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REPORT TO THE
JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

Federal And State Solar Energy Research, Development, And Demonstration Activities

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

RED-75-376

JUNE 10, 1975

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-178205

The Honorable Hubert H. Humphrey
Chairman, Joint Economic Committee
Congress of the United States

Dear Mr. Chairman:

In response to your request of March 18, 1975, we obtained information on specific areas of Federal and State solar energy research, development, and demonstration activities.

Generally our review was limited to interviewing officials of various Federal agencies involved in solar energy research, development, and demonstration activities and making limited verification of the information obtained. We obtained information on the States' involvement in solar energy research and development from the National Governors' Conference in Washington, D.C. The results of our review are contained in Appendix I.

Generally, we noted that:

--Four agencies carry out most of the Federal Government's solar energy research and development programs--the Energy Research and Development Administration, the National Science Foundation, the Department of Agriculture, and the National Aeronautics and Space Administration.

--Estimated Federal funding for these agencies for fiscal years 1975 and 1976 for solar energy research and development activities is $52.7 million and $78.0 million, respectively. (See p. 2.)

--As of April 30, 1975, about $22.1 million of the $49.7 million available ($3 million of fiscal year 1975 funds were deferred to fiscal year 1976) had been spent or obligated on solar energy research and development activities. The remaining $27.6 million is expected to be obligated by the end of the fiscal year. (See p. 3.)

--The major Federal funding emphasis is on research, development, and demonstration of the solar heating and cooling technology. (See p. 7.)

--The executive branch has not issued guidelines on the allocation of solar energy research and development funds to avoid duplication of activities. (See p. 8.)

--Programs do not exist for evaluating or certifying solar energy devices; however, Federal efforts to develop a certification program are underway. (See p. 9.)

--In addition to Federal funding of solar energy research and development activities, at least five states--Arizona, Florida, Maryland, New Mexico, and Ohio--are funding solar energy projects. Projects funded by these States which were underway during the period July 1, 1974, through April 8, 1975, amounted to about $200,000. (See p. 10.)

This report may be of interest to committees and other Members of Congress.

Sincerely yours,

Comptroller General
of the United States

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
ERDA	Energy Research and Development Administration
HUD	Department of Housing and Urban Development
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
OMB	Office of Management and Budget
R&D	Research and Development

APPENDIX I

APPENDIX I

FEDERAL AND STATE SOLAR ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACTIVITIES

BACKGROUND

Solar energy in its broadest sense is the energy obtained from the heat or light of the sun. As a fuel, it is free. The cost of using such energy is essentially for equipment, installation, and maintenance cost.

The following are some of the advantages of solar energy.

--It is a virtually inexhaustible source.

--It is widely distributed.

--Its use introduces minimum environmental effects.

--Its use will save fossil fuels for alternate uses.

--Its successful development by the United States can contribute to an improved balance of trade and the creation of an exportable industry.

Until recently, solar energy was considered to have only long-term potential in helping to solve the Nation's energy problems. Presently, however, the Energy Research and Development Administration (ERDA) expects solar systems for heating and cooling buildings, wind energy conversion, and bioconversion of fuels to be available commercially by the late 1970s. Also, power systems based upon solar energy conversion through solar thermal, photovoltaic, and ocean thermal technology are expected to be available commercially by the mid-1980s. These systems are more fully described on pages 4 to 6.

The Energy Reorganization Act of 1974 (Public Law 93-438) was enacted on October 11, 1974, and went into effect on January 19, 1975. It established ERDA which consists of an Administrator, a Deputy Administrator, and six Assistant Administrators, one of whom is responsible for solar, geothermal, and advanced energy systems. ERDA is to bring together and direct Federal activities relating to research and development (R&D) of various energy sources--including solar. Before Public Law 93-438 went into effect, the National Science Foundation (NSF) was the lead Federal agency for all solar energy R&D.

There are three recent public laws which, together with the Energy Reorganization Act of 1974, bear on solar energy technology and implementation. These are (1) the Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409), (2) the Solar Energy Research, Development, and Demonstration Act of 1974 (Public Law 93-473), and (3) the Federal Non-nuclear Energy Research and Development Act of 1974 (Public

Law 93-577). These four laws give ERDA general authority to conduct a wide range of activities related to insuring that economically competitive and environmentally acceptable solar energy technologies are available to the Natior at the earliest feasible time.

At the request of the Chairman of the Joint Economic Committee, we obtained information on the following areas of solar energy research and development activities.

--Federal funding of solar energy research and development activities in fiscal years 1975 and 1976.

--The various areas of solar energy research and development activities.

--Guidelines issued by the executive branch on the allocation of solar energy R&D funds to prevent duplication.

--Certification programs for evaluating solar energy devices.

--State-funded solar energy research programs and their funding levels.

FUNDING DATA FOR
FISCAL YEARS 1975 AND 1976

Four agencies--NSF, the Atomic Energy Commission (AEC)/ERDA, the Department of Agriculture, and the National Aeronautics and Space Administration (NASA)--carry out most of the Federal solar energy R&D. These agencies perform work within their own agencies or have the work performed under interagency agreements with other Federal agencies or under contracts and grants with private industry or educational institutions. For fiscal year 1975 the Congress appropriated about $52.7 million as follows to these agencies for such activities.

	FY 1975 estimated funding (millions)
National Science Foundation	$50.0
Atomic Energy Commission	1.2
Department of Agriculture	.7
National Aeronautics and Space Administration	.8
Total	$52.7

APPENDIX I

These agencies have requested about $78 million for fiscal year 1976 for solar energy R&D.

Officials of these agencies told us that as of April 30, 1975, the status of the $52.7 million was as follows:

--$22.1 million had been spent or obligated.

--$3 million has been deferred to fiscal year 1976.

--$27.6 million is expected to be spent or obligated by June 30, 1975.

The following table presents more specific information on funding for solar energy R&D by these four agencies.

Funding, Expenditures, And Obligations
Of Solar Energy R&D Activities
By Agency

Agency	Fiscal year 1975 Estimated funding	Fiscal year 1975 [a]Amount spent or obligated as of 4/30/75	Fiscal year 1975 Funds remaining	Fiscal year 1976 Estimated funding
	(millions)			
National Science Foundation	$10.0	$ 7.2	$ 2.8	[b]$ 6.0
Atomic Energy Commission/ Energy Research and Development Administration	[c]38.2	14.0	24.2	70.3
Department of Agriculture	0.7	0.7	-	0.8
National Aeronautics and Space Administration	0.8	0.2	0.6	0.9
Total	$49.7	$22.1	$27.6	$78.0

[a]Differences between the figures in this table and those in the table on page 8 are the result of rounding.

[b]Includes $3 million in fiscal year 1975 funds deferred to fiscal year 1976.

[c]With the creation of ERDA on January 19, 1975, $37 million of NSF and $1.2 million of AEC solar energy R&D funds were transferred to ERDA.

We noted that other Government agencies were doing solar energy R&D which had not been specifically funded. This work was being conducted as part of these agencies' basic programs. These agencies and the amount of funds they applied to solar energy R&D for fiscal year 1975 and the amount planned for fiscal year 1976 follow.

	Estimated funding	
	FY 1975	FY 1976
	(millions)	
Federal Energy Administration	$0.1	$0.3
Department of the Interior	0.1	0.1
Department of Transportation-Coast Guard	0.3	-
Department of Defense	0.1	-
United States Postal Service	0.4	-
Total	$1.0	$0.4

SOLAR ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACTIVITIES

Federal solar energy efforts are being carried out in six major program areas.

--Solar heating and cooling,

--Solar thermal conversion,

--Photovoltaic conversion,

--Wind energy conversion,

--Bioconversion to fuels, and

--Ocean thermal conversion.

The projects we identified that are being carried out by Federal agencies, and the agencies' descriptions of such projects for each of the above areas, are shown beginning on page 11.

Solar heating and cooling

Solar heating of buildings is one of the most common uses of solar energy. In a typical solar heating and cooling system, water is heated as it passes through a solar collector and is then stored in a tank. In the winter, the hot water would be circulated to the building heating

system; in the summer, the hot water would be used to power a system to supply cold water or chilled air for use in the building air conditioning system.

The overall objective of the heating and cooling programs is to provide a base for developing a commercial solar energy industry. To achieve this, ERDA is sponsoring solar heating and cooling research, development, and demonstration projects at other Federal agencies and at commercial and educational institutions.

The Congress appropriated about $17.5 million to ERDA, NSF, NASA, and the Department of Agriculture in fiscal year 1975 for solar heating and cooling projects. As of April 30, 1975, these agencies had spent or obligated about $7.6 million on solar heating and cooling projects.

Solar thermal conversion

Solar thermal conversion systems collect solar radiation which may be used directly as thermal energy or converted to electric power. Heat is transferred from a collector system to a working fluid to generate electricity or provide both electricity and thermal energy.

The overall program objectives for the use of solar thermal conversion techniques are to provide full system capability for widespread production of supplementary electric and thermal power in the 1980s and to provide full system capability for total energy systems for Government installations, urban and rural communities, and industrial load centers.

The Congress appropriated about $10.1 million to ERDA and NSF for fiscal year 1975. As of April 30, 1975, these agencies had spent or obligated about $2.1 million on solar thermal conversion projects.

Photovoltaic conversion

Photovoltaic energy conversion is a process which generates electrical energy directly from sunlight falling on a photo-sensitive material (solar cells). The cost of power production by solar cells is extremely high and is the major obstacle to overcome. For this reason, ERDA-supported projects are concentrating on improvements in solar cells that will decrease the cost of photovoltaic power.

The overall program goal in photovoltaic conversion is to develop economically viable photovoltaic electric power systems that are suitable for a variety of terrestrial applications and are capable of providing a large amount of the Nation's energy requirements by the year 2000.

The Congress appropriated about $7.5 million to ERDA and NSF in fiscal year 1975 for photovoltaic conversion R&D. As of April 30, 1975, these agencies had spent or obligated about $5.6 million on photovoltaic conversion projects. We also identified the Department of Transportation and the Department of the Interior as other agencies having photovoltaic projects.

Wind energy conversion

Solar heat circulates the atmosphere, therefore, wind-driven machines are considered a form of solar power. The wind turns propellers which drive generators to produce electricity.

The primary objective of this program is to develop a technology base of large-scale, economically viable wind energy systems for supplying commercial electric power. The commercial implementation is to be demonstrated through large-scale experimental systems.

The Congress appropriated ERDA and NSF about $6.9 million in fiscal year 1975 for wind energy conversion. ERDA and NSF had spent or obligated about $3.1 million, as of April 30, 1975, on wind energy conversion projects.

Bioconversion to fuels

The term bioconversion describes the process by which certain organic materials produced by photosynthesis are converted to usable fuels. The objective of the program is to establish the commercial practicability of producing large quantities of such materials, some which are currently considered wastes, and converting them into clean fuels. Fuels and energy products that may be produced from the bioconversion process include synthetic natural gas, alcohol fuels, solid fuels, heat, and electricity.

The Congress appropriated about $4.6 million in fiscal year 1975 to ERDA, NSF, and the Department of Agriculture for bioconversion. As of April 30, 1975, these agencies had spent or obligated about $1.3 million on bioconversion projects.

Ocean thermal conversion

The ocean thermal conversion process uses the difference between the temperature of the ocean's warm surface water and the deep, cold water to produce electric power. The goal of this program is to establish the technology base for demonstrating and commercially implementing large-scale floating powerplants capable of converting ocean heat into electric power.

The Congress appropriated about $2.8 million in fiscal year 1975 to ERDA and NSF for ocean thermal conversion. These agencies had spent or obligated about $1.5 million, as of April 30, 1975, on ocean thermal conversion projects.

Summary of Federal funding by program areas

The following tables summarize Federal funding of solar energy R&D activities by program areas.

APPENDIX I

Estimated Federal Funding Of Solar Energy R&D Activities By Program Areas

Program area	ERDA Fiscal years 1975	ERDA Fiscal years 1976	NSF Fiscal years 1975	NSF Fiscal years 1976	Agriculture Fiscal years 1975	Agriculture Fiscal years 1976	NASA Fiscal years 1975	NASA Fiscal years 1976
	(millions)							
Solar heating and cooling	$14.1	$26.0	$ 2.6	$0.9	$0.3	$0.3	$0.5	$ -
Solar thermal conversion	9.0	13.2	1.1	1.3	-	-	-	-
Photovoltaic conversion	5.2	12.8	2.3	1.7	-	-	-	-
Wind energy conversion	5.0	11.5	1.9	0.5	-	-	-	-
Bioconversion to fuels	3.1	3.6	1.1	0.6	0.4	0.5	-	-
Ocean thermal conversion	1.8	3.2	1.0	1.0	-	-	-	-
Other (note a)	-	-	-	-	-	-	0.3	0.9
Total	$38.2	$70.3	$10.0	[b]$6.0	$0.7	$0.8	$0.8	$0.9

[a]NASA projects related to satellite power systems.

[b]Includes $3.0 million in fiscal year 1975 funds deferred to fiscal year 1976.

APPENDIX I

APPENDIX I

Fiscal Year 1975 Funds Spent Or Obligated
On Solar Energy R&D Activities
By Program Areas
As Of April 30, 1975

Program area	ERDA	NSF	Agriculture	NASA	Total
			(millions)		
Solar heating and cooling	$ 6.1	$1.1	$0.3	$0.1	$ 7.6
Solar thermal conversion	1.5	0.6	-	-	2.1
Photovoltaic conversion	3.5	2.1	-	-	5.6
Wind energy conversion	1.5	1.6	-	-	3.1
Bioconversion to fuels	0.3	0.6	0.4	-	1.3
Ocean thermal conversion	0.7	0.8	-	-	1.5
Other	[a]0.3	[a]0.5	-	[b]0.1	0.9
Total	$13.9	$7.3	$0.7	$0.2	$22.1

[a]Projects relating to general solar energy R&D activities which could not readily be classified into one of the other program areas.

[b]Includes NASA projects related to satellite power systems.

GUIDELINES FOR ALLOCATION OF SOLAR ENERGY RESEARCH AND DEVELOPMENT FUNDS

ERDA and Office of Management and Budget (OMB) officials told us that the executive branch has not issued guidelines dealing specifically with duplication of Federal efforts in carrying out solar energy R&D.

According to an OMB official, however, mechanisms exist inside and outside OMB which are in part aimed at avoiding duplication in allocating solar energy R&D funds. These mechanisms are:

--A division within OMB which reviews agencies' funding requests for solar energy programs to identify any duplications in program objectives. If duplicate program objectives are identified, OMB would take the necessary action to terminate one of the programs.

--An Interagency Panel for Terrestrial Application of Solar Energy chaired by ERDA which reviews solar energy R&D programs on a bimonthly basis to identify duplication of efforts in solar energy programs.

CERTIFICATION PROGRAMS FOR SOLAR ENERGY DEVICES

A certification program is aimed at attesting or certifying that a system or each of its components meets specified performance standards under specified conditions. Federal officials told us that certification programs do not exist for evaluating solar energy devices with or without Federal funds.

However, within the Government, efforts are underway for developing a certification program. The Solar Heating and Cooling Demonstration Act of 1974 (Public Law 93-409) provides for programs to demonstrate within a 3-year period the practical use of solar heating technology and to provide for developing and demonstrating within a 5-year period the practical use of combined heating and cooling technology. To carry out these programs, the act directed the Secretary of Housing and Urban Development (HUD), with the assistance of the National Bureau of Standards, NASA, and NSF, to prescribe and publish interim performance criteria for solar heating and cooling components and systems for use in residential dwellings under the demonstration program. Establishing interim performance criteria would be an important initial step leading to a certification program. ERDA plans to follow the interim performance criteria with the additional steps needed to implement a certification program.

The act also directed the Secretary to, as soon as feasible, use data available from the demonstration programs to prescribe and publish (1) definitive performance criteria for solar heating and cooling components and systems to be used in residential dwellings, (2) definitive performance criteria for such residential dwellings, and (3) procedures whereby manufacturers of solar heating and cooling components and systems shall have their products tested to provide certification that such products conform to the above performance criteria.

Several agencies have made some progress towards achieving a certification program:

--On January 1, 1975, HUD published interim performance criteria for solar heating and cooling systems. These criteria are to be used for design, development, technical evaluation, and procurement of the solar heating and cooling systems to be used in the demonstration programs.

--ERDA has supported two programs with the objective of helping to achieve a certification program. These programs were funded to develop standard procedures for testing and rating two components of the solar heating and cooling system--the solar collector and heat storage media--for which commercial standards do not exist. A performance and testing stardard for solar collectors was published in December 1974 and a draft of a proposed standard for storage devices has been given to industry for their comments.

--NASA, in providing supporting research, has continued its program for defining standard facility instrumentation and equipment needed in a certification laboratory.

STATE-FUNDED SOLAR ENERGY RESEARCH PROGRAMS

ERDA and NSF officials said that information on State-funded solar energy programs was not readily available at the Federal level. These officials told us, however, that such information was available through the National Governors' Conference.

This organization provided us a listing of State-funded projects. This listing showed that, as of April 8, 1975, five States--Arizona, Florida, Maryland, New Mexico, and Ohio--were supporting on-going solar energy projects.

As of April 8, 1975, State funding for the projects identified totaled almost $200,000. A listing of the State-funded projects is presented below.

State-Funded Solar Energy
Research And Development Projects
On-Going As Of April 8, 1975

Organization	Project title	State funding level
Arizona:		
Arizona State University	New concept for solar electric generation	$ 4,500
Arizona State University	Efficient photovoltaic power generation	3,900
Florida:		
Florida Technological University	User survey and technical assessment of solar systems in Florida	38,705

APPENDIX I

Maryland:		
University of Maryland	Solar energy panel	$ 15,300
New Mexico:		
University of New Mexico	Heat pipe performance and life test:	18,688
New Mexico State University	Thermal trap solar energy collector	30,000
Ohio:		
Battelle Memorial Institute	Solar power heat pump utilizing pivot tip-vane rotating equipment	88,743
Total		$199,836

FEDERAL SOLAR ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROJECTS

The following schedule shows information about fiscal year 1975 solar energy research, development, and demonstration grants, contracts, and in-house projects.

Federal agency and recipient	Description	Amount
Solar Heating And Cooling		
Energy Research and Development Administration		
University of California, Los Angeles	Research on transparent structures for energy loss control in solar energy collectors	$ 84,400
Los Alamos Scientific Laboratory	Research on integrated solar collector roof structures	126,000
Texas Instruments, Inc.	Research on cost-effective and durable composite collector plates for solar energy collectors	79,100

APPENDIX I

Federal agency and recipient	Description	Amount
Lockheed Missile and Space Company, Inc.	Research on metal and plastic honeycomb flat plate solar collectors	$ 86,513
University of Waterloo	Research on methods for reducing heat losses from flat plate solar collectors	48,900
Honeywell, Inc.	Research on low cost means of achieving solar collector absorber coatings and anti-reflector coatings	144,000
Dynatherm Corporation	Research on flat plate solar collectors employing the heat pipe principle for heating and cooling	54,300
Battelle Columbus Laboratories	A critical review and analysis of the implications of the Phase 0 program	40,200
University of Delaware	Consumer demand analysis	55,500
AAI Corporation	Timonium, Maryland, school air conditioning	294,074
University of Virginia	Personal mobility	34,815
Westinghouse Electric Corporation	Town Elementary School, Atlanta, Georgia	648,775
Inter Technology Corporation	Fauquier school experiment	54,655
Inter Technology Corporation	Fauquier school experiment, continuation	144,693
General Electric	Grover Cleveland Junior High School experiment	81,474
Honeywell, Inc.	North View Junior High School experiment	128,978
Honeywell, Inc.	Transportable solar laboratory	293,100
City of Santa Clara	Solar heating and cooling as a public utility	404,200

APPENDIX I

Federal agency and recipient	Description	Amount
North Carolina State University	Greenhouse heating and cooling	$ 58,000
Hittman Associates	Assessment of rankine cycle engine	32,439
Auburn University	Potential for conversion and utilization of solar energy in poultry production	41,200
State of Connecticut, Department of Community Affairs	Utilization of solar energy and energy conservation measures in a State-supported housing project for the elderly	131,200
Department of Housing and Urban Development	Solar house evaluation	18,500
Department of Housing and Urban Development	Solar energy residential design and site planning guide	120,000
Department of Housing and Urban Development	Application of solar energy for heating and cooling of buildings	16,000
Department of Agriculture	Solar grain drying	300,000
Department of Agriculture	Solar heating and cooling in greenhouses and rural residences	430,000 (estimate)
Department of Agriculture	Solar energy for drying peanuts, forage, and tobacco	175,000
Corps of Engineers	Solar heating and cooling demonstration project--Ft. Hood, Texas	588,000
National Aeronautics and Space Administration	Solar heating and cooling technology	400,000

APPENDIX I

Federal agency and recipient	Description	Amount
In-house project	Demonstration to test the concept of an entire solar community (electricity, space heat, air conditioning, and hot water for a 12,000 sq. ft. building)	$ 800,000
In-house project	Demonstration to test practical use of a solar pond as a collector for industrial use	100,000
Department of Health, Education, and Welfare	Solar energy applications program for health facilities	75,000
Pennsylvania State University	Heat pump workshop	42,073
Energy Research and Development Administration Total		$6,131,089
National Science Foundation		
Associated Universities, Inc.	Support of U.S.-U.S.S.R. cooperation in solar and geothermal energy	226,200
Massachusetts Institute of Technology	Exploration of molecular sieve zeolites for the cooling of buildings with solar energy	138,700
Boeing Aerospace Company	Research on vacuum-insulated glass solar energy collectors with dyed fluid absorbers for heating and cooling of buildings	75,400
University of Maryland	Workshop on solar collectors for heating and cooling of buildings	57,300
Texas A&M University	Further development of the compressed film floating-deck solar water heater	73,900

APPENDIX I

Federal agency and recipient	Description	Amount
University of Virginia	Workshop on solar energy storage subsystems for heating and cooling of buildings	$ 59,400
Southern California Gas Company	Study of the future roles of the utility companies	25,000
National Oceanic and Atmospheric Administration	Improvement of solar radiation data	415,000
National Science Foundation Total		$1,070,900
National Aeronautics and Space Administration		
In-house project	Residential building solar heating and cooling at Marshall Space Flight Center	125,000
National Aeronautics and Space Administration Total		$ 125,000
Department of Agriculture		
In-house project	Improvements in heating and cooling of buildings through the use of forest materials	90,000
In-house project	Design and performance of solar heating systems for broiler houses	60,000 (estimate)
In-house project	Minimizing fuel required for grain drying	60,000 (estimate)
In-house project	Peanut drying	60,000 (estimate)
Department of Agriculture Total		$ 270,000
Air Force		
In-house project	Solar energy for Air Force facilities requirements	100,000
Air Force Total		$ 100,000

APPENDIX I

Federal agency and recip ent	Description	Amount
U.S. Postal Service		
In-house project	Solar system demonstration post office--Ridley Park, Pennsylvania	$ 175,000
In-house project	Design and engineering parametric program design of solar system for the Ridley Park, Pennsylvania, post office demonstration and future uses	178,500
U.S. Postal Service Total		$ 353,500
Federal Energy Administration		
National Science Foundation	Solar assisted water heater for apartment houses	25,000
National Bureau of Standards	Analysis of solar water heating systems in detached homes, townhouses, and mobile homes	30,000
National Bureau of Standards	Retrofit an existing house to receive a sterling engine	50,000
In-house project	Program to evaluate and demonstrate conservation of fossil fuel energy for single family dwellings	25,000
Federal Energy Administration Total		$ 130,000
Department of the Interior		
In-house project	Inclusion of a solar heating system in the construction of the Lovell Visitors Center, Big Horn Canyon National Park	94,800
In-house project	Studies to analyze the use of solar energy to save fossil fuels	40,000

APPENDIX I

Federal agency and recipient	Description	Amount
Department of the Interior Total		$ 134,800
Solar Heating And Cooling Program Total		$8,315,289
	Solar Thermal Conversion	
Energy Research and Development Administration		
The Aerospace Corporation	Solar thermal conversion program management support	83,276
Argonne National Laboratory	Experimental investigations of non-imaging solar energy collectors	186,000
University of Chicago	Analytical investigations of non-imaging solar energy concentrators	62,500
University of Houston	Solar thermal power systems based on optical transmission	40,000
Atomic Energy Commission	Measurement of circumsolar radiation	233,800
Martin-Marietta Corporation	Solar power system and component research	20,400
University of Minnesota	Extension of research applied to solar thermal power systems	34,400
University of Minnesota	Extension of research applied to solar thermal power systems	374,200
Naval Weapons Center	Model heliostat test program	34,400
G. T. Sheldahl Company	Solar power array for the concentration of energy	25,000
University of Minnesota	Solar power systems	18,300
American Technological University	Analysis of the applicability of solar thermal systems to military installations	17,500
The Aerospace Corporation	U.S. mission analysis	360,413

Federal agency and recipient	Description	Amount
National Aeronautics and Space Administration	Dynamic conversion of solar generated heat to electricity	$ 53,200
Energy Research and Development Administration Total		$1,543,389
National Science Foundation		
The Aerospace Corporation	Solar thermal conversion mission analysis	38,200
Colorado State University	Analysis of solar thermal electric power systems	1,300
New Mexico State University	Seminar on large-scale solar energy test facilities	20,100
Cornell University	Optical properties of metallic surfaces, small particles, and particulate coatings	100,000
University of Arizona	Investigation of chemical vapor methods for fabrication of solar energy converters	100,000
National Science Foundation Total		$ 259,600 [note a]
Solar Thermal Conversion Program Total		$1,802,989 [note a]
Photovoltaic Conversion		
Energy Research and Development Administration		
Texas Instruments, Inc.	Research on the optimum silicon quality for cost effective solar cells suitable for large-scale terrestrial utilization	172,400
National Aeronautics and Space Administration-Jet Propulsion Laboratory	Assessment of photovoltaic conversion of solar energy for terrestrial applications	129,300

APPENDIX I

Federal agency and recipient	Description	Amount
National Aeronautics and Space Administration-Jet Propulsion Laboratory	Silicon solar array project	$2,869,800
National Aeronautics and Space Administration	Photovoltaic testing and evaluation	300,000
National Aeronautics and Space Administration	ERDA-NASA workshop on solar cell measurement methods	10,360
Energy Research and Development Administration Total		$3,491,860
National Science Foundation		
Boston University	Photochemical conversion of solar energy	9,500
California Institute of Technology	Exploratory study of microanalysis of thin films by backscattering spectrometry	130,400
Itek Corporation, Central Research Laboratories	Exploration of unconventional solar cells	57,800
Ohio State University Research Foundation	Semiconductor-electrolyte photovoltaic energy converter	49,300
University of Pennsylvania	Semiannual review meeting of the NSF photovoltaic conversion program	18,800
Stanford University	Applied research on II-VI compound materials for heterojunction solar cells	52,600
Syracuse University	Investigation of low cost solar cells based on semiconducting Glass-Si heterojunction	147,900
Westinghouse Electric Corporation Research Laboratories	Thin film solar cells for terrestrial applications	247,200

APPENDIX I

Federal agency and recipient	Description	Amount
Rutgers University, College of Engineering	Research on silicon Schottky photovoltaic diodes for solar energy conversion	$ 28,700
University of Delaware	Direct solar energy conversion for large-scale terrestrial use	366,500
RCA Laboratories	Expitaxial silicon technology for low cost solar cells	163,900
American Cyanamid Corporation	Cadmium stannate selective optical films for solar energy applications	160,000
Southern Methodist University (with Texas Instruments, Inc.)	Low cost thin film polycrystalline solar cells for terrestrial applications	300,000
National Science Foundation Total		$1,732,700 [note a]
Department of Transportation		
In-house project	Solar power for aids to navigation	328,000
Department of Transportation Total		$ 328,000
Department of the Interior		
In-house project	Installation and operation of 12 solar energy powered mountain top radio repeater communications facilities	4,400
Department of the Interior Total		$ 4,400
Photovoltaic Conversion Program Total		$5,546,960 [note a]
Wind Energy Conversion		
Energy Research and Development Administration		
National Aeronautics and Space Administration	Design study of a 1-MW scale aerogenerator	600,000

APPENDIX I

Federal agency and recipient	Description	Amount
Michigan State University	Application study of wind power technology to the city of Hart, Michigan	$ 93,400
Department of Agriculture	Wind energy	250,000
National Aeronautics and Space Administration	Experimental 100-kW wind energy conversion system	120,000
National Aeronautics and Space Administration	Design, fabrication, and testing of composite blades for the experimental 100-kW wind energy system	430,000
Energy Research and Development Administration Total		$1,493,400
National Science Foundation		
Boston University	Nonpotential aerodynamics for windmills in Shear-winds	35,300
University of Wyoming	Locating areas of high wind energy potential by remote observations of aeolian geomorphology	36,600
Northwestern University	Stochastic modeling of site wind characteristics	45,700
University of Massachusetts	Investigation of the feasibility of using windpower for space heating in colder climates	130,000
Colorado State University	Sites for wind power installations	50,500
Scientific Applications, Inc.	Research on wind energy conversion systems	140,505
AAI Corporation	Production of methane using offshore wind energy	80,400
Colorado State University	Windpowered aeration for remote locations	39,600

APPENDIX I

Federal agency and recipient	Description	Amount
University of Wisconsin	Novel electric generation schemes for wind energy systems	$ [illegible],400
University of Wisconsin	A wind-power supplementary electric source employing a nonsynchronous AC/DC/AC link as an aid in energy management	28,400
Oklahoma State University	Development and adaptation of field modulated generator systems for wind energy applications	71,800
The Mitre Corporation	Dissemination, utilization, and coordination of wind energy research	54,400
Institute of Gas Technology	Wind-powered hydrogen electric systems for farm and rural use	56,950
Georgia Institute of Technology	National wind energy statistics for large arrays of aerogenerators	65,700
University of Oklahoma	Wind velocity as modified by geomorphology	40,300
West Virginia University	Innovative vertical axis wind machines	87,000
Massachusetts Institute of Technology	Research on wind energy conversion systems	137,500
Planning Research Corporation	Development and experimental application of a research program planning protocol	10,545
Battelle Memorial Institute, Battelle Columbus Laboratories	An evaluation of the potential effects of wind energy systems development	82,500
National Science Foundation Total		$1,246,100 [note a]
Wind Energy Conversion Program Total		$2,739,500 [note a]

Federal agency and recipient	Description	Amount
	Bioconversion to Fuels	
Energy Research and Development Administration		
The Mitre Corporation	Solar energy research and technology--planning for Project Independence	$ 62,962
University of Washington	Personnel mobility assignment	33,220
Department of Agriculture	Utilization of agricultural and forest residue for the production of energy	250,000
Energy Research and Development Administration Total		$ 346,182
National Science Foundation		
University of California, San Diego	Bioconversion of solar energy and production of hydrogen by photolysis	108,100
Midwest Research Institute	Affinity cross-linking agents for enzyme stabilization and immobilization	84,300
University of Miami	Survey of hydrogen producing photosynthetic organisms in tropical and subtropical marine environments	68,100
Columbia University	Oxygen removing systems and partial or complete replacement of hydrogenase with synthetic catalysts	70,500
University of Tennessee	Workshop on solar energy for nitrogen fixation and hydrogen production	13,100
National Science Foundation Total		$ 344,100 [note a]
Department of Agriculture		
In-house project	Photosynthetic sources of energy	464,000

Federal agency and recipient	Description	Amount
Department of Agriculture Total		$ 464,000
Department of the Interior		
In-house project	Materials for solar energy conversion	149,000
Department of the Interior Total		$ 149,000
Bioconversion to Fuels Program Total		$1,303,282 [note a]
	Ocean Thermal Conversion	
Energy Research and Development Administration		
TRW Systems and Energy Group, TRW, Inc.	Ocean thermal energy conversion--research on an engineering evaluation and test program	391,427
Oklahoma State University of Agriculture and Applied Science	Heat exchanger system evaluation for the ocean thermal energy conversion program	24,800
Naval Facilities Engineering Command, Navy Department	Ocean thermal energy conversion program	75,000
Naval Sea Systems Command, Navy Department	Ocean thermal energy conversion workshop, Houston, Texas, 5/8-10/75	25,000
U.S. Naval Research Laboratory	Theoretical fluid dynamical state of resource availability and environmental impact of ocean thermal powerplants	205,200
Energy Research and Development Administration Total		$ 721,427
National Science Foundation		
University of Massachusetts, Amherst	Technical and economic feasibility of the ocean thermal differences process	190,000

Federal agency and recipient	Description	Amount
American Society of International Law	Ocean thermal energy conversion--legal considerations	$ 60,700
Carnegie-Mellon University	Solar ocean-based powerplants	2,000
University of Massachusetts	Technical and economic feasibility of the ocean thermal differences process as a solar-driven energy process with potential for significant impact on the U.S. energy market	2,000
University of Miami	Ocean thermal research conference and workshop	24,400
National Science Foundation Total		$ 279,100 [note a]
Ocean Thermal Conversion Program Total		$1,000,527 [note a]

Miscellaneous Solar Energy Research And Development Projects

Energy Research and Development Administration		
Department of Agriculture	Assessment of solar energy applications to agriculture	116,000
Department of Agriculture	Study of solar energy for cattle feedlot operations and irrigation pumps	172,000
Energy Research and Development Administration Total		$ 288,000
National Science Foundation		
Planning Research Corporation	Project development plan support	80,100
American Bar Foundation	Legal issues related to the utilization of solar energy	85,300
Inter Technology Corporation	A systematic analysis of the energy problem within the United States	14,581
National Science Foundation Total		$ 179,981 [note a]

Federal agency and recipient	Description	Amount
National Aeronautics and Space Administration		
In-house project	Space based solar power conversion and power relay system	$ 115,000
National Aeronautics and Space Administration Total		$ 115,000
Miscellaenous Projects Total		$ 582,981 [note a]

Note a: Total does not include obligations for which detailed project information was not available as of April 30, 1975.