5220-6
Photovoltaics Program
Technology Development and Applications
Lead Center

Photovoltaic Residential Applications Program Implementation Workshop Proceedings

February 12-13, 1980

(NASA-CR-163274) PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP PROCEEDINGS (Jet Propulsion Lab.) 166 p HC A08/MF A01 CSCL 10B

N80-26768

Unclas
G3/44 23617

May 15, 1980

Prepared for
U.S. Department of Energy
Through an agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

(JPL PUBLICATION 80-22)

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SECTION I

INTRODUCTION

Prepared by: Rosalyn Barbieri (JPL)

A workshop was held at the California Institute of Technology on February 12-13, 1980 to discuss factors which would impact the implementation of a Photovoltaic Residential Applications Program. Sponsored by the Jet Propulsion Laboratory (JPL), this workshop brought together twenty-six individuals from private industry, universities, national laboratories, and the Department of Energy (DOE).

There were two major aspects of the workshop:

(1) Presentations on aspects of the Photovoltaic Program and the National Solar Heating and Cooling Demonstration Program to provide a common basis for discussion.

(2) Focused discussions to elicit response and dialogue on the issues pertinent to the Residential Applications Program.

The workshop consisted of four sessions composed of brief presentations by participants and moderated discussions. The first session was an introduction to the Photovoltaics Program as a context for the Residential Applications Program. The second session discussed the Solar Heating and Cooling Demonstration Program and the structure and operation of the residential market. The third session studied the factors to be considered in the design of non-hardware experiments. The fourth session consisted of a working forum in which the ideas and suggestions from the previous sessions were summarized and synthesized.

The agenda for the Photovoltaic Residential Application Program Implementation Workshop (Appendix A) shows how the workshop was broken down into the various presentations and topics discussed. Copies of the conference viewgraphs (Appendix B) provide further detail on the presentations. Remarks from attendees (Appendix C) are included with suggestions stimulated from the workshop. A bibliography (Appendix D) indicates the amount of information available on issues relevant to the program. It is no way inclusive nor does it indicate a higher value of those documents over those not included. Preconference communications and a list of attendees (Appendix E) are also included.

A. OBJECTIVE OF THE WORKSHOP

The objectives of the Photovoltaic Residential Applications Program Implementation Workshop were:

(1) To provide a forum for dialogue on JPL/DOE plans for the residential applications program in the context of the entire Photovoltaics Technology Development Program;

(2) To discuss approaches to the detailed implementation of the Residential Applications Program based on the experience of the Solar Heating and Cooling Program and other relevant concerns;

(3) To aquaint potential program participants with program objectives and begin to involve them in the planning process.

SECTION II

SUMMARY OF PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

Prepared by: Dr. Richard Tabors, MIT-Energy Laboratory

A. PURPOSE

The Photovoltaic Residential Application Implementation Workshop was held to introduce and discuss a set of concepts in the development and implementation of the residential component of the photovoltaics program. Because there was a significant number of individuals present who had not been previously involved in the photovoltaics program, the purpose was extended to include an introduction to the photovoltaics program, the residential implementation plan as currently drafted and the activities currently being proposed as components of the multiyear purchase program.

B. SESSION I - INTRODUCTION AND CONTEXT

The first session introduced the concepts involved in the Multi-Year Program Plan (MYPP), the current residential program and the multi-year purchase program. Given the nature of the session there was little discussion of the underlying assumptions of the program, or of the technology development objectives and their likelihood of achievement.

C. SESSION II - INFRASTRUCTURE DEVELOPMENT

The second session focused attention on the development of an infrastructure within the construction industry from which to build a residential photovoltaics market. The first component discussion focused around the activities which were undertaken by the Department of Housing and Urban Development in the Solar Heating and Cooling (SHAC) program. While there was explicitly not an effort to evaluate SHAC, there was considerable discussion concerning the purpose of the SHAC program and its targets and implementation. There was considerable discussion on the correct audience for activities such as a solar heating and cooling demonstration program and/or a photovoltaics demonstration program. There was concern that there be a clear definition of the audience in the early phases of the program lest there be a misconception of the readiness of the technology or specific components for the market.

Five conclusions/recommendations emerged from the first component of this portion of the workshop.

(1) Experiments should be advertised as experiments not as demonstrations and the objectives of the experiments should be spelled out carefully so that persons looking into the program will recognize them for what they are.

(2) It is likely that the cast of characters involved in development of the market for residential photovoltaic power systems will evolve as the program evolves. It is not necessary to have a complete organization in place or to have all actors involved in every stage of the process.

(3) An experiment which can parallel the technical development work over the next several years should be developed to handle the "soft" issues of the market development process.

(4) If there is to be a significant involvement of electric utilities in the residential photovoltaic power system and/ and/or the decision of an individual to purchase such a system, the state public utility commissions should be involved as soon as possible.

(5) Considerable thought should be given to the channels of information used to communicate the concept of photovoltaics to the potential buyers or installers. It was pointed out that one visit between trades persons may be worth one ton of paper generated by governmental study groups.

The second component of the infrastructure section of the workshop dealt specifically with the role of the builder and/or contractor in the market development process. The discussion involved a number of attendees formerly active in the SHAC photovolatics program. Their comments reinforced and added to many of the conclusions from the proceeding session.

There is a tremendous conservatism in the residential building industry which makes innovation a difficult and slow process. In general, the labor pool works inversely to the economic structure of the industry. In good times the skilled labor pool is diluted as additional workers are pulled in, making innovation unlikely given skills levels. At bad times, when there may be excess skilled manpower, there is frequently additional financial conservatism working against innovation. It was generally agreed that innovation occurred within the residential sector at times of stability both within an individual firm and within the industry as a whole.

Large builders generally will innovate with processes while small builders will innovate with materials.

A discussion was introduced on how best to bring a concept into the residential market — working from the custom built homes or from public housing (governmental sector). The strong conclusion was that the housing market always began at the best homes and worked its way down. The reasoning behind this was twofold. First "aspiration" played an important part in the filtering down effect. Second, placing any new product in low income housing both guaranteed its rejection from above and its rejection within the lower income environment where the "guinea pig" syndrome was of major concern.

Finally, the pathway used for introduction of the product must be the established one. Communications occur between the manufacturer, supplier, subcontractor, etc. These should be maintained and strengthened for photovoltaics to enter smoothly and routinely.

D. SESSION III - NON-HARDWARE AND SUB-EXPERIMENT DESIGN

The third session focused on the development of experimental designs for collection of market data in conjunction with the residential experimental work currently a portion of the program, or with the proposed multi-year purchase. Strategy discussion centered in two specific areas. The first was the development of market response data using rolling panels to collect large quantities of data from relatively smaller samples of respondents. The second discussion area was the use of experiments designed to collect specific data for econometric analysis of potential consumer response.

The conclusions drawn from this session were similar to those of the first session.

Technical experiments should be designed so as to collect a maximum quantity of economic and market data from those participating in and/or observing the experiment.

It is important to carry out the experiments in an environment where there is contact with those individuals who will be involved in the final marketing of the residential systems. It is also important to maintain the experimental nature of the presentation and the data collection activity.

There are a number of data analysis and organization structures which may be of use in planning for the governmental role in final market deployment of residential photovoltaic systems. The data requirements for each of these should be evaluated in the near term if they are to be incorporated into the experiments of the next two years. This will assure that the programs management will be able to prepare appropriate solicitations and seek the participation of groups and institutions which would further the objectives of the photovoltaics program. This should also include the ability to incorporate individual components of the residential program into an overall program structure that includes both milestones for governmental activities and points of evaluation for further governmental involvement. In addition, it is necessary to recognize that it is the private marketplace that is the final instrument for acceptance of photovoltaics. Many activities can be accomplished more effectively through private industry than through government intervention.

There were a number of specific suggestions as to programmatic activities both to introduce photovoltaic systems to the residential housing market and to solicit information from individuals within that market.

The following is a summary of suggestions:

A set of smaller workshops for subgroups within the building community should be held. These should involve a separate small workshop for architects, for professional engineers, for architectural and engineering firms, and for builders. A note of caution was requested in the timing and information presented in these sessions and it was suggested that the material and meetings be presented by members of the craft rather than by members of the photovoltaics program. By extension, it may be argued that this suggestion carries over into other specific portions of the market such as electric and public utility commissions, insurance industry representatives and possible to the financial community.

A set of comments focused specifically on the organization of cycles or rounds associated with the proposed multiyear purchase strategy. The most frequent of these was a concern for involvement of a number of groups.

E. SESSION IV -- WORKSHOP SUMMARY AND SYNTHESIS

The final session of the workshop was intended to bring together a number of the themes covered in the earlier sessions and to elicit from the individual participants a sense of the meeting in terms of the potential areas of action -- and areas of potential problems -- within the residential sector.

In response to governmental initiatives, there were a number of points brought out concerning both the type of solicitation required and the anticipated lead organization. The model which appeared to have the most support was one in which the solicitation appeared directly from the government and called for a team effort involving the architect, builder, photovoltaic manufacturer, developer and possibly also the final consumer. The discussion from representatives of architectural firms was that they would be the logical leaders for such a team effort, and that in all liklihood they could and would respond on relatively short notice. The model of going directly to the developer did not have much support, particularly given the problems associated with this model when used with the SHAC program. Other models such as complete laboratory control were seen as necessary in early experiments but less acceptable later in the market development process.

Throughout the meeting, there was a stress on stating the objectives of the experimental, purchase strategy or market development programs early in the planning process. This would include architects, developers, builders, etc., in a program that could, with a relatively small number of experiments, work out many of the logistical bugs. Such early actions could accelerate the rate of purchase activities and, at the same time, absorb some of the risk associated with the much larger purchases scheduled for one to three years later. It was pointed out, however, that these activities should be integrated with the technical experimental work already underway.

The workshop ended with a number of the participants agreeing to later discuss the organization of additional meetings which would involve smaller professional groups. It was evident from the discussions that the first of these proposed meetings will be open to architects and planners.

SECTION III

RESULTS AND PROGRAMMATIC RESPONSE

Prepared by: Rosalyn Barbieri, Tom W. Hamilton (JPL)

The workshop elicited a great deal of discussion, ideas, suggestions, and recommendations on issues pertinent to the Photovoltaic Residential Applications Program. While specific action items did not come out of the workshop, issues and approaches were raised which have generated programmatic activities and discussion on how to formulate the Residential Applications Program. In addition, the workshop stimulated certain participants to subsequently provide additional suggestions of benefit to the program.

The group of participants also has created a resource for the photovoltaics program which can be used to provide advice, review and comment, and channels of communication to their colleagues. Feedback from these individuals will increase the ability of the photovoltaics program to provide credible programmatic activities. It will also provide a real world perspective on the ability of the program to perform certain functions and meet established goals and objectives.

The wealth of discussion that resulted from the workshop supports the need for continuing these types of interactions. A different organization of the workshop would have elicited different types of discussion and participation from the attendees. Issues not discussed but which are important, are seeds for other workshops of this nature. The workshop provided a much clearer insight for the photovoltaics program as to the parameters required to successfully implement and manage a residential applications program, and particularly the importance and the proper design and use of experiments.

Appendix C contains some after the fact impressions of the workshop. Dorothy Leonard-Barton of SRI International discusses the market diffusion strategy, the importance of proper timing and targeting of experiments and information. She suggests how marketing activities should parallel and complement the system and technology development process. A mission team concept is introduced and described.

Jeffrey L. Smith has summarized his impressions and conclusions arising from Session III. He focused on the distinction between "experiments" designed to elicit new information and "demonstrations" designed to disseminate known information. A clear statement of detailed objectives of each phase of the residential program is essential to an efficient program.

Tom W. Hamilton discusses some nomenclature inconsistencies and offers his impressions of what was learned and what direction the program should take.

APPENDIX A

AGENDA

AGENDA

FEBRUARY 12,1980

SESSION I - INTRODUCTION AND CONTEXT
8:30 a.m. - 11:30 a.m.

Moderator: PAUL CARPENTER, JPL

Presenters: BOB EASTER, JPL
TOM HAMILTON, JPL
ED KERN, MIT/Lincoln Laboratory

Topics:

1. The context of the residential applications program within the photovoltaics program as a whole.

2. The status of current residential technology development and experimentation plans (strawman scale and timing).

3. The objectives of and a strawman implementation approach to the Multi-Year Purchase Program aspects of the Residential Applications Program.

LUNCH
11:30 a.m. - 1 p.m.

SESSION II - INFRASTRUCTURE DEVELOPMENT
1 p.m. - 3:30 p.m.

Moderator: RICHARD TABORS, MIT/Energy Laboratory

Presenters: TOM NUTT-POWELL, Harvard/MIT Joint Center for Urban Affairs
DICK RITTLEMAN, Burt, Hill, Kosar & Rittleman
(presentation Wednesday morning)

Topics:

1. Development of issue agenda--recommendations if appropriate.

2. Work assignments.

End of Day One Sessions

AGENDA (contd)

FEBRUARY 13, 1980

SESSION III

NATURE OF THE HOUSING INDUSTRY AS IT PERTAINS TO THE PHOTOVOLTAIC PROGRAM
8:30 a.m. - 9:30 a.m.

Presentor: DICK RITTLEMAN

Moderator: JEFF L. SMITH, JPL

Presentors: TOM HAMILTON, JPL
FRANK CAMM, Rand Corporation
GARY LILIEN, MIT Sloan School

Topics:

1. Experiment and sub-experiment implementation.

2. Example sub-experiment concepts: user response measurement and rate structure experimentation.

3. Implications of sub-experiment concerns for program design.

LUNCH
11:30 a.m. - 1 p.m.

SESSION IV - WORKSHOP SUMMARY AND SYNTHESIS
1 p.m. - 3:30 p.m.

Moderators: TOM HAMILTON, JPL
PAUL CARPENTER, JPL

Topics:

1. Development of issue agenda--recommendations if appropriate.

2. Work assignments.

APPENDIX B

CONFERENCE VIEWGRAPHS

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

INTRODUCTION, OBJECTIVES AND FORMAT

Paul R. Carpenter

Photovoltaics Lead Center
Planning, Assessment and Integration

February 12-13, 1980

DOE PHOTOVOLTAICS PROGRAM

RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

OBJECTIVES

- TO DISCUSS CURRENT JPL/DOE THOUGHTS ON THE RESIDENTIAL APPLICATIONS PROGRAM IN THE CONTEXT OF THE ENTIRE PHOTOVOLTAICS PROGRAM
- TO CONSIDER APPROACHES TO THE DETAILED IMPLEMENTATION OF THE RESIDENTIAL PROGRAM BASED ON EXPERIENCES IN THE SHAC PROGRAM AND OTHER CONCERNS
- TO ACQUAINT PRESENT AND POTENTIAL PROGRAM PARTICIPANTS WITH PROGRAM OBJECTIVES AND INVOLVE THEM IN THE PLANNING PROCESS

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DOE PHOTOVOLTAICS PROGRAM

RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

I. INTRODUCTION AND CONTEXT

- OVERVIEW OF PV PROGRAM PHILOSOPHY, STRUCTURE AND SCHEDULE

  CONTEXT SURROUDING RESIDENTIAL PROGRAM

  Robert Easter, Jet Propulsion Laboratory

- ON-GOING RESIDENTIAL ACTIVITIES AND PLANS

  TECHNOLOGY DEVELOPMENT, SYSTEMS DESIGN, INITIAL EXPERIMENTATION

  Ed Kern, MIT Lincoln Laboratory

- RESIDENTIAL ASPECTS OF THE "MULTI-YEAR PURCHASE PROGRAM."

  AN IMPLEMENTATION APPROACH AND STRAWMAN SCHEDULE AFTER INITIAL EXPERIMENTATION

  Tom Hamilton, Jet Propulsion Laboratory.

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2/12/80

DOE PHOTOVOLTAICS PROGRAM

RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

AGENDA

TUESDAY 2/12

I. INTRODUCTION AND CONTEXT

II. INFRASTRUCTURE DEVELOPMENT

WEDNESDAY 2/13

III. NON-HARDWARE SUBEXPERIMENT DESIGN

IV. SUMMARY AND SYNTHESIS

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PHOTOVOLTAICS PROGRAM OVERVIEW

Bob Easter

Jet Propulsion Laboratory

Prepared For
Residential Applications Program Implementation
Workshop
February 12-13, 1980

DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

OBJECTIVE

PROVIDE WORKSHOP PARTICIPANTS WITH BACKGROUND AND CONTEXT VIS-A-VIS RESIDENTIAL APPLICATIONS WITHIN PHOTOVOLTAICS PROGRAM AS A WHOLE

RWE 1
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DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

OUTLINE

- CURRENT PHOTOVOLTAICS TECHNOLOGY EVOLUTION SCENARIO
- PHOTOVOLTAICS APPLICATIONS STRATEGY
- UNDERLYING PROGRAM STRUCTURE (THE "LAZY Y")
- KEY MILESTONES
- COMMERCIAL READINESS GOAL SETTING
- COMMERCIAL READINESS PRICE GOALS
- THE PROGRAM MATRIX
- SUBPROGRAM FUNCTIONS
- ROLES (PROGRAM ORGANIZATION CHART)
- RELEVANT PLANS, DOCUMENTS, LEGISLATION
- COMMERCIAL READINESS REQUIREMENTS
- ROLE OF THE MULTI YEAR PURCHASE PROGRAM
- SOME INSTITUTIONAL ISSUES

RWE 2
2/12/80

DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

A PV TECHNOLOGY EVOLUTION SCENARIO

CY	79 – 81	82 – 85	86 – 89	90 – 91	2000
	PHASE 1	PHASE 2	PHASE 3	PHASE 4	
INDUSTRY AND TECHNOLOGY	● Si INGOT COLLECTORS ● NO AUTOMATION ● MODULE SUPPLIERS ● "CUSTOM" SYSTEMS	● Si INGOT AUTOMATED ● Si NON-INGOT PILOTS AND AUTOMATION INITIATED ● CONCENTRATORS (Si) ● MODULE AND SYSTEM SUPPLIERS	● Si NON-INGOT AUTOMATED ● Si INGOT TECHNOL-EXPORTABLE ● ADVANCED COLLECTORS PILOTS	● STABLE (GROWTH) INDUSTRY ● COLLECTOR MIX	.1 TO 1.0 QUAD ANN. DISPL.
MARKETS	● FOREIGN AND DOMESTIC REMOTE UNATTENDED ● 1-5 MW/YR	● FOREIGN AND DOMESTIC REMOTE ATTENDED ● FOREIGN DOMINATES ● 10-100 MW (?)	● FOREIGN AND DOMESTIC GRID-CONNECTED DISTRIB ● DOMESTIC DOMINATES ● FOREIGN MARKET FOR PRODUCTION EQ. 100 MW - ?	● FOREIGN AND DOMESTIC DISTRIB AND CENTRAL 500 MW - ?	
SYSTEM PRICES	10-25 $/Wp	△ CR 6-13 $/Wp	△ CR 1.60 - 2.60 $/Wp	△ CR < 1.60 $/Wp	

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2/12/80

DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAICS APPLICATIONS STRATEGY
(as put forth in the MYPP)

GRID-CONNECTED EMPHASIS - MAJOR SAVINGS OF CONVENTIONAL FUELS REQUIRES PENETRATION OF PV INTO APPLICATIONS NOW SERVED BY ELECTRICAL GRID.

RESIDENTIAL EMPHASIS - FAVORABLE ECONOMICS (RELATIVE TO OTHER GRID-CONNECTED APPLICATIONS) ALLOW RELATIVELY EARLY PENETRATION.

INTERMEDIATE LOAD CENTERS - DIVERSE CLASS, SELECTED ELEMENTS OF WHICH ALSO HAVE POTENTIAL FOR EARLY PV PENETRATION.

CENTRAL STATION - 1990 CR TARGET, TO ALLOW DEVELOPMENT OF LOWER-THAN-BASELINE COST TECHNOLOGIES. AEROSPACE CENTRAL STATION ACTIVITIES SUGGEST POSSIBILITY OF LIMITED PRE-1990 MARKET FOR BASELINE (1986) TECHNOLOGY.

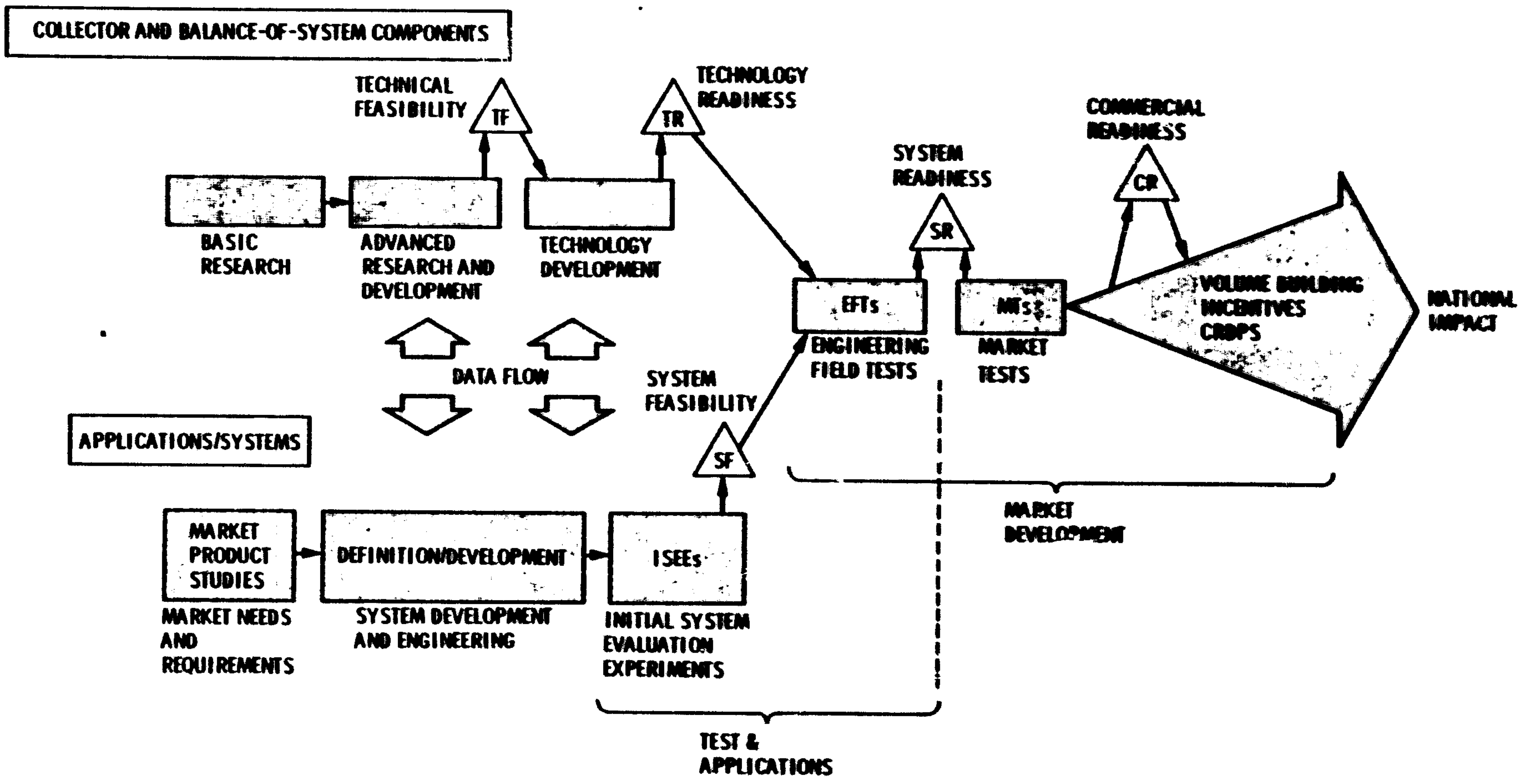
REMOTE STAND ALONE - IMPORTANT AS NEAR-TO-MID-TERM PRODUCT FOR INDUSTRY IN INTERNATIONAL MARKETS

RWE 4
2/12/80

DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

UNDERLYING PROGRAM STRUCTURE



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DOE PHOTOVOLTAICS PROGRAM

KEY MILESTONES IN THE PHOTOVOLTAIC RD&D PROCESS

MILESTONE	DEFINITIONS/REQUIREMENTS
TECHNICAL FEASIBILITY (TF) OF COMPONENTS	TECHNICAL FEASIBILITY IS REACHED FOR A PARTICULAR TECHNOLOGY WHEN: (A) STABLE AND REPRODUCIBLE PERFORMANCE CHARACTERISTICS HAVE BEEN ACHIEVED: (B) A LABORATORY-SCALE PROCESS HAS BEEN DEFINED THAT YIELDS PRODUCTS WITH CONSISTENT CHARACTERISITICS AND: (C) ANALYSIS INDICATES THAT MASS PRODUCTION IS TECHNICALLY FEASIBLE AND LIKELY TO YIELD A TECHNICALLY AND ECONOMICALLY VIABLE PRODUCT AFTER SUITABLE TECHNOLOGY DEVELOPMENT
TECHNOLOGY READINESS (TR) OF COMPONENTS	TECHNICAL READINESS IS ACHIEVED: (A) WITH A SUCCESSFUL SUB-SCALE DEMONSTRATION OF ALL THE INDIVIDUAL STEPS IN A PRODUCTION PROCESS THAT WOULD YIELD ECONOMICALLY COMPETITIVE AND RELIABLE PRODUCTS IF PRODUCED IN SUFFICIENT QUANTITY AND: (B) WHEN PROTOTYPES ARE AVAILABLE FOR INTENSIVE PERFORMANCE AND RELIABILITY ANALYSIS
SYSTEM FEASIBILITY (SF)	SYSTEM FEASIBILITY IS ACHIEVED IN A GIVEN APPLICATION WHEN A PHOTOVOLTAIC SYSTEM CONCEPT IS FIRST CARRIED THROUGH DESIGN, INSTALLATION AND OPERATION IN AN ACTUAL USER'S ENVIRONMENT
SYSTEM READINESS (SR)	SYSTEM READINESS IS ACCOMPLISHED WHEN FULLY INTEGRATED SYSTEMS, USING AVAILABLE TECHNOLOGY READY COMPONENTS OR PROTOTYPES THEREOF ARE DESIGN, BUILT AND SUCCESSFULLY OPERATED IN AN ACTUAL USER'S ENVIRONMENT
COMMERCIAL READINESS (CR) OF COMPONENTS & SYSTEMS	COMMERCIAL READINESS IN A GIVEN APPLICATION CLASS IS ACCOMPLISHED WHEN PRODUCTS OR SYSTEMS ARE OFFERED FOR SALE AT A GIVEN PRICE

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DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

COMMERCIAL READINESS GOAL SETTING

- CONVENTIONAL ELECTRICITY COSTS AS FUNCTION OF TIME, LOCALE, APPLICATION
- COMPARABLE ELECTRICITY COST FROM PV SYSTEM AS FUNCTION OF SYSTEM PRICE, LOCALE, ETC.
- PV SYSTEM PRICE AS FUNCTION OF PRODUCTION VOLUME, TIME (STAGE OF DEVELOPMENT)
- TIME REQUIRED TO BUILD PRODUCTION VOLUME

COMMERCIAL READINESS GOALS

RSA SYSTEMS \$6 - 13/W IN 1982

RESIDENTIAL SYSTEMS \$1.60 - 2.20/Wp IN 1986

INTERMEDIATE SYSTEMS \$1.60 - 2.60/Wp IN 1986

CENTRAL STATION SYSTEMS \$1.10 - 1.30/Wp IN 1990

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2/12/80

DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

COMMERCIAL READINESS PRICE GOALS (1980 $)

APPLICATION AND YEAR	COLLECTOR PRICE (FOB) ($/Wp)	SYSTEM * PRICES ($/Wp)	PRODUCTION SCALE (MWp/YEAR)	USER ENERGY ** PRICE (¢/kWh)
REMOTE-STAND ALONE 1982	2.80	6 - 13		
RESIDENTIAL 1986	0.70	2.20 - 1.60	100 - 1000	3.5 - 10.5
INTERMEDIATE LOAD CENTER 1986	0.70	2.60 - 1.60	100 - 1000	5.0 - 13.5
CENTRAL STATION 1990	0.15-0.50	1.80 - 1.10	500 - 2500	4.0 - 10.0

* SYSTEM PRICE CORRELATES WITH PRODUCTION SCALE

** USER ENERGY PRICE RANGE REFLECTS VARIATIONS IN LOCALE (INSOLATION). SYSTEM PRICE AND UTILITY SELLBACK ARRANGEMENT

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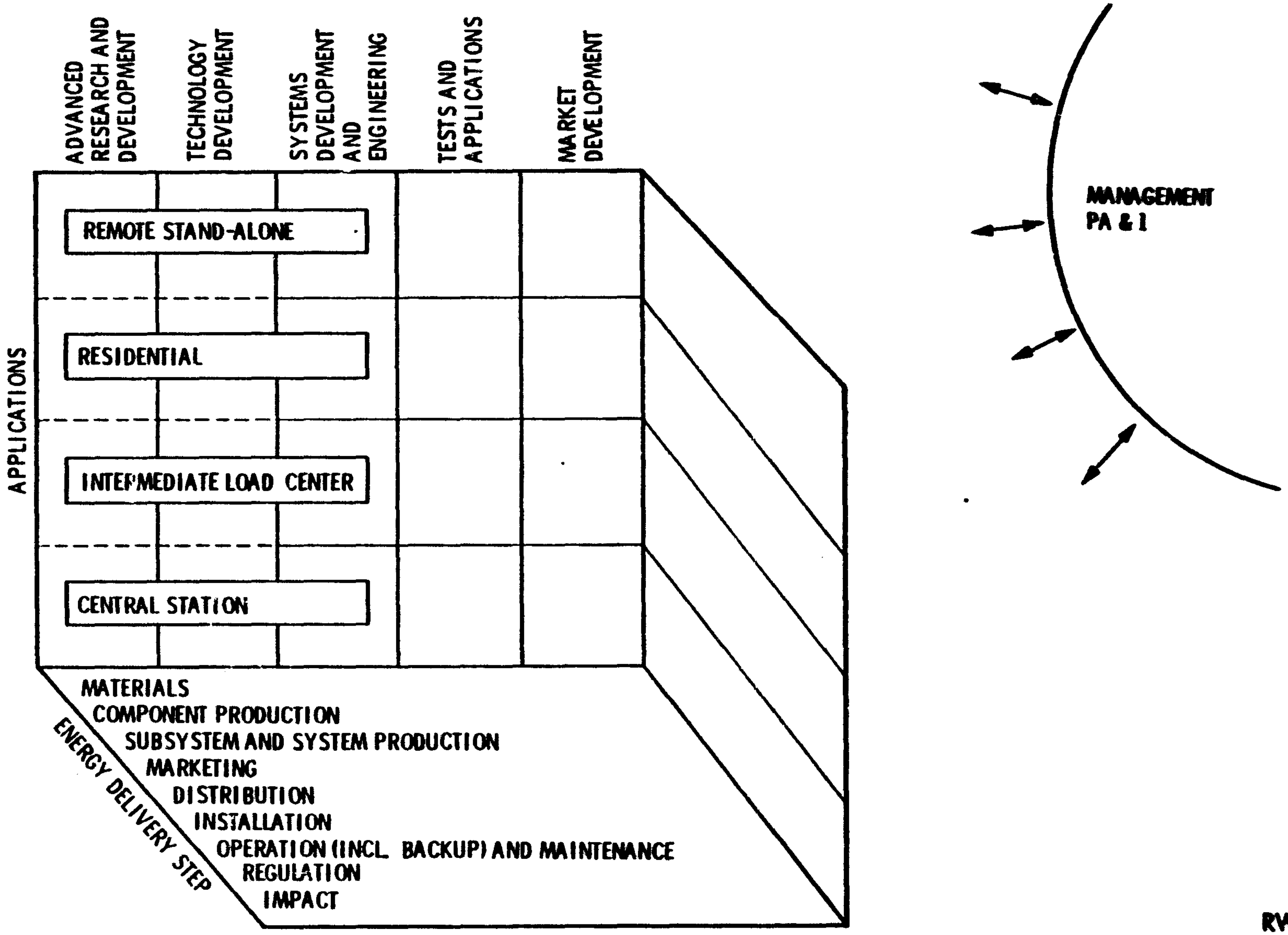
DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

THE PROGRAM MATRIX



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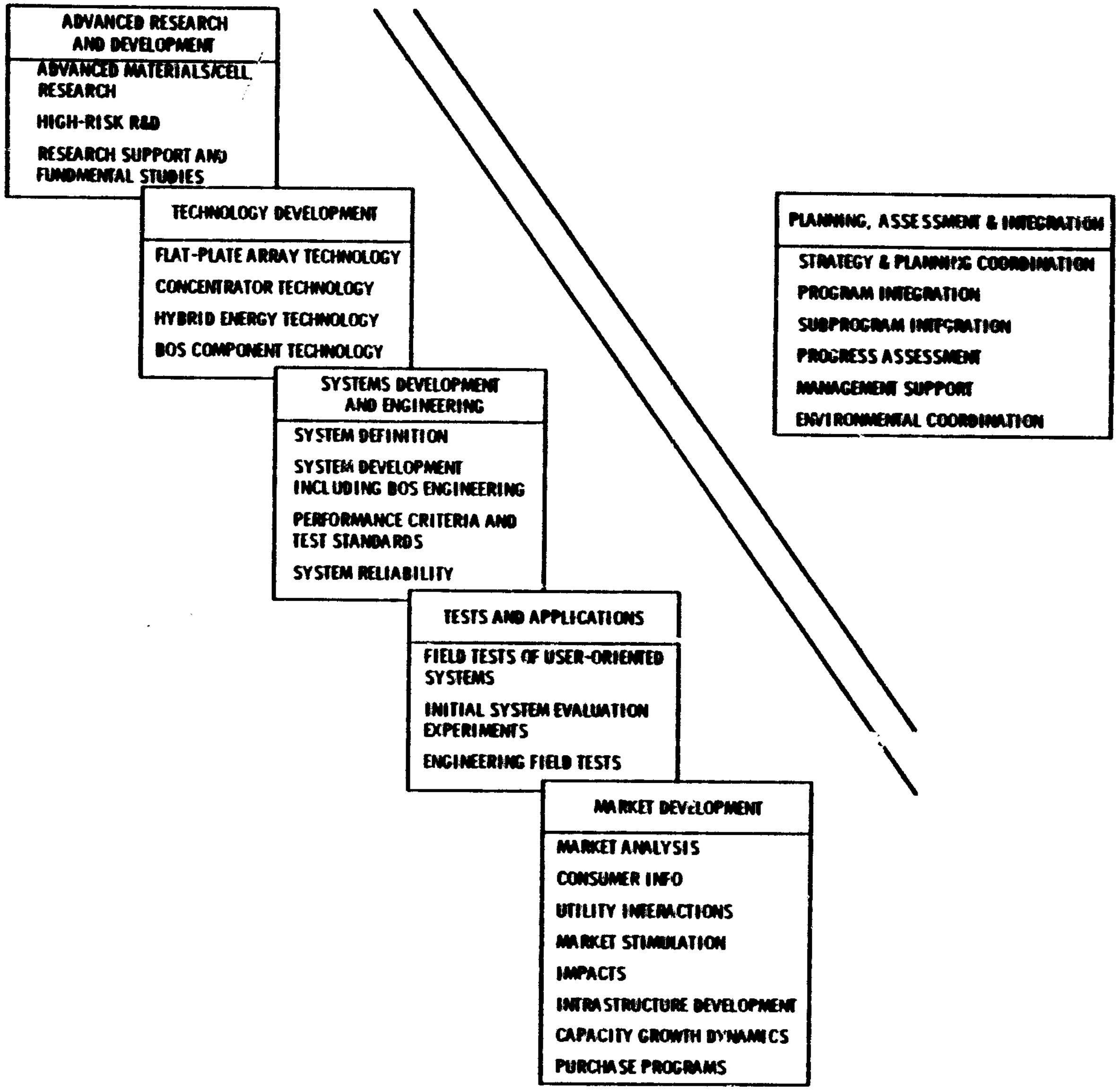
DOE PHOTOVOLTAICS PROGRAM
PROGRAM OVERVIEW
SUBPROGRAM FUNCTIONS



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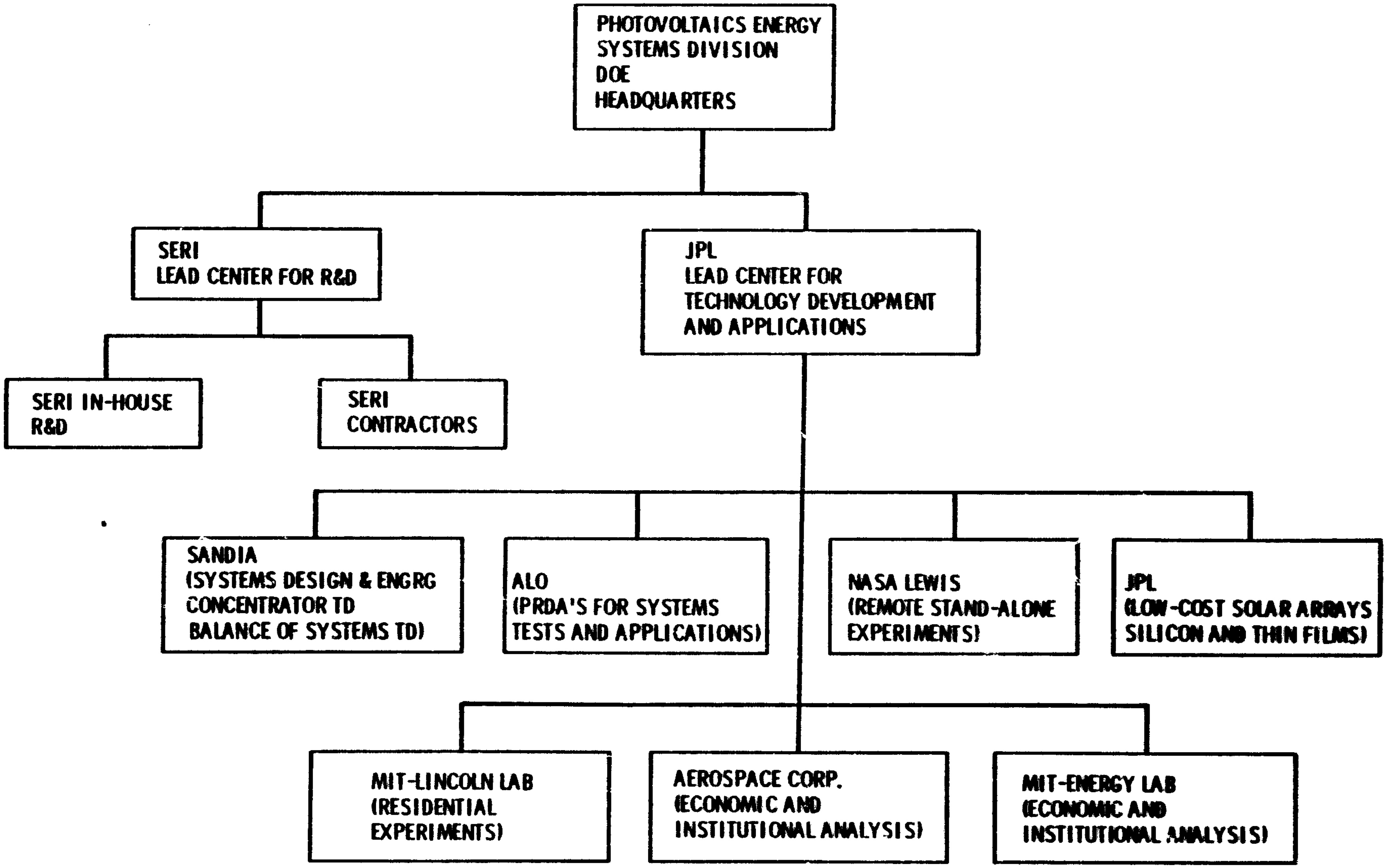
DOE PHOTOVOLTAICS PROGRAM
PROGRAM OVERVIEW
ROLES



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DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

RELEVANT PLANS, DOCUMENTS, LEGISLATION

- "THE PV MULTI YEAR PROGRAM PLAN" (JUNE 6, 1979): PUBLICLY RELEASED (DRAFT) DELINEATING PROGRAM STRATEGY, GOALS, APPROACH
- "THE INTERNATIONAL PHOTOVOLTAIC PROGRAM PLAN" (NOV '79): PUBLICLY RELEASED, RECOMMENDING APPROACH FOR INTERNATIONAL ASPECTS OF PROGRAM
- APPLICATION REQUIREMENTS DOCUMENTS (FORMERLY APPLICATION IMPLEMENTATION PLANS): DRAFT PROGRAM DOCUMENTS DETAILING PROGRAM APPROACH TO RESIDENTIAL, INTERMEDIATE, CENTRAL STATION AND REMOTE STAND ALONE APPLICATIONS
- "FEDERAL POLICIES TO PROMOTE THE WIDESPREAD UTILIZATION OF PHOTOVOLTAIC SYSTEMS" (IN PROGRESS): REPORT TO CONGRESS DELINEATING ISSUES AND BARRIERS TO PV UTILIZATION AND DISCUSSING USE OF PURCHASE PROGRAMS OF VARIOUS SCOPE
- THE PHOTOVOLTAIC ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION ACT OF 1978 ("THE RD&D ACT"): P.L. 95-590, SETS FORTH SPECIFIC GOALS FOR DEVELOPMENT AND UTILIZATION OF PHOTOVOLTAICS

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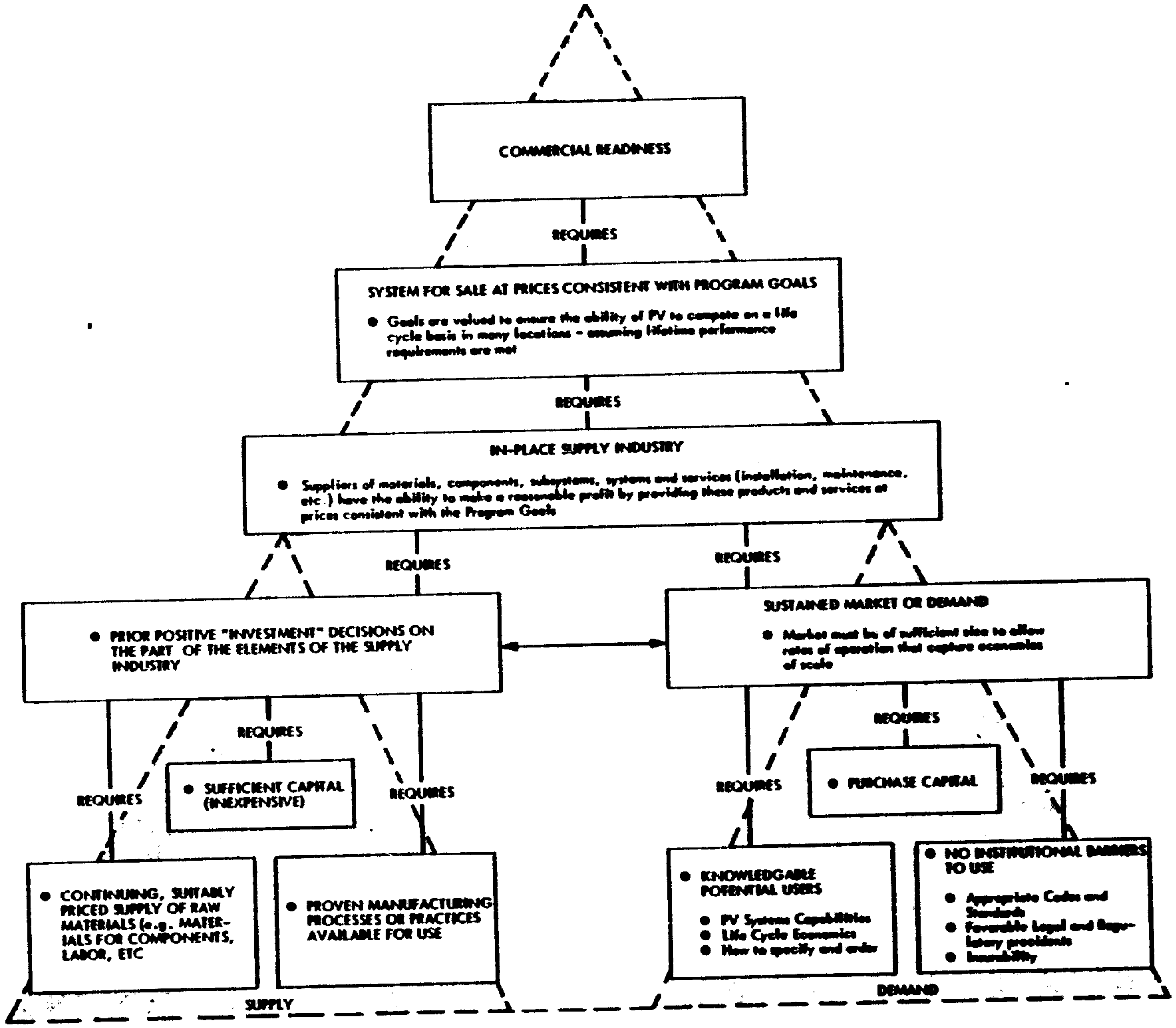
DOE PHOTOVOLTAICS PROGRAM

PROGRAM OVERVIEW

COMMERCIAL READINESS REQUIREMENTS



RWE 13
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THE ROLE OF THE MULTI YEAR PURCHASE PROGRAM

- MULTI YEAR COMMITMENT TO PROVIDE CAPITAL FOR DESIGN, INSTALLATION AND OPERATION OF PV SYSTEMS IN REAL APPLICATIONS

- PROVIDES:
  - "LABORATORY" FOR SOLVING TECHNICAL, INSTITUTIONAL AND ACCEPTABILITY PROBLEMS
  - A MARKET THAT CAN BE COUNTED OR BY MANUFACTURERS DECIDING WHETHER OR NOT TO ENLARGE OR ENHANCE CAPACITY
  - INTRODUCTION OF POTENTIAL USERS TO PHOTOVOLTAIC CAPABILITIES AND ECONOMICS

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2/12/80

DOE PHOTOVOLTAICS PROGRAM

PARTIAL LIST OF INSTITUTIONAL ISSUES

SUN RIGHTS. CONCERN EXISTS THAT PEOPLE WILL BE RELUCTANT TO PURCHASE SOLAR SYSTEMS WITHOUT A GUARANTEED RIGHT TO THE SUNLIGHT WHICH CROSSES ADJACENT PROPERTY. FOLIAGE AS WELL AS BUILDINGS ARE MENTIONED.

ZONING. ZONING PLACES CERTAIN AESTHETIC, AND SOMETIMES DESIGN, RESTRICTIONS ON STRUCTURES AND THEIR CONSTRUCTION.

BUILDING CODES. CERTAIN SAFETY RESTRICTIONS WILL APPLY TO SOLAR SYSTEMS. THE PROBLEM IS WORSENED BY DIFFICULTY IN APPLYING OLD CODES TO NEW TECHNOLOGY.

FINANCING. SOME CONCERN EXISTS THAT FINANCIAL INSTITUTIONS WILL BE RELUCTANT TO LEND MONEY TO PURCHASE AN UNPROVEN TECHNOLOGY.

INSURANCE. SIMILAR TO FINANCING; LACK OF EXPERIENCE MAY RESULT IN HIGH RATES.

WARRANTIES, LIABILITY. THE BASIC QUESTION IS BALANCING THE ADDED COSTS TO THE MANUFACTURER AGAINST CONSUMER DEMANDS FOR PROTECTION.

UTILITIES. CONCERN IS WITH THE WILLINGNESS OF UTILITIES TO PROVIDE INTERCONNECTION FACILITIES (AND POSSIBLY EVEN PAY FOR THEM) AND TO PROVIDE BACKUP POWER AT REASONABLE RATES; THE RATE AT WHICH UTILITIES BUY BACK EXCESS POWER IS ALSO HIGHLY IMPORTANT.

RWE 15
2/12/80

DOE PHOTOVOLTAICS PROGRAM

PARTIAL LIST OF INSTITUTIONAL ISSUES (CONTINUED)

PROPERTY TAXES AND CREDITS. THE TAXABILITY OF PV SYSTEMS COULD SERIOUSLY IMPAIR PV ECONOMIC BREAKEVEN; SIMILARLY, CREDITS AND EXEMPTIONS APPLICABLE TO PVs COULD HAVE A NEGATIVE IMPACT ON COMMERCIALIZATION IF THEY ARE APPLIED IMPROPERLY.

INSTALLATION/SERVICE INDUSTRY. LACK OF SUCH AN INDUSTRY COULD SLOW OR STOP PV PENETRATION.

LABOR UNIONS. SQUABBLES BETWEEN UNIONS OVER JURISDICTION TO CONSTRUCT AND INSTALL PV SYSTEMS MAY POSE PROBLEMS.

STANDARDS. PRODUCT STANDARDS CAN EITHER HELP OR HURT. THEY HELP DEFINE THE MARKET IN WHICH PVs COMPETE AND CAN INFLUENCE THE PRODUCT'S COST, THE DEMAND FOR IT, AND THE COMPETITIVE NATURE OF THE INDUSTRY.

ENVIRONMENTAL IMPACT. SINCE SOME OF THE PHOTOVOLTAIC MATERIALS ARE TOXIC (NOTABLY CADMIUM, ARSENIC, AND PHOSPHOROUS) THERE IS A NEED TO ASSESS THE DEGREE OF SEVERITY OF THIS PROBLEM AS A FUNCTION OF PV PENETRATION LEVEL. ALSO, IT SHOULD BE ASSESSED UNDER EXACERBATING CONDITIONS SUCH AS IN A FIRE.

RVE 1/5
2/12/80

MULTI-YEAR PHOTOVOLTAIC SYSTEM PURCHASE PROGRAM

Briefing to Residential Applications Program Implementation Workshop

Session I

Caltech

February 11, 1980

Tom W. Hamilton, Manager for Planning, Assessment, and Integration
Technology Development and Applications, Photovoltaics Lead Center

PURPOSES OF THIS PRESENTATION

- Describe the residential applications part of the Purchase Program as presently planned
  - January 29, 1980, briefing "Multi-Year Photovoltaic System Purchase Program" is starting point
  - Narrow to residential; new and retrofit
  - Identify unplanned areas, issues, and concerns
- Provide a context for your comments, criticisms, and suggestions

MULTI-YEAR PHOTOVOLTAIC SYSTEM PURCHASE PROGRAM

OBJECTIVES

- Accelerate commercialization of photovoltaic systems
- Encourage investment in low-cost component production facilities

DESIRED CHARACTERISTICS

- Maximum long-term (Yr 2000) domestic energy displacement for given federal investment
- Credible multi-year DOE commitment while retaining flexibility to respond to industry/market changes
  - Adjust timing, scale for maximum impact
  - Encourage timely supply-side private investment
- Market development, resolution of barriers
- Fosters competition in cost-reduction, price, and performance; encourages design maturation
- Supports infrastructure development without interfering in current private market (stress system sizes expected in 1986); encourages small and minority business participation (20% goal)
- Manageable

PURCHASE PROGRAM IN CONTEXT: PLANNED STRUCTURE

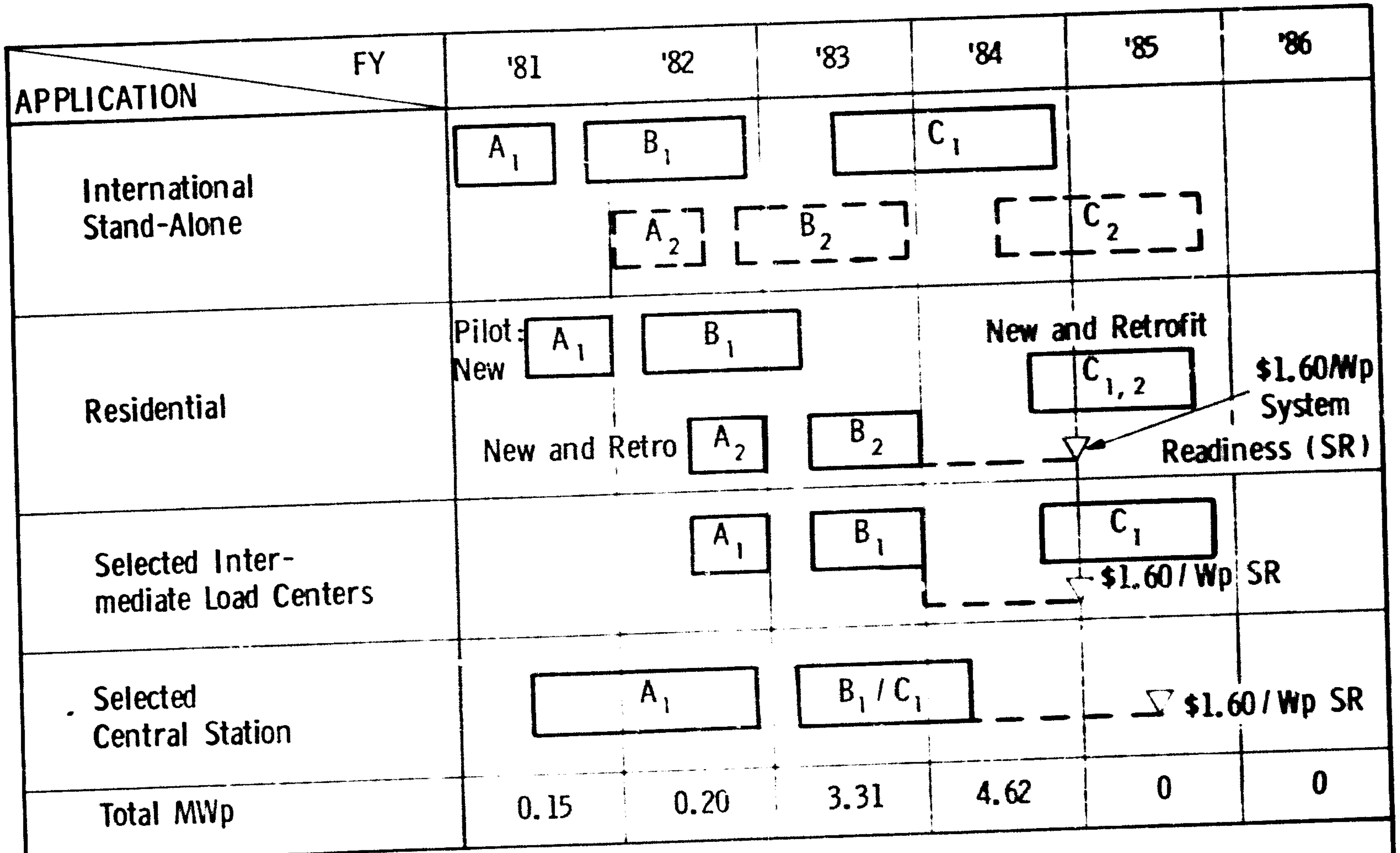
SYSTEM FEASIBILITY → SYSTEM READINESS → GO / NO-GO DECISION → COMMERCIAL READINESS

PROGRAM PHASE	FIRST-OF-A-KIND EXPERIMENTS (ISEE)	ENGINEERING FIELD TESTS (EFT)*	MARKET TESTS (MT)	VOLUME BUILDING	FREE MARKET
PRIMARY OBJECTIVES	• Demonstrate technical feasibility of regionally-appropriate system designs in the user environment	• Develop and evaluate cost-reduction approaches and verify system performance • Demonstrate that system price goals are likely to be met if factory-produced components meet goals • Attack market development barriers	• Major test of market acceptance of selected systems • Support development of industry infrastructure • Verify that systems can meet price goals at specified volume • Resolve market development barriers	• Support achievement of sales volume needed to justify earlier private investment in low-cost production facilities Achieve commercial readiness price goals	• Provide sufficient incentives for rapid market growth needed to support a competitive private industry

DESCRIPTION (NEW RESIDENTIAL EXAMPLE)	• One of each kind
	  • Region
	  • Design
	• Uses available components
	• Fully instrumented and monitored
		• 225 systems, 45 contractors
		• Minimum monitoring; full monitoring on a sample basis
		• Uses prototypes of low-cost components
			• 370 systems/20 contractors
			• Firm fixed-price contracts with federal cost-share
			• Minimum monitoring
				• Decreasing subsidy as volume increases
				• Up to 12,500 units/yr
				• User incentives to accelerate market penetration of cost-effective systems	

*ALSO CALLED SYSTEM READINESS EXPERIMENTS

PURCHASE PROGRAM SCHEDULE



A = Project and System Detailed Design (Includes B and Preliminary C)
B = Engineering Field Test (EFT) System Installation Phase (Keyed to Technical Readiness of $1.60/Wp Components)
C = Market Test (MT) System Installation Phase

PHOTOVOLTAIC SYSTEM PURCHASE PROGRAM IMPLEMENTATION DETAILS

System Feasibility — $1.60/Wp System Readiness — Go / No-go Decision — Commercial Readiness

	FIRST-OF-A-KIND	ENGINEERING FIELD TESTS (EFT)	MARKET TESTS (MT)	VOLUME BUILDING
CONTRACTOR SELECTION	• RFP • Unsolicited proposals • Innovative concepts	• RF:	• RFP	• By End User
REQUIREMENT for ENTRY	• Equivalent of system test facility experience • Complements planned experiments	• System feasibility established • Complete project plan • Prototypes of low-cost components	• Demonstrated competence (EFT or equiv experience) • Complete project plan	
FINANCIAL ARRANGEMENTS	• Contractor cost-share encouraged • Initial title to Federal	• Contractor cost-share encouraged • Title to contractor • Fixed-price contract	• Firm fixed-price contracts with Federal cost-share based on initial bid • Title to contractor	• Decreasing subsidy to user/supplier as volume increases • User incentives

$\underbrace{\text{ENGINEERING FIELD TESTS (EFT) + MARKET TESTS (MT)}}_{\text{PURCHASE PROGRAM}}$

SOME PROPOSAL EVALUATION FACTORS

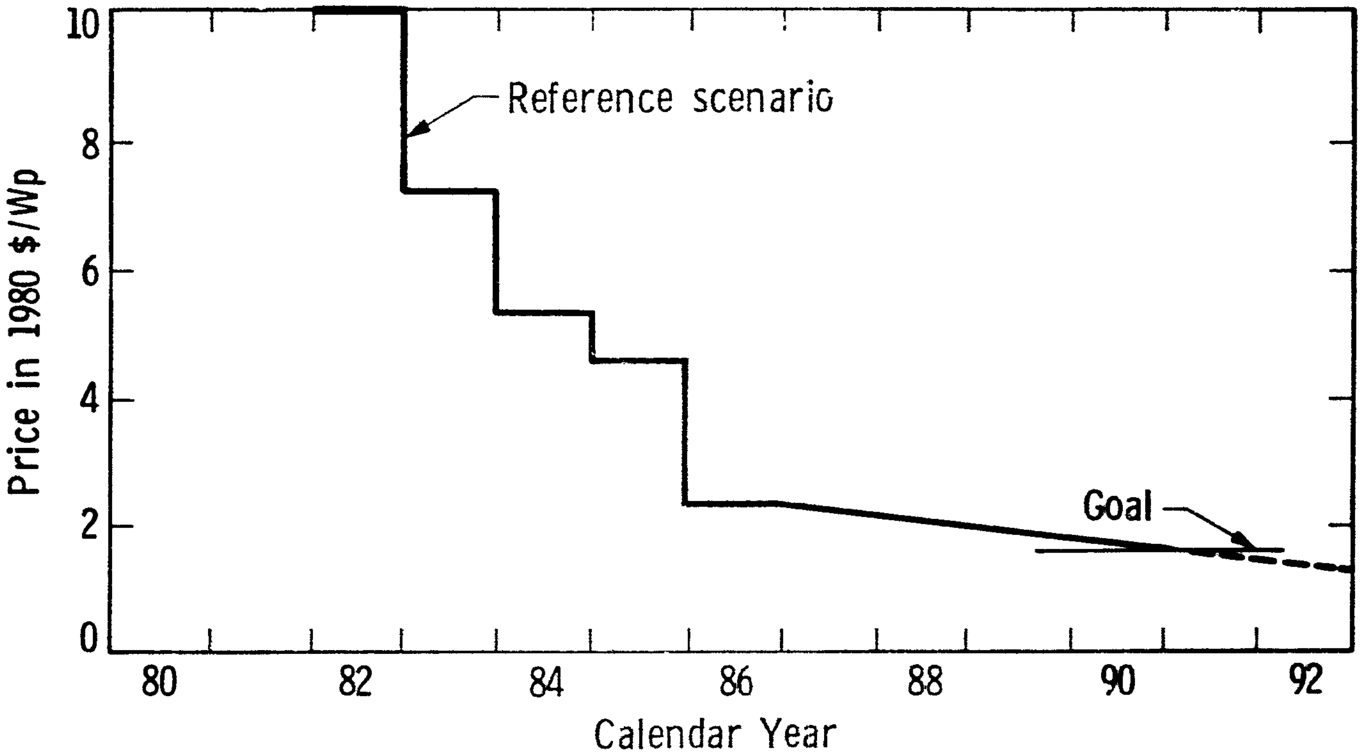
<table>
<tr><th colspan="3">PROGRAM PHASE</th></tr>
<tr><th>A = Project Design</th><th>B = Engineering Field Test</th><th>C = Market Test</th></tr>
<tr><td rowspan="2">• System meets Entry Requirements
• Acceptance of Phase B and C information requirements
• Contractor's intent to enter commercial market assuming program goals are met
• Unique approaches to cost reduction, market development
• Budget and extent of cost share or previous effort
• Ability to perform proposed work
• Cross-sectional representation of supplier types, regions and approaches
• Small and minority business participation
• Market potential (1986)</td><td>• Project and System meet Entry Requirements
• Acceptance of Phase B and C information requirements
• Potential for meeting goals
• Unique cost reduction approach</td><td>• Project, System and Contractor meet Entry Requirements
• Acceptance of Phase C information requirements
• Acceptable Costs in Phase B</td></tr>
<tr><td colspan="2">• Life-Cycle Cost of system to user (including warranty) for reference case (now, anticipated 1986)
• Initial System Cost (now, anticipated 1986)
• Life Cycle value of energy generated at location (now, reference case 1986)
• Extent of cost sharing
• Market potential (1986)
• Cross-section of regions, suppliers and systems
• Flexibility: Alternate component suppliers, installation schedules</td></tr>
</table>

RESIDENTIAL SYSTEM PRICE BREAKDOWN STRUCTURE* (1980$)

DIRECT COSTS	GOAL	$/Wp**	REMARKS
1. P-V Module FOB ($/Wp)	0.70	0.70	Module η = 0.1
2. P-V Module M+D (% of 1)	30	0.21	Includes warranty
3. Structure + Installation ($/m^2)	26	0.26	Includes field wiring, lightning protection
4. Power Conditioning ($/Wp)	26	0.26	Includes M+D, installation, warranty
Total Direct Costs		1.43	
INDIRECT COSTS			
Fraction of Direct Costs (β)	0.12	0.17	Includes A+E fees, sales fee, interest during construction, spares + misc.
TOTAL SYSTEM PRICE ($/Wp)	1.60	1.60	Life-cycle excluding O+M

**For Preferred Design #1 (Module η = 0.1, 8 kWp system in southwest)
*Values shown are currently hypothetical

RESIDENTIAL SYSTEM PRICES



- Prices are assumed to be higher at low sales volumes
  - Power conditioning cost at 1 MWp/yr 3.5x at 100 MWp/yr
  - Structures and installation at 1 MWp/yr 2x cost at 100 MWp/yr
  - Indirects at 1 MWp/yr 2x fraction (β) at 100 MWp/yr
  - Module prices depend more on total module sales rate (international, domestic)
- Actual prices depend on system size, actual sales, accuracy of assumptions

OPEN AREAS

- Information dissemination and education
- Training programs
- Who manages MTs?
- Which sections of P-V RD+D Act (PL 95-590) will be used?
    - Section 5, 6
    - Rules

ISSUES

- Should there be a pilot Phase A_1, B_1 and what is appropriate scale?
- How many contractors (teams) to seek in Phase A_2, B_2? Why? Where?
- Development of selection criteria and process
- What kind of warranties should be required and how should cost/risk be shared?
- Program is geared to TR'82; what about systems using components not ready at that time?
- Utility payment for generation beyond user's need strongly affects best system size; case-by-case resolution expected
- How can program aid market development without distorting private markets which would arise without A, B, C?
  - Federal tax credit (40% of first $10,000), 1981-1990, opens small systems market
  - Should A, B, C exclude federal tax credit and encourage larger systems?
  - Should A, B, C exclude solar bank?

ISSUES (Cont'd)

- How should markets be subdivided to identify and encourage most promising market sectors?
  - New, retrofit
  - Region
  - System design
  - Federal, private buyers
  - 1990, 2000 market impact
  - Housing price

- What are appropriate figures of merit?

- What evolution of market sectors and participants is favored by proposed approach? Is this appropriate?
  - High-price housing
  - P-V system integrators
  - Builder/developer
  - System size, design
  - P-V manufacturers

- Who will be the central players in A, B, C?

- Have the SHAC experiences appropriately influenced the program?

RESIDENTIAL APPLICATION IMPLEMENTATION PLAN

UNITED STATES DEPARTMENT OF ENERGY

PHOTOVOLTAIC PROGRAM

EDWARD C. KERN, JR.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

NATIONAL PHOTOVOLTAIC PROGRAM

- SOLAR PHOTOVOLTAIC ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION ACT OF 1978.

- TEN YEAR, $ 1.5 BILLION AUTHORIZATION

- FOUR APPLICATION SECTORS

    REMOTE-STAND ALONE
    RESIDENTIAL
    INTERMEDIATE LOAD CENTER
    CENTRAL STATION

WHY RESIDENTIAL PHOTOVOLTAICS?

- LARGE 1985-2000 MARKET

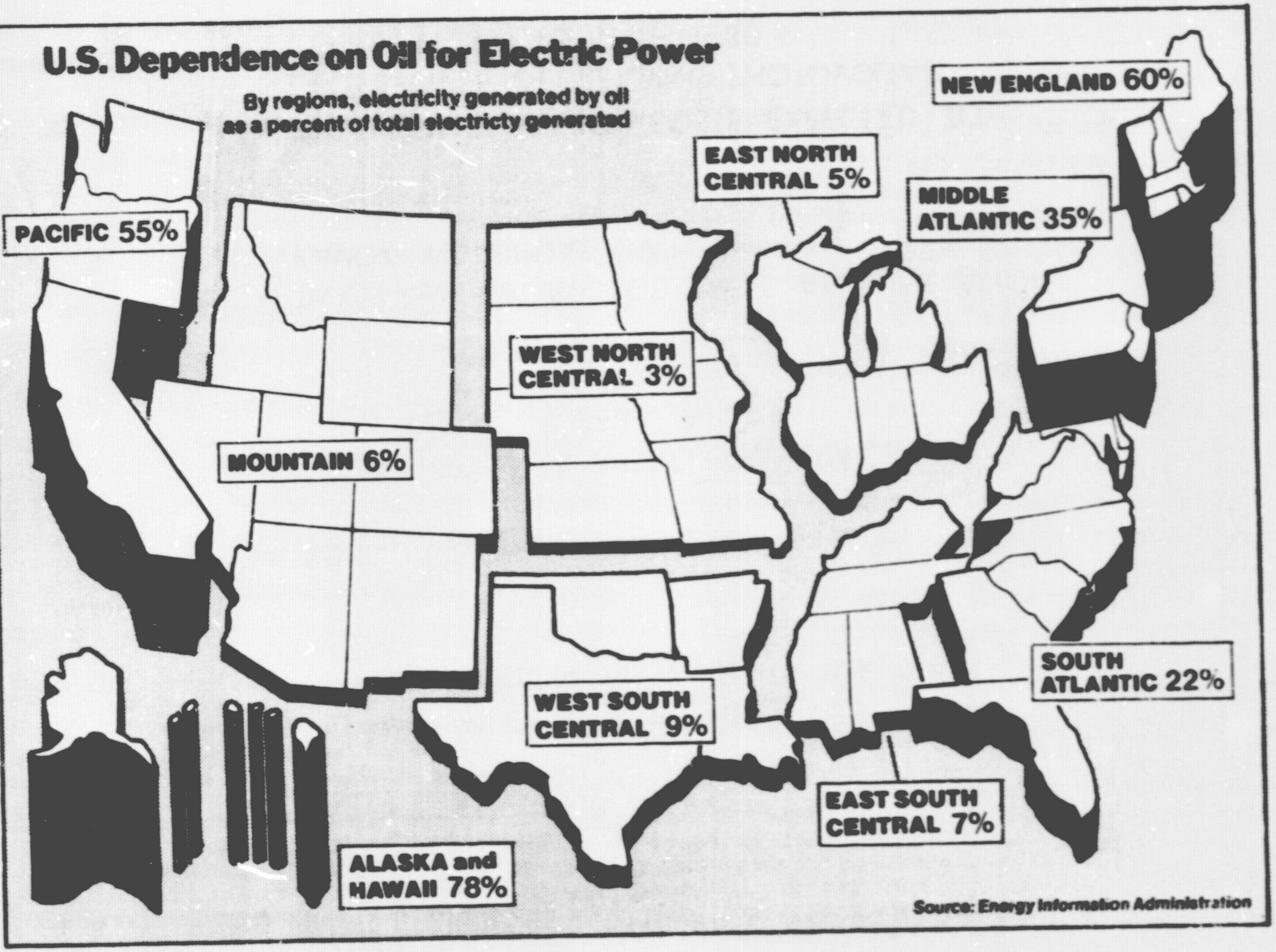
  75 MILLION EXISTING UNITS
  1.5 MILLION NEW UNITS PER YEAR

- ADEQUATE ROOF AREA

  40-80 M^2 IS MOST ECONOMIC (4-8 KILOWATT PEAK ARRAY)

- TAX LAWS, MORTGAGE RATES AND INFLATION FAVOR INDIVIDUAL OWNERSHIP

- ESCALATING ENERGY COSTS EXPECTED TO CROSS-OVER DECREASING PHOTOVOLTAIC COSTS IN MID-TO-LATE 1980'S



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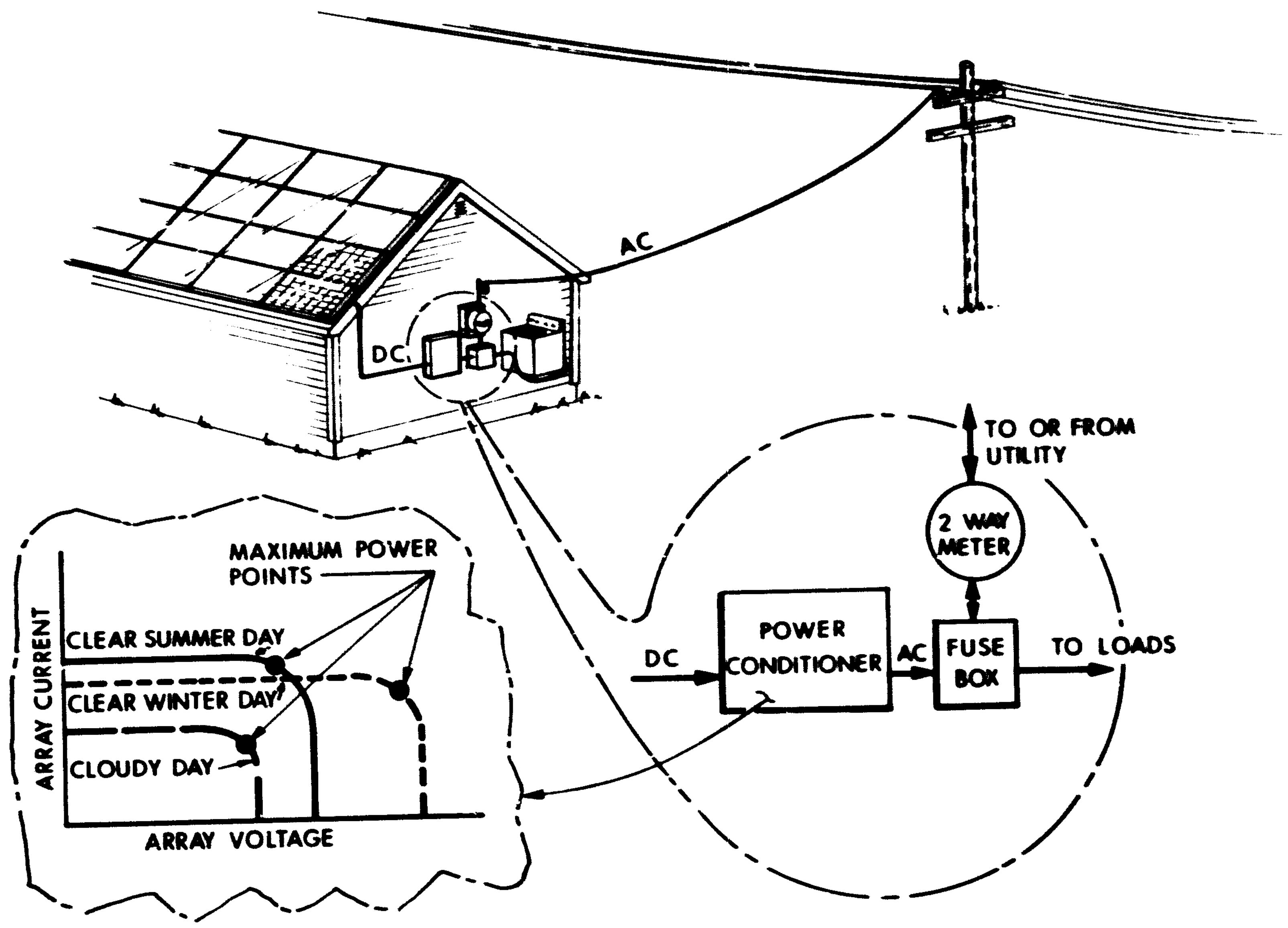
A RESIDENTIAL PHOTOVOLTAIC SYSTEM

- USES ON-SITE PHOTOVOLTAICS
- IS DESIGNED TO MINIMIZE <u>HOMEOWNER'S</u> COST
- EMPLOYS CONSERVATION, PASSIVE SOLAR HEATING AND PHOTOVOLTIAC/THERMAL COLLECTORS AS APPROPRIATE

INITIAL RESIDENTIAL PV SYSTEMS

- REQUIRE NO ON-SITE STORAGE
- UTILIZE 2-WAY POWER FLOWS
- 4-8 kWp ARRAY (50-70% of Electricity Needs)



UTILITY INTERACTIVE RESIDENTIAL PV SYSTEM

RESIDENTIAL PV PROGRAM

PROTOTYPE DEVELOPMENT

- RESIDENTIAL EXPERIMENT STATIONS: 1980-82

LIVED-IN EXPERIMENTS

- PRIVATE AND FEDERAL RESIDENCES: 1981-83

LIVED-IN RESIDENCES

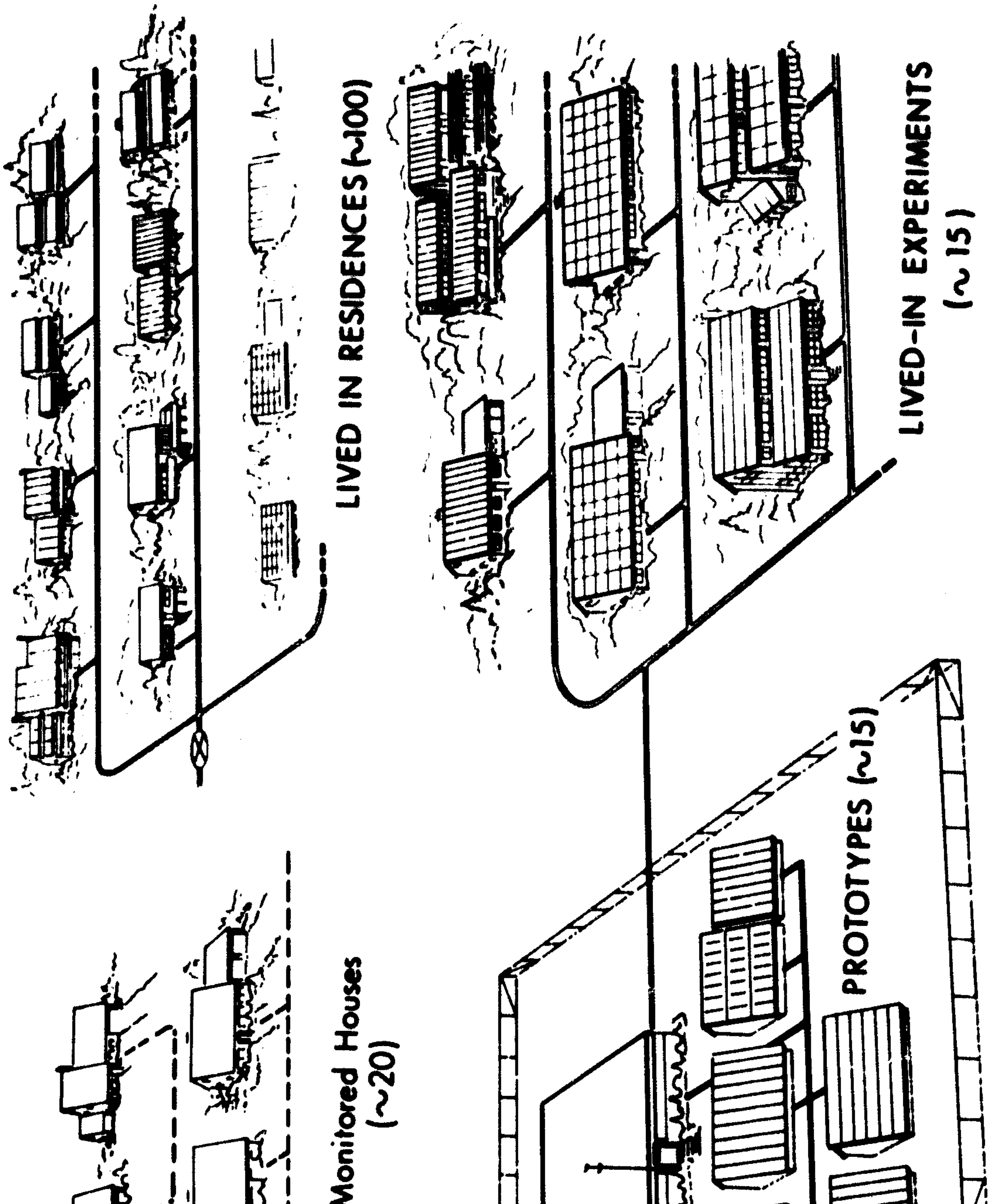
- CLUSTERED FOR UTILITY IMPACT: 1983-86

MARKET DEVELOPMENT

- INCENTIVES, ECONOMICS AND INFRASTRUCTURE: LATE 1980s

RESIDENTIAL EXPERIMENT STATIONS

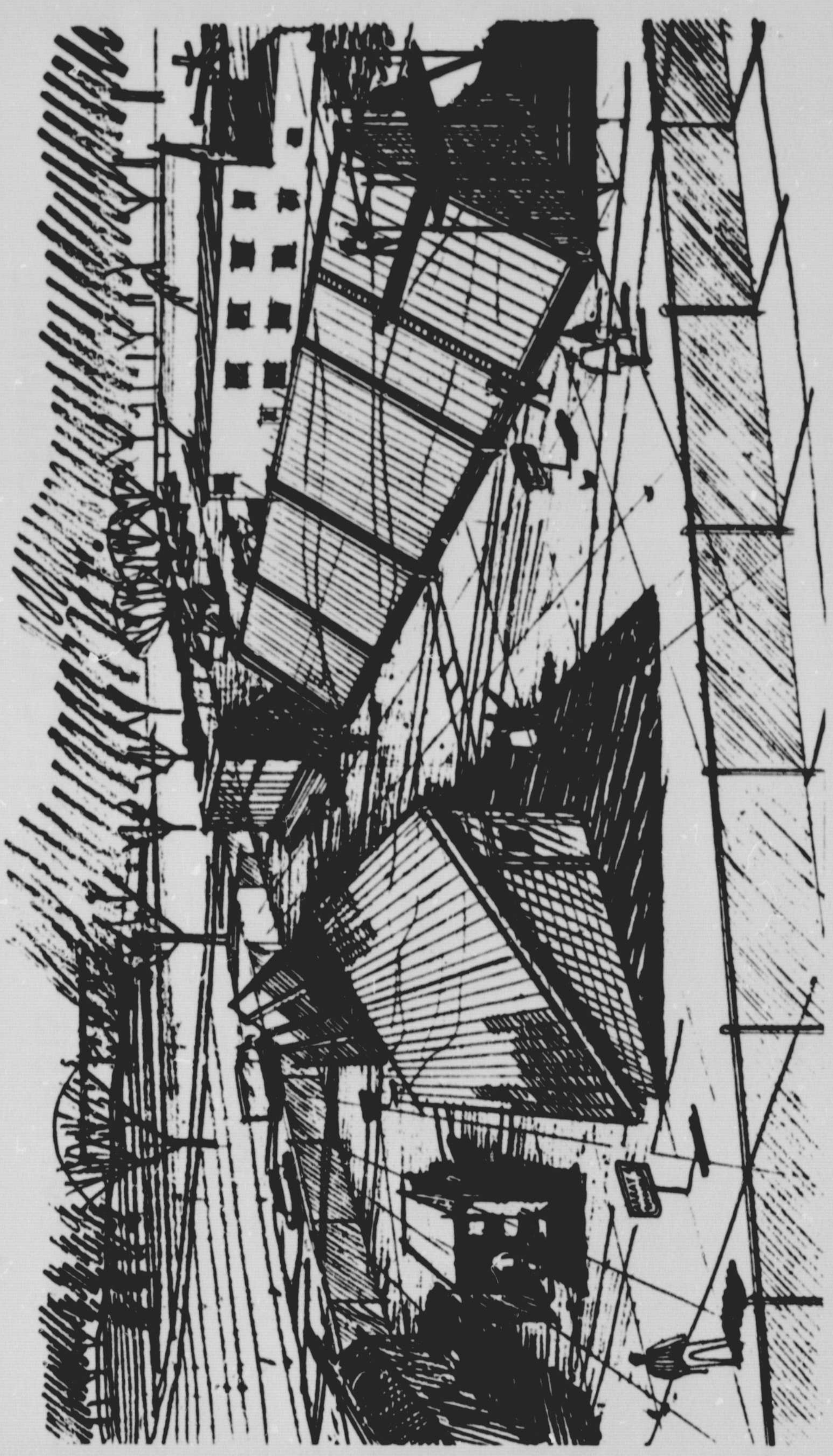
- SYSTEM TESTING
- DIRECT SYSTEM-TO-SYSTEM COMPARISON (EQUAL SUN, WEATHER AND LOADS)
- REGIONAL FOCAL POINTS
  - SOLAR INDUSTRY
  - ELECTRIC UTILITIES
  - BUILDING CODE ORGANIZATIONS
  - HOME BUILDERS
  - DEVELOPERS
  - INSURANCE COMPANIES
- LOCATED IN
  - NORTHEAST (FY-80)
  - SOUTHWEST (FY-80)
  - SOUTHEAST (FY-81)



RESIDENTIAL
EXPERIMENT
STATION
Monitored Houses
(~20)
PROTOTYPES (~15)
LIVED IN RESIDENCES (~100)
LIVED-IN EXPERIMENTS
(~15)

PROTOTYPE SYSTEMS

- INDUSTRY DETAIL DESIGN AND BUILD
- BUILD ONLY ROOF-ARRAY, ELECTRIC AND THERMAL ENERGY DELIVERY SYSTEMS
- LINCOLN LABORATORY INSTRUMENTS AND CONDUCTS EXPERIMENT
- EMPHASIS ON PHYSICAL PERFORMANCE



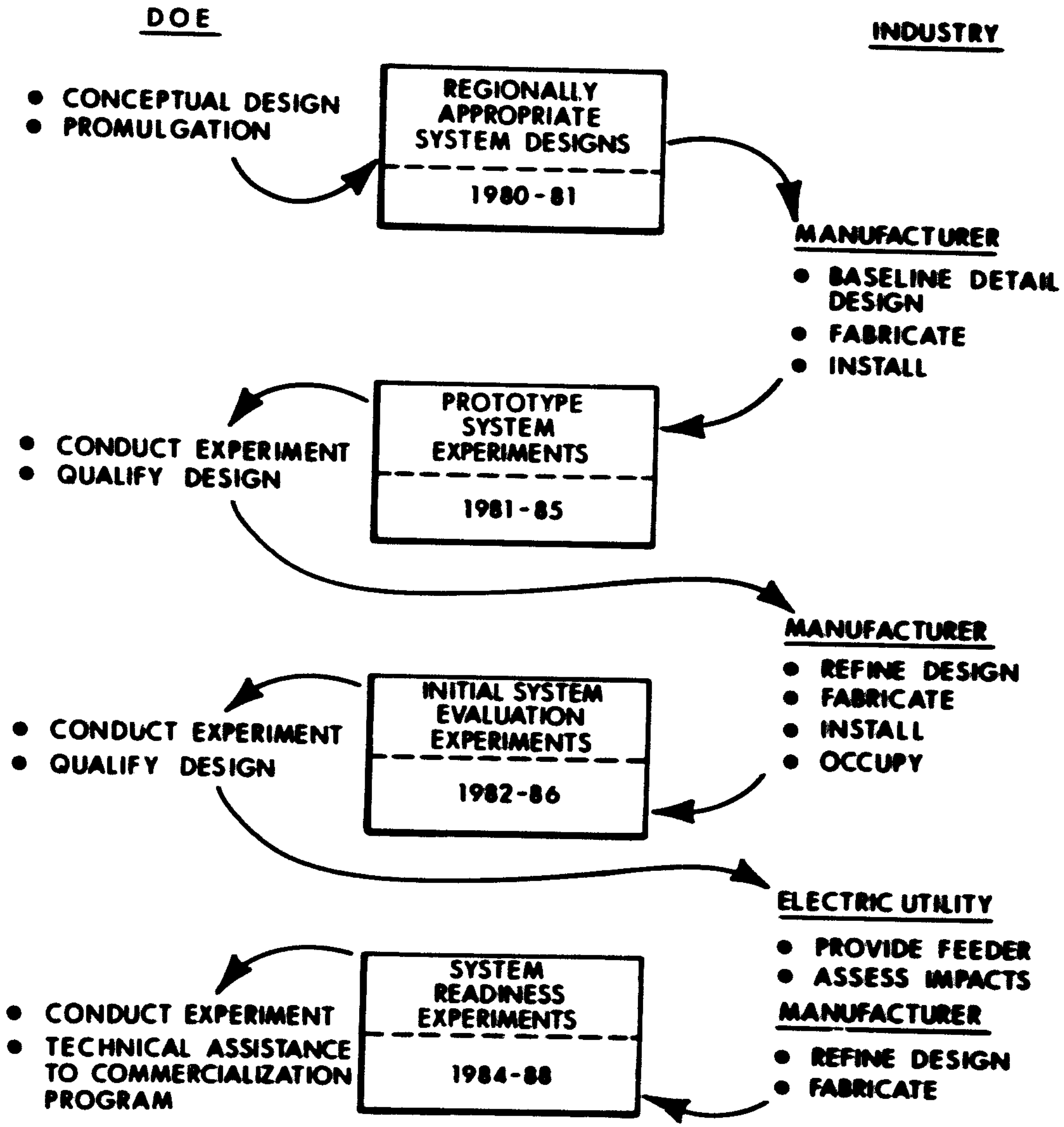
INITIAL SYSTEM EVALUATION EXPERIMENTS

- REFINEMENTS OF SUCCESSFUL PROTOTYPE SYSTEMS
- NEW RESIDENCES WITH BUILDING INTEGRATED PHOTOVOLTAIC SYSTEMS
- OCCUPIED AND NEAR EXPERIMENT STATION
- LINCOLN LABORATORY INSTRUMENTS AND MONITORS SYSTEM PERFORMANCE
- EMPHASIS ON PHYSICAL PERFORMANCE, OCCUPANT AND INSTITUTIONAL RESPONSES

SYSTEM READINESS EXPERIMENTS

- REFINEMENTS OF SUCCESSFUL INITIAL SYSTEM EVALUATION EXPERIMENTS
- CLUSTERS OF $\sim$100 OCCUPIED RESIDENCES TIED TO COMMON UTILITY DISTRIBUTION FEEDER
- SYSTEMS COST EFFECTIVE IF MASS PRODUCED
- EMPHASIS ON UTILITY PENETRATION, INSTITUTIONAL RESPONSES AND PUBLIC ACCEPTANCE
- SEED POINT FOR THE GROWTH OF PRIVATE MARKET

RESIDENTIAL SYSTEM DEVELOPMENT



PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

ANALYSIS OF THE SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

Tom Nutt-Powell
MIT/Energy Laboratory

February 12-13, 1980

Copies of the text for Analysis of the Solar Heating and Cooling Demonstration Program are available by request from:

Thomas E. Nutt-Powell

Joint Center for Urban Studies of the Massachusetts Institute of Technology and Harvard University

53 Church Street

Cambridge, Massachusetts 02138

OUTLINE

AN ANALYSIS OF THE SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

INTRODUCTION

SHAC PROGRAM

OUTCOME

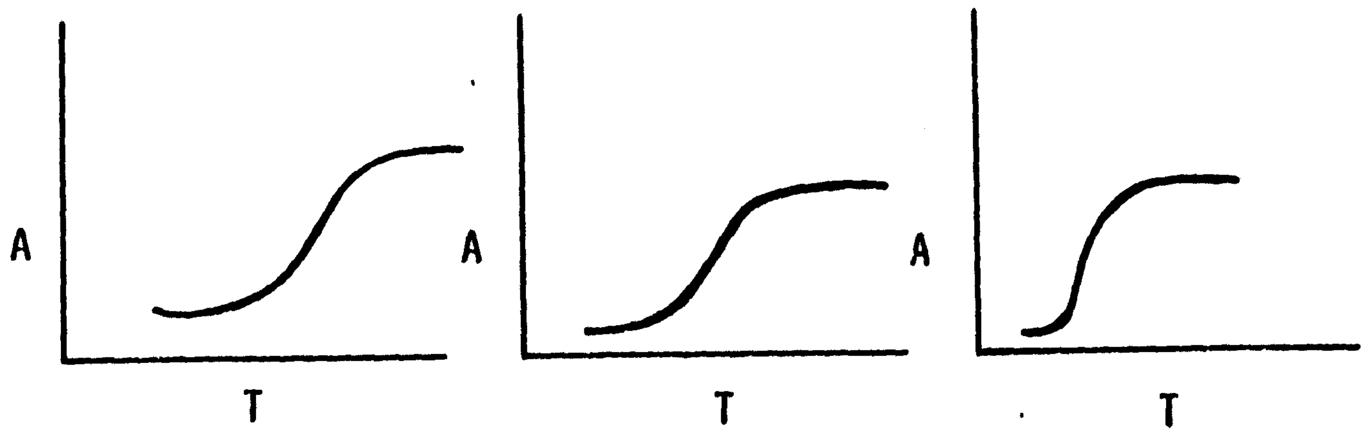
FACTORS IN SOLAR ACCEPTANCE IN HOUSING

CONCLUSIONS

LESSONS

OBJECTIVE

PROGRAM DESIGN TO FACILITATE RAPID ACCEPTANCE OF PV IN THE RESIDENTIAL SECTOR



NO INTERVENTION

MARKET INTERVENTION

T EARLIER

INSTITUTIONAL INTERVENTION

T EARLIER

SLOPE STEEPER

WHAT CONSTITUTES ACCEPTANCE?

. . . . . MAKING SOMETHING NEW A ROUTINE

STAGES, ACTORS, CONSTRAINTS
IN THE HOUSING PRODUCTION PROCESS

	ACTORS	CONSTRAINTS
BUILDING CONCEPT *the generation of an idea*	DEVELOPER ARCHITECT ENGINEER PLANNER CONSULTANT	ZONING LAW USER NEEDS MARKET CONDITIONS
BUILDING DESIGN *establishing use, design, specifications*	DEVELOPER LAWYER REAL ESTATE BROKER TITLE COMPANY ARCHITECT ENGINEER SURVEYOR PLANNER CONSULTANT ZONING & PLANNING OFFICIALS	REAL ESTATE LAW RECORDING REGULATIONS & FEES BANKING LAW ZONING LAW SUBDIVISION REGULATION PRIVATE DEED RESTRICTION PUBLIC MASTER PLANS
BUILDING FINANCE *price estimation and obtaining of funds*	LENDING INSTITUTIONS FHA/VA MORTGAGE COMPANIES INSURANCE COMPANIES INDIVIDUALS PENSION FUNDS REIT'S/MIT'S	BANKING LAW FHA/VA STATE LAW GNMA/FNMA
CONSTRUCTION *physical production*	DEVELOPER CONTRACTOR SUBCONTRALTOR TRADE UNIONS MATERIALS MANUFACTURERS & DISTRIBUTERS BUILDING CODE OFFICIALS INSURANCE COMPANIES ARCHITECTS ENGINEERS	RULES OF TRADE AND PROFESSIONAL ASSOCIATIONS BUILDING & MECHANICAL CODES SUBDIVISION REGULATIONS UTILITY REGULATIONS UNION RULES INSURANCE LAW MATERIALS TRANSPORT LAW
SERVICE AND OCCUPANCY *maintenance, management, repair, improvements, additions*	DEVELOPER LENDERS MORTGAGE COMPANY MAINTENANCE FIRMS PROPERTY MANAGEMENT FIRMS INSURANCE COMPANIES UTILITY COMPANIES TAX ASSESSORS REPAIRMEN UNIONS ARCHITECTS ENGINEERS CONTRACTORS SUBCONTRACTORS ZONING & BUILDING OFFICIALS MATERIALS SUPPLIERS REAL ESTATE BROKER	PROPERTY TAXES INCOME TAXES HOUSING & HEALTH CODES INSURANCE LAWS UTILITY REGULATIONS UNION RULES ZONING LAW BUILDING AND MECHANICAL CODES MATERIALS TRANSPORT LAWS BANKING LAW RULES OF TRADE & PROFESSIONAL ORGANIZATIONS
DISTRIBUTION *sale and subsequent resale and refinance*	DEVELOPER REAL ESTATE BROKER LAWYERS LENDERS TITLE COMPANIES FHA/VA/PRIVATE MORTGAGE/ INSURANCE COMPANIES BUYER	RECORDING REGULATIONS & FEES REAL ESTATE LAW TRANSFER TAXES BANKING LAW TAX LAW
TEAM SELECTION *a continuous choosing of actors*	DEVELOPER ARCHITECT ENGINEERS CONTRACTORS FINANCERS	DEVELOPMENT REGULATIONS RULES OF TRADE AND PROFESSIONAL ORGANIZATIONS

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TABLE 1

THE INSTITUTIONAL ANALYSIS OF SHAC WAS A STUDY

<u>OF</u> A COMPARABLE TECHNOLOGY - SOLAR THERMAL

<u>BY</u> CASE STUDY

<u>TO</u> YIELD INSTITUTIONAL DATA FOR PROGRAM DESIGN

<u>TO FACILITATE</u> PV ACCEPTANCE AS <u>ROUTINE</u>

THE SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

+ SOURCES
+ DESIGN
+ IMPLEMENTATION
+ OUTCOME

SHAC CHRONOLOGY

SOURCES

1951-72	-	DIVERSE BILLS FILED; NONE PASSED
1952	-	PALEY REPORT - ON MATERIALS POLICY NEED FOR SOLAR ENERGY RESEARCH
1971-72	-	TASK FORCE ON ENERGY, HOUSE COMMITTEE ON SCIENCE & ASTRONAUTICS (S & A)
DEC., 1972	-	NSF/NASA SOLAR ENERGY PANEL REPORT
1972	-	COMMITTEE STAFF REPORT, S & A

DESIGN

JUNE 7,12 1973	-	HEARINGS ON SOLAR ENERGY TECHNOLOGIES S & A SUBCOMMITTEE ON ENERGY SUPPORTED EXPANDED FEDERAL SOLAR PROGRAMS
JUNE-OCT. 1973	-	HR 10952 DRAFTED NSF, NBS, NASA, HUD, DOD INTRODUCED 10116 BY MCCORMICK
NOV. 2, 1973	-	S.2650 INTRODUCED (CRANSTON - BANKING, HOUSING AND URBAN AFFAIRS)
NOV. 5, 1973	-	S.2658 (H11864 COMPANION) INTRODUCED - MOSS & WEICKER

DESIGN

Nov. 13-15, - 1973	Hearings on HR 10952 - Energy Subcommittee
Dec. 10, - 1973	HR 11864 (amended version of 10952) to full committee
Jan. 28, - 1974	Reported to House
Feb. 13, - 1974	Passed, with amendments, by House
Feb. 19, - 1974	HR 11864 - referred to Senate Committee on Aeronautical & Space Sciences
Feb. 25, - 1974	Senate Hearings on HR 11864, S.2658
March 11, - 1974	Senate Comm (A.S.S.) reports HR 11864 substituting S.2658 language
March 13, - 1974	HR 11864/S.2658 referred to 4 Senate Committees Commerce Banking, Housing & Urban Affairs Labor & Public Welfare Interim & Insular Affairs
March 20-21- 1974	BHUA Subcommittee on H & VA Hearings on S.2650 & HR 11864
March 27, - 1974	L & PW Subcommittee on NSF Hearing on S.2650 & HR 11864

DESIGN

March 29, 1974 & April 5, 1974	-	C Subcommittee on Science and Technology Hearing on S.2650 & HR 11864
May 21, 1974	-	HR 11864 passes Senate, with ammendments
Aug. 12, 1974	-	Conference Report Senate agrees
Aug. 21, 1974	-	House agrees
Sept. 3, 1974	-	President Ford signs PL 93-409

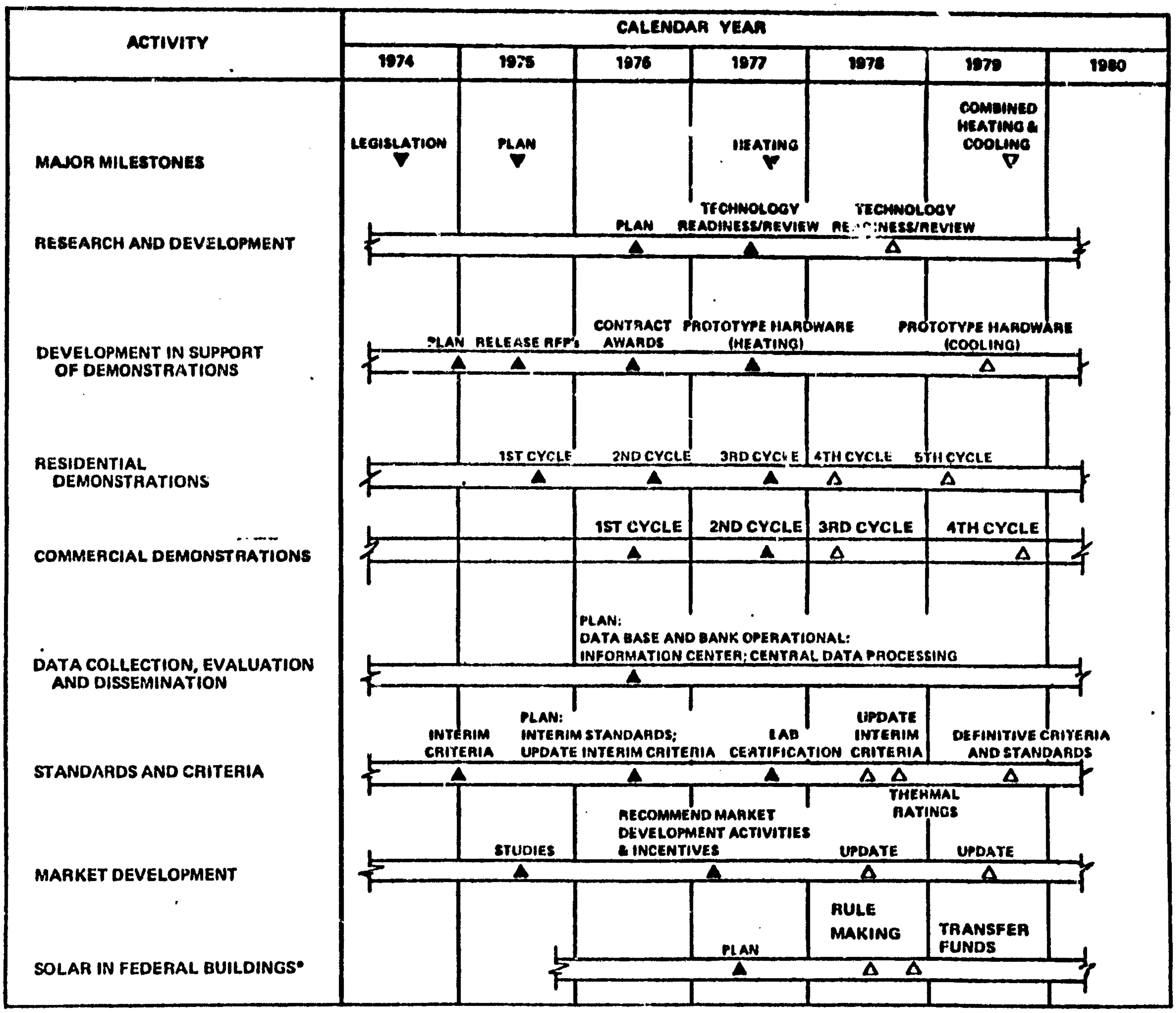
IMPLEMENTATION

Sept.-Dec. 1974	-	NASA/HUD with NBS, DOD, NSF prepare program plan submitted to Congress 12/30/74
Sept.-Dec. 1974	-	HUD prepares interim performance criteria for systems and dwellings to White House/ Congress 1/1/75
Jan. 19, 1975	-	ERDA established - PL 93-438
March 1975	-	ERDA 23 - National Plan

IMPLEMENTATION

OCT. 1975	-	1ST NATIONAL CONFERENCE ON SOLAR STANDARDS
SEPT. 13-15 1975	-	2ND NATIONAL CONFERENCE ON SOLAR STANDARDS
JAN. 19, 1976	-	HUD CYCLE 1
NOV. 1976	-	ERDA 23A - (76-6) UPDATED NATIONAL PLAN
JAN. 1, 1977	-	HUD CYCLE 2
MAY 30, 1977	-	HUD CYCLE 3
OCT. 1977	-	DOE ESTABLISHED
MAR. 29, 1978	-	HUD CYCLE 4
JULY 1978	-	DOE/CS-0007 NATIONAL PLAN
SEPT. 28, 1978	-	HUD CYCLE 4A - PASSIVE

SOLAR HEATING AND COOLING PROGRAM

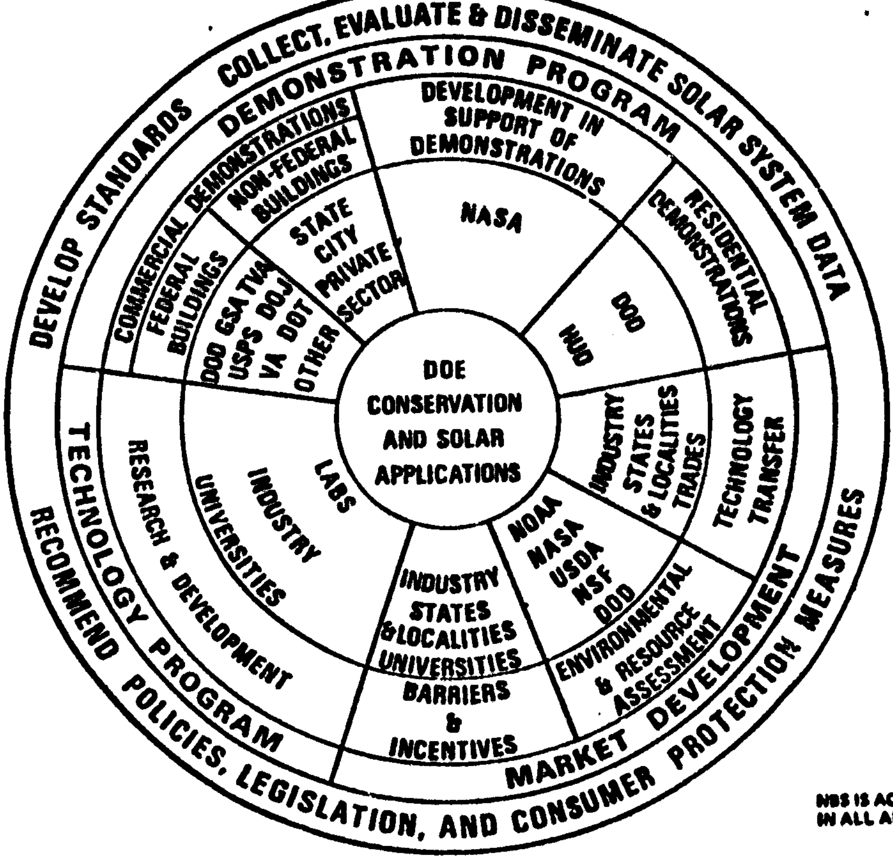


*A NEW THREE YEAR PROGRAM TO BE DEVELOPED IN ACCORDANCE WITH THE NEP.

▲ ACCOMPLISHED ACTIVITIES

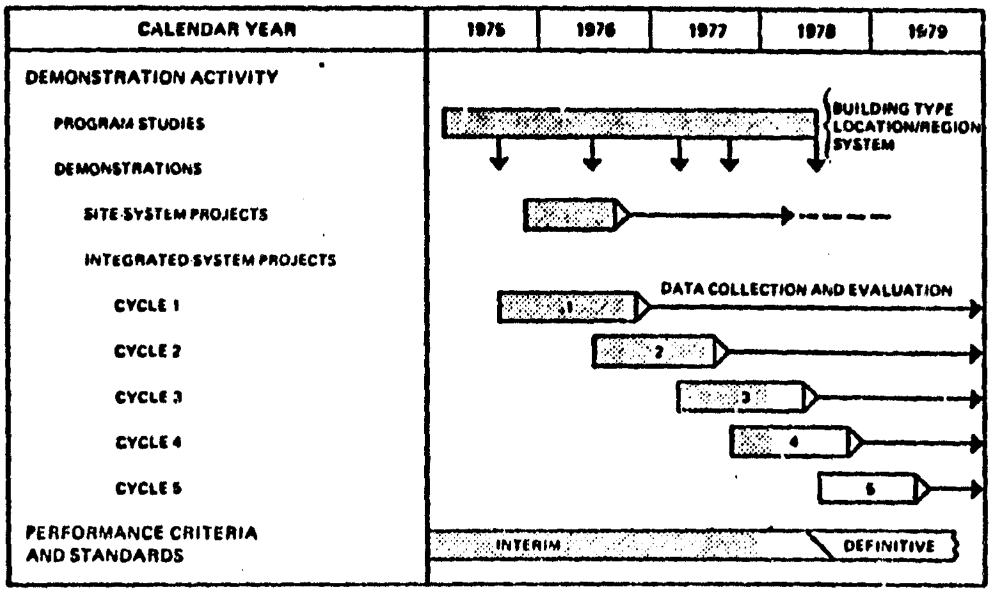
△ SCHEDULED ACTIVITIES

PROGRAM PARTICIPATION
NATIONAL HEATING AND COOLING OF BUILDINGS



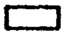
NBS IS ACTIVE
IN ALL AREAS

HUD RESIDENTIAL DEMONSTRATION PROGRAM



*IMPLEMENTATION OF THE RESIDENTIAL DEMONSTRATION PROGRAM 5TH CYCLE IS PREDICATED ON THE SOLAR COOLING R&D PROGRAM DEVELOPING TECHNOLOGIES WHICH WILL BE BENEFICIAL

ACCOMPLISHED ACTIVITIES



SCHEDULED ACTIVITIES

SHAC RESIDENTIAL STRATEGY

- DEVELOPER/BUILDER MOTIVATED BY THE BOTTOM LINE.
- THE BOTTOMLINE IS $S.
- INDUCE THE DEVELOPER/BUILDER WITH $S.

SHAC IMPLEMENTATION

+ SITE-SYSTEM
+ INTEGRATED SYSTEMS - 5 CYCLES, RFGAs
+ PASSIVE DESIGN COMPETITION
+ INSTRUMENTATION

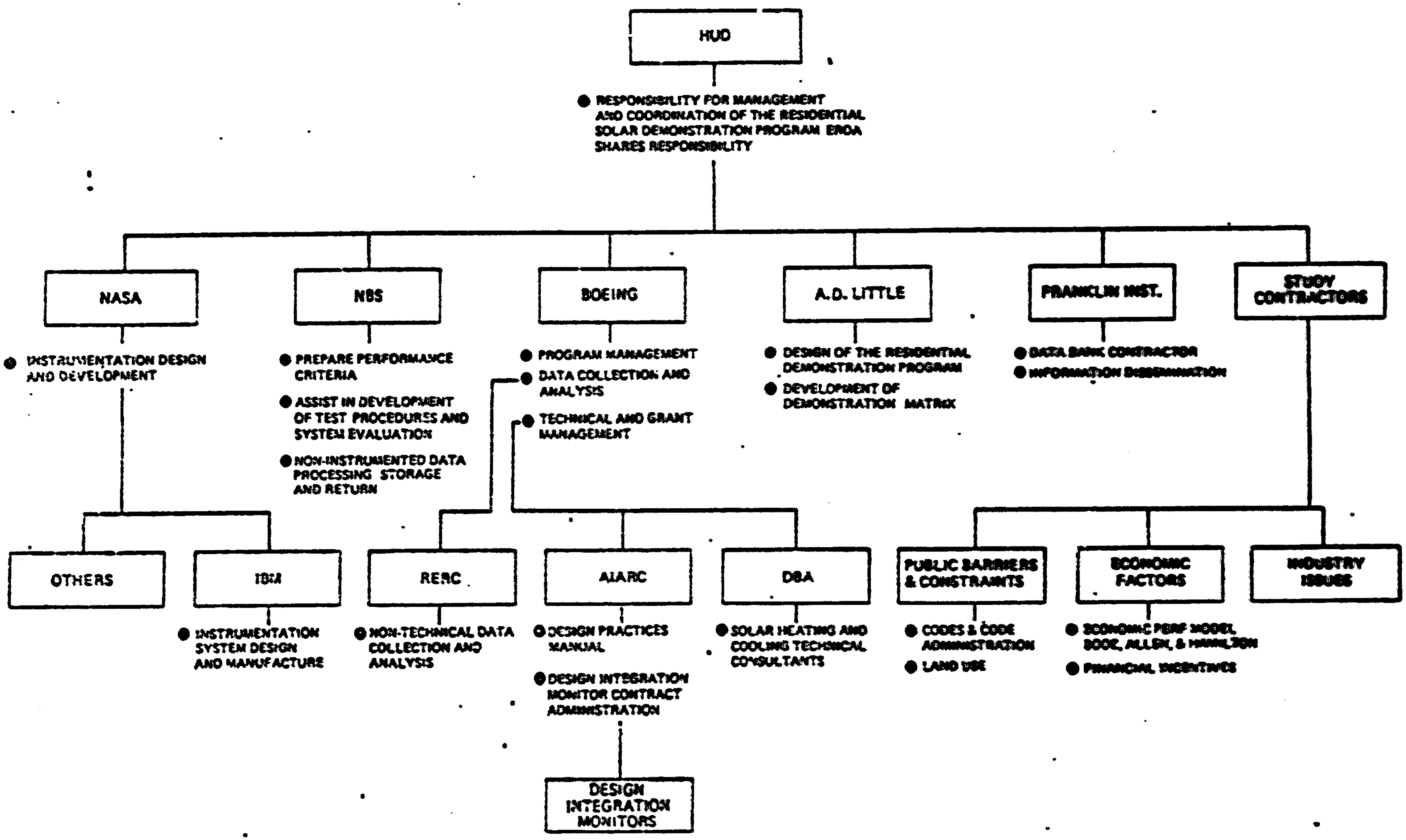


Figure . HUD Solar Energy Demonstration Program Organization Chart

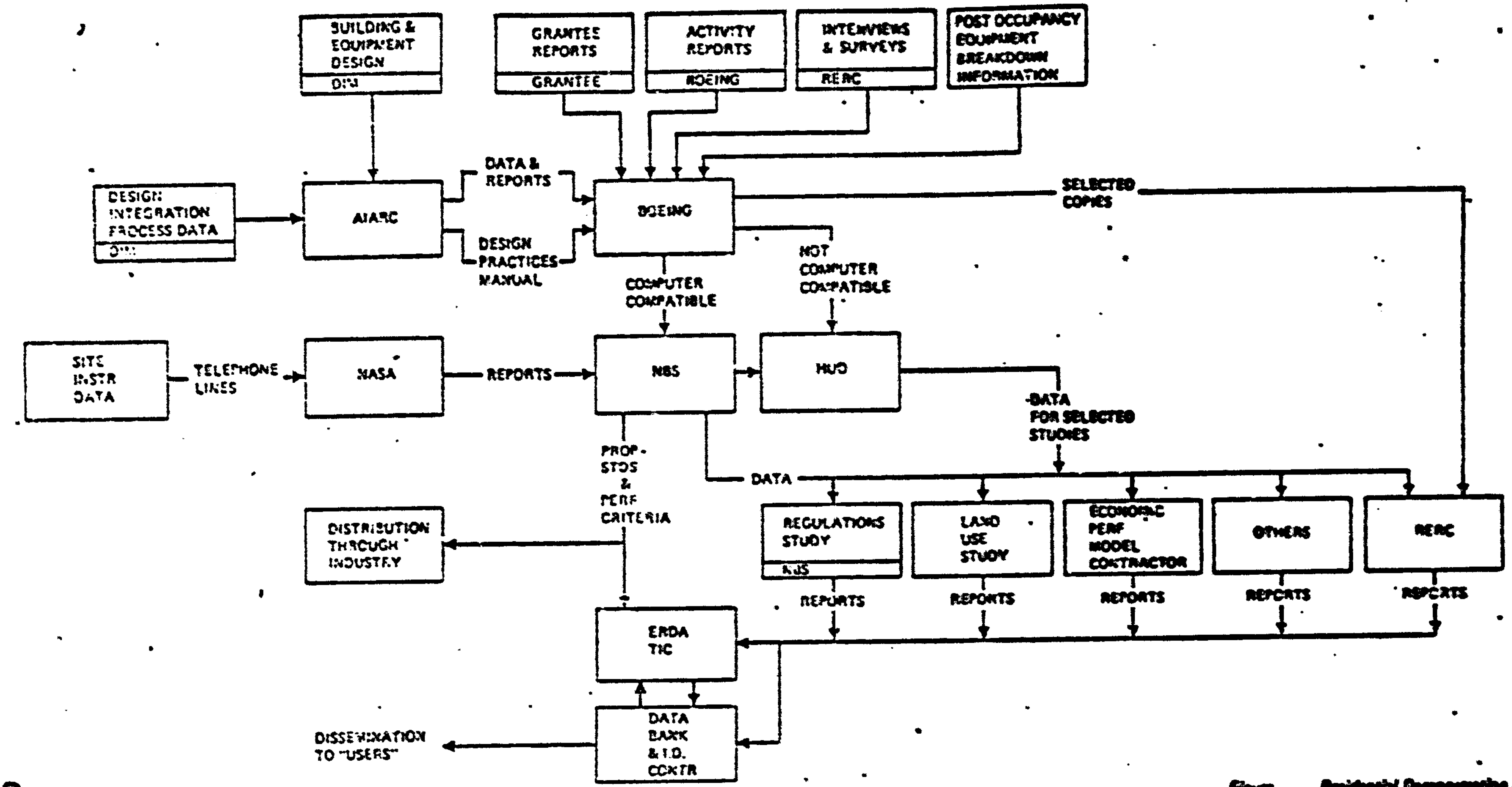


Figure . Residential Demonstration Prog Data Flow Chart

SHAC SUMMARIZED

+ THE INTENT -- DEMONSTRATION PROGRAM

+ THE REALITY -- RESEARCH & TECHNOLOGY DEVELOPMENT PROGRAM

+ THE OUTCOME -- A MUDDLED PROGRAM

WHY A MUDDLED PROGRAM?

IN CRISIS, FALL BACK ON ROUTINES

ROUTINES, BY FAMILIARITY, PROVIDE CONFIDENCE THAT THE PROCESS IS LEGITIMATE AND THE OUTCOMES ACCEPTABLE

NO MATCH BETWEEN OR AMONG THE
ROUTINES OF THESE INSTITUTIONAL ARENAS;

1) FEDERAL POLICY

2) FEDERAL PROGRAM ADMINISTRATION

3) TECHNICAL DEVELOPMENT

4) HOUSING

Table 2

The Four Institutional Arenas in the SHAC Program

ARENA 1

+ **Institutional Arena -- Federal Policy**
+ **Currency of Exchange -- Money**
+ **Atmosphere -- National Energy Crisis**
+ **Routine -- Congress Enacts, Authorizes, Appropriates**

ARENA 2

+ Institutional Arena -- Federal Program Administration
+ Currency of Exchange -- Status
+ Atmosphere -- Turf Protection
+ Routine -- Obtaining and Running Programs

ARENA 3

+ Institutional Arena -- Technology Development
+ Currency of Exchange -- Quantifiable Data
+ Atmosphere -- Engineering Crisis
+ Routine -- Instrument

ARENA 4

+ Institutional Arena -- Housing
+ Currency of Exchange -- Marketability
+ Atmosphere -- Market Risk, Mitigated by Interdependencies
+ Routine -- Word-of-Mouth

FACTORS IN SOLAR ACCEPTANCE IN HOUSING

+ DEVELOPER MOTIVATIONS
+ INFORMATION EXCHANGES
+ COMPREHENSIBILITY

DEVELOPER MOTIVATIONS

+ FRIENDS -- REALIZATION OF IDEALS
+ INDIANA -- TEAM SPIRIT
+ RESERVOIR HILLS -- ORGANIZATIONAL FOUNDATION
+ AMREP -- CORPORATE EXPANSION

INFORMATION EXCHANGES

+ TYPE -- RESERVOIR HILLS, FINANCIAL
+ SOURCE -- INDIANA, FROM HBAI
+ DENSITY -- AMREP, MITRE CONFERENCE
+ CONTINUITY -- SANTA CLARA, SCIENCE ADVISOR

COMPREHENSIBILITY

VIA THE SUPPORTING INSTITUTIONAL NETWORK
(MARKET RISK MITIGATED BY INTERDEPENDENCIES)

+ LEGITIMATOR HBAI
+ TRANSLATOR REDDING
+ LINKING-PIN AMREP ENVIRONMENTAL CONSULTANT
+ PLUNGER FRIENDS
+ REGULATOR SAN DIEGO COUNTY GOVERNMENT

CONCLUSIONS

1. THE SHAC PROGRAM IS A LEGISLATIVE HYBRID OF TECHNOLOGY DEVELOPMENT AND HOUSING DOOMED TO FAILURE.

2. IN THE HOUSING MARKET NEITHER FINANCIAL INCENTIVES NOR TECHNICAL DATA ARE SUFFICIENT FOR A SOLAR INNOVATION TO BE ACCEPTED.

3. INNOVATION ACCEPTANCE IN THE HOUSING SECTOR REQUIRES MEDIATION THROUGH ROUTINE AT THE LOCAL MARKET LEVEL.

4. RECIPIENTS OF SHAC SUBSIDIES HAD MOTIVATIONS OTHER THAN CONVENTIONAL MARKET OBJECTIVES.

5. ACCEPTANCE OF SUBSIDY DOES NOT NECESSARILY MEAN ACCEPTANCE OF THE INNOVATION.

6. THE PROBABILITY OF ACCEPTANCE OF AN INNOVATION INCREASES WHEN INFORMATION COMES THROUGH ROUTINE EXCHANGES.

7. INFORMATION MUST BE ABOUT THE INNOVATION, NOT THE SUBSIDY.

LESSONS

* RESEARCH IS RESEARCH; DEMONSTRATION IS DEMONSTRATION

* DESIGN/ADMINISTER OUTSIDE D.C.

* MATCH ROUTINES OF THE ACCEPTING INSTITUTIONAL ARENA
  -- IN HOUSING
     DISSEMINATION STRATEGY IS THE KEY
  -- AS THE CURRENCY IS WORK-OF-MOUTH
     MULTIPLE ACTORS, MULTIPLE MOTIVATIONS,
     MAXIMUM INTERDEPENDENCIES

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

THE RESIDENTIAL BUILDING INDUSTRY INFRASTRUCTURE

Richard Rittleman
Burt, Hill, Kosar & Rittleman

February 12-13, 1980

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Emphasis in Introducing Solar Heating/Cooling Systems

	Builders	Architecture for Commerce and Industry Committee	Architecture for Education Committee	Architects' Housing Committee	Architects' Design Committee
Single Family Detached Homes	4.38	4.50	3.97	4.00	4.23
Townhouses	4.16	4.30	3.83	4.15	4.50
Low-Rise Apartments	4.23	4.10	3.90	4.00	4.36
Medium-Rise Apartments	3.84	3.90	3.76	3.52	4.23
High-Rise Apartments	3.51	3.80	3.72	3.45	4.09
Schools		4.90	4.47	4.05	4.59
Office or Professional Buildings		4.60	4.38	3.32	4.36
Commercial Buildings		4.40	4.14	3.55	4.36
Condominiums		4.10	3.82	4.00	4.45
Fitting Systems to Newly Designed Buildings		4.40	4.47	4.85	3.73
Fitting Systems to Existing Buildings		2.00	3.30	2.42	2.73

74-0212-V-10

Emphasis in Introducing Solar Heating and Cooling Systems

New Construction	Strong %	Some %	Little%
Commercial Building	69	23	8
High Priced, Custom Designed Residence	71	29	—
Lower Cost Home	31	54	15
Apartment House	69	15	15
School Building	50	43	7
Office or Professional Building	69	23	8
Condominium Apartment	64	29	7
Large-Scale Developments Such as Malls, 'New Towns'	77	15	8
Small-Scale Developments Such as Small Subdivisions	31	46	23
Existing Buildings			
Commercial Building	33	25	42
High Priced, Custom Designed Residence	42	17	42
Lower Cost Home	25	8	67
Apartment House	25	25	50
School Building	23	31	46
Office or Professional Building	17	42	42
Condominium Apartment	25	17	58
Large-Scale Developments Such as Malls 'New Towns'	33	25	42
Small-Scale Developments Such as Small Subdivisions	17	17	66

74-0212-VA-38

GRAPH 1. THE INDICATED AND WEIGHTED RELATIVE DECISION PROCESS BY BUILDERS WHEN CONSIDERING USE OF A COST SAVING INNOVATION BY ORDER AND MAGNITUDE OF CONSTRAINT CATEGORIES

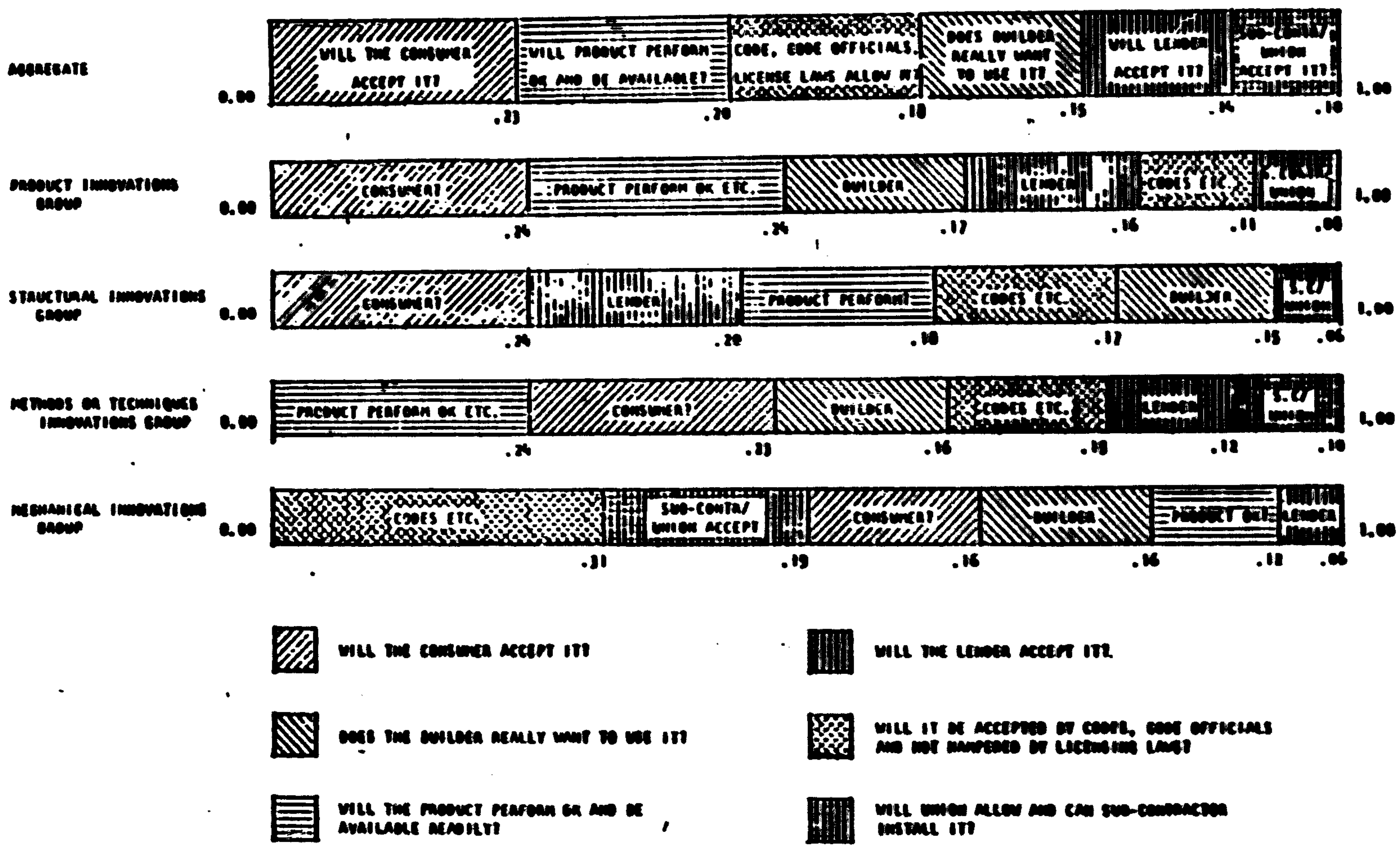


TABLE 35. Summary of constraint ranking for all innovations: builder, building code official and manufacturer responses.
(Ranked in order of significance)

Rank	Builder	Building Code Official	Manufacturer
1	Not considered using	Building code prohibits	Building code prohibits
2	Poor performance risk	Not considered using	Union rules prohibit
3	May damage reputation	Poor performance risk	Requires sub to change
4	Building code prohibits	May damage reputation	Material not available
5	Not enough technical information	Costs more	Building officials frown
6	Building officials frown	Not applicable to design	Not considered using
7	Not applicable to design	Unsatisfactory experience	Appraisal penalty
8	Not marketable	Requires sub to change	Costs more
9	Expect too many callbacks	Union rules prohibit	Poor performance risk
10	Costs more	Not enough technical information	Not enough technical information
11	Appraisal penalty	Building officials frown	Licensing system prevents
12	Lenders frown	Expect too many callbacks	May damage reputation
13	Unsatisfactory experience	Material not available	Lack of Management/supervision
14	Material not available	Not heard of item	Expect too many callbacks
15	Requires sub to change	Not marketable	Lenders frown
16	Not worth extra training	Lenders frown	Not worth extra training
17	Union rules prohibit	Not worth extra training	Not heard of item
18	Lack of management/supervision	Licensing system prevents	Unsatisfactory experience
19	Licensing system prevents	Lack of management/supervision	Not applicable to design
20	Not heard of item	Appraisal penalty	Not marketable

TABLE 31. Rank order of constraints by aggregate weighted values.

Rank Order	Constraint	Aggregate Weighted Value
1	Not considered using	.45
2	Poor performance risk	.44
3	May damage reputation	.39
4	Building code prohibits	.34
5	Not enough technical information	.32
6	Building officials frown	.30
7	Not applicable to design	.30
8	Not marketable	.26
9	Expect too many callbacks	.26
10	Appraisal penalty	.21
11	Costs more	.21
12	Lenders frown	.20
13	Unsatisfactory experience	.19
14	Material not available	.17
15	Requires sub to change	.16
16	Not worth extra training	.13
17	Union rules prohibit	.11
18	Licensing system prevents	.09
19	Lack of management/supervision	.09
20	Not heard of item	.08

OF POOR QUALITY

PV MARKET ANALOGY

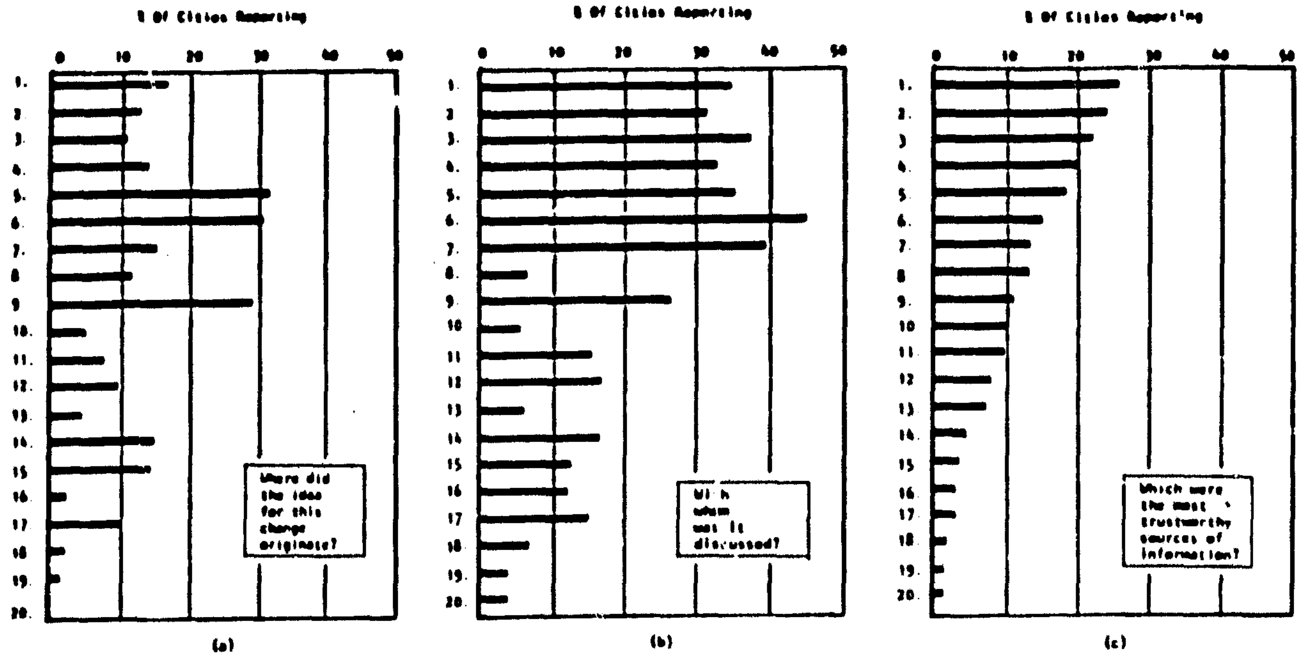
$.50/$W_p$ PV APPROX. EQUAL TO $.50/LB. CATFISH

	PV	CATFISH
SATISFIES STRONG BASIC NEED	ENERGY	FOOD
SATISFIES STRONG SPECIFIC NEED	ELECTRICITY	PROTEIN
ECONOMICALLY COMPETITIVE	COMPETETIVE WITH MANY POWER SOURCES	BEATS CHICKEN
RECENT STRONG TECHNOLOGY DEVELOPMENT	LSA	CATFISH FARM CONTROLLED GRAIN FEEDING
ENVIRONMENTAL ACCEPTABILITY	ENVIRONMENTALLY BENIGN	MOST EFFIC. PROTEIN PRODUCER KNOWN
MALLEABLE TECHNOLOGY	• FLAT PLATE • CONCENTRATOR • REMOTE SITE • CENT. POWER • THERMAL/PV	BROILED FRIED STUFFED CASSEROLE

	P/V	CATFISH
COMMERCIAL AVAILABILITY	SUPPLY CAPABILITY EXCEEDS DEMANDS	DITTO
PUBLIC ACCEPTANCE	BOTH COMMAND A SMALL BUT DEDICATED GROUP OF DEVOTEES.	
MARKET DEPENDENCY	IF YOU LOOK HARD ENOUGH YOU CAN FIND A PRIVATE PURCHASE OUTSIDE OF THE GOVERNMENT PROGRAM.	IF YOU LOOK HARD ENOUGH YOU CAN FIND A PIECE OF FROZEN CATFISH OUTSIDE OF THE DEEP SOUTH.
RESOURCE IMPACT	RAPID INCREASE IN P/V MARKET GROWTH COULD CAUSE Sr SHORTFALL.	RAPID INCREASE IN CATFISH MARKET COULD RELEASE SUBSTANTIAL AMOUNTS OF GRAIN TO THE WORLD MARKET.

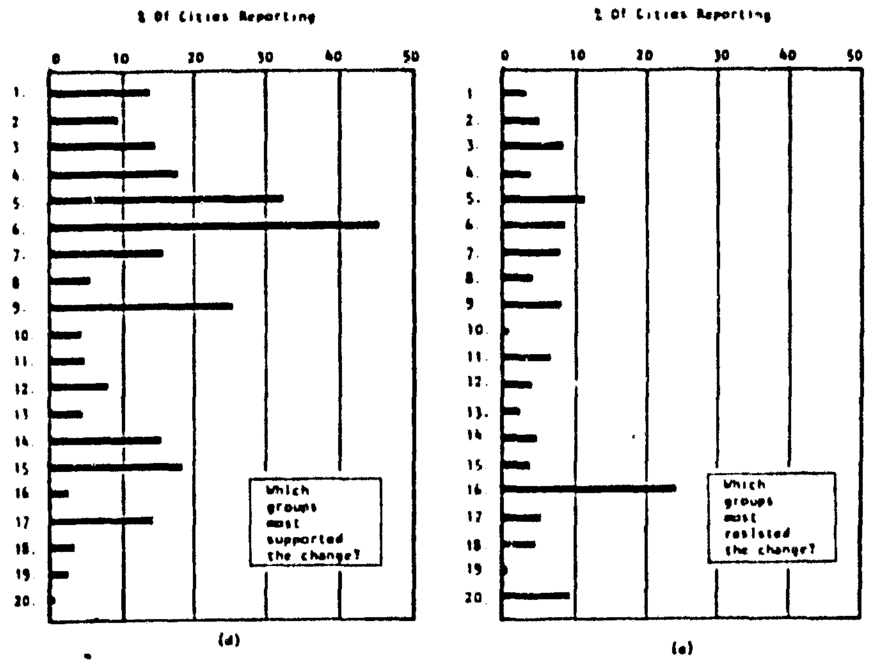
SO WHY HASN'T CATFISH PENETRATED THE MARKET?

C-2



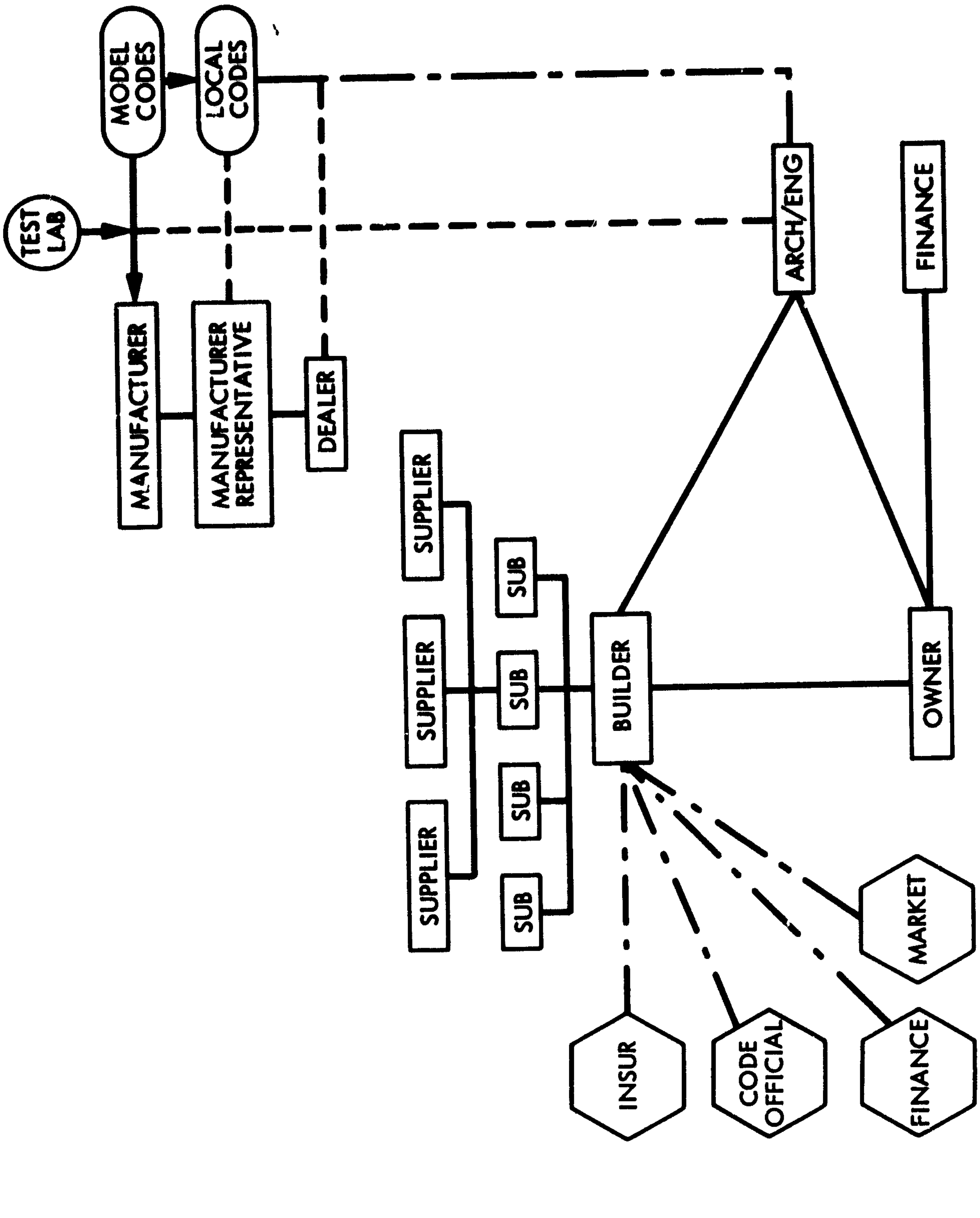
1. Meetings of professional associations 2. Building officials from cities outside county. 3. Building officials from cities within county. 4. Architects or engineers 5. Building material producers or supplier representatives local. 6. Builder representatives local. 7. Building department staff. 8. Trade or professional magazines. 9. Building material producers or supplier representatives out-of-town 10. Government publications. 11. Other sources. 12. Meetings or conventions of materials producers. 13. Building product catalogs. 14. Yourself. 15. Prefabricated home manufacturer representatives. 16. Union representatives local. 17. Building representatives. out-of-town 18. Civic or voter groups. 19. Mass media (TV, magazines, newspapers). 20. Union representatives. out-of-town.

For the most difficult code item adoption with responses disaggregated by code type (a) where did the idea for this change originate? (b) with whom was it discussed? (c) which were the most trustworthy sources of information? (d) which groups most supported the change? (e) which groups most resisted the change?



PARTICIPATION IN COLLECTIVE DECISION MAKING IN THE LOCAL BUILDING DEPARTMENT BY ACTOR AND ROLE

FIGURE 2


MODEL CODES
LOCAL CODES
TEST LAB
MANUFACTURER
MANUFACTURER REPRESENTATIVE
DEALER
ARCH/ENG
FINANCE
SUPPLIER
SUPPLIER
SUPPLIER
SUB
SUB
SUB
SUB
BUILDER
OWNER
MARKET
FINANCE
CODE OFFICIAL
INSUR

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

NON-HARDWARE SUB-EXPERIMENT DESIGN

Jeff L. Smith

Photovoltaic Lead Center

February 12-13, 1980

DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

PROGRAM

- PROGRAM OBJECTIVE

  MAXIMIZE DEPLOYMENT OF PHOTOVOLTAIC SYSTEMS WITHIN RESOURCE AND OTHER CONSTRAINTS IMPOSED

- PROGRAM TOOLS
  - RESEARCH
  - TECHNOLOGY DEVELOPMENT
  - SYSTEM TESTS AND DEMONSTRATIONS

- USE OF TESTS AND DEMONSTRATIONS TOOL
  - TRIAL AND ERROR
  - EXPERIMENT DESIGN

- CONSTRAINTS ON TESTS AND DEMONSTRATIONS
  - TIME
  - MONEY/SIZE
  - REQUEST FOR PROPOSAL

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DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM

IMPLEMENTATION WORKSHOP

INTERMEDIATE OBJECTIVES, TESTS AND DEMONSTRATIONS

DESIGNED TO SERVE:

- POLITICAL MANDATE
    - TIMING
    - GEOGRAPHICAL DISPERSION
    - SYSTEM TYPE
- INFORMATION DISSEMINATION ⟶ DEMONSTRATION
    - DESIGN DIFFUSION STRATEGIES
    - INCLUDE APPROPRIATE PLANNERS

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INTERMEDIATE OBJECTIVES, TESTS AND DEMONSTRATIONS (contd)

- INFORMATION PRODUCTION ⟶ EXPERIMENTS (TESTS)
  - IDENTIFY UNCERTAINTIES
  - FORMULATE HYPOTHESES
  - DESIGN EXPERIMENT
    - SAMPLE SIZE
    - EXPERIMENT DURATION
    - ESTABLISH CONTROL
    - DESIGN DATA COLLECTION

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DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

SAMPLE EXPERIMENTS

- SYSTEM PERFORMANCE
  - CONFIGURATION
  - INTEGRATION
  - TILT ANGLES
  - DISPLAY INSTRUMENTATION
  - PREDICT FUTURE PERFORMANCE
- SYSTEM COST
  - MEASUREMENT
  - PREDICTIONS
- MARKET DEFINITION
  - HOMEOWNER PROFILE
  - GEOGRAPHIC LOCATION
  - HOUSING STOCK (RETROFIT)
  - UTILITY CHARACTERISTICS
- "OPTIMAL"/ APPROPRIATE RATE STRUCTURES
  - LOAD SHIFTING
- TEST OPTIMAL DIFFUSION HYPOTHESES
  - INSTALLATION TRAINING
  - DEMONSTRATION DESIGN

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DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

SAMPLE EXPERIMENTS (contd)

- INFRASTRUCTURE ARRANGEMENTS
  - INSTALLATION
  - BUILDER / DEVELOPER / PHOTOVOLTAIC SYSTEM SUPPLY
- EFFECTS OF PHOTOVOLTAIC DEPLOYMENT ON UTILITIES
- COMPLEMENTARY APPLIANCE AND CONSERVATION TECHNIQUE DETERMINATION
- EFFECTS OF STANDARDS
- EFFECTS OF CONTRACTING ARRANGEMENTS

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2/13/80

MULTI-YEAR PHOTOVOLTAIC SYSTEM PURCHASE PROGRAM EXPERIMENTAL DESIGN

Residential Applications Program Implementation Workshop

Session III

Caltech

February 12, 1980

Tom W. Hamilton, Manager for Planning, Assessment, and Integration
Technology Development and Applications, Photovoltaics Lead Center

PRIMARY EXPERIMENTAL OBJECTIVES

First-of-a Kind Experiments (ISEE)	Engineering Field Tests (EFT)	Market Tests (MT)
• Demonstrate technical feasibility of regionally appropriate system designs in the user environment	• Demonstrate that system price goals are likely to be met if factory-made components meet goals • Evaluate alternative cost-reduction approaches, verify system performance • Start infrastructure development • Attack market development barriers	• Test market acceptance of selected systems • Verify that systems can meet price goals (at a specified volume) • Support infrastructure development • Resolve market development barriers • Determine major utility impact at sub-station level

DEVELOPMENT OF BASELINE EXPERIMENT PLANS

- Overall guidance from top-level documents
  - Multi-year Program Plan
  - Residential Applications Requirements
  - Guidelines for specific program phases

- MIT-LL leads development of Baseline Experiment Implementation Plans for ISEE, EFT
  - Detailed objectives
  - Selection criteria and process
  - Planned instrumentation, monitoring, and reporting
  - Basic experiment design

EXPERIMENT (OR MISSION) TEAM CONCEPT

Description

- Competitively selected contractors (hardware exclusion clause) funded to design and perform specific subexperiments they propose to complement the Baseline Experiment Plans in support of the EFT / MT objectives
- One team for all residential applications

Purposes

- Augment EFT / MT plans and measurements to enable a more rigorous and complete evaluation of the degree to which objectives are met
- To generate original ideas which can enhance the value of the experiment
- To assist selected contractors in resolving market and institutional barriers

Output

- Subexperiment plans including requirements on EFT / MT
- Documented results, recommendations
  - Measurement of market acceptance
  - Regulatory and institutional intervention (e.g., rate structure experimentation)
  - Institutional issues from various viewpoints
  - Evaluation of cost-reduction, learning experience

SCHEDULE

- White papers on selected topics: mid-March
- Workshop Proceedings: April
- Decision on Experiment (or Mission) Team Concept: May
- Utility Interface Meeting: June
- Pilot Residential Phase A_1
  - RFP issued October-December
  - Awards April-May, 1981

PHOTOVOLTAIC RESIDENTIAL IMPLEMENTATION WORKSHOP

NON-HARDWARE EXPERIMENT DESIGN: SOME ANALYTICAL SOLUTIONS TO WICKED PROBLEMS

FRANK CAMM
THE RAND CORPORATION

FEBRUARY 1[illegible] [illegible], 1980

This presentation illustrates the potential for collecting data to examine residential photovoltaics with three possible subexperiments. It emphasizes that, before any data collection begins, you must ask what it is you want to know. The data you collect and the experiments you design will serve you better if they are specifically targeted early in your planning. It then looks at what experiments can tell you about the basic questions you ask. And it suggest three three experiments you may wish to consider. These are illustrative and meant more to spark your thinking than to specify your plans in any way.

The fact that soft tissues, or "wicked problems" as they have come to be known during this conference, are often difficult to address in a rigorous way does not mean that they cannot be addressed rigorously. We are fortunate that soft problems associated with consumer demand, pricing policy, and consumer response to policy changes are well understood and can, if properly approached, be analyzed in a precise and productive way. Analysis of such problems, however, requires data collection that is at least as demanding as the collection of data on hardware issues like system performance. In this sense, these soft issues are every bit as hard as the hardware issues and require an equally hard-headed approach. The hardware experiments being proposed here offer the opportunity to collect data on issues important to eventual consumer acceptance of photovoltaics.

OUTLINE

- WHAT YOU WANT TO KNOW
- WHAT EXPERIMENTS CAN TELL YOU ABOUT THAT
- THREE SUGGESTIONS FOR EXPERIMENTS

When one starts to think of all the questions one might ask about nonhardware issues associated with photovoltaics, it quickly becomes clear that many are possible. The presentations this morning emphasized the range of institutional questions we can ask. They tend to have a relatively short term, tactical emphasis. I would like to suggest some issues of a more long term, strategic nature--questions which are likely to generate information more useful to the development of the market for photovoltaics over the long run. Since we are concentrating on new construction and the housing stock turns over at a rate of only about 2 percent a year, I would expect the long run to receive special attention in questions addressed to nonhardware issues.

The issues I raise all relate to the question of how consumers will react to the availability of residential photovoltaic technology. I have broken out what may appear to be sequential decisions--purchase, sizing, and use--but in fact they are joint decisions. While we may wish to look at one at a time, we should never forget the relationships among them. As a result, the same factors are likely to be important determinants of all of them.

The determinants listed are factors typically considered in studies of housing-related investments. One, the terms of purchase, may be of particular interest because of the persisting puzzle that consumers typically do not invest in energy saving options even when engineers and economists think they should. Careful attention to the terms of purchase may tell us why household investment behavior differs from that one would predict for "rational" households. This is a key factor--perhaps the key factor--of importance to the eventual acceptability of photovoltaics in the residential market.

WHAT IS IT YOU WANT TO KNOW ?

DETERMINANTS OF:

- PURCHASE
- SIZING OF COLLECTORS AND STORAGE
- PATTERN OF ELECTRICITY USE FOLLOWING PURCHASE

POSSIBLE DETERMINANTS INCLUDE:

- TYPE OF HOUSING
- TYPE OF HOUSEHOLD
- PATTERN OF INSOLATION, DEGREE-DAYS
- TERMS OF TARIFF
- TERMS OF PURCHASE

What an experiment can tell you about these issues is limited by the expense and productivity of the data an experiment produces. For a given cost, the quality of information one can generate falls with the number of parameters which must be estimated (unless they can be shown or assumed to be dependent), falls with the number of locations which must be studied (unless the underlying structure of one's model can be shown or assumed to be stable across locations), and falls as the length of the time horizon of decisionmaking rises. What that means is that, within a given budget, one faces an unavoidable tradeoff between the quantity and quality of information. In a moment we will see that the tradeoff can be demanding. High quality information is available only if an experiment is designed to define the values of a very limited set of policy-relevant parameters.

Anything that can "loosen up" the terms of this tradeoff, then, should be exploited. Fortunately, careful foresight and planning can wring much better and much more information out of the data collected for a given cost than might first be evident. Reference to earlier housing studies, for example, can help pin down what parameters are important and what functional forms to expect. Though no demand studies of photovoltaics are available, photovoltaics display a striking similarity to housing insulation in the way they affect a consumer's demand for external power. Hence studies of the demand for insulation may prove quite helpful. Similarly, the importance of the power grid/household interface to photovoltaics makes previous experiments on electricity rates helpful. They not only provide information on the potential relationship between rate structure and demand for photovoltaics; they may also provide valuable empirical baselines for data collection aimed at photovoltaics. And, of course, most important of all, the theory of consumer response will be invaluable in imposing structure on questions about consumer acceptance of photovoltaics. It is this theory that makes a potentially soft area not only manageable but potentially invaluable to policy formation and market development.

WHAT CAN AN EXPERIMENT TELL YOU ?

IT IS LIMITED BY:

- NUMBER OF PARAMETERS
- NUMBER OF LOCATIONS
- TIME HORIZON

BUT IT IS GREATLY ENHANCED IF COMBINED WITH

- EARLIER HOUSING STUDIES
- EARLIER RATE EXPERIMENTS
- THEORY OF CONSUMER RESPONSE

With these simple guidelines in mind, let us consider three potential subexperiments. The first two exploit econometric techniques and demand theory to exploit a potential data source in a precise and controlled way. The third is more speculative and is probably not appropriate with the current state of knowledge. It is, however, an experiment which will be conducted in the future; cognizance of it now should speed the date when it can be conducted.

THREE TYPES OF EXPERIMENTS

- DETERMINANTS OF HOUSEHOLD PURCHASE
- HOUSEHOLD RESPONSE TO OWNERSHIP
- RESPONSE TO RATE DEREGULATION

The first subexperiment we will consider is one designed to collect data on what factors are important to the decision to purchase residential photovoltaics. Reviewing a similar study of household insulation briefly will help raise the problems and potential one should expect from such a subexperiment. Robert Smiley's analysis of the determinants of household insulation is based on a random sample of 1049 observations from a survey data base about ten times as large. The survey collected unaudited, qualitative data on households in New York State. Smiley posited a logistic model for each of three dependent variables and used various subsets of 21 demographic, housing, and weather variables to "explain" the behavior of each of these dependent variables.

PURCHASE DETERMINANTS: AN EXAMPLE
SMILEY'S "DETERMINANTS OF HOUSEHOLD INSULATION"

MODEL: $E(p) = e^{X\beta} / (1 + e^{X\beta})$

DEP VAR:
- a) LEVEL OF INSULATION
- b) ADDITIONS OF INSULATION
- c) INTENTIONS TO ADD INSULATION

IND VAR:

$$\left.\begin{array}{ll} \text{a)} & \text{DEMOGRAPHIC} \\ \text{b)} & \text{HOUSING} \\ \text{c)} & \text{WEATHER} \end{array}\right\} k = 21$$

SAMPLE: $n = 1049$

PROBLEMS:
- a) SURVEY BIAS
- b) RESPONSE BIAS
- c) LACK OF CONTROL OVER DATA COLLECTED
- d) COLLINEARITY

His first equation suggests the kind of results he got. Two general observations are important. First, given that the variables are all dummies, the coefficients are small relative to the constant term. Second, for a sample of 1046, the t-values are rather small.

These results can be explained at least in part by considering some of the problems Smiley had. First, unaudited survey data are known to be undesirable; they lead to measurement errors that bias coefficient estimates toward zero. Second, response bias--the bias introduced by using data only from households who respond to a survey--can push the coefficient estimates in any direction. Smiley believes he has avoided response bias but cannot test for survey bias. Third, and most serious, Smiley had no control over the survey or sample design. The use of qualitative data as crude as those illustrated in Slide 7 is bound to lead to measurement error. Poor phrasing of questions and choice of variables also lead to (a) the need to use crude proxies and (b) dependencies among variables that induced collinearity. Had Smiley been able to collect these data in an experiment and to choose precisely the data he wanted to collect, he could have avoided all of these problems.

SMILEY'S 1st EQUATION
DEP VAR: PR [INSULATION >6 INCHES]

IND VAR	$\hat{\beta}$	t
$\$10\,K \leqslant y < \$15\,K$	0.35	1.27
$\$15\,K \leqslant y < \$20\,K$	0.34	1.23
$\$20\,K \leqslant y < \$30\,K$	0.51	1.84*
$\$30\,K \leqslant y$	0.74	2.60**
ELECT. SPACE HEAT?	2.88	7.25**
GAS SPACE HEAT?	-0.22	1.19
CENTRAL AIR COND?	0.74	3.11**
$30 < age \leqslant 50$	-0.15	0.45
$50 < age \leqslant 64$	-0.59	1.72*
$65 \leqslant age$	-0.56	1.47
PRICE/MM BTU	-0.18	3.66**
HEATING DEGREE DAYS	0.21	2.66**
HOUSE AGE	-0.09	0.45
CONSTANT	-1.74	

n=1046

I would suggest that you consider a model that jointly determines (a) purchase and (b) sizing. Purchase could be modelled by a logistic function and sizing by a simple linear relationship. You should anticipate an intercorrelated error structure. Data on the household, house, tariff, and terms of purchase would be collected to estimate these two relationships. To the extent that you must focus your interest, I would focus on the tariff and terms of purchase. This immediately raises a difficult problem. If a purchaser expects a tariff to last only for the length of the experiment, the tariff imposed during the experiment is unlikely to be representative of the one he uses in his life cycle investment decision. Hence, I would focus on response to alternative experimental tariffs only if you get the local utility to cooperate and maintain that tariff indefinitely.

Other key issues also arise. First, should the household or the builder/contractor be the focus of the analysis? On the one hand, demand for photovoltaics ultimately lies with the household that purchases a house; on the other, the household is unlikely to be well enough informed to choose a system and size it without the builder's assistance. My inclination is to treat the builder's decision as a veil and concentrate on the household, but this question obviously deserves careful attention. Second, where should the experiment be conducted? I would recommend limiting the experimental sites to no more than two or three cities. Each additional city requires control of weather and (unless experimental tariffs are used) utility nuisance variables that can be avoided if the number of sites is limited. Third, can sampling design make a difference within a site? The answer is a resounding "yes!" but that is best discussed with reference to our second experiment. Let me just note here that explicit determination of the data to be collected and the model to be estimated as early as possible opens the way for a variety of nonrandom sampling designs that significantly enhance the information available within a given budget. The last issue is perhaps the most fundamental: is the information from an experiment representative of the behavior we would expect from consumers once photovoltaics are actually introduced? No, but demand theory allows us to make inferences about future behavior on the basis of experimental behavior. How much one trusts those inferences or how much they are worth will obviously have a fundamental effect on how desirable this kind of experiment is.

EXPERIMENT 1
DETERMINANTS OF HOUSEHOLD PURCHASE

QUESTION: WHAT AFFECTS A HOUSEHOLD'S DECISION TO PURCHASE?

MODEL: a) $E(p) = e^{x_1 \beta_1} / (1 + e^{x_1 \beta_1})$

b) $E(s) = X_2 \beta_2$

X_1, X_2 INCLUDE DATA ON HOUSEHOLD

HOUSE

TARIFF

TERMS OF PURCHASE

KEY ISSUES:

a) UNIT OF OBSERVATION

b) BREADTH OF EXPERIMENT

c) SAMPLING STRATEGY

d) EXTENT OF KNOWLEDGE, ROUTINE

The second type of experiment looks at the way a household responds to electricity rates if it owns photovoltaic capacity. To get an idea of what such an experiment might look like, consider the Rand Corporation electricity pricing experiment in Los Angeles. That experiment posited a linear regression of per period consumption on a fairly general functional form of prices in various rate periods and on demographic, housing, and appliance data. It collected detailed consumption data on 1800 Los Angeles households over a 30 month period.

The most important feature of this experiment is its use of nonrandom sampling devices to enhance the information one could infer from the data collected. Two are especially important. It used an "Allocation Model" to choose the experimental tariff treatments that should be used in the experiment and the number of households that should face each treatment in the experiment. A "Finite Selection Model" was then used to assign specific households to specific treatments in order to assure balance and orthogonality across plans. Both of these models minimize a loss function based on the precision of estimates of the effects of a set of predetermined policy changes. To specify such a loss function, one must know both (a) very specifically what policy questions are important, and (b) what the functional form of the response surface will be. Both must be known before sample selection even begins! But the payoff is worth the trouble.

HOUSEHOLD RESPONSE: AN EXAMPLE
RAND ELECTRICITY PRICING EXPERIMENT

MODEL: $KWH_i = a_{io} + \sum_j \alpha_{ij} P_j + \sum_j \beta_{ij} P_j^2 + \sum_k \gamma_k Z_k + u_i, \; i = 1 \ldots 5$

DEP VAR: CONSUMPTION IN TARIFF PERIOD i

IND VAR: PRICES IN 5 TARIFF PERIODS

DEMOGRAPHIC

HOUSING

APPLIANCES

SAMPLE: n = 1800

DESIGN: ALLOCATION & FINITE SELECTION

LENGTH: 30 MONTHS

PROBLEMS:
a) ROBUSTNESS
b) EFFECT OF HORIZON ON LEARNING
c) EFFECT OF HORIZON ON STOCK ADJUSTMENT
d) HAWTHORNE EFFECTS

Slide 10 shows the relative variances of predictions of the effects of a number of different treatments. $\sigma^2_{FSM}/\sigma^2_{Random}$ is the theoretical ratio of the variances from Finite Selection and Random Samples; $\sigma^2_{Actual}/\sigma^2_{Random}$ is the actual ratio observed. The ratios differ because the Finite Selection Model could not be perfectly implemented. Even in the imperfect implementation, however, nonrandom sampling reduced the variance about estimates of (increased the quality of information about) the effects of important policy actions an average of 28 percent. More complete implementation could have reduced that variance by up to 40 percent. These are equivalent approximately to 28 and 40 percent increases in sample size. The Allocation Model enhanced the sample in similar ways. In the Rand experiment, where observations cost about $100 to $400 each, the savings easily outweighed the additional cost associated with nonrandom sample design. The savings would be even more dramatic in a photovoltaic experiment where observation costs two orders of magnitude larger are anticipated.

The Rand experiment is not without its problems. First, the validity of the sampling techniques depends on the model assumed; significant changes in the model after the experiment starts both reduce the advantages of the sample design and introduce potential biases which must be corrected before the coefficient estimates can be accepted. The Rand experiment uses a relatively robust model in the key pricing variables to avoid these problems.

Second, the experimental horizon limited the amount of learning and stock adjustment we can expect in households. The Rand experiment is designed to be long enough to allow experience over at least two summers and winters; to the extent that learning is important, it can probably be measured over the course of the experiment and the extent of convergence on some final pattern of behavior can be detected. Little stock adjustment is expected; the experiment is meant to measure response only in the short run before such adjustment occurs.

Finally, any experiment must cope with Hawthorne or placebo effects-- behavioral changes induced by the simple fact that an experiment is on. The Rand experiment attempts to detect these effects in a number of ways, but cannot be certain that all are recognizable.

EFFECT OF FSM AND ACTUAL ALLOCATIONS ON "POLICY VARIANCES"

TREATMENT P_{sum}	P_{win}	SAMPLE SIZE	$\frac{\sigma^2_{FSM}}{\sigma^2_{RANDOM}}$	$\frac{\sigma^2_{ACTUAL}}{\sigma^2_{RANDOM}}$
-CONTROL-		39	0.73	0.57
2	2	41	0.86	0.83
5	5	43	0.74	1.11
5	2	54	0.89	0.95
8	2	21	0.76	0.93
2	5	59	0.97	1.47
2	8	9	0.54	0.65
MEAN		-	0.60	0.72

The photovoltaic rate experiment could be quite similar to the Rand rate experiment. The principal difference would be inclusion of a sellback price to supplement the purchase rate structure. Economic theory tells us that if purchase and sellback prices are equal in all periods, consumers will be unaffected by ownership of photovoltaic capacity (except for a minor income effect). That suggests that data from the Rand experiment or one of the other FEA-sponsored experiments might provide a useful baseline for the photovoltaic experiment. Experiments conducted to meet the requirements of the Public Utilities Regulatory Policy Act of 1978 (PURPA) might also be available. It also suggests that the photovoltaic experiments should concentrate more on differences between purchase and sellback prices than on other rate structure questions. It does not rule out, however, that the economic theory itself should be tested. This experiment offers an ideal opportunity to do that.

The very high cost of observations in the photovoltaic experiment suggests that a great deal of attention should be given to the experimental design. The sample size is the key constraint; its effect can be ameliorated to some extent by special attention to sample design and by an extended experimental horizon which reduces the potential importance of Hawthorne effects. Note, however, that the more important the sample design associated with this experiment, the harder it will be to use the sample for other experiments. In general, nonrandom sample designs reduce the number of experiments that can be performed with a sample of given size. And, of course, they put a premium on the robustness of the model used in association with each experiment.

EXPERIMENT 2
HOUSEHOLD RESPONSE TO OWNERSHIP

QUESTION: HOW DOES OWNERSHIP CHANGE BEHAVIOR?

MODEL:

a) $kwH = f(\boxed{P_{purchase}, P_{sell\ back}}; Z)$

b) POSSIBILITY OF f_{with}, $f_{without}$

KEY ISSUES:

a) SAMPLE SIZE

b) SAMPLE DESIGN

c) COMPATIBILITY OF EXPERIMENTS

d) HORIZON

Unlike the first two, the third experiment is not built around econometric estimation of a clearly specified model. It looks forward to the time when electricity is provided in something approaching perfect competition and the social experiments that will have to be used to implement this post-regulation era of electricity production. Those experiments will require information about consumer behavior that we can start collecting in less ambitious, near-term experiments of the type suggested above. Understanding the issues that will arise in post-regulation experiments may help frame the issues to be addressed in nearer term efforts.

Interest in deregulated electricity production will grow as officials discover that (a) the accounting-based rates called for under PURPA cannot provide tariffs truly based on marginal cost, particularly tariffs for the new intermittent solar technologies; and (b) new microelectronic technologies now becoming available facilitate networks of information that will allow workable free competition in electricity production. Under free competition, photovoltaic options can compete freely with more traditional utility sources of power and need not suffer from the utilities' dominant position in power production and hence accounting-based rate making. There is significant reason to believe that competitively determined electricity prices will represent the single most important institutional development required to set photovoltaic energy production free.

Such a radical change will not come spontaneously and the body politic cannot be expected to accept it without initial tests. Those tests are most likely to be successful--informative--if they are planned well in advance on the basis of a solid empirical understanding of the supply and demand sides of a free electricity market. A long-term perspective for the experiments now being planned can assure that the empirical data needed for the far more important experiments to come will be there when they are needed.

EXPERIMENT 3
RESPONSE TO RATE DEREGULATION

QUESTION: WHAT ROLE WILL PV PLAY IN A COMPETITIVE MARKET FOR ELECTRICITY GENERATION?

BASIC ISSUES:

- ACCOUNTING APPROACH IMPLICIT IN PURPA CANNOT EASILY PROVIDE RATES "FAIR" TO PV
- NEW ELECTRONIC TECHNOLOGIES NOW EXIST TO SUPPORT A SPOT MARKET IN ELECTRICITY
- NEAR-TERM NON-HARDWARE EXPERIMENTS CAN PROVIDE INPUTS TO DESIGN OF DEREGULATION EXPERIMENT

This brief presentation of principles to consider in experimental design for "soft problems" raises four important points.

First, as much as possible, experiments and the data they are designed to collect should be chosen and refined as early as possible. An evolutionary planning approach which brings actors--vendors, contractors, builders, consumers, and so on--in sequentially as the hardware data of most interest to them emerges will not allow proper consideration of the nonhardware data needs of actors brought in late. By the time they enter the process, sample selection will be well under way and proper experimental design to address their needs will no longer be possible. The information needs for nonhardware issues must be determined early, must be narrowed and refined early, and must be treated with the same respect given to the information needs for hardware issues.

Second, experiments cannot fulfill excessive information needs. Within a given budget, the quantity of information can be increased only by sacrificing its quality. Experiments, particularly properly designed experiments, can provide significant, good quality information within a tight budget, but the budget constraint cannot be dismissed by even the best experimental design and execution. The high anticipated cost of observations dictates very careful attention to the information to be gathered by experiment and careful control on the expectations of those scheduled to receive the experimental results.

Third, an experiment should not proceed in a vacuum. Experience with social experimentation is growing and the photovoltaic experiment should exploit both the available human capital of researchers who have run experiments and their documented experience. The experiment designers should also give careful attention to more general empirical work in housing and demand analysis. Given the high anticipated cost of observations, every effort should be made to integrate the experiment with existing data bases, empirical evidence, and experience in order to maximize the productivity of each observation.

Finally, the experiment should keep its full future potential in mind. Only under the most extraordinary circumstances will residential photovoltaics become a significant factor in the national housing market during the next decade. Data collected today will have their greatest impact on policy and market development in the mid- to long-term. Those who design the experiments should keep that perspective in mind and pursue data that can best affect integration of photovoltaics into the national grid over the long term. Data relevant to deregulation of electricity generation fall into that category and should be given careful consideration.

CONCLUSIONS

- DETERMINE WHAT INFORMATION YOU WANT MOST.
- BE AWARE OF LIMITATIONS OF EXPERIMENTS.
- USE PAST EXPERIENCE WITH EXPERIMENTS.
  - INTEGRATE WITH PREVIOUS FINDINGS
  - EMPHASIZE RESPONSE SURFACES
  - EXPLOIT NONRANDOM SAMPLING TECHNIQUES
  - EXPLOIT ADMINISTRATIVE EXPERIENCE
- KEEP FUTURE OPTIONS IN MIND.

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

SESSION IV WORKSHOP SUMMARY AND SYNTHESIS

Tom Hamilton

Photovoltaic Lead Center

February 12-13, 1980

jpl

DOE PHOTOVOLTAICS PROGRAM

PHOTOVOLTAIC RESIDENTIAL APPLICATIONS PROGRAM IMPLEMENTATION WORKSHOP

PHOTOVOLTAIC MARKET DEVELOPMENT ACTIVITIES: ACTORS AND INFORMATION*

	RESID'L EXPT ST'N RES	INITIAL SYST EVAL EXPTS ISEE	ENG FIELD TEST EFT	MARKET TEST MT
PARTICIPANTS	SYST DESIGNER COMP SUPPL	A&E SYST DES UTILITY	A&E BUILDER/DEV SYST (PV) SUPPL UTILITY PUBLIC	BUILDER/DEVEL UTILITY SYST SUPPL FINANCING PUBLIC
ACTOR NEEDING TARGETED INFORMATION	A&E UTILITY CODE OFF'LS	BUILDER/DEV FINANCING CODE OFF'LS	COMP SUPPL FINANCING PUBLIC BLDG TRADES	A&E INSURANCE COMP SUPPL BLDG TRADES
GENERAL INFORMATION	PUBLIC	PUBLIC BLDG TRADES INSURANCE	INSURANCE	

*THIS WAS A ROUGH ATTEMPT TO SUMMARIZE DISCUSSIONS IN REAL-TIME ON INFORMATION NEEDS AND ACTORS WHICH CORRESPONDED TO STAGES OF PHOTOVOLTAIC TECHNOLOGY AND MARKET DEVELOPMENT PROGRAM

TWH
2/13/80

APPENDIX C

REMARKS

SRI International

4 BARBIERI
MAR 05 1990

March 3, 1980

Rosalyn Barbieri
Jet Propulsion Laboratory
4800 Oak Grove Drive
m/s 506-418
Pasadena, CA 91103

Dear Ros:

I appreciated being included in the Residential Applications Program Implementation Workshop last week, although we did not really get to the point of working out implementation plans, as I had hoped. Probably it was too much to expect, for JPL had to educate half of us to what the program was all about before we could begin to think about specific plans. I had the feeling, however, that we were at the point when we broke up of being able to retire in groups of four or five to hash out specifics on the blackboard.

I have a number of specific observations and recommendations to make, but before I do, let me note some of the major points that became clear to me as I listened to the presentations:

1. The careful design of information presentations about the technology is just as important in the marketing process as the development of the equipment.

Generally a person's decision whether or not to make a purchase, or to adopt some innovation, follows a generalizable pattern. The potential consumer (1) becomes aware of the product, (2) seeks information about it and evaluates it or else is offered information/judgment about it by a friend, and (3) tries it.

One of the most successful commercial marketing strategies today is to distribute promotional samples of the product, thereby truncating the purchase-decision process. The prospective customer becomes aware of the product, gets his/her own information about it, and tries it, all at the same time. This marketing strategy is effective because people tend to be wedded to the tried and if not true, at least well understood products they are accustomed to purchasing.

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For large purchases, marketers have to substitute information and satisfied customers for the free samples as agents of persuasion. Demonstrations and careful documentation of success stories thus become surrogates for widespread personal experience with the innovation.

2. The selection of the appropriate recipients for information and the timing of the information will be critical.

Jet Propulsion Labs is in the unenviable and perhaps unasked-for position of a firm with a brand-new and desperately desired product. Generally, the newer a product is, the less experience people have with it, and in the case of PV, with anything like it. Information is therefore absolutely crucial--the amount, the timing, the target.

The S-shape of the diffusion curve is determined by peoples' experience with the innovation. That is, were potential adopters to get their information on a one-by-one basis, from media, the diffusion "curve" would in fact be the straight linear function of media messages affecting individual decisions over time: .

However, each person who adopts an innovation passes judgment on it and becomes a positive (or negative) opinion leader for other potential adopters. If he or she influences, let us say, two others, who in turn each influence two others, the diffusion curve "takes off," and adoption of the innovation increases at an algebraic rate.

The S-shaped curve was mentioned at the workshop, and mention was made of the fact that the curve can be steepened, that is, the diffusion accelerated, by various interventions. I am not sure that the workshop participants recognized, however, that: (1) Interpersonal communication is crucial to achieve an S-shaped curve, and (2) that communication must be mostly <u>positive</u> or the curve will be downward, not S-shaped.

Therefore, it is vitally important to know whom to introduce PVs to, at what stage of the technology's development. As Dick Rittleman observed, to show builders an otherwise barren room full of equipment could do more damage than good to the PV program.

The audience for information will grow as the technology matures over the first few years of experimentation, as will the need for widely-available <u>detailed</u> information. The first performance data generated by the experimental systems will be of immediate interest to the PV industry and to inventors working on the technology, although this same data may be important at a later date to architects and builders.

3. There is often a vast difference between information given and information received. People do not make purchase decisions entirely "rationally."

People are not passive, empty receptacles which we can fill with information and then expect appropriate responses from. Potential users of PV will judge the technology by such criteria as:

a. Associations with other technologies. Perhaps consumers will think PV are like active thermal solar systems. Or perhaps the fact that PVs generate electricity will make them seem more like non-solar electric appliances.

b. Compatibility with present practices and values. "Eco-chics" will buy PV because the solar cells on the roof are visible symbols of commitment to a purer environment. Developers may shun PVs because their use requires hiring an entirely different set of sub-contractors.

c. Perceived attributes or characteristics of the technology. These characteristics may bear little resemblance to engineering "reality." People's perceptions are shaped by rumor, by their degree of understanding of the technology, by the state of the national economy, etc. Many products fail on the market because their inventors and promoters make the mistake of believing the public will see the engineering or technical advantage and will therefore quite logically accept the innovation.* In fact very few products sell to the general public on the basis of performance statistics alone.

The following steps seem to be essential in planning the PV program: Marketing studies should parallel and complement the engineering program. While I believe this need was generally recognized at the workshop, there was no agreement on the mechanism for starting such studies. I would suggest the following:

1. A Pre-experimental (pre-mission) team of 4-5 people should meet to draw up a tentative master marketing plan, which could then be submitted to the mission team for comment and emendation. These 4-5 people would, in essence, fill in Tom Hamilton's handwritten viewgraph plan, deciding tentatively which "actors" should be introduced at each stage of the program design, and what essential social questions need to be answered at which points.

It seems to me that the following skills are needed at such an interim meeting:

---

*Recently some of my colleagues and I were asked to help advise the inventor of an extremely fuel-efficient (68-100 miles per gallon) three-wheel vehicle which was not being accepted, on how to promote his product. The engineer-inventor chose to ignore the fact that most potential users regarded the design as unsafe, since he could "prove" with figures and statistics that the vehicle was more stable than it appeared and that the probabilities of a crash into the exposed side of the car were very slight. Therefore he dismissed as irrelevant the market perceptions of the car as unsafe.

a. Since the engineering side of the program is well developed, one person should be present who knows that program very well.

b. The intent of the program is to boost PV up the diffusion curve at an accelerated rate, so a person with background in marketing new products could help identify the issues in entry marketing.

c. As I noted (ad nauseum) at the workshop, the program requires the careful targeting of information, at differing levels of specificity, through appropriate channels, so an information-dissemination person would be valuable.

d. The presentations showed how vital it is to have an understanding of the building industry for any residential programs. Hence the need for a Dick Riddleman or his equivalent.

e. Solar is an unusual technology on numerous counts, e.g.:

i. Residential solar equipment does not replace existing equipment but supplements it.

ii. Because of the energycrisis, solar is an overtly value-laden technology choice.

iii. Government at all levels is pushing solar with unprecedented vigor.

For these reasons (and others), there are similarities between SHAC and PV commercialization and therefore, as the presentation demonstrated, a person with extensive experience in the commercialization of SHAC would be helpful.

2. The mission team should refine the objectives and research issues conceived by this first planning committee into specific research questions, which would then be set into RFPs. In other words, besides the two kinds of RFPs mentioned at the workshop, aimed at equipment developers, there should be several RFPs for the necessary marketing and communication studies. While bidders could be encouraged to evolve their own research designs, the designs would have to be responsive to the questions asked.

While I believe that a pre-mission team committee of 4-5 people could best evolve a marketing plan, let me suggest a few preliminary thoughts I have about such a plan.

It occurs to me that our discussion of when is an experiment an experiment and when is it a demonstration was actually a bit misleading. At different points in the technology development, the equipment serves as a "demonstration" to different groups. At the "experimental" stage, the photovoltaic array is a demonstration to industry and equipment designers, since the intent at that point is to stimulate innovation and solve design problems. At this point, the equipment is by no means a demonstration for potential residential users.

There are, in fact, at least three activities which are occurring simultaneously at each stage of the engineering development plan:

1. Market-Acceptance Testing/Identifying Future Information Needs.

Panels of future "actors" are asked to (1) react to the design as far as it has developed and (2) identify the information needs they foresee from their particular perspective. (Thus, it would be important, as was pointed out in the workshop, for someone to give the architect's viewpoint early in the performance data gathering, so that information about structural needs, for example, is collected.) These small panels representing particular professional or interest groups, would in effect serve as consultants to the marketing/commercialization teams, to ensure that information will be available to bring "on line" as needed in the future.

2. Information-Dissemination

At each point in the technical development, information is being generated which is of immediate concern to some actors. Therefore key opinion leaders for those groups are invited in to see the equipment demonstrated. When the equipment is still behind the fence, homeowners would not be invited en masse, for instance, but engineers would be. Builders might be invited when the equipment was installed in a home. When the home is occupied, then the homeowners would be targeted. In short, the populations targeted to receive information at this time would be those for whom PV systems at that point in their development were of immediate relevance.

3. Awareness-Raising

At the same time that small market panels representing groups of "actors" who will need information later are being questioned about anticipated information needs (#1) and that specially targeted audiences for whom the equipment is a demonstration in its present state are being fed detailed, extensive information relevant to their needs (#2), general information should be given out through the media to arouse interest in residential photovoltaics (#3). For instance, long before the equipment is installed in a house and therefore could be considered a demonstration for architects, articles about the equipment should have appeared in architectural magazines, suggesting this equipment as a coming attraction to be watched.

Generally, people have to be aware of a new idea for a while and then to evaluate it, before they try it themselves. Media is the most efficient way to raise awareness. Personal contact is relatively more important when the time comes for people to consider adopting the innovation.

As an example of the three-tiered approach I am suggesting, I have attached an outline of the kind of framework a pre-mission team might start work with. This is by no means complete; the 4-5 people I mentioned could fill the outline in and determine the relevant research questions as their first task.

Hope these suggestions are of some use to you. I have just returned from D.C. where I testified at hearings on D.O.E. appropriations held by Rep. Ottinger's sub-committee on Energy Development and Applications of the House Science and Technology Committee. I feel the fact that two diffusion scholars were asked to recommend what kinds of "behavioral and motivational" research should be done by D.O.E., evidences growing awareness of the importance of social science theory to the development of energy programs.

Warm regards,

Dotty

Dorothy Leonard-Barton

DLB:pq

MARKETING ACTIVITIES

Stage in Technology Development:	#1 Panel Indicates Information Needs	#2 Specific Information Targeted to User Groups	#3 General Information Used to Raise Awareness	Possible Research Issues
First-of-a-Kind Objectives: test equipment, stimulate innovation and technical problem-solving.	PV Industry Architects Engineers Patent Attorneys	PV Industry Engineers Utility Companies	Engineering Media Urban Planning Media Utility Industry Media Potential PV Distributors	What groups should be utilized to identify future information needs? What potential noneconomic market barriers could be lessened by design alteration?
Engineering Field Tests Objectives: solve technical problems *in situ*, in response to simulated user needs.	Lawyers Builders (Construction) Consumer Groups Potential PV Distributors	Architects Real Estate Industry	Construction Industry Architects General Media Real Estate	Who are the "legitimizers" in the targeted professions? What are the major commercialization barriers foreseen at this point?
Market Tests Objectives: solve problem in totally real-life situation; determine response of social, institutional environment. Anticipate problems of service, distribution which will arise when volume raised.	Lawyers	Real Estate Industry Builders (construction) Homeowners Building Inspectors Distributors/ Supplies	Home Improvement Media General Media	Information should be targeted to which: • media? • geographic regions? What information sources are credible to the targeted user groups? What is the best way to "multiply" the effect of the demonstrations?

RESIDENTIAL APPLICATIONS WORKSHOP

Session III - Experiment & Sub-Experiment Design

Prepared by: J.L. Smith, JPL

Session Overview

This session introduced the topic of experiment design within the residential applications experiment program. Three presentations were given in the two-hour session. Tom Hamilton, Manager, Planning Assessment and Integration, Photovoltaics Technology Development and Application Lead Center, gave an introductory presentation that reviewed the current status of planning for the experiments and presented contextual information on the photovoltaic program. Dr. Frank Camm of the Rand Corporation discussed some of the constraints and difficulties involved in designing and implementing social experiments. Given that the program wishes to increase its understanding of non-hardware issues, as well as hardware related issues, during its conduct of the residential experiments, careful attention must be paid to sample design, experiment design, measurement and objectives. Gary Lillien of MIT Energy Laboratory presented approaches to and results of several surveys (experiments) conducted by MIT in conjunction with early photovoltaic experiments. The reactions of potential purchasers to several photovoltaic installations were measured and correlated with the potential purchaser's preconceived attitudes toward solar systems, energy problems, previous innovative behavior, etc.

The session was truncated due to lack of sufficient time to complete all the presentations. No discussion of the presentations was possible within the time constraints.

It was clear, however, that the participants of the workshop did not share a common perception of the purposes and objectives of the residential experiments. Even though the word "experiment" was explicitly adopted to imply that the major intended purpose of the activities is the production of new information, many of the workshop participants apparently believe that issues such as "involving the right players" or "contacting the appropriate people" are dominant considerations in the design of the experiments. In my opinion this confuses "information dissemination" or "demonstrations" with "discovery or production of new information" or "experiments". Obviously, one cannot disseminate something one does not know. Thus, discovery of nonexistent information must precede its dissemination.

The session emphasized the huge gaps in our knowledge with respect to the "barriers" facing deployment of grid-connected photovoltaic systems as well as the inherent difficulty in designing, implementing and conducting experiments* to fill in those gaps. Careful attention must be paid to designing the experiment and selecting the experimental sample.

In summary, the session revealed wide differences in the perceptions of the workshop participants of the purposes and implementation planning requirements of the residential application program.

*Experimentation is the classical scientific method for advancing the state of knowledge.

RESIDENTIAL IMPLEMENTATION WORKSHOP
SOME CLARIFICATIONS, IMPRESSIONS, AND POSSIBLE FUTURE DIRECTIONS

Prepared by: Tom W. Hamilton, JPL

The first day was spent discussing and clarifying the context and terminology being used. Participants began to work on improving the design and the implementation details of the Photovoltaics Residential Program. I concluded that a series of meetings with continuity of participation is necessary to round out the residential plan. The first session introduced a great deal of information to persons not familiar with the program. A better degree of coordination of nomenclature could have made this information easier to digest. In the Session I presentation, a sequence of phases shown in the Figure 1, below, were described. In the following discussion, Ed Kern, of MIT/Lincoln Laboratory described the phases shown below in the dotted boxes. The "Prototype Development" phase is done in the regional Residential Experiment Stations, as necessary, as a precursor to the "ISEE" which is the first block. The terms "EFT" and "SRE" can be (and were) used interchangeably.

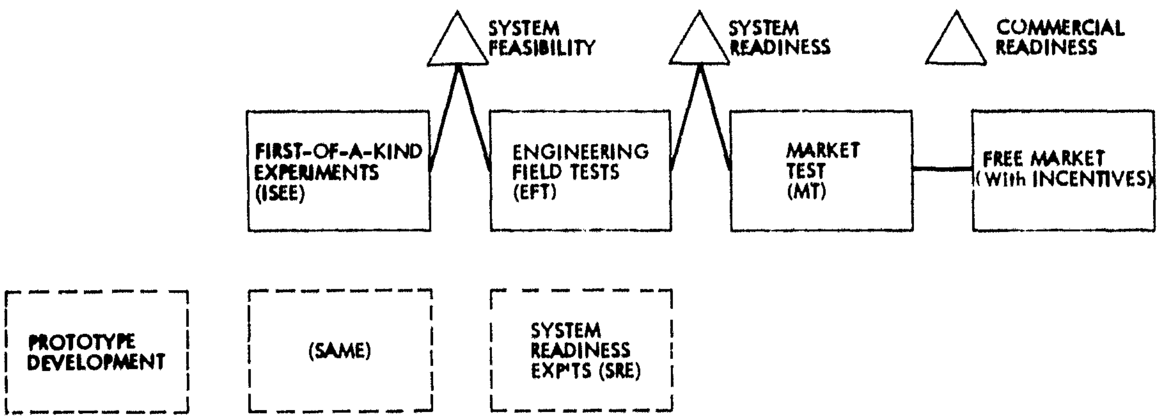

Figure 1. Residential Program Phases Reconciled;
Top Line: Tom Hamilton's Presentation
Bottom Line: Ed Kern's Presentation

The workshop was held before solid content of the EFT, MT phases of the program were developed. This was done with the intent of obtaining help and guidance in rounding out the DOE plans by adding the appropriate market development plans to those already existing. I believe we underestimated the time required to become familiar with photovoltaics and the existing thought and plans for the residential market. The ideas offered by several participants, and well expressed by Dorothy Leonard-Barton's comments earlier in Appendix C, have influenced my thinking about how we should proceed to further develop residential plans. It is clear to me that we need to establish a temporary two-part team consisting of "plan developers and integrators" and relevant reviewers who can interact on a regular basis over a period of months. Plans along this line are under development as are considerations on how the multi-phase process described in current plans might be accelerated without excessive risk. I believe that the information generating and information dissemination functions of experiments and demonstrations can be overlapped when we carefully consider who needs information in the following stages and what the most credible source is to each party.

APPENDIX D

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BIBLIOGRAPHY

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APPENDIX E

PRECONFERANCE COMMUNICATIONS/LIST OF ATTENDEES

PRE-CONFERENCE COMMUNICATIONS

A letter was sent to potential workshop participants. A sample letter follows:

Dear :

Thank you for agreeing to participate in the Photovoltaics Residential Applications Program Implementation Wrokshop. This workshop is being conducted by the Jet Propulsion Laboratory Photovoltaics Lead Center for the Department of Energy and is being held in the Millikan Board Room of the California Institute of Technology of February 12-13, 1980.

It is the first in a series of workshops designed to assist the photovoltaic program in further developing its program implementation plans. Due to their high priority, we are beginning with a focus on residential applications.

Enclosed is a brief statement of the workshop objectives, an agenda and participant list. Note that we plan to start at 8:30 a.m. on Tuesday morning. The enclosed maps should assist you in locating Caltech and the Millikan room.

You will also find enclosed a copy of the Photovoltaic Program Multi-Year Plan (if you have not been closely involved in the program) and a copy of the slides from a recent presentation I made to representatives of the Photovoltaics industry on current plans for the so-called "Multi-Year photovoltaic System Purchase Program". The Multi-Year Plan should serve as background for aspects of program philosophy and the timing of certain technology-related events. It is currently being revised to include the content of the purchase program. The plans for detailed timing of the residential aspects of the program will be introduced during the first workshop session.

We are looking forward to your participation in a stimulating and constructive workshop.

Sincerely,

Tom W. Hamilton
Manager, Planning, Assessment
and Integration
Photovoltaics TD & A Lead Center

ATTENDEES

Rosalyn Barbieri	Jet Propulsion Laboratory
Dorthy Leonard-Barton	Stanford University
Drew Bottaro	MIT Energy Laboratory
Frank Camm	The Rand Corporation
Paul Carpenter	Jet Propulsion Laboratory
Dennis Costello	Solar Energy Research Institute
Bob Easter	Jet Propulsion Laboratory
Francis Greehan	SRI International
Tom Hamilton	Jet Propulsion Laboratory
Charles Hulick	National Bureau of Standards/ETIP
Tom Jaras	Science Applications, Inc.
Gary Jones	Sandia Laboratory, Albuquerque
Earle Kennett	AIA Research Corporation
Ed Kern	MIT Lincoln Laboratory
Gary Lilien	MIT Sloan School of Management
Glenn Lovin	Edison Electric Company
Ed Mehalick	General Electric Company
Peter Morton	Architects Collaborative, Inc.
Mary Pope	MIT Lincoln Laboratory
Tom Nutt-Powell	Harvard-MIT Joint Center for Urban Studies
Lewis Perelman	Jet Propulsion Laboratory
David Posner	Solar Energy Research Institute
Dick Rittleman	Burt, Hill, Kosar & Rittleman
Ted Schlie	National Bureau of Standards/ETIP
Elaine Smith	Department of Energy
Jeff L. Smith	Jet Propulsion Laboratory
Pete Spewek	Regional Solar Energy Centers
Richard Tabors	MIT Energy Laboratory