponsored by the National Science Foundation
and organized by Carnegie-Mellon University.
Its objectives were to afford an opportunity
for information exchange, identification of
key problems, and for discussions of how to
implement the ocean solar power plant
technology. Key workers and researchers were
brought together, they first reported on
existing studies as to technology and design
problems of ocean thermal energy conversion.
The edited versions of the oral
presentations are contained in these
proceedings. Following these presentations,
six working groups were convened, for
discussions on technological and
environmental aspects of the subject.
Summaries of the working groups' outputs are
presented for the following topics: power
plant siting, economic and political
problems, environmental considerations; low
temperature gradient heat transfer; turbines
and fluidics; plant anchoring; cold water pipe
design. (1973)

AVAILABILITY: NIS, PB 228 066 ($6.76 paper
copy/$1.45 microfiche).

TITLE: Turbine Design: Sea Solar Power Plants
AUTHOR: Anderson, J.H.
CORPORATE AUTHOR: University of Massachusetts,
Energy Program
ADDRESS: Amherst, MA
PUBLICATION DESCRIPTION: Report No.
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BPA Program
ABSTRACT: The low temperature differences between
the heat source and the heat sink in a Sea
Thermal Power Plant affect the turbine design
requirements. The design problems are more
similar to those of water turbines than those
of steam or combustion gas turbines. Turbine
size and speed and design characteristics are
discussed. Vapor turbines for Sea Thermal
Plants combine the good features of many
other turbines and should be capable of
higher efficiency and lower cost than
turbines for almost any other type of power
plant. (MPG)
SOLAR SEA POWER.
C. Zener.

Heat engines operating in the tropical oceans, capitalizing on the temperature differential between upper and lower levels, could provide a source of economical, pollution-free electricity.


The author describes how vast amounts of power can be generated from the sun warmed ocean waters in conjunction with the cold waters underneath. The potential supply of power and economics are compared to other possible sources of energy. The various legal, environmental, technical and economic problems are discussed, with suggestions for required development programs. The conclusions are that Sea Solar Power can be economically practical in a short time with a rather small development program compared to its huge potential. (1 ref.)

Amer. Geophys. Union, 54 h
Ann. Meeting, Apr. 16-20, 1973,
Wash., D.C.

U8 (Invited Paper: 30 min)
J. Hilbert Anderson
Consulting Engineer
1645 Hittuck Lane
York, Pa. 17401

The Potential for Solar Sea Power Generation. Vast amounts of power can be generated at low cost by utilizing the upper sun heated surface layers of water in the tropical oceans to boil a high pressure fluid such as propane. The propane is expanded through a turbine to produce power, then condensed at low pressure by cold water pumped from deep in the ocean. The warm water discharged from the power plant can then be deoxygenated and partially evaporated to produce fresh water condensed by the cool water discharged from the propane condensers. The potential quantities of power that can be generated from the Gulf Stream and the Caribbean Sea are enormous. Some estimates of their magnitude will be given. Preliminary estimates of effects on the natural heat balance will be given, as well as some discussion of possible effects on the marine ecology.

POWER, FRESH WATER, AND FOOD FROM COLA.
DEEP SEA WATER. Othmer, D. F.; Ross, O. A.; Schuman;
Solar heat energy accumulates in the vast volume of warm tropical seas. The looming energy crisis causes a renewal of interest in utilizing this stored solar heat to give, in addition to electric power, vast quantities of fresh water. Warm surface water, when evaporated, generates steam, to power a turbine, then fresh water when the steam is condensed by the cold water. A great increase in revenues over that from power and fresh water is shown by a substantial mariculture pilot plant. Deep seawater contains large quantities of nutrients. These feed algae that feed shellfish, ultimately shrimp and lobsters, in shallow ponds. Waste grow seaweed of value and combined revenues from desalination, power generation, and mariculture will give substantial profit. (auth)

The main difficulty in harnessing solar energy is collecting it. The collection mechanism for solar sea power in the ocean. Solar energy, absorbed by the surface waters of tropical oceans, can be converted first into electric power by solar sea power plants, then converted by electrolysis into chemical energy, and transported by ship for distribution to heat homes, power transportation facilities, and form a basic ingredient in materials processing. The problems involved in a SSPP are insufficient temperature difference, corrosiveness of seawater, microbial fouling, plant anchoring, diluteness of solar energy in the ocean, and environmental effects. (MCW)

OCEAN THERMAL DIFFERECNE
POWER-PLANT DESIGN. Paper discusses the preliminary design of a closed Rankine cycle power system using the ocean temperature difference as an energy source. A thermal cycle analysis and hull design factors for the system are presented. Graphical and tabular results which illustrate the importance of various cycle and design parameters are included as well as the outline of the digital-computer-based cycle analytical model. In addition, one design for a 400-kwp power plant is shown. 27 refs.

Conceptual Design of a Rankine Cycle Powered by the Ocean Thermal
Difference - J. G. McGOWAN, J. W. CONNELL, L. L. AMBS, W. P. GOSS...

THE SEA PLANT—A SOURCE OF POWER, WATER, AND FOOD
WITHOUT POLLUTION.
Anderson, J. H.

Abstract—This article expands the idea of sea thermal power to show how it can be used to produce fresh water as a by-product or a major product from the plant. Limitless quantities of fresh water can be produced at a cost of less than five cents per thousand gallons.

The warm water leaving the boilers of the power plant is deaerated, then boiled under vacuum conditions to produce steam. The heat to evaporate steam comes from the water and lowers its temperature a few degrees.

The steam is condensed in condensers cooled by the cold water discharged from the power plant condensers. The power required for pumping the water and for deaeration is produced by the sea thermal power plant. More than a billion gallons of water per day can be produced by a power plant of 100 MW capacity.

Since the condenser water from the deep ocean is warmed by the power plant and desalting plant, it will remain near the surface, and can therefore provide food for fish. We estimate that a 100 MW power plant can supply enough nutrient-rich water to grow up to seven million kilograms of fish per year.
Research Applied to Ocean Sited Power Plants.
J. Hilbert Anderson.
Massachusetts Univ., Amherst. 31 Jul 73, 67p NSR-RA/N-73-056 NSR-RANN/SE/GI-34979-73-2
PB-228 878/SWE PCS6.50/01-45

Additional subsystem and component sizes were produced for the Ocean Thermal Power Plant. The math model of the cycle calculates effects from single or group parameter variations. Results are given in terms such as overall thermal efficiency, size and cost. Efficiencies close to 2.0% are indicated for a 32F (delta t). Three working fluids remain competitors. One Total System Configuration is in use as a common denominator for all research effort; other configurations are under study. Prospects for economic thermal plants look very good. Solutions to remaining major problems appear to be state-of-art. A 1100 mWe submerged nuclear power plant has been arranged and balanced. The condenser exhaust plume has been described for one circular cross section discharge nozzle. New design techniques applicable to thick large diameter concrete cylindrical and spherical pressure hull shells have been elaborated. Two major problems seem to cloud the prospect for application of OMNFEGS: (a) LWR plant costs have escalated so drastically that OMNFEGS economics are border line, and (b) this team lacks expertise needed to identify reactor compartment shell material that would contain a meltdown. Redirection of this project to large offshore coal burning plants is suggested.

Warm ocean water in the tropics moves toward the poles, and ice melts. Cold water at the poles slides into the depths of the oceans and slowly moves toward the equator. In the tropics this cold water provides a nearly infinite heat sink at about 5 C at a depth as shallow as 1000 m. Both the hot surface water and the cold deep water are replenished by solar energy. The temperature differentials in the tropics are not large, but can be used to generate electricity. Far more energy than that consumed throughout the world is potentially available from the seas. In 1964, Hilbert Anderson and James Anderson of York, Pennsylvania, suggested the economic viability of a power plant operated by the ocean thermal gradient. The thermal efficiency of an ocean gradient power plant is low, but the heat exchanger walls may be made thin making it economically feasible. In addition to electricity, an ocean thermal gradient plant could produce fresh water, and hydrogen and oxygen through electrolysis of water. Another product of the plant is food. The artificial upwelling necessary to provide cold water from an ocean gradient plant could be used to cultivate algae, crustaceans,
DESIGN OF A SEA THERMAL ENERGY POWER PLANT.
A.E. Snyder.

A unique 8000-kw gross power and sea water conversion plant is described which uses the temperature difference of the ocean to produce usable energy and fresh water. This plant has been designed for installation along coastlines in a semitropical area. Estimated cost is 2.5 to 3 million dollars, including building and erection costs.

DEEP OCEAN WATERS AS A RESOURCE FOR COMBINED MARINE CULTURE, POWER, AND FRESH WATER PRODUCTION.
Marine Technology Soc. Jour., v.4, no.5, Sept/Oct '70

Tidal energy from the Severn Estuary

T. L. Shaw
Department of Civil Engineering, University of Bristol, Bristol BS8 1TR, UK

Energy generation from the tides is widely regarded as economically less viable than that from conventional thermal alternatives. Although economic comparisons are unfavourable the potential overall improvements in network operation indicate the true value of new plant.

The article briefly reviews the incidence and possible developments of sites for tidal energy, the effects of barraging estuaries for such development, and the principles of operation of various kinds of tidal-power schemes, including the integration of the output into power systems.

The experience gained from six years' operation of the Rance scheme at St Malo is discussed and Russian experimental work is described.

Modern developments in the technology are dealt with in the next section where some of the latest ideas are mentioned, and their possible application to the Bay of Fundy and Severn estuary sites is discussed.
TIDAL ENERGY FROM THE BAY OF FUNDY

KEY WORDS: Basins; Environmental engineering; Nuclear power plants; Power; Powerplants; Pumped storage; Tidal power generation; Tidal power plants

ABSTRACT: A new concept in the use of tidal power is proposed for a project in connection with the recent Bay of Fundy studies. This scheme is based on the two-basin principle, extended to perform a pumped storage role using the same facilities. Much increased efficiency results; the 'thermal' input creates operating heads well beyond those from tides alone. The main feature of this plan is the combining of a varying tidal input with off-peak/nigh-time storage from thermal plant, for release during the day according to demand.


PUMPED STORAGE AND TIDAL POWER IN ENERGY SYSTEMS.
C.K. Haswell, et al.

Prospects for the use of pumped storage and tidal energy are reviewed. Discussions are included on tidal energy, electric systems, suiting tidal power to electric systems, uniting pumped storage with tidal power, construction, and economic evaluations.

ENERGY FROM FUNDY TIDES. R.H. Clark.

Tidal possibilities in the Bay of Fundy with tables, charts, and maps.

TIDAL POWER
Tidal Energy and Its Development. Dr. E. M. Wilson,
University of Salford, England

Ocean '72; record. [New York, Institute of Electrical and Electronics Engineers, 1972]
viii, 613 p. illus. 28 cm.
Held Sept. 13-15, 1972 in Newport, R. I.
"IEEE publication 72 CH0 660-1 OCC."

TIDAL BASIN RESONANCE FOR POWER
W. H. Cobble*

The damped wave equation is solved for the displacement in a channel of linearly varying width and constant depth. The displacement equation is subject to a time dependent forcing function at the open end of the channel, and a dam is at the narrow end of the channel. The general solution of the problem is developed. A graph of the displacement amplification is shown for several positions along the channel.
TIDAL POWER. Proceedings include 25 papers on the various design features, performance, and economy of both already existing and planned tidal power schemes around the world. Several associated problems, such as that of integration of tidal energy into public electricity supply, environmental effects of tidal power development, and selection of structural materials resistant to seawater corrosion are also examined.


1970

Tidal power

Anon., Electr Rev., 187 (3), 72, (17 July 1970). The main reason for the rejection of the Bay of Fundy scheme by the Atlantic Tidal Power Programming Board was the current high interest rate of 7% on the estimated capital cost (£93/kW installed). Tidal power will be one of the alternatives investigated whenever the new Brunswick Electric Power Commission next reviews its generation programme.

A reconsideration of tidal power: T.L. Shaw (Univ of Bristol, England). S.W. Huntingdon; Water Power v 22 n 5-6 May-June 1970. p 219-24: The various combinations of basins, turbines and locks that could best serve different conditions are examined. From the various calculations that were carried out, it is concluded that single-basin single-tide working is the preferable technique for harnessing tidal power, particularly when a high level in the basin is desirable. 6 refs.

TIDAL BASIN RESONANCE FOR POWER. M.H. Cobble.

p.243-

Space Technology and Earth Problems. -Edited by

TL787.6462, V.23

1969

Soviet tidal power

Anon., Energy Int., 6 (1), 29, (Jan. 1969). The first tidal station on the USSR under construction near Murmanak (with an annual output of 4 000 GWh) will be followed by the Lomniv 300 MW, Lower Bay 1 300 MW, and White Sea 5 000 - 6 000 MW stations. Total annual output of tidal stations in the USSR will eventually amount to 100 000 GWh.

Tidal power becoming more feasible

Brundrett, F., Electr Rev., Lond., 185 (22), 787, (28 Nov. 1969). Developments in engineering technology, construction techniques, and control of the generating cycle are increasing tidal power feasibility. The continual increase in power demand makes the inherent large scale of tidal power stations advisable.

Integration of pumped storage with tidal power with particular reference to the Severn Estuary


1969


"Tidal & Wave Power"
(3 rift) (6-32 to 6-37)

"Handbook of Ocean & Underwater Engineering" 1969

TC1645
H35 HR

Soviet's first tidal station
Anonymous, Energy Int., 8, (3), 42 (Mar. 1968). Experimental turbine will be actuated by rise and fall of nearly 60 feet.

Optimization of tidal power generation

Magnetohydrodynamics considered for tidal generation
Anonymous, Electr. Times, 154, 20, (4 July 1968). In a recent paper by R.R. Lloyd presented to the Engineering Institute of Canada, it is suggested that MHD tidal power generation might be economical within 10 years. Within a few years superconducting magnets should provide high enough flux densities to make feasible MHD generation using the velocities obtained from tidal flow of sea water. Despite many difficulties, a system is proposed based on 120 units each of 9.6 MW.

Tidal power with special reference to plant, construction techniques and the integration of the energy into existing electricity systems
Swales, M.C., et al., Wat. Pwr. Conf., Plenary Meet., Moscow, Aug. 1962. Future tidal power development is reviewed, and an assessment made of the tidal power pumped storage method. For a typical scheme the cost of energy at the barrage has been estimated at 4 mills/kWh. Taking into account the energy supplied via pumped storage, the corresponding average energy cost would be 8 mills/kWh, and so, in certain areas, tidal power is competitive with any alternative peak energy source.

Tidal power: a new opportunity?
Brakewitch, M., Engineering, Lond., 200, (5342), 358, (6 Sept. 1968). The energy produced is either used for pumping on the system or else as pumping power for a high-head pumped-storage plant, depending on the time, in relation to the electrical demand, at which favourable tidal conditions occur.

Estimated Effects of Barrage on Tides in Bristol Channel, E.K. NEAPs. Instn Civ. Engns—Proc v 40 Aug 1968 p 495-509. Possibility of harnessing great amount of tidal energy in Bristol Channel by construction of hydroelectric barrage scheme is considered; study was conducted to determine how introduction of barrage across flow would affect overall tidal conditions in channel; estimates are made of changes which might occur in both tidal elevation and current; method employed is based on integration of one-dimensional hydrodynamical equations for channel, using step-by-step numerical procedure.

Tidal power with special reference to plant, construction techniques and the integration of the energy into existing electricity systems
Swales, E.M., et al., Wat. Pwr. Conf., Moscow, Section 11, Pap. 299, (28 Aug, 1968). 47 pp. Critically examines inherent limitations of the La Rance tidal power station, France, which exploits the pump/turbine concept. The pump/turbine method is compared with the more adaptable tidal power pumped storage (p.p.s.) method, where the primary low-grade energy generated on the ebb tide is stored, when not immediately required. The p.p.s. concept is more economic when the barrage generating plant is simple and robust. Describes the straight flow turbine and rim-generator, which satisfy these conditions, the way in which the number of turbines and sluice-gates may be selected so energy costs are optimized, ways of adapting the coisson method so the power station sluices may be built and largely equipped before being floated into position and sunk on a prepared foundation, prospects of future tidal power, and the economics of p.p.s. For a typical scheme the cost of energy at the barrage is estimated at 4 mills/kWh.

Optimization of Tidal Power Generation, M.C.SWALE, E.M. WILSON. Water Power v 20 n 3 Mar 1969 p 109-14. Method for energy and economic optimization of tidal power generation by using computer is described; method is explained in relation to ebb-generation schemes, but could be applied to multiple basin and simple two-way generation design where pumping is not proposed; results are given from study of tidal generation in Fatik Arm, Alaska.
Bristol Channel tidal power scheme
Anon., Electr Rev., Lond., 195, (6), 318, (5 Mar. 1967). A tidal power scheme for the Bristol Channel using two separate basins has been proposed by E.N. Underwood and Partners and Sir Frederick Snow and Partners. The scheme would have a continuous power output of 1 800 MW or 5 000 MW for three hours per day. Details of the plan, which would cost £400 million, have been discussed with the MoP and CEBG. Equinomial tidal levels could be established throughout the year by lowering the level of basin B at low tide and raising the level of basin A at high tide, using separate pumps installed in the barrage.

Undercurrent power plants: a variation of tidal power
Anon., Power, 111, (6), 147, (June 1967). As ocean current flows through a funnel-shaped orifice, its speed increases substantially, e.g. from 2.3 mph to 94.5 mph. The high-speed current could be used to drive underwater turbines and generate electricity.

A fundamental approach to tidal power
Fentsloj, H.E., Wat. Wpr., 19, (6), 318-322, (Aug. 1967). A comprehensive systematization of water power utilization on a dimensionless basis. From this work is formulated the "Law of Antithesis" as between river and tidal power utilization. The failure to recognize this law is the reason why complete utilization of tidal power has not been achieved. Supports the suggestions made by E.M. Wilson, but considers the double cycle to be superior to the single cycle system.

Tidal power from the Severn
Anon., Engineer, Lond., 223, (5802), 513, (7 Apr. 1967). A proposal for a two-basin scheme for tidal power generation in the Severn estuary has been put forward jointly by two firms of consulting engineers, E.N. Underwood and Partners and Sir Frederick Snow and Partners. The scheme is illustrated and described. It is estimated that annual power output could be 11.8 TWh. Cost of the scheme would probably lie between £360-400 m. Some comparison is made with another scheme. Editorial comment is offered.

TIDAL POWER COMES TO FRANCE.

This month the world's first tidal power station starts generating. Situated in Rance estuary in northwestern France, it utilizes one of the highest tidal ranges in the world.

Fundy Tidal Power—Canada's Biggest Project. B.C. Halls, Elec. News & Eng. v. 74 n. 19 Oct 1965 p. 46-59. Study for development of tidal energy on Minas Basin in Canada, is considered short sighted since it develops only part of full potential; dam across Bay of Fundy is proposed to develop full potentially available tidal power of about 75 million kw; preliminary analysis showing feasibility of dam across Fundy Bay; technical aspects of tidal energy.

Solway Firth Tidal-Power Project. E.M. Wilson, Water Power v. 17 n. 11 Nov 1965 p. 431-2. Study of technical and economic feasibility of developing tidal energy on Solway Firth, a low tide of Irish Sea in England, estimates of probable cost of necessary works in Solway Firth and calculations of available tidal energy under various regimes and plant dispositions; method of integrating tidal energy with mixed thermal, nuclear and hydro generation of combined North and South of Scotland system is examined; integration of tidal energy into combined system is achieved by using proposed Loch Fyne pumped-storage scheme developed to 1200 MW.

POWER FROM THE TIDES.
J. Dupont, et al.

By adapting lunar rhythm of the tides to the solar cadence of our daily needs we can harness the endless energy of the oceans that ebb and flow across our shores.
Feasibility Study of Tidal Power from Loughs Strangford and Carlisle with Pumped Storage at Royston, E.M. WILSON. Ireland Civic Engr. Proc v. 22 Sep. 1965 p. 23-27. Cost of tidal power, as it could be generated at two sites in Northern Ireland, is evaluated. Recent developments in low-head turbine and generator design and in development of reversible pump turbines for high heads are bringing cost of tidal energy, even at sites with quite low tidal ranges, into competition with other more conventional power sources. Author reports proposed development in detailed way and shows how proposals might be implemented against background of existing, almost exclusively thermal, power supply system in Northern Ireland.

Bulb Turbines Will Harness Tides and Supply Power to French Grid, F.C. LIVINGSTONE. Power Eng. v. 68 n. 5 May 1966 p. 68-69. Flow of River Rance water at high tides will turn 24 double-acting bulb-type turbines and produce peak output of 240 MW at flood tide and high tides; flow of water reaches 23,540 cu yd/sec; 1214-ft long concrete tunnel connects engine room, and has floor at crest of low tides; engine room consists of 24 bulb sets, each having capacity of 10 MW; power will be produced at 3.5 kv and sent out by three 80,000-kv transformers at 220 kv.

Potentials of Tidal Power on North Atlantic Coast in Canada and United States, 1. T. LAFLA, Coastal Engr. 9th Conference, June 1964 p. 69-87. Most suitable locations for erection of tidal power plants on North Atlantic Coast are reviewed and classified in respect to possible pool arrangements; harvesting of tides to produce power in various layouts is discussed; power output from two proposed tidal power projects, Passamaquoddy Bay and Sheepody Bay is compared and some auxiliary power sources to supplement varying output of tidal power are discussed; tides producing forces and effect of constrains on tidal height.

Rance Tidal-Driven Power Plant, M. LONGEAUX. Indus. J Power 4, River Valley Development v. 14 n. 11 Nov. 1964 p. 40-41. Construction and state of progress of Rance, on the North Coast of Brittany world's first tidal-driven power plant; during highest tides, volume of water cycle four times every 24.8 hr and flows reach 18,000 cu m/sec; structure as whole, with its piers, may be likened to conventional mobile dam for harvesting low heads, with peculiarity that sluice gates must withstand pressures on both faces; between two structures new power house proper, consisting of 24 "bulb" sets generating 10 MW, transformers and auxiliary services.

QUODDY QUESTION—TIME AND TIDE.
G.D. Friedlander.

Historical back-
ground and present status of Tidal Power Project for generating electric power in Passamaquoddy Bay area on border between Maine and New Brunswick by harnessing power of great tides; discussion of construction problems, Cofferdaming, filling and empting gates, navigation locks, flood control and economic factors; description of analogous in Rance project in Brittany, France, with capacity of 369 MW in 24 turbine sets; comparison between these projects; summary of studies by various government agencies; graphs and maps.
HYDROELECTRIC POWER: A NON–RENEWABLE RESOURCE?
Ian C.T. Nisbet.
Technology Review, June 1974, p.5,64.

United States has little potential for significant hydroelectric development: most of the best sites are already exploited, and even damming the Grand Canyon would do little to relieve the nation’s energy problem. But in the present climate of resource crisis and environmental concern, even small projects are attractive enough to put their opponents on the defensive. Elsewhere in the world, hydro schemes have much greater economic appeal, and vast projects are underway—if all the dams on the drawing board come to fruition, most of the major rivers of the world will be under control within 50 years.

CHEAP POWER—AN EXPENSIVE FAILURE: HYDRO-ELECTRIC POWER AND INDUSTRIAL DEVELOPMENT IN NEWFOUNDLAND. Several problems associated with the water resources and hydro-electric power developments are discussed from the economic point of view. 19 refs.


The report on the Mottville development pertains to the development of the hydroelectric power potential of the St. Joseph River Basin within the limitations of other desirable water uses and environmental concerns.

ELECTRICAL FEATURES OF THE CHURCHILL FALLS DEVELOPMENT.
R.H. Stuart, et al.

This paper contains a brief outline of the principal elements of the 5225-MW Churchill Falls hydroelectric power development, together with a review of the significant electrical features. It describes the 500-MVA generating units, the arrangement of busses, transformers and 240-kV cables used to transmit energy from the underground powerhouse to the surface, the 735-kV switchyard, the auxiliary power system, protective relaying, control and annunciator schemes, and the data logging computer installation.


The object of this study is to determine the feasibility of utilizing the energy resources available in the coastal region of Saudi Arabia adjacent to the western shore of the Arabian (Persian) Gulf for the development of an agro-industrial complex in that area. The book actually comprises two studies. The first is based on utilizing natural gas to power a number of hypothetical projects, which are then weighed in terms of their economic viability. The second study is based on a novel means of hydroelectric power generation—heliohydroelectric.
THE CONTROL OF THE WATER CYCLE.
J.P. Selicko and M. Al Kettani.

The recent emphasis in hydrologic studies on the crucial role played by the general circulation of the atmosphere has led to schemes for altering this vast natural process.
THE KETTLE HYDRO-ELECTRIC DEVELOPMENT ON THE NELSON RIVER.
L. Ingram and W. Gouldsborough.
IEEE Trans. Power App. & Syst., v. PAS-90, May/June 1971, p.1207-

The Kettle hydro-electric development by Manitoba Hydro is located on the Nelson River in the Province of Manitoba and is unique in that, up to now, it is the only generating station in the Western world which will feed exclusively into a dc transmission system. Because of this, some features associated with this plant are somewhat different from conventional hydro-electric developments and this paper will describe these features together with certain other electrical and mechanical aspects of the project.

COMPOSITE REPRESENTATION OF A MULTIRESERVOIR HYDROELECTRIC POWER SYSTEM.
N.V. Arvan'tidis.

Abstract—A composite model for multireservoir hydroelectric power systems is constructed for studying the monthly decision concerning total hydropower. This is an important decision when the inflows are uncertain and when hydro, with zero marginal cost, can be used not only to satisfy firm load commitments but also to displace other firm resources or to serve secondary loads. In such a case, the tradeoff between savings at the present and expected benefits in the future is determined mainly by the total hydropower. The construction of a composite representation for the multireservoir hydroelectric power system in the Pacific Northwest is described. The composite model is based on a single measure "potential energy" which is indicative of the system's generating capability. This results in a one-dam representation of the multireservoir system which, in effect, receives, stores, and releases potential energy, in a statistical model for the potential energy inflow and in a generation function which relates potential energy released to actual electric power generated. It has applications in the study of different operating policies, market structures, and investment programs through simulation or optimization. As an example, it is used to obtain the net operating revenues as a function of the excess thermal in the system.

TITLE: Hydroelectric Power Policy
AUTHOR: Pelco, T.P.
CORPORATE AUTHOR: National Water Commission
PUBLICATION DESCRIPTION: PB 204 052,
NWC-SDB-71-012, 63 p.
PUBLICATION DATE: 1971, February

POWER FROM LABRADOR: THE CHURCHILL FALLS DEVELOPMENT.
G.D. Friedlander.

One of the worlds largest hydroelectric projects has passed the halfway mark toward completion.
A/GOFREY, F. A.

MAJOR HYDROELECTRIC POWERPLANTS IN TEXAS: HISTORICAL AND DESCRIPTIVE INFORMATION, BY F. A. GODFREY AND C. L. DOWELL.

TEXAS WATER DEVELOPMENT BOARD; (AUSTIN) VII; 93 P. ILLUS. 28 CM.

TEXAS WATER DEVELOPMENT BOARD. REPORT 81 BIBLIOGRAPHY: P. 93.

LC: WATER POWER ELECTRIC PLANTS -- TEXAS.

ADDED: M•US•TX DOWELL, CLEO LAFOY, JOINT AUTHOR.

MAIN-AUTH. TRACE-SERS•TITL•AUTH• CATLG BY-LC

625
N74-18600* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
H2-O2 COMBUSTION POWERED STEAM-MHD CENTRAL POWER SYSTEMS also A74-27775 #

Estimates are made for both the performance and the power costs of H2-O2 combustion powered steam-MHD central power systems. Hydrogen gas is assumed to be transmitted by pipe from a remote coal gasifier into the city and converted to electricity in a steam MHD plant having an integral gaseous oxygen plant. These steam MHD systems appear to offer an attractive alternative to both in-city clean fueled conventional steam power plants and to remote coal fired power plants with underground electric transmission into the city.

Author

N74-18657* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIGHT BULB HEAT EXCHANGER FOR MAGNETOHYDRODYNAMIC GENERATOR APPLICATIONS - PRELIMINARY EVALUATION

The light-bulb heat-exchanger concept is investigated as a possible means of using a combustion heat source to supply energy to an inert gas MHD power generator system. In this concept, combustion gases flow through a central passage which consists of a duct with transparent walls through which heat is transferred by radiation to a radiator receiver which in turn heats the inert gas by convection. The effects of combustion-gas emissivity, transparent-wall transmissivity, radiation-receiver emissivity, and the use of fins in the inert gas coolant passage are studied. The results indicate that inert gas outlet temperatures of 2500 K are possible for combustion temperatures of 3200 K and that sufficient energy can be transferred from the combustion gas to reduce its temperature to approximately 2000 K. At this temperature more conventional heat exchangers can be used.

Author

N74-18967* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA LEWIS H2-O2 MHD PROGRAM

Performance and power costs of H2-O2 combustion powered steam-MHD central power systems are estimated. Hydrogen gas is assumed to be transmitted by pipe from a remote coal gasifier into the city and converted to electricity in a steam MHD plant having an integral gaseous oxygen plant. These steam MHD systems appear to offer an attractive alternative to both in-city clean fueled conventional steam power plants and to remote coal fired power plants with underground electric transmission into the city. Status and plans are outlined for an experimental evaluation of H2-O2 combustion-driven MHD power generators at NASA Lewis Research Center.

Author

N74-189338* # National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CLOSED CYCLE MHD POWER GENERATION EXPERIMENTS IN THE NASA LEWIS FACILITY

Many modifications were made in the MHD facility. These include a redesign of the MHD duct interior, addition of mixing bars, increased electrical isolation of all the high temperature components from each other and from ground, and experimentation with various cesium seed vaporization and injection techniques. With the exception of the cesium system which needs further improvement the above modifications were quite successful and resulted in improvements in generator performance. The facility was run for a total of 400 hours in the past year, with 70 hours of this operation at temperatures of 2000 K or more with hot generator walls. With the exception of replacing one cracked brick in the MHD channel no repairs were required in the high temperature loop components for the duration of these tests. Uniform Faraday and Hall voltage profiles were obtained and the Faraday open circuit voltage varied from 90 to 100 percent of the ideal uh. The magnitudes of the measured parameters are: Faraday open circuit voltage approximately 70 V, total Faraday current approximately 20 A, Hall voltage approximately 250 V, power output approximately 300 W, and power density 0.36 W/cm^2.

Author
Cryogenics & Industrial Gases, v.9, no.1, Jan/Feb.1974.

MHD: A realistic solution to the energy crisis

This report, compiled by New York economic consulting firm Lionel D. Edie & Company, says the economics of this power generation method justify further funding, emphasis and support by government, utilities, coal producers and other suppliers to utilities.

Thermodynamic Data for Air Preheaters in Direct Coal-Fired Magnetohydrodynamic Power Generation Systems.
F. E. Spencer, Jr. and J. C. Hendrie, Jr.
PQ-228 109/SWE PC-GPO/MFS1.45-NTIS

Calculated equilibrium composition and thermodynamic functions for three phases in the flue stream from a hypothetical open cycle MHD generator fired with coal combustion products. Stoichiometry specified as 1.0 kilogram of average Upper Freeport seam hvBb coal plus 1.0 gram mole K2O plus 101% of stoichiometric air slag rejection figures of 75 and 90%. Data useful in design of high temperature air preheaters. Brief discussion of certain points of agreement between experiment and present mathematical model. (Author)
Chun Hsu, and Ho-Tien Shu.
New Technology Inc Huntsville Ala Mar 74, 149p
NTI/TI065A
AD-778 757/SWE PC$4.75/MFS1.45

A comprehensive survey of the current development status of all MHD power cycles was made to assess the relative merit of the various cycles for naval applications. Dynamic System model was formulated to analyze the system performance. First, detailed component model was formulated and component designs were performed to determine the geometric configuration of each component. Next, a method based on variational 27 principle and the steady-state system solutions was developed to determine the component node models. A manageable dynamic system model and a simplified linear system model were then formulated. Finally, system stability analysis on the linear node model was performed to examine the local system stability. (Author)

Magnetohydrodynamic Generators.
Foreign Technology Div Wright-Patterson AFB Ohio 9 Apr 74, 76p FTD-MT-24-238-74
AD-779 787/IWE PC$15.00/MFS1.45

The monograph discusses problems of the theory, calculation and design of magnetohydrodynamic generators, and also some experimental studies relating to them.

N73-29867* Georgia Inst. of Tech., Atlanta.
POWER PLANT SYSTEMS ANALYSIS
CSCL 18E

Three basic thermodynamic cycles of advanced nuclear MHD power plant systems are studied.

AD-778 435/8GA PC$3.25/MFS1.45
Systems Research Labs Inc Dayton Ohio EXPERIMENTAL CHARGE PRODUCTION IN A TWO-DIMENSIONAL ELECTROFLUID DYNAMIC TEST GENERATOR.
Russell W. Griffith. Jan 74, 39p ARL-74-0002 Contract F33615-70-C-1315


The effects of pressure and electric field strength on corona are presented with the goal of showing how corona can be produced under favorable to the EFD process. Unique properties of the two-dimensional electric field are shown along with their effects on corona charge production. Experiments are described which compare the performance of various corona electrodes in the amount of current they can produce under similar conditions, as well as the effects of pressure and relative humidity levels on corona current. The eff ect of an electric distribution in producing a non-uniform electric field is shown. One electrode shape, the flat-edged corona disc, was found to be superior to the others in the amount of current produced, durability, attrator voltage required, and anticipated operation at very high pressure levels. (Author)
QC809. M3593 1973


Calculation and measurement of MHD generator boundary-layer velocity profiles, stability of a nonequilibrium helium-cesium MHD plasma in a regime of fully ionized seed, and thrust stand performance measurements of a lithium fueled applied field MHD arcjet are among the topics covered in papers concerned with plasma flows and instabilities. Other areas covered include liquid-metal generators, system and design studies, and pollution and combustion plasma properties.

M.V.E.

1973


Extensive data on the contoured generator has been taken which corroborates the very preliminary data reported previously. Detailed experimental parametric studies were completed which mapped generator performance as a function of mixture quality, magnetic field, and generator loading. Turbine efficiencies of 50% have been achieved for the first-generation contoured generator. The experimental data, coupled with theoretical analyses and modeling, however, has shown conclusively that an electrical shunt exists within the generator. Extensive data has also been taken on the generator with constant cross-sectional inserts; similar results were obtained. Several possible causes for the electrical shunt were identified. In order to identify and isolate the principal electrical shunt, the following steps were taken: the generator was redesigned and rebuilt to completely eliminate leakage and thus the shunt behind the insulator wall, a gas-cleaning system and a micropore NaX filter was installed to minimize the amount of gas impurities that could enter the test facility and remove any oxides as soon as they are formed. These steps were successfully carried out and a new series of performance runs are planned. As the testing proceeds, the effects of the mechanical and fluid boundary-layer-type shunts can be separated. Control of the boundary-layer shunt will be accomplished with a gas injection system. (auth)
Coal fired MHD for central station power generation.


The ability of the MHD generator to operate at high overall thermal efficiency with combustion gas products which contain particulates and chemical impurities gives it a significant advantage over other methods of high efficiency in the development of high capacity fossil fired combined cycle systems which meet both air and thermal pollution standards. A coordinated development program is needed to explore the implementation of these advantages and this must include the design and construction of an MHD pilot plant operating with coal as primary fuel. (10 refs.)

N74-16620# Bureau of Mines, Pittsburgh, Pa. Energy Research Center

AN ECONOMIC EVALUATION OF MHD-STEAM POWER PLANTS EMPLOYING COAL GASIFICATION

P.D. Bergman, K.D. Plants, J.J. Deemer, and D. Bienstock

1973. 37 p (BM-Ri-7796) Avail: NTIS HC $4.00

To assess the efficacy and economics of producing power from coal, four open-cycle magnetohydrodynamic (MHD) processing schemes were selected for study. Each involved a different mode of coal combustion and level of gas cleanliness. The options considered were: (1) coal burned in a lagging combustor; (2) suspension gasification with slag removal prior to combustion; (3) parallel cyclone combustors, one operating fuel rich and the other operating with excess air; and (4) suspension gasification by the hot exhaust gases from the MHD duct with ash removed prior to combustion. Option 1 has the highest ash content in the combustion plasma and as a result would have the greatest operational difficulties associated with it. Options 2 and 4 have the cleanest MHD combustion plasma. For coal priced at $4/ton, the power generating cost of Option 4, 11.78 mills/kWh, is the highest, with Option 1 at 9.04 mills/kWh the lowest. These costs may be compared with a conventional power cost of 9.92 mills/kWh for the late seventies. Capital costs of three of the four options were competitive with those of conventional coal power plants employing stack gas SO2 cleanup systems. Option 2 has the most favorable combination of operating characteristics and power cost. It was concluded that a clean, high-temperature fluid can probably be produced from coal without leading to depressed system efficiencies and exorbitant capital cost.

A 1 MW, magnetohydrodynamic generator designed and constructed at ICFET, Bucharest is described. The MHD-02 generator operates in open circuit with plasma obtained by the combustion of natural gases in preheated air enriched with oxygen. It includes a combustion chamber, an acceleration nozzle, a conversion channel, a diffuser, a scrubber, an air preheater, an electromagnet, a seeding device, an oxygen installation, a water cooling installation, an inverter and a measurement installation. The operation regimes of the subassemblies are described within the preliminary tests of the generator. Also given are the results of measurements in the conversion channel. (auth)

Magnetohydrodynamic power generation.

Energy Dg.: 2: No. 4, 22-23(Jul 1973).

A materials program for magnetohydrodynamic power generation at the US National Bureau of Standards is summarized. Initially the research was concentrated on defining the behavior characteristics of construction, insulating and conductive materials that may be used in MHD, and in characterizing the coal slag that will be flowing through the system. Chemical analysis, x-ray diffraction, petrographic examination, differential thermal analysis and Mössbauer spectroscopy methods are used. Information was also collected on vaporization, viscosity and electrical conductivity of the slag. Properties of seed materials are also being studied. (UK)

R. BÜNDE and J. RAEDER, Max-Planck Institut für Plasmaphysik, Garching, Germany.


Summary—The calculation of the thermodynamic and electrical data, on the one hand, and the power production costs, on the other, of a kerosene-oxygen fired supersonic MHD generator was taken as a starting point to study the influence of the design parameters on the power production costs. The results of this investigation allow optimum design of the MHD power plant as regards power production costs and operational safety.

Key words: Thermodynamic and electrical data, power production costs, kerosene-oxygen, supersonic, MHD generator, design parameters, operational safety.
TITLE: Auxiliary Components: Their Effect on Plant Design Performance and Economics
AUTHOR: Hulse, P.J; Gannon, B.
CORPORATE AUTHOR: Avco Everett Research Laboratory Inc.
ADDRESS: Everett, MA
PUBLICATION DESCRIPTION: Paper presented at 13th Symposium on the Engineering Aspects of Magnetohydrodynamics
PUBLICATION DATE: 1973
SPONSOR: U.S. Dept. of Interior, Office of Coal Research; Edison Electric Institute
ABSTRACT: The design, performance and economics of open-cycle fossil-fired central-station MHD power plants are discussed with particular reference to important components and items, such as MHD generator performance, air preheat, oxygen enrichment of the combustion air, combustion process and waste heat utilization. (Auth)
AVAILABILITY: Dr. John Fox, Dept. of Mechanical Engineering, University of Mississippi, University, MS 38677 ($15.00 for entire proceedings)

N73-28749/7 Naval Postgraduate School, Monterey, Calif.
ELECTROHYDRODYNAMICS (EHD) RESEARCH Final Report, 1971-1972
Oscar Biblarz 12 Feb. 1973 100 p refs (AD-759971; NPS-572173021A) Avail: NTIS CSCL 20/9
The report contains further considerations of the slip parameter for unsteady flow. Several important gas/liquid combinations are represented and conclusions regarding electrical efficiencies are given. Also, a computer study which solves the combined Laplace/Poisson equations for geometries representing the EHD channel is included. This program is used to predict the effect of voltage scheduling electrodes, and the predictions are checked out experimentally. Author (GRA)

THERMAL CYCLE AND EFFICIENCY OF A VERSATILE POWER UNIT WITH A MAGNETOHYDRODYNAMIC GENERATOR AND THERMOELECTRIC GENERATOR
A MHD generator circuit is described with an overload mode capacity making operation possible in a wide range of loads. Author

N74-11852/7 ARO, Inc., Arnold Air Force Station, Tenn.
DEVELOPMENT OF DESIGN CRITERIA, COST ESTIMATES, AND SCHEDULES FOR AN MHD HIGH PERFORMANCE DEMONSTRATION EXPERIMENT Final Report, Apr. 1972 - Apr. 1973
(AD-766232; ARO-PWT-TR-73-75; AEDC-TR-73-115) Avail: NTIS CSCL 10/2
The successful application of magnetohydrodynamics (MHD) for commercial, coal-fired, base-load power generation requires that the generator have an energy extraction ratio of approximately 0.20 with a turbine efficiency of 70 percent. There is a significant gap between this required performance and the generator performance which has been achieved to date. The commercial MHD concept is critically dependent upon the generator achieving this required performance, and it is therefore essential that a demonstration of this generator performance be the highest priority. Of equal importance, the generator channel configuration and operating conditions which are necessary in order to achieve the required performance will be determined while accomplishing the performance demonstration. Thus other Office of Coal Research (OCR) sponsored MHD research efforts can be directed toward the real problems and configurations as determined by solid experiments. (Modified author abstract) GRA

TITLE: Economic Leverage Points of Open Cycle Magnetohydrodynamic Power Systems
AUTHOR: Oliver, D.A.
CORPORATE AUTHOR: Massachusetts Institute of Technology
ADDRESS: Cambridge, MA
PUBLICATION DATE: 1973
ABSTRACT: The importance of powerplant capital investment costs in the past and in the near future in controlling energy production costs is pointed out. The leverage which an advanced fossil fuel system such as the MHD/steam cycle can bring to bear on plant capital costs is examined in two key areas: diminished capital costs due to diminished cooling tower requirements for high efficiency MHD and the capability of the MHD/steam plant to utilize sulfur bearing fuels without the added cost of desulfurization. These advantages are compared to alternative fossil fuel systems including conventional steam plants and combined gas turbine/steam plants. It is shown that significant reduction of the MHD system capital costs over conventional steam plants may be required to give MHD/steam plants a strong advantage over combined cycle systems. (Auth)
AVAILABILITY: Dr. John Fox, Dept. of Mechanical Engineering, University of Mississippi, University, MS 38677 ($15.00 for entire proceedings)

The AFAPL-MHD Facility (KIVA-I) was used to conduct an extensive series of tests on the pegwall diagonally connected generator. Extensive knowledge was gained in the areas of conductivity, oxygen-to-fuel ratios, interelectrode connection angles, seed particle geometry, and optimum loading conditions. A peak power of 210 KW was achieved. A DC-to-DC Inverter was successfully operated on the MHD generator, providing an output of 50 KW at 50 KV dc. Numerous modifications were made to the KIVA-I facility, including a new high-speed data acquisition system, a close circuit television system, a pulse-control network for the main burner, a new set of pole faces for the magnet, a digital display panel, and an instrumented copper electrode assembly. Author (GRA)


Electrogasdynamics (EGD), a technique for generating electrical power directly from a moving gas stream, is reviewed. An important characteristic of proposed EGD energy-conversion systems is the absence of any mechanical moving parts. Instead, use is made of the interaction between a stationary electric field and charged particles which are swept through the field by a moving gas stream. Single stage and multistage EGD expanders are shown schematically. Efficiency problems are discussed. In the existing ambient-pressure EGD generator at Reading an isentropic efficiency (the ratio of the useful power output to the sum of the useful power output and the power losses) of 33% is theoretically possible whereas the maximum efficiency so far achieved is 12%. Using a multistage EGD expander with reheat, the Ericsson cycle, one can expect to convert heat to electricity at an overall efficiency of about 42%. The range of applications of the EGD system is discussed with especial reference to the field of low temperature refrigeration. (UIG)


The potential application of liquid metal magnetohydrodynamics (LMMH) to central station utility power generation through the period to 1990 is examined. Included are: (1) a description of LMMH and a review of its development status, (2) LMMH preliminary design for application to central station utility power generation, (3) evaluation of LMMH in comparison with conventional and other advanced power generation systems and (4) a technology development plan. One of the major conclusions found is that the most economic and technically feasible application of LMMH is a topping cycle to a steam plant, taking advantage of high temperatures available but not usable by the steam cycle. Author


For abstract, see N74-13466.

MHD POWER GENERATION.
R. J. Rosa.

The MHD conversion process is discussed and compared with the operation of a plasma fusion reactor. The potential advantages of the MHD generator over a turbine for the conversion of heat into a more usable form of energy are also pointed out. (I refs.)
Papers presented at the ASME Winter Annual Meeting, Nov. 11–15, 1973, are available to Aug. 1974 from ASME.


In this era of energy shortage and increased environmental restraints, coal-fired MHD power generation offers a promising option to ameliorate these problems. It has very low pollution potential. Emissions of SO₂ are practically eliminated.

Costs of removing SO₂ from a 1000-MWe MHD-steam plant are calculated to be $10.4/kw, approximately ½ of that for conventional coal-fired power plants. Seed makeup costs are marginal even at potassium recoveries as low as 95 percent. Through use of two-stage combustion, NOx emissions were reduced to 150 ppm or 0.12 lb NOx/million Btu, well below EPA regulations.

Capital investment for such a two-stage combustion, MHD-steam power plant is about 10 percent lower than for a single-stage combustion plant.

73-WA/Ener-9 ■ MHD Generator Experimental Activity at Avco Everett Research Laboratory, Inc., by R. Rosa, S. Petty, J. Klepeis, and O. Sonju, Avco Everett Research Laboratory, Inc., Everett, Mass.

The MHD generator is now recognized as offering one of the more promising possibilities for substantially increasing the efficiency of thermal to electric energy conversion, together with advantages of scale, quick response, and adaptability to all fuels regardless of ash content. Also of increased importance are its advantages with respect to environmental impact.

These features of MHD are discussed in more detail along with a discussion of the development program on MHD plant auxiliary components, in a companion paper (F. Hals and R. Gannon).

In this paper the test program currently underway at AFRL, Inc., on the MHD generator itself is described.

MAGNETOHYDRODYNAMIC GENERATOR FOR A COMBINED MAGNETOHYDRODYNAMIC ELECTRIC POWER PLANT WITH A FIRST GENERATION OPEN CYCLE


Contents: Preliminary analysis of the best magnetic systems; Variation problem in the technical and economical optimization of an MHD generator; Characteristics of optimum MHD generators.

THERMODYNAMIC DATA FOR AIR PREHEATERS IN DIRECT COAL-FIRED MAGNETOHYDRODYNAMIC POWER GENERATION SYSTEMS. Calculated equilibrium data are presented for three phases of the flue gas stream from a hypothetical open cycle MHD generator. A typical coal is "burned" with 1.0 gram-mole K₂O seed per kilogram coal and with 101 percent of stoichiometric air. Tables of composition and the overt thermodynamic properties, enthalpy, and entropy, are given for the temperatures 2200 (–100) 1100 kelvins. Pressures 1.0 and 1.5 atmospheres; and slag rejection figures of 90 and 75 percent. 4 refs.


The report presents research results on the following: the ST-40 MHD channel; the 4 Tesla magnet for the ST-40 MHD channel; MHD generator theoretical analyses; Gas dynamic performance, ST-40 channel; MHD generator performance, ST-40 channel; and gas dynamic performance. (aut)


CLOSED CYCLE MHD FOR CENTRAL STATION POWER WITH FOSSIL OR NUCLEAR FUELS


A closed cycle MHD generator using a noble gas with allsili metal vapor as the working fluid, when used as a topping unit for a conventional steam plant, can yield cycle efficiencies in excess of 60% at peak stagnation temperature of 3000F. While high enough for substantial gains in thermodynamic efficiency, this temperature is relatively low for an electrically conducting gas and conductivity is achieved by decoupling electron temperature from gas temperature. A ceramic regenerative heat exchanger supplies thermal energy to the working fluid. The latter carries any clean fossil fuel, preferably low BTU (about 150 BTU/GD) coal gas. With multi-stage combustion, pulverized coal is also a possible fuel. On a long range basis, closed cycle MHD is ideally suited for high temperature gas cooled fusion reactors and probably also to fusion reactors. The closed cycle MHD generator is adaptable to the Brayton cycle, the regenerative Brayton cycle and eventually the Rankine cycle. Author (GRA)

CONGRESS GETS STATUS REPORT ON MHD POWER GENERATION. (Second part of Energy Digest's coverage of House hearings on MHD research.)


MAGNETOHYDRODYNAMIC POWER: MORE EFFICIENT USE OF COAL. A.L. Hammond.


It is noted that MHD generators offer a method of eliminating sulfur oxides and reducing nitrogen oxides emissions from coal fired plants.
Feasibility of Utilizing MHD for Powering High-Speed Land Vehicles
J. J. Lacey, F. E. Spencer, J. J. Demeter, D. Bienstock

Hall Current Effects in the Lewis Magneto-hydrodynamic Generator
L. D. Nichols, R. J. Sovie

Slip Parameter for Electrogasdynamic Generators with Unsteady Flow, O. Biblerz

Exploratory Investigation of an Electric Power Plant Utilizing a Gaseous Core Reactor with MHD Conversion, J. R. Williams, Y. Y. Yung, K. D. Kirby, J. D. Clement

Open Cycle Coal Burning MHD Power Generation—An Assessment and a Plan for Action (Revision of OCR Report No. 64)
Issued August, 1972
R&D Report No. 71
Contractor: Massachusetts Institute of Technology
Refer to: Titled report and GPO Catalog No. 163.10:71
Price: $1.50

Magnetohydrodynamic Power Generation with the Combustion Products of Char
Issued January, 1972
R&D Report No. 65—Interim Report No. 1
Contractor: University of Tennessee Space Institute
Refer to: Titled report and GPO Catalog No. 163.10:65/Int. 1
Price: $0.75

An electrogasdynamic generator model is presented in which account is taken of the influence of the outlet section of the process in the region of conversion. By formulating appropriate boundary conditions for the selected generator model, it was possible to determine nonlinear internal resistance of the generator as a function of flow parameters and the model geometry. (Appl. Mech. Rev.)
MAGNETOHYDRODYNAMIC METHOD OF PRODUCING ELECTRICAL ENERGY, PART 1
ky Metod Poluchenya Elektroenergi" Moscow, Energija. 1972 380 p 
(JPRS-57940-1-Pt-1) Avail: NTIS HC $12.50

A collection of articles on magnetohydrodynamic energy
generation is presented. The topics discussed are: (1) the theory
and calculation of flows in a MHD generator operating on an
equilibrium plasma, (2) experimental investigation of open-cycle
MHD generators, (3) investigations of the physical processes
diagnostics and diagnostics in open- and closed-cycle MHD generators, (4)
investigations of the basic equipment of MHD generators, (5)
investigations of circuits and cycles of power stations with
MHD generators, (6) liquid-metal MHD plants, and (7) material
for MHD generators. Author

MAGNETOHYDRODYNAMIC METHOD OF PRODUCING ELECTRICAL ENERGY, PART 2
ky Metod Poluchenya Elektroenergi" Moscow, Energija. 1972 380 p 
(JPRS-57940-2-Pt-2) Avail: NTIS HC $12.50

A collection of articles on magnetohydrodynamic energy
generation is presented. The topics discussed are: (1) the theory
and calculation of flows in a MHD generator operating on an
equilibrium plasma, (2) experimental investigation of open-cycle
MHD generators, (3) investigations of the physical processes
diagnostics and diagnostics in open- and closed-cycle MHD generators, (4)
investigations of the basic equipment of MHD generators, (5)
investigations of circuits and cycles of power stations with
MHD generators, (6) liquid-metal MHD plants, and (7) material
for MHD generators. Author

ECONOMICS OF MIXED POTASSIUM-CESIUM SEEDING OF AN MHD COMBUSTION PLASMA
P. D. Bergman and D. Bienstock Dec. 1972 17 p refs (PB-214314/7; BM-R-7717) Avail: NTIS HC $3.00 CSCL 108

The proposed use of cesium-seeded combustion plasmas for
open-cycle MHD power generation has attracted considerable
interest. Cesium-seeded combustion plasma exhibits a greater
electric conductance than a potassium-seeded combustion
plasma. However, there are drawbacks to cesium seeding such as:
the need to use low sulfur coal because of cesium's inability to
effectively remove SO2 from the combustion products; the
high cost of the cesium ore, pollucite, and cesium's limited
availability. This report looks at the alternative of using a
mixture of both potassium and cesium for seeding to overcome
these problems. Costs and techniques are also briefly discussed.

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MHD CENTRAL POWER: A STATUS REPORT.
J.B. Dicks, Univ. Tennessee.

MHD ELECTRICAL POWER GENERATION: 1972 STATUS REPORT.

by Joint ENEA/IAEA International Liaison Group on MHD Electrical Power Generation.

PROBLEMS IN MHD ENERGY CONVERSION. A REVIEW.
S.A. Medin, et al.

MHD: HIGH PROMISE, UNSOLVED PROBLEMS.
D.E. Thomsen.

FIRST PLASMA POWER PLANT IN OPERATION.
The principle on which MHD generators are based is explained
in brief. The economic and other advantages of using plasma as
the conductor in an MHD generator for the production of electricity
is brought out by comparing this technique with other conventional
ones. It is reported that power plants employing this method can
turn 50 to 60% of the heat consumed into electricity, i.e., 50% more output with the same input of fuel, as compared to the other
methods. The working of the U-23 power plant in the USSR, which
operates on the above principle, is described. A brief mention is
made of the success of this plant which has led the USSR to launch
a future plan of having many more such MHD generators for
coping with the sharp power-consuming peaks in power grids
in the country. (TINS)

N73-30899J Kernforschungsanlage, Juelich (West Germany).
Inst. fuer Technische Physik.
APPLIED MAGNETOHYDRODYNAMICS. VOLUME 11:
OUTLOOK AND POSSIBILITY FOR MHD GAS COMBUSTION
GENERATORS WITH AIR TURBINE FOR NUCLEAR
PLANT APPLICATION IN THE BRD
G. Noack Oct. 1972 155 p refs in GERMAN
(JUL-852-TP-Vol-11) Avail: AEC Deposition Libraries $9.75
Based on the present and on the projected energy needs of
West Germany, MHD generators with gas fuel are analyzed.
The analysis considers natural gas and air enriched with oxygen
to obtain the high temperatures required by the MHD generator.
Data about high flame temperatures are listed and discussed
in detail. Under the conditions prevailing in West Germany, the
best arrangement is offered by an MHD generator with subsequent
air turbine. The design of such an arrangement is discussed
thoroughly from the technical as well as the structural point of
view.

CONSTRUCTION AND TEST OF AN MHD GENERATOR
CHANNEL AND ELECTRICAL POWER CONVERTER
(Contract F33615-71-C-1425; AF Proj. 3148)
(AD-758783: AFAPL-TR-73-5) Avail: NTIS CSCL 10/2
The AFAPL MHD Facility was placed in operation. A peg
wall, diagonally connected MHD channel was constructed, making
use of materials evaluated in a Hall channel. Seed handling
procedures, a new seeding wheel, and timing relations for the
burner, fuel flow, oxygen flow, and seed injection were developed.
A series of conductivity tests were conducted, and a conductivity
of 10 mhos per meter was established. The MHD generator
was run at an output of 800 volts, 125 kW with a 2.2 Tesla
magnetic field strength. A 2000 Hz converter was designed,
constructed and tested to convert a 600 volts dc input to a
50,000 volts ac output. The MHD generator was operated
successfully with the new channel for 15 runs of 4 to 6
seconds each, with no appreciable deterioration of the MHD
channel or support equipment.

 NSA

Open Cycle Coal Burning MHD Power Generation
Issued November, 1971
R&D Report No. 64—Final Report
Contractor: Massachusetts Instituté of Technology
Refer to: Titled report and GPO Catalog No. 163.10:64
Price: $1.75
N71-38469# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMBINED TURBINE-MAGNETOHYDRODYNAMIC BRAYTON CYCLE POWER SYSTEM FOR SPACE AND GROUND USE


NASA-TN-D-6513; E-6442) Avail: NTIS CSCL 10A

A combined turbine-MHD generator operating in a Brayton cycle with a NERVA nuclear reactor is considered, both for use in space and on the ground. The combined system is compared with an all-MHD Brayton system and an all-turbine system. The combined cycle systems have higher thermodynamic efficiencies than the other systems. The combined system with 1500 K turbine inlet and the all-MHD system with generator efficiency of 0.8 have the lowest specific recuperator plus radiator mass of those systems considered. But the combined system considered has an average radiator temperature of 200 to 250 K lower than the other. For ground use, a cycle efficiency of greater than 0.55 can be achieved.

Author

N71-33861# Avco-Everett Research Lab., Everett, Mass.

MHD POWER GENERATION: STATE OF THE ART AND PROSPECTS FOR ADVANCED NUCLEAR APPLICATIONS

Richard J. Ross In Florida Univ. Res. on Uranium Plasmas and Their Technol. Appl. '1971 p 315–328 refs

Avail: SOD $3.75: NTIS CSCL 18E

State-of-the-art developments in magnetohydrodynamic power generation are reviewed. Base load, emergency, and peaking power generation are included. Economic and environmental factors are considered in relation to MHD generator location. Applications of MHD generators in radiating power plants, propellant-cooled propulsion systems, and commercial industries are cited. J.M.

N72-23664# Aerospace Research Labs., Wright-Patterson AFB, Ohio.

DESCRIPTION OF A HIGH PRESSURE ELECTROFLUID DYNAMIC (EFD) FACILITY Final Scientific Report

Theodore L. Wilke and Ernest F. Bretter Nov. 1971 59 p refs (AF Proj. 7116)

(AAD-727380; ARL-71-0280) Avail: NTIS CSCL 10/2

A facility is described which simulates EFD generator operation using high pressure air as the working fluid. The humidity, temperature, mass flow, and pressure of the air can be controlled and monitored in two nearly identical air systems. The working fluid is supplied to one of three high pressure lines. Two of them are supplied. Types and specifications of various types of instruments used are described as well as the types of experiments performed.

Author (GRA)

N73-31848# Army Foreign Science and Technology Center, Charlottesville, Va.

DEVELOPMENT AND INVESTIGATION OF HIGH TEMPERATURE COMBUSTOR TO BE USED FOR A SOLID FUEL MHD GENERATOR AND THERMODYNAMIC ANALYSIS OF COMBUSTION CONDITIONS


(AAD-764153; PSTC-HT-23-2007-72) Avail: NTIS

The basic principles of the high-temperature combustion of natural solid fuel are formulated. Variants are optimized; the scheme of a vertical cyclone with lower gas discharge, hardened slag lining protection of walls, and side removal of slag was adopted. Complete preliminary mixing of dry coal dust with all the high-temperature heated air and uniformly distributed fuel of a ready dust-air mixture along the entire cyclone perimeter were carried out. A revised method of calculating high-temperature regimes for the combustion of solid fuel is presented that takes into account the actual operating conditions of the combustor chamber. The maximum attainable temperatures in the combustion of natural fuel were estimated. The combustor chamber methods and conditions of the experiments are described. (Modified author abstract)

MHD generators are uniquely capable of fully exploiting advances in high-temperature reactor technology for electric power generation. Extension of NERVA technology could make 2500 K long-life inert-gas-cooled reactors feasible. Such reactors and MHD generators make attractive multi-MW electric power systems for either space or ground applications. A turbo-MHD system using a turbine driven compressor is the most attractive cycle. It has high cycle efficiency and low radiator area and temperature for space applications. A space-power system with 10 MW electric output, shielded for manned missions, could achieve specific masses of 3.5 to 5 kg/kWe. A ground-power station with 60 percent efficiency also appears feasible.

(Author)

73V22419 1971 ISS 00 TK2970.146 1971A 0-119204-86-X 621.312139
LC-72-181669
PROCEEDINGS. COMPTRE RENDU.
5TH INTERNATIONAL CONFERENCE ON MAGNETOHYDRODYNAMIC ELECTRICAL POWER GENERATION. MUNICH, 1971.
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT; H.M.S.O.
PARIS, LONDON, 501 P. ILLUS. 30 CM.
IN ENGLISH, FRENCH. INCLUDES A CONTRIBUTION IN FRENCH. "ORGANIZED JOINTLY BY THE OECD EUROPEAN NUCLEAR AGENCY AND THE INTERNATIONAL ATOMIC ENERGY AGENCY." INCLUDES BIBLIOGRAPHICAL REFERENCES.
LC MAGNETOHYDRODYNAMIC GENERATORS -- CONGRESSES.
ADDED ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT.
EUROPEAN NUCLEAR ENERGY AGENCY. INTERNATIONAL ATOMIC ENERGY AGENCY.
MAIN-MEET TRACE-CORP* CATLG BY-LC
// Published in France

1970

TK2896. ISS 1970

From fifth annual interociety energy conversion engineering conference; Las Vegas, Nev. (21 Sep 1970). See CONF-700913-
(Vol.5).

The status of combustion-driven MHD generator technology is reviewed from the viewpoint of electric utility applications and its prospects for utilisation are discussed. Both base load and emergency or peaking systems are considered. In the case of base load stations, MHD systems reach substantially higher overall thermal efficiencies than those attainable with conventional methods together with greatly reduced pollution of both air and water. For emergency or peaking power, MHD offers a relatively simple power system with the capability of delivering full rated power from a cold start in a few seconds. System design studies, economic estimates and pollution control aspects are presented. The overall benefits offered by these MHD generator systems warrant the further development required for their commercial realization and a program to achieve this goal is outlined. (auth)


The aerodynamic and design parameters of a system for generation of electrical power from coal or char by the MHD process, which features utilisation of exhaust stream heat for the endothermic heat of reaction in a char gasification process, are described. (TDF)
MHD System with Dual Pressure Melt Gasification and CO₂ Recycle
Issued July, 1970
R&D Report No. 58—Final Report
Contractor: Westinghouse Electric Corporation
Refer to: Titled report and GPO Catalog No. 163.10:58
Price: $0.55

Study of MHD Power System Burning Char with Oxygen
Issued June, 1970
R&D Report No. 54—Final Report
Contractor: Avco Everett Research Laboratory
Refer to: Titled report and GPO Catalog No. 163.10:54
Price: $0.35

MHD System with Dual Pressure Melt Gasification and CO₂ Recycle
Issued July, 1970
R&D Report No. 58—Final Report
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Study of MHD Power System Burning Char with Oxygen
Issued June, 1970
R&D Report No. 54—Final Report
Contractor: Avco Everett Research Laboratory
Refer to: Titled report and GPO Catalog No. 163.10:54
Price: $0.35

Qc 809, M 3593 1970

A71-13704 # Electrofluid dynamic energy conversion - Present status and research areas, Maurice Lawson and Hans von Ohain (USAF, Aerospace Research Laboratories, Wright-Patterson AFB, Ohio). American Society of Mechanical Engineers, Paper no. 70-Ener-A, 1970. 20 p. 70 refs. Members, $1.00; nonmembers, $2.00.

This paper presents in depth the major basic performance characteristics of electrofluid dynamic (EFD) energy conversion processes, which are shown to be complementary to magnetofluid dynamic processes. With a view toward making possible effective thermal electric energy conversion without moving parts, the potential compatibility of incorporating low pressure ratio EFD processes into high pressure ratio thermodynamic cycles is shown. Investigations of scaling, similarity, performance characteristics, and the effects of physical properties of working media containing electric charges of one polarity are used as a basis to determine the major problems and corresponding research areas in EFD energy conversion. In general these are: generation of charged colloids; electrode and conversion duct geometry; and fluid dynamic energy transfer phenomena. In multicomponent, multiphase flows. Also given are typical configurations of EFD energy converters, and a look at potential applications, especially those associated with encapsulated, long-duration power supply for operations in space, under the ocean, or at remote unattended sites. (Author)

A system for burning pulverized coal at high pressure with preheated, oxygen-enriched air at high volumetric heat release rates was developed. The experimental program showed that a residence time of 30 milliseconds is sufficient to obtain over 85% combustion efficiency. Volumetric heat release rates of the order of 10^7 Btu/hr/ft^2 were obtained. Heat flux in an insulated combustion chamber of 10 x 10^6 Btu/hr/ft^2 was measured. A wide variety of coals can be handled by the system, with the indication that low-grade coals can be used without difficulty, (auth)

TK2970. 15


A basic and comprehensive treatment of the engineering aspects of MHD power generation is presented. The ionization and electrical conductivity of the working gas is examined together with the motion of the conducting incompressible fluid in a magnetic field. Special attention is given to the Saha equation and its different forms. The electrodynamics of an MHD generating duct are considered, starting from simplified electrodynamics of MHD generators and description of the Hall effect of electrons and ions. The basic configurations of an MHD generator are then described and a summary is presented of the applications of the four generator configurations.

TK2970. 15

MHD POWER GENERATION: CURRENT STATUS.

TK970. British MHD Collaborative Committee.


N70-37070# Scientific Translation Service, Santa Barbara, Calif.
DEVELOPMENT OF INSTALLATIONS FOR DIRECT CONVERSION OF HEAT INTO ELECTRICAL ENERGY BY MEANS OF MHD GENERATORS AND OTHER NEW ENERGY DEVICES
Avail.: CSSTI CSCL 10A.

Research connected with the development of stationary electrical power plants is reported and includes the following: (1) Investigations were conducted on metallic electrodes of steel and copper and also on ceramic electrodes of silicon carbide and zirconium dioxide. (2) Experimental equipment was built for studying the dynamics of processes adjacent to electrodes and permitting electro-optical detection of spots with time resolutions down to 10 to the minus 8th power sec with simultaneous measurement of charged particle concentration in the cathode region with time resolutions as low as 5 x 10^-10 to the minus 8th power sec. (3) Investigation of the high-current discharge on electrodes covered directly with an additive in the MHD generator channel demonstrated that the intensity of the electrode disintegration process by pinched discharge is reduced by a factor of ten. (4) Thermal efficiency studies were made of the combined open cycle MHD power plants with various methods of achieving the high temperatures of the combustion products. (5) Theoretical and experimental studies of problems connected with the development of liquid metal MHD power plants were conducted.

D.G.

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1. THE ROLE OF ELECTROFLUID DYNAMICS IN THE FIELD OF DIRECT ENERGY CONVERSION H. V. Ohain (Aerospace Res. Labs.) p. 5–13
2. ELECTROFLUID DYNAMIC ENERGY CONVERSION PROCESSES CHARACTERISTICS AND RESEARCH AREAS M. O. Lawson (Aerospace Res. Labs.) p. 14–33 ref.
3. EFFECTS ON ELECTRODE GEOMETRY SIMILARITY AND SCALING LAWS IN EFD ENERGY CONVERSION PROCESSES. PART 1: FUNDAMENTAL CONSIDERATIONS J. A. Decaire (Aerospace Res. Labs.) p. 34–63 ref.
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10. COMMENTS ON ELECTROFLUID DYNAMICS AND RELATED RESEARCH IN FRANCE J. Fabri (Office Natl. d'Etudes et de Recherches Aerospatiales) p. 207–209
ELECTRICITY FROM MHD, 1968.
Gilli, P.V. and Tchernilin, Yu.

SPECIAL ISSUE ON MHD POWER GENERATION.
19 papers on generator theory, plasma properties, electrode and wall phenomena, and experiments.

A66-11394
MHD - WHERE AT AND WHERE TO?
Thomas R. Brogan.
33 refs.
Discussion of the present state and future prospects of MHD technology. Possible MHD applications in industry are considered, along with the performance and cost of existing MHD generators and MHD is viewed as a space-derived technology promising high profits and economic advantages but requiring large investment on a national scale. MHD principles, background information, and comments on work in the U.S., the USSR, the UK, France, and Japan are given.

A66-34577
A REVIEW OF FLUID MECHANICAL AND RELATED PROBLEMS IN MHD GENERATORS.
E. G. Broadbent (Ministry of Technology, Royal Aircraft Establishment, Farnborough, Hants., England).
IN: PROGRESS IN AERONAUTICAL SCIENCES. VOLUME 9.
Edited by D. Küchemann.
158 refs.
Review of some fundamental aspects of MHD power conversion, together with a survey of recent developments in MHD power generation from the viewpoint of fluid mechanics - i.e., with particular attention to the flowfield in the MHD duct. Preliminary attention is given to linear-type channel geometry, followed by an introduction to the basic Faraday generator and to the mixed-type generator. Gasdynamics, boundary layers, and some stability problems are discussed. Certain thermodynamic cycle considerations are discussed, together with parametric studies for duct optimization. Methods available for determining the current and velocity distribution in a straight duct with segmented electrodes are outlined for both dc and ac output. Engineering problems which arise in an MHD plant are discussed in terms of the provision of the magnet and appropriate heat exchangers.

T. M.
Electricity from MHD, 1968.


5 v. (Proceedings series)

Contents.--v. 1. Closed-cycle MHD with gaseous working fluids (Sec.1-a-1-g).--v. 2. Closed-cycle MHD with gaseous working fluids. (Sec.1-h-1-K).--v. 3. Closed-cycle MHD with liquid-metal working fluids. (Sec.2).--v. 4. Open-cycle MHD. (Sec.3-a - 3-3).--v. 5. Open-cycle MHD. (Sec.3-f - 3-h).
A68-42500
MAGNETOHYDRODYNAMIC ENERGY CONVERSION,
R. J. Rosa (Avco Corp., Avco-Everett Research Laboratory,
Everett, Mass.). TK2970. R65
$17.50.

This volume reviews the basic principles and practical aspects
of MHD energy conversion for graduate students and engineers inter-
ested in applied MHD. Detailed explanations and derivations from
first principles are avoided, although the principal characteristics
of an MHD generator, the basic concepts, and the magnetic Reynolds
numbers are treated. Ionization and conductivity are treated, and the
basic equations and general features of fluid mechanics are described.
Hall and ion slip effects are investigated with regard to the engineer-
ing consequences. Design considerations are noted, and practical
applications such as rocket generators, cavity reactors, radiating
power plants, and propellant-cooled propulsion systems in the
aerospace field are discussed. The appendices give transport
properties in a multicomponent gas; calculated curves of conduc-
tivity and Hall parameters, magnetic strengths, constants; and a
method for the calculation of the generator performance. R.M.

FACTORS INFLUENCING ELECTRO-FLUID DYNAMIC POWER
GENERATION,
H.E. Brandmaier and T.H. Dimmock.
J. Spacecraft & Rockets, v.4, no.8, Aug.1967,
p.961-966.

N65-26381# Brookhaven National Lab., Upton, N. Y.
POLLUTION-FREE HYBRID FOSSIL-NUCLEAR FUELED MHD
POWER CYCLE
M. Steinberg, J. R. Powell, M. Beller, and B. Munowitz [1968]
51 p. refs. Presented at the Conf. on Intern. Energy Conversion
Eng., Denver Spons. by AEC.
(BNL-12319; CONF-660837-1) CFSTI: HC $3.00/MF $0.65

A hybrid power plant is developed based on a hydrogen-oxygen
combustion MHD cycle. Hydrogen is generated by reforming fossil
fuel with nuclear generated steam and oxygen is obtained from air
in an air separation plant. Steam is injected into the combustion
chambers to control temperature and pressure through the duct. A
preliminary parametric study of the cycle efficiency and MHD
characteristics is made with steam and hydrogen as diluents. Overall
thermal efficiencies of 55% appear practical with nuclear energy
contributing 38% and coal 62% to the power cycle. The hybrid
system allows the use of fossil fuel in a pollution-free plant;
conventional water and gas-cooled nuclear reactors can be utilized
in an MHD cycle. Thermal pollution is significantly decreased; a
clean MHD duct is provided. Author (NSA)

NUCLEAR REACTOR MAGNETOHYDRODYNAMIC POWER
GENERATION
Ralph S. Cooper, Lawrence A. Booth, R. J. Fries, P. G. Salgado,
L. D. Kirkbride et al 20 Jan. 1966 52 p. refs
(Contract 7-405-ENG-36)
(LA-3368) CFSTI: HC $3.00/MF $0.50

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13. TURBOMACHINERY FOR MHD APPLICATION W. E.
Crowe p 61

TK2970. 59 1966 v.1-3
Symposium on Magnetohydrodynamic Electrical Power
Generation, Salzburg, 1966.

Jointly organized by the International Atomic Energy Agency and the European Nuclear Energy
Agency of the CEC.
Intersociety Energy Conversion Engineering Conference,
Miami Beach, Fla., 1967.
Advances in energy conversion engineering; papers, critiques, and summaries. New York, American Society of Mechanical Engineers, 1967;
xv, 1124, v. 250 p. illus. 29 cm.
Sponsored by the American Society of Mechanical Engineers.
Includes bibliographies.

**MAGNETOHYDRODYNAMICS AND ELECTROGASDYNAMICS**

**Chairman: Malcolm S. Jones Jr.**

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MAGNETOHYDRODYNAMICS

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Current-Voltage Measurements in a Supersonic MHD Generator with an Arc Heated Argon Plasma by M. A. Manteniekis and L. D. Nichols

Calculation of Idealized MHD Generator Performance with Non-Equilibrium Electron Heating by D. A. Oliver and R. H. Eustis

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Analytic Solution for a Two-Dimensional, Axisymmetric EGD Conversion Channel by Kenneth Wong

Magnetohydrodynamic Squeeze Film Energy Converters by F. T. Dodge, J. F. Osterle, and W. T. Rouleau

The Prospects for Closed-Cycle MPD Power Generation by B. C. Lindley

N70-36803* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TWO-FLUID MAGNETOHYDRODYNAMIC SYSTEM AND METHOD FOR THERMAL-ELECTRIC POWER CONVERSION Patent
David G. Elliott, inventor (to NASA) Issued 24 Nov. 1964 (Filed 25 Jul. 1962) 8 p Cl. 310-11 Sponsored by NASA (NASA-Case-XNP-00644; US-Patent-3,158,764; US-Patent-Appr-SN-212496) Avail. US Patent Office CSCL 108 A gas driven jet pump is used to provide high velocity flow of a liquid metal through a magnetic field to generate electrical energy. The liquid metal and gas mixture expands through a nozzle where the liquid metal is immediately separated from the gas and forced to flow as a thin film between two pole pieces which establishes current flow through the liquid.

651
SATKOWSKI, J. A., ED.


TK2970.53, V/4


THE FEASIBILITY OF MHD POWER GENERATION


The principle of the magnetohydrodynamic (MHD) generator and average characteristics of such generators are presented. The most noteworthy experimental results was 11 MWe generated during 55-sec runs and 10 KWe during 1-hour runs, with open cycle generators. Experiments with closed cycle generators are promising but are not as advanced as those with the open-cycle types. An experimental MHD generator is shown capable of developing 10 kW. The combustion system uses fuel oil and oxygen and was designed on the basis of jet-engine principles. The system operated for about 1 hr at which time the oxygen supply was exhausted. The experiment confirmed the MHD laws used to design the generator and established sufficient evidence for extrapolation of the design to generators of much larger size.

E. E. B.

N62-22534 POTENTIALITIES OF DIRECT ELECTRO-FLUID DYNAMIC ENERGY CONVERSION PROCESSES FOR POWER GENERATION. Hans Von Ohain and Frank Wattendorf.

IN: COMBUSTION AND PROPULSION: AGARD COLLOQUIUM ON ENERGY SOURCES AND ENERGY CONVERSION, 6TH, CANNES, FRANCE, MARCH 16-20, 1964, PAPERS. (A68-22534 09-01) Research sponsored by the Combustion and Propulsion Panel of NATO-AGARD.


Discussion of current research on electrofluid dynamics (EFD) conversion, whereby the fluid dynamic energy of a working medium containing ions or charged colloids is transformed into electrical energy by passing through an electrostatic field. EFD processes are characterized by low current density and high voltage. While the power density is lower than that indicated for magnetofluid dynamics, the power-to-weight ratio may still prove favorable, due to the lack of need for heavy magnetic equipment. A review given is recent studies of the fundamental relationships between aerothermodynamic and electrical performance characteristics.


ELECTROHYDRODYNAMIC POWER GENERATION—EXPERIMENTAL STUDIES.

John M. Smith, Mar. 1962. 20 p. 3 refs. (R625027) (Contract AF 33(610)-7339)

The series of experiments reported here were performed to establish the feasibility of generating electrical power by means of a generator based upon the principle of the Von de Groff generator, the primary difference being that the charge is transported in a moving gas rather than on a moving belt. The experiments were performed using a corona ionization source and showed that a net electrical output could be obtained, thereby establishing the feasibility of such a generator.

(Author Abstract)

TK2970.53

M3

1961

McGrath, Ian Alexander, ed.

Advances in magnetohydrodynamics; proceedings of a colloquium organized by the Department of Fuel Technology and Chemical Engineering at Sheffield University, October 1961. Edited by I. A. McGrath, R. G. Siddall, and M. W. Thring.


x, 140 p. illus. 24 cm.

TL500. N6 no. 81

£52
FLUIDIZED BED COAL COMBUSTION SYSTEM COUPLED WITH A POTASSIUM VAPOR CYCLE.

A.P. Fraas.

Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.238-44.

A fluidized bed coal combustion system operating at 1600° to 1700°F. could be used to boil potassium at 1500° to 1600°F. and thus drive a potassium vapor topping cycle. The vapor leaving the potassium turbine would be condensed at about 1000°F. and the heat would be rejected to a conventional steam cycle with a peak steam temperature of 950°F.

By burning the coal in a fluidized bed of limestone or dolomite, the sulfur content of the stack gases can be reduced by a factor of about 10. The high peak temperature of the potassium vapor topping cycle makes possible a combined cycle efficiency of over 50% as compared to 35 to 40% for conventional steam plants and thus reduces the fuel consumption by about 25% and the waste heat rejection by about 50%.

A review of a set of conceptual design studies and the state of the art indicates that the furnace-potassium boiler, the potassium turbine, and the potassium condenser-steam generator can have quite reasonable proportions and that the overall capital cost of the plant would be about the same as for a conventional coal-fired steam plant. The biggest uncertainties appear to be associated with the problems of regenerating the limestone and combustion gas-side corrosion of the stainless steel tubes in the potassium boiler. The meager data available on these two problem areas indicate that the prospect for adequate solutions are promising.
PRODUCTION OF LOW-B.T.U. GAS FROM COAL IN COMBINATION WITH ADVANCED POWER CYCLES.
S. Dobner, M.J. Glueckman, and A.M. Squires.
Recent Advances in Air Pollution Control, AIChE Symposium Series, v.70, no.137, 1974, p.223-229.

Under Grant GI-34286 from the RANN Program ("Research Applied to National Needs") of the National Science Foundation, a team at The City College has begun "studies toward improved techniques for gasifying coal." Our primary objective is to study chemistries and unit operations that could be useful in a Coalplex for simultaneous production of pipeline gas, a light aromatic liquid fuel, and electricity (7). We are also undertaking flow sheet studies to identify commercial opportunities as quickly as possible and to guide our experimental work. This paper is our first report on results of flow sheet studies.

RATING, CAPABILITIES, AND OPERATION OF COMBUSTION GAS TURBINE DRIVEN GENERATORS.
C. Flick.

Combustion gas turbine driven generators, now widely used for both utility and industrial power generation, require output characteristics that are properly matched to the prime movers' capabilities at varying ambient temperatures as well as the varying turbine combustion temperatures. This paper reviews the requirements for securing such a match and the methods of determining the operating capabilities of such generators, as proposed for the forthcoming ANSI Standard C50.14.

GAS TURBINES AND EMERGENCY DIESEL PLANTS IN WEST BERLIN'S POWER SUPPLY SYSTEM.
K.D. Schellenberg.

The power supply system will be described. Operating problems due to West Berlin's "island" situation and site problems when adding new generating plants are shown. Design and specifications of various gas turbine plants are given. Distinctive features of two types of turbines will be described.
TITLE: Advanced Power Cycles for Generating Electricity from Coal
AUTHOR: Squires, A.R.
CORPORATE AUTHOR: City College of The City University of New York, Energy Resources Project, Dept. of Chemical Engineering
ADDRESS: New York, NY 10031
PUBLICATION DATE: 1973
SPONSOR: National Science Foundation, BPAW Program
ABSTRACT: This paper reviews the status of combined cycle plants for electric power generation and considers opportunities and alternatives for the future. The most urgent task is to develop technologies for supplying low-Btu gas to combined cycle systems. Additional important efforts are work on systems for cleaning low-Btu gas at high temperature, work on fluidized-bed combustion of coal with special attention to gas cleaning, and study of systems that can burn coal for peakload power. Less urgent tasks include development of combined cycle systems with improved efficiency for firing with low-Btu gas and development of advanced cycles to work in conjunction with fluidized-bed combustion. (30G)

N74-14465# Solar, San Diego, Calif.
LOW NOx EMISSION COMBUSTOR FOR AUTOMOBILE GAS TURBINE ENGINES
David J. White, P. B. Roberts, and W. A. Compton. Feb 1973 104 p
The aim was to develop, through both analytical and experimental studies, the basic design criteria and data necessary to produce a low emission combustor. This information was to be utilized in the production of two combustor designs, one for a typical low-pressure regenerative type of engine and the other for a high-pressure engine with partial recuperation. Several model combustors were produced employing various concepts to obtain low emissions, and these were evaluated as to their suitability for incorporation into a practical engine system. (GRA)

N74-10746# Northern Research and Engineering Corp., Cambridge, Mass.
LOW NOx EMISSION COMBUSTOR FOR AUTOMOBILE GAS TURBINE ENGINES
E. P. DeMati and R. J. Murad. Feb 1973 182 p refs
Two research combustors were designed and tested, one of which was representative of low pressure-ratio, regenerative gas turbine cycles and the other representative of high pressure-ratio, nonregenerative cycles. The design goal was to achieve emission levels not exceeding one-half of the Federal 1975/76 emission standards. The overall aim was to develop design guidelines on the basis of detailed experimental data. Extensive modifications were made to conventional combustor configurations, but direct use was made of existing combustor design technology. Full-scale models were tested over wide ranges of operating conditions representative of typical driving cycles. Cold-flow tests were made to measure aerodynamic performance and detailed combustion tests were made to measure emission, combustion, and thermal performance. (GRA)

A combined cycle is any one of combinations of gas turbines, steam generators or heat recovery equipment, and steam turbines assembled for the reduction in plant cost or improvement of cycle efficiency in the utility power generation process. The variety of combined cycles discussed for the possibilities for industrial applications include gas turbine plus unfired steam generator; gas turbine plus supplementary fired steam generator; gas turbine plus furnace-fired steam generator; and supercharged furnace-fired steam generator plus gas turbine. These units are large enough to meet the demands for the utility applications and with the advent of economical coal gasification processes to provide clean fuel, the combined-cycle applications are solicited. (MCW)


A review is given on the most important problems and various possibilities of application of the gas turbine. (GE)


The low thermal efficiency of the simple cycle gas turbines as compared with conventional steam installations have delayed the extension of the application of these engines. With about 70% of the energy leaving the system through the exhaust gases, methods are needed for recovery of the waste heat that is at a temperature of 400 to 600°C. The oxygen concentration is such that additional firing is possible. Based on these conditions a full range of heat recovery boilers and accessories were developed.
Design of Reciprocating Single Cylinder Expanders for Steam.
S. E. Eckard, and R. D. Brooks.
General Electric Co., Cincinnati, Ohio. Nuclear Systems
Programs. Oct. 73, 23p EPA-460/3-73-003
PB-231 004/3WF PC$1.50/MT$1.45

A reciprocating expander is one type of expander which may
be applicable to an automotive Rankine cycle engine. Single
cylinder reciprocating expanders were designed and fabricated
for the purpose of evaluating solid lubricants and other sup-
porting materials. For high engine efficiency, steam pressure
and temperature up to 1000 psia and 1000 F, respectively, are
necessary. Several lubricants and wear resistant materials
were tested in both a crosshead piston and trunk piston con-
figuration. Also a specially compounded water resistant
synthetic hydrocarbon oil was evaluated as a crankcase bear-
ing lubricant. Both the crosshead piston and trunk piston ex-
panders were fabricated and tested over a range of conditions
depicted as follows: (1) speed range, 500-2000 RPM; (2) inlet
steam temperature, 700-1000°F; (3) inlet steam pressure, 400-
1000 psia; and (4) condenser pressure approximately 20 psia.
(Modified author abstract)

N74-184069 National Academy of Sciences - National Research
Council, Washington, D.C. Committee on Motor Vehicle
Emissions.

NAS REPORT ON TECHNOLOGICAL FEASIBILITY OF
1975-1976 MOTOR VEHICLE EMISSION STANDARDS. AN
EVALUATION OF ALTERNATIVE POWER SOURCES FOR
LOW-EMISSION AUTOMOBILES. NATIONAL ACADEMY OF
SCIENCES
Apr. 1973 161 p refs
(Contract EPA-68-01-0402)
(PB-224859/9GA) Avail. NTIS HC $4.75; HC also available
from NTIS $26.00/set of 8 reports as PB-224866-SET CSCL
21E

The panel has evaluated several near and long term alternative
power systems including diesel, gas turbine Rankine cycle and
Stirling engines. In addition electric vehicles and alternative
fuels were studied. Various aspects of each engine-system was
considered including emissions, fuel economy, noise, cost size
and weight, producibility and driveability. The report also
discusses the lead time necessary to begin limited and mass
production of each system. GRA
1973


GAS turbine reliability and maintainance were discussed by personnel from Public Service Electric and Gas Company, Newark, New Jersey, Philadelphia Electric Company, Philadelphia, Pennsylvania, and Long Island Lighting Company, Hicksville, New York. Many areas of discussion were presented including such things as avoiding engine-generator mismatch; fuel quality; start-up factors; control systems; lubricating systems; overhaul facilities; inspections; instrumentation; and all accessories. Total energy systems must be considered since exhaust stacks are getting higher, environmental standards changing, and engineering problems encountered due to multiple unit construction. (MCW)

1973


Data are given to help industry select the economic fuel and economic mix of steam and gas turbines for energy-conservation measures and costs. Utilities and industries can no longer rely on a firm supply of natural gas to fuel their boilers and turbines. The effect various liquid fuels have on gas turbine maintenance and availability is summarized. Process heat requirements per unit of power, process steam pressure, and the type of fuel will be factors in evaluating the proper mix of steam and gas turbines. The plant requirements for heat, and the availability of a reliable source of electric power will influence the amount of power (hp and kW) that can be economically generated by the industrial. (auth)
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Emission Measurement Techniques for Non-Conventional Powerplants
M. W. Korth, H. A. Ashby, R. C. Stahman

New Prime Movers for Ground Transportation–Low Pollution, Low Fuel Consumption
E. J. Ward, J. O. Spriggs, F. M. Verney

Combined Nuclear Gas Turbine Power and Desalination Plant, P. H. Sager, J. M. Krase

N73-27551# Environmental Protection Agency, Ann Arbor, Mich.
Test and Evaluation Branch.
EXHAUST EMISSION ANALYSIS OF THE WILLIAMS
RESEARCH GAS TURBINE AMC HORNET
Leonard D. Verrelli and Casimer J. Andary
May 1972 15 p
(PB-218687/2; APTD-1410; Rept.-72-27) Avail. NTIS HC $3.00 CSCL 13B

An evaluation was made of field experience with a turbine powered passenger car. The Williams Gas Turbine Wr-26, regenerative turbine automotive engine was mounted in an AMC Model 2 Hornet test vehicle. The engine uses a single power turbine to develop 80 horsepower. The engine regenerator incorporates two large disks of a ceramic-glass material for inlet air preheating. Testing was accomplished using the 1970, 1972, and 1975 Federal Test Procedures. In addition, steady state and proportional sampler tests were conducted. By positioning of the power turbine bypass in the closed position, it was demonstrated that low hydrocarbon emissions are possible with this engine; however carbon monoxide and nitric oxides were not reduced sufficiently to be able to meet 1975 or 1976 emission standards.

N73-28739# Thermo Electron Engineering Corp., Waltham, Mass.
Research and Development Center.
DETAILED DESIGN: RANKINE CYCLE POWER SYSTEM
WITH ORGANIC-BASED WORKING FLUID AND RECIPROCATING EXPANDER FOR AUTOMOBILE PROPULSION.
VOLUME 1: TECHNICAL REPORT
5 May 1972 271 p
(Contract EPA-EHSH-70-102)
(PB-210836: TE-4134-71-72-Vol-1; APTD-1154) Avail. NTIS HC $3.00 CSCL 21G

The detailed, optimized design of the system including packaging of the complete system in the reference car, the 1972 Ford Galaxie is described. The results of experimental development in several critical areas are also presented. The system is designed to provide performance approximately equivalent to use of a 351 cubic inch displacement internal combustion engine in the reference car.

N74-13747# Chandler Evans Inc., West Hartford, Conn.
VAPOR GENERATOR FEED PUMP FOR RANKINE CYCLE AUTOMOTIVE PROPULSION SYSTEM (CHANDLER EVANS)
R. M. Riedman
Dec. 1972 213 p
(Contract EPA-68-01-0430)
(PB-222849/2; R-679-S; APTD-1357) Avail. NTIS HC $5.50 CSCL 21G

A project was undertaken to conduct comprehensive design studies pursuant to the selection of conceptual models of vapor generator feed pumps that will satisfy the performance requirement of each of three Rankine cycle automotive power systems currently under development to reduce fuel consumption. In pursuing the objective of providing variable output pumps for these applications investigation were conducted of two selected courses: (1) fixed displacement pumps with variable speed drives, and (2) variable displacement pumps. The report presents a detailed summary of the project, describes the technical results, and gives conclusions.

N74-15138# Lear Motors Corp., Reno, Nev.
VAPOR GENERATOR FEED PUMP FOR RANKINE CYCLE AUTOMOTIVE PROPULSION SYSTEM Final Report
Max K. Winkler
Dec. 1972 72 p refs
(Contract EPA-68-01-0437)
(PB-222871/6; APTD-1358) Avail. NTIS HC $3.50 CSCL 13K

Results are presented on preliminary design studies conducted to define feed pumps that satisfy the performance requirements for the following Rankine cycle automotive power systems: (1) steam engine systems; (2) aerojet liquid rocket company; and (3) thermo electron corporation. The approach consisted of establishing feed pump requirements for the three applications. Investigations revealed that the feed pump developed by Lear Motors Corporation satisfies the basic requirements of the three system contractors. A description of the Lear feed pump and its operating principle is presented. A summary of the flow requirements and estimated brake horsepower for the 3 system contractor feed pumps is shown graphically.
Steam generators for nuclear power plants. P.V. Gilli, R. Fritz.

Steam generators for nuclear power plants are typical examples of modern high duty heat exchangers with stringent requirements on performance and reliability. Extreme compactness of the heat transfer surface is mandatory because of high unit performance and high operating pressures on both the heat transferring and the steam/water side. Availability of a nuclear power plant depends to a considerable extent on the steam generators, tube failures being a typical reason for steam generator down time. The design and assessment of steam generators for existing and future reactor types is discussed. [45 refs.]
ELECTRIC POWER - VIA MARRIAGE OF CHEMICAL AND AEROSPACE INDUSTRIES.

F.L. Robson.

Chemtech, Apr. 1972, p. 239-249.

The approach that shows the most potential benefits involves essentially pollution free, low-heating value gaseous fuels for use in advanced-cycle power systems that operate at new levels of efficiency. Binary cycles, gas turbine systems, combined-cycle systems, and the COGAS systems are discussed.
REHEAT STEAM TURBINES FOR COMBINED POWER AND HEAT GENERATION.
The design and heat diagram of two types of special turbines for heat and power plants are outlined. The first type contains a condensing, reheat, extraction turbine, 125/135 Mw, for the steam condition of 138 bar 535/535°C while heat is extracted from the turbine at 125°C. The other type is a back-pressure turbine, 113 Mw, designed for the steam condition of 148 bar, 535/535°C. The heat diagram of a nuclear heat and power plant under study with turbine grid for the saturated input steam and power output of 117 Mw is presented.


ECONOMIC ASPECTS OF COMBINED GAS-STEAM CYCLES APPLIED TO INDUSTRIAL HEAT AND POWER PLANTS. A survey of gas-steam cycles applicable to industrial heat and power plants with back-pressure turbines is presented. Of six basic cycles for detailed technical and economic investigation, a cycle is chosen in which the outlet gases of a gas turbine are utilized as air required for combustion in a steam boiler and the heat of boiler flue gas is utilized in the feed heating system. Independent operation of steam and gas parts is possible. For the selected gas steam cycle, a computer program has been prepared to determine the effect of the basic parameters on system profitability. As the profitability criterion, the critical specific fuel consumption index per electric energy unit produced is an equivalent method of condensing plant is accepted. The profitability indices are given as calculation results as a function of the basic variable parameters.


N71-38769/* Massachusetts Inst. of Tech., Cambridge. Fluid Mechanics Lab. THE AUTOMOTIVE GAS TURBINE AND NITRIC OXIDE EMISSIONS Thomas Mikus and John B. Heywood. Jun. 1971 30 p refs (Grant NSF GK-15409) (FMI Publ-71-111 Avail: NTIS) A model for the formation of nitric oxide, NO, in regenerative automotive gas turbine engines is presented. The model is shown to closely predict relative NO emission trends for an existing engine, while predicting absolute levels within a factor of 2. A typical near-future automotive turbine cycle is then described. Engine performance and NO emissions are calculated for this cycle. The trade-off between fuel consumption and NO emissions for conventional combustor design is presented as a function of turbine inlet temperature. The methods by which NO emissions can be reduced are examined, and it is found that to meet the proposed 1976 Federal Emissions Standard for NOx, the combustor's primary zone must be made considerably leaner and more homogeneous than is typical of current combustor designs.

Author

N71-38460/* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio. COMBINED TURBINE-MAGNETOHYDRODYNAMIC Brayton Cycle Power System for Space and Ground Use Letter D. Nichols Washington Oct. 1971 48 p refs (NASA-TN-D-8513; E-6442) Avail: NTIS CSSL 10A A combined turbine-MHD generator operating in a Brayton cycle with a NERVA nuclear reactor is considered, both for use in space and on the ground. The combined system is compared with an all-MHD Brayton system and an all-turbine system. The combined cycle systems have higher thermodynamic efficiencies than the other systems. The combined system with 1500 K turbine inlet and the all-MHD system with generator efficiency of 0.8 have the lowest specific recuperator plus radiator mass of those systems considered. The combined system considered has an average radiator temperature of 200 to 280 K lower than the other. For ground use, a cycle efficiency of greater than 0.55 can be achieved.

Author State of the art of small gas turbine engines for helicopters and surface transport; H.R. Langshur (United Aircraft of Canada Ltd, Longueuil, Que), B.J. Palfreeman, AGARD 10th Propulsion and Energetics Panel and Consultant Exchange Program, May 1971 paper 2, 16 p: The paper reviews the current technical and market status of below 1000 shp turboshaft engines, as applied to helicopters and surface transport. Major data are given for the successful engines and comparisons of salient design features are made. Engines now in development are discussed. Advances to be expected in a 1980 helicopter engine are described and the expectations are critically reviewed, 14 refs.
RANKINE CYCLE POWER SYSTEMS FOR AUTOMOTIVE APPLICATION

Jerry A. Peoples
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Abstract

The importance of developing effective, efficient steam propulsion systems is recognized as a mandatory step in our country's technology applications to environmental improvements. With this in mind, several years of effort have been placed into the exploration of new concepts related to Rankine cycle engine systems. From this effort, several concepts believed to be unique have emerged. These include a variable pressure boiler (VPB) passive pressure and temperature control, and hermetically-sealed engine configurations.

The entire problem of a steam automotive system is manifested in the control required to maintain boiler pressure and temperature under varying loads, throttle changes, and engine cutoff settings. The control problem is based upon a fuel rate proportional to the pressure error between command and actual pressures. Speed and power are controlled by the throttle which can be varied manually by the operator. The VPB concept overcomes the control problems of the conventional fixed boiler pressure concepts.

A passive control concept is discussed which allows the boiler pressure to seek its own equilibrium level. The throttle is eliminated. The block diagram for conventional steam system operation is reviewed and compared with the VPB block diagram. Advantages of the VPB concept are discussed in terms of passive pressure control and system performance. Finally, a provocative idea of passive temperature control is introduced. Passive temperature control is a natural consequence of a VPB.

1970


An organic Rankine cycle system utilizing waste exhaust gas heat from a 30 KW gas turbine generator set has been built and tested. Utilizing a new fluorocarbon fluid, the system furnishes 18.9 KW of additional electrical power output along with 120,000 BTU/hour for air heating and 180,000 BTU/hour for water heating for environmental control. The primary gas turbine engine fuel control furnishes the speed control for the mechanically locked-in Rankine turbine and permits fuel saving-operation under power sharing conditions from full load to idle conditions. This system concept provides electrical energy output at a fuel consumption rate approaching that of the diesel set but at a small fraction of the diesel set weight. (Author)


Discussion of the design and early development efforts of an organic Rankine cycle power system for commercial on-site electrical power generation as well as on-site heating and cooling requirements. The considerations involved in the design of a natural gas fired total energy system capable of delivering 40 kW of electrical power over 500,000 Btu/h of thermal energy suitable for either heating or cooling purposes are discussed. The predicted performance of the system and its major components are presented. G.R.

1970


Rankine cycle performance with three different fluids is evaluated: water, CP-34, and freon TF. Performance with CP-34 and a reciprocating expander using fluidic flow diverters instead of mechanical valves is examined. The control criteria for the boiler and feed pump are also investigated. It is concluded that the use of fluidic flow diverters in place of mechanical valves is not feasible and that any further effort to apply fluidic controls to automotive engines should be in information sensing and processing rather than in direct control of power. (Author)

An American Astronautical Society publication.

Proceedings of a special AAS/AIAA technical event, held October 30, 1970 at Winrock, Arkansas at the invitation of Governor Winthrop Rockefeller. p. 29—

NONTOLLING CENTRAL POWER STATIONS

F. L. Robson and A. J. Giammotti
United Aircraft Research Laboratories
East Hartford, Connecticut 06108

One of the most promising advanced-cycle power systems consists of a combined gas turbine-steam turbine (COGAS) system in which the hot exhaust of the gas turbine is used to raise steam in an unfinned waste-heat recovery boiler. The gas turbine used in this system would be an evolution of current turbomachinery and would utilize aerodynamic and blade cooling concepts and blade materials which are now used or proposed for use in advanced aircraft gas turbines. Approximately two-thirds of the power output would come from the gas turbine and one-third from the steam turbine.

Using technology judged to be available by 1980, the COGAS system could achieve overall station efficiencies of approximately 25%, with the potential of even higher efficiencies with more advanced technology. Conventional fossil-fuel steam stations currently have station efficiencies of approximately 35%, and projections for future steam stations indicate only minor increases.


Summary of the research work accomplished on the Brayton space power system during the 1962-1972 period. It is shown that a great amount of Brayton system technology has been developed over this period.

1970

A SURVEY OF PROPULSION SYSTEMS FOR LOW EMISSION URBAN VEHICLES
W. E. Fraize and R. K. Lay Sep. 1970 118 p refs. Sponsored by DOT (Contract F19628-68-C-0388) (PB-200144; UMTA-TRD-82-70-2; M70-4B) Avail. NTIS CSCI 13F

An overview is presented of low and negligible emission urban vehicle technology. Propulsion systems suitable for low emission urban vehicles are described. The state-of-the-art of low emission systems is surveyed by direct contact with active development efforts in industry; the more promising areas for future development are reviewed. Exhaust emissions for fossil-fueled heat engines are summarized. A computer program was developed to demonstrate the effect of various route cycle and vehicle parameters on required power and vehicle speed: results are presented for a typical small urban bus.

Author (GRA)

1970

PB-198 393
United Aircraft Corp., East Hartford, Conn.

TECHNOLOGICAL AND ECONOMIC FEASIBILITY OF ADVANCED POWER CYCLES AND METHODS OF PRODUCING NONPOLLUTING FUELS FOR UTILITY POWER STATIONS


Identifiers: COGAS power system.

Analytical studies have been made to identify the technical and economic factors that will govern future selection of fuel cleanup processes and advanced-cycle central power stations which in combination, will be responsible for producing electric power at the lowest possible cost while reducing substantially the emissions of sulfur oxide pollutants resulting from the combustion of high-sulfur coal and residual fuel oil. The technical approach was based upon technology currently available, but possibly not reduced to commercial practice as well as technology judged to be attainable for commercial use within the next ten and twenty years. This approach included evaluations of current and projected, fossil-fuel desulfurization and conversion processes, current and advanced-cycle central power stations, and integrated fuel cleanup and power stations. (APCO abstract)

Discussion of development tests which demonstrate the suitability of a reciprocating expander of conventional design and materials for an organic Rankine-cycle system. The developments considered include single-cylinder expander testing using Monsanto Cp-34 (Thioiphene, C4H4S) fluid. A parallel effort on a similar test loop has been devoted to expander testing using various refrigerants. It is pointed out that on the basis of the results obtained Thermo Electron is proceeding with the prototype systems phase of development of Rankine-cycle powerplants using organic working fluids.

G.R.


The three-stage potassium test turbine includes (1) refractory metal forgings in the fabrication of the first two stage wheels; (2) refractory-metal rotor blades in stages two and three; and (3) material specimens in the casing downstream of the last rotor wheel for observation of possible impingement erosion from liquid slung off the rotor periphery. The report provides a discussion of the significant fabrication problems and accomplishments, and presents a photographic description of the actual physical hardware, along with a description of assembly, and a record of all hardware weights, dimensions, etc. prior to immersing potassium testing. It discusses only the configuration employing tip shrouded rotor configuration.

Author

Economic Feasibility of the Steam Ammonia Power Cycle

Issued July, 1969

R&D Report No. 47 (2)—Final Report

Contractor: The Franklin Institute Research Laboratories

Refer to: Titled report and PB-184331

Price: $6.00 NTIS

N70-13927# Politecnico di Torino (Italy). Centro Studi Motorizzazione Agricola.

POSSIBILITIES AND PROBLEMS OF GAS TURBINE APPLICATION FOR GROUND MOTION MACHINES [POSSIBILITÀ E PROBLEMI DELL'APPLICAZIONE DELLE TURBINE A GAS ALLE MACCHINE PER MOVIMENTO TERRA]

Gianni Rigamonti and Fiorenzo Morra (Fiat) Assoc. Tec. Automobile Jun. 1969 19 p refs in ITALIAN Sponsored by Consiglio Naz. delle Ric. its Ric. ATA, Quaderno 69, Suppl. to No. 6 (Publ-18) Avail: CFSTI

The present state of development of gas turbine engines for surface propulsion through a mechanical transmission is outlined. The space/power and weight/power relationship and the operational characteristics are discussed, as well as the utilization of the prime mover as a power supply to the auxiliaries. For gas turbine drives special systems of motor braking must be devised and new problems are encountered in installation, noise level, air filtering and exhausts.

ESRO

N70-14488# Air Force Systems Command, Wright-Patterson AFB, Ohio, Foreign Technology Div.

CERTAIN DESIGN PECULIARITIES OF AUTOMOTIVE GAS TURBINES


This paper examines design characteristics of automobile gas-turbine engines: the engines almost always operate at considerably below rated power and over a wide rpm range and they are often shifted from mode to mode and therefore must have good pickup. A twin-shaft turbine with heat exchanger is considered, but almost everything discussed applies to any automobile gas-turbine engine. It is shown that the rated pressure increase in the compressor must ensure minimum specific fuel consumption under average operating conditions. Selection of the basic engine parameters on the basis of minimum total cost per unit of transport work is proposed as a general approach to design. Author (TAB)

N71-13767# Scripta Technica, Inc., Washington, D.C.

FUNDAMENTALS OF THE THEORY OF TURBINES OPERATING ON WET STEAM


The theoretical and experimental condensation processes and gas dynamics of two-phase flows in wet-steam turbines are studied. Problems of gas dynamics are examined as applied to the motion of moisture droplets of various sizes in the flow of steam. Particular attention is paid to clarification of physical phenomena in flow passages of the turbine. The motion of droplet and films are studied for solving practical problems, i.e., determining losses and separation of moisture.

Author
SUMMARY OF COMMENTS ON 100,000 KW GAS TURBINE-GENERATOR


The 100,000-kw gas-turbine-generator units are being built for peaking service in electric utility systems. These units are conservatively rated 100,000 kw at 80°F ambient inlet air temperature, and 1,000-ft altitude, when burning liquid jet-aircraft fuel. With ambient temperatures of 20°F, the output can be increased to 125,000 kw. Sixty-cycle/sec a.c. generators are being furnished with these units; however, the gas turbine may also be used to drive large acyclic d.c. generators.

A description of the 100,000-kw gas turbine generator and the electric generator is presented along with the advantages of this gas-turbine-generator unit.

R.T.K.
III. ENERGY AND POWER STORAGE AND TRANSMISSION
MECHANICAL AND BATTERY STORED ENERGY SYSTEMS
FOR MEETING UNINTERRUPTIBLE AND BUFFERED ELECTRIC
POWER NEEDS.
G.E. Comeau.
IEEE Trans Industry Applications, v. IA-10, no. 2,

Abstract—Mechanical or battery-stored energy systems are used when
an uninterruptible or buffered power system is required. Seven dif-
f erent types of systems available are described and compared.

ENERGY STORAGE (I): USING ELECTRICITY MORE
EFFICIENTLY. A.L. Robinson.

Article discusses pumped storage, compressed
air storage, and storage batteries.

ENERGY STORAGE (II): DEVELOPING ADVANCED TECHNOLOGIES.
A.L. Robinson.

Article discusses superconducting magnetic,
superflywheel, hydrogen, and thermal energy storage.
TITLE: New Frontiers in Energy Storage
AUTHOR: McCallum, J.; Faust, C.L.
CORPORATE AUTHORT: Battelle, Columbus Laboratories
PUBLICATION DESCRIPTION: Battelle Research Outlook, 4(1), 26–29
PUBLICATION DATE: 1972

Article discusses various methods of storing energy.
ENERGY STORAGE PROBLEMS.

P. Daniels.


Sections on mechanical storage, storage batteries, fuel cells, hydrogen fuel (electrolysis), chemical and photochemical energy storage, heat storage, and electrical network.
Fuel cells: past, present and future
A.D.S. Tantram

Some of the euphoria of the early 1960s, which led to over optimistic predictions of the future of fuel cells, has now worn off.

Mr Tantram charts the development of fuel cells from early laboratory experiments to the highly efficient, but expensive cells used in the Apollo space programme and assesses their future commercial prospects.

MODULAR FUEL CELL PROGRAM ADVANCES.

Fuel cell powerplant includes individual modules combined on a half-acre site into a 26 Mw generating system. Units are truck transportable and can be installed with conventional construction equipment. A joint program by Pratt & Whitney Aircraft and nine utility companies.

O. J. Adhart.

Low Wattage fuel cells based on the matrix type phosphoric acid cell are discussed. Nominal ratings of 5-watts or less are considered. Bottled hydrogen or metal hydrides are used as fuel. Two approaches are taken. One relying on a conventional bipolar cell design with water removal by the air stream. In an alternate approach, metal hydrides are integrated with the fuel cell into a device resembling a primary battery. Hydrogen is generated by reaction of the hydrate fuel with the fuel cell product water. Power sources based on the phosphoric acid cell exhibit favorable life characteristics and power densities comparable to or exceeding low rate primary batteries.

(Author)

The research on electrochemical energy conversion systems has involved work on two tasks: a search for electrolytes alternative to phosphoric acid for direct and indirect hydrocarbon-air fuel cells, and a study of the corrosion characteristics of electrolytes for intermediate-temperature hydrocarbon-air fuel cells. The work during this reporting period was concentrated on the first task. Two alternative electrolytes, trifluoromethanesulfonic acid monohydrate and dichloroacetic acid, representative of two classes of compounds, were studied in some depth. The trifluoromethanesulfonic acid compound shows definite promise as an alternative electrolyte. It is physically and electrochemically stable up to 135°C for periods of time up to six weeks. The limiting current density for the oxidation of propane at 135°C is approximately 15 times that observed in H3PO4 at the same temperature. Certain problems associated with the use of dichloroacetic acid were encountered. These were interpreted in terms of the state of the "unbound" water in the electrolyte. (GRA)


The author describes initially the principle of operation of a fuel cell and this is followed by a detailed account of the alkaline fuel cell, first with respect to choice of electrolyte and working temperature and secondly choice of materials and electrode design. A description is given of the hydrogen-oxygen fuel cell system used in the Apollo space flights, and the results obtained. Acid fuel cell development is also considered and mention is made of recent developments with acidic ion exchange membranes as electrolyte and a brief description is given of the early design used in the Gemini space flights. The terrestrial applications of fuel cells, energy storage, and synthetic fuels are topics also considered. (16 refs.)


(AD-767302; PWA-4704) Avail: NTIS CSCI 10/2

Four advanced development model 1.5kW fuel cell power plants were delivered to the Army for evaluation. The delivery configuration power plant weighs 292 lbs. and has a volume of 9.7 cubic feet. Startup and Operation are fully automatic and the power plant operates on JP-4 fuel with a specific fuel consumption of less than 2.2 lbs/kWh. Output voltage is adjustable from 26 to 34 volts at any output from 0 to 1.8kW. The power plant consists of four subsystems, a regenerative thermal cracker, which converts liquid fuel to hydrogen, an acid fuel cell power section which generates dc power from hydrogen and air, a voltage regulator and an automatic control system. A core technology program was conducted to develop the cracker, voltage regulator and automatic control unit. Limited development of the power section, which is based on commercial technology fuel cells, to tailor the design to Army requirements was also conducted. The program culminated with development testing of a complete power plant and delivery of four power plants to the Army. Author (GRA)


Donald R. McVey Jul. 1973 29 p. (Contract DA4002-70-C-0518; DA Proj. 1G6-63702-DG-10)

(AD-774274; PWA-4704-Suppl) Avail: NTIS CSCI 10/2

The objective of this program was to improve the PC14 powerplant thermal cracker catalyst and to define its performance characteristics. Five areas were investigated: (1) the type of catalyst ceramic support and the level of nickel loading, (2) the effect of shock and vibration on performance, (3) performance on leaded gasoline and JP-4, (4) the effect of high sulfur fuel on performance, and (5) endurance on leaded gasoline. The results of the study are given in the report. (GRA)

Summary—In a design of an integrated fuel-cell power system, conceived by Westinghouse under contract to the Office of Coal Research, it is important to maximize the power output per unit volume of fuel-cell batteries, because of heat-release and material-conservation considerations. A battery-design study has been completed, in which the optimum film lengths on a tubular substrate have been calculated for a range of values of electrolyte and interconnection resistivity-thickness products and electrode resistivity-thickness quotients. The analysis shows that power densities of greater than 8 kW ft⁻⁴ of battery volume would be possible, assuming that the batteries operate at 80 per cent electrical efficiency and are constructed on tubes, one-half inch in diameter, which are spaced in the manner of tubes in a shell and tube heat exchanger.

Key words: Battery design fuel cell optimization power density solid electrolytes zirconia

The Lockheed Power Cell - H. J. HALBERSTADT................................. 63

Electricity for Developing Areas via Fuel Cell Power Plants - J. M. KING, S. H. FOLSTAD........................................... 111

TK  6540


"IEEE cat. no. 72 CHO 581-9 IEEE."

Battery and Fuel Cells in Future Energy Handling, R. F. Hanlen and H. A. Christopher................................. 148


Current commercial fuel cell technology and the requirements of utility applications lead to a fuel cell system design which is modular in configuration and is composed of three major subsystems. The subsystems include a fuel processor, a fuel cell power section, and an inverter. Fuel cell operational characteristics are discussed, giving attention to its high efficiency, its environmental characteristics, the load response, and the operational modes. G.R.

Autonomous Hydrogen/Air Fuel Cell for Long-Life Missions
Y. Breille, J. Cheron, A. Greiher ........................................... 1
Low Cost Air Cathodes, R. N. Camp, B. S. Baker .................... 7
Thin Carbon Electrodes for Acidic Fuel Cells, K. F. Kordesch, R. F. Scarr 12
Fuel Cell Battery with Non-Noble Metal Electrodes and Acid Electrolyte
L. Baudendest, H. Bohm, J. Helflir, G. Louis, F. A. Pohl 20
Observations on Electrolyte and Product Management for Hydrazine–Oxygen Fuel Cells
Undergoing Changes in Pressure, H. B. Urbach, R. J. Bowen, D. E. Icenhower 23
Design Parameters of a 300 Watt Ammonia-Air Fuel Cell System
M. F. Collins, R. Michalek, W. Brink ................................. 32
1.5KW Open Cycle Hydrocarbon-Air Fuel Cell, E. A. Gillis .............................................. 1097


Topics discussed include: the anodic oxidation of methanol; the reaction mechanism of the hydrazine electrode; the adsorption of hydrogen by platinum; the influence of structural perturbations on kinetic processes at platinum and gold electrodes; the effect of 'compensated diffusion' on the potential difference between two immiscible media; the use of nitrogen containing active carbon as a cathode catalyst; the use of cobalt phosphate, various organic compounds, and mixed oxide systems as catalysts; and the use of electronically conducting oxides as cathodes or interconnection materials. A high-performance air cathode is described, as well as bipolar noble-metal free and noble-metal containing electrodes, and some comments are made on Raney, nickel catalysts. Various applications of hydrogen/air fuel cells are considered. A.B.K.

R. E. Sedlak and R. J. Dumas May 1972 84 p refs
(Contact DAA070-70-C-0136)
(AD-744477: ECOM-0136-F) Avail: NTIS CSCL 10/2

A hydrazine fuel cell power generating module capable of 120 watts continuous output was designed, constructed, evaluated. The fuel cell module incorporated design features permitting low cost manufacturing techniques to be used. This approach permits the economic use of the desirable characteristics of a fuel cell power module with the life attainable commensurate with the present state of the art. A fuel cell module from the units delivered was selected at random and subjected to an evaluation test program. The report describes the original design as represented by the Design Plan, the Final Design Incorporated in the delivered hardware, and the Evaluation Testing Conducted to assure compliance with the contract technical requirements.

Author (GRA)

FUEL CELLS: DISPERSIVE GENERATION OF ELECTRICITY
T.H. Maugh II
N72-33068\# Institute of Gas Technology, Chicago, Ill.
LOW-COST ACID FUEL CELL STACKS Final Report
Jun. 1972 108 p refs
(Contract DAAK02-67-C-0063)
(AD-744806) Avail: NTIS CSCL 10/2

The report concerns research to redesign and to improve compact, low-temperature, acid electrolyte fuel cell stacks. These stacks, which use low-platinum loading electrodes, are operated on air and reformed CITE fuel or combat gasoline. Author (GRA)

PROSPECTS FOR THE APPLICATION OF HIGH TEMPERATURE FUEL CELLS
(AD-727497; FTD-HT-23-894-70) Avail: NTIS CSCL 10/2

The work is concerned with prospects for application of high-temperature fuel cells (HTFC) as power sources. Results of analytical research on determination of cell parameters as functions of working process temperature and fuel type are given. Author (GRA)

N72-14040\# Pratt and Whitney Aircraft, East Hartford, Conn.
(Contract DAAK02-70-C-0158; Contract DA Proj. 1-G-663702-DG-1003)
(AD-730798; PWA-4210) Avail: NTIS CSCL 10/2

A 1.5 KW fuel cell powerplant was designed for field power supply. The design was validated by testing a breadboard powerplant incorporating the features of the design. It operates automatically on military logistic fuels over a 0-1.65 kW output power range. The powerplant consists of a dual bed regenerative thermal cracker, an air-cooled phosphoric acid fuel cell subsystem, a solid state voltage regulator, and an automatic control unit. The design is validated by 153 hours of operation of a functionally identical breadboard powerplant. An analysis was conducted to determine the potential of the powerplant. Author (GRA)

N72-13066\# Army Foreign Science and Technology Center
Charlottesville, Va.
FUEL CELLS AND PROSPECTS FOR THEIR USE IN RAILROAD TRANSPORTATION
(AD-747512; FSTC-HT-23-960-72) Avail: NTIS CSCL 10/2

The principles of the direct conversion of chemical energy into electrical energy are examined. Different types of fuel cells are described and existing power plants and power plants with fuel cells are compared.

Project Fuel Cell
Issued January, 1971
R&D Report No. 57—Final Report
Contractor: Westinghouse Electric Corporation
Refer to: Titled report and GPO Catalog No. 165.10:57
Price: $6.75
TK 2931. V513


An attempt is made to present a comprehensive but concise account of research and development in the field of the direct generation of electrical energy by electrochemical processes, to the stage achieved in 1964. The results of extensive hitherto unpublished research are included. In introductory chapters, ideas, terminology, and basic physicochemical principles of electrochemical energy conversion are summarized. Special attention is given to the kinetics of electrode processes from a technological point of view. The recent original work of numerous electrode reactions is reported. The physicochemical and technological problems involved in the construction and operation of complete cells are described. The most promising electrochemical methods for electrochemical conversion of heat and nuclear energy into electrical energy are described. The electrochemical methods for storing electric energy are examined together with the separation of the isotopes of hydrogen accompanying the electrolysis of aqueous solutions. In conclusion, the whole field is briefly reviewed and possibilities of future applications of the new sources of energy are discussed. The book is intended not only for electrochemists but for all groups of research workers interested in energy conversion.

Z.W.

TK 2931. F76


The papers deal with research and development work performed for the entire field of fuel cells, with emphasis on the results of research on electrocatalysts. Included are discussions of the state of the art of fuel cell technology for a variety of fuel cell systems. Results obtained for secondary battery systems are used to compare the properties and applications of various energy conversion devices in the light of the last findings, and to discuss in what way to what extent fuel cells and secondary batteries can supplement each other. Much attention is given to new organic and inorganic electrocatalysts and to electrotraction and implantable fuel cells.


Review of the progress achieved to date in the field of designing portable and transportable power sources. The basic principles of electrochemical power sources are outlined, and the manufacturing processes and performance of the main types are briefly described. Some details are given of new cell types capable of much higher outputs than conventional batteries - in particular, sodium-sulphur, lithium-chlorine, and zinc-air cells. Fuel cells are described in some detail and indications are given of outstanding problems. Finally, the characteristics of the various power sources are summarized, and the relationships between the power and energy densities are illustrated graphically.

O.H.


Consideration of a hydrogen-oxygen fuel cell which has a hydrazine electrode with an active two-phase boundary. This electrode has one or more meshes which are covered with a catalyst which consists of nonnoble metals or their compounds, such as NiZB, CoZB, or Raney nickel either used alone or as a base for other noble metals (Pd-Ru). The cell also has a supported oxygen electrode. The powder catalyst may consist of Raney silver or carbon with silver. The cover layer of the electrode serves simultaneously as the diaphragm. It must consist of electronically nonconductive material, asbestos is mostly used.

F.R.L.

N71-15723# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Abt. Magnetofluidodynamische Energiewandlung. THE FUEL CELL CONCEPT. A REVIEW OF BASIC PRINCIPLES


The discussion of single cell electrochemistry includes performance characteristics of the Apollo fuel cell using hydrogen-oxygen reactants. Modern applications of cells using air oxidant and hydrocarbon fuels are described and the relatively pollutant-free fuel cell exhaust is compared with that from commercial powerplants.

Author (ESRO)

Paper reviews the extent to which fuels other than hydrogen have found use in fuel cells and examines the problems to be overcome before any of them is likely to achieve commercial acceptance.
Proceedings. [New York, American Institute of Chemical Engineers, 1969]

xxxiii. 1080 p. Illus. 28 cm.

 Held at Washington, D. C., September 22-26, 1969.
Sponsored by American Institute of Chemical Engineers, American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics, American Nuclear Society.

Economic High-Pressure Hydrogen-Oxygen Regenerative Fuel-Cell Systems
Page 1042  699129
H. J. Allison, R. Ramakumar and W. L. Hughes, Oklahoma State University, Stillwater, Oklahoma

Ammonia-Air Fuel Cell System
Page 1048  699130
P. L. Terry (Speaker) and O. J. Adlhart, Englehard Industries, Newark, New Jersey

The Hydrazine-Air Bi Cell, A Simplified Fuel Cell System
Page 1052  699131
J. Perry, Jr. and L. J. Rogers, U.S. Army Electronics Command, Fort Monmouth, New Jersey

A Circulating Electrolyte Hydrogen/Air Fuel Cell System
Page 1057  699132

High Power Density Fuel Cell
Page 1065  699133
B. Durante (Speaker), U.S. Air Force, Wright-Patterson Air Force Base, Ohio, J. K. Stedman and C. L. Bushnell, Pratt & Whitney Aircraft, South Windsor, Connecticut

£32
PROJECT FUEL CELL.

Harris F. White, senior member, IEEE

Reviews the status of high-efficiency, coal-oxidation, solid-electrolyte fuel cells being developed under Project Fuel Cell. Describes the manufacturing technique of thin film batteries consisting of numerous fuel cells and a 100-kW power plant now under construction, and projects the economies of a 1000-MW fuel-cell power plant.

A68-41848

FUEL CELLS - THEIR STATUS AND FUTURE OUTLOOK.
E. Yeager (Case-Western Reserve University, Dept. of Chemistry, Cleveland, Ohio).
42 refs.

Examination of the status of the art and future potential of fuel cells such as hydrogen-oxygen cells, hydrazine-oxygen cells, hydrocarbon-consum ing cells, and sodium amalgam-oxygen cells. An \( \text{H}_2-\text{O}_2 \) type (by Gil) has been used as a nonpropulsive power source for orbital missions in the Gemini project; another (by Pratt and Whitney) will be applied in the Apollo project; and a third (by Allied Chemical) is under study for later space projects. Voltage output under operating conditions is about 0.9 V for the hydrogen-oxygen type. Problems that remain to be overcome in all types are low power density and short operating life. Some materials problems arise from the high operating temperatures required in the case of the hydrocarbon-consuming cell. In regions with high cost of electrical power the further development of the sodium amalgam-oxygen cell might be attractive. R. M.
Review and Evaluation of Project Fuel Cell
Issued February, 1967
R&D Report No. 17—Final Report
Contractor: Jackson & Moreland Division of United Engineers & Constructors, Inc.
Refer to: Titled report and PB-173765
Price: $6.00 NTIS

TK2931.B3 1965
BAKER, B. S., ED.
xiv, 560 p. TK2931.B3 1965

TK2896.I5 1965c
Engineering Developments in Energy Conversion.
(Presented at Intemat. Conf. on Energetics, Rochester Univ.,

The Growth of Fuel Cell Systems by Ernst M. Cohn 252

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Galen R. Fryninger 266

The Methanol Fuel Cell Battery by Barry L. Tarmy and
George Ciprios 272

Operating Characteristics of an Economical High Temperature
Fuel Cell by S. S. Baker and L. G. Marianowski 284

The Electrochemical Engine by R. E. Hendolson, B. Agruss, and
D. A. J. Swinkels 293

Heat and Mass Transfer Characteristics in Ion Exchange
Membrane Fuel Cells by Jacob G. Bortas 309
HOW FORD EVALUATES THREE TYPES OF ELECTRIC VEHICLES.
L.W. Unnevehr, et al.
Automotive Engineering, v.32, no.6,

Here are results of in-depth feasibility studies on a small, minimum
performance city car, a higher-performing metropolitan car, and a
delivery van/city bus with electric drive. Also included is a
state-of-the-art look at storage batteries, and future drivetrain,
braking, steering needs.

SWITCHING ON ELECTRIC VEHICLES.
Environmental Sci. & Engineering, v.8, no.5,
May 1974, p.410-411.

Speakers and exhibitors at the re-
cent "Third International Electric Ve-
hicle Symposium and Exposition" (Washington, D.C.) extensively dis-
cussed the makeup of the electric
vehicles.

THE ELECTRIC CAR: WILL IT REALLY GO?
T.J. Healy.

It may not save energy, but it could be cheaper,
less polluting, and in the long haul, petroleum
conserving.

THE NEED FOR DEVELOPMENT OF HIGH-ENERGY BATTERIES
FOR ELECTRIC AUTOMOBILES.
P.A. Nelson, et al

Lithium - Inorganic Electrolyte Batteries.
David R. Cogley, and Michael J. Turchan.
Eic Inc Newton Mass. Feb 74. 41p C-401, ECOM-0030-1-74
AD-775 420/3WE. PCS3.25/MF$1.45
The purpose of the present program is to study the feasibility
of an all-inorganic electrolyte lithium primary battery operable
and storable over the temperature range of -40F to -160F. The
desired energy density is 150 watt-hours per pound of total
battery weight and the desired power density is 50 watts per
pound.
S-446
SUPERBATTERIES.
J.R. Free.

They'll store electric power using molten salts hotter than your oven. And they pack the wallop need for electric vehicles.

Oct. 1973 356 p refs
(AD-768500, DDC-TAS-73-59) Avail: NTIS CSCL 10/3
The bibliography is a selection of unclassified and unlimited citations on batteries. These references present information on design, cells, test, development, components, and performance characteristics. Discussed are many types of batteries, with most references relating to the nickel cadmium batteries and organic batteries.

847 p. illus. 20 cm.
Sponsored by: American Institute of Aeronautics and Astronautics [and others]

Stable, High Energy Non-Aqueous Electrolyte Lithium Batteries - M. EISENBERG, K. WONG

The Development of Lithium/Sulfur Cells for Application to Electric Automobiles - E. C. GAY, R. K. STEUENBERG, J. E. BATTLES, E. J. CAIRNS

Description of the performance and design characteristics of recently developed silver-hydrogen cells. The first phase of this program encompassed design and electrical cycling of single and multiple plate cells. Based on the high rate (2C) long cycle life performance demonstrated by these cells, a series of production type 4.0 and 20.0 amper-hour cells were designed, constructed, and electrically characterized. The basic cell design consists of rectangular silver and catalyzed fuel cell plates alternately stacked in a hermetically sealed prismatic container. Electrical connection is provided by ceramic-metal seals. Heat is dissipated from the cell core through the flat container surfaces to intercostal thermal shunts, minimizing temperature gradients within the cell. In general, the performance indicates that this design is capable of producing energy densities in excess of 80 watt hours per pound. (Author)

N73-20068/ Argonne National Lab., Ill.
LITHIUM/SULFUR BATTERIES FOR OFF-PEAK ENERGY STORAGE: A PRELIMINARY COMPARISON OF ENERGY STORAGE AND PEAK POWER GENERATION SYSTEMS
(Contract W-31-109-eng-38)
(ANL-7958) Avail: NTIS HC $5.45
The use of lithium/sulfur batteries as load-leveling devices in electrical utility networks could provide both economic and ecological benefits in meeting the growing demand for energy. A battery designed for this application should have an initial capital cost of $12 to 15/kW-h of energy storage capacity and a lifetime of at least five years. A typical duty cycle is expected to be 10 to 14 hr discharge followed by a 4 to 8 hr charge with the battery operating about 5 days per week.
Economic and cell performance goals for the development of a battery system are presented. A preliminary comparison of the costs of batteries, pumped hydroelectric storage and gas turbines indicates that, under some conditions, batteries should be considered as load-leveling devices. The lithium/sulfur battery system is in too early a state of development to accurately predict its place in the utility system. Author (NSA)

A74-22709/# Techttran Corp., Glen Burnie, Md.
MEETING FUTURE PEAK ELECTRICAL ENERGY DEMANDS BY MEANS OF ELECTROCHEMICAL STORAGE SYSTEMS
Klaus D. Beccu Washington NASA May 1974 12 p refs
(Contract NASw-2485)
(NAS-TT-F-15634) Avail: NTIS HC $4.00 CSCL 10C
The electrical energy crisis is considered in terms of storage equipment. Various types are compared in terms of costs, efficiency, maintenance, and raw material reserves. It is concluded that more study and research is needed before adequate energy storage systems can cover peak load periods. Author

P. A. Lewis and J. Zemkoski, Public Service Electric and Gas Co., Newark, N. J.

Electric power system load characteristics and capacity requirements are discussed. The merits of dispersed electrochemical energy storage generation devices are discussed. Optimum sizes, amounts, and points of installation are described and savings associated with the installation of such storage devices are estimated. The characteristics of existing types of batteries and those currently under development are reviewed.

N74-18737# Energy Research Corp., Bethel, Conn.
Allen Chaney Nov. 1973 44 p
(Contract DAA07-72-C-0114. DA Proj 177-62705A-053)
(AD 772944; ECOM-0114-F) Avail. NTIS CSCL 10/3

A sealed 7 Ah/6.5 volt nickel-zinc battery has been developed which is capable of 160-200 cycles of operation at approximately 60% depth of discharge at the C/4 rate. Initial energy density obtained was 28 Wh/lb at the C/4 discharge rate. The battery will deliver about 40% of its energy at -20°F at the C/4 rate. With silver amalgam oxygen recombination electrodes the battery is capable of continuous overcharge at 0.5 amperes at a safe steady state pressure below 50 psi. Improved inorganic separators (ERC-2002) have been developed which are chemically inert in KOH. have a uniform pore size distribution and stop the occurrence of zinc dendrites. The primary cause of failure of the battery was found to be from the zinc electrode failure. (Modified author abstract)
High-Performance Batteries for Off-Peak Energy Storage.
Argonne National Lab., Ill. Mar 74, 67p
ANL-8038 PCS$5.45/MFS$1.45

The report is the first in a series of semiannual reports on a program to develop high-specific-energy lithium/sulfur batteries for off-peak energy storage in electric utility networks. The design goals for the battery include a specific energy of 150-200 W-hr/kg, a specific power of 25-50 W/kg, and a lifetime of 5 years and more than 1250 charge-discharge cycles. Initial cell tests have been directed toward development of (1) a Li-Al alloy electrode, formed by electrochemical deposition of lithium on a porous substrate of aluminum fibers and (2) a sulfur electrode consisting of a mixture of a sulfur-arsenic alloy and finely divided carbon. The cell development effort is supported by laboratory studies, in which problems associated with cell reactions are investigated. The materials studies, in which cell components are fabricated and new materials of construction are identified and tested to determine their corrosion resistance to the cell environment. (modified author abstract)

Low Power Methanol-Air Battery.
John Perry, Jr.
Army Electronics Command Fort Monmouth N J Apr 74,
24p ECOM-4213
AD-779 183/3WE PCS$3.00/MFS$1.45

An increased need for low power, long life power supplies has become apparent with the development of transistorized military communications and surveillance equipments. In view of this, a set of test specifications approximating characteristic performance requirements was defined in order to establish the feasibility criteria for a low power methanol-air battery. An energy density of 88 Wh/lb was set as a goal, at a continuous drain of 45 mW for 2,000 hours, with the capability of response to 15 W pulses for 6 seconds at 10-minute intervals. A 9-cell battery stack was fabricated in-house for test and evaluation under the 45 mW/15 W load profile. The teflon-bonded anode was catalyzed with 75% Palladium/25% Platinum and the cathodes catalyzed with silver. The total

BATTERIES: The first volume in a survey series on various types of batteries, beginning with manganese dioxide batteries. Alkaline cells are also treated. The series is directed at electrical and electronics engineers, physical chemists, and other scientists and engineers working with battery power systems. 592 pages. (ISBN: 0-8247-6084-0, available at $47.50 from Marcel Dekker, Inc., 305 E. 45th St., New York, N.Y. 10017.)

A CAR TO BEAT THE FUEL CRISIS?
N. Valery.

The electric car is just about feasible using present-day technology. The electric commuter vehicle needs at least a further five years of development.
Theoretical Simulation of the Performance of Molten Salt Thermal Batteries.
Alan S. Kushner.
Naval Ordnance Lab White Oak Md Aug 73, 29p NOLTR-74-24
AD-779 269/0WE PC$3.25/MS$1.45

A computer program for the Thermal and Electrical Analysis of Batteries (Ti:AB) has been developed as a tool for the computer-aided design of molten salt thermal batteries. TEAB solves the coupled set of equations describing the temperature distribution within a molten salt cell and the electrical characteristics of the cell. Heat generation due to start-up heat source, electrochemical phenomena, and the flow of electric current within the cell are all included. The program calculates the spatial and time temperature variation within the cell during start-up and during cell operation, checks for a satisfactory molten electrolyte zone for cell operation, and calculates the cell voltage-current characteristics as a function of time. TEAB has been utilized in the Li-C2 Battery Development Program at the Naval Ordnance Laboratory. (Modified author abstract)

It is shown that LaNi5 hydride can be used to reduce the operating pressure of a nickel/hydrogen cell without affecting its high cycle-life expectancy. Advantages of this concept are: safe operation at high hydrogen pressures, cell volume reduction of almost 50%, and simplification of cell pressure vessel design through prismatic-type cell construction; this eliminates electrolyte loss problems, provides an electrode stack design with improved shock and vibration characteristics, and simplifies battery packaging. V.P.

N74-16784* National Aeronautics and Space Administration. Lewis Research Center. Cleveland, Ohio.

BATTERIES FOR STORAGE OF WIND-GENERATED ENERGY Harvey J. Schwartz In its Wind Energy Conversion Systems Dec. 1973 p 146-151 (For availability see N74-16757 08-03) CSCL 10C

Cost-effectiveness characteristics of conventional-, metal gas- and high energy alkali-metal-batteries for wind generated energy storage are considered. A lead-acid battery with a power density of 20 to 30 watt/hours per pound is good for about 1500 charge-discharge cycles at a cost of about $80 per kilowatt hour. A zinc-chlorine battery that stores chlorine as solid chlorine hydrate at temperatures below 10 C eliminates the need to handle gaseous chlorine: its raw material cost is low and inexpensive carbon can be used for the chlorine electrode. This system has the best chance to replace lead-acid. Exotic alkali-metal batteries are deemed too costly at the present stage of development. G.G.

TRANSPORTATION: The Electric Car - fact or fancy? Can we meet the demand for energy by electric cars? And will our air be any cleaner with the widespread use of electricity? By Jalal T. Salihi.


The technology required to construct secondary batteries having the performance capabilities required for pollution free electric automobiles is discussed. Batteries for this application should have an energy storage capability of 220 W/kg. Their capacity should not exceed about 310/kW-hr of energy storage capability. Lithium/sulfur cells using a molten lithium halide-containing electrolyte and operating at 350 to 390 C have achieved capacity densities of up to 0.9 A-hr/sq cm (above 1 V) at a current density of 0.8 A/sq cm with a cycle life of more than 2000 cycles during 7000 hr of operation. The enclosed mixed-cathode cell L-9 had a cycle life and lifetime of 150 cycles and 1000 hr, respectively, with a capacity density up to 0.4 A-hr/sq cm at a current density of 0.24 A/sq cm to a 1.0-V cutoff. These results are consistent with the specific energy and specific power goals, but the cycle life and the sulfur electrode performance require further improvement. Author


The objective of the program was to develop a high charge rate, high discharge rate lead-acid battery compatible with the requirements of a hybrid heat-engine/electric vehicle. Because the power requirements and charge-discharge profiles for a hybrid-vehicle battery are sufficiently different than those for a conventional lead-acid battery, a development program was undertaken to optimize the lead-acid battery for hybrid-vehicle use. As a result of this program, ten test cells producing specific powers of 150 W/lb for a 75-sec discharge and 204 W/lb for a 20-sec discharge were developed and tested. The achievements under the program included: fabrication of thin, conductive vitreous carbon-epoxy substrates, chemically inert to lead-acid cell environment; a method for applying (pasteing) the active material onto the substrate; and negative bipolar plates that exceeded the performance target of 2A/sq in (0.3 A/sq cm) at 1.5V for 60 sec and out performed standard pasted plates.
Recent Development of the Ford Sodium-Sulfur Battery
Electrical Performance of a Prototype Sodium Sulfur Battery, R. W. Minck ......................... 42
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Dual Turbine—Battery Electric Vehicle Drive System, C. J. Heise .............................. 1103—
THE SOLAR ERA: PART 4 - THE UNIVERSITY OF FLORIDA "ELECTRIC".  
H.R.A. Schaeps and E.A. Farber.  

The "electrics" are coming, or will be, if the I-C engine finds the price of its fabulous success— 
cleaning up its massive pollution of the ambient air—too steep. Now undergoing a feverish rush of 
development, the electrics will then get a second change. Here's a report on a GM Corvair converted 
into a test bed for battery-electric propulsion.

TK Smith, George, 1911- 
Storage batteries, including operation, 
charging, maintenance and repair [by] G. 

xiii, 231 p. illus. 23 cm.
LONG SHELF LIFE ORGANIC ELECTROLYTE BATTERY
Final Report
(Contract DAAE07-70-C-0076)

The fabrication of prototype organic electrolyte-lithium cells having wide operating temperature range and high energy density has been completed. Seventy of these cells were assembled and delivered for evaluation tests. In tests of samples of these cells carried out at this laboratory, energy densities of 95 watt hours per pound at room temperature and 55 watt hours per pound at -30 C were obtained. Similar cell components were assembled to make fifteen 36 volt batteries with a diameter of 2.75 in. and a height of 5.0 inches. The discharge of a prototype battery at room temperature using the specified discharge regime was performed. Improved cells of the type used to make the 36 volt batteries were tested at room temperature on the specified loads. The contractual objective for charge retention, high efficiency performance following three months storage at SSC, was not attained. Reduced temperature storage is recommended for the cells and batteries. Some redesign of cell and battery structures is required to prevent electrolyte leakage and internal corrosion observed in the delivered end items.

Author (GRA)

HIGH ENERGY DENSITY NICKEL-Cadmium Cells/
A. Charley/M. Klein/Energy Research Corporation.

ELECTRICAL CHARACTERISTICS OF NICKEL-ZINC
SECONDARY CELLS/S. Charlip/S. Lerner/
Colton Industries, Incorporated

HIGH ENERGY DENSITY LONG LIFE SECONDARY
SLER-ZINC BATTERIES/J. K. Wilson/D. Standlee/
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S. B. Self/Lockheed Missiles and Space Company.

PERFORMANCE CAPABILITIES AND APPLICATIONS
OF THE LI/MH 32 BATTERY SYSTEM/L. H. Gaines/
R. Jasinski/Tyco Laboratories.

NICKEL-Cadmium Battery Evaluation for Apollo
Telescope Mount Application/W. W. Kirch/
A. Shikoh/Sperry Rand Corporation

MERCURY ELECTROCHEMICAL COULOMETER AS A
BATTERY STATE-OF-CHARGE INDICATOR/
R. R. Secunde/A. G. Bierchenough/
Lewis Research Center/National Aeronautics
and Space Administration.

AN ELECTROCHEMICAL CELL EQUIVALENT CIRCUIT
FOR STORAGE BATTERY/POWER SYSTEM CALCULATIONS
BY DIGITAL COMPUTER/R. G. Zimmerman/
Lockheed Missiles & Space Company/R. G.
Peterson/Lockheed Aircraft Corporation.

N71-22199# National Research Council of Canada, Ottawa
(Ontario). Low Temperature Lab.

PRESENT STATUS OF ELECTRIC AUTOMOBILES
reft (See N71-22199 11-15)
Avail: NTIS

The scope of the study includes developments in batteries,
fuel cells and hybrid systems, controllers, chargers, electric motors,
and body design features. Problems due to thermal conditioning
and corrosion are also discussed.

Author

Hietbrink, E. H., and Tricklebank, S. B., "Electric Storage Batteries for
Falk, S. Uno.
356 p. illus., facsim., ports. 23 cm. (The Electrochemical Society series)
Includes bibliographies.

Symposium on Zinc-Silver Oxide Batteries, Montreal, 1968.
Zinc-silver oxide batteries. Edited by Arthur Fleischer, with John J. Landers.
New York, J. Wiley [1971]
xviii, 544 p. illus. 23 cm.

Held during the 1968 fall meeting of the Electrochemical Society and co-sponsored by the Battery Division of the Society and the Air Force Aero Propulsion Laboratory.
### Intersociety Energy Conversion Engineering Conference, Miami Beach, Fla., 1967.

Advances in energy conversion engineering; papers, critiques, and summaries. New York, American Society of Mechanical Engineers (1967).

### ELECTRIC AUTOMOBILE POWER

Chairman: William T. Reid

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THE STORAGE OF HYDROGEN AS METAL HYDRIDES.
D.L. Cummings and G.J. Powers.

Metal hydrides offer a reversible, chemical means for storage of hydrogen and could be used as mobile and stationary fuel sources. The properties and uses of metal hydrides are reviewed. A magnesium hydride bed, used in a hydrogen-powered automobile, is modelled.

UNDERGROUND ENERGY STORAGE:
F.C. Rogers and W.E. Larson.


From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).

Hydrogen, an alternative to gasoline fuel in vehicle applications, can be stored as a metal hydride and released for use by the application of waste heat from the engine. Present investigations include a review of known and possible hydrides with a potential for automotive use. Hydride bed types and their application to vehicles are discussed. FeHx and MgH2 are considered. Their merits and potential for use in meeting various transportation needs are discussed. Implementation through fleet vehicle systems is proposed as a means of gaining practical experience with reasonable control during the introduction of the advanced technology. (auth)


From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).

Modelling studies are of a practical importance in understanding and characterizing the behavior of hydride beds now being developed for storing and supplying hydrogen fuel in power plant and automotive applications. A convection bed model, in which heat is transferred to or from the bed by a flowing stream of hydrogen in direct contact with the particles, and a conduction model in which heat is transferred through a containment wall, were developed. FeHx and catalyzed MgH2 were evaluated using the model. (auth)


From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).

Electricity must be provided by the utilities on demand that varies daily, weekly, and in a seasonal cycle. This results in the under-utilization of high capital cost generating facilities and the reliance on peaking devices such as gas turbines and pumped storage. Gas turbine generators, though presently economical, are highly inefficient and use high grade liquid or gaseous fossil fuels which may eventually be in short supply. The role of electric storage in utility systems is discussed. The technology of hydrogen production, storage, and reconversion to electricity as a technique for electric energy storage is discussed and shown by means of an optimization model to fit well into the United States energy system. (auth)
THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar. 18-20, 1974.

Hydrogen Storage and Transmission
Session Chairman: J. E. Johnson,
Union Carbide Corp.
Linde Division,
New York, New York
Session Co-Chairman: S. S. Lee, University of Miami,
Coral Gables, Florida

TRANSPORTATION AND STORAGE OF HYDROGEN
R. A. Reynolds, W. L. Slager, General Electric
Company, Santa Barbara, California

ECONOMICS OF PIPELINE TRANSPORT FOR
HYDROGEN AND OXYGEN
G. B. Ghe, Euratom, Ispra, Italy

LOW THERMAL FLUX GLASS-FIBER TUBING FOR
CRYOGENIC SERVICE INCLUDING LH2 STORAGE
SYSTEMS
C. A. Hall, D. E. Spond, Martin Marietta Corp.,
Denver, Colorado

ELECTRIC POWER AND FUEL TRANSMISSION BY
LIQUID HYDROGEN SUPERCONDUCTIVE PIPELINE
R. L. Whitlaw, Virginia Polytechnic Institute and
State University, Blacksburg, Virginia

ARCHITECTURE OF AN AUTOMATIC SYSTEM FOR
SAFETY, METERING, AND CONTROL OF A
HYDROGEN TRANSMISSION PIPELINE
J. G. Burgen, Teledyne Geotech, Garland, Texas

OPTIMAL LOCATION OF HYDROGEN SUPPLY
CENTERS TO MINIMIZE DISTRIBUTION COSTS
M. Avriel, V. Gurovich, Israel Institute of Technology,
Haifa, Israel

HYDROGEN AS AN ENERGY CARRIER
R. G. Murray, Oklahoma State University, Stillwater, Oklahoma

THE ROLE OF HYDROGEN IN ELECTRIC ENERGY
STORAGE
F. J. Salzano, R. J. Isler, E. A. Cherniavsky, K. C.
Hoffman, Brookhaven National Laboratory, Long
Island, New York

HYDROGEN ENERGY STORAGE FOR ELECTRICAL
UTILITY SYSTEMS
C. Kippenhan, R. Corlett, University of Washingon,
Seattle, Washington

AN ECONOMIC STUDY OF ELECTRICAL PEAK-
SHAVING ALTERNATIVES
W. R. Parrish, U.S. Department of Commerce,
Boulder, Colorado

HYDROGEN AS ENERGY STORAGE ELEMENT
L. Zelby, The University of Oklahoma, Norman,
Oklahoma

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THE HYDROGEN ECONOMY MIAMI ENERGY (THEME) CONFERENCE.
Presented by The School of Engineering &
Environmental Design, Univ. Miami, Coral
Gables, Florida.
Sponsored by The National Science Foundation,
Defense Advanced Research Projects Agency,
and The School of Continuing Studies, Univ.
of Miami.
Miami Beach, Florida, Mar.18-20,1974.

Metal Hydride Storage
Session Chairman: F. Schulman,
Fred Schulman Associates,
Silver Spring, Maryland
Session Co-Chairman: W. B. King, University of Miami,
Coral Gables, Florida

THE ACTIVATION OF A LANTHANUM-NICKEL-
FIVE HYDROGEN ABSORBENT
H. H. van Mal, Philips Research Laboratories,
Geldrop, Netherlands

AN ENGINEERING-SCALE ENERGY STORAGE
RESERVOIR OF IRON TITANIUM HYDRIDE
G. Strickland, J. Reilly, R. Wiswall, Brookhaven
National Laboratory, Long Island, New York

THE STORAGE OF HYDROGEN AS METAL
HYDRIDES
D. L. Cummings, G. J. Powers, Massachusetts
Institute of Technology, Cambridge, Massachusetts

MODELING STUDIES OF FIXED-BED METAL-
HYDRIDE STORAGE SYSTEMS
W. S. Yu, E. S.ுuberg, C. H. Waide, Brookhaven
National Laboratory, Upton, New York

THE SAFETY CHARACTERISTICS OF LaNi5
HYDRIDES
C. E. Lundin, University of Denver, Denver,
Colorado

THE FORMATION AND PROPERTIES OF RARE-
EARTH AND TRANSITION METAL HYDRIDES
L. C. Beavis, R. S. Blewer, J. W. Guthrie, E. J.
Nowak, W. G. Perkins, Sandia Laboratories,
Albuquerque, New Mexico

Hydrogen Storage in Vehicles
Session Chairman: L. W. Jones,
University of Michigan,
Ann Arbor, Michigan
Session Co-Chairman: J. Alexander,
University of Miami,
Coral Gables, Florida

AMMONIA AS A HYDROGEN CARRIER AND ITS
APPLICATION IN A VEHICLE
R. L. Graves, J. W. Hodgson, J. S. Tennant, The
University of Tennessee, Knoxville, Tennessee

METAL HYDRIDES: EXPERIMENTAL METHODS
AND APPLICATION TO THE ELECTRIC VEHICLE
P. Jonville, H. Stohr, R. Funk, M. Kornmann,
Battelle Centre de Recherche de Geneve, Geneva,
Switzerland

THE APPLICATION OF METAL HYDRIDES TO
GROUND TRANSPORT
C. H. Waide, K. C. Hoffman, J. J. Reilly, R. H.
Wiswall, Brookhaven National Laboratory, Long
Island, New York

HYDROGEN STORAGE FOR AUTOMOBILES USING
METAL HYDRIDES AND CRYOGENICS
R. E. Billings, Energy Research Corporation,
Provo, Utahs,

STUDIES OF THERMAL STRATIFICATION IN LH2
AUTOMOTIVE FUEL TANKS
K. D. Williamson, Jr., J. R. Bartlit, F. J. Edeskuty,
W. F. Stewart, Los Alamos Scientific Laboratory,
University of California, Los Alamos, New
Mexico.

From hydrogen economy Miami energy conference; Miami Beach, Florida, USA (18 Mar 1974).

A hydrogen reservoir containing 14 lb of H₂ in the form of 893 lb of granular iron titanium hydride was constructed and tested. The reservoir will be used by Public Service Electric and Gas Co. of New Jersey to study the feasibility of storing off-peak electrical energy through the use of a water electrolyzer, a hydride reservoir, and a fuel cell stack. The internal functional components of the stainless steel vessel consist of a barrier in the form of porous metal tubes, and heat exchanger tubes. Details of construction, preparation of the hydride, and performance tests made at BNL are described. (auth)


One of the recent important achievements of the research work carried out in the Philips laboratories is the discovery of metallic hydrogen storage devices. The metallic storage material is described by the formula AB₂H₂, with A standing for rare earth, B for either cobalt or nickel, and H for hydrogen. Hydrogen being added to LanH₂, e.g., will result in the formation of the hydride LnH₆H₄, with six H atoms being bound to one unity, whereas in SmCo₅, 2.5 H atoms are added to the compound. (GE)
N74-16789* Oklahoma State Univ., Stillwater.
ENERGY STORAGE USING HIGH PRESSURE ELECTROLYSIS AND METHODS FOR RECONVERSION
William L. Hughes; In NASA. Lewis Res. Center Wind Energy Conversion Systems Dec. 1973 p 123-129 (For availability see N74-16757 08-03)
CSCL 10C

Theoretical and experimental studies on high pressure electrolysis producing hydrogen and oxygen for energy storage and reconversion are reported. Moderate temperature, high pressure hydrogen/oxygen fuel cells with nickel electrodes are investigated for effects of pressure, temperature, and membrane porosity. Test results from an aphid burner turbine generator combination obtained 40 percent kilowatt hours out of the fuel cell divided by kilowatt hours into the electrolyzer. It is concluded that high pressure hydrogenation of organic materials can be used to synthesize hydrocarbons and methanes for making synthetic vehicular fuels.

G.G.

TITLE: Heat-Storage Wells for Conserving Energy and Reducing Thermal Pollution
AUTHOR: Meyer, C.P.; Todd, D.K.
CORPORATE AUTHOR: General Electric-TEMPO, Center for Advanced Studies; University of California, Berkeley, Dept. of Civil Engineering
ADDRESS: 88, Santa Barbara, CA; UC, Berkeley, CA.
PUBLICATION DATE: 1973
ABSTRACT: Storing large amounts of useful heat in groundwater appears feasible. Preliminary analysis shows that more than three-fourths of the stored heat can be recovered after 90 days; heat-storage wells cost less than the cooling facilities they replace; and the necessary underground formations are widely available. For each unit of electricity generated today, two units of low-temperature heat energy typically are wasted. Higher temperature heat (350 degrees fahrenheit) is usable for space heating, absorption air conditioning, water heating, and process heat. Heat at 350 degrees fahrenheit can be recovered from the exhaust gases of combustion gas turbines. Nuclear power stations using a topping or backpressure cycle also can provide heat at 350 degrees, with good thermodynamic efficiency because credit is taken for the exhaust heat. This heat can be transmitted in large quantities with acceptable loss. Heat storage can provide the bridge that is needed between the spring and fall seasons when heating and cooling loads are light, thus making electrical and heat outputs compatible and enabling exhaust heat to be utilized on a large scale. (Auth)

AUTHOR: Yeh, H.
CORPORATE AUTHOR: Pennsylvania, University of
PUBLICATION DESCRIPTION: Report No. NSF/RAAN/66/S127976/P73/3; 30 p.
PUBLICATION DATE: 1973, March
TITLE: Thermostability of Salt Hydrates
AUTHOR: Belo, G.; Ajami, F.
CORPORATE AUTHOR: University of Pennsylvania, National Center for Energy Management and Power, University of Pennsylvania, Towne School of Civil and Mechanical Engineering
ADDRESS: Philadelphia, PA 19104
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: This report describes research performed on materials suitable for thermal energy storage (TES) applied to solar heating and air conditioning of buildings. Following a brief survey of the various means of TES, it is shown that the latent heat of fusion offers the best possibility for these applications. The thermal energy that can be stored by this method is of the order of 50 plus or minus 10 cal/g (50 plus or minus 18 Btu/lb). Criteria for candidate materials are developed, and the various classes of materials that undergo a phase transformation at the required temperatures are briefly reviewed in that light. Most of the report then concentrates on one class of materials: inorganic salt hydrates. An extensive literature survey on phase diagrams and thermodynamic properties of salt hydrates was carried out; its results are presented in the appendix. The kinetics of nucleation of the solid from the melt are considered from the theoretical point of view, since past studies indicated that supercooling is a serious problem in these materials. An empirical relationship between the viscosity of the melt at the melting point and its tendency to supercool is developed. It is found that salt hydrates are half-way between the good glass formers (which strongly supercool) and the non-glass formers (which do not supercool); as a result, it is suggested that the use of outside agents, such as a small weak supersaturated field, may prevent supercooling. The recommendations for future work include a search for new materials both within and outside the classes mentioned, and a detailed study of the kinetics of nucleation of salt hydrates. (Auth)

TITLE: Congruently Melting Materials for Thermal Energy Storage in Air Conditioning
AUTHOR: Kanfman, E.; Pan, Y.C.
CORPORATE AUTHOR: University of Pennsylvania, National Center for Energy Management and Power, University of Pennsylvania, Towne School of Civil and Mechanical Engineering
ADDRESS: Philadelphia, PA 19104
PUBLICATION DESCRIPTION: Report No. NSF/RAH/SE/G127976/TR73/5, 19 p., 7 references
PUBLICATION DATE: 1973, May
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: Because of the as yet unsolved difficulties in utilizing sodium sulfate decatohydrate mixtures as phase change materials suitable for thermal energy storage for air conditioning, an effort was made to find suitable materials which melt congruently. A congruently melting material would need no heterogeneous nucleating or thickening agents, but could have other problems, such as a slow rate of nucleation or a slow rate of crystal growth. A suitable material must melt within the required temperature range, possess a high latent heat (heat of fusion) per unit volume, be inexpensive, stable, and noncorrosive. Two classes of materials were investigated: inorganic hydrates and organics. After an extensive literature survey, samples of potentially suitable materials were obtained and calorimetrically tested. A number of paraffin waxes were identified as promising thermal energy storage materials. (Auth)

AUTHOR: Ye, H.
CORPORATE AUTHOR: University of Pennsylvania
ADDRESS: Philadelphia, PA 19174
PUBLICATION DESCRIPTION: Report No. NSF/RAH/SE/G127976/DD37/2
PUBLICATION DATE: 1973, June 30
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: Concern for maintaining reliable and economical energy supplies and for supplying electrical power demand has led to the examination of techniques for better utilization of existing resources. The use of thermal energy storage and solar energy to provide comfort conditioning by methods which consume less fuel and require less peak power is to be studied. One task of the project is the investigation of off-peak air conditioning systems which perform much of the power consuming function at night. This would reduce peak demand loads on mass peak shaving utilities. A second project task is the use of solar energy for heating residential buildings. This would reduce fuel consumption. Both of these systems involve heat storage to deliver the required commodity, heating or cooling, subsequent to the time the commodity is best obtained. This logically led to a third project task: the investigation of materials for storing thermal energy. The economic conditions required for successful introduction of the novel systems are to be defined, and the effect of such systems on electric utilities are to be investigated. (Auth, Objectives)
TITLE: Thermal Energy Storage Unit for Air Conditioning Systems Using Phase Change Material
AUTHOR: Dudley, J.C.
CORPORATE AUTHOR: University of Pennsylvania, National Center for Energy Management and Power; University of Pennsylvania, Towne School of Civil and Mechanical Engineering
ADDRESS: Philadelphia, PA 19104
PUBLICATION DESCRIPTION: Report No.
WSF/RANN/SE/GET7976/772/8, 23 p.
PUBLICATION DATE: 1972, August
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: A thermal energy storage unit using salt hydrate material was designed for an off-peak air conditioning system. The unit is sized for a two ton peak load and a one ton Asly average load. It is suitable for use with the prototype recouderd thermal energy storage air conditioning system constructed at the University of Pennsylvania. Based on the stated characteristics of Na2SO4.SH2OCl.10H2O the unit has a rated capacity of 100,000 Btu. The heat transfer surface is a stack of 42 horizontal aluminum sheets, spaced one inch apart, with labeled refrigerant passages. The uniqueness of this design is that the refrigerant is in intimate thermal contact with the phase change thermal storage material. The unit is suitable for use in air conditioning cooling storage systems or in space heating storage systems with suitable choices of materials. It has a smaller volume than a thermal energy storage unit using the sensible heat of water. However, it is more expensive.---A cost comparison between a conventional refrigeration unit and recouderd off-peak units storing thermal energy in water or in phase change materials shows the latter to be the most expensive unit, even if the phase change material is obtained at zero cost. Only the lower space requirement justify the continued development effort on phase change materials suitable for air conditioning thermal energy storage. (Auth, Abstract modified)

TITLE: System and Economic Analysis for Off-Peak Air Conditioning
AUTHOR: Saaty, T.L.; Lapide, L.; Tinkleman, H.
CORPORATE AUTHOR: University of Pennsylvania, National Center for Energy Management and Power; University of Pennsylvania, Towne School of Civil and Mechanical Engineering
ADDRESS: Philadelphia, PA 19104
PUBLICATION DESCRIPTION: Report No.
WSF/RANN/SE/GET7976/772/14, 76 p.
PUBLICATION DATE: 1972, August
SPONSOR: National Science Foundation, RANN Program
ABSTRACT: An economic model of off-peak air conditioning systems was created in order to evaluate the relationship between equipment cost and power reduction. Cost and power reductions were determined for operational control policies varying from continuous operation to exclusively off-peak operation for a range of costs of thermal energy storage material. Economic evaluations were performed with current electrical rates and with postulated discounts for systems designed for off-peak operation. It was determined that without subsidy the minimum cost system was the one using a continuously operating compressor. This system requires the smallest compressor and the least thermal energy storage material. The incremental cost of systems with larger compressors and more thermal energy storage (which would further reduce the power demand during peak periods) was evaluated in order to have a basis for comparison with the cost of the incremental generation capacity. Depending on the cost of the thermal energy storage material, the system costs range from slightly advantageous to slightly disadvantageous. Incremental implementation strategies were postulated for the introduction of off-peak air conditioning systems over a given planning period. (Auth)
CONSERVATION AND BETTER UTILIZATION OF ELECTRIC POWER BY MEANS OF THERMAL ENERGY STORAGE AND SOLAR HEATING, PHASE II - PROGRESS REPORT.
Altman, M.

TK2896. I55 1972
TITLE: Off-Peak Air Conditioning Using Thermal Energy Storage
AUTHOR: Freedman, S.J.; Dudley, J.C.
CORPORATE AUTHORITY: Pennsylvania, University of
PUBLICATION DATE: 1972, September

TK2896. I55 1972
The use of metal hydrides as hydrogen reservoirs facilitates the storage and subdivision of central-station power for automotive and other purposes. Hydrides with a wide range of properties have been synthesized and studied, and several appear to have promise for specific storage applications. Results are reported on the effect of alloy constituents on hydride stability; on the formation of hydrides by metals reacting with gas mixtures such as those produced by the steam reforming of hydrocarbons; and on the feasibility of integrated systems of hydride reservoir plus engine or fuel cell. (auth)

TITLE: Hydrogen for Energy Transport and Storage in Solar Energy Systems
AUTHOR: Hoffman, R.C.; Winsche, W.E.
CORPORATE AUTHORITY: Brookhaven National Laboratory
PUBLICATION DATE: 1971

NT3-10976# Pennsylvania Univ. Philadelphia, Towne School of Civil and Mechanical Engineering.
CONSERVATION AND BETTER UTILIZATION OF ELECTRIC POWER BY MEANS OF THERMAL ENERGY STORAGE AND SOLAR HEATING Interim Report. 1 Feb. - 1 Jul. 1971
Manfred Altman 1 Oct. 1971 265 p refs. (Grant NSF GI-27976)
(IP8-210359: UPS-71-1) Avail. NTIS HC $6.75 CSCL 13A
A project to investigate the application of heat and coolness storage for comfort heating and air conditioning was initiated. Inexpensive salt hydrates exhibiting phase change temperatures between 40 F and 60 F were found appropriate with use of off peak generation of coolness for storage and subsequent use during peak demand periods to supplement or replace electrically powered air conditioning units. Other inexpensive salt hydrates, with phase change temperatures of 89 F to 195 F were found for use as heat storage materials with solar heat collectors and off peak electric heating units. A feasibility demonstration of the off peak air conditioning system was built and successfully tested. Author (GKR)

TITLE: Thermal Energy Storage in Rock Chambers, A Complement to Nuclear Power
AUTHOR: Kargol, P.H.
CORPORATE AUTHOR: A.E. Atomenergi
PUBLICATION DATE: 1971, September
USE OF ENERGY STORAGE WITH UNCONVENTIONAL ENERGY SOURCES TO AID DEVELOPING COUNTRIES.
K.A. McCollom.
Advances in Energy Conversion Engineering, 1967

Development of an energy storage system using electrolysis of water to produce hydrogen and oxygen has led to an investigation of the use of unconventional energy sources in assisting developing countries.

THERMOPHYSICAL AND TRANSPORT PROPERTIES OF HIGH TEMPERATURE ENERGY STORAGE MATERIALS.
(Grant NSG-316)
(NASA-CR-53807) CFSI: HC $2.00/MF $0.50 CSCL 10C

The paper describes the prospective thermal energy storage materials and the techniques to be used for the measurements of their thermo physical properties, such as melting points, heats of fusion, and thermal transient transport properties. On the basis of the data available in the literature, several metals and compounds appear to be promising thermal energy storage materials. The suitability of the eutectic mixtures of certain oxides and fluorides is shown by making the estimations of their heats of fusion.

Callery Chemical Co., Pa.

K. W. Beam and H. W. Wilson et al Wright-Patterson AFB, Ohio, Directorate of Aeromechanics, Jan. 1963 113 p 10 refs
(Contract AF 33(616)-7224)

N-100,895

Callery Chemical Co.
Aeronautical Systems Div. TR 61-187
Contract AF-33(616)-7224

Thermal energy storage methods may be classified as chemical methods (heat of reaction) and physical methods (heat of fusion). This study screened various groups of compounds which might be applicable to these methods of heat storage. The results of a literature search are discussed and the physical property data are tabulated. Experimental results and descriptions of the apparatus and methods used for experimentally determining physical properties are presented. The heat transfer characteristics of three basic heat storage configurations (storage material in cylindrical capsules, storage material in the annulus between concentric cylinders, and storage material in thin blocks conforming to the shape of the working fluid reservoir) using heat of fusion are described. The storage of 400 BTU/lb of storage material was the objective of this work.
GAS TURBINE SYSTEMS USING UNDERGROUND COMPRESSED AIR STORAGE.

D.L. Ayers and D.Q. Hoover.

TK 2896. I 55 1973
TITLE: Compressed Air Energy Storage System Characteristics
AUTHOR: Decker, R.
CORPORATE AUTHORITY: University of Washington, Dept. of Aeronautics and Astronautics
ADDRESS: Seattle, WA 98195
PUBLICATION DATE: 1973
SPONSOR: Seattle City Light
ABSTRACT: An analysis of compressed air energy storage has been carried out to determine the feasibility of its use in commercial power peak shaving. The study identifies several system configurations which are characterized by the vessel's pressure and the cyclic pressure variation. These configurations are shown to be thermodynamically superior to pumped hydro storage when state of the art turbine engine components are used. The energy storage cost of such systems is shown to be potentially competitive depending on recovery requirements, land costs, the availability of natural cavast or the vessel manufacturing costs. The relative importance of component performance is delineated in this study. The behavior of the vessel's temperature and pressure over various time scales is discussed. Practical means of minimizing the system capital costs are outlined. (Auth)
AVAILABILITY: American Institute of Aeronautics and Astronautics, Order Dept., 1200 Avenue of the Americas, New York, NY 10019 ($60.00 for entire proceedings)

1973
TITLE: Air Storage Peaking Power Plants - Utilizing Modified Industrial Gas Turbine and Cavities Filled With Nuclear Explosives
AUTHOR: Ayers, D.C.
CORPORATE AUTHOR: Battelle, Pacific Northwest Laboratories
ADDRESS: Richland, WA 99352
PUBLICATION DESCRIPTION: Report No. BNW-1740, 39 p., 19 references
PUBLICATION DATE: 1973, May
SPONSOR: U.S. Atomic Energy Commission
ABSTRACT: Efforts to reduce the cost of peaking power have led to reconsideration of the air storage type peaking plant. In this plant, concept air is compressed and stored in a chamber during low demand periods. During peak demand periods air is withdrawn from the cavity, mixed with fuel, heated in a combustion chamber, and expanded through a turbine producing electrical power. This report summarizes a preliminary economic and system assessment of air storage peaking power plants utilizing modified industrial gas turbine and air storage cavities filled with nuclear explosives. Cost estimates indicate that the air storage plant based on current gas turbine technology could produce peak power at significant savings over other types of plants, provided: (1) air storage temperature is kept low; and (2) site rock properties are conducive to the production of a high void volume per kiloton of explosive. Cost estimates based on 1980 gas turbine technology indicate that the air storage system is clearly economically competitive to other peaking systems - even under the worst possible conditions of air storage temperature and rock properties. (Auth)
An air storage gas turbine project in Sweden—overall concept and operating features. B. Nordstrom, N. Holmin, I. Cedell (Swedish State Power Board, Vallentuna).

In an air storage gas turbine power station, air is used during the night compressed into an underground storage. During the peak-load period in the day, the compressed air is utilized for operation of the gas turbine for what reason all the turbine power can be used for production of electricity, as no simultaneous compression is required. Such a plant for the unit size about 200 MW and the pressure 25 bar and for ultimately 10 hours daily output is studied in Sweden in order to be constructed in the last 1970's. The authors report general design and especially the role and value of the station in the power system. (5 refs.)

N74-16785* InterTechnology Corp., Warrenton, Va.
ENERGY STORAGE BY COMPRESSED AIR
CSCL 10C
The feasibility of windpower energy storage by compressed air is considered. The system is comprised of a compressor, a motor, and a pump turbine to store air in caverns or aquifers. It is proposed that storage of several days worth of compressed air up to 650 pounds per square inch can be used to push the aquifer up closer to the container dome and thus initiate piston action by simply compressing air more and more. More energy can be put into it by pressure increase or pushing back the water in the aquifer. This storage system concept has reheat flexibility and lowest cost effectiveness.
G. G.

The Grand Coulee Pumping-Generating Plant is the primary source of water for the vast Columbia Basin Irrigation Project. Two new units will be installed to serve dual purposes of irrigation pumping and pumping storage generation. This project is part of the plans of the United States Bureau of Reclamation for integrating the two new pumping generating units into the ultimate 45 hydroelectric unit complex at Grand Coulee Dam. (3 refs.)

The Seneca pumped storage plant has been in commercial service since 14 Jan. 1970. Synchronous starting of large reversible generator/motors by means of a small generator has proved to be highly reliable and the overall efficiency of the station ranges from 71 to 79 percent. Design modifications made since start-up are described. (4 refs.)

The Ludington pumped storage project, when completed at the end of 1973, will have a 1,872-Mw installed capacity. The upper reservoir with 53,000 acre-ft usable vessel is formed by a 6-mile long earth-fill dam with a sandwich type asphalt facing. The six penstocks are encased in concrete, under the embankment, and buried in silty sand on the slope. At the intake structure the gates are suspended by boles that allow for fast emergency closure. A prestressed, precast, concrete baffle wall serves as vortex suppressor and ice barrier. The intake apron, with splitter walls in an energy dissipator for the pumped water energy. The powerhouse, constructed on clay, is protected by a breakwater and two jetties. The 6-312-Mw units are remotely operated and are started in pumping by the synchronous back-to-back method and pony motor. (auth)

HIDDEN VIEW OF PUMPED STORAGE. Energy Int.; 10: No. 11, 44-45 (Nov 1973)
The Ludington, Michigan Pumped Storage Project will be the largest facility of its kind in the world. The large man-made reservoir will serve as a 1872 megawatt peaking plant for the production of electrical power. At low demand periods, electrical power supplied by conventional or nuclear plants will pump water from Lake Michigan through large diameter steel penstock to storage in the reservoir. At peak demand periods, the reservoir water will be released down the penstocks to the powerhouse turbines to produce electricity. The production parameters and assembly of the project are described. The penstocks are buried. (MCW)
Recent experience at Cabin Creek pumped-storage hydroelectric project. F. W. Fastow (Public Service Co., Colorado, Denver, USA). Proceedings of the American Power Conference. Vol. 35, Chicago, Ill., USA, 8–10 May 1973 (Chicago, Ill., USA: Illinois Inst. Technol., 1973), p. 971–9. The Cabin Creek Pumped Storage Hydroelectric Project is located 35 miles west of Denver, high in the Rocky Mountains. Major features include the lower dam and reservoir, powerhouse, and switchyard at an elevation of 10,000 feet in the South Clear Creek Valley, the upper dam and reservoir in a narrow glacial valley just above the powerhouse at an elevation of 11,200 feet, and the power tunnel connecting the upper reservoir and powerhouse. (no refs.)

ELECTRICAL EQUIPMENT FOR THE VILLARINO PUMPED STORAGE. Pantel, W. Brown Bovery Res.; 60: No. 5, 196–204 (May 1973). Pumped storage schemes form an ideal complement for thermal power stations. On the one hand they cover peak loads and, on the other, contribute towards economical utilisation of excess energy during the night and at weekends. The electrical equipment supplied by Brown Bovery for the Villarino pumped storage scheme, the largest plant in Spain and one of the largest in Europe with reversible pump turbines is described. (auth)


ENVIRONMENTAL DESIGN OF BEAR SWAMP PROJECT. Kwiatkowski, R. W. (Charles T. Main, Inc., Boston); Pierce, L. D. J. Power Div., Amer. Soc. Civil Eng.; 99: No. POI, 205–215 (May 1973). The civil engineering design of the Bear Swamp pumped storage hydroelectric project required cognizance of the effect upon environment along each stage of the major design decisions. Final configurations and treatment of reservoir slopes, borrow areas, surface features and recreational facilities took into account the impact of cost as well as potential detrimental effect upon both the immediate and the areal vicinity. After a brief project description, selection of the underground powerhouse is explained followed by a description of the considerations behind the location and procedure for the exploratory adit. Details aimed at preventing any future oil contamination of the reservoir by transformer accident are illustrated. The exterior architectural treatment of the two small power plants, which are integral parts of the project, is related to the environment from the standpoint of blending into the surroundings. Finally, the effect upon the Deerfield River and construction limitations are touched upon. (auth)


House of Commons reported favourably on the Central Electricity Generating Board's proposal for a massive hydroelectric pump storage project in the heart of Snowdonia. This article critically surveys the economic basis of the scheme.


The four 400-MW reversible pump/turbines ordered for the Tennessee Valley Authority's Raccoon Mountain pumped-storage project are the largest machines of their type ever built. The design and fabrication techniques used are described. (LCL)
OPTIMAL PUMPED STORAGE OPERATIONS WITH INTERCONNECTED POWER SYSTEMS.
M.J. Cobian.

Abstract—This paper deals with the problem of obtaining the optimal scheduling of a pumped storage hydroelectric plant in combination with several interconnected power systems. A special case of interest is the scheduling of pumped storage when the plant is jointly owned by several electric utilities. A mathematical model is developed in order to determine the power flows between the different power systems and the pumped storage plant as well as the water flows inside the plant.

A new formulation of this problem is presented which is able to account for changes in the operating characteristics of a pumped storage plant due to significant variations in the head and operating efficiencies of the plant. The mathematical model proposed is essentially a state-bounded nonlinear optimal control problem with a plant capable of operating in a dual mode, namely, pumping and generation. The model developed is primarily an operational one although it can also be used for planning purposes to analyze the behavior of a pumped storage plant under different operating conditions and to predict the corresponding savings due to pumped storage operation.

SUBSURFACE PUMPED STORAGE AND ENVIRONMENT.
R.L. Loofbourou.
CORPORATE AUTHOR: Multipurpose Excavation Group

TITLE: Pumped Storage Development and Its Environmental Effects
AUTHOR: Karjala, G.M. (Ed.); Krizek, R.J. (Ed.); Csatray, S.C. (Ed.)
CORPORATE AUTHOR: American Water Resources Association
PUBLICATION DATE: 1971
LAKE DELIÒ PUMPED-STORAGE HYDROELECTRIC PLANT AND POWER PRODUCTION IN ITALY.
G. Baroncini.

Abstract—After indicating the importance of the role played by pumped-storage hydroelectric plants in Italian power production the author discusses ENEL’s construction program relating to this type of plant.

Detailed reference is made to the Lake Delio pumped-storage hydroelectric plant, now at an advanced stage of construction; in terms of capacity (1,000 MW for generation, 760 MW for pumping) it will be the largest hydroelectric plant in Italy.

PUMPED STORAGE AT OROVILLE—DESIGN AND INITIAL OPERATION.
G.F. Wachter.

Pumped storage equipment has played a significant role in the storage and distribution of water at Oroville. This paper describes the mechanical design features of the pump/turbines installed in the Edward Hyatt Power Plant, and the many tests performed during design and startup to achieve water delivery requirements. The experiences gained from this installation should stimulate the further development of pumped storage by utilities and consulting engineers.

ENERGY REGULATION IN LARGE POWER SYSTEMS BY PUMPING STATIONS.
A.M. Angelini.

Having set forth general information on Italy’s power system, the paper discusses the reasons why a considerable expansion of pumping stations is anticipated in this country. With reference to some of the hydroelectric pumped-storage stations existing or under construction in Italy, a few considerations are made concerning the characteristics which such stations can assume with respect to hourly, daily, weekly and seasonal regulation, integration and reserve.

TITLE: Combined Hydroelectric Pumped Storage and Nuclear Power Generation
AUTHOR: Sumekind, H.; Raseman, C.J.
CORPORATE AUTHOR: Brookhaven National Laboratory
PUBLICATION DESCRIPTION: BNL 50238 (T-579), 83 p.
PUBLICATION DATE: 1970, April

TITLE: Dynamic Programming Approach for Determining the Optimal Dispatching Sequence for a Combined Hydro-thermal-pumped-storage Utility System
AUTHOR: Joy, D.S.
CORPORATE AUTHOR: Oak Ridge National Laboratory
PUBLICATION DESCRIPTION: ORNL-4524, 34 p.
PUBLICATION DATE: 1970, November

TITLE: Electrical Design Aspects of Muddy Run Pumped Storage Plant.
J.J. Ferencsik.

Abstract—A general description is given of the physical plant and electrical system and a rather detailed description of the automatic controls of the Muddy Run pumped storage hydro plant. Conventional controls are used for generating and spin modes and modifications to these controls are made for the pumping mode. In pump mode operation the generator—motors (G-M) are started as induction motors on half voltage and are transferred to full voltage after synchronizing. The design includes remote automatic operation utilizing conventional supervisory control equipment over microwave channels. A digital computer is used to economically load the eight G-Ms.
AN INVESTIGATION OF PUMPED STORAGE SCHEDULING.

C.D. Galloway.

Abstract—This paper describes how a digital computer program intended for system planning studies was used to investigate several questions related to pumped storage planning and operation. Among the items investigated were reservoir size, the influence of cycle efficiency on pumped storage capacity factor and operating cost, and the effect of load forecasting deviations on system economy. A brief description of the program is provided.

A COMPUTER PROGRAM FOR DETERMINING THE ECONOMIC SIZE OF DEVELOPMENT OF PUMPED-STORAGE HYDRO SITES.

M. Schneck and C.W. Watchorn.
IEEE Trans Power Apparatus and Systems, v.PAS-85, no.11, Nov.1966, p.1154-

Abstract—This is a companion paper to an earlier one. The computer program described is divided into three parts: a) the determination of the coefficients for (1), (2), and (4) of Watchorn for the best fit to the calculated cost and plant pumping ratio data, b) the determination of the lowest average unit investment cost, and other pertinent information, to be shown later, for each of the potential sites for various conditions, and c) the arrangement of the results of part b in the order of preference. All the programs are written in Fortran for the 7074 computer.
DISPATCHING PUMPED STORAGE HYDRO.
G.H. McDaniel.

Abstract—While the economic factors associated with the planning and design of a pumped storage hydro project must include system operation concepts, the day to day operation of a given pumped hydro project presents a different set of economic decisions. In this connection, the array of data or information that must be presented to the dispatcher is, of necessity, different in form from that presented to the planner. Therefore, the scope of discussion is limited to the problem of day to day and minute to minute scheduling and dispatching pumped storage hydro in combination with steam generating capacity in an optimum manner. The example used for discussion is the Smith Mountain pumped storage project.

SOME GENERAL BASIC PLANNING CHARACTERISTICS OF PUMPED-STOREAGE HYDRO CAPACITY.
C.W. Watchorn.
IEEE Trans Power Apparatus & Systems, v.PAS-84, June 1965, p.464-

Abstract: This paper first discusses the effect of limited energy hydro capacity, including pump-storage hydro capacity, on system installed capacity requirements, showing that, for a combined thermal and hydro system, the capacity value of the hydro depends primarily on the reduction in the maximum thermal generation requirements that can be effected over the heavier daily peak load hours. Such determinations are inseparable from the load characteristics and the effect of prior installed limited energy capacity. Second, a mathematical basis is presented for the evaluation of the relative economics of alternative potential pump-storage sites based on operating requirements, and for the determination of the most economical size of development for various conditions.

HYDROTHERMAL DISPATCH WITH PUMPED STORAGE.
E.S. Bainbridge, et al.

Abstract—A method is presented for optimizing the weekly or daily dispatch of a power system consisting of 16 hydro plants, 4 thermal plants, and a pumped storage plant. The main features of the method are: treatment of hydro plants in cascade on a river and its tributaries with freedom for heads to vary at each plant; allowances for hydro units out of service; optimum thermal unit scheduling, including the effect of start-up costs; maintenance of a minimum spinning reserve requirement in each interval in the scheduling period; inclusion of speed-no-load losses and head variation effects in scheduling pumped storage units. The optimization techniques and salient features of a computer program using these techniques are presented, together with numerical schedules from a pilot study based on a system model.

A METHOD FOR ECONOMIC SCHEDULING OF A COMBINED PUMPED HYDRO AND STEAM GENERATING SYSTEM.
B.J. Bernard, et al.

Summary: This paper describes a method for the optimum scheduling of pumped storage hydro in combination with a steam generating system. It also describes a computer program which determines weekly operating schedules for a pumped hydro station. The techniques developed can be used to evaluate future peaking capacity of this type and to estimate long-term operating costs for different combinations of steam and pumped storage capacity.
THE PRESENT STATE OF PUMPED STORAGE IN EUROPE.
H.K. Happoldt, et al.
1963, p.618-

Summary: Pumped storage in Europe dates back to the late 19th Century with strong upsurges in the 1930's and 1950's. It is used for various purposes, the extremes of which are seasonal storage and peaking. The paper lists all major pumping stations with complete engineering data, discusses the various possible arrangements of the machinery, the types of pumps and turbines available today, and the coupling and shaft arrangements. A few typical storage and peaking operations are described in some detail. After a short review of the economic aspects, a separate chapter is devoted to reversible pump-turbine units.


FLYWHEELS.
R.F. Post and S.F. Post.

New designs could be used for the storage of energy in electric power systems.

THE SUPER FLYWHEEL: A SECOND LOOK, E.J. Brunelle

NEW UNINTERRUPTIBLE POWER SYSTEM ALTERNATIVES USING HIGH CAPACITY KINETIC ENERGY WHEELS. The application of recent military/aerospace technological advances in kinetic energy wheel design to the field of Uninterruptible Power Systems (UPS) provides new system alternatives which overcome the limitations of previous UPS configurations (both of the inverter-battery and rotating, no-break types). These improvements result from the availability of practical flywheels with energy storage capacities at least ten times greater than those previously applied to UPS. The high capacity kinetic energy storage in conjunction with improved control systems can provide true, no-break systems in which the characteristic frequency droop of flywheel UPS sets is minimized. The new on-line UPS incorporating a kinetic energy wheel, in addition to providing a full-rated UPS capability, offers the advantages of continuous power factor correction, transient suppression, and nearly instantaneous peaking capability.


THE REVOLUTION IN FLYWHEELS.

Richard T. Dann, Assistant Ed.


ROTATING FLYWHEEL STUDIED FOR URBAN TRANSIT USE.


p. 46.
BUILDING THE WIND-UP TUBE TRAIN.

Uses energy stored in a flywheel.

ENERGY STORAGE OF SUPER FLYWHEELS.
N.V. Gulia and L.D. Lunkin.
Russ. Eng. Jour., USSR, v.52, no.12, 1972, p.3-

THE APPLICABILITY OF GOOD TECHNOLOGY TO KINETIC
ENERGY STORAGE. (Superflywheels)
AP. Technical Digest May-June 1972, 2-12.
THE WINDUP CAR.

K. Hohenemser and J. McCaul.


For the long range, an alternative to the fume-spewing internal combustion engine is needed. The superflywheel is a simple and promising candidate. A spinning flywheel would be "wound up" at night by electric power, and would run a bus, or even a car, all day, silently and completely without air pollution.

A73-25979


A unique flywheel configuration is described which provides a new level of applicability for present and future anisotropic materials, including whisker materials. An energy storage capability of 30 watt-hours per pound of flywheel weight should be readily available, while performance in excess of this value is predicted for the future. Some additional improvements described include (1) a magnetic fluid hermetic seal that makes it possible to locate bearings and other equipment outside the vacuum can for lower drag and better lubrication, and (2) a new magnetic fluid bearing. T.M.
Determining Inertia and Time Requirements for Flywheel Machines. M.T. SPOTTS. Machine Design v 35 n 9 Mar 26 1963 p 148-51. Dynamical analysis of flywheel machine so that various requirements of load cycles can be met; analysis takes into account fact that torque of induction motors by which such machines are usually driven, increases as speed decreases.

Testing Magneto Flywheels at Speeds up to 25,000 r.p.m. MACH (Lond) v 103 n 2645 July 24 1963 p 184-5. Tests in question were necessary to assure that flywheel which is in form of aluminum alloy pressure die casting, with permanent magnets, poles and steel center cast in position, would not disintegrate at any speed at which Villiers Starmaker 250-cc motor cycle engine for "scramblers" and short circuit racing is likely to be run. Description of high speed testing machine which is designed to stop automatically when burning or excessive distortion of flywheel occurs and speed is recorded.

Short-term Flywheel APU is Light and Simple. N.M. FRIKTOV, J.J. VENTURA. Space/Aeronautics v 35 n 6 June 1961 p 59-61. Advantages of power supply systems based on principle of storing energy in flywheel; analysis of flywheel auxiliary power unit as hydraulic power source for operation of missile vernier controls after sustainer burnout; 2 design variants could be used, one with separate hydraulic pump and motor and one with combination motor pump. In both cases motor is powered by hydraulic supply of main stage to spin up flywheel which later drives pump to provide power for verniers.
SUPERCONDUCTIVITY: LARGE-SCALE APPLICATIONS.
R.A. Hein.

This article is an overview of areas involving large-scale applications of superconductivity for which the 1970's are a decade of critical decision. Applications to superconducting solenoids, high-energy physics, electric power transmission, rotating electrical machinery, energy storage and transfer, superconducting magnets for superfast trains.

Energy and Superconductivity.
National Bureau of Standards, Boulder, Colo. Cryogenic Data Center. 20 Mar 74. 36p B-1153
COM-74-10719/7WE PC$7.00/MFS7.00
Contents: Generators, motors, transmission lines, transformers, thermonuclear fusion, MHD, magnets, miscellaneous applications, refrigeration, patents, and reviews.

N74-15430 Wisconsin Univ, Madison.
SUPERCONDUCTIVE ENERGY STORAGE INDUCTORS FOR POWER SYSTEMS Ph.D. Thesis
Narendra Mohan 1973 111 p
Avail. Univ. Microfilms Order No. 73-20286
Large toroidal magnets with superconductive windings could serve to perform a system function equivalent to hydro pumped storage. In sizes greater than 1,000 MW-hrs, preliminary economic studies have shown some promise. It is demonstrated by means of computer simulation that the power flow through the energy storage inductor can be reversed within a few cycles using a conventional Graetz converter bridge with an appropriate control. A system with interconnected stream-electric areas is simulated on the hybrid computer. The system performance, with and without the energy storage device, is studied in response to the random load changes. The deviation of area frequency from the normal and the change in tie line power flow are used as error signals for controlling the energy storage inductors.
Dissert. Abstr.

N74-31878f Kenner (Los) Associates, Redwood City, Calif.
Superconducting energy storage is surveyed with regard to advantages, problems and applications. Advantages are large capacity and discharge rate, and relatively high energy density. Problems are optimization of coil form, discharge, development of a suitable superconducting switch, and minimization of alternating-current losses in order to maintain superconduction during discharge. Some proposed solutions are outlined. Envisioned applications include pinch experiments in plasma physics directed toward a pulsed fusion reactor, and power supply for lasers.

The capital costs of superconducting magnetic energy storage systems are calculated for various geometries, sizes, and support configurations. These are used as a basis for calculating, for a variety of operating conditions, the cost of delivered energy, which forms the basis of a comparison with other load-leveling systems. For certain configurations and operating conditions, superconducting magnetic energy storage is shown to be competitive with other load-leveling systems. (auth)

Author
N74-116878 Avco-Everett Research Lab., Everett, Mass.
DEVELOPMENT OF A PULSED HIGH-ENERGY INDUCTIVE
 refs (Contract F33615-71-C-1455; AF Pro. 3145)
 (AD-766518; AFAPL-TR-73-49) Avail. NTIS CSCL 09/1
The work was concerned with the complete investigation
and feasibility demonstration of superconducting inductive energy
storage systems capable of producing high power pulses in the
200 microseconds range on a repetitive basis. The system studied
was a 100 kJ system. A 15 kJ model system was successfully
tested. Also, as part of the program, a complete investigation
of switches appropriate for short pulse inductive energy storage
 systems was made. The investigation led to the preliminary
development of a multiple contact high speed switch which
was successfully tested in model size. (Modified author ab-
stract)

N74-193759 Los Alamos Scientific Lab., N.Mex.
DESIGN OPTIONS AND TRADEOFFS IN SUPERCONDUCT-
ING MAGNETIC ENERGY STORAGE WITH IRREVERSIBLE
SWITCHING
H. L. Laquer, J. D. G. Lindsay, E. M. Little, J. D. Rogers, and
D. M. Weldon 1973 21 p refs Presented at Symp. on
Technol. of Controlled Thermonucl. Fusion Expt. and the Eng.
Aspects of Fusion Reactors, Austin, Tex., 20 Nov. 1973 Sponsored
by AEC (LA-UR-73-910; Conf-731102-1) Avail. NTIS HC $3.25
A program is presently underway at Los Alamos to
determine how superconducting magnetic energy storage in
conjunction with normal-going superconducting switches can be
made to deliver the energies of the order of 200 MJ that will
be needed for plasma compression in a pulsed theta-pinch
scientific feasibility experiment. After a review of the circuit
configurations, the properties of commercially available and of
some developmental superconductors relevant to both the energy
storage coil and to the switch are discussed. Critical current
densities at low fields and stability requirements both with respect
to rapidly changing external fields and to self fields are of particular
importance in determining optimum operating fields and tempera-
tures. The tradeoff between eddy current losses in the stabilizing
material and the need for coil protection if a coil normalcy should
occur is described. Problems in potting or other forms of
mechanical stabilization for both superconducting elements are
pointed out. (Author (NSA)

N74-260645 Magnetic Corp. of America, Waltham, Mass.
DEVELOPMENT OF PULSED HIGH ENERGY INDUCTIVE
ENERGY STORAGE SYSTEMS. VOLUME 3: WEIG1
OPTIMIZATION FOR ENERGY STORAGE, COIL, CRYOGEN
Edward J. Lucas, William F. B. Puchard, and Richard J. Thome
Wright-Patterson AFB, Ohio. AFAPL Dec. 1972 109 p
(Contract F33615-71-C-1454; AF Pro. 3145)
(AI-755360; AFAPL-TR-72-38-Vol-3) Avail. NTSI CSCL
10/2
The report provides weight estimates for possible configurations
which may be used in one of these subsystems, that which is
devoted to energy storage. For the purposes of this study, it
will be assumed that the energy storage subsystem consists of
three components: (1) the cryogenic coils, (2) the cryogen and
(3) the dewar. The limits of the subsystem are the electrical
terminals entering and leaving the dewar. All other components
are assumed to be located in other subsystems. The method
of determining the weights of the components of the subsystem
will be discussed, followed by a discussion of the manner in
which subsystems were optimized. The section closes with tables
giving characteristics of weight optimized systems for a range
of energy, pulse length, total pulses, wire diameter, and copper
to superconductor ratio.

N72-266569 Deutsche Forschungs- und Versuchsanstalt fuer
Lufth. und Raumfahrt, Stuttgart (West Germany). Inst. fuer
Energieverwaltung und Elektrische Antriebe.
ENERGY STORAGE IN SUPERCONDUCTING COILS
C. Carpenis 6 Mar. 1972 59 p refs In GERMAN; ENGLISH
summary (DLR FB-72-10) Avail. NTIS HC $5.00; DFVLR Porz-Wahn:
20, DM
The storage of energy in superconducting coils and the
capital costs of such a practice are discussed. The field intensity
in the coil, the current density of the superconductor, and a
characteristic dimension of the coil are related to the geometry
of coil and the energy stored in it. Such data allows optimization
of the coil with respect to its specific mass. A comparison of the
superconducting coil with other energy storage systems revealed
that the superconducting systems are characterized by relatively
low specific mass and low capital costs, especially where high
discharge power is required.
RESEARCH ON CRYOGENICS AND INDUCTIVE ENERGY STORAGE AT THE DFVLR c23
C. Carpentia In AGARD Energy for Aircraft Auxiliary Power systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)
The use of superconducting coils for energy storage is discussed. The objective was to find the optimizing parameters and to define the problems which involve the technical use of inductive energy storage. It was determined that: (1) the geometry of the coils is essential for optimal performance, (2) high critical current density rather than high critical field is important for optimal devices, and (3) the mass of the superconductor may be small as compared with the needed structural mass. The development of cryogenically cooled devices, particularly in the presence of time varying fields, is reported. Author

NONRADIATING SUPERCONDUCTING COILS FOR ENERGY STORAGE c23
M. Gayte, B. Girard, and A. Malandain In AGARD Energy for Aircraft Auxiliary Power Systems Feb. 1972 6 p refs (For availability see N73-19030 10-03)
The characteristics of superconducting coils as energy storage elements are investigated together with the main problems affecting their design: electromagnetic forces, energy radiation and discharge losses.

HD 9540.4 I 5 1973
The large capital expense of central power stations, such as coal-fired power plants, has led to the consideration of various types of energy storage for peak power shaving. Superconducting inductors with energy storage capacities of 10^3 to 10^6 J (the equivalent of 46 to 460 MW for a 3-h period) are discussed as advanced energy storage system. Possible inductor configurations and their relative advantages are described. Preliminary estimates of capital and operating costs are given. (auth)

This paper deals with the problems associated with superconducting field windings. The basic requirements for the field are discussed in terms of size, magnetic energy stored, power level, speed of rotation, number of poles. While the field winding is basically dc in nature, it is exposed to time varying magnetic fields and forces due to the armature currents generated by loading transients, faults, unbalanced electrical loads, as well as load generated harmonics. The effect of these on the design of the field as well as on the performance of the superconductor is discussed. (Author)

A review is given of the design specifications for a 100,000 Joule system and the test results obtained on two model coils having energy storage capabilities of 500 Joules each. The energy storage coils that are being considered must be charged in a fraction of a second and discharged in a fraction of a millisecond. The losses are calculated on two models. Both assume that the coil remains superconducting during the charge period. However, on discharge one model assumes that the coil goes normal and one that it remains superconducting. In both models the losses during the charge period are considered to be the superconductor magnetization losses and eddy current losses in the normal substrate. (Author)

N73-12816f Los Alamos Scientific Lab., N.Mex.
SUPERCONDUCTING MAGNETIC ENERGY STORAGE AND TRANSFER are also A73-11830
H. L. Laquer and J. D. Lindsay 1972 7 p refs Presented at Appl. Superconductivity Meeting. Annapolis, 1 May 1972 Sponsored by AEC
(LA-DC-72-470; Conf-720513-2) Avail: NTIS
Model experiments show that energy transfer at millisecond times from a superconducting storage coil into resistive loads can be achieved with a normal-going superconducting switch. It is planned to extend these studies to 300-KJ and 6-MJ systems, as well as to transformer-coupled inductive loads
Author (NSA)
ENERGY STORAGE CAPABILITIES OF SUPERCONDUCTORS IN VIEW OF HIGH POWER DISCHARGE [STOCKAGE D'ENERGIE POSSIBILITES DES SUPRACONDUCTEURS EN VUE DES DECHARGES DE GRAND PUISANCES]
(Contract NASW-2038)
(NASA-TT-F-13585; CEA-R-3243) Avail: NTIS CSCIL 10C
The energy storage capabilities of superconductors and the associated energy release at high power is discussed. A parallel and comparison is drawn between existing energy storage mechanisms (condensers, rotating machines, reactors, batteries, explosives) and the so called superconductors as seen from French experimental results. Direct comparisons are drawn by using material evaluations, performance equations and cost price ratios. Author

N71-26688* National Aeronautics and Space Administration, Washington, D.C.
THE USE OF SUPERCONDUCTORS FOR STORAGE AND DISCHARGE OF ELECTRICAL ENERGY [L'UTILISATION DES SUPRACONDUCTEURS POUR LE STOCKAGE ET LA DECHARGE DE L'ENERGIE ELECTRIQUE]
(NASA-TT-F-13559; CEA-R-3515) Avail: NTIS CSCIL 20L
The principle of storage and liberation of energy is presented in its elementary form. A more detailed analysis of the successive charging, trapping, storage, and discharge operations shows up the different aspects of the problem, and is followed by a review of the research published so far on this subject. The use of superconductors for application to the storage and discharge of electrical energy is proposed. E.M.C.

N71-19041 Commissariat a l'Énergie Atomique, Saclay (France).
ENERGY STORAGE AND DISCHARGE BY SUPERCONDUCTORS [STOCKAGE ET DECHARGE D'ENERGIE AU MOYEN DU SUPRACONDUCTEURS]
C 28 P. Genevé, G. Prust, J. Soé, and B. Girard In AGARD Energistics for Aircraft Auxiliary Power Systems Jan. 1971 8 p refs In FRENCH (For availability see N73-19030 10-02)
An examination of the principles of electric energy storage and discharge, a detailed analysis was made of load operations, trapping, and different problems raised about storage and discharge. The effects of load operation on the utilization of high flux pumping and the discharge that is released by means of rapid transition superconductor commutators are also analyzed. Experimental results are included. Translated by E.H.W.

DISCHARGE OF A SUPERCONDUCTING ACCUMULATOR INTO AN INVERTED CONVERTER
(LPSE-54685) Avail: NTIS
The use of superconducting inductive energy accumulators as standby electrical energy sources, as energy sources for load leveling in power systems, and as sources for powerful electrical pulses is discussed. An inverted converter is proposed as a means of transferring the superconducting accumulator's energy into an electrical system. J.G.M.

ENERGY STORAGE AND SWITCHING WITH SUPERCONDUCTORS
(LA-DC-12980) Avail: NTIS
Inductive magnetic energy storage with superconductors or superconducting aluminum conductors is discussed in regard to its use in providing the magnetic fields needed in pulsed thermonuclear reactors, and in some large-scale pulsed plasma physics experiments designed to demonstrate the scientific feasibility of controlled fusion. NSA

STUDY AND CONSTRUCTION OF AN ENERGY-STORING SUPERCONDUCTING COIL
Prepared for Los Alamos Scientific Lab.
(LA-TR-70-11) Avail: NTIS
A superconducting coil used to store energy and restore it in about one millisecond is described. Specially studied is the problem of current interruption. The coil was made from Nb-Ti stranded cable stabilized with pure aluminum. Its maximum energy content is approximately equal to 20 kJ and it is closely coupled with an aluminum ribbon coil that takes the place of the secondary coil of a non-iron transformer. The current is rapidly discharged by opening the circuit via a vacuum switch using an artificial zero-current injection system. This switch can break 1,000 A, without failure, with overvoltages of 4000 or 5000 V. It is capable of withstanding even higher voltages. The switching time is only a few microseconds. The stabilized superconducting coil withstood many charge rates of a few tenths of seconds duration and discharge rates of 3 or 4 milliseconds. Transfer energy rating is about 66% At the moment, a part of the coil energy is being lost through induced currents being dissipated through the metal walls of the cryostat. Author (NSA)
ENERGY STORAGE IN A SUPERCONDUCTING WINDING
(STOCKAGE D'ENERGIE DANS UN ENROUEMENT SUPRACONDUCTEUR)

Sponsored in part by AEC Prepared for Los Alamos Scientific Lab. (LA-tr-70-9) Avail. NTIS

The problems of energy storage on the scale of the fluctuations of the national or regional load, i.e., of the order of 1,000 MWh are examined. Various configurations are reviewed, and the short solenoid of circular cross section is selected as being economically the most favorable. The field produced and the distribution of the mechanical constraints are discussed for this configuration. An examination of the various losses (at the surface of the cryostat, by mechanical or magnetic hysteresis) shows that they are acceptable. The circulation of the cryogenic fluid is discussed in detail, and it is shown that the ratio of stabilizing material to superconducting material can be reduced to 10:1. Finally, the modes of connecting the storage device to the grid are examined and there is a discussion of the optimum size of the installation as a function of the financial benefits that can be attributed to the different services provided by the device.  

Author (NSA)

The principal accomplishments reported include technical improvements to the intermediate voltage cryostat, improvements to the test procedure, and the achievement of more reliable breakdown values of liquid helium at atmospheric pressure obtained with gap widths between 0.25 and 3.0 mm. A change of location ramp rates between 0.08 kV/sec and 1.0 kV/sec showed no significant influence on the breakdown values. Due to improvements in the cryostat design, only slow boiling was observed in the helium. Consequently, appropriate statistical evaluation of the breakdown values (considering the relatively small numbers, 12 to 100, obtained with each gap width) showed that the new measurements agree well with measurements of other investigators with externally refrigerated nonboiling helium and are significantly higher than published breakdown values for boiling helium. The experiments were performed with the intermediate voltage cryostat. Several subassemblies of the high-voltage cryostat have been completed. (auth)


An investigation of the dielectric properties of fluids and solids for use in superconducting systems is underway at the Oak Ridge National Laboratory as part of the AEC program in superconducting power transmission. The investigation initially will encompass ac and dc breakdowns and pre-breakdown phenomena in liquid helium and in a variety of solids in liquid helium. Extension to impulse measurements is expected in the near future. A prime objective of the investigation is to determine scaling laws applicable to various models of superconducting cables and other cryogenic apparatus. The experiments are being devised with this objective in mind. Experimental facilities have been set up for ac testing with a series resonant transformer to 700 kV rms and for dc testing to 600 kV. A high-voltage cryostat has been designed for service to 1000 kV with provision for optical as well as electrical recording of both breakdown and pre-breakdown phenomena. Other apparatus for testing to lower voltages is also available. Instrumentation for partial discharge measurements by multichannel pulse height analysis, high-speed oscilloscope, and bridge detection are available. The influence of electrode surfaces and impurities as well as pressure and temperature on the dielectric properties of liquid helium will be determined. The behavior at large gaps is of particular interest. Breakdown and surface flashover of bulk and laminated solids in liquid helium and in vacuum at liquid helium temperatures are to be included in the investigations. (auth)

Energy and Superconductivity.
National Bureau of Standards, Boulder, Colo. Cryogenic Data Center. 20 Mar 74, 36p B-1153
COM-74-10713/TWE PCS7.00/MFS7.00

Contents: Generators, motors, transmission lines, transformers, thermonuclear fusion, MHD, magnets, miscellaneous applications, refrigeration, patents, and reviews.

UHV OR HVDC. That is the Question. Jeffs, E.; Codling, N. Energy Int.; 11: No. 1, 9-12(Jan 1974).

The merits of hvdc and uhv ac transmission systems were discussed at an international conference of Electrical Engineers in London, Nov. 1973. Environmental aspects are discussed in relation to increased power-transmission ratings. Within the next decades, power generation will be concentrated in huge blocks of power between 10 to 20 GW in size, and transmission rights-of-way will be restricted. What the transformer has done for an distribution the solid state rectifier might do for dc transmission. The stability criterion on an interconnected system, the use of shunt capacitors and series reactors, the possibilities of superconducting cables, and hvdc are discussed. Economic aspects of future power transmission systems are outlined.

(MCW)


A Nb3Sn superconductor has been fabricated in rods and tapes by the interaction of the tin contained in a copper-tin alloy with niobium which had been in contact with the alloy material. This conductor has lower alternating-current (60 hertz) losses than any presently available commercial products. (Author)
Los Alamos Scientific Lab., N. Mex. Apr 74, 20p
LA-5581-PR   PCS4.00/MFS1.45

Short sample critical current tests of multiple Nb3Sn commercial tapes arranged on a copper support tube are reported; at 4 K nearly 30,000 A has been carried by one sample. Critical current testing of short samples in the liquid hydrogen temperature range, 17.9 to 20 K, has been initiated and some results are given. The 20-m test bed has been successfully operated at 4000 A with a liquid helium cooled NbTi superconductor. Preliminary considerations for some new small diameter line configuration concepts are presented.

SUPERCONDUCTIVITY: LARGE-SCALE APPLICATIONS.
R.A. Hain.

This article is an overview of areas involving large-scale applications of superconductivity for which the 1970's are a decade of critical decision. Applications to superconducting solenoids, high-energy physics, electric power transmission, rotating electrical machinery, energy storage and transfer, and superconducting magnets for superfast trains.


From winter power meeting; New York, New York, USA (27 Jan 1974).
The Los Alamos Scientific Laboratory has recently initiated a program to study the technical and economic feasibility of a dc superconducting power transmission line. As part of the program, a large sample testing apparatus has been constructed consisting of a test bed that is approximately 10 m long and on hold a 20 m sample in a race track arrangement; high current potentiodes that go from room temperature to cryogenic temperature; and a high current source. The test bed and associated apparatus and a summary of the test procedures to be used are described. (auth)
N74 - 19378#


The aims of the SPTL project include demonstration that incorporation of dc superconducting transmission lines into the present US electrical utility power system is not only feasible but would lead to capital and operating economies compared with either conventional cable systems or superconducting ac lines, wherever large blocks of power are to be transmitted over long distances. The impact on the environment is minimal for the demonstration model is a line 1000 km long capable of carrying 5 GW of power, the type useful for carrying power from the Four Corners production complex to large urban areas in Phoenix, San Diego, or Los Angeles. The experiment includes data on superconducting samples, critical current measurements, test bed parameters, and power engineering studies. Experimental progress and planning are reported. (MCW)


Five year A and D program objectives in transportation and distribution are: (1) continue development of increased-capacity ac and dc overhead power transmission systems by doubling the present capacity by 1985, and achieving a multiplication of 4 to 10 times by the year 2000; (2) to continue the development of reliable and lower-cost underground transmission systems capable of matching future overhead systems in both power capacity and voltage; (3) to develop advanced methods and equipment for systems security and control that will improve reliability and efficiency of generation, transmission, and distribution; and (4) to analyze electrical energy transmission system development in order to identify the more desirable growth options and to pursue fundamental investigations that have potential for long-term (beyond 2000 AD) applications. Five-year objectives in the area of energy storage are: (1) to support completion of bench models of Na/S and Li/S batteries; (2) to complete a 10-MWh pilot model of an advanced battery; (3) to continue development of Zn/Cl2 battery development and support fundamental research in electrochemistry; to provide engineering development of superconducting energy storage magnets and flywheels; and to provide for economic assessment of batteries and other storage systems. (auth)


The makeup of a superconducting three-phase ac cable with coaxial conductor pairs is described. Thermal insulation can be achieved by means of techniques already used in the construction of containers for liquids with low boiling points. Suitable superconductor materials are niobium and niobium-tin. The most effective electric insulation is achieved with a multilayer tape winding of composite metallic plastics. The cable is cooled by two separate cycles operated with liquid nitrogen and liquid helium, both under a raised pressure. Distances of 16 km between cooling stations are possible. Comparisons with other novel high-power underground transmission systems indicate that the superconducting three-phase ac cable will probably be the most economical solution for the power ratings of about 2000 MW and over. (GE)

FUTURE TRANSMISSION - UNDERGROUND
A. F. Corry and E. Kasum.

Abstract: Future transmission systems will handle larger blocks of power and a greater percentage will be installed underground. Solutions to the present limitations on operating such systems are being developed and it is anticipated that the economies of size will reduce the competitive disadvantage. It is important that continued effort be directed in this field so that the necessary systems are developed.
CONSTRUCTION AND UTILIZATION OF CRYOGENIC CABLES IN ELECTROENERGETIC SYSTEMS AND NETWORKS. Cruceru, C. Electrotehnik (Bucharest); 21: No. 12, 408-444 (Dec 1973). (In Romanian).

The building and utilization of cryogenic cables in high and very high voltage networks are presented and the constructive elements of such cables are described showing the technical and economic advantages they offer. The technical importance of cryogenic cables, some recent achievements in the world, and the prospects of their use in Romania are presented. (auth)


A two-element equivalent circuit for the surface impedance of a superconductor is considered in approximations of the frequency response of a superconducting transmission line. It is shown that the model yields good approximate agreement with more rigorous derivations applied to classical or anomalous normal conductivities, as well as to nonlocal conduction effects. (auth)

AUTHOR: Bargsten, R.L.
CORPORATE AUTHOR: Oak Ridge National Laboratory, Environmental Sciences Division
ADDRESS: P.O. Box 1, Oak Ridge, TN 37830
PUBLICATION DATE: 1973
SPONSOR: Eastern Deciduous Forest Bioso, US-IDB; National Science Foundation
ABSTRACT: Although such attention is currently being given to environmental effects in the location of new power plant construction, very little is devoted to the effects of the associated transmission lines. The sight-of-way required for most plant output far exceeds the land area of the plant itself. Careful planning of routes, using available vegetation maps, could do much to alleviate the environmental damage. (JMC)


The six articles included here relate to problems facing the developers of superconducting power transmission lines and their solution, namely: (1) theoretical and experimental investigations related to analysis of electromagnetic, thermophysical, and hydrodynamic processes that take place in power transmission lines; (2) cryogenic high-voltage insulation, basic requirements on insulation constructions, the types of cryogenic insulation, the advantages of coolant and vacuum as the basic insulation, and the scientific research program on high-voltage insulation; (3) investigation of properties of superconducting ac cable (SCC) lines that are largely determined by their transmission capacity; (4) features of heat exchange and hydrodynamics of SCC that are associated with the fact that the range of working parameters of the basic coolant of SCC is the near-critical range; (5) character of pulsation modes and conditions under which they occur in choice of working parameters of the coolant; and (6) in developing superconducting cables, the problems of measuring the parameters of SCC, automation of measurements, and control, regulation, and safety. (MCW)

1973
1973


American utilities are preparing for voltages up to 1500 kV to meet the demand for bulk energy transfer. Power transmission at the uhv is feasible and the technology for designing line, equipment, and substations for these levels is available. Aesthetically acceptable structures can be designed to minimize the impact of the line on the environment. Electrical radiation criteria, the National Electric Safety Code, switching surge flashovers, and heavy mechanical loadings will be used to optimize uhv transmission-line design parameters so as to minimize radio and television interference, ozone generation, audible noise eminission, and induced voltages on nearby structures. (MCW)

RESEARCH ON UHV TRANSMISSION NEARS COMPLETION OF SINGLE-PHASE TESTING AT 1000 TO 1500 KV. EEI (Edison Elec. Inst.) Bull.; 41: No. 4, 190-192(1973).

Bundles of 4, 6, 8, 10, and 12 conductors were tested, using a single-phase overhead test line energized by means of a single-phase bus, which includes a 1500-kV single-phase 250-Mva autotransformer, a lighting arrester, a precision SF6-insulated capacitor, and a coupling capacitor for radio-noise measurements. The test line was energized in March 1970 and was used to determine corona performance of many different bundle conductors. Audible noise, radio noise, and corona loss were measured under varying weather conditions. Two test cages were used for investigations of audible noise, radio noise, corona loss for different conductor bundle configurations, and conductor bundles for voltages up to 1500 kV. Proposals are made for line performance measurements on a three-phase basis from 1974 to 1976. (MCW)

727
A self-contained superconducting cable is under development in West Germany. Superconducting versions of both compressed gas and pipe-type cables are being investigated in the US. Basic measurements have been made of the properties of the conductor and insulating materials and of helium for cable cooling systems. Based on this information, it has been shown that superconducting ac cables possess very favorable electrical characteristics. Impedance matching to existing multiple circuit overhead installations operating between 1 to 3 times S/L should be possible. This is an attribute shared by no other underground cable technology. Performance of these cables under fault conditions is hard to predict without further experimental work. The overload characteristics will be superior to conventional cables. All cost estimates are tentative, but based on the ones that have been made ac superconducting cables may be economically attractive above 2 GVA. Superconducting dc cables appear to be a feasible extension of ac cable design, but the great distances necessary for economic optimization will probably preclude an early application unless converter costs are drastically reduced. Many technical problems have to be solved before viable superconducting cables can be presented to the system planners. The design of low cost, reliable and long-time cryostats is a formidable task. There is a dearth of information on dielectric behavior at cryogenic temperatures, particularly on a long-term degradation.


Six kinds of electrical insulators, three variations of the flow of the cooling medium, ten possibilities for the arrangement of electrical and thermal insulation, and some kinds of conductor constructions are discussed. The justification of the use of a cryocable depends on the construction of the cable, on the materials that are used, and on the cooling machinery. For economic reasons, aluminum or copper will be the preferred material for the conductors. The cooling liquid can only be liquid nitrogen. The costs take into account the capital cost of the cable, termination and fitting costs, including installation, civil engineering, cooling stations, and costs of power losses, i.e., the costs for the electrical losses in the cable and the energy costs for the cooling stations. Advantages for the justification of the development of cryocables are that the width of the cable trench related to the power rating is considerably less when compared with conventional cables; by stepwise upgrading of the installed cooling stations, the transmission capability can be adapted to the growing demand; a multiplication of the transmission capability is possible if more cooling stations are installed along the line; and even operating at the maximum continuous load, a cryocable can sustain a substantially higher short-time overload compared to a conventional cable because of its high heat capacity.


An economic comparison was made between the investigated types of a cryocable and an advanced normal-temperature-cable, i.e., an artificially cooled SF$_6$ cable. As this is done on a uniform basis, the result will surely have a high reliability. The comparison shows that the LN$_2$—vacuum—tube cable is not competitive with the advanced SF$_6$—tube cable within the whole region of power investigated. The LN$_2$—itt—conductor cable on the other hand is able to compete when power and length are high. This is especially true if it can be shown that the estimation of the fabrication costs of the conductor were too pessimistic. Experimental research on losses and fabrication problems of its conductors with high cross sections are very important and will be decisive for cryocable development. (27 figures, 35 references) (auth)


The trend towards ultrahigh voltages in the 1000 to 1500 kV range involves new technological and environmental problems. Technically, there is no difficulty in constructing lines and substations at voltages up to 1500 kV or higher, but the economic, environmental, and aesthetic parameters must be considered.

Underground cables cost 20 times more than overhead lines. Existing electrical transmission systems and future systems necessary are discussed for the UK, the European countries, and North America. (MCW)


The application of thyristor valves rather than mercury-arc valves for rectification in high-voltage dc transmission systems has increased. Schemes in service include Eel River in New Brunswick, Canada, the Gotland extension in Sweden, and the Sakuma extension in Japan. Basic circuits, design, construction, and operation problems are discussed for the use of thyristor valves in HVDC transmission. (MCW)
FLEXIBLE SUPERCONDUCTING POWER CABLES.
E.B. Forsyth, et al.
p.494—

In view of the fact that installation costs may represent up to half the investment in an underground cable system, it is desirable to develop concepts for superconducting cables which, from the beginning, promise to keep this expense to a minimum. Superconducting cable will be very light and, providing it is flexible, the cable should be capable of being pulled in long lengths. Two concepts for flexible superconducting cables are presented together with a discussion of expected performance in the system.

HVDC STATIONS FOR POWER INFEED FROM POWER STATIONS WITH GENERATOR AND STATIC CONVERTOR IN UNIT CONNECTION. Kaefer, J. Brown Boveri Rev.; 60:
No. 8, 205-211 (May 1973).
In cases where a power station feeds an HVDC station direct and exclusively, certain economic and technical advantages are presented as regards the complete system, i.e., power station and HVDC station, by dispensing with the three-phase busbar system and arranging the static converters in unit connection with the generators. The features of such an arrangement are discussed. (auth)

SUPERCONDUCTING POWER TRANSMISSION: COOL SOLUTION TO A HOT PROBLEM.
R.W. Meyerhoff.
Cryogenics & Industrial Cases, July/Aug.1973,
p.19-23.

Underground superconducting transmission holds greatest promise for mid-'80's power transmission requirements, research studies show.
EXPERIENCE WITH THE AEP 765-kV SYSTEM.

The system performance aspects of AEP's experience with its 765-kV transmission network are discussed. The first segment of this network was energized in May 1969. Since that time, a total of 770 miles of 765-kV transmission has been placed in operation. The experiences accumulated thus far with bringing segments of 765-kV transmission into service, as well as with real and reactive power flow, reactive compensation and supply, voltage control, and 765-kV equipment spare requirements are reviewed. (auth)

OPTIMAL CONTROL OF A HVDC TRANSMISSION

The modern control theory is applied to design HVDC controllers. The state regulator and tracking techniques were used to design controller feedbacks to improve system performance. Both optimal and sub-optimal controllers were designed. An "eigenvalue search" technique was also applied to determine the desired controller gain and time constant. Using various designed controllers, the dynamic performance of the system was studied on both a digital computer and a small scale simulator. Some of these time domain studies are included in addition to the root locus plots. (auth)


More dc projects will be commissioned in the future mainly due to the high value placed on the environment. Strides have been achieved in valve technology, in station size reduction, and in simplicity. The justifications for dc transmission are long distance, bulk transmission for economy; stabilizing links between pools; and high capacity underground links. A dc link can reliably mitigate ac transient disturbances that might ripple from one ac system to another. Due its nature limits growth of a system short circuit on duty, which is a bigger problem every day in densely loaded systems. Oscillating disturbances on large regional interconnections can be damped by programmed control of dc flow on a link between pools. Some new domestic applications of long-distance dc transmission are cited, namely, the Basin Electric Power Co-op of Bismarck, N. D.; Tri-State G & T Assoc. of Denver; Square Butte HVDC, the second to use solid state valves in North America; and the 1100-mile HVDC project in the Republic of Saire, central Africa. The problems facing dc breakers are for a method to drive current to zero under constant voltage, and for absorption of magnetic energy stored in the system. (MCW)


The basic equations relating to the cost and effectiveness of transmitting heat over long distances through hot-water pipelines are derived. It gives an insight into the problems associated with hot-water heat transmission. Further, it applies these equations to a 200-mile pipeline and concludes that such a system is not yet cost effective in relation to today's fossil fuel prices. (auth)

DYNAMIC STABILIZATION OF Nb3Sn TAPE SUPERCONDUCTORS

The stabilization of Nb3Sn ribbon superconductor achieved by the interleaving of high conductivity aluminum has been experimentally investigated by observing the flux jumping on a rectangular stack placed in a changing transverse magnetic field. The results show that raising the conductivity of the aluminum leads to significantly increased stability as does increasing the thickness at fixed conductivity. The first flux jump field for both cases is given for various rates of increase of the applied transverse field. The limiting value at fast rates is compared to a new theory of dynamic stabilization recently proposed by one of the authors (KK) and found to agree well for the case where the interleaved aluminum is thermally insulated from the superconductor. Agreement is not good when the aluminum is partially contributing to the thermal diffusion in an undetermined amount. (auth)
CRYOGENIC POWER CABLE: DESIGN AND TEST.
B.C. Belanger and M.J. Jeffries.
Cryogenics and Industrial Gases, Mar./Apr.1972, p.15,18-22.

Test program was designed to demonstrate feasibility of prototype cryogenic power cable.

IS 'POWER TO THE PEOPLE' GOING UNDERGROUND.
G.D. Friedlander.

A report on an important conference regarding the economic feasibility and technological progress toward the construction of underground high-voltage transmission lines.

As the U. S. moves from a fossil fuel economy toward a nuclear age, it is necessary to meet burgeoning energy demands, the problems of electricity transmission, distribution, and storage become accentuated. An alternative exists to the growing number of overhead power lines appearing around cities. Hydrogen is a synthetic fuel that could be made from water and electricity at the power stations and used as a means of underground energy transmission. It is an ideal fuel in many respects for combustion to obtain heat or for reconversion to electricity near the user. Economically, transmission of a gas is far cheaper than transmission of electric power, especially underground. This concept is not without its problems; nevertheless, it surely deserves detailed consideration in the future. (auth)

Conference on research for the electric power industry. [New York, Institute of Electrical and Electronic Engineers, 1973]

455 p. Illus. 28 cm.


SEVENTH SESSION - ENERGY TRANSFER II - UNDERGROUND TRANSMISSION SYSTEMS, p.283-326.

NEW MEANS OF TRANSMITTING ELECTRICITY: A THREE-WAY RACE. W.D. Metz.


Three new technologies for underground power transmission are being studied in addition to ways to improve the conventional overhead transmission lines.
HIGH VOLTAGE DIRECT CURRENT TRANSMISSION.
Robert L. Shedden.
Cornell Univ., Ithaca, N.Y. Cornell Energy Project. Jan 71,
25p Paper-71-1, NSF-RA/N-71-001
PB-228 885/0WE PCS4.25/MFS1.45

The report contains a brief summary of the technical status of
high-voltage direct-current electric-power transmission in
the United States and abroad. Since the first major d-c link from
Stockholm to the island of Gotland began operation in 1954, at
least six additional large-scale lines have been commissioned.
In this country the 1500 Mw, 825-mile Pacific Intertie J is the
only project that has been completed. Solid-state systems are
under design and construction. A sampling of the extensive
bibliography on this subject is included, as well as an appendix
which summarizes pertinent details on a number of the major
lines. (Author)

SUPERCONDUCTING POWER TRANSMISSION.
R.W. Meyerhoff, Union Carbide Corp.

Review article.

Cryogenic and Superconductive Systems for Electrical Power
Transmission.
Keith Sheidler.
Cornell Univ., Ithaca, N.Y. Cornell Energy Project. Jan 71,
11p Paper-71-2, NSF-RA/N-71-002
PB-228 861/1WE PCS4.00/MFS1.45

A brief survey is presented of the current status of cryogenic
and superconductive transmission line research in the United
States. (Modified author abstract)

Cost Comparison between Natural Gas and Electricity.
Rob Hogue.
Cornell Univ., Ithaca, N.Y. Cornell Energy Project. Jun 71,
13p Paper-71-7, NSF-RA/N-71-007
PB-228 862/9WE PCS4.00/MFS1.45

Results are reported of a cost comparison study of gas versus
electrical transmission of large blocks of energy. Representative
present-day gas-line operating standards and procedures
were obtained by consultation with operating engineers of
several gas transmission companies. Results of the application
of these guidelines to a number of gas lines are compared with
the standard costs of operation of electrical lines that can
transmit equivalent amounts of energy for similar distances.
Comparisons are presented in several tables, which show that
transmission of energy via gas is significantly more economical
than by electricity in construction costs, distribution costs,
and in fuel costs. Table 4 is of particular interest for the data
on corresponding power capabilities for several pipe diameters.
Table 3 contains useful comparisons of consumption and
distribution costs of gas versus electricity by the lower 48
states of the United States. (Author)
73V30918 1971 ISS 00 TK3101.U55 621.3190973 LC-72-616371
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A FREEMAN, PETER JOHN.
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3000 KM. (PEPEDACHA ELEKTRII ENERGI PEREMENNYM TOKOM NA RASSTOYANIYA
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Power cables: their design and installation.
Barnes, Cyril Charles.

Power cables: their design and installation by C. C. Barnes. With a foreword by Sir John Hacking. 2nd ed.
xv, 350 p. Illus., 16 plates, tables, diagrs. 24 cm. 6/-

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UNITED STATES. FEDERAL POWER COMMISSION. ADVISORY COMMITTEE ON UNDERGROUND TRANSMISSION.
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741
THE TECHNOLOGY AND APPLICATION OF FREE-SPACE POWER TRANSMISSION BY MICROWAVE BEAM.
W. C. Brown.

The technology is examined in terms of the microwave beam itself, and the conversion technology between microwaves and dc power at either end of the system. The potential applications are discussed in terms of the unique characteristics of microwave power transmission.

— A74-24271 —

The basic thermodynamics of thermal lasers of the gas-dynamic type are reviewed, and it is shown that an efficient coherent photon generator can be developed on a closed-cycle principle. The efficiency limits of such a device are explored, and the results of the analysis indicate that the production efficiency of coherent radiation from heat, in the limit of high component efficiency, is equal to that of the production of work. An indispensable element of any power transmission system also involves an engine capable of transforming the transmitted energy into useful shaft power. It is shown that a closed-cycle system may also be developed in principle which can transform the transmitted laser radiation into shaft power with an efficiency approaching one.

— A73-23601 —


It has been suggested by Glaser (1968) that large arrays of solar photovoltaic cells should be placed into space in near-equatorial synchronous orbit where the sun would shine upon them nearly 100 per cent of the time. The dc power obtained from the photovoltaic arrays would then be converted into microwave power, beamed to the surface of the earth, and there converted back into dc power.

This concept has become known as the Satellite Solar Power Station (SSPS). The system configuration and characteristics of the SSPS are discussed together with the solar photovoltaic cell array, details of the microwave power transmission system, and side effects of the SSPS system.

G.R.

The basic operational highlights of CO2-N2 gasdynamic lasers (GDL's) are described. Features common to powerful gas lasers are indicated. A simplified model of the vibrational kinetics of the system is presented, and the importance of rapid expansion nozzles is shown from analytic solutions of the equations. A high-power pulsed GDL is described, along with estimations of power extraction. A closed-cycle laser is suggested, leading to a description of a photon generator/engine. Thermodynamic analysis of the closed-cycle laser illustrates in principle the possibility of direct conversion of laser energy to work. (Author)


Dr. Krafft Ehricke's proposal for microwave energy relay satellites in geosynchronous orbit. Powerful earth-based atomic power plants, located in unpopulated areas of the earth, would furnish power to wide areas of earth via the space microwave relay system.


A brief review of laser elements is given. Flowing gas lasers are represented to have the best potential for high average power. The background of shock tube researchers and the shock tube itself are alleged to be ideally suited for the development of such lasers. Three types - the electric discharge, the gasdynamic, and the chemical laser - are discussed briefly. A legion number of possible gas lasers is enumerated. With the development of their potential for higher power and efficiency, many additional and important uses of lasers are predicted, even beaming power through space for long distances, up to 1 AU. A few details of some current high-power gasdynamic laser devices are given. (Author)


The Power Relay Satellite (PRS) offers interesting possibilities as a feasible, shuttle-compatible method of transferring energy over continental or global distances. The basic principle of the PRS is that a microwave reflector is placed into geosynchronous orbit to redirect energy beamed from an electric power generation system (power source) to a receiver at a great distance from the power source. There the microwave energy is converted back to electricity for local distribution. Particulars of the transmitter antenna are given. The technology of converting electricity to microwave power was advanced greatly with the development of crossed-field devices. They operate on the principle of electron motion in a crossed electric and magnetic field. Microwave beam transmission is examined. Energy sources to primary electric power plants (PEPPs) in the United States are discussed. Attention is given to the shuttle compatibility of space relaying and its comparison with space power generation. F.R.L.


A microwave, wireless, power transmission system is presented in which the transmitted power level is adjusted to correspond with power required at a remote receiving station in which deviations in power load produce an antenna impedance mismatch causing variations in energy reflected by the power receiving antenna at the receiving station.
A74-19870* National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
MICROWAVE POWER TRANSMISSION SYSTEM WHEREIN LEVEL OF TRANSMITTED POWER IS CONTROLLED BY REFLECTIONS FROM RECEIVER Patent
A microwave, wireless, power transmission system is described in which the transmitted power level is adjusted to correspond with power required at a remote receiving station. Deviations in power load produce an antenna impedance mismatch causing variations in energy reflected by the power receiving antenna employed by the receiving station. The variations in reflected energy are sensed by a receiving antenna at the transmitting station and used to control the output power of a power transmitter. Official Gazette of the U.S. Patent Office.

A74-21002* Phased arrays of lasers for power transmission.
The phased array is a group of regularly spaced lasers with parallel optical axes. Each laser of the group emits light of the same wavelength and the same phase. Mathematical models of laser transmission systems with regular arrays are presented, taking into account rectangular apertures. It is found that an array of free running lasers has the same normalized expected value as the single laser, with the actual power a factor of N greater. — G.R.


Recent developments in rectenna design and microwave beam launching have increased the ratio of the dc power output from the rectifier at the receiving point to the rf power input to the transmitting antenna from 0.41 to 0.60. The efficiency of microwave beam launching has been improved through the use of the dual-mode horn which has exceptionally low power loss in its side lobes. Improvement in the efficiency at the receiving point has resulted from increased capture efficiency of the rectenna. — (Author)

NASA Tech. Brief B73-10353
LASER ENERGY CONVERTED INTO ELECTRIC POWER.
Katsunori Shimada, Caltech/JPL.

Project a laser beam of sufficient power to the remote site and then convert the laser energy directly into electric power.

THE SATELLITE NUCLEAR POWER STATION.
Space World, v.5-6-114, June 1973, p.4-18.
The Satellite Nuclear Power Station would transmit power safely to the ground by a microwave beam.

The principle on which a satellite solar power station (SSPS) is based is the conversion of solar energy into electricity. This electricity would be fed to microwave generators arranged to form an antenna which, in turn, could direct a beam to a receiving station on the earth where the microwave energy could be efficiently and safely converted back to electricity to meet base load power needs. The status of the technology required to meet the objectives of an SSPS is discussed. F.R.L.


The input-voltage standing-wave ratio (v.s.w.r.) of a feed for a reflector-antenna system depends on the mismatch of the horn to free space and the reflection of energy back into the feed. Both these effects must be minimized to ensure a low v.s.w.r. A general computational method is formulated by making use of a power-transfer theorem by Robieux (1959), describing the efficiency of coupling between two apertures. Measured and predicted v.s.w.r. against frequency patterns for 6 deg scalar horn feed with subreflector are shown in a graph. G.R.


National Aeronautics and Space Administration.
Marshall Space Flight Center, Huntsville, Ala.

MICROWAVE POWER TRANSMISSION CONSIDERATIONS FOR EARTH ORBITAL SPACE MISSIONS


Avail. NTIS CSSC 09C

Investigation revealed that the use of microwaves and lasers was feasible for transferring electrical power in space. The results of the study led to a consideration of microwaves for electric power transmission between earth orbital satellites in the late 70's or early 80's. Efforts to develop design information for planning purposes are discussed. K.P.D.

"Status of the Technology and Applications of Free-Space Microwave Power Transmission" W. C. Brown

IEEE-GM IT International Microwave Symposium

Description of studies which have led to the design of a conceptual device in which the limitation of transforming heat into coherent radiation can be examined. By exploring the basic thermodynamic relationships controlling the operation of this device, it is concluded that a closed-cycle gasdynamic laser is possible in which all of the shaft energy supplied can be turned into laser radiation. Hence, it is possible in principle to convert heat into coherent radiation with approximately the same efficiency with which heat may be converted into electricity. By modifying the closed-cycle-gasdynamic-laser system, this system can be operated in reverse and the incoming radiation may be used to pump the gas in the loop so that shaft power can be extracted. By carefully controlling the temperature distribution in the machine, laser energy can be converted into useful shaft energy with an efficiency approaching 1.

M.M.


The development of gas laser technology leading to the present capability of generating high power continuous and pulsed coherent radiation is briefly reviewed. It is pointed out that through these developments it is now possible to consider the radiant transmission of power. The basic thermodynamics of thermal lasers of the gas dynamic type are reviewed, and it is shown that a highly efficient coherent photon generator can be developed on a closed cycle principle. The efficiency limits of such a device are explored, and the results of the analysis indicate that the production efficiency of coherent radiation from heat can, in the limit, be equal to that of the production of electricity from heat. An indispensable element of any power transmission system also involves an engine capable of transforming the transmitted energy into useful shaft power. It is shown that a closed cycle system may also be developed which can transform the transmitted laser radiation into shaft power with an efficiency approaching one.

Author

A concept for a satellite solar power station is described to meet future large scale electrical power requirements without burdening the environment or leading to natural resource exhaustion. Considerations are given to solar energy conversion, microwave generation and transmission, and conversion of microwave energy to electrical power on earth. The system considerations and the development tasks for a large satellite solar power station are reviewed and the potential technological needs are identified. (Author)

NASA plans to have a space station complex in earth orbit by the late 70s to provide a facility for performing scientific experiments over long periods. The plans call for a space station, experimental modules, and logistic vehicles. The experimental modules will include free-flying observatories equipped to measure radiation sources such as X-ray, stellar, solar, and high energy. The problem of providing electrical power to these free-flying satellites has no clear-cut solution. Microwave power transmission is one of several proposed solutions being evaluated by NASA. The in house and contractually supported programs have surveyed the present status of microwave power transmission and sponsored experimental measurements on the overall efficiency of a microwave power transmission link. These experimental results are described. (Author)

The paper considers the problem of microwave power transmission from an orbiting solar power station to the earth. In particular, questions such as the optimum frequency range, antenna dimensions and mechanical tolerances, phasing and directional control, and attainable transmission efficiencies are discussed. (Author)

The proposal to obtain electrical energy from the sun by means of an enormous solar cell array positioned in the earth's synchronous orbit altitude places a challenging requirement upon the means of converting this energy into microwave form so that it can be relayed to the earth's surface. Crossed-field device technology is consistent with the needs for high efficiency, long life, and for either modest or very high power levels in the dc to rf energy conversion process. A dc to rf energy conversion efficiency of 93% in an overall efficiency of 86% have been demonstrated in a high power magnetron. Continuous power over 400 kW at 3000 MHz and an efficiency of 76% have been obtained from the Amplotron, a crossed-field amplifier device. The development of a pure-metal, secondary emitter cathode provides long life capability. Newly developed permanent magnet material provides the high magnetic fields needed for high efficiency with low resulting weight. (Author)

A70-15648  PROGRESS IN THE DESIGN OF RECTENNAS.
Review of progress in the design of "rectennas," devices used to collect and rectify the microwave energy at the receiving end of a microwave beam power transmission system. A new lightweight rectenna which provides 20 W of power but weighs only 20 g is described. Future trends in construction are discussed. (Author)
EXPERIMENTS INVOLVING A MICROWAVE BEAM TO POWER AND POSITION A HELICOPTER.
William C. Brown (Raytheon Co., Burlington, Mass.).

Description of two different experiments involving a microwave beam and a helicopter. The first experiment utilized a CW microwave beam to supply a small helicopter with all of the power that it needed for its propulsion. The second experiment utilized an unmodulated CW microwave beam for supplying a position reference to the helicopter with respect to roll, pitch, yaw, and horizontal translation. The second experiment also involved the construction of a fully articulated helicopter and a complete control system carried on board the helicopter. An attempt is made to relate the small scale experiments and the present state of component technology to practical, full scale microwave-powered helicopter systems that can operate at altitudes of up to 50,000 ft. (Author)

PROPULSION ASSISTED BY MICROWAVE POWER.
J. M. Bonneville (NASA Electronics Research Center, Cambridge, Mass.).

Study of practical applications of microwaves to various propulsion requirements including spacecraft launching, power transmission in space, and ground takeoff assist (for aircraft) for local economy. Power requirements are presented for some specific cases, and problems associated with the use of microwaves as part of the power system are outlined, as are some means of solution. B.H.

THE MICROWAVE-POWERED HELICOPTER SYSTEM.

Development of next phase of the microwave-powered helicopter system. This next phase, which is nearing completion, is the design of a complete microwave-powered helicopter, which will position itself on the microwave beam. For this purpose, a completely articulated helicopter complete with tail rotor and completely self-contained control system is necessary. Of major importance has been the development of new solid-state diodes with a high ratio of dc power output to weight, and integrated circuits. The new diodes make it possible to build a complete receiving antenna and rectifier with a power output of nearly a kilowatt and a weight of 2 lb, while the integrated circuits have made it possible to build a sophisticated control system including sensors and servomotors with a weight of less than 2 lb. P.V.T.

ELECTRONIC COMPONENTS FOR MICROWAVE POWER ENGINEERING.
William C. Brown (Raytheon Co., Microwave and Power Tube Div., Burlington, Mass.).

Description of electronic components for microwave power engineering capable of generating power up to levels of perhaps as high as 1000 kw and rectifying power up to 100 kw. The quasi-optical approach constituted by the electromagnetic amplifying lens (EAL) is illustrated. In principle, the EAL is a device with a large window at either end and an unlimited number of microwave channels through which microwave energy may flow from one face of the lens to the other. As the power flows through the device, its power level is boosted by a dc-rt conversion process which allows the power to flow at nearly the velocity of light and avoids having to slow the wave down to interact with the electrons. It is pointed out that it is also possible that microwave rectifiers which must handle very large amounts of power will be developed along similar quasi-optical lines. M.M.

AN EXPERIMENTAL MICROWAVE-POWERED HELICOPTER.

Description of successful microwave-powered helicopter experiments and discussion of significant design parameters of this helicopter, with a projection of the impact of available but unused technology upon the payload functions of the microwave-powered helicopter. The matters presented are: (1) summary of the experiments, (2) description and performance of the major components of the microwave-powered helicopter, (3) helicopter rotor design, (4) the combination receiving antenna and rectifier, (5) motor, and (6) analyses of the payload fraction of the microwave-powered helicopter. It is concluded that a communications payload of about 6 pounds could be provided by a 1- hp helicopter. Such a helicopter could operate at altitudes up to ten thousand ft, since lift does not vary greatly with density. A 5-pound communications payload could vary greatly with density. M.M.


464-15000
DECOMMISSION OF MICROWAVE POWER.
W. C. Brown (Raytheon Co., Lexington, Mass.) and R. H. George
(Purdue University, Lafayette, Ind.).
Review of the various possible rectifier approaches to the direct
conversion of microwave energy into dc energy at acceptable effi-
ciency, with emphasis upon those already explored. Microwave
tube analogs, the closed-spaced thermionic diode, the semiconduc-
tor diode, the rectenna, and the multipactor rectifier are discussed.
It is concluded that the development of the RF-to-dc conversion
device may be considered as being in its early formative stages
with practical devices for some types of application now available
and with great advances from several different approaches expected
for the future.

M. M.

DEVS-22428
EXPERIMENTS IN THE TRANSPORTATION OF ENERGY BY
MICROWAVE BEAM.
W. C. Brown (Spencer Laboratory, Burlington, Mass.).
(EE Institute of Electrical and Electronics Engineers, International
Convention, New York, N.Y., Mar. 23-26, 1964.)
IEEE International Convention Record, vol. 12, pt. 2, 1964,
p. 8-17. 16 refs.
Review of an investigation into the feasibility of utilizing a
microwave beam as a means of transporting energy from one point
to another. An experiment is described which made use of a CW
magnetron operating at 2450 Mc with several hundred watts of power
output for the power source. Also employed was a 9.5-ft-diam.
ellipsoidal transmitting antenna, a diagonal-horn receiving antenna
separated from the transmitting antenna by 25 ft, and a close-spaced
thermionic diode rectifier. The overall efficiency as measured
from the output of the microwave generator to the input of an electric
motor attached to the output of the microwave rectifier at the rece-
ting point was 26%. It is noted that, although the experiment
handled a modest amount of power over a short distance, sufficient
"off-the-shelf" technology now exists in each of the component areas
to increase the power-handling capability and the distance over which
power can be transferred by at least a thousandfold.

THE CASE FOR THE MICROWAVE POWERED HELICOPTER
AS A COMMUNICATIONS PLATFORM AT 5000-10,000
FOOT ALTITUDE
W. C. Brown 19 Nov. 1964 20 p
(AD-465816)
This paper points out and supports with evidence that micro-
wave powered helicopters can be rapidly developed to an
operational capability of between one and two miles making
use, for the most part, of existing component technology and
a conservative approach to microwave antenna design. N.R.A.
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