

**N76 12473**

**FEA PLANS FOR FEDERAL INCENTIVES  
AND MARKET EVALUATION**

**(Norman Lutkefeder)**

### FEDERAL LAWS COVERING SOLAR ENERGY

- FEDERAL ENERGY ADMINISTRATION ACT (PL 93-275) MAY 7, 1974
- HOUSING AND COMMUNITY DEVELOPMENT ACT (PL 93-383) AUGUST 22, 1974
- SOLAR HEATING AND COOLING DEMONSTRATION ACT (PL 93-409) SEPTEMBER 3, 1974
- ENERGY REORGANIZATION ACT (PL 93-438) OCTOBER 11, 1974
- SOLAR ENERGY R,D&D ACT (PL 93-473) OCTOBER 26, 1974
- FEDERAL NONNUCLEAR ENERGY R&D ACT (PL 93-577) DECEMBER 31, 1974

**FEDERAL ENERGY ADMINISTRATION  
- SOLAR ENERGY -**

**ROLE**

- **CONDUCT BROAD-BASED ANALYSES REGARDING DIRECTION AND SCOPE OF SOLAR RELATED ENDEAVORS FROM AN OVERALL ENERGY DEVELOPMENT/CONSERVATION VIEWPOINT**
- **DEVELOP, IMPLEMENT AND COORDINATE PROGRAMS AND POLICIES TO FACILITATE THE WIDESPREAD APPLICATION AND ACCELERATED UTILIZATION OF PROVEN SOLAR TECHNOLOGIES**

**ORIGINAL PAGE IS  
OF POOR QUALITY**

**FEDERAL ENERGY ADMINISTRATION  
- SOLAR ENERGY -**

**COMMERCIALIZATION EFFORT IS**

- **CONCURRENT, NOT JUST SEQUENTIAL TO RESEARCH, DEVELOPMENT & DEMONSTRATION**
- **PREDICATED ON TWO MAJOR ASSUMPTIONS**
  - 1. A REASONABLY SUCCESSFUL R, D&D PROGRAM**
  - 2. WITHOUT AGGRESSIVE FEDERAL PROGRAM TO COMMERCIALIZE SOLAR ENERGY TECHNOLOGIES, THE SIGNIFICANT PIB PROJECTIONS FOR ENERGY SAVINGS WILL NOT BE REALIZED**

FEDERAL ENERGY ADMINISTRATION

- SOLAR ENERGY -

PROGRAM AREAS

- IDENTIFY AND, WHERE APPROPRIATE, REMOVE ECONOMIC, INSTITUTIONAL, AND LEGAL BARRIERS TO WIDESPREAD COMMERCIAL APPLICATION
  
- STIMULATE MARKET DEMAND
  
- DEVELOP INDUSTRY CAPABILITY
  
- PERFORM TRADE-OFF STUDIES TO ASSURE SOLAR ENERGY DEVELOPMENT PROGRAMS ARE PROPERLY INTERWOVEN WITH:
  - OTHER ENERGY DEVELOPMENT EFFORTS
  - ENERGY CONSERVATION PROGRAMS

**ORIGINAL PAGE IS  
OF POOR QUALITY**

## FEDERAL ENERGY ADMINISTRATION

### - SOLAR ENERGY -

#### PROJECTS CURRENTLY BEING ADDRESSED

- ① ASSESS FOREIGN MARKETS FOR U. S. SOLAR PRODUCTS--WITH DOC/BIC
- ① DEVELOP EARLY MARKET FOR SOLAR ELECTRIC SYSTEMS (PHOTOVOLTAIC AND WIND CONVERSION) VIA DOD'S ENERGY SELF-SUFFICIENCY PROGRAM FOR REMOTE MILITARY FORCES--WITH DOD & ERDA
- ① DEVELOP COMPREHENSIVE PROGRAM DEFINITION REQUIRED UNDER P.L. 93-473--WITH ERDA & OTHERS
- ① DETERMINE IMPACT OF VARIOUS INCENTIVES AND, IF APPROPRIATE, DEVELOP MODEL LEGISLATION AND/OR CONTRIBUTE TO CURRENT CONGRESSIONAL INITIATIVES--WITH OTHERS
- ① ACCELERATE DEVELOPMENT OF "DEFIITIVE" PERFORMANCE CRITERIA AND INDUSTRY STANDARDS TO ASSURE THAT PUBLIC IS PROVIDED WITH QUALITY PRODUCTS--WITH ERDA, HUD, NBS, DOD & OTHERS
- ① ACCFLERATE USE OF SOLAR HEATING AND COOLING SYSTEMS IN GOVERNMENT BUILDINGS--WITH ERDA, DOD, GSA & OTHERS

SOLAR ENERGY

U.S. SENATE PROPOSED BILLS - 1975

NUMBER	SPONSOR	COMMITTEE	DATE ENTERED	PURPOSE
S 28	MOSS	FINANCE	JAN. 15	TAX INCENTIVE
S 168	DOMENICI	FINANCE	JAN. 16	TAX INCENTIVE
S 311	McCLURE	FINANCE	JAN. 21	PROMOTE R&D
S 489	ABOUREZK	JUDICIARY	JAN. 29	ANTI-TRUST
S 875	HART	BANKING, HOUSING & URBAN AFFAIRS	FEB. 27	LOW-INTEREST LOANS
S 1112	GRAVEL	FINANCE	MAR. 7	ENERGY TRUST FUND (R, D&D)
S 622 (AMEND)	FANNIN	INTERIOR & INSULAR AFFAIRS	APR. 7	LOW INTEREST LOANS & LOAN GUARANTEES
S 973	BENSTEN	FINANCE	MAR. 6	PROMOTE R&D
S 1379	FANNIN	FINANCE	APR. 8	TAX INCENTIVES

SOLAR ENERGY  
U.S. HOUSE OF REPRESENTATIVES  
PROPOSED BILLS - 1975

NUMBER	SPONSOR	COMMITTEE	DATE ENTERED	PURPOSE
HR 36	TEAGUE	SCIENCE & TECH.	JAN. 14	ENERGY CONSERVATION R&D CORPORATION
HR 1505	VANIK	WAYS & MEANS	JAN. 15	TAX INCENTIVE
HR 1697	McCLORY	WAYS & MEANS	JAN. 20	TAX INCENTIVE
HR 2873	CONTE	JUDICIARY	FEB. 5	ANTI-TRUST
HR 3849	GUDE	BANKING, CURRENCY & HOUSING	FEB. 27	LOW-INTEREST LOANS RESIDENTIAL BLDGS.
HR 4407	HARRINGTON	JUDICIARY	MAR. 6	ANTI-TRUST
HR 5959	WYLIE	WAYS & MEANS	APR. 15	TAX INCENTIVE
HR 6584	GUDE	WAYS & MEANS	MAY 1	TAX CREDIT/AMORTIZATION NON-RESIDENTIAL BLDGS.
HR 6860	ULLMAN	WAYS & MEANS	MAY 9	TAX INCENTIVE



## MISSION ANALYSIS OF PHOTOVOLTAIC SOLAR ENERGY SYSTEMS

Stanley L. Leonard, The Aerospace Corporation

The overall objectives of The Aerospace Corporation's photovoltaic mission analysis program have been a) to develop procedures for the technical and economic evaluation of terrestrial applications (missions) for the photovoltaic conversion of solar energy and b) to use these procedures to identify the missions most likely to find a significant place in the U. S. energy marketplace in the 1980-2000 period. The greatest emphasis in the study is being placed on two main classes of missions: on-site applications, in which the photovoltaic system serves the electric power demand of a load-point that is co-located with the system, and central station power plant applications. Fuel production applications and a variety of special-purpose missions are also being studied, albeit at a considerably lower level of effort.

Much of the effort during the early part of the reporting period was devoted to the development of the computer software needed in the methodology for evaluating on-site missions. The procedure employs computer simulation to determine performance characteristics. These results are then used, along with a model for the operation of a complete utility system, to determine the amount of back-up energy that the utility grid must provide and the amount of additional generation capacity that is needed in order to maintain reliable service. The economic evaluation of the mission then requires the comparison of the total cost of the energy provided to the on-site load-points in two different situations, one in which photovoltaic systems satisfy most of the demand and one in which the entire load is served directly by the utility grid. This procedure treats the economics of the mission essentially from the utility point of view. The costs associated with the distribution of back-up power are thereby included implicitly.

The evaluation methodology for on-site missions have been used in analyzing a representative base-line mission/system concept in some detail and in assessing the sensitivity of the result to variations in mission or system characteristics. The baseline concept is a residential photovoltaic system located in Phoenix. The analysis presumes the existence of a substantial number of such systems within the service area of an electric utility system; the demand served by photovoltaic systems amounts to about 0.6% of the total system demand. It was found that the use of such residential on-site systems can be expected to become economically competitive in 1990 if photovoltaic array costs can be reduced to about \$100 per peak kW.

The sensitivity analyses have included studies of the effect on performance of variations in array size, in storage capacity, in geographical location (seven different sites), and in types of demand (residential, commercial, or industrial). Both flat-plate and Winston collectors have been investigated and a comparison has been made between performance of collectors with fixed orientation and collectors whose tilt is adjusted monthly. In addition, a brief study was made of the sensitivity of the economic evaluation to variations in photovoltaic conversion efficiency, in the costs of essential subsystems, and in the cost of fuel for competing power sources.

A second major effort, begun late in the reporting period, has been devoted to implementing procedures for evaluating central station power plant applications. This task consists largely in adapting procedures that were developed in an earlier Aerospace Corporation analysis of missions for solar-thermal energy conversion. At the close of the reporting period, this adaptation process is essentially complete and preliminary runs are being made. An improved model for dispatching the output of a solar energy plant is also being developed; it will be incorporated into the methodology when complete.

A start has also been made on the development of evaluation procedures for fuel production (e. g. , electrolytic hydrogen) missions. Central to this evaluation will be the cost of competitive fuel (or of hydrogen produced in other ways), and a study of the projected (1980-2000) costs of such fuels is under way.

During the remainder of the grant period (two months), representative central station power plant missions will be evaluated. The improved dispatch routine will be incorporated into the methodology, as will procedures for evaluating the combined effect of the use of three solar plants, each located at a different site. The study of projected fuel costs will be completed and used in an assessment of the competitive position of electrolytic hydrogen produced with power from photovoltaic arrays.

A proposal for a follow-on study has been submitted to ERDA. It calls for an extension in both breadth and depth of the mission analysis effort and for the provision of direct program support to the ERDA photovoltaic conversion program office. The proposed funding for the Mission Analysis portion of the study is approximately \$400K, while that for the Program Support segment is \$62K, for a total of \$462K.

**The Aerospace Corporation**

**Mission Analysis of  
Photovoltaic Solar Energy Systems**

**CONTRACTING AGENCY:  
NATIONAL SCIENCE FOUNDATION  
RESEARCH APPLIED TO NATIONAL NEEDS**

**GRANT NUMBER: GI-44099**  
**PERIOD OF GRANT: 15 MONTHS [1 June 1974-31 August 1975]**  
**AMOUNT OF GRANT: \$233,900**  
**PRINCIPAL INVESTIGATOR: DR. A. B. GREENBERG**

## STUDY OBJECTIVES AND SCOPE

DEVELOP PROCEDURES FOR EVALUATING CANDIDATE PHOTOVOLTAIC SYSTEMS  
AS APPLIED IN ALTERNATIVE MISSIONS

ASSESS ALTERNATIVE MISSIONS FOR PHOTOVOLTAIC SYSTEMS AND IDENTIFY  
THOSE OF GREATEST POTENTIAL

- FOUR SPECIFIC MISSION CLASSES
  - ON-SITE (supplemental) POWER
  - CENTRAL STATION POWER
  - FUEL/FEEDSTOCK PRODUCTION
  - SPECIAL PURPOSE APPLICATIONS
- GEOGRAPHICAL AREA - SOUTHWESTERN U. S.
- TIME PERIOD - 1980-2000

ESTABLISH TECHNICAL AND ECONOMIC GOALS FOR SYSTEM, SUBSYSTEM, AND  
COMPONENT DESIGN AND PERFORMANCE

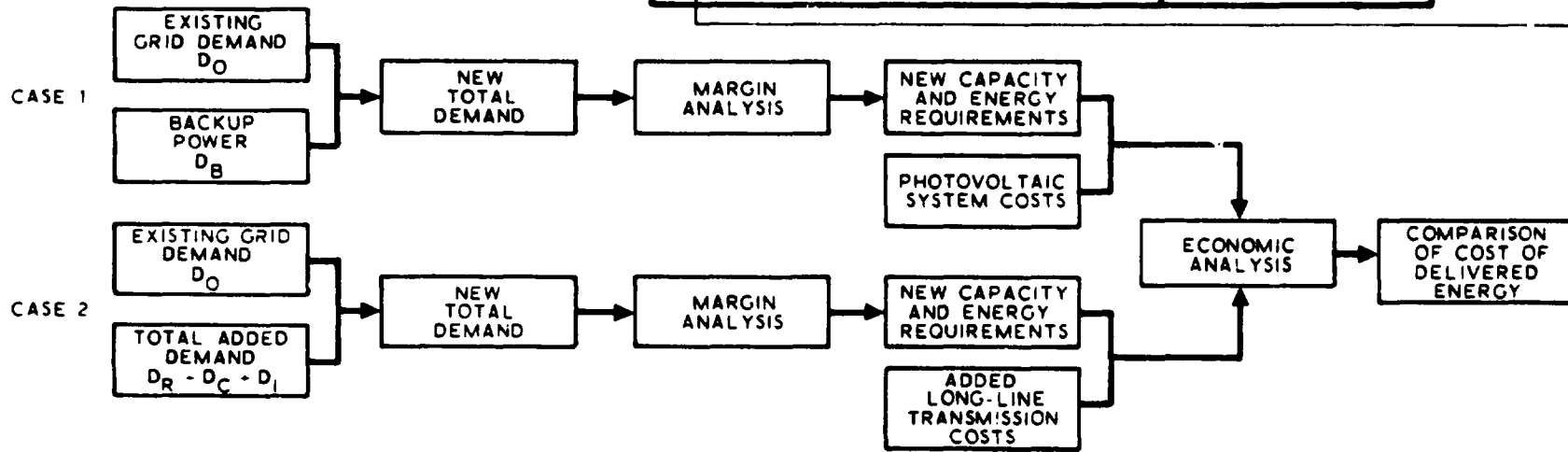
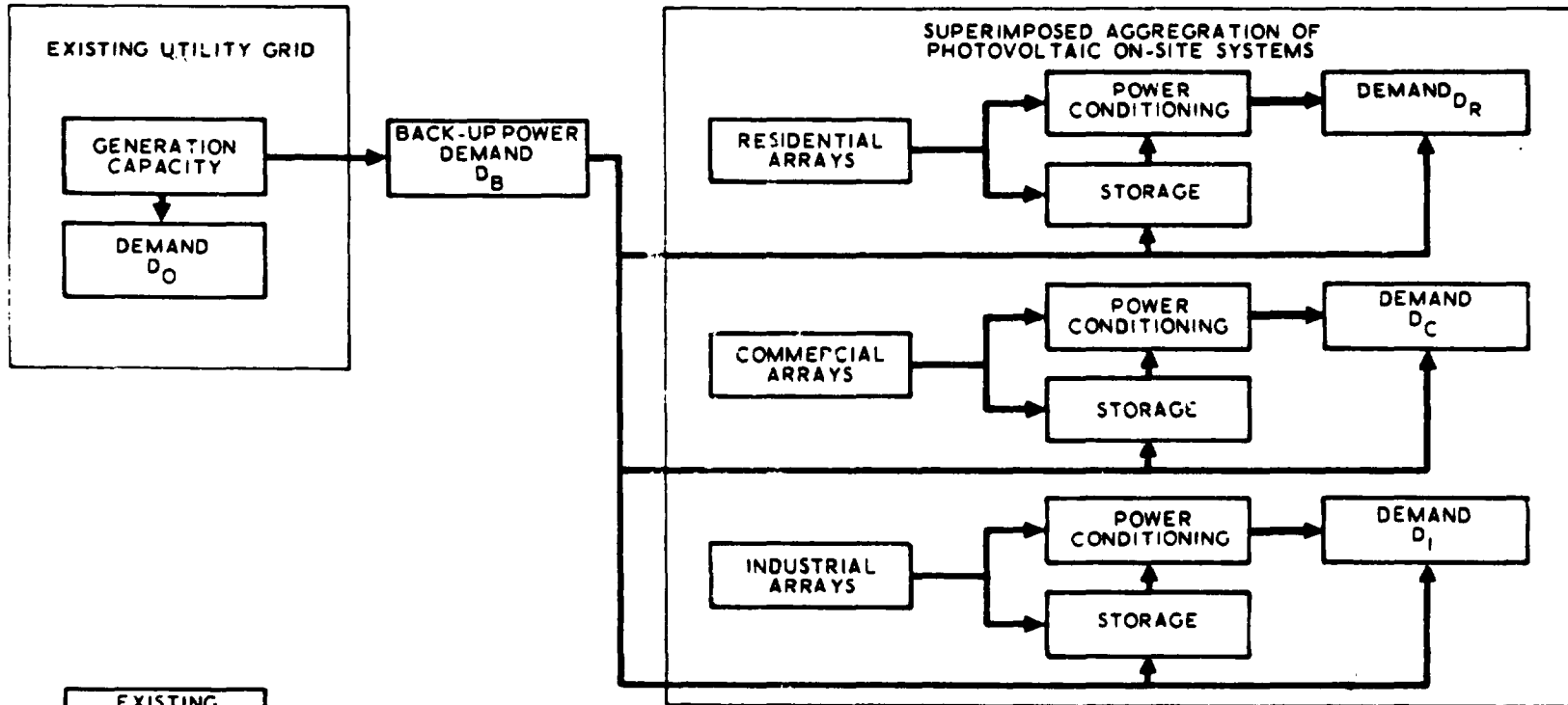
DETERMINE THE MARKET CAPTURE POTENTIAL AND IMPACT ON RESOURCES  
OF THE PREFERRED PHOTOVOLTAIC CONVERSION MISSION(S)

## **Planned Activity: 1 January-30 June, 1975**

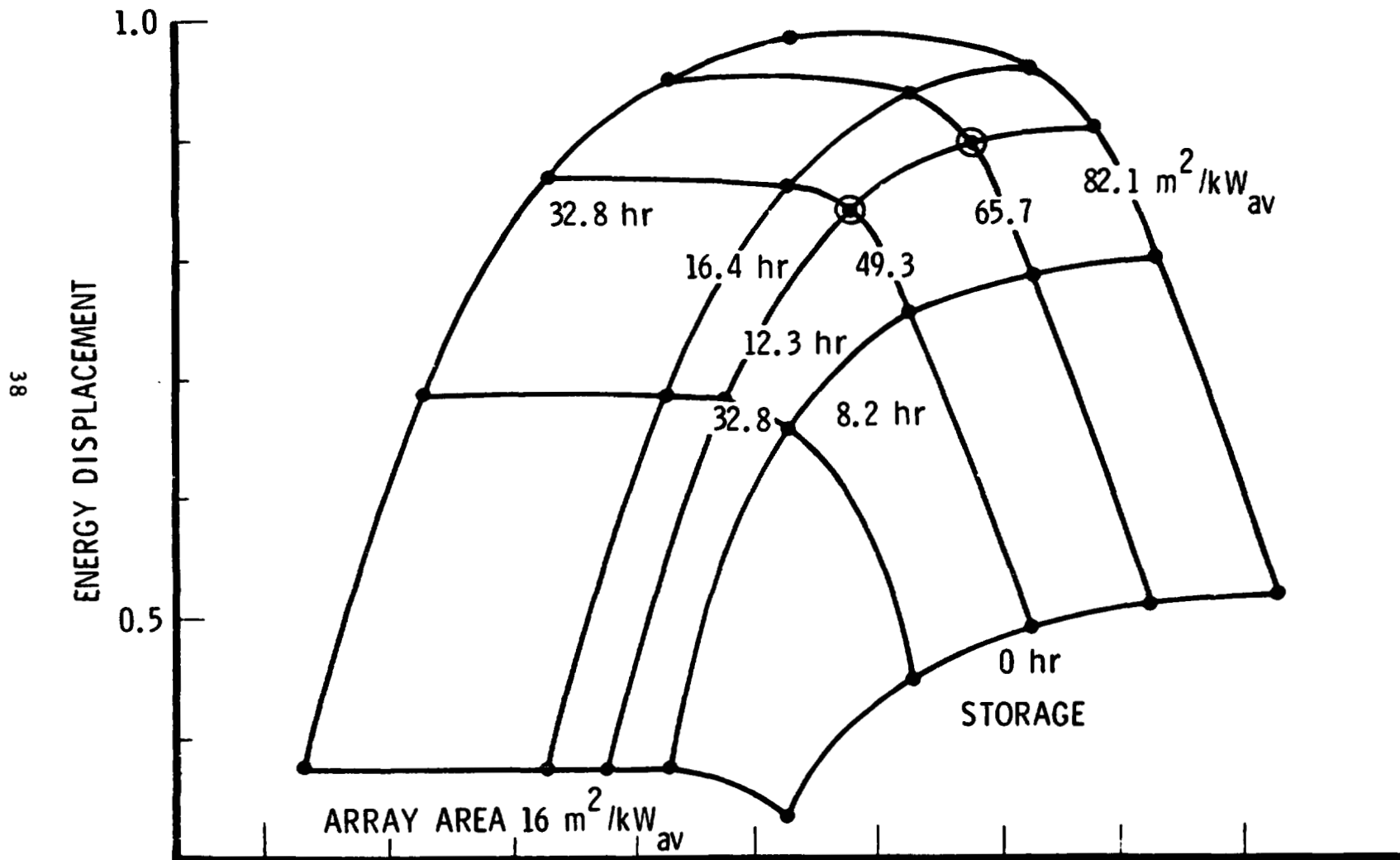
- CONTINUE EVOLUTIONARY DEVELOPMENT OF SYSTEM SIMULATION SUBROUTINES
- FINISH EVALUATION OF ON-SITE MISSIONS
  - USE SYSTEM-SIMULATION MODEL TO EVALUATE PERFORMANCE
  - INVESTIGATE COST/PERFORMANCE TRADEOFFS IN SUBSYSTEM DESIGN
  - CARRY OUT PRELIMINARY COST/PERFORMANCE OPTIMIZATION
  - DETERMINE COST OF DELIVERED ENERGY, COMPARE WITH CONVENTIONAL SYSTEMS
- DEVELOP AND BEGIN APPLICATION OF METHODOLOGY FOR EVALUATING FUEL-PRODUCTION MISSIONS
- BEGIN APPLICATION OF PREVIOUSLY DEVELOPED METHODOLOGY TO EVALUATION OF CENTRAL-STATION POWER PLANTS
- REVIEW EXISTING STUDIES OF SPECIAL-PURPOSE APPLICATIONS
- ASSESS IMPACT ON PHOTOVOLTAIC-SYSTEM DEVELOPMENT OF EXTERNAL ISSUES
  - ENVIRONMENTAL FACTORS
  - DEMANDS ON NATURAL RESOURCES
  - INSTITUTIONAL CONSTRAINTS

# Mission Methodology – On - Site

ORIGINAL PAGE IS  
OF POOR QUALITY



# Residential Photovoltaic System in Phoenix



## Required Additional Conventional Generation Capacity

CASE	MULTIPLYING FACTOR	ARRAY AREA (m <sup>2</sup> /kW <sub>av</sub> )	STORAGE CAPACITY (hr)	FORECASTING	REQUIRED NEW CAPACITY (MW)
PHOENIX INSOLATION	1	49.3	12.3	NO	4.0
		49.3	12.3	YES	0.019
		65.7	12.3	NO	1.8
		65.7	12.3	YES	0
		0	0	-	190.0
SYNTHETIC RESIDENTIAL DEMAND	10	49.3	12.3	NO	150.0
		49.3	12.3	YES	4.7
		65.7	12.3	NO	58.0
		65.7	12.3	YES	0
		0	0	-	2169.0



# Cost of Meeting New Residential Demand

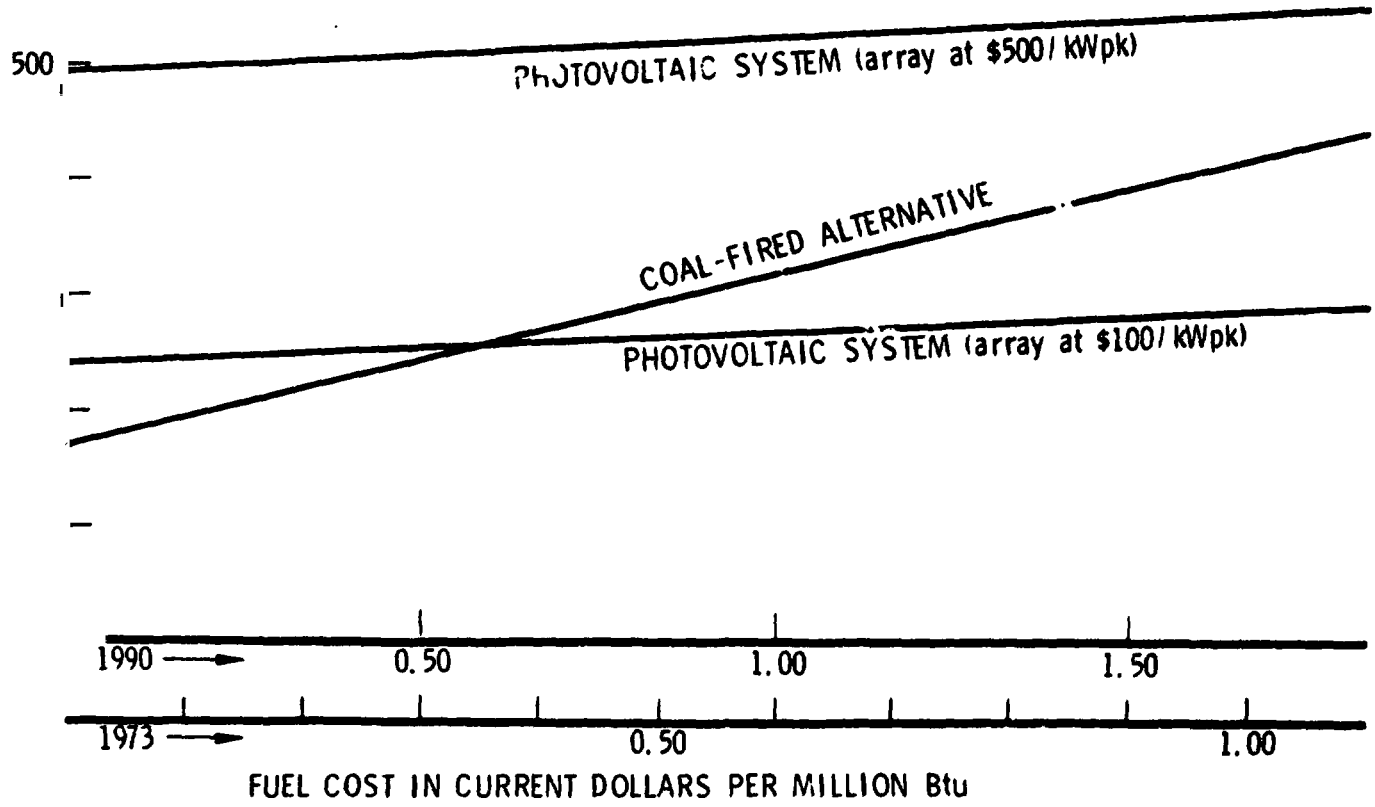
1990 PRESENT VALUE IN MILLIONS OF 1990 DOLLARS

	AVERAGE NEW DEMAND	
	121.8 MW	1218 MW
<u>CONVENTIONAL ALTERNATIVE</u>		
• CAPITAL COST (coal plant at \$11.1/kW)	116.7	1331.8
• OPERATING COSTS		
FUEL (coal at 4.54 mills/kW <sub>h</sub> )	84.9	849.0
O&M (coal plant, \$15.97/kW <sub>av</sub> )	36.8	368.0
• TRANSMISSION (100 miles at \$450/MW-mile)	8.6	97.6
TOTAL	247.0	2646.4
<u>PHOTOVOLTAIC</u>		
(array area = $6(10^6)m^2$ , storage = $1.5(10^6)kW_h$ )		
• CAPITAL COST		
STORAGE (at \$20/kW <sub>h</sub> )	30.0	300.0
POWER CONDITIONING (\$35/kW)	10.3	103.0
ELECTRICAL, WIRING (\$7/kW)	4.5	45.0
ARRAY/SUPPORT STRUCTURES (\$X/m <sup>2</sup> )	6X	6X
• PHOTOVOLTAIC O&M (2 mills/kW <sub>h</sub> )	35.0	350.0
• BACKUP ENERGY		
FUEL (coal at 4.54 mills/kW <sub>h</sub> )	14.0	140.0
O&M (coal plant, \$15.97/kW)	6.0	60.0
• BACKUP CAPACITY (coal plant at \$15.4/kW)	2.5	92.0
TOTAL	102.3 + 6X	1013.0 + 6X

## Allowed Array Costs

CASES	AVERAGE DEMAND 121.8 MW				AVERAGE DEMAND 1218 MW			
	ARRAY PLUS SUPPORT		ARRAY ALONE (support at \$15/m <sup>2</sup> )		ARRAY PLUS SUPPORT		ARRAY ALONE (support at \$15/m <sup>2</sup> )	
	\$/m <sup>2</sup>	\$/kW <sub>pk</sub>	\$/m <sup>2</sup>	\$/kW <sub>pk</sub>	\$/m <sup>2</sup>	\$/kW <sub>pk</sub>	\$/m <sup>2</sup>	\$/kW <sub>pk</sub>
<u>NO FORECASTING</u>								
BASELINE CASE	24.12	227.55	9.12	86.04	25.94	244.72	10.94	103.21
$\eta(70^\circ) = 16\%$	38.59	227.00	23.59	138.76	41.50	244.12	26.50	155.88
STORAGE \$50/kWh	16.62	156.79	1.62	15.28	18.44	173.96	3.44	32.45
POWER CONDITIONING \$100/kW	20.92	197.36	5.92	55.85	22.74	214.53	7.74	73.02
<u>PERFECT FORECASTING</u>								
BASELINE CASE	23.38	220.57	8.38	79.06	26.27	247.83	11.27	106.32
$\eta(70^\circ) = 16\%$	37.41	220.06	22.41	131.82	42.04	247.29	27.04	159.06
STORAGE \$50/kWh	15.88	149.81	0.88	8.30	18.77	177.08	3.77	35.57
POWER CONDITIONING \$100/kW	20.18	190.38	5.18	48.87	23.07	217.64	8.07	76.13

TOTAL PRESENT-VALUE COST-MILLIONS OF 1990 DOLLARS



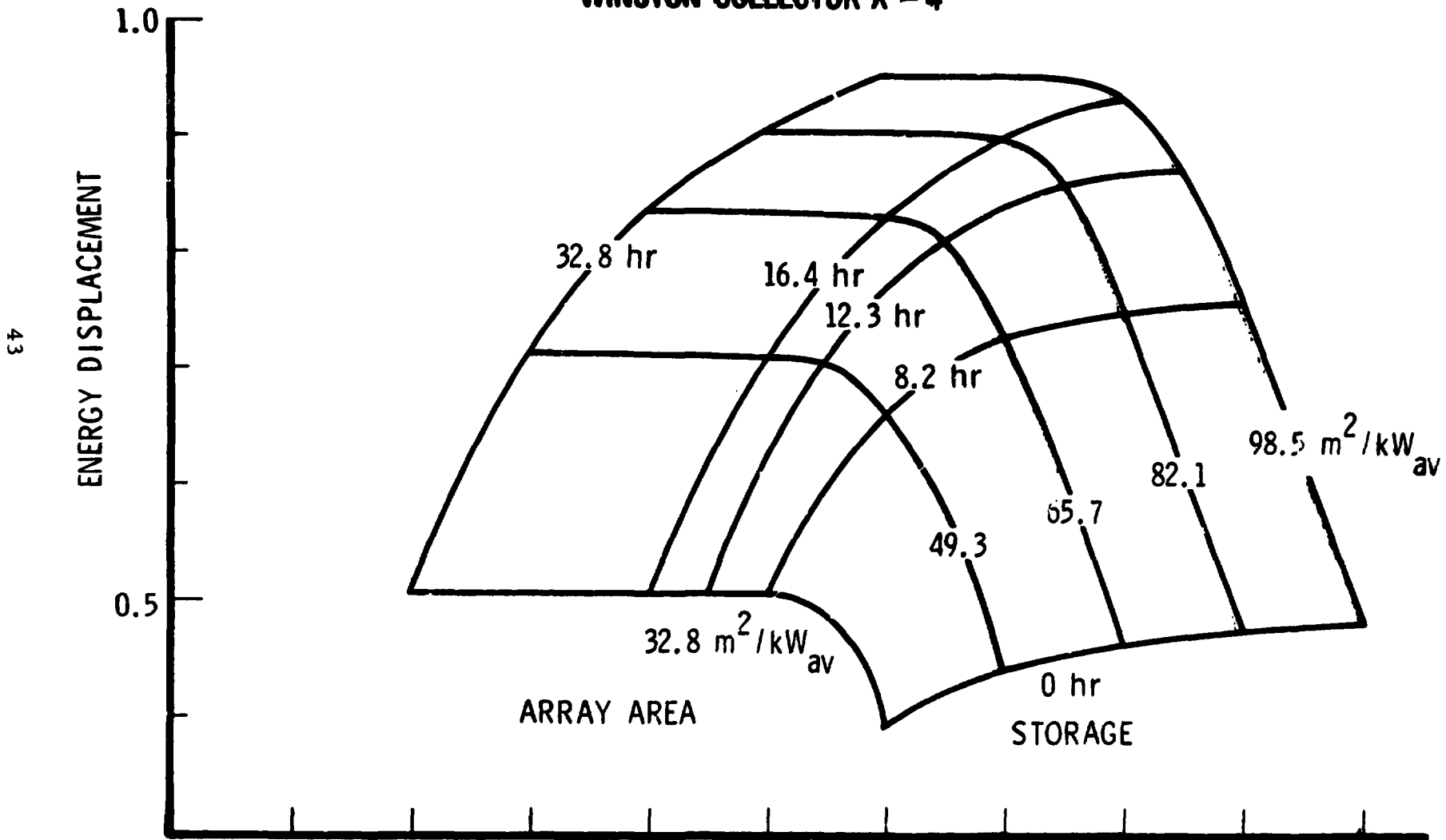
1990 →

1973 →

FUEL COST IN CURRENT DOLLARS PER MILLION Btu

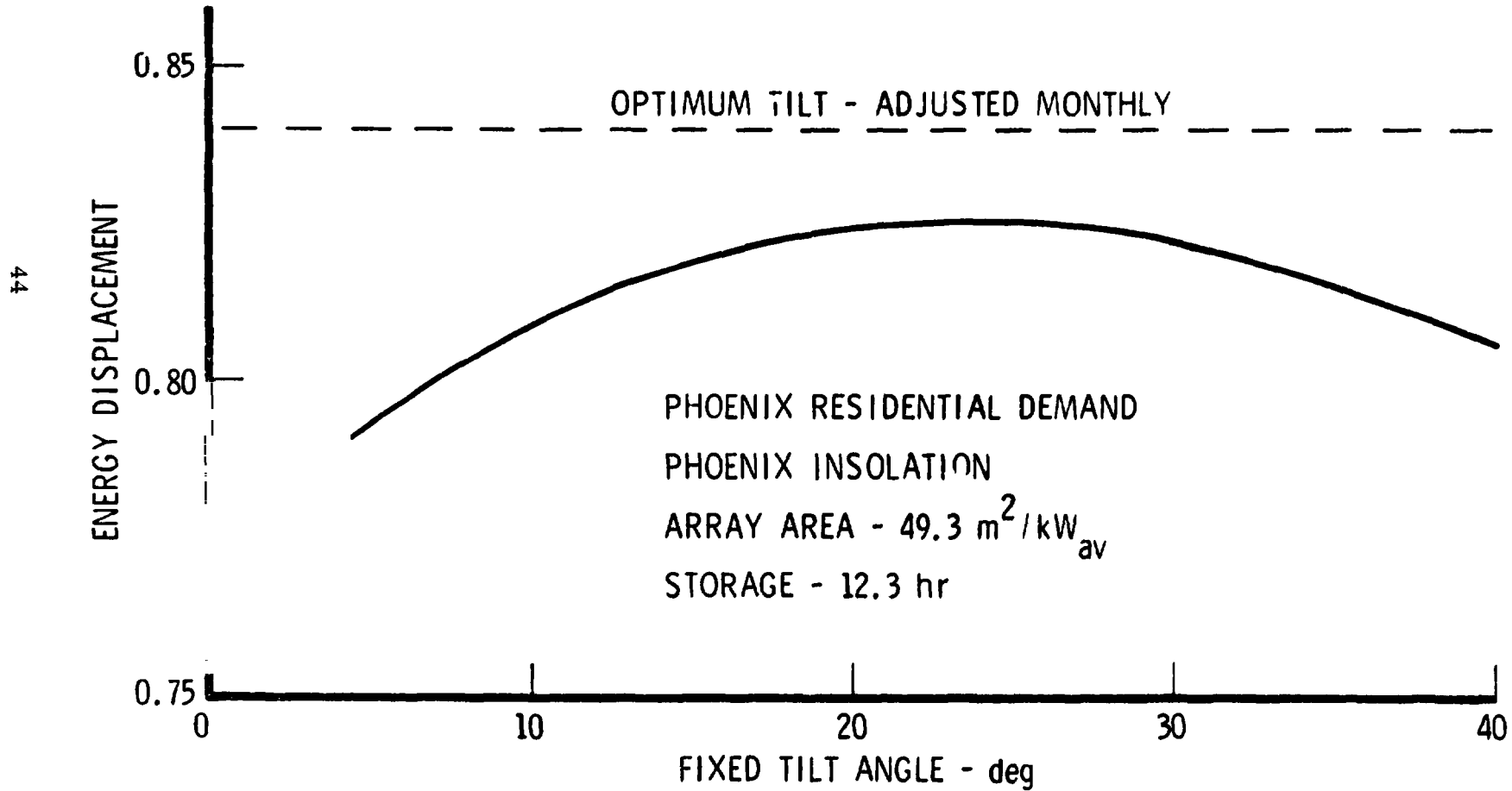
# Phoenix Residential System

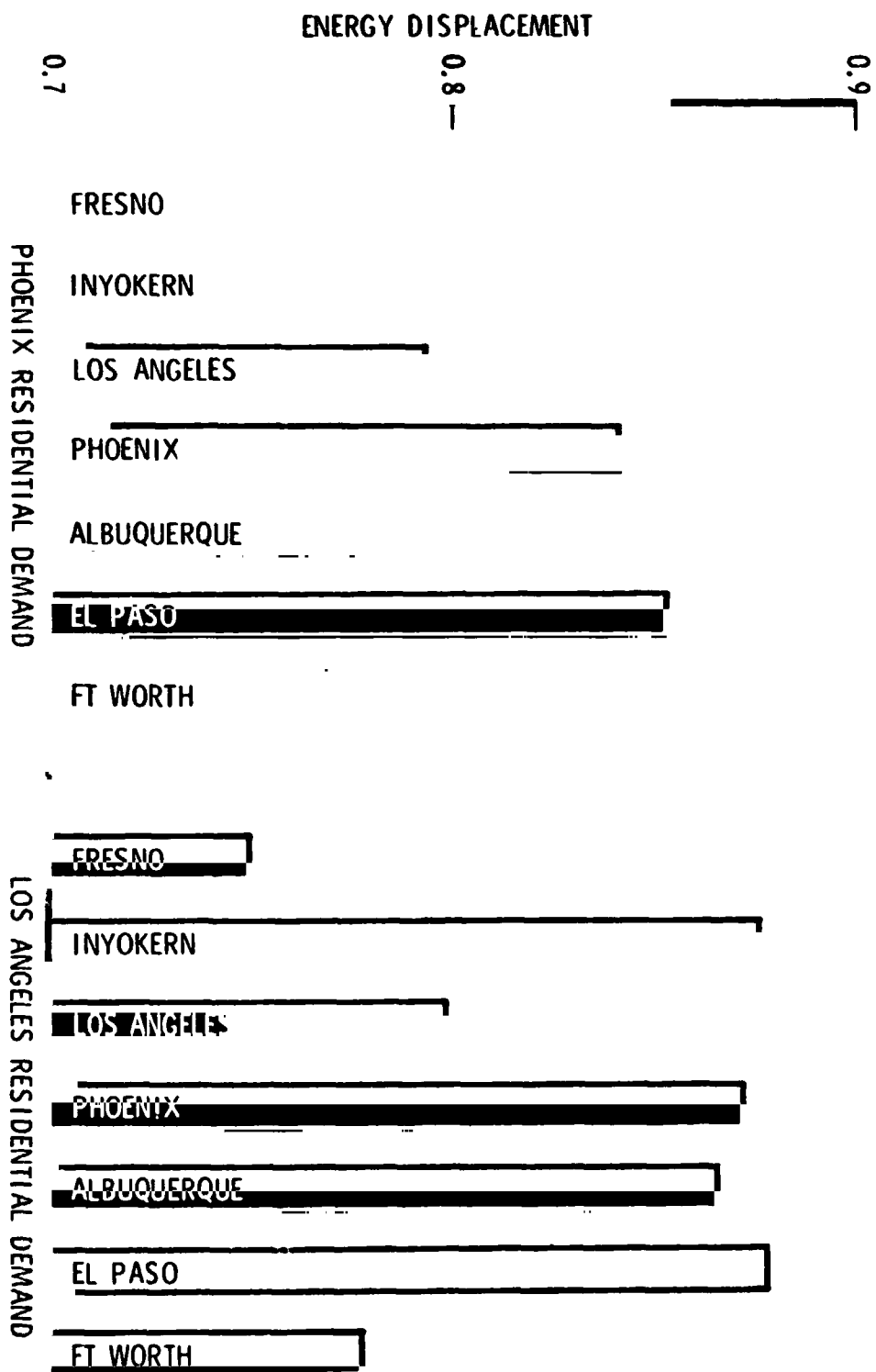
WINSTON COLLECTOR  $X = 4$



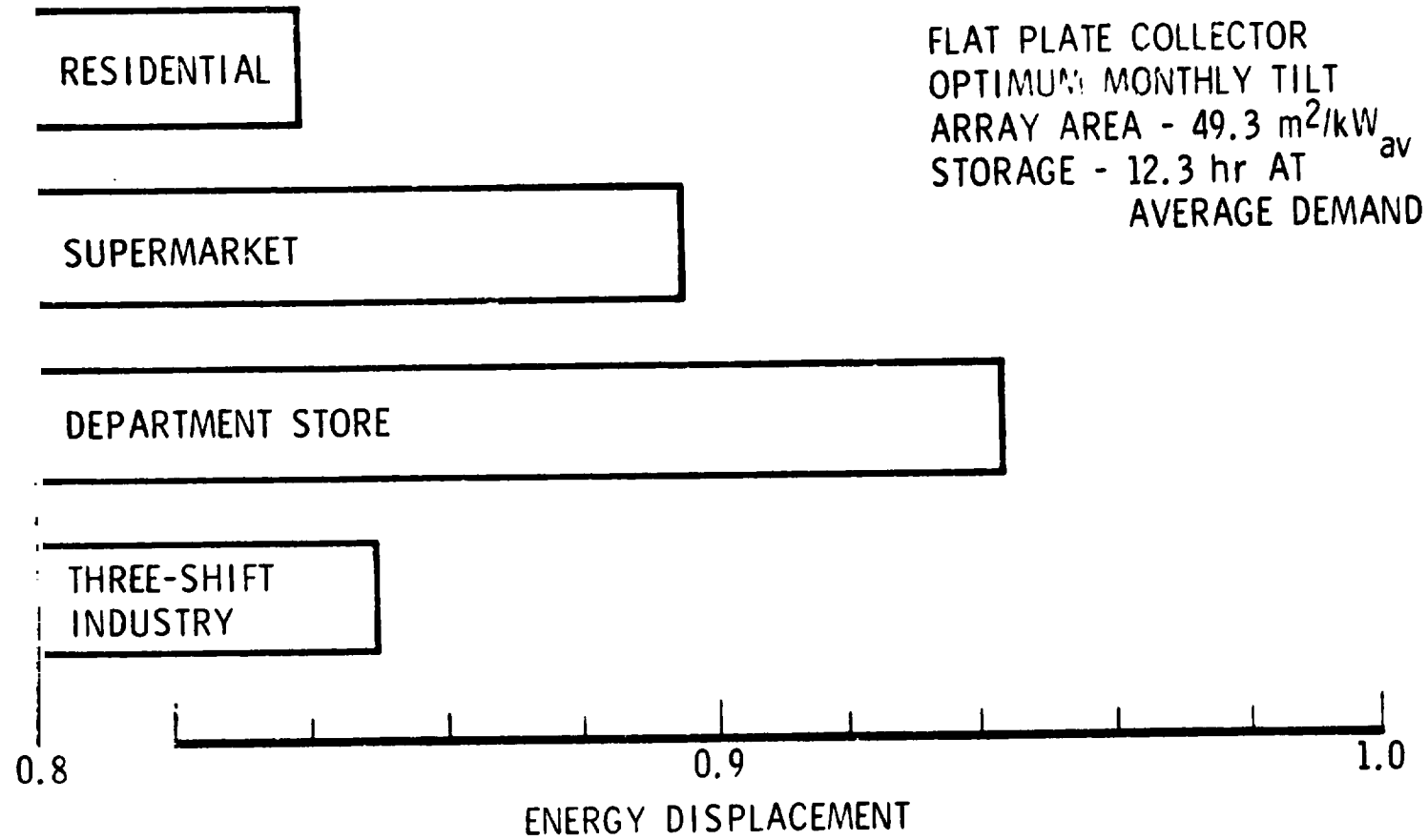
# Performance - Flat Plate Collector

FIXED TILT vs ADJUSTABLE TILT





# Energy Displacement-On-Site Systems in Phoenix



# Summary of Key Results

1 JAN TO 1 JUL 1975

## ON-SITE MISSIONS

- RESIDENTIAL/COMMERCIAL/INDUSTRIAL DEMAND REPRESENTATIONS PREPARED
- SIMULATION MODEL SOFTWARE COMPLETED
- TECHNICAL/ECONOMIC EVALUATION PROCEDURE OPERATIONAL
- ANALYSIS OF REPRESENTATIVE MISSIONS/SYSTEMS
- PERFORMANCE SENSITIVITY STUDIES
  - GEOGRAPHICAL LOCATIONS
  - DEMAND TYPE
  - ARRAY TYPE
  - ARRAY AREA
  - STORAGE CAPACITY
- INITIAL ECONOMIC SENSITIVITY STUDIES
  - FORECASTING vs NO FORECASTING
  - MARKET PENETRATION
  - SUBSYSTEM COSTS

## CENTRAL STATION MISSIONS

- SIMULATION MODEL SOFTWARE ADAPTED FROM SOLAR THERMAL CASE
- POWER PLANT ECONOMIC MODEL ADAPTED
- IMPROVED DISPATCH MODEL UNDER DEVELOPMENT
- INITIAL TECHNICAL/ECONOMIC EVALUATION RUNS UNDER WAY

## FUEL PRODUCTION MISSIONS

- EVALUATION PROCEDURE ADOPTED
- INVESTIGATION OF PROJECTED COSTS OF COMPETITIVE FUELS UNDER WAY



# Planned Activities

1 JUL TO 31 AUG 1975

## CENTRAL STATION MISSIONS

- TECHNICAL/ECONOMIC EVALUATION OF REPRESENTATIVE EXAMPLES
  - BASELOAD
  - INTERMEDIATE
  - PEAKING
- IMPLEMENT IMPROVED DISPATCH ROUTINE
- DEVELOP/IMPLEMENT MODEL FOR THREE SOLAR PLANTS AT DIFFERENT SITES

## FUEL PRODUCTION MISSIONS

- DETERMINE PROJECTED COST OF HYDROGEN FROM PHOTOVOLTAIC ELECTROLYSIS
- COMPARE WITH PROJECTED COSTS OF COMPETITIVE FUELS

## SPECIAL PURPOSE APPLICATIONS

- REVIEW EXISTING STUDIES

# Planned Renewal Request

## MISSION ANALYSIS AND PROGRAM SUPPORT FOR THE SOLAR PHOTOVOLTAIC CONVERSION PROGRAM

SUGGESTED PERIOD: 1 OCTOBER 1976 - 30 SEPTEMBER 1977

ESTIMATED COST: MISSION ANALYSIS - \$400K; PROGRAM SUPPORT - \$62K

### MAJOR OBJECTIVES:

- MISSION ANALYSIS
  - USE DEVELOPED METHODOLOGY FOR SYSTEMATIC EVALUATION OF ON-SITE ELECTRIC AND CENTRAL STATION APPLICATIONS
  - EXTEND COVERAGE TO THE 48 CONTIGUOUS STATES
  - DEVELOP AND UTILIZE PROCEDURES FOR EVALUATION OF PHOTOVOLTAIC TOTAL ENERGY SYSTEMS
  - DETERMINE TECHNICAL AND ECONOMIC REQUIREMENTS FOR SYSTEMS/SUBSYSTEMS
  - ASSESS SOCIETAL IMPACT OF WIDE-SPREAD USAGE
- PROGRAM SUPPORT
  - ASSIST IN MONITORING ERDA SYSTEMS ANALYSIS CONTRACTS
  - PROVIDE PLANNING ASSISTANCE

STATUS OF THE PHOTOVOLTAIC  
CONCEPTUAL DESIGN AND SYSTEMS ANALYSIS RFP

Leonard M. Magid  
Division of Solar Energy  
Energy Research and Development Administration  
Washington, D. C. 20545

The National Photovoltaic Conversion Program has recently awarded three contracts totaling slightly more than \$1.4M for the first Conceptual Design and Systems Analysis (Phase Zero) studies of solar photovoltaic conversion systems.

The systems to be analyzed, as shown in Figure 1, include:

1. An on-site residential system in the 1 to 10 peak kW demand range.
2. A central station power plant in the 50 to 1,000 MW demand range.
3. An intermediate range application in the 100 kW to 10 MW level.

The awards, each for a 12 month effort starting in June 1975, are to:

General Electric Corp.	-	\$472K
Spectrolab, Inc.	-	\$413K
Westinghouse Electric Corporation	-	\$528K

In addition to the technical evaluations, each study will also provide an assessment of the financial, environmental, legal, institutional and related issues associated with the actual implementation of photovoltaic conversion systems. To accomplish these

objectives, the project have formed teams that include engineers, architects, economists, lawyers and representatives from utilities and university research centers, as indicated in Figure 2.



CONCEPTUAL DESIGN AND SYSTEMS ANALYSIS  
OF PHOTOVOLTAIC POWER SYSTEMS

SYSTEMS TO BE ANALYZED

1. ON-SITE RESIDENTIAL

1 - 10 kWe PEAK DEMAND

30 - 100 kWh DAILY DEMAND

2. CENTRAL STATION POWER PLANT

50 - 1000 MWe DEMAND

3. INTERMEDIATE RANGE SYSTEM

100 KWe - 10 MWe DEMAND

FIG. 1



CONCEPTUAL DESIGN AND SYSTEMS ANALYSIS  
OF PHOTOVOLTAIC POWER SYSTEMS

I. GENERAL ELECTRIC CORP. - \$472K

WITH: SHELDAHL CORP.

PENNSYLVANIA POWER AND LIGHT CO.

II. SPECTROLAB, INC. - \$413K

WITH: BECHTEL CORP.

FACILITIES SYSTEMS ENGIN. CORP.

MIDWEST RESEARCH INSTITUTE

ARIZONA STATE UNIVERSITY

III. WESTINGHOUSE ELECTRIC CORP. - \$528K

WITH: BURT, HILL AND ASSOCIATES

CHARLES RIVER ASSOCIATES

FORD, BACON AND DAVIS

PHILADELPHIA ELECTRIC CO.

TRW

UNIVERSITY OF PENNSYLVANIA

FIG. 2