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National Program for Solar Heating & Cooling of Buildings

Annual Report

U.S. Department of Energy
Assistant Secretary for Conservation
and Solar Applications

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July 1978

U.S. Department of Energy
Assistant Secretary for Conservation
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Washington, D.C. 20545

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Foreword

This is the Annual Program Report of the National Program for Solar Heating and Cooling of Buildings, as required by the Solar Heating and Cooling Demonstration Act of 1974, Public Law 93-409. The program, initially developed by an inter-agency task force established and chaired by the Energy Research and Development Administration (ERDA), was described in the "National Program for Solar Heating and Cooling (Residential and Commercial Applications)," ERDA-23A, October 1975. ERDA 76-6, "National Plan for Solar Heating & Cooling of Buildings" November 1976, and The Annual Program Report presented here reflect the results of a continuing assessment of program plans, additional program activities, and experience gained and achievements made since program inception. The current status of program activities funded totally or partially by DOE is presented in this report. This report thus supersedes ERDA 76-6.

To more fully describe the solar heating and cooling program, documentation of individual projects have been published in three companion documents.

These documents are defined and briefly described as follows:

DOE/CS-0008—National Program Plan for Research and Development in Solar Heating and Cooling

This document presents the DOE Conservation and Solar Applications (CS) program plan for research and development in the use of solar energy for heating and cooling and for agricultural and industrial process applications. The objectives of the DOE solar energy R&D program are to identify potentially cost-effective systems for building, agricultural, and industrial process heating and cooling applications, and to provide the emerging solar energy industry with the materials, components, information, and methodology needed for designing, producing, and installing these systems.

DOE/CS-0009—Solar Heating and Cooling Demonstration Project Summaries

This documentation presents brief descriptive overviews of the design and operating characteristics of all commercial and Federal solar heating and cooling demonstration projects funded by DOE Conservation and Solar Applications. Also included are available pictures of the buildings and simplified solar system diagrams. A list of non-Federal residential installations is provided with further details on these projects supplied by HUD in their applicable documentation.

DOE/CS-0010—Solar Heating and Cooling Research and Development Project Summaries

This document describes the research and development program and the projects presently underway for further development of collectors, thermal energy storage, heat pumps and heat exchangers, solar cooling, and systems and controls. The Plan has two parts, an introduction and a series of project descriptions. The introduction describes the evolution of the R&D program and outlines the present program. The second part of the document describes the various R&D projects underway.

This report describes the current status of the DOE solar heating and cooling program activities and plans. It should be noted however, that a Domestic Policy Review on solar energy and the preparation of a solar commercialization plan were initiated in May 1978, with results scheduled as early as September 1978. Accordingly, the use of information in this report should be made with an awareness of possible changes by the end of CY 1978.

I. Summary

In 1974, the Solar Heating and Cooling Demonstration Act (P.L. 93-409) was signed into law, authorizing a vigorous Federal program encompassing a wide range of activities intended to help establish solar energy as a viable energy resource for the Nation. A comprehensive program is being carried out under guidelines established by P.L. 93-409 and by three other legislative acts passed by the 93rd Congress: the "Solar Energy Research, Development and Demonstration Act" (P.L. 93-473); the "Energy Reorganization Act of 1974" (P.L. 93-438); and the "Federal Non-nuclear Energy Research and Development Act of 1974" (P.L. 93-577. These four laws together with the "Department of Energy Organization Act" (P.L. 95-91) give general authority to DOE and other Federal agencies to conduct comprehensive activities in conjunction with research, development, and demonstrations aimed at promoting widespread solar energy utilization.

The Department of Energy is also directed by the Energy Conservation and Production Act, P.L. 94-385, to provide overall coordination of Federal solar energy commercialization and to carry out a program to promote solar commercialization. This report is fully consistent with the intent of P.L. 94-385 and describes the program and activities being undertaken and planned by DOE to accelerate the commercialization of solar heating and cooling. It is in this context that all elements of the program described in this report, from research and development to market development, are viewed and structured to help make solar energy a meaningful resource in meeting our National energy requirements.

DOE is conducting the National Program for Solar Heating and Cooling of Buildings with the assistance of the Department of Housing and Urban Development (HUD), the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the National Bureau of Standards (NBS), the Department of Health, Education, and Welfare (HEW), and other Federal agencies. This Annual Report identifies responsibilities, reviews present program status, and provides a basis for future management review and assessment of progress related to the program.

The program's thrust is to promote and demonstrate the economic viability of solar energy for the heating and cooling of buildings. There are four basic program elements:

- Research and technology development of new and advanced system approaches and subsystems or components to reduce costs, improve reliability, and provide solutions to problems.
- Engineering development aimed at bringing systems, subsystems, and components to a marketable stage for utilization.
- Demonstration of solar heating and cooling in commercial and residential buildings, using available systems installed both in new and existing buildings, and the associated collection, evaluation and dissemination of data and development of standards and performance criteria.
- Market development to assure that an institutional framework exists for widespread use of solar energy including technology transfer, environmental and resource assessment, and studies on barriers and incentives.

The R&D program now has over 200 projects underway directed at providing improved performance in components and systems, improved manufacturing and analysis techniques, and lower solar system costs. Emphasis is currently being placed on solar cooling system cost-effectiveness, passive solar heating and cooling development, and solar retrofit cost reductions.

The development in support of demonstrations activity has resulted in 24 solar system designs being completed for installation in 45 operational test sites. Several of the planned test sites are completed and the solar systems are being monitored and evaluated.

Through three cycles activated in the HUD residential demonstration program to date, there are about 330 residential RFGA projects involving over 5,000 dwelling units now implemented, with the fourth cycle underway (520 grant applications were received and are now under evaluation for awards of up to \$8 million total in FY1978). In commercial demonstrations, there are 108 PON (Program Opportunity Notice) projects from two cycles with the third cycle underway (a total of \$9 million is allocated for an estimated 50 awards). There are 22 other commercial projects which were initiated early in the program, prior to the first cycle.

Projects in private health care facilities are being implemented with an expected 7 awards to be made in early CY1978 for solar hot water applications by HEW. Further awards are planned in FY1978 for solar heating and cooling of health care facilities (with \$2 million allocated for projects to be implemented through HEW). Other demonstration activities have included DOD residential projects and 40 Federal Government buildings projects with 10 agencies and departments of the government. Overall, there are over 100 demonstration projects now operational.

Activities related to the demonstrations being conducted include data collection, evaluation and dissemination, and standards development. There are approximately 50 demonstration projects which have been instrumented through a systematized, automated, data collection network for monitoring and reporting solar system performance data. Other accomplishments to date include the implementation of a National Solar Heating and Cooling Information Center for solar-related inquiries and the integration into the DOE Technical Information Center (TIC) of an extensive solar applications data bank. Also, interim performance criteria for residential and commercial solar systems have been published for use in the demonstration program, intermediate standards for solar heating have been adopted which supplement the existing HUD/FHA Minimum Property Standards and standards for testing solar collectors and thermal storage devices are now in effect.

An area which has become increasingly important as the program has progressed is market development. This is an essential element of the Federal program to accelerate the commercialization of solar heating and cooling and consists of a wide range of activities. Studies and analyses have been completed on economic and institutional aspects of solar deployment and reports published. A regionalized nationwide outreach program is providing solar information and education, training and certification programs are underway. Needed environmental and resource assessments in support of widespread use of solar heating and cooling are continuing.

In support of market development for solar hot water heating and to promote development of the solar industry infrastructure, a solar hot water initiative is underway in three market areas. In the first area, an eleven state program for over 10,000 grants to single family residential homeowners is being conducted. Secondly, some 50 projects in hotels/motels have been implemented throughout the United States. Third, an expected seven awards will be made for projects on health care facilities early in CY1978.

The National Energy Act now before Congress contains specific provision to further stimulate market development. These include Federal Building solar demonstrations and a tax credit on solar installations for homeowners and businesses.

International cooperation is moving forward with two major multinational programs presently underway. These programs are described in Section V of this report.

Other major events that relate to the program have also occurred. For example, the National Solar Energy Research Institute (SERI) has begun operations. Additionally, four Regional solar energy research institutes are planned to be activated in FY1978. These will function as outreach groups or technology transfer points and could do much to speed up the process of solar commercialization. In addition, in the area of consumer protection, a solar collector testing, labeling and certification program has been initiated. A more detailed discussion of these program accomplishments is given in Section VI of this Annual Report.

In terms of an overall assessment of the program and the status of the solar industry, the following highlights are made.

- Solar water heating is competitive today against electricity in most areas of the country; the technical feasibility of heating has been established and in certain areas of the country economic viability exists; therefore, the heating milestone established over three years ago by the Solar Heating and Cooling Demonstration Act of 1974 has been achieved.
- In regard to the health of the industry, it should be noted that it was essentially non-existent in 1974 and has grown to approximately a \$200 million per year industry in three short years. An indication of this is the total area of solar collectors manufactured each year—which has been doubling about every nine months to an estimated rate of over five million square feet per year.

- The industry has established a trade association, the Solar Energy Industries Association (SEIA), made up of large and small businesses, and several fine trade journals exist (Solar Engineering magazine, Solar Age, Solar Heating & Cooling, special ASHRAE and other Association publications).
- The state governments have been responsive to solar, and over 20 states have passed some form of tax incentive; informal discussions indicate as many more have legislation under review. This coupled with the Federal Tax incentives of the National Energy Plan should provide a strong foundation for continued growth of the solar industry.
- Results of a special survey performed by *Professional Builder* magazine indicate that more than 1/2 of HUD demonstration program participants now offer solar systems as standard equipment or options in their new home designs.

SOLAR HEATING AND COOLING OF BUILDINGS PROGRAM MILESTONES*

CALENDAR YEAR	1975	1976	1977	1978	1979
PUBLISH PROGRAM DEFINITION	ERDA 23 ▲				
ANNUAL PROGRAM STATUS REPORTS	ERDA 23A ▲	ERDA 76-6 ▲		DOE/CS 0007 ▲	△
DEMONSTRATE PRACTICAL SOLAR HEATING TECHNOLOGY			▲		
DEMONSTRATE PRACTICAL COMBINED SOLAR HEATING AND COOLING TECHNOLOGY					△
PUBLISH PERFORMANCE CRITERIA	INTERIM CRITERIA ▲				DEFINITIVE CRITERIA △

*SOLAR HEATING AND COOLING DEMONSTRATION ACT OF 1974
P.L. 93-409, SEPTEMBER 3, 1974

▲ ACCOMPLISHED ACTIVITIES
△ SCHEDULED ACTIVITIES

FIGURE I-1

It is anticipated that details contained in this report on planned program actions and accomplishments will be revised in future reports as a result of continuing assessments of program activities.

The program requirements as mandated by the above referenced Federal Legislation, are summarized in Figure I-1.

II. Goals and Objectives

Solar energy is an alternative, inexhaustible energy resource that is well suited for widespread use in residential and commercial buildings. The National Program for Solar Heating and Cooling of Buildings is directed toward stimulating the development of solar water heating, space heating, and space cooling systems by viable industries for residential and commercial use. Industrial viability in terms of satisfying program goals is an industry that could supply a reasonable percentage of the Nation's energy demand. Projections indicate that, by the year 2000, about 20 percent of U.S. energy consumption will be for heating and cooling 75 million commercial and residential buildings. The National Program reported herein is structured to stimulate solar energy applications so that solar energy could provide a significant portion (at least 10 percent) of these heating and cooling energy requirements by the year 2000. The overall goal of the program, therefore, is to assist in the early establishment of a viable solar industry for the design, manufacture, distribution, sales, installation, and maintenance of the solar heating and cooling systems. (This is in keeping with a national policy of reducing our current reliance on oil and natural gas for these purposes.)

Objectives

The following objectives have been formulated in response to the Public Laws that established the program:

- Conduct of a directed research and technology development program for substantially reducing solar heating and cooling system costs and improving system performance;
- Operation of an information system to collect, store, evaluate, and disseminate user-oriented technical, environmental, and socio-economic data relating to solar energy utilization;
- Demonstration of the feasibility of solar heating technology in new and existing residential and commercial buildings by 1977;
- Demonstration of the feasibility of solar heating and cooling in new and existing residential and commercial buildings by the end of 1979, with special emphasis on the development of low cost systems for retrofit installations;
- Development of solar energy system performance standards and criteria for the production and installation of solar energy systems, subsystems, and components, with appropriate provisions for consumer protection;
- Identify and promulgate the necessary legislation, codes, and incentives to mitigate or eliminate existing legal or institutional restrictions which may discourage the development of solar energy;
- Accelerate the development of a solar hot water industry and market, through a concentrated demonstration activity;
- Promote the utilization of solar heating and cooling applications by all Government agencies;
- Conduct rigorous economic and technical assessment of solar energy systems to identify potential markets and to evaluate Federal efforts to accelerate market penetration;
- Develop design guidelines for solar heating and cooling systems, subsystems, and components;
- Assure early availability of accredited private sector testing facilities; and

III. Program Management

PROGRAM PARTICIPATION NATIONAL AND COOLING OF BUILDINGS

FIGURE III-1

- Under Public Laws 93-409, 93-438, 93-473, 93-577, 94-385 and 95-91, DOE is responsible for the management and coordination of the total Federal Solar Energy Research, Development, and Demonstration Program. DOE and HUD have joint responsibility for management and coordination of the residential solar heating and cooling demonstration program for the private sector while DOE and DOD have joint responsibility for management and coordination of the residential solar heating and cooling demonstration program in the Federal sector. DOE's other

responsibilities include management of research and technology development for new and improved solar heating and cooling subsystems and systems; management and coordination of the commercial demonstration program; planning and implementation of specific programs such as the hot water initiatives; and coordination of Federal activities in the solar commercialization area.

- Other Federal agencies have been assigned specific responsibilities in the National

Program under DOE. NASA is conducting the activities associated with development in support of the demonstrations, as described in section VI-D, and provides management support for portions of the commercial demonstration program. NBS is supporting both DOE and HUD in the development of standards and performance criteria for solar heating and cooling systems, subsystems, and components. NBS is also establishing a program for the approval of laboratories qualified to test solar heating and cooling subsystems, and components. HEW is implementing a program for demonstrating solar heating and cooling in private hospitals and other health care facilities. Appendix I presents a summary of the active interagency agreements relevant to the solar heating and cooling program, including those for the above major participants.

- DOE and other Government groups review and assess the progress of their respective activities in relation to agreed upon major program milestones. Periodic reviews of program progress, problems, and possible corrective actions are made. Advisory groups with representation from other interested agencies, industry, and the public are informed of the progress and provide program guidance. In addition, DOE holds periodic reviews for its Secretary and the Secretary of HUD in which program and policy matters of concern to the agencies and Congress are addressed.
- Figure III-1 illustrates the relationship of the public and private sector participants and the commercialization function for all solar technologies.

IV. Strategy

The purpose of this section is to provide background material sufficient to illustrate the program planning and development process as it occurred and the changes in approach and strategy that have taken place since publication of ERDA 23A and ERDA 76-6. The first step necessary prior to development of program strategy was to identify and assess the extent of barriers and constraints to the development of a viable solar energy industry and, in particular, to the market growth necessary for a viable industry.

Market Growth Considerations

Prior to the 1973 oil embargo, there was relatively little interest and investment in solar heating and cooling of buildings. Rising fuel prices, a Federal research, development, and demonstration program, and predicted fuel shortages have combined to foster increased interest in solar energy for heating and cooling. Although the present market is still considered small, over 500 companies offer solar energy systems, subsystems, and components through more than 2,500 distributors. Exclusive of residential and commercial demonstration project installations discussed elsewhere in this report, it is estimated that there were approximately 300 solar heating installations in 1975, 1,700 installations in 1976 and 3,000 installations in 1977.

- While interest is high, a well planned and balanced program aimed at reducing costs; improving performance; disseminating data; creating market demand; developing a solar industry infrastructure; and establishing design, performance, and manufacturing standards is required for a viable market-industry relationship to develop. Though the potential for a large market exists, there are at present barriers which impede the acceptance of solar heating and cooling. A summary list of these existing barriers serves to indicate how program strategies have been developed:
 - Reluctance to invest in equipment with high initial costs;
 - Lack of data on the variety of equipment and on local insolation (solar radiation) and weather patterns available to architects and engineers for the design of safe, reliable, and economical systems;
 - Lack of data and training materials to allow the development of a solar design, production, distribution, installation and maintenance capability within the existing HVAC industry infrastructure;
 - Reluctance to invest in tooling and inventory for a small market that has a high likelihood of rapid technological change and obsolescence;
 - Lack of solar cooling equipment for residential applications;
 - Cost effective solar systems for retrofit applications;
- Customers and manufacturers, concerned with fuel shortages and price increases, await legislation at local, state, and Federal levels to increase their incentives to invest in solar equipment; and
- Legal and financial unknowns, including local building codes, zoning laws, tax assessment procedures, and insurance and liability barriers.

Development of the market and industry is being enhanced by specific projects geared towards resolution of these barriers as well as development of appropriate incentives for maximizing near-term market potential.

Market Potentials and Benefits

Feasibility studies conducted in 1974 by NSF and more recent studies conducted by DOE and independent organizations concluded that a solar energy industry would eventually develop without the current Federal Program. This is based upon the premise that solar heating and cooling is technically feasible, and that fuel prices will continue to escalate at a rate greater than the inflation rate. However, the conduct of a Federal program designed to accelerate the development of solar technology and to remove market barriers will allow for significant market growth in the near-term.

Analysis indicates that the potential solar energy market penetration in the United States could be in excess of 40 percent of new buildings by the year 2000. This would create a multi-billion dollar industry with public benefits which include:

- Substitution of a renewable energy source for non-renewable fossil fuels which are projected to continue to increase in cost at a rate greater than inflation;
- Reduction of pollution and environmental degradation;
- Improvement in the international balance of payments and reduction of economic vulnerability; and
- Development of a labor-intensive solar industry.

The basic program implementation strategy chosen has entailed a five-year, highly visible residential and commercial demonstration program with annual cycles of new projects using currently available solar systems. The projects in each succeeding cycle are intended to extend the types of building, geographical location, and types of solar systems being demonstrated. Additional program elements are directed at: research and technology development to improve system and subsystem performance and to lower manufacturing and installation costs; the formulation of tests, standards, and criteria to enhance product quality and performance; environmental and resource assessment to support the application of technology and design/performance analyses; development of design guidelines and installer training programs; market development and assessment of barriers, incentives and

other factors critical to accelerated market growth; and data collection, evaluation, and dissemination activities on several levels to accelerate the flow of information to user communities. The strategy also entails the creation of a Federal buildings market for solar systems which will evolve into a market of sufficient scale to stimulate private investment in production.

It can be concluded from program results to date that: reliable solar heating and cooling systems can be built and installed in commercial buildings, the further development of residential-sized solar cooling systems is necessary, there are no fundamental barriers to the application of solar energy technology, early market development is necessary, and the high-visibility demonstration program effectively stimulates the market.

The following areas require further effort and are being addressed:

- The interface of solar energy and conventional power systems must be examined in greater detail. Solar energy systems can be designed so as to assist in utility load management; however, they can also increase the reserve capacity requirements in some situations, thus forcing higher back-up costs. Public utility participation in demonstrating effective solar-utility interfaces must be encouraged;
- Sun rights, building codes, and zoning problems require early attention and possibly legislative/legal action;

- Quantitative ranking and benefit/cost scenarios for various tax incentives, grants, low-interest loans, and other solar inducements need development. Analysis and planning is needed to evaluate the range of possible incentives and assess the proper time for their introduction.
- Consumer protection measures such as solar equipment testing, certification, and labelling.

The body of this report amplifies the major program elements supporting the strategy outlined here and reviews the program status.

V. International Cooperation

Multinational approaches can be highly effective in responding to the world-wide energy problems. Underscoring the U.S. commitment to cooperative efforts, including those in the energy area, President Carter stated in October 1977, "It is clearer than ever that none of us will be able to achieve our national goals by unilateral action alone, for the major threats to our physical and social environment transcend national frontiers. We must therefore continue to strengthen international cooperation in dealing with problems of the global environment."

The United States is actively participating in two major multinational programs which provide several approaches to cooperation in solar heating and cooling. The NATO Committee on the Challenges of Modern Society (CCMS) initiated a Solar Energy Pilot Study in 1973, and in 1975 the International Energy Agency (IEA) formulated its Cooperative Program to Develop and Test Solar Heating and Cooling Systems. The objectives of these international cooperative programs are to accelerate the implementation of solar technology by maximizing the flow of information about solar research and development and providing a process for the standardization and distribution of solar design, testing, and performance reporting guidelines.

As the pilot country, the United States plays a lead role in coordinating the activities of the CCMS Solar Energy Pilot Study, in which a total of twenty-four countries participate. The Executive Committee of the IEA Solar Heating and Cooling Program, which supervises the cooperative projects undertaken by the fifteen member countries, is currently chaired by the United States. The Department of Energy is the responsible agency for U.S. participation in these two programs.

The objective of the CCMS Solar Energy Pilot Study is the exchange of information on the solar heating and cooling systems programs and projects of each participating country so as to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, and public buildings, as well as for industrial and agricultural processes.

The key elements in the CCMS information exchange program are: (1) the preparation and distribution of special reports prepared in an agreed format, (the distribution of available reports concerned with solar heating and cooling systems in buildings, and (3) the participation in meetings for the review of research, development and demonstration programs, discussions, and exchange of information and ideas.

A significant contribution of the CCMS Solar Energy Pilot Study has been the development of the CCMS System Reporting Format, which is used for the preparation of special reports on operating solar systems. The format is intended to ensure that such reports provide essential system performance data in a detailed and standardized manner so that the information can be clearly understood and effectively utilized by other researchers.

At the annual CCMS Solar Energy Pilot Study Meeting, it became apparent that certain countries, particularly in similar climatic regions, were stressing similar solar heating and cooling applications. As a result, two sub-groups have been formed which afford the opportunity for experts to meet in small groups for the informal and detailed exchange of information on specific programs and projects. These are called the Zero Energy House Group and the Mediterranean Applications Group. The Zero Energy House Group is comprised of countries experimenting with solar-assisted minimum energy dwellings for northern European-type climates. The focus of the Mediterranean Applications Group is solar energy utilization for Mediterranean-type climates, with emphasis on passive heating and cooling.

Whereas the CCMS Solar Energy Pilot Study is based on information exchange, the International Energy Agency (IEA) Solar Energy R&D Cooperative Program involves additional levels of participation and is hardware oriented. The objective of the IEA Solar Energy Cooperative Program is to reduce overall costs of solar energy systems by the pooling of efforts and experience, and to accelerate the large scale introduction of this technology in the participating countries.

Five cooperative projects (tasks) are included in the IEA program: (1) Investigation of the Performance of Solar Heating and Cooling Systems, (2) Coordination of Research and Development on Solar Heating and Cooling Components, (3) Performance Testing of Solar Collectors, (4) Development of an Insolation Handbook and Instrumentation Package, and (5) Use of Existing Meteorological Information for Solar Energy Application.

VI. Program Plan and Status

SOLAR HEATING AND COOLING PROGRAM

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

- ▲ ACCOMPLISHED ACTIVITIES
- △ SCHEDULED ACTIVITIES

FIGURE VI-1

A. Overview

The solar heating and cooling program strategy is being implemented by DOE through the updated program plan reflected in Figure VI-1.

All major elements and key activities of the Federal demonstration program are identified in Figure VI-2. These program elements were addressed in ERDA-23 A and ERDA 76-6 and are updated in this report. However, because of the growing importance of certain aspects of the program, special attention is given here to: Data Collection, Evaluation, and Dissemination; Standards and Criteria; and Market Development.

MAJOR ELEMENTS AND KEY ACTIVITIES OF THE PROGRAM

MAJOR ELEMENTS	KEY ACTIVITIES
Demonstrations: Residential Commercial Federal Buildings Program Initiatives	<ul style="list-style-type: none"> Primary emphasis on space heating and domestic hot water in Cycles 1, 2, and 3. Increasing emphasis on technical and architectural excellence, conformance to standards, provision of an effective warranty, and lower costs in terms of energy delivered in Cycle 4. Increasing emphasis on cooling planned for Cycle 5. Existing solar energy systems in Cycle 1 with improved available systems, in subsequent cycles, employing generally combined heating and cooling systems. DOE will evaluate and select candidate Federal buildings for which solar systems will be designed and installed. Program will provide a continuing market for solar equipment. Special initiatives targeted at applications and regions where solar utilization is particularly effective. The hot water initiative targeted health care facilities, hotels/motels, and high electric rate residences for a total of 45 large-scale and 10,000 small-scale projects.
Development in Support of Demonstrations	<ul style="list-style-type: none"> Develop prototype systems Improve existing systems Integrate subsystems Component/subsystem development Test and evaluation Design and installation
Research and Development	<ul style="list-style-type: none"> National Program Plan for SHAC R&D Component/subsystem development Materials and processes Systems analysis and performance Accelerated solar cooling R&D Advanced systems test facilities
Data Collection, Evaluation, and Dissemination	<ul style="list-style-type: none"> Data Collection system development Central data processing facility Information Center Solar demonstration systems evaluation Data bank operation (Oak Ridge TIC) Solar energy system performance simulations Ongoing system monitoring and reporting
Standards and Criteria	<ul style="list-style-type: none"> Interim performance criteria Definitive performance standards Laboratory accreditation Collector testing and rating program Model solar building code Standards Workshops
Environmental and Resource Assessment	<ul style="list-style-type: none"> Environmental consequences Technology assessment Resource data base analysis
Market Development	<ul style="list-style-type: none"> Federal agency involvement Regional outreach program Barrier assessment Incentives/cost effectiveness studies Solar-public utility interface involvement Regional Solar Energy Centers

FIGURE VI-2

CLIMATIC DEMONSTRATION REGIONS OF THE UNITED STATES

FIGURE VI-3

Residential and Commercial Demonstrations

The demonstration program is based on a series of cycles utilizing a variety of systems, building types (Federal and non-Federal, residential and commercial), and climatic regions. Succeeding cycles incorporate upgraded solar systems available on the market from product development activities. Climatic regions illustrated in Figure VI-3 are

based on a correlation of demographic and climatological data. The use of regions allows DOE to assure that solar designs are demonstrated in a variety of climates and allows determination of which types of systems are most effective in each climatic area. Demonstrations are supported by development efforts designed to produce the technology and prototype systems, subsystems, and components for future cycles. This activity provides a variety of technical options and stimulates the development of competitive

systems and new technology. In demonstrations involving new construction, DOE requires that all applicable energy conservation techniques be incorporated in the building design. Generally, this means meeting or exceeding the current requirements of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 90-75.

The first stage of the demonstrations (cycle 1) provided for the installation of available state-of-the-art technology and an early assessment of this program concept. The annual cycle is designed to encourage the use of more advanced technology as it becomes commercially available. The second and third cycles have emphasized demonstration of more advanced combined systems and have served to transfer emerging solar technologies from the research stage towards eventual commercialization. These cycles expand the scope of the overall demonstration program with the aid of continually updated project matrices. These matrices display the parameters critical to demonstration of the range of solar technologies in different building types, different applications, and different climates.

In 1977, initial steps were taken to expand the Federal buildings program. Significant early planning activities have been conducted, and a DOE chaired interagency steering committee has been established which consists of those agencies which represent major Federal building owners. The plan calls for selection of various building types, locations, and applications to ensure a successful and effective approach to the continuing demonstration of solar equipment in Federal buildings.

The required economic and environmental documents, proposal preparation instructions, proposal evaluation criteria, interagency agreements, and data reporting requirements, are in preparation. DOE will select agency projects and interagency funding transfers beginning in 1978, and continuing through 1980, will allow for the design, construction, and installation of agency-proposed solar systems.

Another important aspect within the overall demonstration program are the special initiatives. These initiatives, the first of which was the hot water initiative, are designed to directly stimulate the solar marketplace by providing cost-sharing grants for regions or applications where solar utilization is particularly effective. The hot water initiative, begun in 1977, targeted solar domestic water heating as an application where solar is particularly effective. This hot water initiative involved both the commercial and residential sectors. Health care facility awards are planned, and hotels/motels were awarded 50 projects for hot water heating, while HUD has implemented through 11 state programs a hot water residential initiative which will result in approximately 10,000 awards being made.

Development in Support of Demonstrations

This effort is directed toward bringing solar energy systems at various levels of design maturity to the point of being marketable and acceptable for widespread use. Contracts are awarded to industry for design and development of new prototype systems and components, to further development of existing hardware, and for systems integration of marketable subsystems. Current projects cover a multiplicity of designs and enable an assessment of industry's capabilities, a segmentation of potential system-application combinations, and estimation of the market availability of emerging hardware.

Research and Development

The R&D program encourages product development by the industry which will also market the product by providing industry with the funds and information required for the most effective development of the many emerging solar technologies. To provide for a national context for solar heating and cooling R&D, a directed R&D program plan has been developed (National Program Plan for Research and Development in Solar Heating and Cooling, DOE/CS-0008). This program plan allows for an organized R&D process which pursues solar technology R&D in a directed manner with a minimum of overlap and redundancy among funded projects. This directed R&D plan is recognized as a significant element in the total commercialization process. A successful R&D program provides a direct marketing and production stimulus to advance the state of solar heating and cooling technology.

In FY1977, a series of 11 Request for Proposals (RFP's) and Program Research and Development Announcements (PRDA's) were issued by DOE. These solicitations called for proposals specifically related to one or more tasks in the directed R&D plan. Out of the 1100 proposals received, approximately 130 projects were selected for support. As a result of these most recent awards, the R&D program has expanded to the point where it now supports approximately 225 projects. Most of these are directed at providing improved performance in components, improved manufacturing techniques, and/or lower initial and maintenance costs. The balanced involvement of industry, universities, small business, and government organizations which has characterized the research and development program from its outset has been continued with these most recent selections.

Data Collection, Evaluation, and Dissemination

Information and technical data is being assembled and disseminated to the engineering, scientific and financial communities, the building industry, Federal, State, and local government agencies, as well as the public. The purpose of this activity is to provide reliable, objective information to enable individuals and organizations to make decisions on the utilization and purchase of solar heating and cooling equipment based on an understanding of the risks, costs, and benefits. The applications and performance data needed by system designers, manufacturers, and application engineers also will be derived from this information.

There are several discrete elements within the Data Collection, Evaluation, and Dissemination Program which provide data of different kinds for a variety of user groups. A National Solar Heating and Cooling Information Center answers telephone and written inquiries from potential solar consumers. An automatic performance data acquisition network is on-line which monitors the operation of both commercial and residential demonstration projects. Monthly performance reports are prepared and disseminated to interested groups. A solar data bank is also available through the DOE Technical Information Center. This data bank can provide information on potential solar applications as well as meteorological data and simulation programs for solar design scientists and engineers. Reports and information emerging from the Development in Support of Demonstrations activity and the Environmental and Resource Assessment activity will also be made available through this data bank.

Standards and Criteria

Standards and criteria for solar system and subsystem design and performance are vital to reduce the uncertainties inherent in any new technology and to allow for adequate consumer protection. Federal agencies, especially the National Bureau of Standards (NBS), are cooperating with other organizations in the development of consensus standards, a system extensively utilized by governments and industries in the United States. The American National Standards Institutes Steering Committee on Solar Energy Standards Development is providing direction and continuity in this effort.

Interim performance criteria developed for both residential and commercial solar energy systems have been issued and will be updated as necessary to incorporate experience gained through the demonstration program. Definitive performance criteria for both commercial and residential applications will be established upon the conclusion of the program utilizing the knowledge and experience from the demonstration program.

A program is being conducted through the Solar Energy Research and Education Foundation (SEREF), which is under contract to DOE, to develop and implement a solar collector rating, labeling, and certification program in accordance with consensus tests and standards. SEREF is an affiliate of the Solar Energy Industries Association (SEIA).

Intermediate Minimum Property Standards for solar heating and domestic hot water systems were promulgated in July, 1977, by HUD. These standards apply to all housing built under programs of the Federal Housing Administration, Farmers Home Administration, and Veterans Administration.

Another activity within the standards and criteria area is the development of a model solar building code. Organizations such as architectural and engineering professional societies, state and local building officials, as well as DOE and HUD have, under NBS sponsorship, been developing inputs to a model solar code. This activity will result in the development of model solar code provisions for possible inclusion in the various model building codes during FY1979.

Finally, a standards workshop has been planned for 1978 which will allow interaction between solar professionals involved in consensus standards making, industry, trade associations, and consumers which is intended to accelerate the development of these standards.

Market Development

Technology development and demonstration alone will not ensure achievement of the Nation's solar energy goals. In addition, adequate long-term markets and an appropriate industry infrastructure must be developed. Some of the more significant objectives of the demonstration program which relate to commercialization include the following:

- Develop and implement incentives to stimulate market demand;
- Disseminate information through a Regional outreach program;
- Ensure consumer protection through accelerated standards development, certification, and public education programs;
- Assess sociological and environmental factors;
- Mitigate legal and institutional barriers to the widespread use of solar energy.

Commercialization may be reviewed as the process of assuring that suitable technologies move from the research, development, and demonstration stages to the point where they provide utility to consumers. The function of the Federal government is the counterpart of industrial product development and marketing. It involves assessment of which solar energy technologies are ready to enter the commercial marketplace, where and how they should be utilized, and which factors influence their commercial acceptance. Technology transfer involves extensive liaison and communications with the solar energy industry, consumers, and the institutions whose decisions influence commercial applications of solar energy. It draws upon research, analysis, assessment, and information dissemination functions to provide assistance to the public and industry in making decisions on the implementation of solar energy technologies. It serves as a catalyst in solar energy technology transfer functions to facilitate timely achievement of commercialization objectives.

The market development program is directed towards developing the means by which to effect a transfer of solar technology and research to the marketplace. Activities in the Barriers and Incentives area have included a study of the solar-public utility interface.

Other activities have included the publishing of a study on commercialization options for solar energy, support studies for the National Energy Plan as it relates to solar energy, and ongoing studies of legal and legislative issues. In the Technology Transfer area, in addition to the Regional outreach program, two major installer training efforts are underway to ensure the early availability of competent solar equipment installers.

The development of the data and analytical techniques to assess the sociological and environmental factors associated with solar energy systems is a continuing activity. This includes data on the solar applications potential for a broad range of building types. Such information will serve industry and the public in making critical choices regarding the design, development, and application of solar energy system. In 1977 the Environmental and Resource Assessment activity generated the draft Environmental Impact Statement of the National Solar Heating and Cooling Program. This document after review will be submitted in 1978 to the President, the Council on Environmental Quality, the Environmental Protection Agency, and the public. Another activity being conducted by the Environmental and Resource Assessment program is the development of solar radiation and other meteorological data on a variety of locations for inclusion in the Solar Data Bank and dissemination to user groups. This activity is being conducted in cooperation with NOAA, NASA, USDA, and NSF.

B. Residential Demonstrations

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

FIGURE VI-4

The residential construction market in the United States is made up of many different submarkets. The residential market includes mobile homes, detached single-family houses, townhouses, garden apartments, and high rise apartments. All of these may involve single, cooperative, or condominium ownership or rentals. Single family construction and marketing is organized on a local basis, with no individual firm responsible for as much as one percent of the national residential construction volume.

In addition to the diffuse builder-developer base, the residential housing industry includes real estate brokers, architects, engineers, designers, mortgage bankers, property insurance brokers, and materials and equipment suppliers. These participants work within a loose administrative network of local building and housing codes and zoning and other regulations that affect industry decisions. This complex set of interrelationships makes it difficult for innovations such as solar energy systems to become quickly and widely accepted.

These factors require that a residential demonstration program for solar heating and cooling be:

- Large enough to impact the many residential submarkets in different areas of the United States;
- Directed toward the many types of residential markets (single-family and multi-family, etc.);
- Structured so as to involve and impact the many different portions of the housing industry (from brokers to contractors); and
- Of a long enough duration to allow for and take advantage of emerging design and construction innovations which better integrate solar system into the residence design.

Residential: Non-Federal Buildings

The planned cyclic effort for the HUD residential demonstrations is presented in Figure VI-4. The DOD residential program is discussed later in this section.

Site-System Projects

The site-system project approach was developed to permit a limited number of projects to demonstrate a number of different types of solar systems in a wide variety of climates and housing types. The plan was based on a Location Matrix which related climate, housing type, market potential, constraints (such as building codes and zoning practices), and factors such as fuel costs which impact market potential, constraints (such as building codes and zoning practices), and factors such as fuel costs which impact market acceptance.

- The first cycle of site-systems projects has had limited success due in part to builder-developer unwillingness to accept risks associated with a solar energy system selected by others.
- With the significant increase in integrated projects resulting from increasing program funding, the site-system approach was dropped in order to concentrate activities in the integrated project area. The larger number of integrated projects has permitted achievement of the Location Matrix demonstration plan objectives without forcing an artificial mix of projects.

Integrated-System Projects

The integrated-system projects provide an opportunity for builder-developers and solar energy systems manufacturers and distributors to demonstrate and market their solar energy systems. In this program, the builder-developer proposes the location, building type, and solar energy system as part of his application for a project and incorporates the proposed system into a complete residential project package. These integrated projects provide information on the constraints facing project developers in regard to market acceptance and other important operational and market matters. Some of these projects are also being instrumented for more detailed technical evaluation of the solar system.

- Applications for integrated-system projects are invited through nation-wide Request for Grant Application (RFGA) solicitations. Three cycles of project awards have been made. The first solicitation brought some 250 applications in the fall of 1975; 55 projects were announced in January 1976, 41 of these are either complete or under construction. Over 300 applications were received in response to the second cycle RFGA, issued in July 1976, and 102 project awards were announced in October. Sixty-eight of these projects are complete or under construction. The third cycle RFGA was issued in January 1977 and resulted in over 700 applications, with 169 project awards announced in May. Award details of these solicitations are presented in Figure VI-5.

- The fourth cycle RFGA was issued in November 1977 calling for applications in January 1978. Five hundred and twenty-five applications were received and are currently being evaluated.
- In evaluating project applications, specific consideration is given to the technical suitability of the proposed solar energy system, the type of residential project, and the value of the project as a demonstration of solar energy. Project awards have been given for both new and retrofit installations in both single and multi-family applications.
- Carrying out the primary objective of the residential demonstration program, to encourage the development of a residential market for solar energy systems, HUD has stressed increasing technical and market performance in each subsequent cycle. In the first cycle, projects which were "ready to go" with solar systems which appeared to work were solicited, and the evaluation of these applications considered both the technical and project details. In the second cycle, HUD required specific test information on the collectors as well as firm commitments for project funding. In the third cycle, more complete technical information was required and project cost proposals were evaluated in terms of the solar energy delivered to and used by the residence.

HUD RESIDENTIAL DEMONSTRATIONS INTEGRATED-SYSTEM PROGRAM

HUD RESIDENTIAL DEMONSTRATIONS INTEGRATED-SYSTEM PROJECTS	CYCLE 1 (AS SELECTED)			CYCLE 2 (AS SELECTED)			CYCLE 3 (AS SELECTED)		
	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT	NUMBER OF UNITS	NUMBER OF PROJECTS	TOTAL GRANT AMOUNT
TYPES OF GRANTEEES									
Builders/Developers	82	44	\$ 728,899	1,011	87	\$2,817,863	2,400	143	\$4,596,000
Local Governments	54	8	281,785	308	13	773,961	647	17	1,198,000
Universities	7	3	33,560	92	2	321,500	417	7	242,000
	<u>143</u>	<u>65</u>	<u>\$1,044,234</u>	<u>1,411</u>	<u>102</u>	<u>\$3,913,324</u>	<u>3,464</u>	<u>169</u>	<u>\$6,036,000</u>
UNIT AND SOLAR APPLICATION MIX	NUMBER OF UNITS			NUMBER OF UNITS			NUMBER OF UNITS		
SINGLE FAMILY									
Heating Only	2			2			5		
Hot Water Only	13			110			44		
Heating and Hot Water	76			232			322		
Heating and Cooling	6			4			1		
Heating, Cooling and Hot Water	5			28			2		
	<u>102</u>			<u>376</u>			<u>374</u>		
MULTI-FAMILY									
Heating Only	-			-			40		
Hot Water Only	21			670			2,373		
Heating and Hot Water	20			273			669		
Heating and Cooling	-			-			-		
Heating, Cooling and Hot Water	-			92			12		
	<u>41</u>			<u>1,035</u>			<u>3,094</u>		
ALL UNITS									
Heating Only	2			2			45		
Hot Water Only	34			780			2,417		
Heating and Hot Water	96			505			991		
Heating and Cooling	6			4			1		
Heating, Cooling and Hot Water	5			120			14		
	<u>143</u>			<u>1,411</u>			<u>3,468</u>		
EXISTING VS. NEW CONSTRUCTION	TOTAL	NUMBER OF UNITS		TOTAL	NUMBER OF UNITS		TOTAL	NUMBER OF UNITS	
		EXISTING	NEW CONST.		EXISTING	NEW CONST.		EXISTING	NEW CONST.
SINGLE FAMILY	102	12	90	376	71	305	374	26	348
MULTI-FAMILY	41	21	20	1,035	583	452	3,094	2,376	718
	<u>143</u>	<u>33</u>	<u>110</u>	<u>1,411</u>	<u>654</u>	<u>757</u>	<u>3,468</u>	<u>2,402</u>	<u>1,066</u>

FIGURE VI-5

- In cycle 4, solar systems must meet the new HUD Intermediate Minimum Property Standards, solar systems must carry an effective warranty, and system costs in terms of the energy delivered to and used by the building will be a primary element in project selection. In addition, single family domestic hot water systems will not be considered for grant awards since these systems are now considered ready for commercial marketing.
- The builder-developer receiving a residential solar demonstration grant is required to complete the project design, construct the project, and market the project. Funding is limited to the difference between the cost of the project including the solar energy system and the cost of a comparable project using only a conventional energy system.
- Project awards are made only for projects being built or retrofitted for sale or rental, or for some form of public ownership. Grants are not made to individuals for their private homes or to builder-developers for projects which already have a customer commitment to buy the project.
- Integrated-system projects which fit the Location Matrix research plan are selected for instrumentation, special non-instrumented technical data collection, and non-technical market studies. With the large number of projects permitted by increased funding, this approach has resulted in a project mix matching the planned demonstration program.

- A complete listing of the HUD (non-Federal) residential demonstration projects is contained in a companion report, "Solar Heating and Cooling Demonstration Project Summaries" (DOE/CS-0009). The report includes a summary of the residential demonstration projects showing builder-developer, type of building, number of dwelling units, and type of solar energy application.

Residential Hot-Water Initiative

The rapid development of the solar industry and the increasing technical sophistication of its products has brought solar service and domestic water heating technology to market-readiness. To encourage the development of a market demand for solar water systems, DOE and HUD began a special solar hot water market initiative for residences in the spring of 1977.

- The HUD program involves grants to eleven states with particularly high electric rate structures and with large regional market potential to support a number of partial grants to individuals and builders for solar domestic hot water systems. Eleven states are participating in this program: Connecticut, Delaware, Florida, Maryland, Massachusetts, New Hampshire, New Jersey, New York (13 southeastern countries only), Pennsylvania, Rhode Island, and Vermont. Approximately 10,867 grants of \$400 each will be awarded in this program; this amount represents approximately 20 to 25 percent of the cost of a solar hot water system and the overall program will encourage the installation of approximately 500,000 square feet of collectors.

Residential: Government Buildings

The Federal residential demonstration program is being administered by DOD. This program has undergone substantial redirection as a result of experience gained during 1976 and 1977. Bids obtained for 50 individual residential projects on several military bases were too high to allow for a cost-effective demonstration. One project was implemented in 1977.

- Experience gained in the Federal residential program indicates that a more effective approach to demonstrations is to initiate a series of "solar parks" which will serve the heating and cooling needs of 20-50 individual housing units. Proposals are being evaluated for a 40-unit solar park design in Fort Polk, La., and bids will be requested for similar projects at Newport Naval Station, Rhode Island, and Bolling Air Force Base in Washington, D.C.
- *Residential Program Tasks*
The HUD residential demonstration effort described in ERDA-23A and ERDA 76-6 directed attention to a series of tasks that comprise the non-Federal demonstration program. Figure VI-6 identifies the major tasks and their subtasks with a brief summary of their status. The following discussion expands on the status of these activities.

HUD RESIDENTIAL DEMONSTRATION PROGRAM TASKS AND STATUS

Task A—Program Design and Management

TASK	STATUS
A. PROGRAM DESIGN AND MANAGEMENT	
A.1 Demonstration Design and Location Matrix	Matrix submitted to Government Spring 1976.
A.2 Solar Energy Consultants	Consultant services obtained. Work is in process.
A.3 Program Management	Contractor (Boeing) selected early in 1976.
B. PERFORMANCE CRITERIA AND STANDARDS	
B.1 Interim Performance Criteria	Prepared by NBS: Residential criteria published by HUD, January 1975.
B.2 Definitive Performance Criteria	Awaiting data from demonstrations.
B.3 National Consensus on Solar Standards	Initiated October 1975; ANSI, ASTM and others in cooperation with Government.
B.4 Intermediate Minimum Property Standards	Promulgated by HUD in July, 1977.
B.5 Accreditation of Testing Laboratories*	Procedures under development.
B.6 Certification Procedures*	Private laboratory certification underway. Collector testing, rating, labeling and certification program underway.
C. CONDUCT OF DEMONSTRATIONS	
C.1 Integrated System Project Demonstrations	41 projects in Cycle 1 underway or completed. 102 projects awarded in Cycle 2, with 89 in progress. 169 projects selected for Cycle 3 in May, 1977. Cycle 4 solicitation issued November, 1977.
C.2 Site-System Projects	12 projects underway.
C.3 Repair and Maintenance of Units	Awaiting completion of prior phases. Demonstration projects to date have been funded in 42 states and 12 of the 13 climatic regions.
D. DATA COLLECTION	
D.1 Instrumented Data Collection	Instrumentation, design, and procurement completed; data collection in process on 25 projects.
D.2 Non-instrumented Technical Data	Processing development assigned to NBS; data collection in progress.
D.3 Non-instrumented Market Acceptance Data	Data collection in progress
D.4 Data Evaluation and Analysis	Data evaluation in progress.
E. MARKET DEVELOPMENT	
E.1 Public Barriers and Constraints	Collecting and evaluating information from demonstrations.
E.2 Economic Factors	Solar economic analysis programs (solcost, F-chart) developed.
E.3 Industrial Issues	Collecting and evaluating information from the demonstrations.
E.4 Market Acceptance and Penetration	Collecting and evaluating information from the demonstrations.
E.5 Information Dissemination	National Solar Heating and Cooling Information Center in full operation. "Solar Dwelling Design Concepts" published by HUD in 1976.

* HUD supporting DOE activities in these areas.

FIGURE VI-6

- Program design and management involves the development of a location matrix and the selection of solar energy consultants and a management contractor.

Task A.1—Demonstration Design and Location Matrix. Through a contract awarded in the summer of 1975, a detailed experimental program plan and location matrix was developed to guide the site-system portion of the program. The matrix was provided to the Government in the Spring of 1976, and has been used as an evaluation tool in succeeding demonstration cycles.

Task A.2—Solar Energy Consultants. Successful introduction of solar energy applications into the housing industry requires expertise in both housing and solar energy systems. Experience has confirmed that many of the solar energy system developers and manufacturers are not aware of housing industry issues and, in turn, that builder-developers are unaware of the technical characteristics of solar energy systems. Industry and professional groups are serving as consultants to the Government to foster better communication and understanding in these areas.

Task A.3—Program Management. A support contractor was selected early in 1976 and has been providing general management for the residential demonstration program under HUD's supervision. The contractor's responsibilities include monitoring

both the site-system and integrated-system projects, collecting technical and market acceptability data, reviewing grantee reports, and making program planning and management recommendations to the Government.

Task B—Performance Criteria and Standards

Design and performance criteria and standards are necessary for the production and marketing of solar energy systems and are vital for the protection of the public. Though the following discussion applies to the residential applications, the residential and commercial activities in this area are coordinated and, where possible, combined. Section VI-G presents a more detailed discussion of standards and criteria for both residential and commercial systems.

Task B.1—Interim Performance Criteria. The Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409) called for the development of "interim performance criteria" within 120 days after enactment. These criteria, developed by NBS, were published by HUD under the title "Interim Performance Criteria for Solar Heating and Combined Heating and Cooling Systems for Dwellings" (January 1975.). These criteria provided guidelines for the design of solar energy systems for demonstration projects and have found extensive use both within and outside the scope of the demonstration program. As experience is gained this document will be updated and finally re-issued under the title "Definitive Performance Criteria."

Task B.2—Definitive Performance Criteria. P. L. 93-409 also called for the development of "definitive performance criteria" based upon utilization of the interim criteria and findings from the demonstration program. Establishing such criteria involves: identification or development of standard test procedures to measure performance; determination of desired performance levels of various components, subsystems, and systems; and procedures to utilize the final criteria in such instruments as model or local building codes and Federal specifications. Substantial progress has been made in the area of performance test procedures, and a collector rating and labeling program being conducted by the Solar Energy Research and Educational Foundation (SEREF) is expected to lead to determinations of minimum performance standards for components as well as systems. In addition, the model solar code working group is utilizing the format of the Interim Performance Criteria as a guideline for development of model solar code provisions. Publication of the Definitive Performance Criteria is currently scheduled for 1979.

Task B.3—National Consensus on Solar Standards. The development of product and test standards in the United States is accomplished through a voluntary process, as detailed in Section VI-G.

Task B.4—Intermediate Minimum Property Standards for Solar Energy Housing programs administered by HUD's Federal Housing Administration (FHA) use Minimum Property Standards (MPS) for defining the acceptable level of quality required for participating in these programs. With the assistance of NBS, HUD promulgated in July 1977 modifications to the MPS (HUD 4930.2) which permits HUD/FHA to

accept solar energy systems in HUD's regular housing programs. These standards are also used by the Farmers Home Administration and Veterans Administration for their housing programs. These standards, prescriptive in nature, reflect the general level of information available. They will be revised to reflect the definitive performance criteria when these are published in 1979.

Task B.5—Accreditation of Testing Laboratories. The need for a procedure to accredit qualified testing laboratories for performance tests developed under the voluntary standards program is discussed in Section VI-G. This work has been expanded as part of the Collector Rating and Certification Program being performed by SEREF.

Task B.6—Certification Procedures. Section VI-G discusses the need for product certification procedures. The certification program is expected to be similar to existing product test programs administered by industry; the Government will not provide certification. Under a DOE contract, SEREF is developing an industry sponsored collector rating and certification program which will lead in 1978 to a collector thermal ratings catalogue, a product labeling program, and a certification program.

Task C—Conduct of Demonstrations

Task C.1—Integrated-System Project Demonstrations. Integrated-system projects, where a builder-developer plans a total project incorporating solar energy, are selected through competitive solicitations based on RFGA's issued periodically throughout the program. The first RFGA was issued in September 1975 and, as has been noted, resulted in the selection of 55 projects for early 1976 funding; 41 of these were completed or are under construction. A second RFGA issued in July 1976 brought over 300 applications. In October 1976, 102 grants were awarded, of which 89 are still underway. The third RFGA resulted in over 700 applications and 169 awards. Projects already selected involve active, passive or hybrid solar systems; new and retrofit construction; solar water heating, space heating, and space cooling systems; and combinations of these applications. Government funding is limited to the cost differential between a project with only a conventional heating and/or cooling system and a similar project with a solar energy system. The fourth cycle RFGA was issued in November 1977 with awards to be made in April of 1978.

Task C.2—Site-System Projects. Solar energy systems for the first cycle of HUD site-system projects were selected through a Program Opportunity Announcement (POA) issued jointly by ERDA and HUD in September 1975. A number of projects for solar water heating, space heating, and space cooling systems were identified as acceptable for demonstration. Based on this first experience, it was decided that the POA, which served a useful function in the first demonstration cycle, was not a desirable method for identifying systems for future HUD and DOD demonstrations. No further site-systems projects will be undertaken.

Task C.3—Repair and Maintenance of Units. Solar energy system manufacturers and distributors are required to provide appropriate individual warranties on their equipment and installations, and the builder-developers are required to pass these warranties onto their customers, together with their own warranties for the system installation. In some projects, the installations are covered under the Home Owners Warranty (HOW) program of the National Association of Home Builders (NAHB). However, because this is a demonstration program using relatively untested equipment, a contingency fund has been provided to resolve problems which would cause unanticipated major costs to the builder or the customer.

Task D—Data Collection

Demonstration program data requirements and collection procedures are discussed in detail in Section VI-F. Demonstration program objectives include the provision of data on the technical performance of solar energy systems and on their acceptance by the building industry, its regulatory structure, and the customer.

Task D.1—Instrumented Technical Data. Approximately 100 units will be fully instrumented with the instrumentation package (Site Data Acquisition System) to provide system performance and ambient weather data (temperature, humidity, wind, insolation, etc.) Twenty-five residential projects are currently tied into the Solar Data Network. Similar data requirements, format, instrumentation, collection and reduction procedures, will be used through the demonstration program to simplify data analysis. The choice of which residential projects will be instrumented is based on climatic, solar system, and application considerations for each project. This set of instrumented projects represents the range of climates, systems, and applications present in the residential program.

Sensors, provided by the Government, are being installed in the selected demonstration units to provide data to a Site Data Acquisition System (SDAS). This system, through a telephone data link, transmits stored data to a central processing facility located in Huntsville, Alabama. Reduction and correlation of the instrumented technical data for the program is being accomplished. The resulting information is part of the technical data base for further evaluation. Monthly reports on system performance for each instrumented project as well as system performance evaluations are being distributed through DOE. In addition, program-wide analyses as well as special studies will be initiated at DOE direction.

Task D.2—Non-Instrumented Technical Data. In addition to the instrumented data being collected for a few specially selected projects, technical details and problems experienced in all project sites are being collected through periodic interviews and reviews of project reports. These data include descriptions of the solar systems and projects, information on operating procedures, maintenance history and experience, and the incidence of repairs and service.

This information together with the non-instrumented market acceptance data outlined in Task D.3 is being processed into a computerized data base system at NBS. A data dictionary and a description of the data available in the system will be issued by NBS early in 1978.

Task D.3—Non-Instrumented Market Acceptance Data. Performance of a given solar energy system under various climatic conditions can be determined with relatively few instrumented projects. However, a comprehensive understanding of factors affecting market acceptance requires information from a broad range of demonstration projects. Therefore, information on market development issues and problems is being obtained from all of the demonstration projects, both site-system and integrated-system. This information comes from reports prepared by the grantees during the demonstration project and from the collection of these data has been developed. As noted above, these data are being processed into the NBS data base.

Task D.4—Data Evaluation and Analysis. NBS will use both technical and non-technical data to develop definitive performance criteria and to formulate recommendations for product warranty policies. The data will also be used to identify technology development and commercialization requirements and for such items as design handbooks and operating procedure guides.

Task E—Market Development

A number of market development activities are identified within other tasks of the residential program. The program design (Task A) and conduct of demonstrations (Task C) are directed toward maximum impact on the building industry. The development of minimum property standards (Task B.4) is a necessary prerequisite for expansion of the solar energy market beyond the demonstration program. The collection and evaluation of market development and acceptance data (Task D.3) is an ongoing process to determine marketing procedures and consumer acceptance. Data from these activities could be used to develop marketing strategies by manufacturers and the building industry in promoting solar energy systems.

The market development program also includes a number of additional activities which are further discussed in section VI-H.

C. Commercial Demonstrations

COMMERCIAL DEMONSTRATION PROGRAM

FIGURE VI-7

Demonstrations of solar heating and cooling on both Federal and non-Federal commercial building applications constitute a major element of the demonstration program. Like the residential demonstrations, they are being implemented in cycles to benefit from technological advances and experience gained from previous projects. Since residential and commercial applications profit to a large degree from the experience gained in the common areas of research, development, installation and operations, the two parallel demonstration programs are closely coordinated.

The general plan for the commercial building demonstration program is shown in Figure VI-7 with the shaded bar segments indicating progress to date. The basic program outline was developed in a series of published studies and identified as Phase 0 and Phase 1. Phase 0 studies, sponsored by the National Science Foundation (NSF), were completed in 1974. They addressed general technical problems and issues of commercial application and assessed the feasibility of program development. Phase 1 studies were initiated by NSF and continued by ERDA and DOE. They provided an initial matrix of recommended project types and locations

based on the range of variables required to establish costs, system confidence levels, and the extent of business/public exposure necessary to stimulate the market. This approach was used in identifying the early projects and also served as the basis for continuing efforts in the selection process wherein various combinations of building types, climatic regions, and solar design types are considered in determining a program with adequate balance.

The two major elements of the demonstration program are non-Federal buildings and Federal buildings, both of which are managed by DOE. The non-federal project cycles contain the elements identified in Figure VI-8 which are similar to the elements discussed for the residential demonstration program. The cycles are implemented using Program Opportunity Notices (PON's) which identify bid opportunities for the private sector.

Three cycles have been initiated along with a special Hot-Water Initiative. Each succeeding cycle incorporates more highly developed solar energy systems. The third cycle of demonstrations was initiated with PON-3, issued in November 1977. Awards will be made in 1978.

The Federal program has been implemented with the Interagency Agreements outlined in Appendix I for Federally-owned commercial buildings. These agreements have been transferred from ERDA to DOE. Assuming approval of the National Energy Act, future Federal demonstrations will be in accordance with the "Solar in Federal Buildings Program" as directed by DOE.

Uniform instrumentation systems are being used to monitor the ambient weather data and system performance for selected projects as part of the data collection and evaluation activity. Standard evaluation procedures are used for all sites to assure maximum usefulness and comparability of the results.

Performance criteria and standards for solar have been refined. The current guidance is documented in the 1976 update of Interim Performance Criteria (NBS 76-1187), and systems funded within the demonstration program must conform to these standards.

Commercial: Non-Federal Buildings

In 1974 an initial series of four Proof of Concept experiments in non-Federal commercial buildings was supported by NSF. In January 1974 responsibility for these experimental projects, along with 14 additional non-Federal commercial demonstrations, was transferred to ERDA and subsequently to DOE. The four initial proof of concept experiments are complete. Eight of the fourteen additional projects initiated by NSF are in the operational test phase.

Because a representative mixture of demonstration projects was imperative for planning purposes early in the program, a Phase 1 program was initiated in which study contractors were required to identify and submit for consideration specific demonstration project opportunities. Of the initial recommendations, 11 projects were identified as having potential and the building owners were invited to submit proposals for cost-sharing contracts. Eight projects were eventually selected, one is operational, and the remaining seven are now nearing completion. A summary of these early demonstration projects is provided in an accompanying report, "Solar Heating and Cooling Demonstration Project Summaries" (DOE/CS-0009).

The first cycle of the commercial demonstration program began with the release in Fall 1975 of a Program Opportunity Notice (PON DSE-75-2) which called for proposals to incorporate solar energy in new or existing buildings, with primary emphasis on space heating and

SOLAR HEATING AND COOLING OF BUILDINGS COMMERCIAL DEMONSTRATION PROGRAM REPRESENTATIVE CYCLE

FIGURE VI-8

DOE COMMERCIAL NON-FEDERAL DEMONSTRATION PROJECTS

COMMERCIAL NON-FEDERAL DEMONSTRATION PROJECTS	EARLY NSF PROJECTS TOTAL GRANT AMOUNT \$9,800,000*	PHASE I PROJECTS TOTAL GRANT AMOUNT \$2,400,00*	PON I PROJECTS TOTAL GRANT AMOUNT \$8,000,000*	PON II PROJECTS TOTAL GRANT AMOUNT \$12,000,000*	HOT WATER INITIATIVE PROJECTS TOTAL GRANT AMOUNT \$4,000,000*
BUILDING TYPE AND SOLAR APPLICATION MIX	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS	NUMBER OF PROJECTS
SCHOOLS/UNIVERSITIES					
HEATING/COOLING ONLY	1			6	
HOT WATER ONLY	1				
HEATING/COOLING AND HOT WATER	1		5	12	
HEATING AND COOLING	3		1	2	
HEATING, COOLING, AND HOT WATER	3		1	2	
	<u>9</u>		<u>7</u>	<u>22</u>	
OFFICE BUILDINGS					
HEATING/COOLING ONLY		3	3	8	
HOT WATER ONLY			1	1	
HEATING/COOLING AND HOT WATER		1	3	9	
HEATING AND COOLING	2		1	3	
HEATING, COOLING, AND HOT WATER	2	<u>1</u>	<u>3</u>	<u>3</u>	
	<u>2</u>	<u>5</u>	<u>11</u>	<u>24</u>	
PUBLIC BUILDINGS					
HEATING/COOLING ONLY	1		2	2	
HOT WATER ONLY	1		1		
HEATING/COOLING AND HOT WATER	2		3	14	
HEATING AND COOLING			2	6	
HEATING, COOLING, AND HOT WATER	<u>1</u>	<u>1</u>	<u>8</u>	<u>24</u>	
	<u>5</u>	<u>1</u>	<u>8</u>	<u>24</u>	
HOTELS/MOTELS					
HEATING/COOLING ONLY			1		50
HOT WATER ONLY	2	2			
HEATING/COOLING AND HOT WATER			2	2	
HEATING AND COOLING					
HEATING, COOLING, AND HOT WATER	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	
	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	
COMMERCIAL/INDUSTRIAL BUILDINGS					
HEATING/COOLING ONLY			1	1	
HOT WATER ONLY			1		
HEATING/COOLING AND HOT WATER				4	
HEATING AND COOLING					
HEATING, COOLING, AND HOT WATER	<u>0</u>	<u>0</u>	<u>1</u>	<u>5</u>	
	<u>0</u>	<u>0</u>	<u>3</u>	<u>5</u>	
ALL BUILDING TYPES					
HEATING/COOLING ONLY	2	3	7	17	
HOT WATER ONLY	4	2	3	1	50
HEATING/COOLING AND HOT WATER	3	1	13	41	
HEATING AND COOLING	5		4	7	
HEATING, COOLING, AND HOT WATER	<u>4</u>	<u>2</u>	<u>5</u>	<u>12</u>	
	<u>18</u>	<u>8</u>	<u>32</u>	<u>78</u>	<u>50</u>

*ESTIMATES.

FIGURE VI-9

hot water systems. Thirty-two projects in twenty-two states and the Virgin Islands were selected from among 308 responses to the first cycle PON. The second demonstration cycle was initiated with the release of PON DSE-76-2 in October 1976. This cycle accommodated a wider range of solar applications and building types and required specific attention to energy conservation techniques. Seventy-four projects in thirty-two states were selected from among the responses to the second cycle PON. The scope of the commercial demonstration program was expanded with the release in May 1977 of a Hot Water Initiative for Hotel/Motel Installations (PON EG-88-N-03-1450). Fifty projects in

twenty-seven states and the Virgin Islands were selected from among the 121 responses to the Hot Water Initiative PON.

The third cycle has been recently initiated with the release of the third cycle Program Opportunity Notice in November 1977 with awards expected in 1978. Combined heating and cooling will be emphasized equally with mandatory cost sharing at an increased level expected for incremental solar system costs.

Climate and solar system performance data are required to determine the effectiveness of various commercial solar designs and applications for the different solar climatic regions. DOE's national solar data collection system (see Section VI-F) is now being used to

assemble and analyze the required meteorological and solar performance data. Monthly reports are being provided to project sponsors and to the Solar Data Bank at Oak Ridge. Seasonal reports for individual projects will start with the report for the 1977-78 heating period to be issued in early 1978. Program-wide reports combining data from participating sites will also be produced in 1978.

A summary of the current 187 non-Federal commercial demonstration projects by building type and application is given in Figure VI-9.

Commercial: Federal Buildings

The Federal commercial buildings program involves all Federal agencies with buildings that can utilize solar energy for their hot water, space heating, and cooling applications. The broad range of the program encompasses a variety of building types, climatic regions, and solar energy systems, and addresses specific procedures pertaining to design, procurement, installation, and evaluation.

The initial program conducted under Public Law 93-409 resulted in 40 commercial buildings projects. These projects are listed in the report, "Solar Heating and Cooling Demonstration Project Summaries" (DOE/CS-0009).

Future DOE awards for Federal commercial solar building projects will be affected by the National Energy Act legislation. The Act includes a three-year, \$100 million (maximum) effort to install solar equipment in Federally owned buildings. The Act specifies that project selection criteria and reporting requirements be promulgated "by rule." Accordingly, a draft Notice of Proposed Rulemaking, as well as an environmental assessment and inflationary impact statement, have been developed in draft by DOE in anticipation of the Act's passage in early 1978. Final rulemaking is planned for May 1978 followed by the receipt, evaluation and selection of proposals from interested Federal agencies. Major dollar outlays will commence in FY1978.

The following tasks describe the effort associated with the commercial demonstration program. These tasks and a synopsis of their status are presented in Figure VI-10.

COMMERCIAL DEMONSTRATION PROGRAM TASKS AND STATUS

TASK	STATUS
A. PROGRAM DESIGN AND MANAGEMENT	
A.1 Detailed Design	Completed; will be updated with progress.
A.2 Technical Design and Data Requirements	Guidelines established (NBSIR 76-1137).
A.3 Environmental Impact Assessment	Preliminary Environment Impact Statement completed and under review.
A.4 Utility Options	Utility interface analysis complete. Utility participation will be solicited in 1978.
A.5 Potential Market Incentives	Commercialization Program established; incentives under study.
A.6 Monitoring Progress	In Progress.
B. PERFORMANCE CRITERIA AND STANDARDS	
B.1 Develop Interim Performance Criteria	Report published in February 1975; updated in 1976.
B.2 Develop Definitive Performance Criteria	Periodic updates of interim criteria, definitive criteria in 1979.
B.3 National Consensus on Solar Standards	Plan published (NBSIR 76-1143) Standards workshops, and accelerated standard making planned for 1978.
B.4 Monitor Demonstrations for Feedback	In progress.
B.5 Criteria for Accreditation of Testing Laboratories	Interim standard completed in 1977.
B.6 Certification Procedures	Private testing laboratory accreditation program initiated in 1977.
C. CONDUCT OF DEMONSTRATIONS	
C.1 Integrated Systems	NSF and Phase 1 projects nearing completion; Cycles 1 and 2 underway; Cycle 3 initiated.
C.2 Subsystem and System Selections	PON results available.
C.3 Repair and Maintenance of Units	Negotiated with award.
D. DATA COLLECTION AND EVALUATION	
D.1 Collect and Evaluate Technical Performance Data	In progress; performance reports available for some projects; other reports available in 1978.
D.2 Collect Demonstration Data	Procedures developed and system implemented.
D.3 Prepare Recommendations for Achieving Utilization	In progress.
E. DEMONSTRATION SUPPORT	
E.1 Develop and Publish Manuals	Will evolve from Task D.3.
E.2 Data from Nationwide Survey and Catalog Preparation	Coming from private sector (SEIA).
F. MARKET DEVELOPMENT	
	Market development studies in progress. Outreach programs initiated.

FIGURE VI-10

COMMERCIAL PROGRAM TASKS

Task A—Program Design and Management

Task A.1—Detailed Design. An important part of the commercial demonstration program strategy is the careful analysis of the state-of-the-art and its application in each new demonstration cycle. The initial results of the program can be measured in terms of the further application of the technology in privately financed construction. Based on this measurement, the program has been successful. Studies indicate that for each Federally-financed project, there may be as many as 10 privately financed projects.

Task A.2—Technical Design and Data Requirements. For each demonstration, the contractor is required to conduct a design and system performance analysis and to provide recommendations for data collection. As a result of work to date, DOE has established guidelines for demonstration siting, and data collection, processing, synthesis, transmission, evaluation, and reporting.

Task A.3—Environmental Impact Assessment. DOE has completed an environmental assessment of solar heating and cooling related to the demonstration program. An Environmental Impact Assessment report has been provided to be used as a guide for future program planning and implementation.

Task A.4—Utility Options. Widespread utilization of solar energy can have a significant effect on the public utility sector. DOE has completed detailed analysis of the utility interface problem area, and funds may be allocated to provide for public utility participation in the latter half of the demonstration program. In particular, utility participation in the analysis of solar impacts on utility load and capacity factors will be solicited in 1978.

Task A.5—Potential Market Incentives. DOE established a comprehensive Barriers and Incentives program for Solar Heating and Cooling. Policy papers have been prepared and submitted, detailed analysis were completed for specific problem areas, and a series of commercialization workshops and seminars were held. The *Proceedings of a Workshop on Commercialization of Solar Heating and Cooling Systems* was published in 1977. A comprehensive analysis of commercialization policy options (*Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems*) was published in April 1977. A comprehensive program for 1978 is planned to assess the impact of current incentives, complete cost-benefits analysis of incentives for energy production and initiation of monthly reports on state and local solar activities and legislations. Ongoing studies initiated in 1977 on the legal barriers to solar implementation and the potential utility interfaces with SHAC systems will continue in 1978.

Task A.6—Monitoring Progress. In order to monitor progress toward this desired result and obtain regular feedback to the planning cycle, certain data concerning market development and the solar industry infrastructure will be systematically collected and evaluated. These data are being monitored and they will be used to establish cost-effectiveness indices and production rate trends and to assess the status of solar energy systems standards.

Task B—Establishment of Performance Criteria and Standards The general approach to and need for standards and criteria in the solar heating and cooling program is discussed in Section VI-G. The following tasks support the data development and actions required to allow for the commercialization of solar heating and cooling systems. Similar tasks are being carried out in the residential program and there is close coordination between these efforts. Where possible, the residential and commercial activities are combined into a single effort, as with the development of consensus standards outlined under Task B.3.

Task B.1—Develop Interim Performance Criteria. Interim performance criteria for the commercial demonstration program have been published in the report "Interim Performance Criteria for Commercial Solar Heating and Combined Heating and Cooling Systems and Facilities" (Document No. 98M1001, February 1975). Updated criteria were published in 1976 as "Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings." ASHRAE Standards for Collector and Storage Subsystems (ASHRAE 93-77 and 94-77) were published. Standards for coverplates, sealants and insulation are under development in cooperation with ASTM and will be published in 1978.

In addition, ASHRAE is currently working on a series of solar system standards for hot water heating and swimming pool heating systems and ASTM is working on several standards for materials, components, subsystems and systems.

Task B.2—Develop Definitive Performance Criteria. Based on the results of the various demonstration projects and inputs from participants, the interim performance criteria will be updated as necessary. They will be coordinated with the interim performance criteria for residential systems discussed under Task B.1 of the residential program. Definitive criteria will be issued toward the end of the program (1979).

Task B.3—National Consensus on Solar Standards. As described in section VI-G, product development and test standards are developed through a voluntary consensus process in the United States. The ASHRAE standard for testing solar collectors will be utilized in a Government-sponsored collector testing and rating program which was initiated early in 1978. Other standards are under development and this development process will be assisted through DOE-sponsored standards workshops and participation by DOE personnel within standards making organizations.

Task B.4—Monitor Demonstrations for Feedback. The Government will monitor the application of the interim performance criteria in demonstration projects and use this experience to improve the interim criteria and to develop final definitive performance criteria. This task will be coordinated with Task D.

Task B.5—Criteria for Accreditation of Testing Laboratories. The need for a procedure to accredit testing laboratories is addressed in Section VI-G.

Efforts have been initiated to identify laboratories currently capable of performing collector tests. This effort will be integrated into a more comprehensive program of laboratory accreditation under the National Voluntary Laboratory Accreditation Program, as set forth in Part 7, Title 15, Code of Federal Regulations.

Task B.6—Certification Procedures. Procedures for the certification of solar heating and cooling systems will be developed as outlined in the residential demonstration program. The Government will not certify products, but will assist industry in this process. The DOE sponsored collector testing program is expected to provide the basis for an industry certification program in 1978.

Task C—Conduct of Demonstrations

P.L. 93-409 directs the procurement and demonstration of commercial solar hot water, heating, and cooling systems. DOE's plan for the implementation of the demonstration program involves solicitation of proposals on a National basis. This solicitation is being pursued through the Program Opportunity Notice (PON) procedure. Also, a program for the installation of solar systems in health care facilities was implemented with HEW having administrative responsibility. DOE/HEW awards for several health care facility projects will be made in early 1978. Commercial projects are also being implemented on Federally-owned buildings as discussed in Section VI-B.

Though the PON is the primary means for implementing the program, the Request for Proposal (RFP) mechanism may also be used to solicit specific types of activities as the need arises. Unsolicited proposals for unique and innovative applications of solar heating and cooling also will be considered if they complement the demonstration plan and do not fall within the scope of planned solicitations.

An important criterion in selecting projects from PON solicitations is the proposed system's performance and its potential for commercialization. Willingness of the proposer to share the cost of the demonstration with the Government is another determinant. The level of proposed cost-sharing for each demonstration cycle is an important indicator of the success of DOE efforts to stimulate a viable solar industry. Cost-sharing by proposers has increased significantly within the commercial program. In the PON process, special attention is given to ensure sufficient opportunities for small business solar manufacturers and suppliers.

Task C.1—Integrated Systems. The PON is being used to solicit the commercial integrated-system projects. Proposers are required to have their own financing for the land and building and propose a technically acceptable solar heating and/or cooling system. In the case of an existing building, the proposer must either be the owner or be acting on behalf of the owner. Under this plan, DOE shares part of the extra cost associated with the solar equipment.

Task C.2—Subsystems and System Selections. DOE carefully evaluates the proposals to ensure that the proposed system and its subsystems are technically acceptable for the proposed application and climate. Qualified technical evaluators from DOE, DOE laboratories, NASA, and NBS are used in this evaluation process.

Task C.3—Repair and Maintenance of Units. Systems and subsystems installed in demonstrations will be repaired and maintained during the life of the program as established at the initiation of each project. Information on operation, repair, and maintenance comprises a significant part of the data collected in the demonstration activity.

Task D—Data Collection and Evaluation

Task D covers the acquisition, evaluation, and transformation of data from the commercial demonstrations into design data and recommendations for further program activity. A detailed description of the collection, evaluation, and dissemination activity is provided in Section VI-F.

Task D.1—Collect and Evaluate Technical Performance Data. Uniform instrumentation systems are being installed at solar sites to automatically record and transmit climatic and detailed solar system performance data. Both instrumented commercial and residential projects now feed data to a central collection point, and technical performance data is being evaluated. Monthly performance reports are furnished to users and to the Technical Information Center for public distribution. At the end of the first heating season a season report combining the data from monthly reports will be furnished. Additional sites

are being instrumented and as they are completed the monthly and seasonal reports will be furnished for them as well. These system performance data will be used in evaluating solar system cost and effectiveness. Program-wide reports will be generated as additional projects become operational.

Task D.2—Collect Demonstration Data. This task involves the collection of data prior to and during demonstration project occupancy. Its purpose is to provide for documentation of those factors pertinent to the development of a broad market for solar energy systems, such as operational reliability and costs, system effectiveness, institutional factors, and public acceptance. Important information, particularly recommendations for upgrading system performance and acceptability, will come from designers, contractors, building managers, and users. To insure complete and standardized records, DOE has established recording and analysis procedures for the demonstration data which is now being recorded. A program for field site visits and non-instrumented data collection has been implemented to accomplish the objectives of this task.

Task D.3—Prepare Recommendations for Achieving Utilization. Based upon the results of the two previous tasks, recommendations may be made for changes in existing procedures or legislation to ensure the widespread use of solar energy for commercial applications. Recommendations may relate to financing, incentives, codes, zoning, standards, and warranties.

Task E—Demonstration Support

The results of all phases of the program will be coordinated, documented, and published so that all sectors of commerce can benefit from the demonstration data. The objective of this activity is to allow for parallel documentation and dissemination of data and experience gained through the demonstration program. In particular, information useful to the solar design engineer, the solar installation contractor, the solar equipment manufacturer, and the potential solar investor will be developed and disseminated.

Task E.1—Develop and Publish Manuals. Manuals on design, installation, and operation of equipment will be written to communicate effectively with the user community. To increase user acceptance, the manuals will be prepared in cooperation with the involved trade associations and organizations. In many cases, these groups will give final approval to the documentation. Procedures for this process have been developed and are under current review. Dissemination of these manuals will begin in 1978. Arrangements will be made to facilitate inclusion of this information of the publications issued by these groups. Provision will be made for continuous updating of these manuals during the life of the demonstration program.

Task E.2—Data from Nationwide Survey and Catalog Preparation. A catalog of solar heating and cooling products (ERDA-75) was compiled and distributed by ERDA in 1975. Solar Energy Industries Associates (SEIA) now distributes such data. The first Solar Industry Index was published by SEIA in 1977. In addition, the FEA (now DOE), and SEIA publish a joint semiannual survey of solar collection manufacturing activity (FEA/B-77/135).

D. Development in Support of Demonstrations

Task F—Market Development

The development of a viable market for solar heating and combined solar heating and cooling equipment depends on a number of non-technical factors, including price and availability of conventional fuels, and public policy regarding the use of solar energy.

Commercialization planning as related to the demonstration program is concerned with acquiring accurate cost information (both first cost and operating cost), detailed procedures for applying solar heating and cooling to various commercial uses, and information on user acceptance. This data will be used to assist in the study of economic and institutional barriers to full market implementation and the establishment of legislation, incentives, grant programs, or low-interest loans to assist in the removal of these barriers. In particular, incentives may be required to stimulate the capital investments necessary for rapid commercial development.

It is expected that market demand will be generated through the experience and visibility gained during the demonstration program, as well as through achievement of lower operating costs and associated independence from possible conventional fuel supply interruptions. During 1977 an increased emphasis has been placed upon market development for the latter half of the five-year demonstration program. A comprehensive discussion of market development activities is presented in Section VI-H.

The objective of the Federally financed development activities in support of the demonstration program is to provide the prototype hardware needed for effective, reliable and economically acceptable solar heating and cooling components, subsystems, and systems. The specific intent of this part of the demonstration program is to bring solar energy systems to the point where they have been tested and can be mass-produced and marketed for residential and commercial applications. This approach to hardware development is being pursued because solar heating and cooling technology is at various levels of design and development maturity, and the existing market situation does not foster private investment in system development.

Though directed toward providing prototype system design and development for near future applications, the program also includes development work on advanced subsystems and systems. Special attention is given to testing and evaluation, so that as subsystems and systems complete operational tests and approach marketability, they will be ready for consideration in the competitive demonstration process. Figure VI-11 provides a summary of the development activity that supports the heating and cooling demonstration program described here. Some of the specifics of this effort are discussed in the following sections.

System Design and Development

The design and engineering development of solar heating, hot water, and combined heating and cooling systems will lead to project developers in regard to market acceptance and other important operational and market matters. Some of these projects prototypes for both residential and commercial applications. There is potentially a high

degree of commonality in general technology, design, materials, components, and production techniques for solar energy systems. This commonality enhances the effectiveness of cost-reduction activities in the areas of development, standardization, and production, and provides confidence in estimates of future system costs. The system design and development activities are aimed at the development of economically packaged systems to reduce costs and minimize technical risk in the demonstration program. Contracts were met in 1976 for system design and development by contractors. These System Design and Development (404) Contracts include requirements which provide for a smooth transition from the design and development stage up to the pre-production stage providing the designs hold promise. These contract requirements as they relate to system development, standardization and production may be summarized as follows:

- System designs must meet Interim Performance Criteria (IPC);
- Contractors must provide test data and analyses to verify performance;
- Contractors must provide installation, operation and maintenance manuals. Contractors must provide system, subsystem and component certification by independent laboratories.
- System must be designed to accommodate production tooling.

DEVELOPMENT IN SUPPORT OF DEMONSTRATIONS ACTIVITIES AND MILESTONES

▼ ACCOMPLISHED ACTIVITIES

FIGURE VI-11

These contract requirements insure that the products of the system design and development program represent the solar technology state-of-the-art while at the same time the developed systems hold near-term potential for mass production and implementation.

The scope of the system design and development contracts includes the design of both residential and commercial systems capable of providing either heating or cooling or both.

Program strategy involves the development of three independently designed prototype systems for the categories above. Each contractor will install a prototype system in two Operational Test Sites. These Test Sites will be monitored and comparative performance analyses will be performed.

To date designs for all prototype systems have been completed, test sites have been chosen, and design reviews have been completed. The single family residence solar heating prototypes have been installed and initial check-out has been completed. Installation, check-out, and start-up for the balance of the prototype systems is scheduled to take place throughout 1978.

Additional Development of Existing Systems and Subsystems

Special emphasis has been given to available residential and commercial solar energy systems and subsystems in which significant improvements can be attained in efficiency, reliability, and marketability. A principal criterion for DOE support in this area is the extent of the product development by a potential contractor. Thus, developers of innovative, workable system elements have an opportunity to obtain support for additional work.

A total of nine contractors have been selected to continue development testing work on already-existing system designs. The range of designs includes single family heating, hot water, combined hot water and heating, and combined heating and cooling, as well as a multifamily combined heating and hot water system and a commercial heating system. These designs will be installed in additional Operational Test Sites and performance data will be collected, analyzed, and compared.

In the area of Additional Existing Subsystem development, a total of ten contractors have been brought on board to allow continuation of development work on promising subsystem designs. The range of subsystem design and development includes the following:

- Five collector designs;
- Two solar-powered pump designs;
- One thermal energy storage design;
- An extensive heat transfer fluids study;
- Three microprocessor and modular controller designs; and
- Thermosyphon heat exchanger design.

Extensive progress was made in the subsystems development projects during 1977. Subsystems have been fabricated and tested, and redesign is taking place for several subsystems. Delivery of subsystems began in late 1977 and will continue through 1978.

Systems Integration of Marketable Subsystems

Marketable subsystems have been purchased for test and delivery to the systems integration contractor for integration into prototype systems. The engineering development on these subsystems will continue through laboratory and field testing to determine compatibility and performance.

Seven prototype systems which represent a range of heating and hot water designs for single and multi-family dwellings have been funded. System tests at MSFC have been performed for three systems with tests of two additional systems scheduled for early 1978. System testing, installation, and acceptance reviews will continue through 1978.

Prototype systems installed for field testing and selected demonstration projects are instrumented with standardized data collection subsystems which monitor and collect data. These subsystems are designed, developed, and fabricated for residential and commercial applications to ensure a common data base for evaluation of system performance. Site data collection units are delivered to be installed by the organization responsible for the solar energy system installation.

The central data processing facility, which became operational in October 1976, as scheduled, will process the data collected from the instrumented projects. These data will be evaluated and placed in the DOE data bank for dissemination.

E. Research and Development

New Subsystems and Components Development

Separate procurements will be made for development of critical subsystems and components as they are identified during the program. This is a significant program "insurance factor," permitting intensive concentration on identified problems. In addition to hardware, these efforts will include engineering studies in areas such as materials compatibility, and the development of advanced analytical methods. Innovative subsystem and component developments will be tested and considered for possible integration into prototype systems for both residential and commercial applications. This effort is closely coordinated with the research and technology development program to ensure proper integration of activities.

Task B—Performance Criteria and Standards

Engineering support will be provided during systems testing for the demonstration programs to ensure the operational problems are corrected and solutions incorporated into systems prior to demonstration. This includes fabrication and operation of system models so that operational problems at demonstration sites can be simulated and carefully assessed, and corrective action identified with minimum demonstration delay.

Test and Evaluation

This program effort was significantly enhanced when special solar heating test and evaluation facilities became operational early in FY1977. Systems and subsystems developed under the above tasks are being tested and evaluated under laboratory and operating environment conditions to verify their capability to meet the criteria established by the demonstration program.

The solar heating and cooling research and technology development plan is based upon the recognition that the application of solar energy for the heating and cooling of buildings involves, to a significant degree, existing components such as heat pumps, air conditioning machines, and controls which make up today's heating, ventilation and air conditioning systems. The relatively new and rapidly developing solar energy industrial base is currently integrating many of these key components in solar systems.

The research and development plan builds upon this existing technology and, by supporting work on a broad spectrum of problems, assists the solar energy industry in developing the cost-effective components and systems essential for the widespread use of solar energy for heating and cooling of buildings. A list of the research and development demonstration projects funded in FY1977 is provided in a report, "Solar Heating and Cooling Research and Development Project Summaries" (DOE/CS-0010).

The following findings have consistently emerged from meetings between representatives of industry, universities, and government laboratories and agencies, as critical to the development of a directed solar heating and cooling research and development (R&D) program:

- The development of cost-effective components and systems continued to be the major problem to be addressed;
- The state-of-the-art varies greatly for different components and applications, and solar cooling technology continues to be less developed than solar heating.
- Cost-effective retrofit systems are still not well developed. Techniques for optimizing retrofit design are not readily available.
- Though there are not major scientific barriers to the production of steam from solar energy, there still exist significant engineering and technological obstacles which must be overcome.

Task B-6—Certification Procedures. Section VI-G discusses the need for product certification procedures. The certification requirements must be addressed, either in series or in parallel. These functional requirements may be broken down into five categories: energy collection, energy storage and exchange, space conditioning, systems and function controls, and nonengineering aspects. These requirements can be defined as R&D tasks, and approximately 275 tasks have been identified and grouped accordingly.

Since the directed program is a continuation of the current R&D program, many of the tasks described in this report are already under study. Other tasks will be initiated as indicated in the plan.

Implementation of the directed program will be based primarily on competitive solicitations, rather than on unsolicited proposals. Industry, universities, small businesses, and Government laboratories are expected to continue to perform R&D tasks, with project support coming from the DOE laboratories.

Since the R&D program is part of DOE's total energy program, it has many points of impact on other DOE programs and other Federal agencies. Implementation is being coordinated with appropriate groups, with special emphasis on integration with the residential and commercial demonstration programs.

The paths for solar energy applications will be cost-effective if key problems can be solved. As technology advances and project results are analyzed, the paths will be periodically evaluated and priorities will be adjusted. Milestone schedules and task emphasis will be revised accordingly.

The plan calls for both information dissemination and components development. While major milestones are indicated for each path, it is expected that new components and systems information will be developed throughout the program.

R&D Program Emphasis—An R&D program plan (DOE/CS-0008) has been published which is designed to produce early results and provide maximum support to the developing solar energy industry. Research and development oriented towards meeting longer-term objectives is continuing concurrently. Thus, for example basic or applied research on new surfaces for solar collection or new thermodynamic cycles for cooling will continue to be supported within the broader R&D program.

The directed R&D program meets the needs of the developing solar heating and cooling industry by accomplishing the following:

PATH DESCRIPTIONS FOR HEATING AND COOLING OF BUILDINGS

APPLICATION	DESIGNATION	PATH DESCRIPTION
Hot Water	W1	Liquid-Heating Collectors for Service Hot Water
	W2	Air-Heating Collectors for Service Hot Water
Space Heating	H1	Combined Solar and Heat Pump Systems for Space Heating
	H2	Passive Solar Heating of Space or Structure
	H3	Air-Heating Collectors for Space Heating
	H4	Liquid-Heating Collectors for Space Heating
Space Cooling	C1	High Temperature Collectors with Absorption or Heat Engine/Vapor Compression Chillers for Space Cooling
	C2	Medium Temperature Collectors with Absorption, Heat Engine/Vapor Compression, or other chillers for Space Cooling
	C3	Flat Plate Advanced, Non-Concentrating Collectors with Desiccant Chiller/Dehumidifier for Space Cooling and Dehumidification
	C4	Passive and Hybrid Cooling
	C5	Combined Solar and Heat Pump Systems for Space Cooling

FIGURE VI-12

- Supporting the development of components and systems having improved performance and/or lower cost;
- Conducting tests of systems with advanced components to provide the full range of data essential to the development of new solar heating and cooling systems;
- Providing data, information, and computing techniques that the potential users of solar energy may require in order to determine cost and benefits; and
- Evaluating various economic, environmental, social, institutional, and legal factors which could influence the manner in which solar thermal energy is used.

The DOE Research & Development strategy calls for product development to be carried out by the industry that will eventually market the product. Product development by industry is supported by the R&D program where it is desirable to obtain a prototype or pre-prototype for testing. The R&D program also concentrates on providing the technology and information flow required for an effective near-term development of the expanding solar energy industry.

Materials Characterization and Development—It is necessary to identify the characteristics of materials required for the proper functioning of solar heating and cooling components. The demands, which are usually stringent enough to make the choice of materials difficult, include high performance,

long service life, low initial cost, acceptability in a particular environment (such as a home or factory), compatibility within a system, and availability. A particularly relevant example is that of a suitable liquid coolant. The current choice, a mixture of ethylene or propylene glycol and water, is known to form glycolic acids at temperatures to be experienced in collector operation. These acids can lead to system corrosion and failure.

Significant accomplishments were made in 1977 in the area of coating and surface materials for solar collectors. Development work has led to the incorporation of a black chrome selective surface as well as an anti-reflection glazing coating on commercially available collectors. Other ongoing work in the area of phase-change materials selection for thermal energy storage will continue in 1978.

PATH DESCRIPTIONS FOR AGRICULTURAL AND INDUSTRIAL PROCESS HEAT

APPLICATION	DESIGNATION	PATH DESCRIPTION
Agricultural Process Heat	HP	Passive Solar Heating for Shelters and Greenhouses
	HA	Air-Heating Collectors for Shelters and Greenhouses
	HL	Liquid-Heating Collectors for Shelters and Greenhouses
Agricultural & Industrial Process Heat	DD	Direct Drying of Agricultural and Industrial Products
	DA	Air-Heating Collectors for Drying
	DL	Liquid-Heating Collectors for Drying
Industrial Process Heat	WL	Liquid-Heating Collectors for Process Hot Water
	WA	Air-Heating Collectors for Process Hot Water
Industrial Process Heat	SL	Liquid-Heating Collectors for Process Steam
Agricultural & Industrial Process Heat	CA	Active Cooling and Refrigeration for Agricultural and Industrial Process Applications
	CP	Passive Cooling for Agricultural and Industrial Process Applications

FIGURE VI-12 (Continued)

Development of Components—In order to evaluate the potential of a particular solar heating system component or system configuration, it is necessary to characterize mathematically the performance of the component or the system. Mathematical models of systems must account for both steady-state and dynamic or transient operation of elements of systems. Where models do not exist, they must be developed and validated by comparison with steady-state and transient tests made on operating systems or prototypes. Validation of entire systems, incorporating a variety of components, is necessary to ascertain that the model correctly describes components interaction.

Industrial manufacturers, contemplating the development of a new product line, will generally perform the kind of system modeling described above. However, the job of validating an entire heating and cooling system model is often beyond the means of any single manufacturer; as a result this step may not be taken. This could result in the development of components which are inappropriate or not optimal for use in particular solar heating and cooling systems. For example, absorption chillers used in conventional cooling systems generally need not be designed to account for transient inputs. However, knowledge of their transient behavior is important in their application to solar-powered cooling installations.

A full understanding of design requires careful analysis, including modeling of the complete system to ensure proper selection of design specifications for the final hardware. New component developments in 1977 included a full-scale direct contact liquid-to-liquid-heat exchanger, a prototype phase change storage subsystem utilizing commercially-available waxes, and a prototype jet impingement solar air heater. Extensive R&D in the solar cooling area is generating many new and innovative cooling subsystem designs. Three prototype desiccant subsystems are under study, and new fluids for absorption coolers are under study. Extensive analytic and systems simulation studies to support improved solar heat pump designs will continue into 1978. Finally, progress made in the Rankine system area has included the development of several innovative heat engine designs, including a free piston heat pump, a bi-phase turbine design and the vapor-cushioned rotary vane turbine design. The continuing and directed R&D in the cooling area is oriented towards providing a choice of potential cooling techniques sufficient to satisfy all climatic variations as well as variations in building type and size.

System Analysis—System configuration, climatic zone, building type, and competing energy type and cost are some of the critical parameters in the analysis matrix used to estimate system performance. This analysis includes system modeling and testing to validate performance models and provide data on system and subsystem operation. The development of each research and technology development path is guided by such system analysis.

Accomplishments in 1977 within the area of systems performance and analysis have increased the availability of packaged programs for the analysis and prediction of subsystem and system performance. Systems analysis techniques and programs to date include:

- Heat exchanger optimization code;
- Seasonal storage computer code;
- Passive system simulation codes at several levels of user sophistication;
- SOLCOST available for hot water and liquid space heating systems on cybernet network;
- F-chart for air or liquid space heating and for water heating expanded by addition of 50 sites—now 170 sites in total;
- New version of F-chart developed for absorption cooling;
- Updated version of TRNSYS developed to simplify user inputs, adds histogram plotting capability and reduces computer time.

F. Data Collection, Evaluation and Dissemination

Information Dissemination—

Both component tests and integrated prototype system tests are being performed under the solar heating and cooling research and technology development program. These tests are designed to provide information on the operational and maintenance characteristics of the system, as well as to validate the predictive models. Special attention is given to selecting systems that have the greatest probability of economic and performance benefit for specific applications, for detailed testing of systems, and for data documentation.

The data collection and information activities pertinent to dissemination of R&D program results have been coordinated with the centralized data collection, evaluation, and information dissemination system established under the solar heating and cooling demonstration program.

Non-Engineering Aspects—

The information on the non-engineering aspects of solar heating and cooling is important for establishing priorities for the R&D program as well as for individual paths in the program. This information is being obtained through the activities described in the market development section of this document.

The collection and evaluation of data from the demonstration projects and their dissemination to a wide range of potential users are key objectives of the solar heating and cooling demonstration program. These data must be readily understood by users so that they can be applied to decisions as to the selection and application of solar energy systems. Special emphasis is therefore being placed on the determination of user needs, standardization of data to allow system comparison, and close interagency coordination to minimize duplication of activities.

Organizational responsibilities have been identified for data functions in both the commercial and residential demonstration programs which incorporate supporting research, technology development and engineering development. Figure VI-13 shows three information categories: Instrumented Data, Technical Data, and Non-Technical Data. A specific data processing method, devised to facilitate the flow of information to the public, covers data selection, collection methods, storage, evaluation, documentation, cataloging, and data dissemination. This procedure, which applies to each of the three data categories, is described in the following sections.

DATA COLLECTION, EVALUATION, AND DISSEMINATION ACTIVITIES AND RESPONSIBILITIES

ACTIVITIES	INSTRUMENTED DATA		NON-INSTRUMENTED DATA			
			TECHNICAL DATA		NON-TECHNICAL DATA	
	COMMERCIAL	RESIDENTIAL	COMMERCIAL	RESIDENTIAL	COMMERCIAL	RESIDENTIAL
DEFINE REQUIREMENTS	PERFORMANCE EVALUATION COMMITTEE		DOE/ CONTRACTOR	HUD CONTRACTORS	DOE/ CONTRACTOR	HUD CONTRACTORS
DEVELOP COLLECTION METHODS	DOE/ CONTRACTOR					
STORE DATA			DOE/ CONTRACTOR	NBS	DOE/ CONTRACTOR	NBS
EVALUATE DATA			DOE/ CONTRACTOR	HUD CONTRACTORS	DOE/ CONTRACTOR	HUD CONTRACTORS
DOCUMENT RESULTS						
ARCHIVE DOCUMENTS	DATA BANK - DOE TECHNICAL INFORMATION CENTER (TIC)					
DISSEMINATE INFORMATION	NATIONAL SOLAR HEATING AND COOLING INFORMATION CENTER SOLAR TECHNOLOGY TRANSFER-REGIONAL OUTREACH PROGRAM					

FIGURE VI-13

Instrumented Data

Instrumented data are derived principally from sensors located at the demonstration site. The analyzed data are presented in a format that defines the thermal performance of the solar energy system and the climatic conditions affecting that performance. Several methods have been used to assess the performance of solar energy systems. Although each has technical validity, differences in techniques and presentation require that considerable analysis be done to achieve comparable results. To minimize this problem, an interagency Performance Evaluation Committee was formed in order to:

- Identify those factors which define the performance of a solar energy system;
- Identify the equations used in establishing these factors;
- Identify the required measurements, their accuracy and data collection periods; and
- Define performance formats for presenting performance information

The committee, which includes members and advisors from DOE, HUD, NASA, NBS, and DOD, is anxious to foster broad acceptance and use of program results. To do this, they must ensure that the demonstration data are accurate and satisfy the requirements of the majority of users. Recommendations from industry and nationally recognized consultants have been utilized in this process. Monthly publication of instrumented data from the demonstration program began during 1977. A report entitled "Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program," Report Number NBSIR 76-1137, has been prepared by the committee and was issued in August 1976.

Data Collection and Storage—Collection and storage of instrumented data from the various commercial and residential demonstration sites are accommodated by a National Solar Data Network. Each of the demonstration sites selected for instrumentation is equipped with a set of sensors and a Site Data Acquisition Subsystem (SDAS) which periodically scans and records sensor outputs. A daily electronic command signal from the central processing station initiates the transmission of the recorded data over conventional telephone lines. Data are tested as they are received to ensure their validity and erroneous signals are automatically identified and brought to the attention of the central processing station operators. Incoming data of acceptable quality then are processed and stored on magnetic tape at the station for five years, or until no longer needed. During 1977, the National Solar Data Network became operational on a widely-dispersed group of commercial and residential demonstration sites. The number of SDAS-equipped sites will increase during 1978.

Evaluation—Evaluation of the instrumented data is performed at the central processing facility. Methods prescribed by the Performance Evaluation Committee and other analytical methods are used. Unexpected extensions of the operational starting dates of demonstration projects have delayed this activity, but the initial project reports of performance evaluation were completed during 1977. Performance reports for each demonstration site include:

- Solar energy incident;
- Solar energy collected;
- Space heating, space cooling, and hot water load;
- Solar fraction of space heating, space cooling, and hot water load;
- Total solar energy utilized;
- Total auxiliary energy; and
- Electric and fossil energy saved.

In addition to assessing the performance of solar energy systems in a variety of climatic conditions, the instrumented data will be used to validate a series of mathematical models. By comparing actual performance with predicted performance, appropriate correction factors can be established and incorporated into the models. The verified models may then be used to accurately design solar energy systems and to size the associated subsystems in order to provide the appropriate amount of energy for any specified building type, climatic condition, or thermal load. The models will also provide a means for extrapolating the measured performance of a specific solar site to determine how that system would work under a different climatic or thermal load condition. This technique will permit comparative analyses of various solar energy systems under equivalent conditions.

The instrumented data will also be a key element in determining solar energy cost and carrying out related economic studies; e.g., setting a firm value for the amount of conventional energy replaced through the use of a solar energy system will establish the value of the solar energy supplied. Such an analysis can be extended to define the life cycle cost of a solar energy system, and the cost of solar energy in terms of dollars per unit of energy delivered. This information will be invaluable in the decision-making process for any potential user of solar energy.

Evaluation of instrumented data will also lead to the establishment of an important set of solar/weather data which is essential in the early design phases of any solar energy system. Although comparatively little suitable data of this type have been collected until recently, a standard format (SOLMET) now has been established and useful weather data in this format now are available for many locations across the nation. During the course of evaluation the various demonstration sites, weather data restored at the central processing station for subsequent retrieval and use.

Documentation—Among those reports now being generated for each instrumented demonstration site are:

- Monthly Performance Reports;
- Solar Energy System Descriptions; and
- Solar Energy System Performance Evaluations.

The Monthly Performance Reports include data prepared at the central processing station in standard formats established by the Performance Evaluation Committee with additional manually-incorporated supplemental information as appropriate to clarify results. The other reports include both technical and non-technical information describing the building, solar energy system, and significant performance and other system experience over extended periods of time.

Document Cataloging—All reports describing the results of the instrumented data are being archived by the DOE Technical Information Center (TIC) at Oak Ridge which serves as the National Solar Data Bank. Further functions of the data bank are described in the section on Technical Data.

Information Dissemination—

Reports are available to interested parties through the DOE Technical Information Center at Oak Ridge or the National Solar Heating and Cooling Information Center. In addition, preliminary copies of monthly performance reports and annual reports will be mailed to those directly involved with the project site, including the builder/owner, site manager, manufacturers of key components, government agencies responsible for the subject demonstration site, and government agencies or contractors who have specific assignments for subsequent analysis of the information.

Technical Data

Commercial demonstration program technical site-related data consists of information peculiar to a given site including detailed descriptions of the building and the solar system; design, equipment, and installation cost information; maintenance data; information on design and implementation progress; and monthly purchased energy cost data.

Data collection forms structure the data and help to assure that the information gathered is consistent and complete. Organized according to the order in which the data is to be collected, each of five series of forms calls for information pertaining to a particular event in the demonstration project schedule. The type of information each form compiled is given below:

- Design information;
- Building and solar equipment description;
- Construction information;
- Demonstration observation data;
- Owner/user attitudinal data;
- Servicing and maintenance information; and solar energy systems costs.

Information is needed on the techniques used to integrate the solar energy system into the overall building design. These data include solar energy system performance requirements, design costs, and descriptions of and solutions to problems in meeting performance criteria, codes, zoning, land use requirements, and aesthetic or other architectural controls.

The data collection effort consists of three stages: pre-visit preparation, site visit, and post-visit data completion. Pre-visit preparation involves review of the project proposal and any other documentation available at that time; it allows the data collection team to become familiar with the project before the site visit and to complete portions of the data forms.

During the site visit, interviews are conducted with the project manager and any other cognizant personnel who are available such as the architect, HVAC engineer, and construction supervisor. These interviews provide a general overview of the project as well as information on scheduling, permits, costs, and problems encountered during design, installation, and startup. The site is inspected so that the data collection team can assess general characteristics of the installation and record equipment name plate data, if necessary.

Post-visit data completion involves transcription of data from notes, drawings, and specifications onto the appropriate forms, follow-up queries of project personnel by telephone or mail, contacts with manufacturers regarding specifications for their products, use of reference handbooks, manuals, and specifications, and general review and finalization of the completed forms.

The completion of the maintenance data forms is the responsibility of the demonstration site manager. A copy of the form must be filled out for each maintenance action (scheduled or non-scheduled) and the completed forms are submitted monthly. In order to assure that the component failures or replacements can be identified by the analysts, a system schematic must be developed for each project indicating the components by function in accordance with as-built drawings of the system.

Similarly, the purchased energy costs must be submitted monthly by the site manager. Included are energy used to operate the solar system (pumps, blowers, etc.) and energy used to augment the system (for heating, cooling, or domestic hot water).

Information on progress, problems, and solutions as construction is carried out includes data on shipping and delivery, installation, labor, financing, building permits, zoning and land-use, building codes and inspection, testing, schedules, budgets, warranties, and operating and maintenance instructions.

Information is also collected on events, concerns, impressions, and other observations on the demonstration project from the viewpoint of the site manager.

Information needed to accurately establish the cost of solar energy systems includes:

- Cost to complete design and prepare bid package(s);
- Purchase price of major subsystems such as collectors, control systems, fluid transfer subsystem, and thermal storage subsystem; and
- Major subsystem installation cost.

The technical data collected through the use of these standardized forms is appropriately coded and cataloged for computer storage. After the data have been entered into storage, it will be made available to the contractors and Government agencies assigned responsibility for the analysis and documentation activities. The analyzed data will then be available to all interested parties in the form of reports and documents from the Solar Data Bank of DOE Technical Information Center. Normal practices of contractors in the construction trades have made it difficult to obtain some types of information, especially institutional and malfunction data, but revised approaches are being developed to satisfy these data requirements in more suitable ways.

Evaluation—A number of organizations have specific responsibilities for the evaluation of technical data. Special efforts are being made to subdivide the technical data into logically discrete parts which can be analyzed by teams of specialists. Most of the technical data will be analyzed under contracts which require final reports on analysis of the results.

Documentation—Technical reports will be prepared to describe specific aspects of the program. Representative topics include:

- Design Manuals;
- Solar/Weather Atlas;
- Comparison of Solar Heating, Cooling, and Hot Water Systems in Demonstration Regions;
- Solar System Performance Over Extended Operating Periods;
- Solar System Performance Prediction Techniques;
- Solar System Operating Efficiencies and Techniques for Improvements;
- Solar Energy Economics Based on Actual Operating Experience; and
- Techniques to Minimize Maintenance in Solar Energy Systems.

In addition to such comprehensive documents, other reports focusing on significant problem areas or accomplishments of the solar energy demonstration program will be prepared and distributed.

Document Cataloging—The DOE Technical Information Center (TIC) at Oak Ridge, Tennessee, will serve as the National Solar Data Bank for all reports prepared under funding from the National Solar Heating and Cooling Demonstration Program. This data bank is intended to satisfy the requirements of the Solar Energy Research, Development, and Demonstration Act of 1974 (P.L. 93-473) and the Solar Heating and Cooling Demonstration Act of 1974 (P.L. 93-409), which require the establishment and operation of a solar energy information data bank for the purpose of collecting, reviewing, processing, and disseminating information derived from the solar demonstration program.

The DOE Technical Information Center has extended its activities to include specific evaluation and dissemination items required by the solar energy data bank. In addition, clauses are included in contracts and agreements requiring that all reports be submitted to the data bank.

TIC provides abstracting and indexing coverage of all scientific and technical reports, journal articles, conference papers and proceedings, books, patents, theses, and monographs originating with DOE and its contractors. A comprehensive monthly energy abstract journal, "ERDA Energy Research Abstracts (ERA)" is available to universities, research institutions, industrial firms, and publishers of scientific information. Federal, state, and municipal agencies concerned with energy development, conservation, and usage may obtain ERA free of charge; it is also available to the public on a subscription basis. All DOE reports so indicated in the "ERDA Energy Research Abstracts" are offered for sale by the National Technical Information Service.

TIC has also catalogued, indexed, and stored (in computer compatible form) most of the scientific and technical information published on solar energy research. Coverage in this "Solar Energy Bibliography," (Report No. TID-3351-RIPI) goes back as far as useful references could be obtained and is current through 1977. References are added on a continuing basis and will be available through the DOE on-line computer retrieval system, RECON. In addition, current research results are published quarterly in "Solar Energy Update."

Information Dissemination—

The dissemination of information from the demonstration program is necessary to ensure the widespread application of solar energy. The data bank will play an important role in this task, especially with regard to the technical and scientific community. The data bank and the information dissemination process are described in greater detail under Non-Technical Data.

Non-Technical Data

The development and dissemination of non-technical data is also important for the promotion and widespread utilization of solar energy. This category includes all information which is not necessarily derived from an instrumented source or is not technical in nature, such as the existence of possibly restrictive building codes and zoning regulations, the willingness of bankers, builders, and buyers to accept innovation, and industrial financing practices.

Although a significant amount of these data will be derived from the demonstration sites and the solar demonstration program in general, it is clear that much of the information must be obtained from other sources. For example, market acceptance information based on experience of the project sponsors is being obtained through interviews. Data is being obtained on the degree of user satisfaction with system performance; i.e., whether the users perceived the performance to be what the technical data indicated. Data on legal barriers involved in the development and operation of the solar project, and the actions necessary to overcome such legal obstacles, are also being collected. Special emphasis has been placed on obtaining data on solar energy system and project

costs and steps necessary to secure financing for buildings utilizing solar energy. This information provides a basis for balancing actual performance against initial life-cycle costs.

The activities to be pursued in collection, evaluation, and dissemination are essentially the same for technical and non-technical data. But information dissemination must go beyond the scientific and technical community to reach an equally important user group which includes the building owners, builders, financiers, insurance firms, marketing personnel, service organizations, and the general public. Specialized dissemination techniques are necessary to reach these groups. A program has been developed to provide information to those who are not equipped to work with or directly utilize the reports and products of TIC. Special emphasis has been placed on providing information to the housing industry and its customers.

National Solar Heating and Cooling Information Center

To provide this outreach to the building community HUD, in cooperation with DOE, established the National Solar Heating and Cooling Information Center.

The National Solar Heating and Cooling Information Center provides one point of contact for questions about solar heating and cooling. In response to inquiries, the Center's staff sends out appropriate documents or reports and develops individual answers when necessary.

G. Standards and criteria

Technical literature required to answer requests is obtained from the Energy Data Base at DOE's Technical Information Center; and other DOE contractors. In addition to these sources, the Center has developed its own files of solar equipment manufacturers and distributors; building industry professionals interested and experienced in solar; municipal, state, and Federal legislation affecting solar; courses and conferences about solar; available public speakers; solar buildings available for viewing; solar and energy related associations.

The National Solar Heating and Cooling Information Center receives inquiries at the following toll free numbers:

- 800-462-4983 (in Pennsylvania)
- 800-523-2929 (all other locations)

Written inquiries may be addressed to:

- National Solar Heating and Cooling Information Center
PO Box 1607
Rockville, MD 20850

The center also provides services designed to encourage inquiries and to further develop a consciousness of solar heating and cooling among the public and within the solar and building industries. Some of these activities include:

- Preparation and distribution of special films and documents describing the construction and operation of typical solar energy systems;
- Cooperation with state energy offices in sponsoring solar conferences for building professionals;
- Operation of a traveling exhibit, the HUD Solar Center Van, throughout the country;
- Operation of special exhibits at national trade shows, professional association meetings, public energy programs and other sites where there is high visibility for solar;
- Preparation and distribution of special pamphlets and booklets describing various aspects of solar heating and cooling and its residential and commercial applications. Many of these documents are prepared for specific audiences, such as builders, architects/designers, mortgage lenders, policymakers, and potential solar homeowners.

Appendix II gives a brief review of how to obtain information on solar heating and cooling program activities.

The assurance of safe, reliable, and efficient solar equipment is important to the timely application and public acceptance of solar heating and cooling systems. P.L. 93-409 calls for the development of codes, standards, and criteria for solar energy system equipment. Sections 5 and 6 of the act provide for the development of interim performance criteria. This includes criteria for the buildings themselves, especially their suitability for solar heating and combined solar heating and cooling. Section 8 of the act provides for the use of data from the demonstration program to develop definitive performance criteria, as well as testing procedures whereby manufacturers can certify that their products conform to established standards. Such criteria and standards are essential to the establishment of minimum levels of technical performance to provide a basis for consumer acceptance and protection, and for mortgage insurance, tax credit, or legislative incentive programs.

Building Standards

Standards may be either prescriptive or performance-oriented, voluntary or mandatory. A prescriptive standard is specific, giving details for usage or design procedures for the equipment, product, or system under consideration. A performance standard sets objectives, conditions, and criteria for use, but allows the designer flexibility in achieving intended results. In this program, standards will generally be performance-oriented to encourage the introduction of innovative products and systems.

Most standards used in the United States are developed through a voluntary consensus system, with Government, industry, consumers, institutions, and other interested parties participating and reaching a consensus on standards to be adopted. In practice, a duly-appointed review authority determines when agreement has been reached. This process helps to ensure that the standards will be widely accepted and used. Over 400 organizations in the United States, including engineering societies, trade associations, testing laboratories, building code organizations, and manufacturers are involved in writing standards.

A Steering Committee on Solar Energy Standards Development has been established by the American National Standards Institute (ANSI), with representatives from Government, professional societies, trade associations, consumer interests, and the building industries. The committee has identified needs and formulated task assignments to various standards writing organizations for the development of national consensus standards for solar heating and cooling.

The growing Federal involvement in housing and urban development has had an increasing impact on building standards and codes, as well as on their administration. The result has been the development of a series of mandatory building standards: HUD/FHA Minimum Property Standards (MPS), the Occupational Safety and Health Act (OSHA), and the Federal Mobile Home Standard (FMHS).

FHA developed its own set of minimum standards for new residential housing when faced with the necessity of applying nationwide standardized criteria for underwriting mortgage loan insurance on housing. Though MPS has played a role in the development of local building codes, FHA has not promoted it as a substitute for local codes. However, MPS has played a major role in shaping the design of residential housing, because builders usually tailor their designs to meet MPS requirements, even if those designs were not intended for inclusion under the HUD/FHA mortgage loan insurance program.

The Federal Occupational Safety and Health Act (OSHA) of 1970 authorizes the Secretary of Labor to promulgate national health and safety standards applicable to places of employment. These national standards apply to the construction of all residential dwellings, but their major impact is on commercial and industrial properties.

HUD has issued uniform construction and safety standards for the structural, plumbing, mechanical and electrical elements of residential mobile homes. These standards became mandatory in June 1976, pre-empting all state and local requirements. While HUD is charged with enforcing the standards, its primary activity is encouraging the individual states to assume these enforcement responsibilities under HUD supervision.

Building Codes

The building code picture is quite complex. Building codes are normally enacted into law by local governments exercising the police power delegated to them by the states. There is a considerable diversity in building code provisions due to the use of several different model codes and the impact of local needs and interest.

Except in some of the largest cities, the drafting of basic building codes is accomplished by the model code associations and allied groups. Three of these allied groups are regionally located and their membership is comprised of local officials:

- ICBO - International Conference of Building Officials (Uniform Building Code);
- SBCC - Southern Building Code Congress (Standard Building Code);
- and
- BOCA - Building Officials and Code Administrators International (Basic Building Code)

The first model building code was published in 1905 by the National Board of Fire Underwriters (now the American Insurance Association) to guide municipalities concerned with reducing building fire hazards. This became the National Building Code. The Uniform Building Code, written in 1927 by the Pacific Coast Building Officials Conference (now ICBO), was the first model code prepared by building officials. This code is used extensively on the West Coast. The Southern Building Code Congress (SBCC), recognizing the unique problems of construction in the South, prepared the Standard Building Code in 1945, now the predominant building code in the southern states. The Basic Building Code was published in 1950 by the Building Officials and Code Administrators International (BOCA).

ICBO, SBCC, and BOCA revise their codes annually and publish completely new editions every three years. Generally, this keeps model codes up-to-date and permits the use of new materials and techniques in building construction. Model code associations also review building plans and provide product certification. Product certification allows a manufacturer to get approval for installation of a product at one location, and to have the approval apply in all locations where the model code is used.

There is no general delegation of code-enactment authority to local governments. Within the past several years, many states have assumed a more active role in writing, promulgating, and enforcing building codes. A number of states have assumed virtually all authority to enact building codes, and today 21 states have statewide codes for either mandatory or voluntary application.

DOE and HUD, utilizing the NBS, have initiated a program with the major model code groups to support the development of model code language and administrative procedures to support solar energy regulations.

Current Activities on Criteria and Standards

Intermediate standards for solar water and space heating systems have been developed and adopted which supplement the existing HUD/FHA Minimum Property Standards (MPS). These intermediate MPS form the basis for the acceptance by HUD/FHA of mortgage insurance on solar energy systems and components, and will be used to qualify systems or components for acceptance under proposed tax credit programs. These standards represent the current state-of-the-art, but they also allow for and encourage the development of innovative ideas.

Interim performance criteria for both residential and commercial systems have been published for use in the demonstration program. The criteria for commercial systems have been updated and published and the criteria for residential systems are currently being updated.

Whereas the interim performance criteria are intended primarily for use in procurement during the solar heating and cooling demonstration program, the definitive performance criteria are intended to ensure the safety and reliability of solar heating and cooling equipment used by the general public, including the Federal sector. It is expected that they will serve as the basis for Federal specifications within the Solar in Federal Buildings program. It is desirable that the definitive standards be nationally accepted as voluntary consensus standards that can be used for the certification of solar equipment.

DOE, HUD, and NBS are monitoring and assisting in the development and implementation of consensus standards, maintaining close coordination with the Steering Committee on Solar Energy Standards Development of ANSI and the standards-writing organizations.

A program is being established for the accreditation of laboratories qualified to test solar energy heating and cooling subsystems and components in accordance with a similar national accreditation program recently established by the Department of Commerce. Procedures have been developed and will be submitted to the Department of Commerce by DOE and HUD requesting that an official accreditation program be initiated through the National Volunteer Laboratory Accreditation Program.

Initial studies have been completed on the establishment of model building code provisions. Additional work will be undertaken in 1978 with a target for model code provisions by the end of the year. Organizations involved in this work include the National Conference of States on Building Codes and Standards, the Council of American Building Officials and several professional and trade associations.

A program has been undertaken by DOE to develop procedures for certifying and labeling solar collectors. Initial work was done by the Air Conditioning and Refrigerating Institute Foundation. A competitive solicitation to build upon the AAIF work resulted in a contract award to the Solar Energy Research and Education Foundation (SEREF). In support of an interim certification program DOE has initiated a collector testing program fully coordinated with the SEREF activity. It is anticipated that test results and certification procedures will be available in the fall of 1978.

H. Market Development

The basic purpose of this activity is to accelerate the product development/commercialization process for solar energy technologies to stimulate the development of a viable solar industry. The intent is to introduce into the market place economically competitive, environmentally acceptable, and operationally safe solar energy systems. This programs activity involves additional aspects of the program considered essential to promote development of a viable solar industry as described below.

1. Planning and Coordination Function

This category consists of comprehensive national planning to accelerate commercialization of solar technologies. The Department of Energy is directed by the Energy Conservation and Production Act of 1976 (P.L. 94-385) to provide overall coordination of Federal solar energy commercialization and to carry out a program to develop policies, plans, implementation strategies and program definitions for promoting and accelerating utilization and widespread commercialization of solar energy. Coherent national objectives are needed to stimulate the use of solar energy. Coherent strategies are needed to focus efforts to foster the development of a viable industry/market infrastructure.

Accelerated commercialization is a joint public-private effort. At the Federal level it is a multi-agency activity. State and local governments also play an important role particularly with regard to non-economic barriers—zoning ordinance, building codes, licensing procedures, etc.; thus, the need for an ongoing commercialization planning effort which depends on accurate data collection, concise analysis of institutional problems, and professional cost-benefit analyses.

Planned activities in 1978 call for studies to identify economic, institutional, and legal barriers to solar energy commercialization; for formulation and cost/benefit analysis of market incentives and strategies to overcome those barriers; and for impact evaluation of Federal/State market demonstration and incentive programs. Such studies and analyses will cover all solar technologies and will look at Regional markets as well as the national aggregate. Several studies have emerged from planning activities. An initial assessment of institutional topics and policy options pertinent to solar commercialization, "*Interim Policy Options for Commercialization of Solar Heating and Cooling Systems*" (ERDA 77-62, April 1977) has been published. An analytic overview of commercialization conditions, "Introduction to the Analysis of Commercialization Conditions," (ERDA 76-99, July 1976) has been utilized in planning activities.

2. Technology Transfer and Outreach Activities

This area of activity includes the technology transfer and consumer outreach activities associated with market development. The objective is to stimulate market development forces of private industry and thereby accelerate the commercialization of solar technology. The intent is to target specific markets (i.e., industry, agriculture, utilities, and the general public) and provide them with current and unbiased information on the technical state-of-the-art, as well as the economic, institutional, and legal factors which impact the commercialization of solar technology.

This activity will make use of existing Federal and state information networks to reach each of these potential markets. Industry-related multiplier groups such as architects, builders, engineers, lenders, contractors, plumbers, manufacturers, as well as consumers, are targets for face-to-face contacts.

Technology Transfer

Technology transfer is the important link between the Solar Energy Research, Development, and Demonstration (RD&D) Program and the utilization of its proven technology by a solar industry. However, the complexity and magnitude of solar data and requirements, the rapid dynamics of solar's current level of development, and the broad spectrum of demand for solar technology information require a program of technology transfer with a sophistication considerably beyond that of conventional information services. To meet this requirement, the Solar Technology Transfer Program (STTP) was implemented early in FY 1977.

The objective of the STTP is to assist the Department of Energy Office of the Assistant Secretary for Conservation and Solar Applications in transferring to industry those solar technologies with a potential for early impact application. Technologies with a potential early impact are those which have a potential for significant industry participation by 1980. Early impact technologies are defined as: (1) solar heating of existing homes, new homes, mobile homes, and small office buildings; (2) solar heating and cooling of commercial buildings; (3) solar heating and crop drying in small agricultural applications; and (4) small wind machines (to a lesser degree).

The Solar Technology Transfer Program has been established to:

- Disseminate user-oriented information, such as documents, public media material, exhibits, presentations, workshops, and conferences;
- Identify target opportunities for technologies with direct or related potential for "early impact" on American industry;
- Develop and implement a broad range of educational programs;
- Disseminate solar information through channels designed to reach small business, universities, and organizations in the minority group community;
- Utilize resources of the Regional Solar Energy Centers, DOE Laboratories, Technical Information Centers, Operations Offices, and the Solar Energy Research Institute in the outreach function;
- Develop and implement a consumer representation plan; and
- Develop an international program component which can directly or indirectly assist an earlier, practical, and cost-effective deployment and commercialization of solar energy in the U.S. and throughout the world.

Initial STTP efforts are being directed primarily toward technologies which are appropriate for "early impact" (significant industry participation by 1980). Specific examples of STTP activities with high potential for accomplishing "early impact" are the following:

- Rapid diffusion (into private industry) of a DOE-sponsored packaged solar forced-air heating unit which is free-standing, portable, and designed for low-cost retrofit heating of mobile homes and rural housing, and which can serve as a heat pump supplement for average-sized homes. This solar air heating unit may also be applied to multi-purpose farm uses, such as small lot crop drying and animal shelter heating;
- Development and distribution of an accredited home study course to train and certify heating, ventilation, and air conditioning (HVAC) contractors in the art of installation, operation, and maintenance of solar heating and cooling systems;
- Accelerated development and dissemination of a simplified tool (SOLCOST) designed to assist architects, engineers, etc., in optimizing the size and costs of solar systems;
- Development and introduction of a solar technician curriculum into vocational schools, and a solar educational curriculum into the elementary and secondary levels of the nation's public schools; and
- Dissemination to promote broad public awareness of the Solar Demonstration Program operational design, hardware, and performance data.

Emerging from this media-centered information dissemination role to that of a technology, the new STTP began to look in many other directions to provide information about "early impact" technologies. The plan of this program was to design a dynamic model for the technology transfer system. The first step in this effort was the development of the analytic tool for the design of a system for information outreach. These tools include a structural model of the Solar Technology Delivery System, which developed through collection of information about participants, their interactions, and the relative size of the portion of the system they affect. These data are also used to point out specific changes in approach, information, attitude, skills, or motivation which may be prompted by the actions in technology transfer and which result in improved utilization of solar energy. This Technology Delivery System model is now used as a framework for the design of the remainder of the Technology Transfer System. The Information Outreach effort was designed for active information dissemination using traditional information sources, as well as new ones, to provide change mechanisms.

A design for the monitoring of this system with respect to solar utilization and information usage patterns is also being developed. This will measure the effectiveness of the delivery system. It will also be used to create new mechanisms for solar technology transfer capable of operating in a rapidly changing environment. The STTP is currently conducting a review of these analytical tools and strategies along with a general review of the Federal STTP through the formation of an oversight committee consisting of consumer groups, private industry, government agencies, industrial associations, solar energy associations, and education institutions.

Performing a major function in this Technology Delivery System is the regional program provided by DOE National Laboratories. Efforts in developing and implementing outreach programs are targeted mainly at industry-related liaison groups. This program is the only operational regionalized solar commercialization capability currently available to DOE on a nationwide basis. The specific facilities used in this program are: (1) Brookhaven National Laboratory (BNL); (2) Oak Ridge National Laboratory (ORNL); (3) Sandia Laboratories; (4) Lawrence Livermore Laboratory (LLL); (5) Battelle-Pacific Northwest Laboratory (PNL); and (6) Chicago Operations Office.

One of the four major informational needs of potential solar energy users is the economic feasibility of the solar technologies. In anticipation of these informational needs, STTP has coordinated the development of SOLCOST, a convenient, easily used tool that cost-optimizes proposed solar energy systems for space heating, cooling, and/or domestic hot water. SOLCOST, a digital computer design tool for solar energy systems, uses two national computer time-sharing networks (CDC's CYBERNET and GE's Mark III Service). This computerized information service provides a degree of standardization for the technology, lowers barriers to commercialization, and provides small firms with a competitive position in relation to large firms, thus helping the solar industry to grow and providing numerous small business opportunities in the growing solar energy field.

The STTP will utilize the services of the Solar Energy Research Institute (SERI) as a resource for technical support. This coordination

of effort will also be established with the four Regional Solar Energy Centers, utilizing their services as multipliers in the outreach-to-industry effort. A cooperative relationship is planned with state energy offices as well as state legislative offices to develop incentives for use of solar technology. The STTP will also utilize the resources of the Technical Information Center (TIC) as the principal data base for solar technical information. Information dissemination requirements will also be coordinated with the National Solar Heating and Cooling Information Center.

In addition to providing the mechanism for collection and dissemination of information to potential consumers, this activity will also provide technical and financial assistance to States and local governments so that they may establish and/or improve their ability to identify barriers to solar commercialization within their jurisdictions and to initiate appropriate incentive or legislation programs to remove them.

3. Barriers and Incentives

Solar heating and cooling systems will be widely used only when there are easily recognized economic benefits to be derived from their use and when financial and institutional barriers and constraints have been overcome. A number of studies of the problems involved in the rapid development of a solar heating and cooling industry were prepared by DOE in 1977, including two reports presented to Congress in April, 1977. *Interim Policy Options for Commercialization of Solar Heating and Cooling Systems* (ERDA 77-62) contains a summary discussion of the major constraints to rapid development of the SHAC industry, policy options for dealing with the various constraints, and recommendations for additional research in each problem area. *Analysis of Policy Options for Accelerating Commercialization of Solar Heating*

and Cooling Systems contains in-depth, comprehensive analyses of the issues discussed in ERDA 77-62. *Site and Land-Use Planning*

Work has been initiated relating to solar site and land use planning is to ensure the proper placement and orientation of structures for optimum solar radiation collection, and to preclude possible shading of solar collectors by future construction on adjacent properties. To provide a basis for selecting the appropriate land use controls to assure solar access in new developments, HUD has commissioned the American Society of Planning Officials (ASPO) to develop operating handbooks for site planners and builders and for local officials. These handbooks will outline ways in which existing forms of land use control (such as zoning regulations, private covenants, and easements) can be used to assure that future developments provide for full solar access.

The problem of solar access in already developed areas is more complex due to the legal history of land ownership. Some of the background of this problem is discussed in a booklet entitled "Solar Access and Land Use: State of the Law, 1977", published and distributed by the National Solar Heating and Cooling Information Center. This booklet was developed by the Center from a report prepared for DOE by the Environmental Law Institute (ELI). To develop a methodology for addressing this problem, ELI, together with the American Bar Foundation (ABF), has been commissioned by HUD and DOE to assess the need for and requirements of new legislation establishing "sun rights" as a factor in property law. Both the ASPO and the ABF/ELI projects are to be completed in the summer of 1978.

The Utilities

Care must be taken in the design and application of solar energy systems to minimize incompatibilities with existing electric and gas utilities. The widespread use of solar energy for heating and cooling may have a serious impact upon electric and gas utility companies.

Electric utility rates are based upon expected usage. Although wide seasonal and daily load variations exist, peak demand load determines the amount of generating capacity the utility must provide. All customers pay some premium for this capacity. If solar energy systems enter the market on a wide scale and electricity is used as the auxiliary energy source, there will be times when no electricity is used and short periods when full capacity is required. If provisions are not made to ameliorate this situation, the electric utility may have to establish rates that seem to penalize solar energy customers in order to support a large, seldom used, reserve capacity. Through proper design, a solar energy system with increased storage capability can reduce the peak utility load. DOE is working closely with the utilities to develop operating strategies to achieve this, and several projects involving the participation of electric utilities are underway to examine the available options.

Gas utilities represent different problems and hence different opportunities. Gas distribution systems have built-in storage; therefore, daily and seasonal peaks are of less concern than is the case with electric utilities. With gas presently in short supply, the utilities in some areas of the country are unable to permit new connections and many industrial customers are on interruptible supply. In some instances then, gas may provide a more compatible backup for Solar systems than electricity.

During 1977 several important studies of the solar energy/public utility interface were completed. A major section of *Analysis of Policy Options* was devoted to a discussion of the complex issues involved in the solar/utility interface and the possible policy options. Seminars and workshops were held where these issues were debated at great length. Other reports published in 1977 in which the relationship between dispersed SHAC systems and public utilities is analyzed include *Public Utility and Solar Energy Interface: An Assessment of Policy Options*, *The Impact of Active and Passive Solar Building Designs on Utility Peak Loads*.

Major efforts to resolve the problems involved in the Solar/public utility interface shall be undertaken in 1978. The results of studies presently in progress—such as the relationship between peak/off-peak rates and Solar system design and design and sizing and the impact of passive solar systems on utility load curves—shall be evaluated. Additional analysis shall be initiated in 1978. These include studies of optimal Solar system design when fully integrated with existing utility grid, Solar/utility accounting concepts from public and private prospectives, the potential of Solar systems for utility peak load mitigation, and related topics. In addition, the results of the demonstration projects in which public utilities are involved will be carefully evaluated. Finally, a series of workshops on the Solar/public utility interface will be held in 1978. These workshops will include representatives to the utility industry, public interest groups, public utility commission, the solar energy industry, government agencies, and other interested organizations.

Warranties

The principal protection a consumer has that a product will provide satisfactory performance is provided by the warranty furnished by the product manufacturer and installer. New Federal requirements for warranties were imposed by the Magnuson-Moss Warranty Act of 1975 (15 USC 2301 et seq), which became effective in January, 1977. An assessment of warranties offered in the third cycle of HUD residential demonstrations showed that many of the collector and system warranties did not meet the technical requirements of this Act. As a result, HUD developed minimum warranty requirements for solar installations and for solar collectors in the fourth demonstration cycle. Data from the demonstration program and from other sources will be used to establish more reliable life-expectancy and performance information to permit development of broader industry warranties.

Property Taxes and Assessments

As part of the National Energy Plan, the President submitted legislation encouraging States to exempt solar energy systems from property tax assessment. Bills have been introduced in over 40 States, and legislation has been enacted in more than 20 States, exempting solar installations from property taxation, or reducing the assessment of system value for tax purposes. However, some legislation (pending or enacted) may violate the equal protection clauses of certain State constitutions; this problem is discussed in *Analysis of Policy Options...* and in *Legal Barriers to Solar Heating and Cooling of Buildings*.

NBS recently published a report, "State Solar Energy Legislation of 1976: A Review of Statutes Relating to Buildings" (NBSIR 77-1297, September 1977), which provides a listing of all state legislation on property taxes, income tax credits, and other solar incentives through 1976. The National Solar Heating and Cooling Information Center periodically prepares and distributes a summary of state solar legislation, and maintains an up-to-date file of proposed State solar legislation, its status, and final actions.

Economic Analysis of SHAC Systems

Traditionally, the construction industry, lending institutions, and consumers have been first-cost oriented. To justify the higher initial costs of solar energy systems, potential operation savings and benefits must be clearly demonstrated. A residential economic model has been developed to analyze solar investments in terms prevalent in the residential financing industry. Called RSVP (for Residential Solar Viability Program), the model is available from the National Technical Information Service: HUD Residential *Solar Economic Performance Model*: NTIS #PB 273 592. RSVP is now being disseminated to lenders, builders and others in the housing industry, primarily through industry associations. The model will be used in evaluation of results of the residential demonstration program and to develop simplified manual (i.e., noncomputer) analysis procedures for solar domestic hot water system economic factors.

The report entitled "An Analysis of the Current Economic Feasibility of Solar Water and Space Heating" examined the current (1977) economic feasibility of solar water and space heating for single family detached residences and for multi-family apartment buildings. This study found that while solar heating is at present marginally competitive for some applications in most regions, the enactment of the Federal income tax credit will make many solar applications economically viable.

Work in 1978 will focus on validation of the existing models and data bases and on analysis of passive solar systems, solar cooling, agricultural applications, commercial applications and industrial process heat applications. Analyses for commercial and industrial buildings are underway to determine how changes in critical economic parameters will affect the solar energy industry. The commercial/industrial sector operates under different balance sheet considerations, tax treatments, and decision criteria than does the private residential sector. Results of these analyses for single family, multi-family, commercial, and industrial applications are available to housing and industry groups, consumers, and other interested parties.

Financing Mechanisms

Both new housing and major improvements for existing dwellings are financed through a variety of loan instruments. A general discussion of solar financing issues is given in the booklet, "Home Mortgage Lending and Solar Energy" (GPO #023-000-00387-2), developed from a study conducted for the National Science Foundation. With the publication of

the HUD Intermediate Minimum Property Standards and issuance of appropriate notices by FHA, FMHA, and VA, all three Federal agencies supporting housing through mortgage insurance, loan guarantees or subsidized loans will now accept projects using solar energy systems.

Incentives

Solar energy for heating and cooling is already competitive with conventional fuels for certain applications, and the research and technology development program is expected to further reduce solar costs. However, this does not guarantee the development of a market for solar energy systems. The market generally selects the most expedient, most certain outcome, based upon the available information. For example, when faced with uncertainties about system performance and possible fuel allocation policies, an industry may choose not to modify a plant to make use of solar energy, even though the analysis of life-cycle cost and cash flow is favorable.

Various incentives are being conducted to encourage investment in and production and installation of solar energy equipment. These range from a Government policy to convert a proportion of Federally-owned buildings to solar energy, to guaranteed loans or tax deductions. Options are being assessed in terms of costs, administrative implications, timing, and market impact.

Pursuant to a specific requirement of P.L. 93-409, HUD completed an assessment of the costs and impacts of possible Federal financial incentives to accelerate the residential market for solar heating and domestic hot water systems. This study, which focussed on single family homes, involved some 1,500 interviews in eight cities, as well as an assessment of both various subsidy levels and administrative costs. The major finding from this study was that "front end" incentives in the form of tax credits or other grants are likely to have a greater market impact than will a low interest loan approach. The report also discusses issues involved in the development and implementation of solar incentive programs. The report is entitled "Federal Incentives for Solar Homes: An Assessment of Program Options" and is available from NTIS (#PB 272 299).

During 1977, DOE analyzed the costs and the impacts of a wide range of financial incentives for solar energy to aid the Administration and the Congress in the formulation of the National Energy Plan. It was found that tax credits tend generally to be more cost effective than low interest loans in stimulating purchases of solar energy systems. These and related findings are discussed in two reports available from DOE: "Assessment of Incentives to Accelerate Market Penetration of Solar Heating and Cooling Systems" and "Costs and Impacts of Tax Credits for Solar Energy Systems."

Work is continuing on the development of a comprehensive, qualitative solar energy incentive modelling capability to carefully assess the impact of a wide variety of incentive policies on market penetration, fossil fuel savings, national and international accounts and other variables. This model will assist in determining the level of incentives necessary in specific sectors to achieve desired objectives.

In 1978, this capability for incentives assessment will be improved and integrated with other areas of effort. For example, simulations will be conducted which will examine the impact of incentives on applications in the areas of agriculture and industrial process heat. In addition, work is being planned which will analyze incentives for passive solar systems.

Manpower and Training

Many of the skills involved in designing, installing, maintaining, and repairing solar energy systems are similar to those needed in conventional heating, ventilating, and air conditioning systems. With the rapid growth of the solar energy industry the implications for employment and manpower training are being examined. In 1977, DOE initiated several studies of the manpower implications of the solar energy industries. One of these studies examined the impact on the labor market of achieving the AEP goal of installing solar energy systems in 2.5 million homes by 1985. Total employment requirements were estimated and the manpower requirements were disaggregated by region and occupational skill. A more comprehensive manpower assessment of the solar technologies was also initiated to determine the long run impact of solar energy development on the nation's labor market and educational and vocational training systems.

Industry Capital Requirements

Capital requirements may be a constraining factor in the development of solar energy systems. In FY1978, the direct and indirect capital requirements of solar and alternative energy systems will be investigated and compared. Findings will be analyzed in the context of the capital and financial market

constraints likely to exist in the coming decade. Recommendations will be made on the basis of this analysis.

4. Environmental and Resource Assessment Program

This program effort will continue to provide for the collection of a wide range of geophysical data for design criteria and performance evaluation essential to the successful implementation of the solar energy program. Environmental Resource Assessment utilizes the existing capabilities of other Federal agencies, including NOAA, NASA, NSF, USDA, and DOD, as well as nongovernment sources to collect, analyze, archive, and disseminate information on pertinent data measurements and environmental analyses. Specifically, the objectives are:

- To acquire, analyze and disseminate insolation and spectral data in support of commercialization, and to improve the coverage and accuracy of existing data;
- To identify early in the decision-making process potential environmental and societal effects of new solar technology in order to ensure that harmful impacts are eliminated or minimized.

The program supports demonstration projects by establishing and coordinating a data management network, managing insolation data, and conducting research and analysis projects. Also, it will support demonstrations with required environmental research and preparation of NEPA-mandated documents.

Environment Assessment

The National Environmental Policy Act of 1969 requires all agencies of the Federal Government to prepare detailed Environmental Impact Assessments (EIA) on major Federal actions significantly affecting the quality of the human environment. The need for such statements is based on the findings of an Environmental Assessment (EA). An EA is a study that addresses possible beneficial and/or adverse effects on the quality of the environment and public health and safety. These assessments serve as a basis for determining the need for EIA's for the various heating and cooling demonstration projects and technology development activities.

Although solar energy is a relatively clean source of energy, it is incumbent upon DOE to carefully examine all factors associated with its use to ensure public protection. Initial studies assessing the social and environmental implications of the introduction of solar technology have been completed which includes both regional and site-specific evaluations. An EIA, now under review, is based on the results of these studies.

To enhance future EIA activity, a comprehensive environmental study plan is being developed. Improved methodologies for conducting environmental assessments are being examined. These undertakings support compliance with those laws requiring Environmental Impact Statements based on the results of EIA's—the National Environmental Policy Act of 1969, the Clean Air Act, the Noise Control Act, and the Federal Water Pollution Control Act.

Technology Assessment

Technology assessments are studies directed toward identifying unintended effects of technology on society, including social, legal, institutional, and industrial consequences. A preliminary assessment of the long-term general implications of introducing solar energy technologies will be available soon. During FY 1978, studies will continue to assess such specific implications as the effects of solar energy systems on existing energy industries, the widespread introduction of decentralized solar energy systems, the adjustments in governmental, institutional, and social relationships resulting from or required by the introduction of various solar technologies, and the industrial and business implications inherent in widespread acceptance of solar technology. The Solar Energy Research Institute (SERI) in Denver, Colorado, and the recently initiated regional solar energy study centers are active in this assessment area.

Resource Assessment

The resource assessment effort is supported by the National Oceanic and Atmospheric Administration (NOAA) and supplemented by public and private agencies. These groups collect, analyze, record, and disseminate solar radiation, wind, cloud, and other meteorological information. Resource information is essential in the determination of solar heating and cooling systems applications and the development of systems performance simulation models. Current and near-term efforts are directed toward expansion and improvement of the solar radiation data base, and toward expansion

and improvement of the solar radiation data base, and toward improvement of the utility of these data by the user community. Extensive solar and meteorological data for six locations currently exist in the Solar Data Bank.

Material Assessment

Material assessment encompasses the identification of those raw materials and/or processes which may be critical to the development and large-scale implementation of solar energy technology. The development and widespread utilization of solar energy systems requires the dedication of natural resources in quantities which may represent significant portions of known reserves and production capacities. Forecasts of the impact of solar energy technology on resources are required so energy research and development efforts do not pursue technologies which will prove impractical for commercialization. Currently, methodologies are being developed for identification and assessment of critical materials and manufacturing process that will be incorporated in studies initiated in FY1978.

Appendix I

Interagency Agreement Summaries

Department of Defense

Contract No. EX-76-A-29-1015 May 2, 1975

Solar heating and cooling system, Battalion Headquarters Building, Fort Hood, TX

Contract No. EX-76-A-29-1025 May 11, 1975

Solar heating systems for 50 housing units

Contract No. EX-76-A-29-1042 April 18, 1976

Army and Air Force Exchange Service (AAFES), Solar heating and cooling systems for Randolph AFB, PX shopping center and Kirtland AFB, NM main store

Contract No. EG-77-A-29-1048 May 24, 1977

Design of solar heating systems for 80 housing units

Contract No. EG-77-A-29-1048 May 24, 1977

Fort Polk and Bolling Air Force Base Solar heating and cooling demonstrations

General Services Administration

Contract No. EX-76-A-29-1034 September 8, 1975

Solar heating and cooling in Manchester, NH office building

Amendment December 1, 1975—Solar heating, cooling, hot water in Saginaw, MI office building

Contract No. EX-76-A-29-1049 August 8, 1977

Solar heating and cooling system for Bureau of Prisons Youth Correctional Center in Bastrop, TX

Contract No. EG-77-A-29-1066 September 9, 1977

Solar heating system in Denver, Colorado; Federal Office Building

Department of Health, Education and Welfare

Contract No. EX-76-A-29-1056 October 30, 1976

Implementation of solar demonstrations on private health care facilities

Department of Housing and Urban Development

Memorandum of Understanding June 9, 1976

Cooperative agreement between HUD and ERDA, in accordance with Congressional legislation (P.L. 93-577, P.L. 93-438, P.L. 93-473, P.L. 93-409)

Contract No. E(49-26)-1020 April 14, 1975

Conduct Residential Demonstration Program

Department of Interior

Contract No. EG-77-A-29-1065 February 8, 1977

Solar heating system for Bread Springs School in Gallup, NM

National Aeronautics and Space Administration

Contract No. EX-76-A-29-1037 December 12, 1975

NASA support of the commercial demonstration program

Contract No. EX-76-A-29-1024 May 28, 1975

Marshall Space Flight Center—NASA (MSFC) Support for ERDA programs; program planning, instrumentation and data collection and dissemination

Contract No. EX-77-A-29-1055 October 1, 1976

ERDA support of solar demonstrations on NASA facilities

National Bureau of Standards

Contract No. E(49-1)-3800 November 6, 1975

Development of Standards and Performance Criteria

Contract No. EA-77-A-01-6010 October 1, 1976

Technical support to ERDA heating and cooling buildings

Contract No. EA 77-A-01-6010 September 1, 1977

Passive building performance criteria

Tennessee Valley Authority

Contract No. EX-76-A-29-1046 August 6, 1976

Solar heating and cooling in Visitor's Center, Land Between the Lakes, Kentucky

Department of Treasury

Contract No. EG-77-A-29-1002 September 22, 1977

Solar system Hamlin, ME

United States Postal Service

Contract No. EX-76-A-29-1036 December 18, 1975

Solar energy retrofit for Post Office, Boulder, CO

Veterans Administration

Contract No. EX-76-A-29-1052 September 21, 1976

Solar heating demonstration on Veterans Hospital in San Diego, CA

Appendix II

Information Sources on Solar Heating and Cooling and Program Activities

General Information Sources

A source of information for general questions about solar heating and cooling, a National Solar Heating and Cooling Information Center, has been established. For information on solar heating and cooling of buildings and planned program activities, write:

National Solar Heating and
Cooling Information Center
PO Box 1607

Rockville, Maryland 20850

Or call, toll free: 800-462-4983
(from Pennsylvania)

800-523-2929 (all other
locations)

Information on the availability of
solar heating and cooling equipment
is available from:

Solar Energy Industries
Association (SEIA) 1001
Connecticut Avenue, N.W.
Washington, D.C. 20036

Technical Information

The DOE Technical Information Center (TIC) in Oak Ridge, Tennessee has been established to disseminate scientific and technical information data base and provides microfiche service. "ERDA Research Abstracts" (ERA), published monthly, provides abstracting and indexing coverage of all scientific and technical reports, patents, journal articles, conference papers, theses, and monographs originating with DOE and its contractors. ERA is available on a subscription basis from the Superintendent of Documents. Inquiries should be directed to:

DOE Technical Information
Center
PO Box 62
Oak Ridge, Tennessee 37830

There are also 54 libraries across the country which maintain microfiche collections of DOE and foreign reports on solar energy research abstracted from National Science Abstracts.

Solar Energy Solicitations

DOE solicitations such as Program Opportunity Notices and Request for Proposals are announced in "Commerce Business Daily." An annual subscription to this publication is available for \$75.00 from the Superintendent of Documents.

Residential Demonstrations

The residential non-Federal building demonstration program is being administered by the Department of Housing and Urban Development (HUD). Information on program participation can be obtained from the National Solar Heating and Cooling Information Center.

Commercial Demonstrations

The commercial non-Federal building demonstration program is being administered by DOE. Information on program participation can also be obtained from the National Solar Heating and Cooling Information Center.

Unsolicited Proposals

Projects for solar heating and cooling are conducted primarily by competitive solicitation procedures in accordance with procurement regulations. Unsolicited proposals are considered if the projects proposed are not within the scope of planned competitive solicitations. These projects must be unique and innovative while still fitting the stated objectives of the National program. Guidelines for the preparation of unsolicited proposals can be obtained from:

DOE Technical Information
Center
PO Box 62
Oak Ridge, Tennessee 37830

Note to Inventors

The Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93-577) assigned to ERDA the functions of energy research, development, and demonstration. In addition, Section 14 of this Act specifically requests the National Bureau of Standards to evaluate all promising energy-related inventions, particularly those submitted by individual inventors and small companies. If you have such an idea for an invention, you are encouraged to contact:

Office of Energy-Related In-
ventions
National Bureau of Standards
Washington, D.C. 20234