IMPACT OF ALTERNATIVE ENERGY FORMS ON PUBLIC UTILITIES*

by

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*This presentation is based largely on the attitudes, philosophies, and studies developed by EPRI and EEI.

INTRODUCTION

The Electric Power Research Institute (EPRI) was established by the electric utility industry in January, 1973, for the purpose of performing energy research and development under the sponsorship of the nation's utility industry. Its goal is to develop a broad coordinated advanced technology program for improving electric power production, transmission, distribution, and utilization in an environmentally acceptable manner.

The EPRI budget for 1976 was $130 million, with funding provided by voluntary contributions from public and private utilities across the nation. There are more than 700 member organizations supporting the EPRI program. These utilities account for approximately 85 percent of the electric power generating capacity in the nation. The EPRI research programs are closely coordinated with parallel efforts of Federal agencies such as the Energy Research and Development Administration (ERDA), National Aeronautics and Space Administration (NASA), and others.

The Edison Electric Institute (EEI) is an association of electric light and power companies in the United States. Its affiliate members consist of investor-owned electric utilities in North, Central, and South America and contiguous islands in the Western Hemisphere. The objectives of EEI are:

1. The advancement in the public service of the art of producing, transmitting, and distributing electricity and the promotion of scientific research in such field.

2. The ascertainment and making available to the members and the public factual information, data, and statistics relating to the electric industry.

3. To aid its operating company members to generate and sell electric energy at the lowest possible price commensurate with safe and adequate service, giving due regard to the interests of consumer, investor, and employee.

Alabama Power Company is a private investor-owned electric utility engaged in the generation, transmission, and distribution of electric energy to approximately 921,000 customers. These customers are located throughout 56 of Alabama's 67 counties in a service area of approximately 44 500 square miles. The total generating capacity is 6120 MW. Alabama Power Company is also one of the operating affiliates of the Southern Company.

The presently installed generating capacity of The Southern Company system is nearly 20 500 MW, and projects to increase this capacity are currently committed and are in various stages of design and construction. Despite recent delays in new plant construction, the system construction budget was $995 million for 1976 and it is $3.8 billion for 1977-1979 combined. System energy sales for 1976 amounted to 80.3 billion kW-h.

A quick review of these statistics clearly indicates that The Southern Company system is deeply involved in and will be vitally affected by the national energy problem and any policies or strategies which may be developed to address this problem. As is well known, the national energy problem arises primarily from a mismatch in the supply and demand relationships of specific energy resources, namely oil and natural gas. A comparison of the current patterns of energy use and the relative amounts of domestic energy resources shows that the U.S. has become dependent on oil and natural gas to supply approximately 80 percent of its needs. It is significant to also note that these two sources represent less than 7 percent of its domestic fuel resources.

Americans have come to think of this significant dependence upon natural resources as a recent development. This attitude was developed primarily at the gasoline lines in 1973 and from headlines describing rising utilities costs, supply shortages of natural gas, and unforeseen technical problems.

ENERGY GROWTH

Energy is the backbone of modern society. It is also an extremely complex subject which includes economic, political, social, and technological considerations. Many uncertainties exist in each of these areas which lead to conflicting positions among experts in a given discipline. This has led to the development of many diverse energy scenarios for the future.

One such study was conducted during the summer of 1974 at MSFC for the purpose of developing a methodology for assessing alternative energy futures. A systems approach methodology was used to examine three energy scenarios — the Westinghouse Nuclear Electric Economy, the Ford Foundation Fix Base Case, and a MEGASTAR-generated Alternative to the Ford Technical Fix Base Case. The three scenarios represent different paths of energy consumption to the year 2000.

The existence of many uncertainties, whether relating to nuclear safety, energy needs, health effects, our oil and gas resources, or the electrical-generation capacity required for the future, makes it imperative that multiple pathways are pursued to assure that the lack of energy will not force us to compromise either our economic and social goals or our national security in the future.

Most discussions of U.S. energy requirements begin by pointing out that energy consumption in the U.S. has been increasing at 2.9 percent annually over the last 30 years (4.1 percent for the years 1960-1973). With 10 percent of the world's population, this country accounts for approximately 35 percent of the world's annual energy consumption, which is the highest energy use per capita of any country in the world.

Economists point out that the U.S. also has the largest gross national product (GNP) and, more important, one of the largest GNP's per capita. The U.S. also produces one-third of the world's goods. The U.S. energy requirements per unit of GNP exceed that of most of the industrialized nations of the world. There is no denying the energy-intensiveness of the U.S. society. It is very productive, mobile, best fed, clothed, housed, entertained, educated, and informed of any in the world. Its pace leads the world; people, goods, production lines, etc., move freer and faster.

What does this indicate for the future?

The EPRI plan for answering this question is based on estimates of future electric energy consumption, fuel needs, and utility plant additions required to support a healthy economy. It also recognizes that the utility industry is operating under a variety of external forces: new economic, political, and social concerns. Environmental issues, regulatory uncertainties, restrictions on the choices of fuel, and limitations on the availability of capital are all anticipated to have a substantial effect on both the technological base and systems and equipment options required over the next few decades.

There are two good indicators which help us fix the target for the future demand for electricity: our anticipated standard of living and the size of our future labor force. Historically, energy consumption and prosperity rise and fall together. A strong appetite for energy marks those periods when employment is healthy and the economy is growing. Energy consumption tends to fall with waning employment and sagging national economy.

Over the next quarter century, energy consumption may be marked by fuel switching from natural gas and oil to electricity; consequently, assumptions

about total energy needs are necessary to set bounds on the amount of fuel switching that can be reasonably expected. Total U.S. energy demand also provides a measure of the future competition for primary fuels and the effect of this competition on utility fuel costs and the markets for advanced technology. Projections made by both governmental and private organizations, however, have revealed significant uncertainty about the future rate of growth in total energy consumption.

Typical forecasts for total U.S. energy consumption in the year 2000 range from 135×10^{15} Btu to 192×10^{15} Btu. For purposes of research and development planning, EPRI has adopted an intermediate expected value of 150×10^{15} Btu. These figures compare with the total energy use of 71.1×10^{15} Btu in 1975. The expected energy curve does not represent an absolute forecast of future U.S. energy needs, but does constitute a baseline for EPRI planning. The expected energy curve is subject to change, based on continuous analysis, economic events, and policy changes.

This projection of total U.S. energy consumption anticipates continued economic growth over the next quarter century to provide income for a labor force of 113 million and a total population of 263 million people by the year 2000. Rising energy prices, governmental policy, new construction codes, and public concern are expected to result in some conservation of energy. The expected energy curve used for planning by the Institute assumes that a reasonable level of conservation will be achieved by the year 2000. Without this conservation effort, an additional 37×10^{15} Btu would probably be added to the year 2000 demand for primary fuels.

The EEI's energy philosophy is based on its energy policy statement adopted a year ago. EEI's current position embraces the broad national goal of achieving a high degree of energy self-sufficiency in order to protect the public wealth and economic welfare and to promote national security. To achieve this goal, it is essential that the policies and efforts of government and industry work together to minimize waste and make the most efficient use of energy, to increase domestic energy resources, to develop new sources of energy, and to promote environmental and economic balance.

Underlying the EEI policy recommendations is recognition of the fact that more and more electricity will be needed by the nation for its economic and social well being. After zero growth in 1974 and a 2 percent increase in 1975, electric output for 1976 was up over 6 percent, primarily due to increased industrial activity. Among the areas where increased use of electricity is taking place are the following:

1. Industry and commerce — Changeovers range from hamburger stands to automobile manufacturers and from steel to glass-makers.

2. Environmental programs — More electricity will be required for processes such as water purification and waste recycling.

3. Transportation — ERDA is projecting an all-electric transportation economy involving an "almost total switch to electric cars and delivery vans by the year 2000."

4. Electric home heating — Data shows that 49 percent of new single-family homes had electric heating in 1975. This compares with 40 percent for gas and 9 percent for oil. When new multifamily buildings, for which the electric percentage was 59 percent, are included, the weighted average for both types was 52 percent. For the second straight year electric had a larger share of new homes than did gas.

In 1975, coal provided approximately 45 percent of the electric generation. In the year 2000, fossil fuel, primarily coal, will account for about 40 percent of generation.

Nuclear fuel provided about 9 percent of electricity generation in 1975, and by the year 2000 it is expected to provide 50 percent.

ALTERNATIVE ENERGY RESOURCES

Through the energy programs which are being conducted by both EPRI and EEI, individual electric utility companies are being encouraged to participate in the development and demonstrations of various solar energy applications. This encouragement is essential if new sources of energy and new techniques for using existing fuels more efficiently are to be developed.

During February 1976 the EPRI staff prepared a report entitled "Electric Utility Solar Energy Activities 1976 Survey." The report identifies 295 projects sponsored by 116 utility companies. The projects were grouped into the six categories listed in Table 1. As indicated in Table 1, solar heating and cooling of buildings (SHACOB) and related projects accounted for 73 percent of utility activity, with 98 of the 116 utilities sponsoring at least one project in this category. Participation ranged from providing monetary support for experiments conducted by colleges and universities to full sponsorship of design,

TABLE 1. SUMMARY OF ELECTRIC UTILITIES SOLAR ENERGY PROJECTS

Category	Utilities Participating in Project Area	Active and Planned Projects	
		Number	Percent of Total
SHACOB[a] and Related Projects	98	216	73
Wind	20	29	10
Solar Data Collection	15	17	6
Solar-Thermal Central Power	8	11	4
Photovoltaics	5	5	1
Other	10	17	6

a. Solar heating and cooling of buildings.

construction, instrumentation, and evaluation of installations with solar heating and cooling (SHAC) systems. This category includes efforts involving solar system instrumentation and monitoring, utility impact studies, systems design studies, computer simulations of SHAC systems, and experimental rate design studies.

Projects in the wind energy category consisted of 10 percent of the total. The major thrust of these projects involved wind data acquisition in support of the ERDA large wind turbine generator program. Several projects featured residential wind generator demonstrations. Combination SHAC-wind energy projects are included in the SHACOB category. Solar-thermal central power and photovoltaics activities, comprising 5 percent of the total, were also generally found to be associated with the ERDA solar energy program. The solar data collection activities (6 percent of the total) were found to be independent of the Federal solar data acquisition and reporting program. Concentrated in the western United States, the majority of the 20 utilities in this category are participating in the WEST Associates' Solar Resource Evaluation Study. The remaining 6 percent of the efforts identified in the survey included solar crop-drying projects, public information programs, industrial applications, and materials and components testing projects.

Despite accelerated research and development efforts, electric power will not be generated in any significant quantities from such sources as solar, geothermal, wind power, or fusion until after the turn of the century. By the year 2000 sources other than nuclear and fossil will be supplying about 10 percent of electric generation and most of that will be hydro.

Solar Energy

Solar energy is manifested in several forms other than direct radiation from the sun, in forms such as wind, waves, biomass, and ocean thermal-gradients. All are technically capable of producing energy, but at costs that substantially exceed other alternatives. In all, more than $20 million has been earmarked by the electric utility industry for research, development, and demonstration of the solar concept through EPRI. This funding has been committed through 1982, and equal efforts will be geared toward solar heating and cooling applications as well as electric power production.

The sun's most significant contribution this century will more likely relate to space and water heating. The easiest and most cost-effective contribution can come from simply improving building design and orientation — taking full advantage of the sun for heating purposes, or minimizing its impact in hot climates.

Solar water-heating is presently used in many parts of the world and its applications are likely to increase. Solar heating of homes is still not economically viable in most parts of the country. Principal costs involve the collectors and the thermal-storage system. Backup energy supply systems are also important factors to be considered. Widespread use of such systems could create serious load imbalance problems for a winter-peaking utility, forcing it to invest in additional generating capacity that would be used only a small fraction of the time. Some utilities are considering demand charges on solar users whose systems contribute to such problems.

EPRI's thrust in its SHAC program is to optimize these systems in terms of capacity displacement as well as fuel displacement. The key to solar utilization for space conditioning is in collector cost and performance. Both must improve substantially and/or coal and nuclear-produced electricity must increase in price to make SHAC economic. While the solar industry is growing rapidly, it should be kept in mind that if solar captured 100 percent of the new construction space heating after 1985, this would represent only about 65 percent of our total primary energy requirement by the year 2000.

Solar-electric systems are being actively developed, but their contribution this century will be far less significant. Two approaches are being pursued: solar thermal, which utilizes the Sun's energy to drive a conventional power cycle, and photovoltaic (solar cells), which converts solar radiation directly to dc electricity. Both approaches are far from being competitive with nuclear or fossil options at the present time.

The central-receiver-plant costs are dominated by heliostat costs. These plants will be concentrated in the arid Southwest because of the abundance there of direct solar radiation. ERDA is planning a 10 MW central-receiver pilot plant utilizing a conventional steam cycle. EPRI is developing a Brayton system using helium or air as a working fluid and operating at temperatures of 1500 to 2000°F. Brayton systems can significantly reduce cooling-water requirements — an important consideration in the Southwest. The possibility of reducing costs by providing a fossil-fuel backup energy supply as opposed to energy storage is also being considered.

As for solar cells, these are several orders of magnitude too costly for large-scale power production at the present time.

Not only must solar-electric power-system components (heliostats, solar cells, etc.) be substantially reduced in initial cost, but they must also demonstrate sufficient durability to permit a long usable life. Only then will solar power significantly contribute, and even then only in regions where the quality and quantity of solar energy reaching the Earth's surface justify the investment.

In addition to EPRI projects, over 200 solar demonstration programs are being conducted separately by utility companies. The following is a list of some of the individual projects which are being conducted within the industry:

1. San Diego Gas & Electric Company — The San Diego Gas & Electric Company has begun a three-year research program in which the utility will monitor a solar demonstration house and evaluate its solar climate control system.

2. Massachusetts Electric Company — The Massachusetts Electric Company has a project to install solar hot water heaters in 100 homes to test their potential for solar heating.

3. Niagara Mohawk Power Corporation — The Niagara Mohawk Power Corporation is funding a project at the State University of New York to utilize solar heating.

4. Pacific Power & Light Company — The Pacific Power & Light Company is funding a solar energy center at the University of Oregon.

5. Pennsylvania Power & Light Company — The Pennsylvania Power & Light Company has funded research on an experimental home which uses solar panels for heating.

6. Alabama Power Company — The Alabama Power Company is building a solar energy demonstration office to serve its Montevallo District. The structure will serve as a research project to obtain data on the effectiveness of solar energy components and system and energy savings through solar application.

Wind Energy Conversion

Wind machines are being developed by ERDA and NASA which could lead to limited energy contributions in regions where suitable wind conditions and natural energy storage exist. Remote regions are likely to be favored because of asthetics, better match of load requirements to wind-generator size, and reduced transmission costs from central power stations.

Since wind energy is intermittently available and less predictable than direct solar energy, it requires energy storage devices or very widespread interconnections to achieve reliable capacity displacement. Research issues include accurate assessment of wind patterns and vertical profiles, and techno-economic determinations of feasibility for rural or urban applications.

Central Vermont Public Service Corporation has constructed and operated a 1.25 MW windmill-driven generator, and Minnesota Power & Light Company is involved in a project with ERDA to determine the economic feasibility of using wind generators to supplement conventional generating systems.

Less certain in terms of economic feasibility are some of the mid-term projects, such as large windmills coupled to electric generators.

Photosynthesis of Biomass

Another long-term possibility for generating electricity with solar energy is the biomass or photosynthesis method. It is known that through the age-old process of using energy captured by plants from the Sun, urban refuse, forestry and agricultural wastes and special energy crops can be converted to fuels. This concept is being studied by both ERDA and EPRI.

Studies are underway at EPRI to check the environmental impact of growing trees or sorghum on large solar plantations. The major problems are availability of water, the energy input needed to make fertilizers, and most important, the fact that the currently projected costs of fuel production are much higher than those for alternative methods.

It is believed that by the year 2000, fuels derived from biomass will have a small impact on a national scale.

Ocean Thermal Energy Conversion

Unfavorable economics, coupled with major technical problems, makes ocean thermal-gradient generation systems relatively unattractive and limited to only a few U.S. locations for electric power production. The physical size of the system is large, consisting of pumps, heat exchangers, and other expensive equipment required to generate a relatively small amount of power. Significant problems of materials, operation, and lifetimes are encountered due to corrosive environments. Another problem is to economically transport the power generated to land-based load centers. Consequently, ocean thermal energy conversion ranks lower among EPRI research priorities.

Environmental Impact

In addition, the EPRI solar program incorporates two studies to evaluate the environmental impact of the various types of solar power, including solar thermal conversion, photovoltaic conversion, wind energy conversion, ocean thermal conversion, and biomass. These studies are to provide inputs for utilization by the utilities in filing the alternative section of the Environmental Impact Statement for conventional power plants, or, alternatively, when solar systems become economically viable, to provide the framework for making an environmental impact application and assessment for these power plants.

Geothermal Energy

In rare instances can geothermal energy be extracted directly as steam and used to produce power, as is done at the Geysers in California. Pacific Gas & Electric Company operates this power generating plant which is the only commercial geothermal development in the country.

Dry steam produces about 500 MW at The Geysers, and any significant additions elsewhere will have to come from the hydrothermal resource. EPRI has recently completed a feasibility study for a 25 to 50 MW low-salinity-hydrothermal demonstration plant. However, the site-specific nature of the resource, geology, and environmental considerations will limit the rate of growth in the early years of hydrothermal development. Geothermal power does have the potential for becoming an important supplement in parts of the West and Southwest by the year 2000.

At the present time, five utilities have supported the drilling of geothermal sites in western states — Arizona Public Service Company, San Diego Gas & Electric Company, Southern California Edison Company, Tucson Gas & Electric Company, and Utah Power & Light Company. Florida Power & Light Company has also provided funds to the Florida Institute of Technology to determine geothermal energy's potential in Southwest Florida.

Fusion

Several projects are underway in the fusion area. Public Service Electric and Gas Company and other utilities have provided support for fusion research at the Princeton Plasma Physics Laboratory. The Texas Atomic Energy Research Foundation, supported by ten utilities in that state, has provided support for extensive controlled-nuclear-fusion research at the University of Texas at Austin, and Wisconsin Electric Power Company and Wisconsin-Michigan Power Company have provided major funding for fusion research design study at the University of Wisconsin. Further, seven New York state electric utilities, under Empire State Atomic Development Associates, Inc., have provided funds to Cornell University for long-range basic research on controlled fusion.

SUMMARY

In summary, the electric utility industry is not without a plan. The industry does, however, face a number of formidable problems, and some of the decisions which must be made are outside the realm of industries control. The task of removing bottlenecks and roadblocks will not be easy, but the task should be approached with optimistic realism.

As the problems are resolved, it is anticipated that solar energy will assume an increasingly important role. Even though solar systems require heavier investment of capital and resources than most alternative systems, solar energy may account for 1 to 2 percent, or up to 40 000 MW of the nation's electric power capacity by the year 2000 (solar thermal conversion and photovoltaic conversion). It is anticipated that about 2 percent of the total energy used for heating and cooling of buildings will come from solar (4×10^{15} Btu).

To assure that this goal is met, the EPRI through its New Energy Resources Department has budgeted approximately $64 million for Solar, Geothermal, and Fusion R&D projects for the period 1977-1982. In other words, careful, responsible energy development today will enable our nation to find a path to the time when new, almost limitless energy forms will be available.