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Wind Energy Systems Program Summary

May 1980

Prepared for:
U.S. Department of Energy
Assistant Secretary for Conservation and Solar Energy
Office of Solar Power Applications

Under Contract No. ACO1-78ET 20097

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May 1980

Prepared by:
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PREFACE

The Federal Wind Energy Program (FWEP) was initiated to provide focus, direction and funds for the development of wind power. Its primary objectives are:

- To accelerate the development of reliable and economically viable wind energy systems.
- To assure the earliest possible commercialization of wind power.

Each year a summary is prepared to provide the American public with an overview of government sponsored activities in the FWEP. This program summary describes each of the Department of Energy's (DOE) current wind energy projects initiated or renewed during FY 1979 (October 1, 1978 through September 30, 1979) and reflects their status as of April 30, 1980. The summary highlights on-going research, development and demonstration efforts and serves as a record of progress towards the program objectives. It also provides:

- The program's general management structure.
- Review of last year's achievements.
- Forecast of expected future trends.
- Documentation of the projects conducted during FY 1979.
- List of key wind energy publications.

The FY 1979 Program Summary is a follow-up to the FY 1978 *Wind Energy Systems Program Summary*, DOE/ET-0093, published in December 1978, which is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC, 20402.

2 kW WECS at Rocky Flats, Colorado

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INTRODUCTION

Wind energy has long been recognized as a potentially abundant source of clean, renewable mechanical and electrical power. In the early 1970s, the impending worldwide shortage of nonrenewable energy sources and the nation's increasing dependence upon imported fossil fuels led to an expanded investigation of the feasibility of converting the wind into useful energy.

The Federal Wind Energy Program (FWEP) was initiated in response to this national challenge. Its objectives are to accelerate the development of reliable and economically viable wind energy systems and to assure the earliest possible commercialization of wind power. At the start of this effort, numerous technical, economic, environmental and social issues had to be resolved before significant benefits from wind power could be realized. In particular, it was recognized in the early phases that the greatest single barrier to the use of wind systems was their high cost. Costs of wind power had to be reduced to be competitive with the costs of other power sources.

During the program's early years, significant progress was made in resolving these issues and in attaining program objectives. Much has been accomplished, yet much remains to be done. As a result, the primary emphasis of the FWEP is:

- Advancement of wind systems technology.
- Development of sound industrial manufacturing technology.
- Evaluation of institutional, economic, and environmental deterrents.
- Activities which accelerate development of commercial markets for wind systems.

The major challenge of the Federal Wind Energy Program remains the development of rugged, economical wind energy conversion systems (WECS) capable of providing up to 30 years of reliable and relatively maintenance-free service.

This summary report describes the Federal Wind Energy Program and outlines the steps it took during FY 1979 toward the achievement of this goal.

PART II
THE FEDERAL WIND ENERGY PROGRAM

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THE FEDERAL WIND ENERGY PROGRAM

—OVERVIEW—

To meet the challenge of commercial wind systems development, a federal program was initiated to implement wide-ranging research and development (R&D) tasks and to provide coordination for the efforts of government, private industry, universities, and laboratories. The program began under the sponsorship of the National Science Foundation's Research Applied to National Needs (RANN) program in 1973.

As part of the nation's solar energy development program, the Federal Wind Energy Program was expanded in 1974 by legislative action of the 93rd Congress. In that year, a national solar energy mandate was established through the Solar Energy Research, Development and Demonstration Act (PL 93-473), the Solar Heating and Cooling Demonstration Act (PL 93-409), the Energy Reorganization Act (PL 93-438) and the Federal Non-Nuclear Energy Research and Development Act (PL 93-577). Together, these four laws established a research program designed to develop solar energy technologies and to complement the efforts of the private sector.

Between 1975 and 1977, the staff of the Division of Solar Energy of the Energy Research and Development Administration (ERDA) led the federal effort in wind energy technical research, hardware development and systems demonstration. In October 1977, this program was integrated into the U.S. Department of Energy (DOE) through the Department of Energy Organization Act (PL 91-569).

PROGRAM ORGANIZATION AND FUNCTIONAL RESPONSIBILITIES

The Wind Energy Systems Branch is part of the Department of Energy's Office of Solar Power Applications, one of four administrative offices forming the Conservation and Solar Energy Office. An overview of this organizational structure is shown in Figures 1 and 2.

The Wind Energy Systems Branch has the primary management responsibility for the Federal Wind Energy Program. It provides overall direction to and coordination of the program elements. The administration of the program elements is decentralized and shared by the DOE Albuquerque Field Office, the NASA Lewis Research Center and the Solar Energy Research Institute (SERI). These three organizations manage the specific program activities of the FWEP.

The specific project activities of the Federal Wind Energy Program pertain to technical research, prototype equipment development and field testing. These projects are conducted primarily by industrial and university contractors. They are contracted, monitored, directed and coordinated by six federal agencies and laboratories (Table 1), each of which is responsible to one of the three administrative offices of the Wind Energy Systems Branch (Figure 3).

Table 1. Coordinating Laboratories, Federal Agencies and Their Responsibilities

ORGANIZATION	ACTIVITY
Solar Energy Research Institute Golden, Colorado	Economic, institutional, environmental, market analysis, innovative concepts research and information dissemination
U.S. Department of Agriculture Beltsville, Maryland	Agricultural, rural and remote applications of small wind systems
NASA Lewis Research Center Cleveland, Ohio	Development of intermediate and large scale wind systems and supporting studies
Rocky Flats Plant Golden, Colorado	Development and testing of small wind systems and supporting studies
Pacific Northwest Laboratory Richland, Washington	Wind resource research, site evaluation, and wind characteristics support for design and operations
Sandia Laboratories Albuquerque, New Mexico	Development of vertical axis wind turbine technology

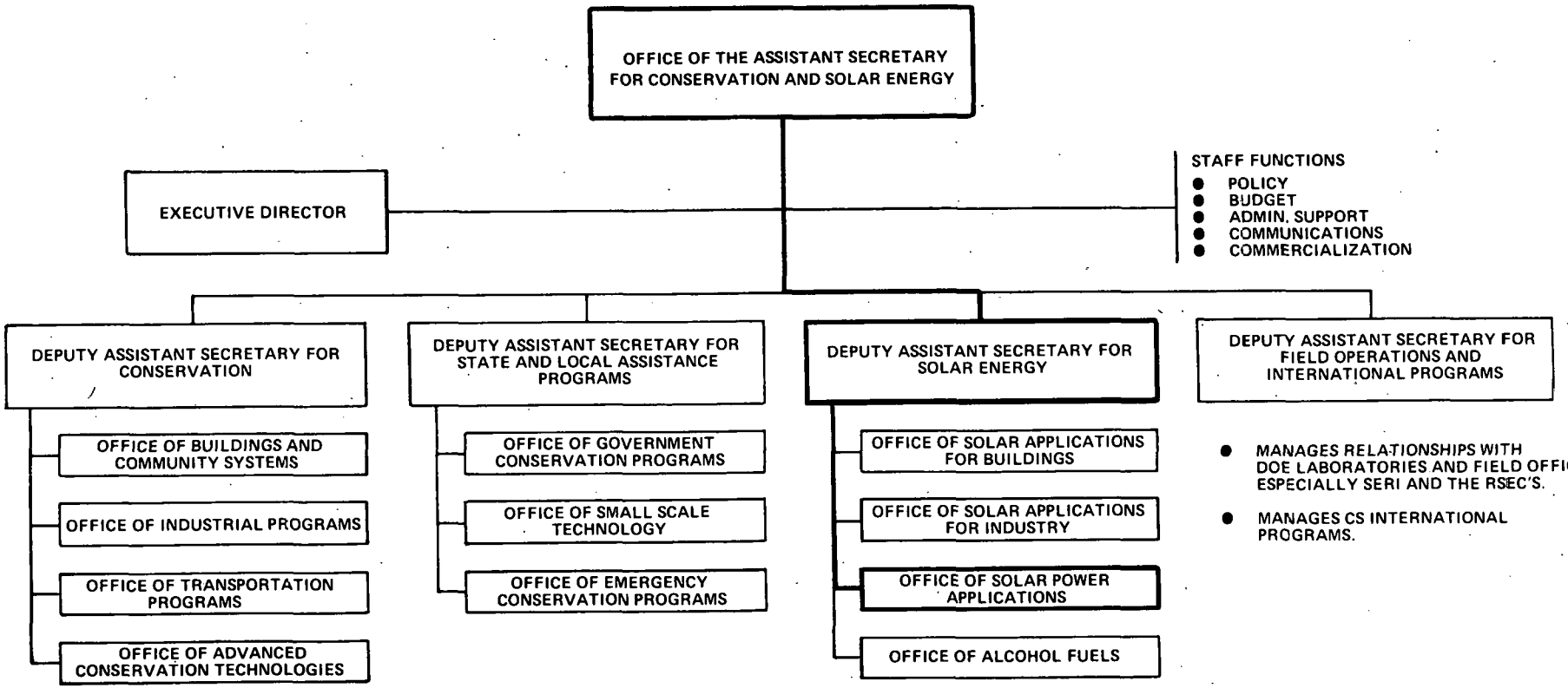

Figure 1. Conservation and Solar Energy Office Management Organization

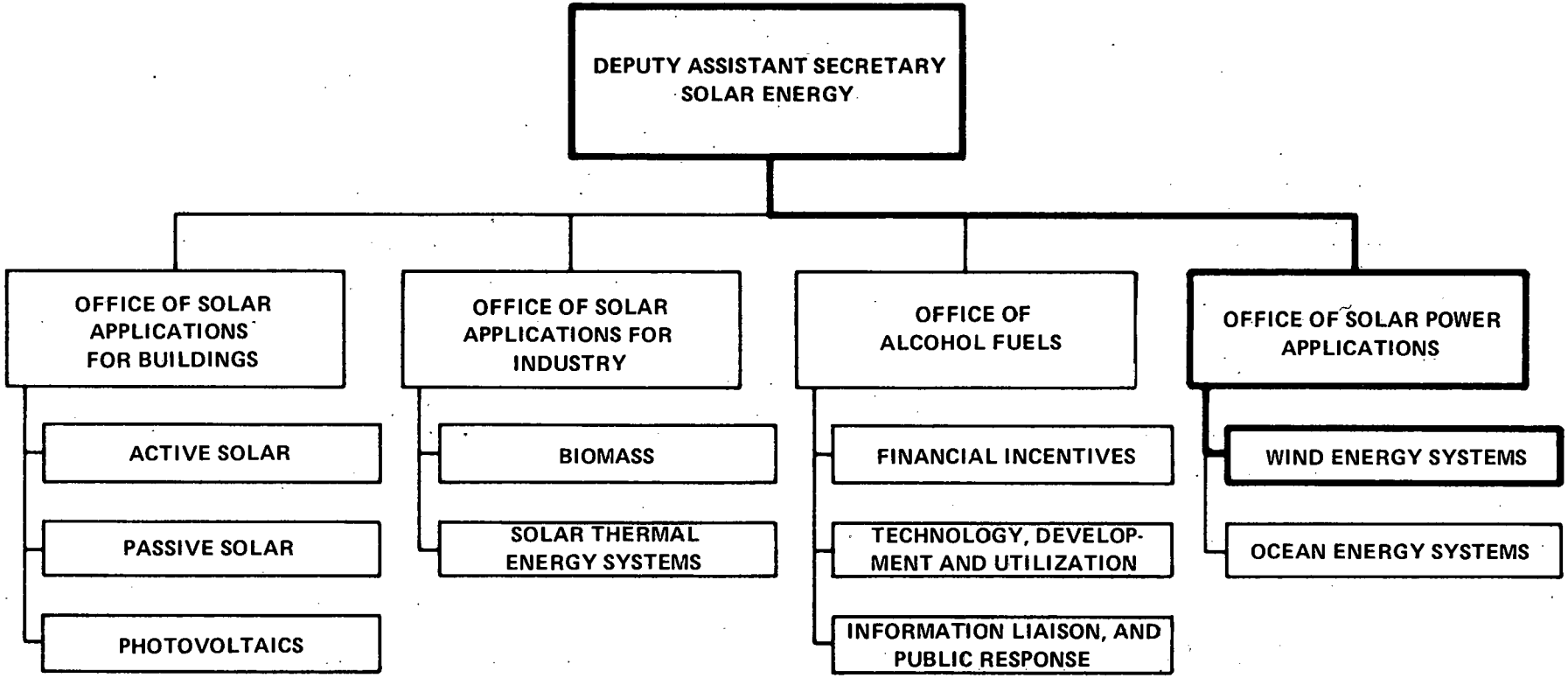

Figure 2. Solar Energy Management Organization

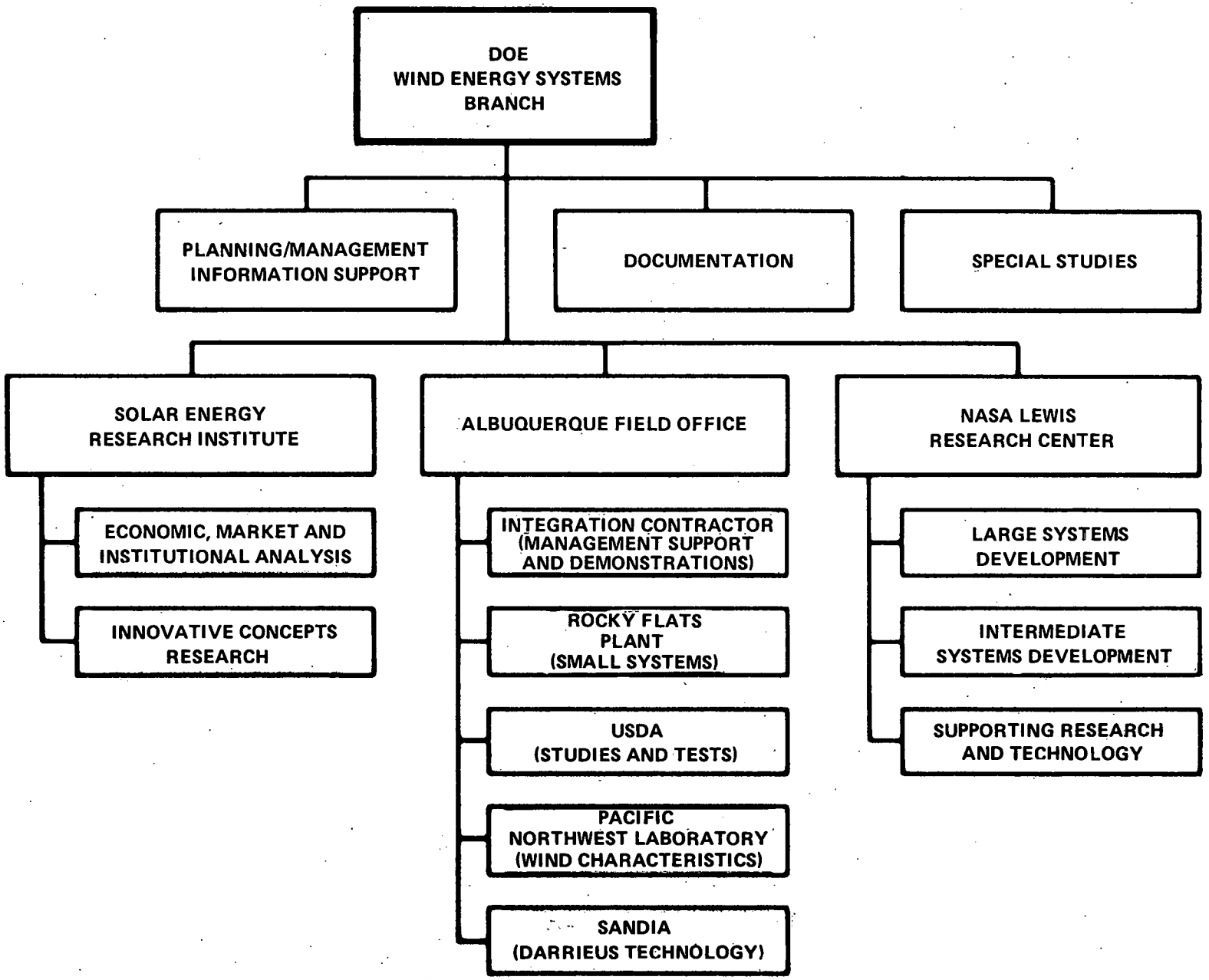

Figure 3. Wind Energy Systems Branch Management Organization

PROGRAM ELEMENTS

The Federal Wind Energy Program is subdivided into program elements. They are designed to provide a framework whereby program activities advance the general and technical knowledge of wind systems in a rapid, systematic manner. As the size and scope of the FWEP have evolved, so too have the program elements. In FY 1979, they were reorganized into the following five elements and 18 sub-elements.

1.0 Planning, Management and Analysis
- 1.1 Economic Analyses
- 1.2 Operations and Applications Requirements
- 1.3 Institutional/Environmental Analyses
- 1.4 Program Development/ Planning

2.0 Wind Characteristics
- 2.1 Wind Energy Prospecting
- 2.2 Support for Design and Operations
- 2.3 Site Evaluation

3.0 Technology Development
- 3.1 Small Systems Technology
- 3.2 Intermediate and Large Systems Technology
- 3.3 Evolving Technologies
- 3.4 Innovative Concepts

4.0 Engineering Development
- 4.1 Small Systems Development
- 4.2 Intermediate Systems Development
- 4.3 Large Systems Development

5.0 Implementation and Market Development
- 5.1 Small Systems Implementation and Market Development
- 5.2 Intermediate Systems Implementation and Market Development
- 5.3 Large Systems Implementation and Market Development
- 5.4 User Outreach Program

1.0 PLANNING, MANAGEMENT AND ANALYSIS

This program element is concerned with the systematic study of WECS market issues and economic applications. Analyses of environmental problems — noise and potential electromagnetic signal interference; social issues — public acceptance; and institutional factors — rates and regulations are grouped in this element.

The Planning, Management and Analysis element is divided into four sub-elements: Economic Analyses, Operations and Applications Requirements, Institutional/Environmental Analyses and Program Development/Planning. The sub-element, Economic Analyses, groups together efforts to determine the value of wind systems in specific applications and in specific economic environments. The sub-element, Operations and Application Requirements, focuses on the manner in which wind systems are matched to specific applications, such as utility power networks. The Institutional/Environmental Analyses sub-element identifies the influences of these two factors on wind systems commercialization. The Program Development/ Planning sub-element provides planning and management support of the wind energy program.

2.0 WIND CHARACTERISTICS

This program element is concerned with the wind resources available throughout the nation and U.S. territories (Figure 4). This effort is intended to increase the basic scientific knowledge and quantitative understanding of the wind energy resource on a national and regional scale. It provides information on wind loads to designers and operators. Research being conducted on the flow of wind over the United States

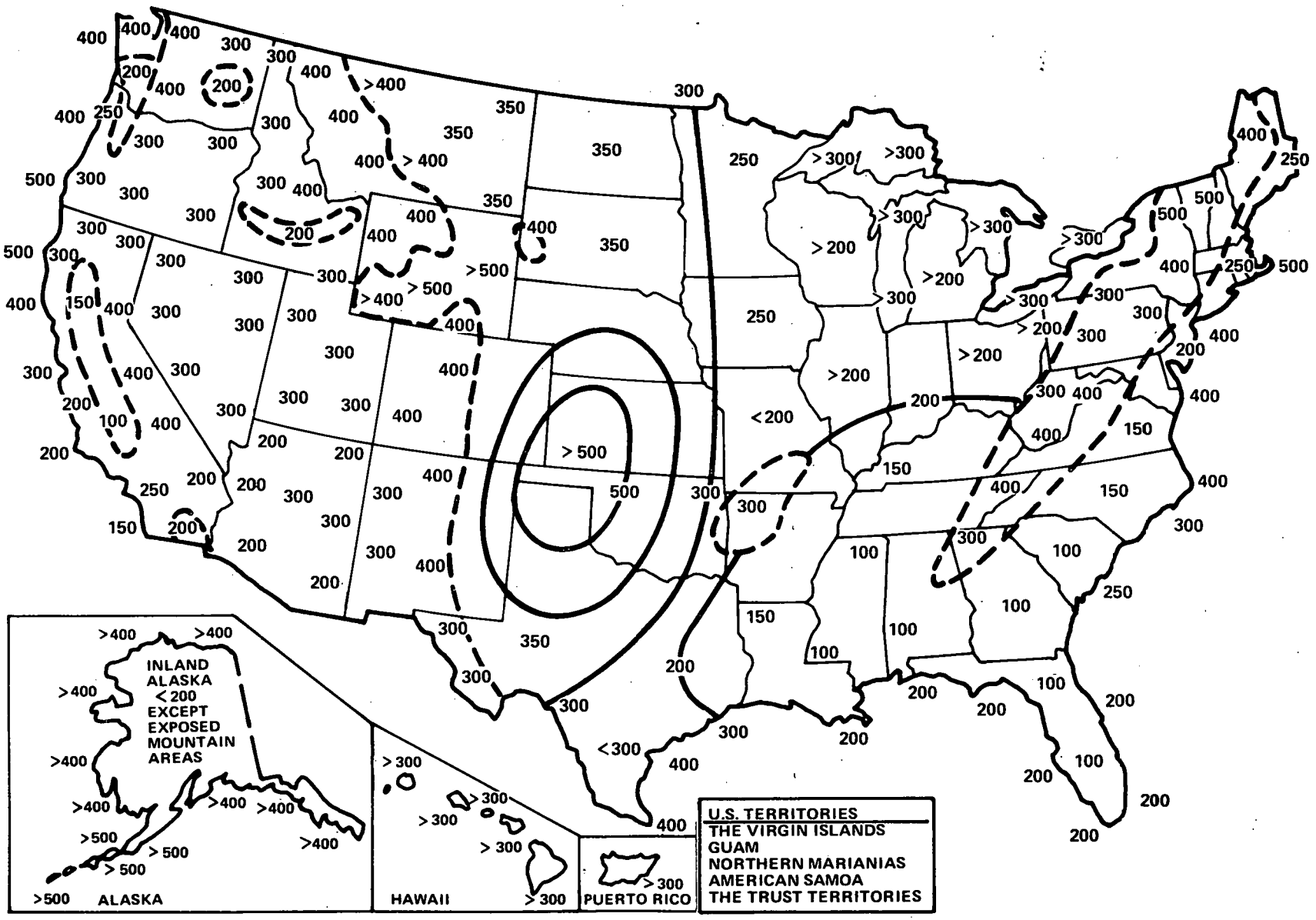

Figure 4. National Wind Resource Map

helps define ways to choose the best, high velocity wind sites for erecting WECS and is used for predicting the output of wind turbines. Figure 5 shows the location of the candidate wind energy sites which have been considered by the Wind Energy Systems Branch.

The Wind Characteristics element is divided into three sub-elements: Wind Energy Prospecting, Support for Design and Operations, and Site Evaluation. Wind Energy Prospecting analyzes the national potential for wind energy and develops methodologies for selecting sites for wind energy systems. The Support for Design and Operations sub-element analyzes the relationship between meteorological phenomena and wind systems, focusing on instrumentation, wind loads, wind modeling and forecasting techniques. The Site Evaluation sub-element groups together efforts to identify specific sites for prototype wind machines.

3.0 TECHNOLOGY DEVELOPMENT

The development of the science of wind systems is the primary concern of the Technology Development element. The wind machines and their component parts are tested for performance characteristics and safety. Projects designed to lower system costs and to develop the components and tools to assist the design of advanced systems are included in this element.

The Technology Development element is divided into four sub-elements: Small Systems Technology, Intermediate and Large Systems Technology, Evolving Technologies, and Innovative Concepts. Small Systems Technology focuses on the research related to systems whose rated power is 100 kW or less. This sub-element also groups together work conducted on agricultural applications of small wind systems. Intermediate and Large Systems Technology groups projects to develop systems with rated power in excess of 100 kW. Evolving Technology projects concentrate largely on vertical axis machines, such as the Darrieus, and includes other potential designs not as well developed as the horizontal axis systems. Innovative Concepts is a sub-element through which advanced and innovative designs can be investigated for technical and economic feasibility and developed according to their potential.

4.0 ENGINEERING DEVELOPMENT

This program element is designed to group together activities for the development of complete wind systems and for the evaluation of their use in purposeful applications. Its primary objective is the development of commercial systems which can be produced by industry.

The Engineering Development element is divided into three sub-elements: Small Systems Development, Intermediate Systems Development, and Large Systems Development. The Small Systems Development sub-element is responsible for systems of from 1 to 100 kW; Intermediate Systems Development for systems of from 100 to 1000 kW; and Large Systems Development for systems greater than 1000 kW (1 MW).

Under this element, prototype development contracts are competitively awarded to private industry. When possible, multiple contracts reduce technical risks, provide differing technical approaches and further enhance a competitive industry. Prototype systems developed under these contracts are field tested in typical operational conditions by potential users.

5.0 IMPLEMENTATION AND MARKET DEVELOPMENT

Making wind power available to the public and firming and increasing the market for wind energy systems is the concern of this program element. The federal program relies heavily on free market activities while helping to create a favorable environment for public acceptance of these new systems. Consumer supports, outreach programs and consumer-oriented field evaluation and system performance demonstrations are a major part of this element. It is an element in its formative stage and reflects the evolution of the program from technology development to commercialization.

The Implementation and Market Development element is divided into four sub-elements: Small Systems Implementation and Market Development, Intermediate Systems Implementation

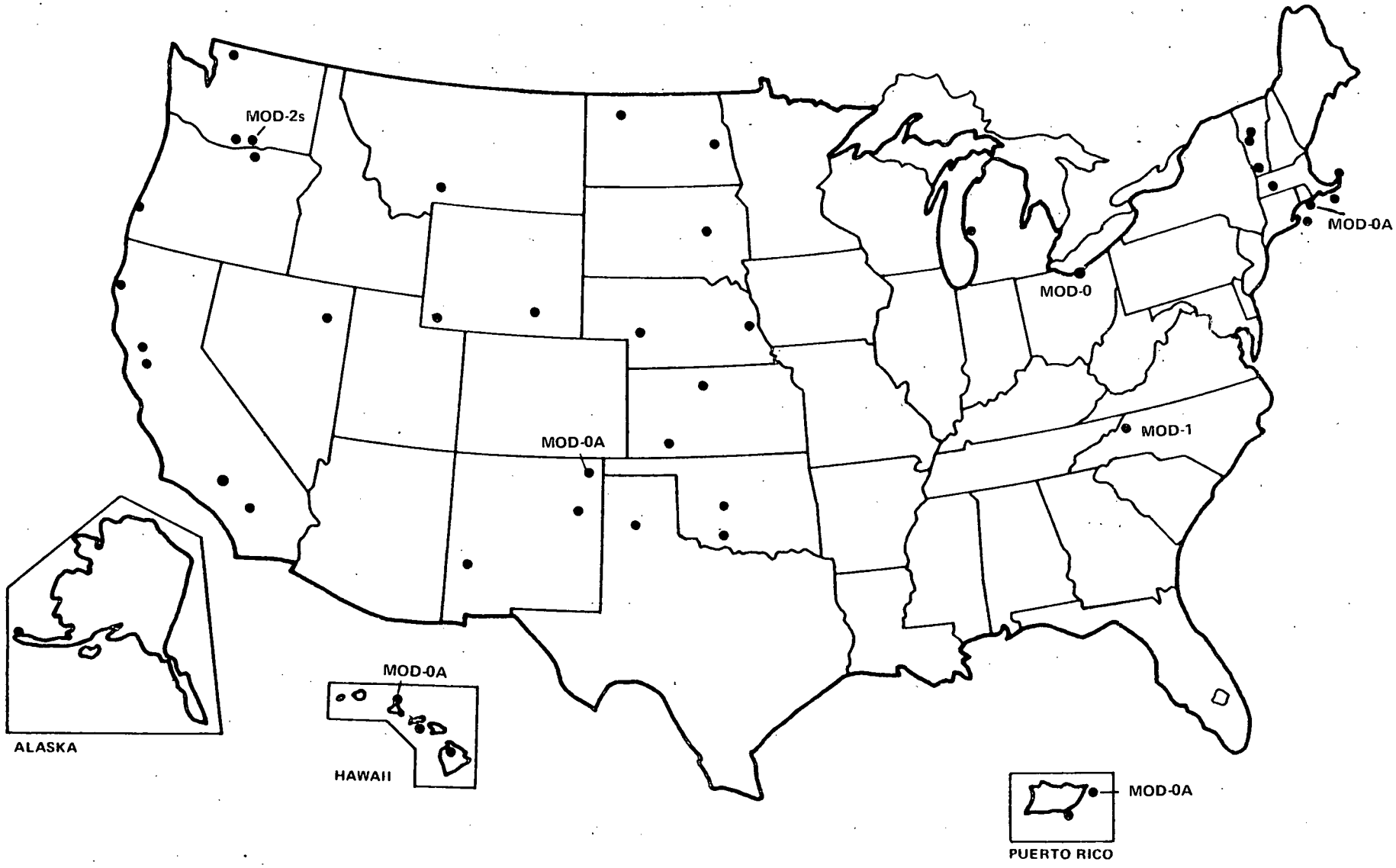

Figure 5. Installations and Candidate Wind Energy Sites

and Market Development, Large Systems Implementation and Market Development, and the User Outreach Program. The Small, Intermediate and Large Implementation and Market Development programs are organized around the machine size classification used in the Engineering Development element. The User Outreach Program organizes projects to disseminate information on all aspects of wind systems to all potential users.

CURRENT PROGRAM

During the early years of the program, the Federal Wind Energy Program focused on basic R&D. The technical problems of wind energy systems were defined and the groundwork carried out. Testing of wind systems, even though at an experimental stage, was carried out directly in user applications to gain early practical information. The FWEP established logical and achievable milestones for fundamental research, design concepts, engineering development, testing and pilot installations. Today, as a result, WECS hardware is in a maturing stage of engineering development. In FY 1979, the FWEP was reassessed and revised to reflect the experience of the preceding years. The evolution of wind energy technology and, more importantly, the reduction of power output costs enabled the Wind Energy Systems Branch to shift its strategy. Program areas important to wind systems commercialization now receive more attention. Engineering development, field testing and newly initiated market development activities account for an increasing proportion of the program's budget. Market identification, information dissemination and reduction of social and institutional barriers to wind systems also have increased priority. The objectives, activities and key products of each element are briefly summarized in Table 2.

The Federal Wind Energy Program has grown from a budget of less than $2 million in 1973–74 to an estimated budget of $63.4 million in FY 1980 (Figure 6). The funding of the program elements and sub-elements in FY 1979 and FY 1980 are recorded in Table 3.

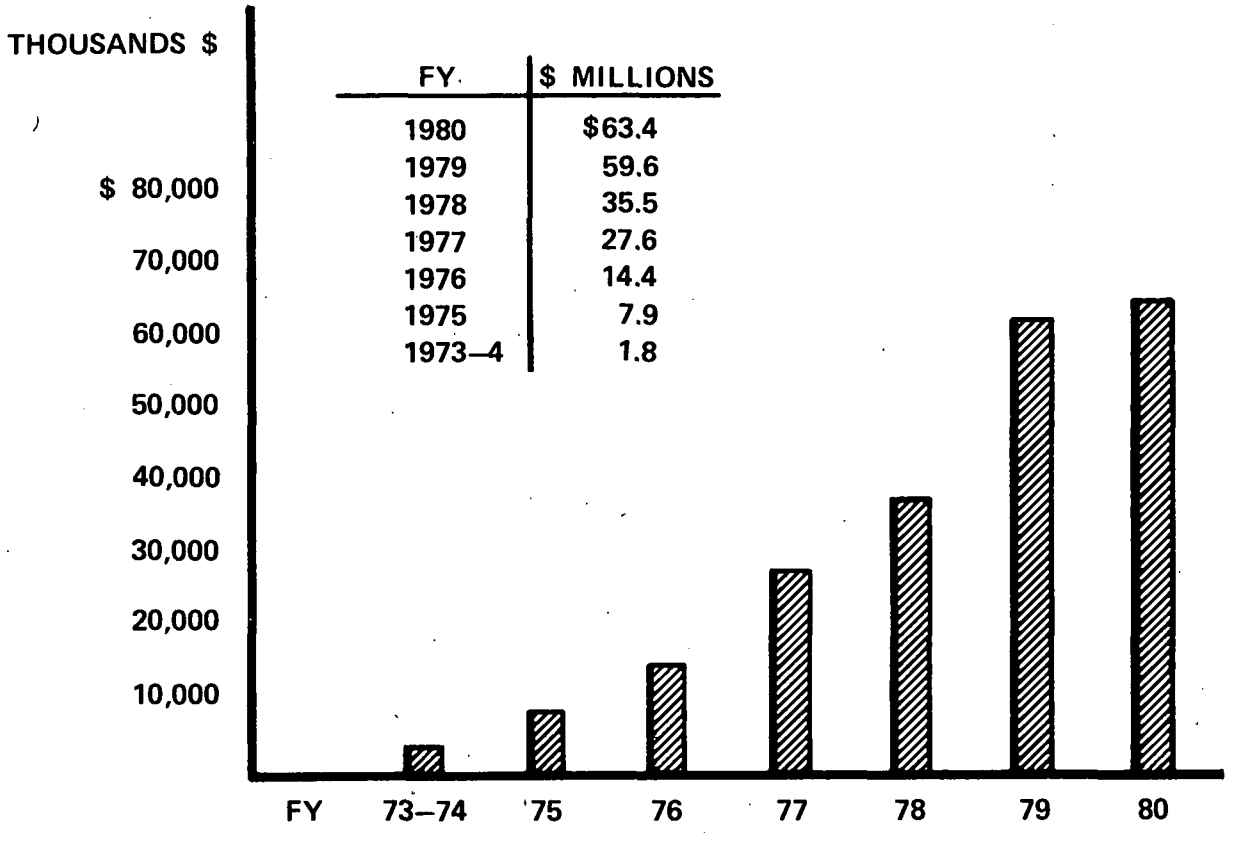

Figure 6. Federal Wind Energy Program Funding

Table 2. Program Elements: Objectives, Activities and Key Products

PROGRAM ELEMENT	OBJECTIVES	ACTIVITIES	KEY PRODUCTS
Planning, Management and Analysis (1.0)	Assess Economics of Wind Energy Assess Barriers to Acceptance Assess Incentives Study Market Needs	Marketing Assessments Incentives Studies Economic Analyses	Information for Decision Makers and Users Estimates of Market Size versus Cost
Wind Characteristics (2.0)	Improve Capability of Evaluating Wind Sites Develop Wind Survey Techniques Provide Design Requirements for WECS Improve Operational Use of WECS	Collect Wind Characteristics Data Develop Wind Forecasting Models Develop Siting Methods	Large-Area Wind Survey Techniques National Wind Resource Assessment Performance and Design Data Siting Handbooks
Technology Development (3.0)	Reduce System Costs Improve Performance Provide Analytical Tools and Component Performance Data to WECS Producers and Users Determine Potential of Innovative Concepts	Component Development Research and Tests Conceptual Systems Designs Evaluation of Innovative Concepts Development and Validation of Analytical Tools	Higher Performance, More Reliable, Lower Cost Systems and Components Improved and Validated Design Models Concepts with Potential for Further Development Industry Consensus Standards
Engineering Development (4.0)	Determine Operating and Economic Characteristics of User Operated WECS Reduce Systems Costs and Improve Performance of WECS	Design, Fabricate, Install, and Operate WECS Intertied with Utilities Improve Systems Design Through Use of Technological Advances	Utilities Gain User Experience Improved Systems Performance and Reduced Costs Validated WECS Designs
Implementation and Market Development (5.0)	Reduce Cost Through Production Efficiencies Establishment of a Commercialization Infrastructure Promote Market Demand Growth Reduce Institutional Barriers to WECS Users	Initiate Market Purchases for Demonstration Projects *Investigate Incentive Package for Manufacturers and Users *Develop Standards and WECS Assessment Methodology	High-Efficiency Competitive Production Facilities User Acceptance of WECS Commercialized Wind Technology Contributing to National Energy Needs

*To be initiated in FY 1980

Table 3. Program Funding: FY 1979 – FY 1980

		FY1979 ($000)	FY1980 (est.) ($000)
1.0	Planning, Management and Analysis		
1.1	Economic Analyses		
1.2	Operations and Applications Requirements	5,015	6,219
1.3	Institutional/Environmental Analyses		
1.4	Program Development/Planning		
	Total	5,015	6,219
2.0	Wind Characteristics		
2.1	Wind Energy Prospecting	1,536	2,515
2.2	Support for Design and Operations	860	1,240
2.3	Site Evaluation	1,978	1,196
	Total	4,374	4,951
3.0	Technology Development		
3.1	Small Systems Technology	3,715	3,723
3.2	Intermediate and Large Systems Technology	4,489	5,614
3.3	Evolving Technologies	646	1,282
3.4	Innovative Concepts	950	1,456
	Total	9,800	12,075
4.0	Engineering Development		
4.1	Small Systems Development	8,092	7,685
4.2	Intermediate Systems Development	5,949	2,275
4.3	Large Systems Development	19,894	9,483*
	Total	33,935	19,443
5.0	Implementation and Market Development		
5.1	Small Systems	4,692	2,008
5.2	Intermediate Systems	0	0
5.3	Large Systems	0	0
5.4	User Outreach Program	339	564
	Total	5,031	2,572
	Total All Elements	58,155	45,260
	Capital Equipment and Construction	1,400	18,140*
	Total	59,555	63,400

*Includes large system project capital and construction costs.

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PART III
PROGRAM HIGHLIGHTS

PROGRAM HIGHLIGHTS

1.0 PLANNING, MANAGEMENT AND ANALYSIS

- **Sponsored Research**

In FY 1979, initial studies were underway or completed on a variety of issues. Particular attention was given to the WECS market, possible economic incentives to encourage wider commercialization and environmental assessments. One study, for example, provided government planners with basic information and an analysis of ways to stimulate WECS commercialization. This study analyzed the potential impact of incentives such as direct grants, tax credits, loans and loan guarantees on different WECS markets: utilities, residential, industrial, agricultural and remote applications.

Environmental, legal, and social impact assessments conducted for the Wind Energy Systems Branch indicated that WECS are acceptable to the general public and to groups specifically concerned with these issues. TV and other electromagnetic interference, risks to birdlife and vegetation, noise, land use and aesthetics were specifically examined. A programmatic environmental assessment was prepared to evaluate and compare WECS alternatives to ensure that environmental values were considered and to facilitate decisions in accordance with the requirements of the Environmental Protection Agency.

- **Albuquerque Field Office**

In accordance with DOE's policy of decentralization, in FY 1979, the Wind Energy Systems Branch established the Albuquerque Field Office within the Albuquerque Operations Office. The Albuquerque Field Office is responsible for managing the development of small wind systems, evolving systems, the wind characteristics program and their respective research and analysis efforts.

2.0 WIND CHARACTERISTICS

- **Wind Resource Assessments**

National and regional wind resource assessments were among the research projects conducted in FY 1979. A key document, *Wind Energy Resource Atlas: The Northwest Region,* was published in 1979. This atlas contains maps and graphs depicting the geographic distribution of wind resources in Washington, Oregon, Idaho, Montana, and Wyoming, with details refined to the sub-county level. Eleven additional atlases covering the rest of the U.S. will follow by late fall 1980.

3.0 TECHNOLOGY DEVELOPMENT

- **The Small Systems Test Center**

The technology development and testing of small wind energy systems is being conducted at DOE's Rocky Flats Plant, managed for DOE by Rockwell International. The Small Systems Test Center at Rocky Flats, Colorado, is used extensively to assess the current state-of-the-technology and to identify required technological improvements.

In FY 1979, 17 small commercially available wind systems, ranging in rated power from 1 kW to 40 kW, underwent testing at the Rocky Flats Test Center (Figure 7). Each machine is subjected to a two year program of reliability and performance testing under actual environmental conditions. To assist in these evaluations, a temporary dynamometer and vibration testing facility was erected in FY 1979. This facility will enable the test center to define generator and gearbox performance for a broad variety of loads under controlled input.

- **Controlled Velocity Testing**

During FY 1979, use of the Controlled Velocity Testing Facility continued at Pueblo, Colorado, in collaboration with the Department of Transportation (DOT). At the facility, prototype wind machines with rotors up to 15 feet in diameter are propelled on a railway test track to provide controlled wind velocity.

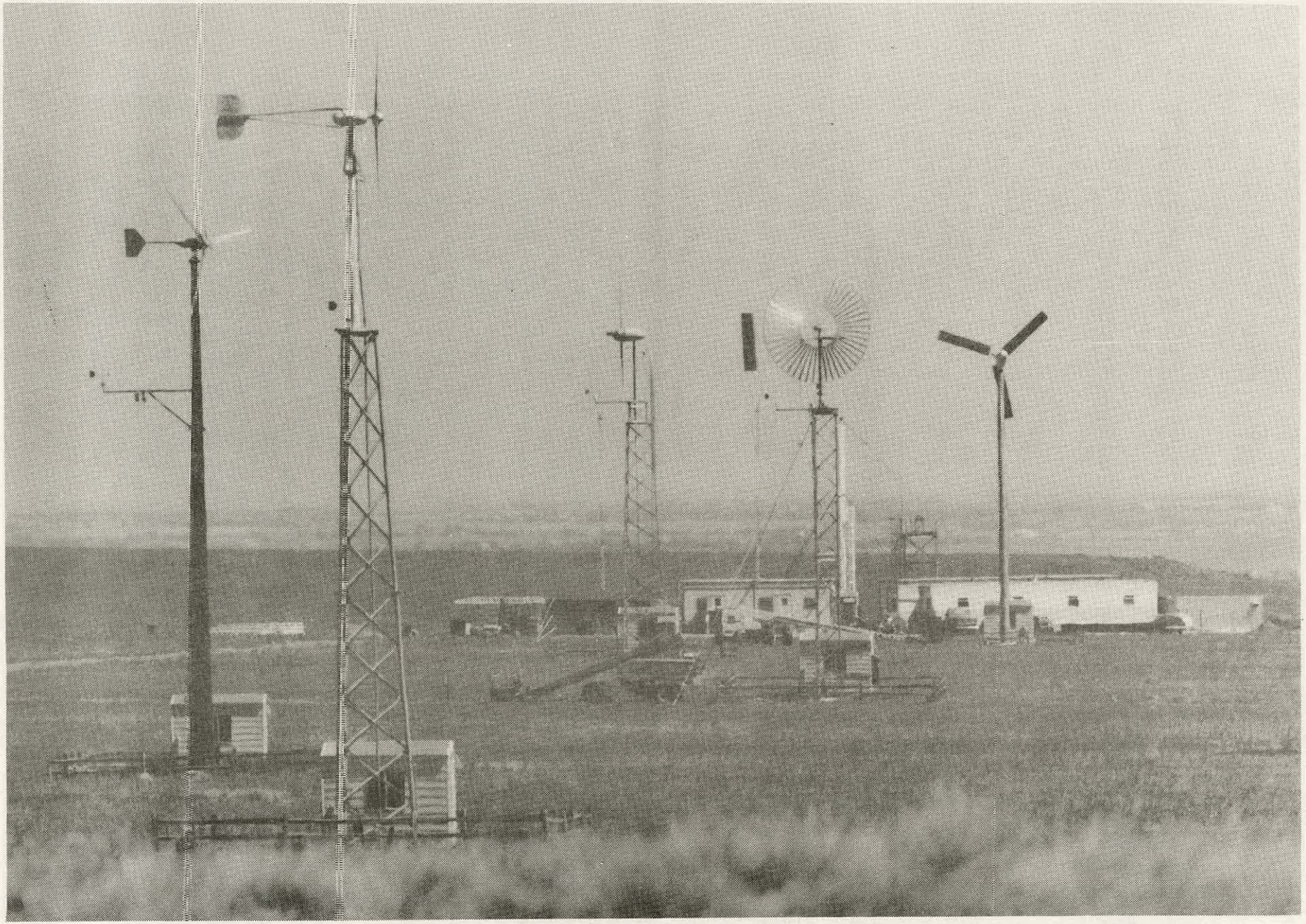


Figure 7. Rocky Flats Wind Energy Test Site

- **Large Systems Research**

The NASA Lewis Research Center in Cleveland, Ohio, is reponsible for the technology research required for the development of intermediate and large size, horizontal axis wind turbines (HAWT).

In FY 1979, for example, NASA Lewis conducted concept verification and component tests for the MOD-2, 2.5 MW wind turbine. Flexible tower, teetered hub and tip control rotor concept design tests were performed at NASA's MOD-0 test site at the Plum Brook Station in Sandusky, Ohio (Figure 8). These tests began in April 1979 and showed that these techniques would reduce the yaw and blade loads.

Blade development received considerable attention by NASA Lewis researchers in FY 1979. In particular, the 150-foot composite blade project, completed this year, resulted in the lowering of projected construction costs for very large blades. This success led to the initiation of four new and similar blade development projects. In addition, three low cost, intermediate size blade development projects were started to investigate wood, fiberglass reinforced plastic (FRP) and steel composite designs.

NASA Lewis also conducted a major test program of the dynamic loads of wind turbines. Methodologies were improved for the analysis of structural stress caused by the force of wind and the analyses of air flow through single and multiple wind machine layouts. Mechanical and electrical dynamics analysis of wind turbine clusters coupled to a utility grid were conducted by NASA through subcontracts to Purdue University and Power Technology, Inc.

- **Evolving Technologies Research**

Sandia Laboratories of Albuquerque, New Mexico, is responsible for the technical development of the Darrieus vertical axis wind turbine (VAWT). In FY 1979, Sandia continued its tests of the 2-, 5- and 17-meter machines (Figure 9). More significantly however, Sandia completed a cost study showing that the Darrieus system appears to be cost competitive with propeller-type systems in intermediate sizes.

Furthermore, in FY 1979 the 17-meter Darrieus was redesigned to lower its construction and installation costs.

- **Innovative Concepts**

In FY 1979, new methodologies to assess technical and economic feasibility of innovative WECS concepts were developed. A model which incorporates these methodologies and estimates energy costs of the systems was revised and improved. This model is used to evaluate innovative concepts in order to determine the practicality of the concept's design and its feasibility prior to initiating a technology development program.

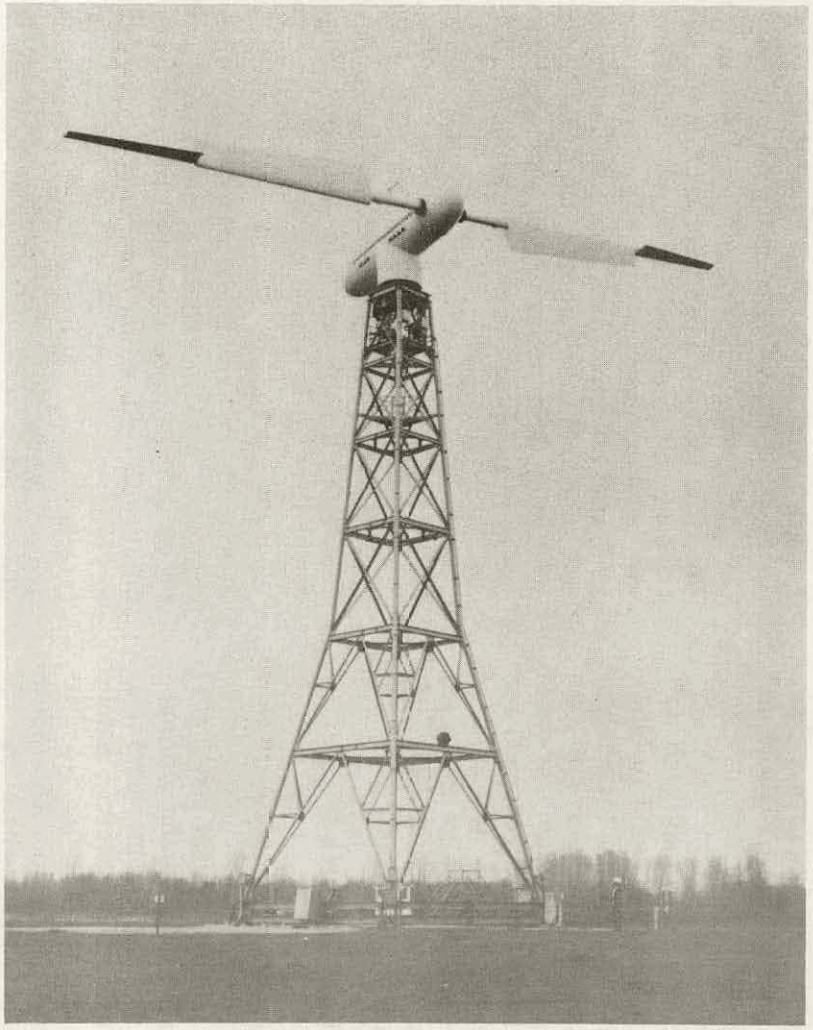
The evaluation of innovative wind energy concepts is the responsibility of SERI. In FY 1979, SERI managed several innovative concept R&D projects such as the tornado-type system, the Madaras rotor power plant, and the innovative straight-bladed VAWT illustrated in Figure 10. In addition, SERI initiated six new assessment studies for various innovative concepts.

- **Agricultural Applications Program**

Given the long tradition of wind power on American farms, it is appropriate that the U.S. Department of Agriculture would collaborate with DOE in a program of wind power research. Its overall objective is the identification,design, development and testing of applications for the production and utilization of wind-generated energy in rural and remote areas.

In FY 1979, field experiments were completed on several projects including milk cooling and apple storage applications. Other projects have indicated a high potential for wind power use, particularly for irrigation needs.

In addition, the U.S. Department of Agriculture completed a major market research project in FY 1979. The project developed estimates of the number of wind turbine generators which might be used on American farms. Several key criteria, e.g., geographical distribution, appropriate machine size and cost of electricity, were analyzed.



(a) Present configuration, with tip-controlled teetered rotor and steel spar blades.

(b) Original configuration, with fully pitched aluminum blades and rigid hub.

Figure 8. MOD-0 Wind Turbine, 100 kW

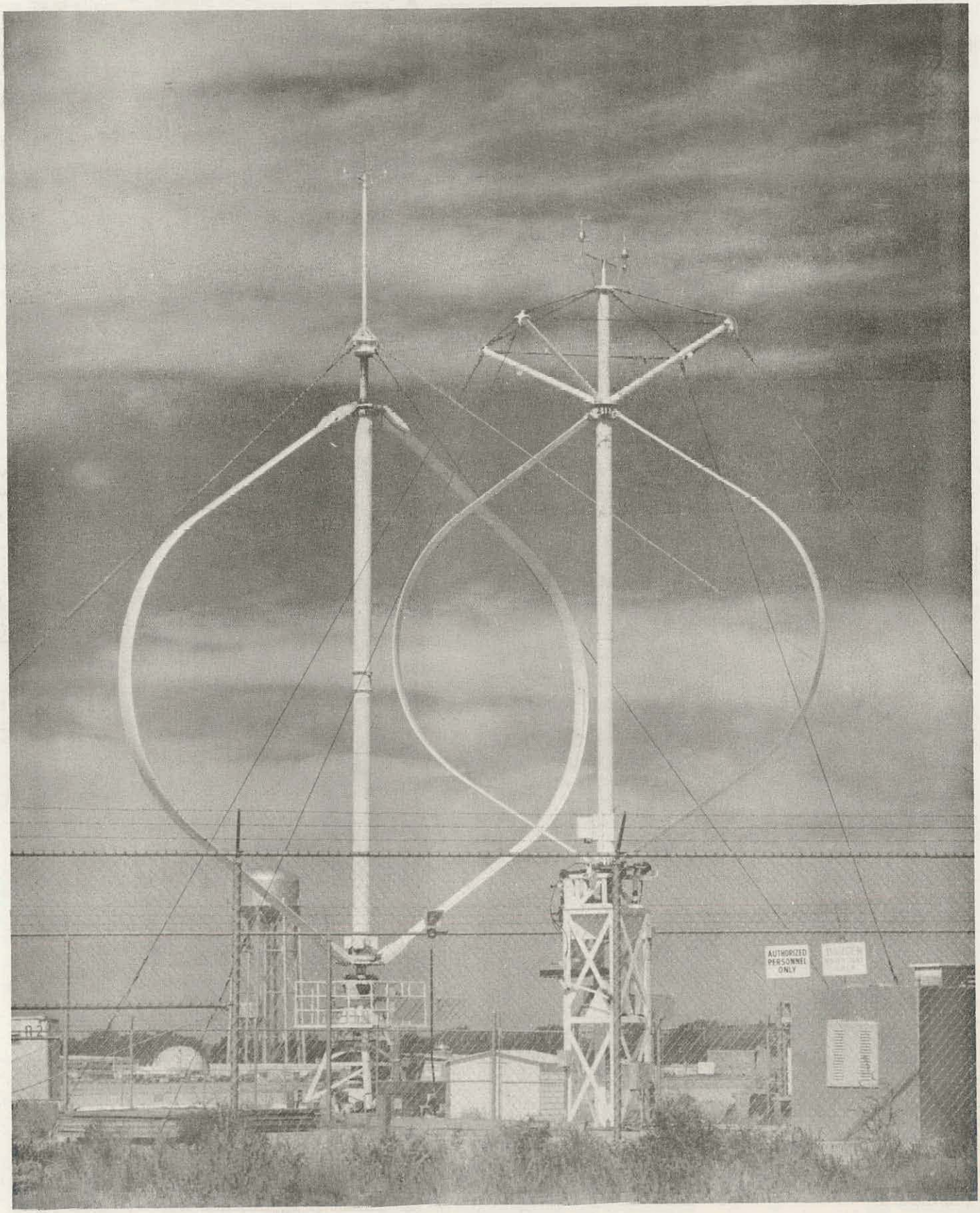


Figure 9. 5 m and 17 m Darrieus Vertical Axis Wind Turbine

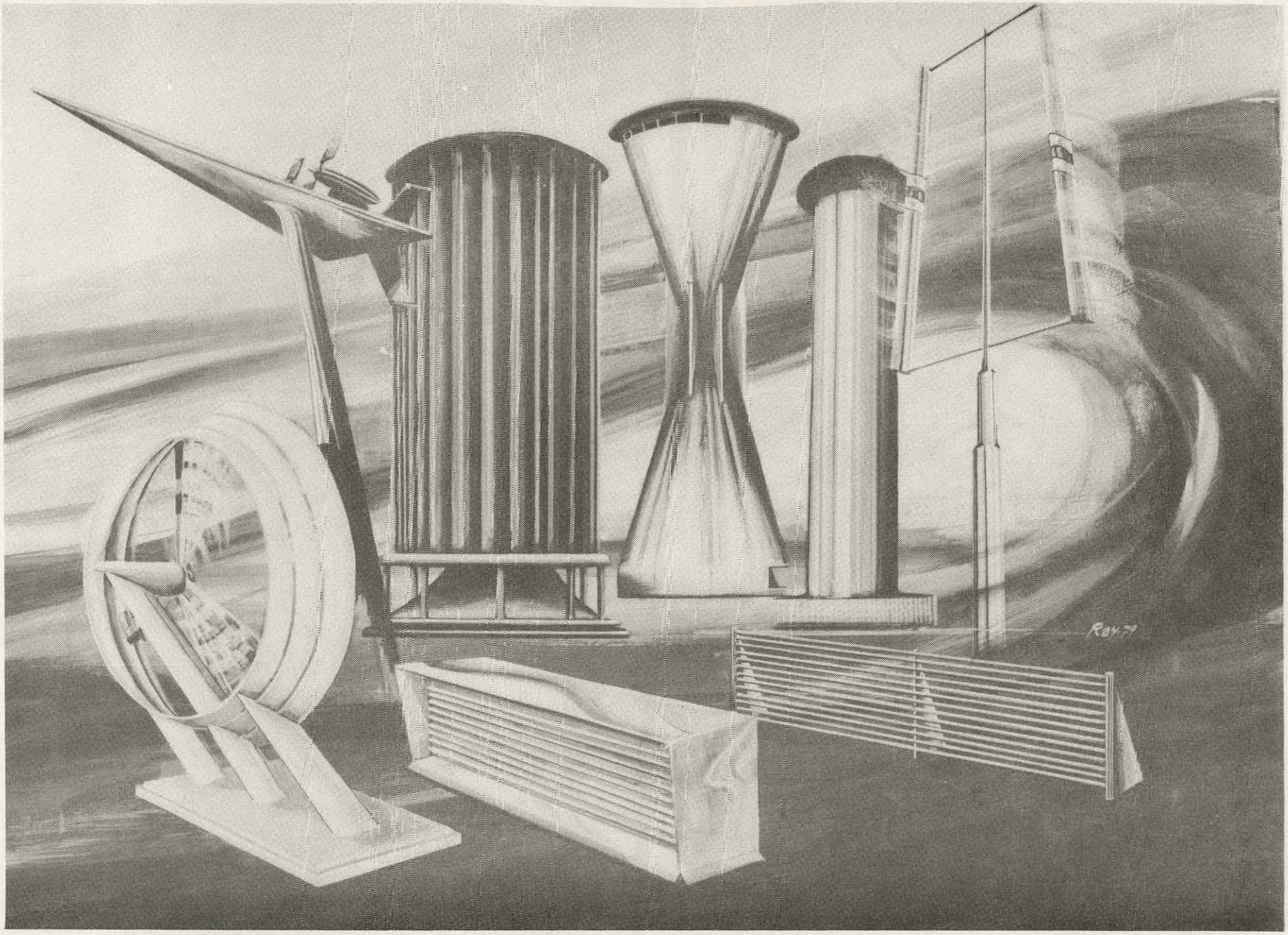


Figure 10. Innovative Concepts

1 Vortex Augmentor Concept (VAC) Wind Energy System
Polytechnic Institute of New York

The Vortex Augmentor Concept is designed to extract the energy from vortices shed from the leading edge of a delta wing surface at incidence.

2 Tornado-Type Wind Energy System
Grumman Aerospace Corporation

The formation of a vortex/tornado in the slotted, cylindrical tower produces a low pressure center in the tower. Energy is extracted from the air flowing into the bottom of the tower of the "Tornado" system by a high speed turbine.

3 Energy from Humid Air
South Dakota School of Mines and Technology

A vast amount of energy is contained in the latent heat of vaporization of water present in humid air. The purpose of the study is to extract a portion of this energy using an expansion and compression process combined with a turbine for output power.

4 Madaras Rotor Power Plant
University of Dayton Research Institute

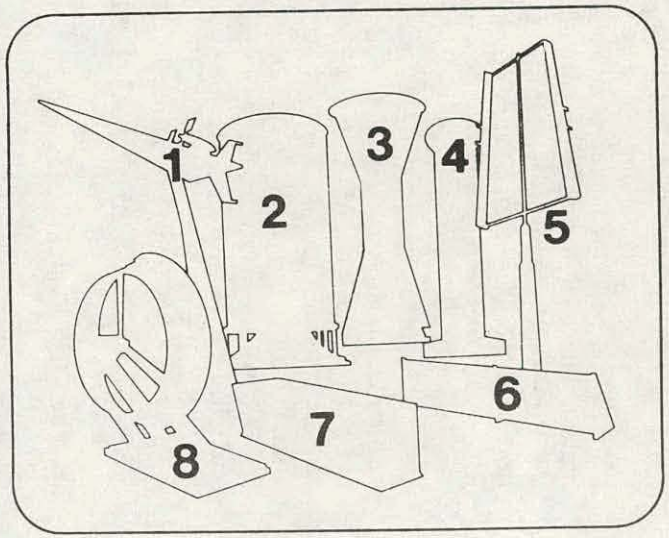
This concept utilizes rotating cylinders, vertically mounted on flat cars, to extract the energy in the wind. The rotating cylinders, which generate a lift force ten times that of an airfoil, propel an endless train of cars around a closed track at constant speed. Alternators geared to the wheels of each car generate the electrical power.

5 Innovative Straight-Bladed Vertical Axis Wind Turbine
West Virginia University

This concept is a straight-bladed vertical axis wind turbine with circulation control airfoils that exhibit higher lift-to-drag ratios than conventional airfoils. This can offer improved turbine performance with corresponding improved cost effectiveness. The circulation control is brought about by blowing air from inside the blade over and around the trailing edge of the airfoil. This blowing is alternately applied to the upper and lower surfaces or the airfoil 180° out of phase.

6 Wind/Electric Power Transduction Using Charged Aerosols
Marks Polarized Corporation

The Wind/Electric Power Generator is a charged aerosol dynamic generator directly powered by the wind. Water droplets emitted into the wind stream from micro jet orifices are charged, pushed to a high potential, and collected by the earth's surface at ground potential.



7 Electrofluid Dynamic (EFD) Wind Driven Generator
University of Dayton Research Institute

This concept directly converts wind energy into electrical energy with no moving parts. The system introduces aerosol particles into a neutrally charged wind stream. These aerosols are then charged by a corona discharge. The viscous interactions of the wind drive these aerosols against an electric potential past the attractor electrode and towards the collector electrode to produce DC power. The generator uses high voltages with low currents.

8 Diffuser Augmented Wind Turbine
Grumman Aerospace Corporation

The concept uses a diffuser that creates a low sub-atmospheric pressure behind the turbine rotor by expanding the wind stream. A result of this pressure differential is a suction that causes significantly more air flow across this turbine than would be present in a conventional wind turbine. The resulting increased mass flow increases the output power and allows smaller turbine blades to be used for the DAWT than for a conventional wind energy conversion system of equal rating.

4.0 ENGINEERING DEVELOPMENT

- **Small Systems Engineering Development**

Small wind systems are being engineered to meet predetermined cost, performance and reliability goals. These systems are being designed to serve in numerous agricultural and residential applications. In FY 1979 projects were initiated to develop 15 kW and 4 kW wind machines with two contractors and three contractors respectively. These projects joined those in the 1-2 kW, 8 kW and 40 kW rated power categories initiated in FY 1977 and FY 1978 (Figure 11). In addition, Alcoa began a project to produce up to four, 17-meter, low cost Darrieus wind turbines.

- **The MOD-0A Program**

In FY 1979, a MOD-0A, 200 kW, intermediate size wind system was installed on Block Island, Rhode Island. This system is the third MOD-0A to be completed in this program and was preceded by one at Clayton, New Mexico, and one at Culebra Island, Puerto Rico.

The MOD-0A program is managed by NASA's Lewis Research Center and is conducted in cooperation with the local utilities. These utilities and their customers are already receiving useable electricity from MOD-0A wind power. The three operating machines are shown in Figure 12 and the major characteristics of DOE/NASA machines are compared in Table 4. A fourth MOD-0A is being constructed on Oahu, Hawaii and should be installed in FY 1980.

- **The MOD-1**

The dedication of the MOD-1 at Boone, North Carolina, on July 11, 1979, was the highlight of the year for large system engineering development (Figure 13). The MOD-1 is a 2 MW wind system built by General Electric Co. It is a first generation, prototype large system for which two 100-foot blades were manufactured by The Boeing Engineering and Construction Company. It is the largest wind turbine ever built and will supply electric power to the Blue Ridge Electric Membership Cooperative which will operate it over a two year test period.

- **Advanced Large and Intermediate Systems**

Progress on the second generation large horizontal axis wind systems proceeded in FY 1979. The MOD-2, a 2.5 MW system, is under construction. Three of these machines will be installed in FY 1980 and FY 1981 near Goldendale, Washington. These will be tested in cooperation with the Bonneville Power Administration. In addition to the MOD-2, an advanced, multi-megawatt wind turbine, MOD-5, using advanced design concepts is now underway. The development of a medium scale, multi-purpose wind turbine, designated MOD-6, was also initiated in FY 1979. Both the MOD-5 and MOD-6 projects are intended to have two competitive development contractors. It is planned that one MOD-6 will be a horizontal axis machine and one will be a vertical axis machine.

5.0 IMPLEMENTATION AND MARKET DEVELOPMENT

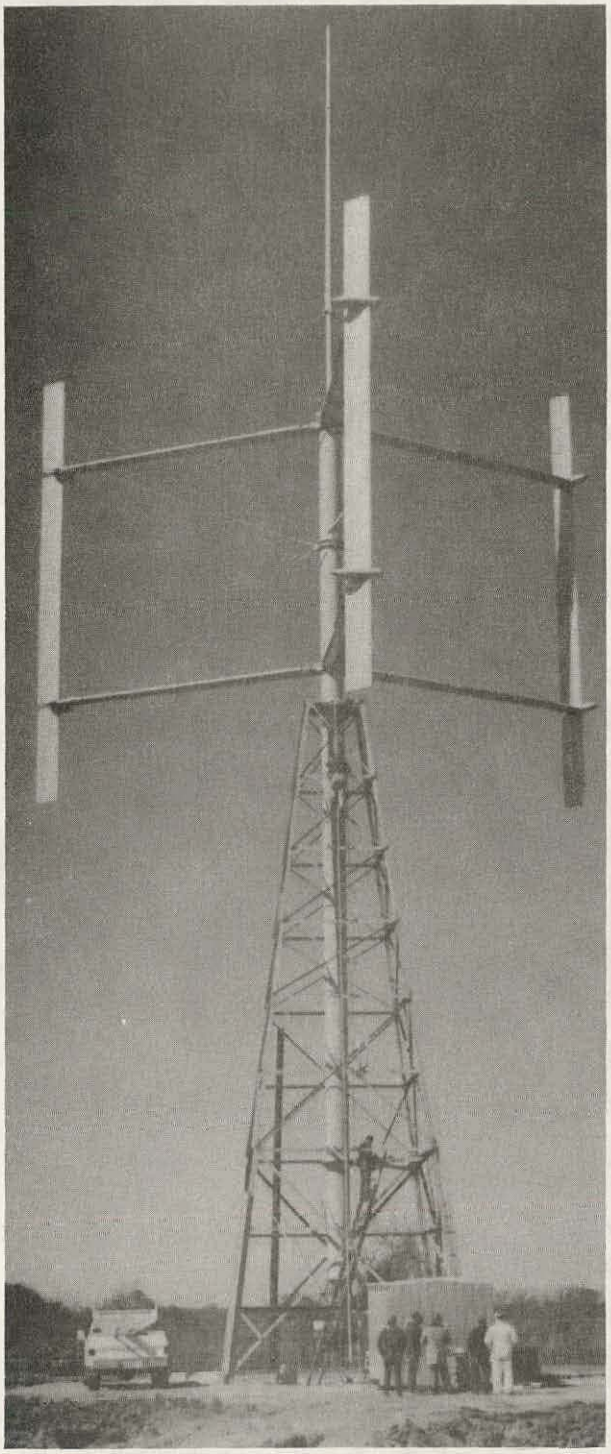
- **The Field Evaluation Program**

The DOE Field Evaluation Program for small wind energy systems began in FY 1979. This program involves the field evaluation of commercially available small systems interconnected with electric utility systems at user sites. Close cooperation with state energy offices, utilities and utility regulatory agencies is maintained to help identify and overcome institutional barriers to small system use.

By the close of FY 1979, orders for 120 commercially available small systems were placed with the wind industry and six sites from four states were selected by the state energy offices. The first two systems were installed in Epping, New Hampshire (Figure 14), and Kotzebue, Alaska.

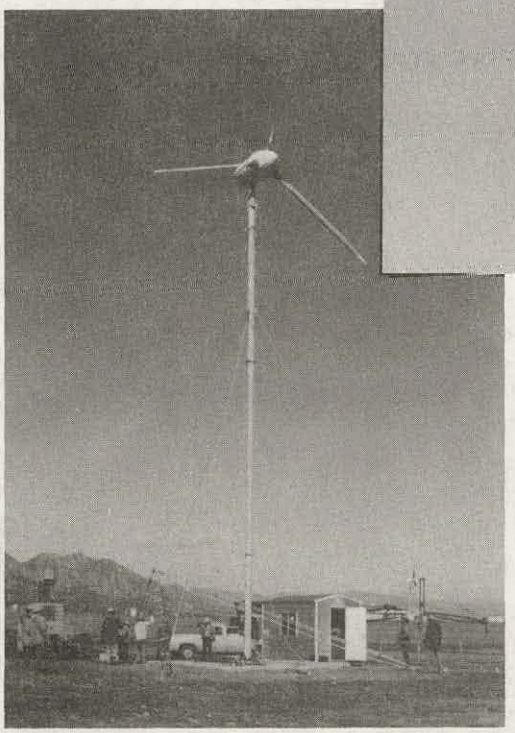
- **User Outreach**

A user outreach program was initiated in FY 1979 to provide the public with information on wind systems. Through conferences, seminars, workshops, audio-visuals, and publications the outreach program is providing the kinds of information service which will help develop the wind energy market. SERI has prepared a series of information materials including a poster introducing the DOE Federal Wind Energy Program through color photos and text describing

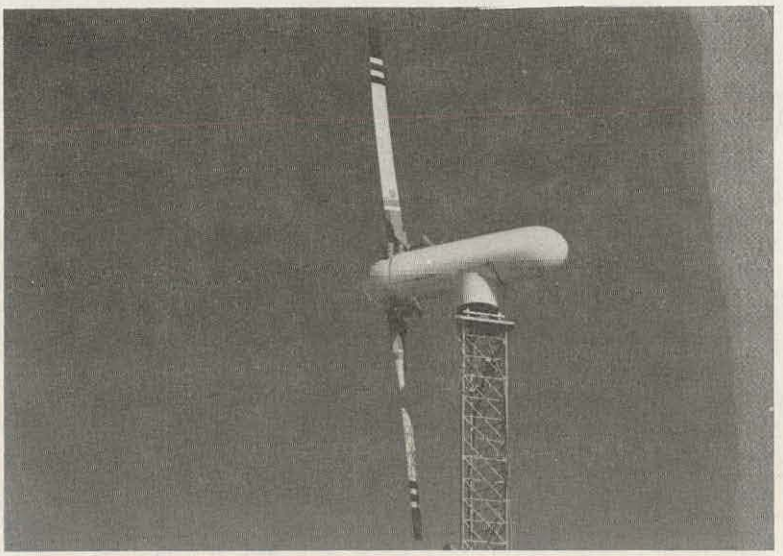


40 kW

8 kW



8 kW



1 kW

Figure 11. Small Wind Energy Conversion Systems

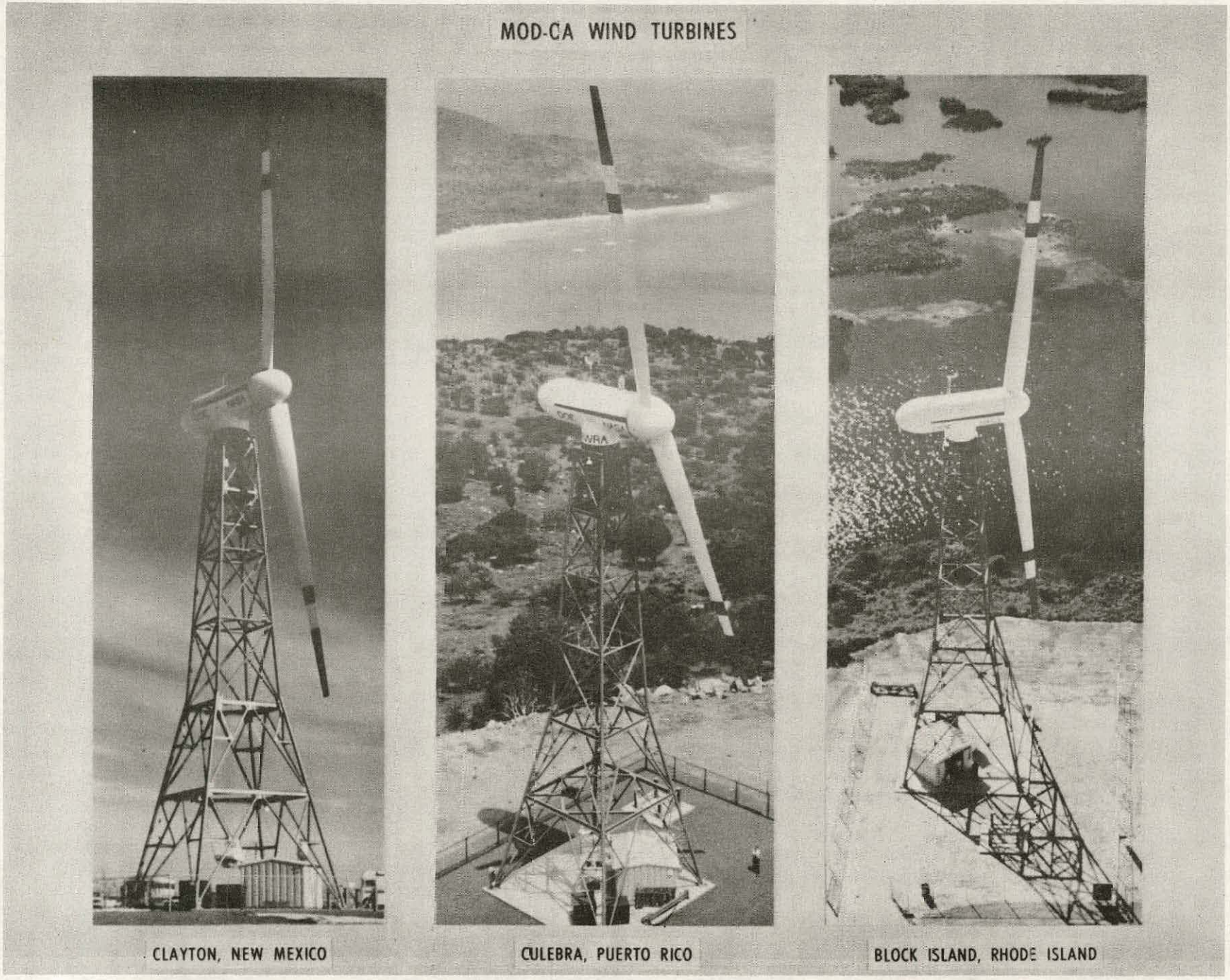


Figure 12. MOD-0A Wind Turbines, 200 kW

its field experiments; a directory of information sources for researchers, developers and users of wind systems; and a film on wind energy shown at state fairs and energy expositions across the country.

- **Workshops**

During the year, several workshops were held on research and development in wind energy conversion systems. These workshops served to facilitate the exchange of information and the transmittal of new ideas between organizations currently involved in development and assessment of wind as an alternative source of power. Of particular importance were the six specialized workshops on major wind program topics which led up to the Fourth Biennial Conference and Workshop on Wind Energy Conversion Systems in October 1979.

Table 4. Characteristics of Intermediate and Large Wind Turbines

Type	Rotor Diameter	Capacity/Rated Wind Speed (at 30 ft.)	Location	First Run
MOD-0	125 ft.	100 kW/18 mph	Plum Brook, OH	FY 1975
MOD-0A	125 ft.	200 kW/22 mph	Clayton, NM	FY 1978
			Culebra, PR	FY 1978
			Block Island, RI	FY 1979
			Oahu, HI	FY 1980
MOD-1	200 ft.	2 MW/26 mph	Boone, NC	FY 1979
MOD-2	300 ft.	2.5 MW/20 mph	Goldendale, WA	FY 1981
MOD-5	TBD*	TBD*	TBD*	FY 1983
MOD-6H	TBD*	TBD*	TBD*	FY 1983
MOD-6V	TBD*	TBD*	TBD*	FY 1983

*To be determined.

H = horizontal axis wind turbine
V = vertical axis wind turbine

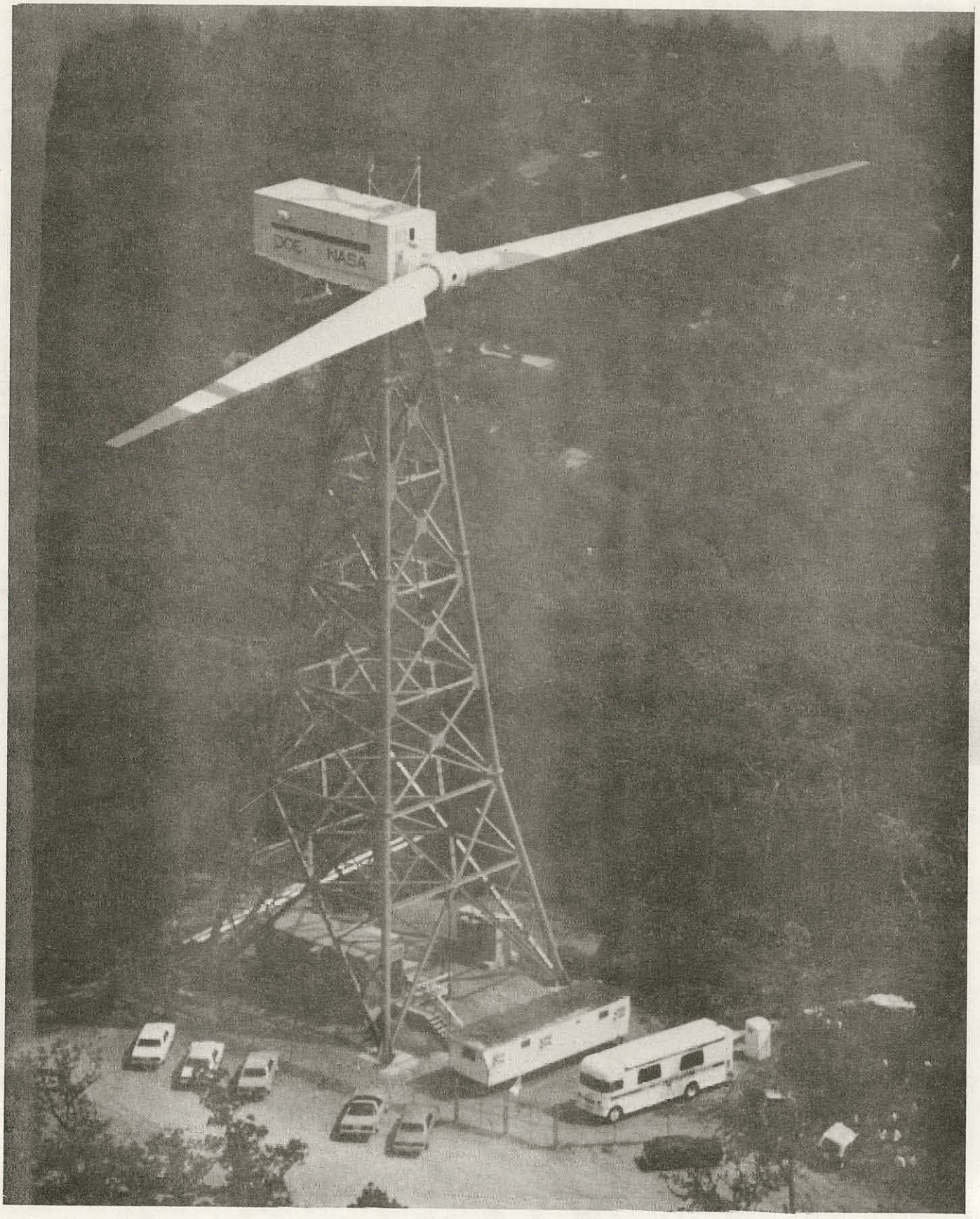


Figure 13. MOD-1 Wind Turbine, 2 mW

Figure 14. Field Evaluation Program at Epping, New Hampshire

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PART IV
FUTURE

FUTURE

During FY 1980, the Federal Wind Energy Program will continue to emphasize the development and commercialization of reliable wind systems. Technical and engineering programs, designed to increase energy conversion efficiency and to lower manufacturing costs, will lead the program towards its cost goal of 2.3 cents–3.4 cents per kWh (1980 dollars). Such costs can be competitive with conventional energy sources and will provide a solid economic base for WECS commercialization efforts. Advanced marketing research will provide a realistic picture of the market prospects for wind generated power.

In the near future, the Federal Wind Energy Program will concentrate on continued field testing of early prototype machines, development of advanced lower-cost systems and performance of necessary studies and analyses to support the approaching wide scale commercialization. The field testing will provide valuable performance data and operational experience in all system size ranges. These tests will include the four MOD-0A's, MOD-1 and, later, the three-unit cluster of MOD-2 machines. To provide the larger power requirements of utilities, and to determine the interaction and efficiency of multi-unit clusters, this first effort involving three MOD-2's will verify engineering projections of grid stability and power quality. Testing of federally sponsored small systems in the 1-2 kW, 8 kW, 15 kW and 40 kW ranges will begin at Rocky Flats, later moving into field testing in various applications. Commercially available machines and privately developed prototypes will be tested at the Rocky Flats test center. State and local institutional issues will continue to be investigated through the Field Evaluation Program by installing over 100 small wind systems at various sites across the country and in U.S. territories.

New programs for the development of more advanced, lower-cost systems are planned. Three contracts for the design and development of 4 kW machines will begin in the near future. Rocky Flats will assess the need for further systems development and product improvement. Advanced designs of the small machines will be competitively selected for applications which range from remote communication stations through residential use to large farms or small businesses and factories. Two competitive contracts are planned for the design and development of the third-generation large scale system, designated MOD-5. Similar competitive contracts are planned for a second-generation intermediate scale system designated MOD-6, one of which is to be a horizontal axis machine and the other a vertical axis machine. If successful, the MOD-5 will be the last planned large-scale horizontal axis development project of the federal program. Further market definition will be required before the need for a third-generation intermediate scale system can be determined.

Also, in the near future, performance, testing and safety standards will become better defined through industry consensus. For the potential user, pertinent and accessible public information about WECS will be forthcoming from the offices associated with the wind power development effort. In early FY 1981, regional atlases prepared from detailed wind resource assessments of the United States and its territories will be completed.

The growing potential of wind energy is receiving increased recognition within both the public and private sectors. Other federal agencies, such as the Department of Defense and the Water and Power Resources Service, formerly Bureau of Reclamation, are helping to sponsor interagency programs. For example, a more comprehensive evaluation of wind power's contribution to national defense will begin in FY 1980 through support of the land-based MX missile system. The Water and Power Resources Service is examining a combined wind and hydropower project. Additional interagency programs are being developed. In the private sector, an increased number of firms are developing or improving their own machines. New firms are being formed to sell wind generated electricity to utilities, reflecting the favorable regulations and tax incentives recently established by Congress. Collectively these public and private sector activities will further the growth of production capacity within the wind industry and create greater awareness and acceptance of wind systems by the general population.

As a reliable, safe and cost-effective wind technology emerges, the Federal Wind Energy Program will intensify its market and industry infrastructure development efforts. With a decreasing emphasis on research and development, the program expects to employ limited demonstrations to acquaint a wider group of users with the potential of wind systems and to support a market for early production capacity. Eventually, the demonstrations will be phased out in favor of a more cost-effective incentives program to stimulate a self-sustaining market and permanent large-scale production facilities.

The President's Domestic Policy Review estimated that about 1.7 quadrillion BTUs per year could be supplied by wind systems by the year 2000. In many respects then, these are the pioneering years which will lead towards the achievement of the national goals and an informed and active market for efficient, quality machines capable of harnessing the power of the wind. The Federal Wind Energy Program, in this effort, will continue to support and encourage the development of reliable low-cost machines that are compatible with the environment and to stimulate and support the development of the market and industry.

PART V
WIND ENERGY PROJECTS — FY 1979

WIND ENERGY PROJECTS—FY 1979

The projects identified in the tables and summaries which follow were initiated or renewed by the Federal Wind Energy Program between October 1, 1978, and September 30, 1979. They constitute the major research and development efforts undertaken during that period, but do not include minor program support work. The funding levels refer to FY 1979 funding only.

Many projects initiated in previous years were continued through FY 1979. Earlier editions of the Program Summary should be consulted for further details about these projects. These editions are available to the general public.

Program Summary 1975

Energy Research and Development Administration. *Federal Wind Energy Program, Summary Report,* October 1975, Document No. ERDA-84, NTIS.

Program Summary 1976

Energy Research and Development Administration. *Federal Wind Energy Program, Summary Report,* January 1977, Document No. ERDA-77-32, Stock No. 060-000-00048-4, Superintendent of Documents.

Program Summary 1977

Department of Energy. *Federal Wind Energy Program, Program Summary,* January 1978, Document No. DOE/ET-023/1, Stock No. 061-00-00050-0, Superintendent of Documents.

Program Summary 1978

Department of Energy, *Wind Energy Systems Program Summary,* December 1978, Document No. DOE/ET-0093, Superintendent of Documents.

FY 1979 SUMMARY

PLANNING, MANAGEMENT AND ANALYSIS (1.0)*

The objectives of this program element are to provide analyses, assessments, models, and studies, and to support decision makers at consumer, distributor, manufacturer, financial, regulative, administrative and legislative levels. The primary thrust of the 1.0 area is the reduction of uncertainties which may act as barriers to wind energy commercialization.

ECONOMIC ANALYSES (1.1)

The objective of this sub-element is to perform economic analyses which define the potential for user acceptance of wind systems as a function of economic factors, applications, and operational environments.

Organization	Project	Contribution
Regional Systems Service Group (Page 51)	An Economic Analysis of the Impact of Dispersed Wind Turbine Generators on the Operation of a Rural Electric Distributor Cooperative.	Assess the value of WECS on rural (cooperative) systems both for individual ownership and utility ownership.
Lead Laboratory		
Solar Energy Research Institute (Page 52)	Economics of SWECS Tied to the Utility	Investigate the economics of user owned, on site, SWECS with utility backup and provide a guide for the technical evaluation of SWECS applications to electrical utility grids.
• (Page 53)	Selected Utilities Value Analyses	Provide WECS value analysis studies for selected utilities of the U.S.
• (Page 54)	Utility Analytical Modeling	Develop computer programs and methodology needed to perform electric utility value analyses of WECS.
Lead Agency		
U.S. Department of Agriculture		
Subcontractors:		
Development Planning & Research Associates (Page 55)	Agricultural Wind Energy Applications	Estimate the extent to which wind energy can be exploited in agriculture.
SW Research and Development Co. (Page 56)	Economic Analysis of Irrigation Pumping	Obtain estimates of the size and cost of wind-powered irrigation systems.
Tetra Tech, Inc. (Page 57)	Economic Analysis of Wind-Powered Grain (Crop) Drying	Obtain estimates of the sizes and cost of a wind-powered grain drying system.

*With the completion of the decentralized management approached described on page 4, contracts issued in the past by DOE headquarters are in the process of being transferred to and/or having technical management performed by the lead laboratories and agencies.

OPERATIONS AND APPLICATIONS REQUIREMENTS (1.2)

The objective of this sub-element is to perform analyses of operational techniques and equipment requirements which are most suited to the various wind system applications.

Organization	Project	Contribution
University of Tennessee (Page 58)	Power Systems Aspect of Multi-Unit Wind Systems	Review technical information of DOE contractors investigating wind machines and the utility interface.
Tennessee Valley Authority (Page 59)	Analysis of the Operation of an Electric Power System with and without Wind Generation	Assess impact of significant amounts of wind generation on electric power systems.
Lead Laboratory		
Solar Energy Research Institute (Page 60)	A Comprehensive Guide: WECS Connected to Electric Utilities	Provide a comprehensive, consolidated, source of information on WECS as it relates to electric utilities.

INSTITUTIONAL/ENVIRONMENTAL ANALYSIS (1.3)

The objectives of this sub-element are to identify institutional and environmental factors which can influence wind systems commercialization and to specify means to remove barriers and to benefit from advantages where appropriate.

Organization	Project	Contribution
University of Michigan (Page 61)	Electromagnetic Interference by Wind Turbines – Siting Handbook	Provide handbook to characterize the impact of wind turbines on the range of electromagnetic signals and provide guidance in siting to evaluate and avoid these effects.
Lead Laboratory		
Solar Energy Research Institute (Page 62)	Environmental Impact Assessment of Small Wind Energy Conversion Systems	Identify and analyze the life-cycle environmental impacts of manufacturing, deploying and decommissioning small wind machines (SWECS).
• (Page 63)	Noise Measurements at Selected Wind System Sites	Systematically measure and document the noise generated by wind turbines and relate the measurements, their analyses, and appropriate regulations in a handbook suitable for future siting of wind turbines.
• (Page 64)	Television Interference and WECS	Technical management of the University of Michigan subcontract.
• (Page 65)	Products Liability Issues Associated with SWECS	Identify product liability issues which may inhibit commercialization of SWECS and develop policy alternatives.

PROGRAM DEVELOPMENT/PLANNING (1.4)

The objective of this sub-element is to provide for planning and program development needs at the federal and state government levels.

Organization	Project	Contribution
Raytheon Service Company (Page 66)	Technical Management Support of the Federal Wind Energy Program	Provide technical management functions such as planning, specifying, coordinating, monitoring, and reporting the activities of contractors and users.
Lead Laboratory		
Solar Energy Research Institute (Page 67)	Program Planning and Administration	Develop plans and coordinate the efforts of the SERI Wind Energy System program.

WIND CHARACTERISTICS (2.0)

The objective of this program element is to provide wind characteristics information that directly affects the siting, reliability, operation and economics of both large and small wind systems.

WIND ENERGY PROSPECTING (2.1)

The objectives of this sub-element are to analyze the potential for wind energy and identify favorable regions at the meso- and micro-scales; and to devise and implement strategies for the selection of specific sites for installing wind energy systems.

Organization	Project	Contribution
Lead Laboratory		
Pacific Northwest Laboratory (Page 69)	Coordination of Regional Analyses	Coordinate the production of wind resource assessments for eleven regions of the United States and its territories.
• (Page 70)	Northwest Analysis Prototype for Determining Wind Energy Potential	Develop techniques for assessing wind energy potential over large regions.
• (Page 71)	Climatological Adjustment of Short Term Wind Statistics	Apply climatological data and statistical theory to evaluation of data for WECS sites.
• (Page 72)	Coordinate and Interpret Model Verification	Evaluate accuracy of numerical models for wind field simulation.
• (Page 73)	Evaluation of Inexpensive Meteorological Instrumentation	Identify, test, and evaluate inexpensive wind instrumentation.
• (Page 74)	International Model Verification	Evaluate accuracy of numerical models over complex terrain.

Organization	Project	Contribution
Lead Laboratory (cont'd)		
• (Page 75)	Large WECS Siting Handbook	Produce handbook of methodology for wind turbine siting.
• (Page 76)	Siting Course for Small WECS	Prepare short course to assist potential SWECS owners in siting.
• (Page 77)	Update Small WECS Handbook	Revise publication: *A Handbook for Siting Small Wind Energy Conversion Systems.*
Subcontractors:		
University of Alaska (Page 78)	Alaska Regional Assessment	Provide regional assessment for Alaska.
University of Virginia (Page 79)	Coastal Zone Wind Energy	Determine the coastal zone wind energy potential from Maine to Texas and provide guidelines for determining favorable wind sites in coastal areas.
Marlatt and Associates (Page 80)	Coordination of Large Area Analysis – National Fire Weather Data Library	Develop procedure for using National Fire data to estimate wind energy in Forest Service regions.
University of Hawaii (Page 81)	Hawaii and Pacific Trust Territories Regional Assessment	Produce regional assessment of wind data.
North American Weather Consultants (Page 82)	Innovative Techniques for Identifying and Screening Potential Wind Energy Conversion Sites	Obtain quantitative estimates of long-term wind data in data-sparse areas.
University of Wyoming (Page 83)	Locating Areas of High Winds by Remote Observations	Determine the feasibility of identifying high wind sites from satellite imagery.
Geomet, Inc. (Page 84)	Northeast Regional Assessment	Produce regional assessment of wind data.
Global Weather Consultants (Page 85)	Southwest Regional Assessment	Produce regional assessment of wind data.
University of Texas (Page 86)	Wind Power Potential in a Coastal Environment	Further knowledge of wind energy potential in the Western gulf coast region.
Aerovironment, Inc. (Page 87)	Assessing the Local Wind Field with Instrumentation	Identify cost effective measurement systems for WECS sites.
New Mexico State University (Page 88)	Assessing the Local Wind Field with Instrumentation	Identify cost effective measurement systems for WECS sites.

Organization	Project	Contribution
Subcontractors (cont'd)		
Science Applications, Inc. (Page 89)	Numerical Model Verification	Use and verify mathematical models for wind field estimation.
Colorado State University (Page 90)	Sites for Wind-Power Installations	Compare data from physical model to field data.
Northwestern University (Page 91)	Stochastic Modeling of Site Wind Characteristics	Develop and apply wind turbine site evaluation techniques using probabilistic models and statistical methods.
FWG Associates, Inc. (Page 92)	Technology Development for Assessment of Small-Scale Terrain Effects on Available Wind Energy	Characterize the effects of micro-scale terrain features on near-surface wind.
Oregon State University (Page 93)	Vegetation as an Indicator of High Wind Velocities	Determine the feasibility of using wind deformation of vegetation as an indicator of mean wind velocity.
Flow Industries, Inc. (Page 94)	Wind Turbine Wake Flow	Determine technical issues in wind farm wake effects and how to model them.

SUPPORT FOR DESIGN AND OPERATIONS (2.2)

The objectives of this sub-element are to: analyze the direct interaction between meteorological phenomena and a wind system; characterize the environment by studying aspects of the flow in the atmosphere; recommend meteorological instrumentation, data collection and techniques for testing wind systems; identify specific wind forecasting needs for potential wind system users; and determine if current forecasting techniques are suitable for meeting the users needs.

Organization	Project	Contribution
Lead Laboratory		
Pacific Northwest Laboratory (Page 95)	Environmental Design Criteria for WECS	Provide new or improved wind characteristics information.
• (Page 96)	Flow Through a Vertical Plane	Characterize flow field in the disk of rotation of a WECS.
• (Page 97)	International Forecast Verification Program	Define criteria, provide wind forecasts, and observations for verification scheme.
• (Page 98)	Upgrade-Specialized Wind Forecasts	Upgrade or tailor wind forecasting techniques to meet needs of WECS users.
• (Page 99)	Wind Forecast Verification	Determine reliability at existing wind forecasting technology for 24-hour period.

Organization	Project	Contribution
Lead Laboratory (cont'd)		
• (Page 100)	Wind Characteristics at Singular Topographic Features	Characterize wind at singular topographic features such as mountains or ridges.
Subcontractors:		
NOAA/Wave Propagation Laboratory (Page 101)	Characteristics of Strong Down-Slope Wind	Provide experimental measures and statistical analyses of gust amplitudes.
FWG Associates, Inc. (Page 102)	Error Band Analysis	Evaluate statistical parameters for estimating wind characteristics from meteorological data.
Oregon State University (Page 103)	Measurement Methods for Performance Evaluation	Provide methods for measuring and analyzing wind near a WECS for performance evaluation.
Colorado State University (Page 104)	Measurement Methods for Performance Evaluation	Provide methods for measuring and analyzing wind near a WECS for performance evaluation.
Virginia Polytechnic Institute (Page 105)	Meteorological Guidelines for WECS Design	Develop reference documents for estimating atmospheric characteristics for WECS design.
Desert Research Institute (Page 106)	Meteorological Guidelines for WECS Design	Develop reference documents for estimating atmospheric characteristics for WECS design.
Science Applications Inc. (Page 107)	Physical Analysis of Wind Speed Distribution Functions	Provide method for estimating the probability density function for hourly mean wind speeds.
Pennsylvania State University (Page 108)	Turbulence Characteristics Over Non-Uniform Terrain	Develop model relating wind fluctuation to parameters such as surface roughness, atmospheric stability and mixing depth.
Georgia Institute of Technology (Page 109)	Turbulence Effects on WECS Output	Evaluate turbulence effects on wind turbine performance as well as monthly and annual variations in mean wind speed.
Western Scientific Services, Inc. (Page 110)	Wind Characteristics at Singular Topographic Features	Characterize wind at singular topographic features such as mountains or ridges.
Oregon State University (Page 111)	Wind Shear in the Nocturnal Boundary Layer	Determine the statistics of strong nocturnal wind shears.
NOAA – Technique Development Laboratory (Page 112)	Development of Wind Forecasts for WECS Operations by MOS	Examine reliability of deterministic and probabilistic forecasts.
Weather Services Corp. (Page 113)	Historical Subjective Forecasting	Produce and evaluate subjective wind forecasts.

Organization	Project	Contribution
Subcontractors (cont'd)		
Accu-Weather (Page 114)	Real-Time Subjective Wind Forecasts	Produce and evaluate subjective wind forecasts using only data normally available to a forecaster.
Freeze-Notis (Page 115)	Real-Time Subjective Wind Forecasts	Produce and evaluate subjective wind forecasts using only data normally available to a forecaster.
General Weather Center (Page 116)	Real-Time Subjective Wind Forecasts	Produce and evaluate subjective wind forecasts using only data normally available to a forecaster.
Global Weather Services (Page 117)	Real-Time Subjective Wind Forecasts	Produce and evaluate subjective wind forecasts using only data normally available to a forecaster.
Murray & Trettel (Page 118)	Real-Time Subjective Wind Forecasts	Produce and evaluate subjective wind forecasts using only data normally available to a forecaster.
Simpson Weather Associates (Page 119)	Wind Characteristics for Solar-Wind Desalting	Evaluate feasibility of wind energy to assist in solar desalting to obtain potable water.

SITE EVALUATION (2.3)

The objectives of this sub-element are to: measure, analyze, and evaluate wind characteristics at potential candidate and turbine sites; install meteorological measuring equipment; and assist DOE in site selection process.

Organization	Project	Contribution
Lead Laboratory		
Pacific Northwest Laboratory (Page 120)	Data Analysis and Reporting	Develop data analysis procedures for use in site selection and R&D efforts.
• (Page 121)	Evaluation of Wind Turbine Installation Sites	Identify pertinent meteorological characteristics and develop fast response measurement programs to quantify.
• (Page 122)	Support to DOE's Selection of New Candidate Wind Turbine Sites	Provide technical assistance to DOE in preparing Program Opportunity Notices and selecting sites.
• (Page 123)	Support to DOE's Turbine Installation Site Selection Program.	Support DOE's wind turbine site selection process.

Organization	Project	Contribution
Subcontractors:		
SRI International (Page 124)	Estimating Wind Characteristics at Candidate Sites	Refine and validate previously developed numerical wind flow model which uses nearby National Weather Service data.
Environmental Systems Corp. (Page 125)	Meteorological Measurements at Candidate Sites/Metcorological Measurements at Wind Turbine Sites	Obtain sufficient wind data to accurately assess sites.

TECHNOLOGY DEVELOPMENT (3.0)

The objective of this program element is to improve the performance and lower the cost of wind systems and their mechanical and electrical components.

SMALL SYSTEMS TECHNOLOGY (3.1)

The objective of this sub-element is technology development of wind systems with power ratings of 100 kW or less.

Organization	Project	Contribution
Lead Laboratory		
Rocky Flats Plant (Page 127)	Technical and Management Support for the Development of Small Wind Systems	Develop and test small wind systems to increase performance and reliability and reduce their costs.
• (Page 128)	Rocky Flats Small Wind Systems Test Center	Establish, develop and operate a test facility for small wind systems.
• (Page 129)	SWECS Noise Assessment	Measure and evaluate impacts of noise from small wind systems.
• (Page 130)	SWECS – Rotor Wake Investigations	Measure the wake around a horizontal-axis wind turbine.
• (Page 131)	Synthesis of Tower Dynamics Analysis Methods	Identify and evaluate available structural dynamics computer codes.
• (Page 132)	Tower Dynamics Response Characteristics	Develop data base on tower vibration.
Subcontractors:		
Systems Control, Inc. (Page 133)	Dispersed Small Wind Systems Interconnected with a Utility Distribution System	Identify the concerns and impacts of SWECS interconnected with utility systems.
New Alchemy Institute (Page 134)	Matching SWECS Rotor Capabilities to Driven Loads	Provide design criteria for matching rotor output to a given load.

Organization	Project	Contribution
Lead Agency		
U.S. Department of Agriculture (Page 135)	Program Management, Rural and Remote Areas of Wind Energy Research	Develop plans, manage projects, report on progress of rural and remote agricultural program area.
• (Page 136)	Dairy Milk Cooling/Water Heating – Feasibility Study	Evaluate wind turbine used in direct drive to a heat pump.
• (Page 137)	Evaluation of Pumps for Wind-Driven Irrigation Proof-of-Concept Experiment	Provide guidance for windmill and pump manufacturers on pump development.
• Wind Erosion Laboratory (Page 138)	Low Lift Pumping Proof-of-Concept Experiment	Provide data and operational characteristics of a wind-powered, low lift irrigation pump.
• Southwestern Great Plains Research Center (Page 139)	Wind-Powered/Engine Powered Hybrid-Drive Pumping Proof-of-Concept Experiment	Develop design criteria, performance and cost data for hybrid systems.
Subcontractors:		
Virginia Polytechnic Institute (Page 140)	Apple Storage Cooling Proof-of-Concept Experiment	Provide information on the practicality of using wind power for apple storage cooling.
Cornell University (Page 141)	Direct Hydraulic Dissipation to Heat Proof-of-Concept Experiment	Evaluate system converting wind power to heat through hydraulic dissipation.
Iowa State University (Page 142)	Wind-Powered Farmhouse Heating Proof-of-Concept Experiment	Measure performance to ascertain the economic value of wind power for heating farm structures.
Colorado State University (Page 143)	Wind-Powered Heat Pump in a Dairy Operation	Determine the technical and economic feasibility of a windmill-driven heat pump in a dairy operation.

INTERMEDIATE AND LARGE SYSTEMS TECHNOLOGY (3.2)

The objective of this sub-element is technology development of wind systems with power ratings between 100 kW and 1 MW.

Organization	Project	Contribution
Lead Agency		
NASA Lewis Research Center (Page 144)	MOD-0 Operations and Tests Dissemination	Operate large wind turbines to identify and resolve problems, investigate feasibility of advanced design concepts, and provide experimental data.
• (Page 145)	MOD-02-Design – Standards, Second Generation Experimental 200 kW Wind Turbine (WT)	Develop low cost 200 kW wind turbine design.

Organization	Project	Contribution
Lead Agency (Cont'd)		
• (Page 146)	One Blade Rotor for Test on MOD-0 Cost Analysis, WTG	Determine if cost of electricity can be reduced by using a one-bladed rotor.
• (Page 147)	Operating WT Evaluation – Performance – Operations – Maintenance and Reliability – Standards	Provide means for evaluating all operating wind turbines in a consistent manner.
• (Page 148)	Power Train Design – Cost Analysis	Identify drive train concepts which will result in net reduction of cost of electricity.
• (Page 149)	Teetered Tip-Controlled Rotor for MOD-0 Test Design, Evaluation, Test	Verify teetered tip control analysis techniques.
Subcontractors:		
Kaman Aerospace Corporation (Page 150)	100 Foot Fiberglass Composite Blades MOD-1-Fabricate-Test	Qualify the blade composite technology by fabricating and testing two large blades.
• (Page 151)	150-Foot Wind Turbine Blade Project Cost Analysis, Fabrication, Tests	Develop and test a 150-foot fiberglass blade.
Wichita State University (Page 152)	Analysis and Conceptual Design of Spoiler (Blade) Control – Large WTG	Determine feasibility of using spoiler and flap for control of large wind turbines.
University of Toledo (Page 153)	Analytical Services	Provide analytical support to the NASA Wind Energy Project Office.
Paragon Pacific, Inc. (Page 154)	Analytical Services	Provide analytical support to the NASA Wind Energy Project Office.
Power Technology, Inc. (Page 155)	Cluster/Grid/Farm Wind Turbine Stability Study Computer/Modeling	Provide design information for wind turbines and the utility interface.
Gougeon Brothers, Inc. (Page 156)	Low Cost Blade Design and Fabrication Contracts	Develop low cost wind turbine blade fabrication methods.
Structural Composites Industries, Inc. (Page 157)	Low Cost Blade Design and Fabrication Contracts	Develop low cost wind turbine blade fabrication methods.
The Budd Co. (Page 158)	Low Cost Blade Design and Fabrication Contracts	Develop low cost wind turbine blade fabrication methods.
IIT Research Institute (Page 159)	Low Cost Blade Design and Fabrication Contracts	Develop low cost wind turbine blade fabrication methods.

Organization	Project	Contribution
Subcontractors (Cont'd)		
EMR Telemetry, Inc. (Page 160)	Coordination Wind Energy Remote Data System Operational Data, Installation	Acquire, process, and analyze data generated during all wind turbine operations.
Purdue University (Page 161)	Wind Turbine Clusters/Grid Simulator	Investigate mechanical and electrical dynamics of wind turbine generators connected to a utility grid.

EVOLVING TECHNOLOGIES (3.3)

The objective of this sub-element is the technology development of wind systems concepts other than the horizontal-axis types.

Organization	Project	Contribution
Lead Laboratory		
Sandia Laboratories		
Subcontractors:		
Texas Tech University (Page 162)	Aerodynamic Model-VAWT-Wake-Flow-Computer-Modeling-Codes	Develop a theoretical aerodynamic model to predict experimental results for Darrieus wind turbines.
Oregon State University (Page 163)	Aerodynamic Performance Tailoring of the VAWT	Investigate relationship between aerodynamic parameters and machine economics.
Hibbitt & Karlsson (Page 164)	Develop Finite Element Analysis Structural Dynamics VAWT – Computer/Modeling	Determine vibrational response of the Darrieus turbine.
University of New Mexico (Page 165)	Guy Cable Anchor and Foundation Design	Minimize cost and improve design of vertical-axis turbine foundation and guy anchors.

INNOVATIVE CONCEPTS (3.4)

The objective of this sub-element is to: determine technical and economic feasibility of advanced and innovative wind systems; perform R&D studies supported by concept, analytical/experimental, and verification phases; and prepare recommendations and guidance as to the continuation of the development of a particular innovative system.

Organization	Project	Contribution
Grumman Aerospace Corporation (Page 166)	Tornado-Type Wind Energy Systems (Phase II)	Test a tornado-type turbine for its practicality and potential for cost competitiveness.

Organization	Project	Contribution
Polytechnic Institute of New York (Page 167)	Vortex Augmentors for Wind Energy Conversion	Determine the potential of the delta-wing vortex device for improved performance per unit cost over conventional systems.
South Dakota School of Mines and Technology (Page 168)	Energy from Humid Air	Investigate feasibility and cost-effectiveness of converting the latent heat energy in humid air into mechanical work.
University of Dayton Research Institute (Page 169)	An Analysis of the Madaras Rotor Power Plant	Evaluate comparative cost-effectiveness of Madaras and conventional horizontal axis wind turbines.
West Virginia University (Page 170)	Innovative Wind Turbines	Determine the cost and performance benefits of a vertical-axis device which features circulation control of the air-flow across its articulated rotor.
Lead Laboratory		
Solar Energy Research Institute (Page 171)	Engineering Analysis and Cost Estimating of Innovative WECS	Provide methodologies suitable for estimating life-cycle costs of an innovative wind system.
• (Page 172)	Wind Energy Innovative Systems (WEIS)	Conduct research and development studies aimed at determining technical and economic feasibility of innovative systems.
Subcontractors:		
Aerovironment, Inc. (Page 173)	A Definitive Generic Study of Augmented Horizontal Axis WES	Provide technical evaluation and economic assessment of augmented horizontal axis wind energy systems.
Tetra-Tech, Inc. (Page 174)	A Definitive Generic Study of Augmented Horizontal Axis WES	Provide technical evaluation and economic assessment of augmented horizontal axis wind energy systems.
New York University (Page 175)	A Definitive Generic Study of Augmented Vertical Axis WES	Provide technical evaluation and economic assessment of augmented vertical axis wind energy systems.
Aerovironment, Inc. (Page 176)	A Definitive Generic Study of High Lift Devices WES	Provide technical evaluation and economic assessment of high lift wind energy systems.
Washington University Technology Association (Page 177)	A Definitive Generic Study of Sail Wing WES	Provide technical evaluation and economic assessment of sail wing wind energy systems.
JBF Scientific Corporation (Page 178)	A Definitive Generic Study of Vortex Extraction WES	Provide technical evaluation and economic assessment of vortex extraction wind energy.
Aerovironment, Inc. (Page 179)	Advanced and Innovative Wind Energy Concept Development – Dynamic Inducer	Determine performance and cost effectiveness of tip vane power augmentation.

Organization	Project	Contribution
Subcontractors (cont'd)		
University of Dayton Research Institute (Page 180)	Electrofluid Dynamic (EFD) Wind Generator Program	Develop a practical configuration for the electrofluid dynamic (EFD) wind generator and determine its performance and economics.
Grumman Aerospace Corporation (Page 181)	Further Investigations of Diffuser Augmented Wind Turbines	Refine a diffuser design developed under previous efforts and provide data to allow assessment of the design's potential cost benefits.
Marks Polarized Corporation (Page 182)	Tests and Devices for Wind/ Electric Power Charged Aerosol Generator	Characterize five methods of producing charged particles for electrofluid dynamic wind power generators.
Washington University Technology Association (Page 183)	The Yawing of Wind Turbines with Blade Cyclic Pitch	Determine the potential for wind energy conversion using a horizontal axis rotor with blade cyclic pitch variation.
United Technologies Corporation (Page 184)	Oscillating Vane Concept	Evaluate the feasibility of the oscillating vane concept as applied to wind energy conversion.

ENGINEERING DEVELOPMENT (4.0)

The objective of this program element is to design, fabricate and test a series of progressively more advanced experimental wind systems with improved capabilities leading to systems capable of being commercially produced by industry.

SMALL SYSTEMS DEVELOPMENT (4.1)

The objective of this sub-element is to develop and test complete wind energy systems with a power rating of 100 kW or less.

Organization	Project	Contribution
Aluminum Company Of America (Page 185)	Low Cost Vertical-Axis Wind Turbine Fabrication	Obtain low cost machines for testing and detailed fabrication and cost data.
Lead Laboratory		
Rocky Flats Plant		
Subcontractors:		
Aerospace Systems, Inc. and Pinson Energy (Page 186)	Development of a 1 kW High Reliability Wind Turbine Generator	Develop and test 1-2 kW designs and determine their costs, performance and durability.
Enertech (Page 187)	Development of a 2 kW High Reliability Wind Machine	Develop and test advanced 2 kW designs and determine their costs, performance and durability.

Organization	Project	Contribution
Subcontractors (cont'd)		
North Wind Power Company (Page 188)	Development of a 2 kW High Reliability Wind Machine	Develop and test 2 kW designs and determine their costs, performance and durability.
Aluminum Company of America (Page 189)	8 kW Wind Turbine Generator Development	Develop and test 8 kW wind turbine designs and determine their costs, performance and durability.
Grumman Corporation (Page 190)	8 kW Wind Turbine Generator Development	Develop and test 8 kW wind turbine designs and determine their costs, performance and durability.
United Technologies Research Center (Page 191)	8 kW Wind Turbine Generator Development	Develop and test 8 kW wind turbine designs and determine their costs, performance and durability.
Windworks, Inc. (Page 192)	8 kW Wind Turbine Generator Development	Develop and test 8 kW wind turbine designs and determine their costs, performance and durability.
Enertech (Page 193)	Development of a 15 kW Wind Turbine Generator	Develop and test 15 kW wind turbine designs and determine their costs, performance and durability.
United Technologies Research Center (Page 194)	Development of a 15 kW Wind Turbine Generator	Develop and test 15 kW wind turbine designs and determine their costs, performance and durability.
Kaman Aerospace Corporation (Page 195)	Development of a 40 kW Wind Turbine Generator	Develop and test advanced 40 kW designs and determine their costs, performance and durability.
McDonnell-Douglas Aircraft Corporation (Page 196)	Development of a 40 kW Wind Turbine Generator	Develop and test advanced 40 kW designs and determine their costs, performance and durability.

INTERMEDIATE SYSTEMS DEVELOPMENT (4.2)

The objective of this sub-element is to develop and test complete wind energy systems with a power rating between 100 kW and 1 MW (1000 kW).

Organization	Project	Contribution
Lead Agency		
NASA Lewis Research Center (Page 197)	Design, Fabricate, Test Advanced, Multi-Purpose, Medium Scale Wind Turbine: MOD-6 H	Develop design and validate performance of medium size wind turbine.
• (Page 198)	Design, Fabricate, Test Advanced Multi-Purpose, Medium Size Wind Turbine: MOD-6 V	Develop design and validate performance of medium size wind turbine.

Organization	Project	Contribution
Subcontractors:		
Westinghouse Electric Corporation, Lockheed Aircraft Corporation, Gougeon Brothers, Inc. (Page 199)	Field Tests Experimental 200 kW Wind Turbine Designs (MOD-0A Project)	Provide manufacturing and field test data to determine machine operating performance and dynamic characteristics of large utility-based wind systems.
Cooperating Utilities:		
Town of Clayton, New Mexico	MOD-0A	Provide information on wind turbine operational performance, reliability, electrical system stability and control requirements in utility systems applications.
Block Island Power Company, Block Island, Rhode Island	MOD-0A	
Puerto Rico Water Resources Authority, Island of Culebra, Puerto Rico	MOD-0A	
Hawaiian Electric Company, Oahu, Hawaii	MOD-0A	

LARGE SYSTEMS DEVELOPMENT (4.3)

The objectives of this sub-element are to develop and test complete wind energy systems with a power rating of 1 MW (1000 kW) or larger.

Organization	Project	Contribution
Lead Agency		
NASA Lewis Research Center (Page 200)	Design, Fabricate, Install Advanced Multi-Megawatt Wind Turbine – AMMWT (MOD-5)	Determine manufacturing requirements and operational characteristics, and provide information on the feasibility of a multi-megawatt wind turbine.
Subcontractors:		
General Electric Company (Page 201)	Field Tests of Experimental 2 MW Wind Turbine Design (MOD-1 Project)	Determine manufacturing requirements and operational characteristics, and provide information on the feasibility of a utility-intertied megawatt-scale wind turbine.

Organization	Project	Contribution
Cooperating Utility:		
Blue Ridge Electrical Membership Corporation, Boone, North Carolina	MOD-1	Provide information on large wind turbine components and systems operational performance, electrical system stability and control requirements in a utility system application.
The Boeing Engineering and Construction Company (Page 202)	Design, Fabricate, and Test Three Experimental 300-Foot Diameter Wind Turbines (MOD-2 Project)	Provide information on the practicality of using 300-foot diameter rotors to increase cost-effectiveness at moderate wind sites and identify and solve problems associated with constructing turbines of this size.
Cooperating Utility:		
Bonneville Power Administration Portland, Oregon	MOD-2	Provide information on large wind turbine components and systems operational performance, electrical system stability and control requirements in a utility system application.

IMPLEMENTATION AND MARKET DEVELOPMENT (5.0)

The objective of this program element is to implement consumer supports, outreach programs, and consumer-oriented field evaluations of system performance which capture and accelerate private and institutional sector interest (measured by sales of wind systems) while supporting manufacturer growth and capitalization in the early commercialization years.

SMALL SYSTEM IMPLEMENTATION AND MARKET DEVELOPMENT (5.1)

The objective of this sub-element is to manage a field evaluation and market development program for systems with a power rating of 100 kW or less.

Organization	Project	Contribution
Lead Laboratory		
Rocky Flats Plant (Page 203)	Field Evaluation Program	Coordinates and manages the small wind energy conversion systems field evaluation program.
Subcontractors:		
JDB and Company (Page 204)	Financial Problems Facing the Manufacturer of Small Wind Energy Conversion Systems	Identify and assess issues affecting availability of venture capital and loans to SWECS manufacturers.
Windworks (Page 205)	Review of SWECS Interconnected with Utility Networks	Determine and report on technical and institutional problems of SWECS integrated into a utility network.

Organization	Project	Contribution
Lead Laboratory		
Solar Energy Research Institute		
Subcontractor:		
American Wind Energy Association (Page 206)	(Wind Energy TID) Capital Formation and the SWECS Industry	Familiarize SWECS manufacturers and the financial community with issues of capital acquisition.

USER OUTREACH PROGRAM (5.4)

The objectives of this sub-element are to disseminate information on all aspects of wind systems to all potential user-sectors, e.g., public, private, utility, state and federal governments, etc., and to promote increased user-awareness.

Organization	Project	Contribution
Lead Agency		
U.S. Department of Agriculture (Page 207)	USDA Extension Circular – *Wind Power and Windmills*	Provide information needed by the farmer to select and size a water pumping windmill or wind powered electric generator.
• (Page 208)	USDA Production Research Report: *Agricultural Use of Wind Power*	Communicate program results to potential equipment manufacturers and the agricultural industry.
• (Page 209)	USDA Program Aid: *USDA-DOE Research on Use of Wind Power*	Communicate program results to the general public.
• (Page 210)	USDA Film – *Gusts of Power*	Communicate program results to the agricultural industry and general public.
Subcontractor:		
Iowa State University (Page 211)	1979 Workshop on Wind Energy Applications in Agriculture	Present findings of research program to date and obtain recommendations concerning future work.
Lead Laboratory		
Solar Energy Research Institute (Page 212)	Wind Energy Technical Information Dissemination	Make results of the federal R&D program available to a wider-audience.
Subcontractor:		
Regional Systems Service Group (Page 213)	(Wind Energy TID) Planning Guide for Community	Bring existing information for DOE reports together into a readable guide for communities considering wind energy.

1.0 PLANNING, MANAGEMENT AND ANALYSIS PROJECT SUMMARIES

1.1 ECONOMIC ANALYSES

CONTRACTOR	TITLE
Regional Systems Service Group 5680 South Syracuse Circle Suite 514 Englewood, CO 80111	An Economic Analysis of the Impact of Dispersed Wind Turbine Generators on the Operation of a Rural Electric Distributor Coop.
	CONTRACT NO. DE/ACOI-79-ET-23067
PRINCIPAL INVESTIGATOR Wayne Stafford	**PERIOD OF PERFORMANCE** April 1979 - April 1980
WORK LOCATION Englewood, Co.	**FISCAL YEAR 1979 FUNDING** $140,000
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Dean Nordman - SERI	**CUMULATIVE FUNDING** $140,000

PROJECT SUMMARY

OBJECTIVE

Small and large WECS are to be studied to assess the value of WECS on rural (cooperative) type systems both for individual ownership and utility ownership.

APPROACH

RSSG has developed a methodology to determine the wind energy available for the rural electric system and the value of WECS given the assessment of available energy. SERI is serving as technical manager.

OUTPUT

RSSG has developed tools to approximate wind energy. A preliminary cut on the economic structure for the rural system has been completed. The total effort is comprised of eight tasks.

By the end of FY 1979, the first two tasks were completed and approximately one-third of each of the remaining six tasks had been performed. Study completion is expected in March 1980, and a draft final report in April 1980. Results of first two tasks indicate that individually owned WECS appear economic, assuming life-cycle economics and the achievement of DOE technology goals.

1.1 ECONOMIC ANALYSES

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	Economics of SWECS Tied to the Utility
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Michael Edcsess/Irwin E. Vas	**PERIOD OF PERFORMANCE** October 1978 - December 1979
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $120,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $120,000

PROJECT SUMMARY

BACKGROUND

User owned small wind energy conversion systems (SWECS) with utility backup will have an economic effect on the user and the utility. A tool to determine the value of these SWECS when tied to the utility is needed.

OBJECTIVE

The objective of this task is to investigate the economics of the user-owned, on-site SWECS with utility backup and provide a useful guide for the technical evaluation required for the application of SWECS to electrical utility grids.

APPROACH

The study will analyze the effect of the substitution of SWECS power for conventional purchased electrical power on the rate of return on investment for a hypothetical electricity user.

OUTPUT

A report analyzing the economic impact on the end-user of the substitution of SWECS generated electricity for some of the electricity which would otherwise be purchased from the utility grid.

1.1 ECONOMIC ANALYSES

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	Selected Utilities Value Analysis
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR George Fegan/Irwin E. Vas	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Golden, CO.	**FISCAL YEAR 1979 FUNDING** $500,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO.	**CUMULATIVE FUNDING** $500,000

PROJECT SUMMARY

BACKGROUND

DOE and EPRI have funded utility value analysis studies on a few utilities in the U.S.

OBJECTIVES

The objective is to perform WECS value analysis studies for selected utilities of the U.S. The utilities containing the 16 candidate sites for the DOE large experimental wind turbines have been selected as the initial candidates for the study. Additional sites may be selected in the future.

APPROACH

Phase 1: 2 subcontracts will be let to perform the utility value analyses. Each site will be studied by one of the subcontractors. To compare results and methodology, 2 of the 16 utility systems will be studied by both the subcontractors and by SERI.

Phase 2: Value analysis studies for additional utilities will be done in a manner similar to that of Phase 1.

OUTPUT

Phase 1: Each subcontractor will report on data utilized, methodology and results obtained for each of the utility systems studied.

SERI will compare methodologies and results used by each contractor and by SERI for the two common utility systems studies.

Appropriate portion of results or conclusions will be included in the "Utility Planning Handbook".

Phase 2: Similar reports will be produced for the additional systems studies.

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	Utility Analytical Modeling
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR David Percival/Irwin E. Vas	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $145,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $145,000

PROJECT SUMMARY

BACKGROUND

Several computer models exist that convert wind resource data to electric energy (wind models). An evaluation and initial assessment of these codes are to be performed.

OBJECTIVES

The objective is to develop the computer programs and methodology needed to perform electric utility value analyses of WECS.

APPROACH

Acquisition of the basic codes and development of the wind methodology commenced in FY 1979 and is planned for completion in FY 1980. Critical evaluation of the codes is to be carried out and selection and enhancement of one of the wind models is to be performed.

OUTPUT

- State of art code which meets above objective, available to WECS evaluation.
- Wind model and methodology manuals and codes suitable for dissemination to industry, governments and public.
- Appropriate portions of this information will be included in the "Utility Planning Handbook".

1.1 ECONOMIC ANALYSES

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Development Planning and Research Assoc. Post Office Box 727 Manhattan, Kansas	Agricultural Wind Energy Applications
	CONTRACT NO. E-76-A-29-1026
PRINCIPAL INVESTIGATOR R. Buzenberg	**PERIOD OF PERFORMANCE** 1977 - 1979
WORK LOCATION Manhattan, Kansas	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $185,000

PROJECT SUMMARY

BACKGROUND

Agriculture is expected to be a major beneficiary of small wind power systems. Consequently, it would be of value to manufacturers, farmers, and federal research planners to know what sizes of wind power systems would be best for farm use and what conditions would make them economical. The wide variations which exist in types of farms and their power usage, as well as the seasonal and geographical variation in wind power availability, make this estimation a complex task.

OBJECTIVES

The objective is to estimate the extent to which wind energy can be exploited in agriculture, identify specific applications that are the most feasible, and estimate the windmill sizes most likely to be used in various enterprises.

APPROACH

All of the major energy and power-using operations in agriculture were reviewed for major types of agricultural enterprises to estimate the cost of substituting wind power and wind energy for the power and energy source now used. The general procedure was to select a discrete wind turbine size which maximizes energy saving for each enterprise, given different levels of conventional energy cost.

OUTPUT

A final report was submitted to DOE for its release containing data on the sizes of wind turbines which will be most economical for farm use and estimates of the number of wind power systems which could be economically used.

1.1 ECONOMIC ANALYSES

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontactor: SW Research and Development Co. 1825 Imperial Ridge Las Cruces, New Mexico 88001	Economic Analysis of Irrigation Pumping
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR R. Landsford	**PERIOD OF PERFORMANCE** 1979 - 1980
WORK LOCATION Las Cruces, NM	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $45,000

PROJECT SUMMARY

BACKGROUND

The decision by farmers to use wind power in their operations will be strongly influenced by its economic value. This will depend on the amount and cost of energy the wind machine replaces, and the cost of the wind machine. There is a need to make a preliminary assessment of this relationship in the use of wind power for irrigation pumping.

OBJECTIVES

The objective is to obtain estimates of the size and cost of wind-powered irrigation systems which will compete with conventional power sources, given various levels of energy.

APPROACH

This will be an analytical study. Using available information on the cost of irrigation pumping in various areas and information on expected plant factors of wind-powered irrigation systems, the investigator will estimate the cost targets for wind-powered irrigation systems which will compete with conventional power sources. The cost of the present energy sources will be considered a variable in such an analysis, so the results will be expressed in terms of cost of energy from natural gas, diesel fuel, electricity, etc.

OUTPUT

A final report of the analytical study, presenting conditions for economical use of wind power for irrigation pumping, will be prepared.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Tetra Tech, Inc. 1911 Fort Meyer Drive Arlington, Virginia	Economic Analysis of Wind-Powered Grain (Crop) Drying
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR W. Garling	**PERIOD OF PERFORMANCE** 1979 - 1980
WORK LOCATION Arlington, Virginia	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $40,000

PROJECT SUMMARY

BACKGROUND

The decision by farmers to use wind power in their operations will be strongly influenced by its economic value. This will depend on the amount and cost of energy the wind machine replaces, and the cost of the wind machine. There is a need to make a preliminary assessment of this relationship in the use of wind power for crop drying.

OBJECTIVES

The objective is to obtain estimates of the size and cost of a wind-powered grain drying system which will compete with conventional energy sources, given various level of energy costs.

APPROACH

This will be an analytical study. Conceptual designs for the wind-powered units will be developed which could be substituted for the present systems. The analysis will be based on previously reported research on crop drying and storage systems, such as use of refrigeration or unheated, high volume air; on previously reported data on wind energy distribution and areas producing crops which require extensive drying; on data from engineering handbooks; and on data from literature of manufacturers of refrigeration components which would be used in such a system. The cost estimated by this means will be compared with cost of drying with unheated air drying, and with propane-fired heated air drying, for a variety of levels of cost of propane and electric energy.

OUTPUT

A final report of the analytical study, presenting conditions for economical use of wind power for crop drying, will be prepared.

1.2 OPERATIONS AND APPLICATIONS REQUIREMENTS

CONTRACTOR	TITLE
University of Tennessee Department of Electrical Engineering Knoxville, Tennessee 37916	Power Systems Aspects of Multi-Unit Wind Systems
	CONTRACT NO. DE-AC-01-79ET 23016
PRINCIPAL INVESTIGATOR Thomas W. Reddoch	**PERIOD OF PERFORMANCE** February 1979 to June 1980
WORK LOCATION Washington, DC and Knoxville, Tennessee	**FISCAL YEAR 1979 FUNDING** $30,727
CONTRACTING OFFICE DOE Headquarters Washington, DC	**CUMULATIVE FUNDING** $30,727

PROJECT SUMMARY

BACKGROUND

The development of the interface between the wind energy conversion system (WECS) and the conventional electric utility system is one vital part of the DOE wind program since the intermittent nature of the source represents a significant departure from classical electric power producing apparatus. Specific requirements of the interface as well as operational and planning methodologies for electric utilities utilizing WECS demand research, development, and demonstration.

OBJECTIVES

The primary objective is the review of technical information generated by DOE contractors investigating the systems dynamics of wind turbines and their interconnection with utility systems. From the assessment of the potential impact of WECS on electric utility practices, planning strategies are provided to the Wind Energy Systems Branch for the WECS/utility interface requirements.

APPROACH

Programmatic needs are supplied through written reports, contractor quarterly review meetings, and regular meetings with the staff of DOE Wind Energy Systems Branch. These meetings will define major issues pertaining to the interconnection of WECS to the electric utility system.

OUTPUT

Technical correspondence, topical reports, and planning details are provided on the requirements of the WECS/utility interface as well as operational and planning functions for utilities employing WECS.

CONTRACTOR	TITLE
Tennessee Valley Authority 345 Commerce Union Bank Bldg. Chattanooga, Tennessee 37401	Analysis of the Operation of an Electric Power System with and without Wind Generation
	CONTRACT NO. ET-78-A-29-1117
PRINCIPAL INVESTIGATOR D.W. Hilson	**PERIOD OF PERFORMANCE** November 1978 to December 1980
WORK LOCATION Chattanooga, Tennessee	**FISCAL YEAR 1979 FUNDING** $198,000
CONTRACTING OFFICE DOE Headquarters Washington, DC	**CUMULATIVE FUNDING** $298,500

PROJECT SUMMARY

BACKGROUND

The impact of significant penetrations of geographically dispersed wind generators and wind farms on the operations of an electric power system is the subject of much discussion in the industry. The intermittent nature of the source (wind) must be considered along with operating strategies that may differ markedly with those designed for conventional electric power systems.

OBJECTIVES

The primary objective is to assess the impact of significant amounts of wind generation (up to 30 percent) on the operations of an electric power system.

APPROACH

The day to day operations of the TVA electric power system with hypothetical wind generators (MOD-2 characteristics assumed) penetrating up to 30 percent of installed capacity will be simulated. The simulation will make use of TVA's existing generating unit scheduling program and a wind performance program model obtained for EPRI. TVA's 1978 electric power system is assumed. Through the use of load flow and transient stability analyses, the bulk transmission network will be strengthened (hypothetically) to accommodate the wind generation for 5 percent increments from 0 to 30 percent penetration.

OUTPUT

The output will consist of interim reports, as required, leading to a final report containing the results and documentation of the following three phases:

Phase I – Documentation of the 1978 TVA power system including a description of the actual operations of three consecutive day periods in each of the four seasons of 1978.

Phase II – Results of the load flow and transient stability analyses of the bulk transmission network and the modifications necessary for accommodating the wind generators.

Phase III – Results of the simulation of the power system with assumed wind generation, including conclusion and recommendations.

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	A Comprehensive Guide: WECS Connected to Electric Utilities
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Roger Taylor/Irwin E. Vas	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $240,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $240,000

PROJECT SUMMARY

BACKGROUND

A centralized document is needed to assist various planning entities to properly evaluate the generation of power by utilizing the available wind resource.

OBJECTIVES

- Provide a comprehensive, consolidated, source of information on WECS as it relates to electric utilities.
- Provide a key reference document to utilities, public utility commissions, state energy offices and others on the developments which have taken place in the recent past and are currently taking place in the field of wind energy.

APPROACH

This effort is primarily a synthesis of previous and ongoing work. First, a review will be performed to develop a complete bibliography of the relevant work. Copies of the more important documents will be obtained and catalogued per the appropriate sections of the Guide. Secondly, contacts will be made with the project managers of ongoing research to obtain results from their work as soon as it becomes available. Third, the information obtained from the literature and ongoing programs will be consolidated into the appropriate volume to insure comprehensiveness and readability.

OUTPUT

A Planners Handbook is to be developed for distribution. This may be done by sections as results become available.

CONTRACTOR	TITLE
University of Michigan Radiation Laboratory Department of Electrical and Computer Engineering Ann Arbor, MI 48109	Electromagnetic Interference by Wind Turbines - Siting Handbook
	CONTRACT NO. EY-76-S-02-2848
PRINCIPAL INVESTIGATOR Thomas B.A. Senior	**PERIOD OF PERFORMANCE** January 1976 - April 1979
WORK LOCATION Ann Arbor, MI Golden, CO	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Chicago Operations Office, Argonne, IL Technical Mgr. SERI, Bob McConnell	**CUMULATIVE FUNDING** $317,186

PROJECT SUMMARY

BACKGROUND

Prior contract work has demonstrated that wind turbines can cause TV reception interference in the area immediately adjacent to a wind energy conversion system (WECS) installation. Interference was more pronounced for the higher frequency UHF TV channels and is apparently confined to the amplitude modulated or video portion of the signal.

OBJECTIVES

The objectives are to analyze and quantify the effect of wind turbines on electromagnetic reception by means of theoretical analyses, laboratory simulations, and field tests. Emphasis will be on: 1) updating siting guides to include near-zone effects on TV reception; 2) determining wind turbine generator (WTG) effect on circularly polarized TV broadcasts; 3) determining criteria for assessing practical severity of interference at a given WTG site; 4) determining WTG effect on navigation aids such as LORAN C, OMEGA, and ILS; and 5) extending the analysis to include vertical-axis wind turbines.

APPROACH

Laboratory experimentation, field measurements, and analysis will be continued to extend the results of previous analyses of TV interference by a horizontal-axis WTG. The model for determining wind turbine-induced TV interference is being further developed to provide simpler expressions and greater accuracy. Extended laboratory simulations and field tests of this interference are performed as an input to the model.

OUTPUT

The WECS TV Siting Handbook developed in the previous contract will be updated and extended as required. A final report will be prepared that documents the results of the studies set forth in the project objectives. The results will be used to determine if additional work is needed to assess, quantify, and ameliorate potential legal, social and environmental barriers to wind systems commercialization in this area.

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	Environmental Impact Assessment of Small Wind Energy Conversion Systems
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Kathryn Lawrence, Carl Strojan/Irwin E. Vas	**PERIOD OF PERFORMANCE** October 1979 - December 1980
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $123,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $123,000

PROJECT SUMMARY

BACKGROUND

Past DOE wind system environmental research has focused primarily on medium to large scale designs (i.e., power ratings of 100kW or larger). This research has been expanded to include the institutional issues (legal, environmental, etc.) associated with small wind machines.

OBJECTIVES

The objectives are to identify and analyze the life-cycle environmental impacts of manufacturing, deploying and decommissioning small wind machines (SWECS) for use in residential and small commercial applications; and to determine whether aesthetic preference for SWECS is affected by machine design.

APPROACH

The approach will determine types of quantities of materials required for SWECS manufacture; calculate air and water emissions of manufacture and assess ecological and occupational health hazards through use of recent EPA, Department of Labor, and OSHA statistics; assess impacts of operation (i.e., noise, TVI, etc.) through literature review and selected interviews; and develop (and distribute at the Rocky Flats Small Wind Systems Test Center) a survey in aesthetic preference for SWECS designs.

OUTPUT

Through project funding, a 15 minute color videocassette will be developed outlining potential TVI effects of the Block Island, RI, WTG; an examination of the life-cycle environmental effects and net benefits of SWECS deployment; and information on the aesthetic preference for SWECS based on a nonrandom field survey) will be provided.

1.3 INSTITUTIONAL/ENVIRONMENTAL ANALYSES

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	Noise Measurements at Selected Wind System Sites
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Robert McConnell/Irwin E. Vas	**PERIOD OF PERFORMANCE** August 1979 - 1981
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $150,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $150,000

PROJECT SUMMARY

BACKGROUND

Several studies measuring noise have been conducted by other sub-contractors as part of an overall study of possible environmental effects caused by wind turbines. However, none of these studies have systematically measured noise as a function of distance separating the wind turbine and the observer or as a function of wind direction or for different turbine operating conditions such as wind speeds or power loadings.

OBJECTIVES

The objectives of this task are to systematically measure and document the noise generated by wind turbines and relate the measurements, their analysis, and appropriate regulations in a handbook suitable for future siting of wind turbines.

APPROACH

The approach consists of taking noise measurements at operational wind turbine sites, analysis of those measurements by SERI personnel and appropriate outside experts and identification of pertinent noise regulations for inclusion in a siting handbook.

OUTPUT

A handbook will be prepared identifying potential situations where wind turbine noise could cause problems and pertinent noise regulations to aid in siting wind turbines.

1.3 INSTITUTIONAL/ENVIRONMENTAL ANALYSES

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	Television Interference and WECS
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Robert McConnell/Irwin E. Vas	**PERIOD OF PERFORMANCE** August 1979 - 1980
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $15,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $15,000

PROJECT SUMMARY

BACKGROUND

This task began during the last quarter of FY 1979 and primarily involves technical management of the WSB/DOE Contract with the University of Michigan. The scope will be expanded in FY 1980.

OBJECTIVE

The objective is to measure and document the interference to television and other electromagnetic signals in the vicinity of operational wind turbines.

APPROACH

Technical management of the WSB/DOE contract with the University of Michigan will be continued.

OUTPUT

Systematic TVI measurements will be made at large wind turbine sites to update the TVI Siting Handbook for large wind systems. A TVI Siting Handbook for homeowners contemplating the installation of a small wind system will be prepared.

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	Products Liability Issues Associated with SWECS
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Robert Noun/Irwin E. Vas	**PERIOD OF PERFORMANCE** October 1978 - November 1979
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $52,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $52,000

PROJECT SUMMARY

BACKGROUND

Various legal issues are raised at each stage of the SWECS manufacturing and marketing process. SWECS manufacturers will need to recognize these issues and understand the requirements of product liability law to minimize potential liability.

OBJECTIVES

The objectives of this project are to identify product liability issues which may inhibit the commercialization of SWECS and to develop policy alternatives for addressing those issues.

APPROACH

1. Identify critical issues and formulate in an issue paper.
2. Policy alternatives to deal with selected issues will be developed and refined.
3. Final set of policy alternatives will be prepared.

OUTPUT

The results of the study will be documented in a report containing analysis of selected issues and suggested policy alternatives.

1.4 PROGRAM DEVELOPMENT/PLANNING

CONTRACTOR	TITLE
Raytheon Service Company 2 Wayside Road Burlington, MA 01803	Technical Management Support of the Federal Wind Energy Program
	CONTRACT NO. ET-78-C-01-4115
PRINCIPAL INVESTIGATOR Chester A. Wendell	**PERIOD OF PERFORMANCE** September 1978 - September 1980
WORK LOCATION Albuquerque, NM, Washington, DC and Burlington, MA	**FISCAL YEAR 1979 FUNDING** $650,000
CONTRACTING OFFICE DOE Headquarters Washington, DC	**CUMULATIVE FUNDING** $1,300,00

PROJECT SUMMARY

BACKGROUND

In its active pursuit of the utilization of wind energy conversion systems, DOE incurred a need for a systems contractor to provide management support of the diverse tasks required of contractors and utilities involved in the fabrication, siting, installation, and field testing of experimental wind turbines.

OBJECTIVES

This program will ensure the necessary systems capability to exercise technical management functions such as planning, specifying, coordinating, monitoring, and reporting the activities of contractors and users with a major goal of minimizing machine fabrication and installation costs.

APPROACH

Specific tasks to be performed include planning the operations of field-test programs, generating performance parameters, coordinating contractor operations, and assuming responsibility for accuracy and quality of contractor reporting.

OUTPUT

In order to keep the technical aspects of the wind program on a cost-effective and goal-oriented track, the systems contractor will detail program schedules, costs, and task activities through review presentations on a regular basis.

1.4 PROGRAM DEVELOPMENT/PLANNING

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	Program Planning and Administration
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Irwin E. Vas	**PERIOD OF PERFORMANCE** June 1978 - continuing
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $62,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $62,000

PROJECT SUMMARY

BACKGROUND

During FY 1978, responsibility for the projects in the program element advanced and Innovative Concepts was transferred to the Solar Energy Research Institute.

OBJECTIVE

The major effort of this task is to develop plans and coordinate the efforts of the SERI Wind Energy Systems Program.

APPROACH

After reviewing past and current efforts in the Federal Wind Energy Program, study areas which require further attention will be identified. Initially, these studies are to pertain to economic, utility and institutional/environmental analysis.

OUTPUT

The output for these tasks include the preparation of reports, the development of the program development plan, annual operating plan and several other plans and documents as required by SERI management and WSB/DOE.

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2.0 WIND CHARACTERISTICS PROJECT SUMMARIES

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Coordination of Regional Analyses
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR W.R. Barchet D.L. Elliott	**PERIOD OF PERFORMANCE** 1978 - 1979
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $66,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $66,000

PROJECT SUMMARY

BACKGROUND

The thrust of this task is to develop techniques for resource assessments and to test these techniques by producing a wind resource atlas for the Northwest. The techniques are then to be applied by other contractors to 11 other wind resource regions in the United States and its territories.

OBJECTIVES

The primary objective is to produce wind resource assessments for eleven regions of the United States and its territories in a timely and cost-effective manner. Furthermore, these assessments should be comparable to and compatible with one another.

APPROACH

Coordination will require contractor training sessions and careful monitoring of contractor performance. The cost of analyzing the National Climatic Center magnetic data tapes will be minimized by analysis at a central location (PNL). National Fire Weather Library data will be handled in a similar manner by a subcontractor.

OUTPUT

Computer generated graphics and tabular data summarizing the data contained on the NCC tapes will be provided to each contractor. Similar summaries of National Fire Weather Library data will be provided by the subcontractor.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Northwest Analysis Prototype Techniques for Determining Wind Energy Potential
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR D.L. Elliott	**PERIOD OF PERFORMANCE** 1977 - 1979
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $132,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $338,000

PROJECT SUMMARY

BACKGROUND

Existing national-scale wind resource assessments for the United States are unable to efficiently utilize the existing wind data resource or produce reliable assessments in data-sparse areas. Hence, the national assessments lack the spatial and temporal resolution needed for decisions concerning WECS utilization.

OBJECTIVES

The primary objective is to develop techniques for assessing the wind energy potential of large regions which are applicable to the United States.

APPROACH

Data sources are identifed; criteria for screening and selecting data are established; and the analysis techniques are developed to analyze quantitative wind data. Techniques for assessing the wind resource in data-sparse areas and for delimiting the geographical distribution of the wind resource are also required. These techniques are then tested in the Northwest region.

OUTPUT

Prototype techniques for wind resource assessments have been described at several conferences. Draft maps of the wind-resource for the Northwest have been prepared and color-coded for presentations. An atlas, that describes the Northwest wind resource for the region and on a state-by-state basis through maps of annual and seasonal wind power and graphs of wind speed and power statistics, is in preparation. This atlas will be complemented by a final report that describes in detail the procedures used in the assessment.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Climatological Adjustment of Short Term Wind Statistics
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.V. Ramsdell	**PERIOD OF PERFORMANCE** October 1978 - February 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $17,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $17,000

PROJECT SUMMARY

BACKGROUND

The limitations and uncertainty associated with many data collection and analysis techniques currently in use in site selection and evaluation are not well known. Some of the techniques may not even be useful or valid. The limitations and uncertainties must be determined.

OBJECTIVE

The primary objective is to apply existing climatological data and statistical theory to the evaluation of data handling techniques related to the selection and evaluation of WECS sites. The limitations and uncertainties of these techniques will be documented.

APPROACH

Data collection and analysis techniques will be evaluated using existing data. Each technique will be applied where wind characteristics are known and the results compared with known values. These comparisons will be made for sites in various topographic and climatological regimes throughout the United States, and any systematic variation in results will be noted.

The following areas have been identified for examination:

1. Use of data from a climatological reference site to adjusted short-term data at a potential WECS site for departure from climatological norms.
2. Use of a mean wind speed estimate with an assumed Rayleigh distribution for estimating available and extractable wind power.
3. Variation of data collection strategies to balance cost and uncertainty in estimating wind characteristics.
4. Analysis of wind data to permit evaluation of the correlation between available wind power and expected loads.

OUTPUT

The primary products of this task will be documented data handling techniques suitable for use in the selection and evaluation of WECS sites.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Coordinate and Interpret Model Verification
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR Thomas R. Hiester	**PERIOD OF PERFORMANCE** April 1979 - July 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $17,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $17,000

PROJECT SUMMARY

BACKGROUND

Numerical modeling is one technique that has received considerable attention as a possible WECS site screening tool. Numerical wind field models provide objective methods for including terrain effects and interpolating existing wind data to locations with no observations. The accuracy of this interpolation depends upon the quality of the input data and the ability of the model to simulate complex interactions between the atmosphere and surface of the earth. However, the performance of these models has not been tested. Testing is the purpose of this task.

OBJECTIVE

The objective of this work is to evaluate the accuracy of numerical models in simulating the wind field over complex terrain.

APPROACH

Two types of numerical models have been proposed for site screening – primitive equation models and objective analysis schemes. Models representing these generic types have been developed in the wind program for DOE. These models will be applied to several mesoscale regions of complex terrain where measurements of wind speed and direction are available at numerous locations. Model performance will be evaluated by comparing observed and simulated surface wind fields for several cases. Sensitivity tests will be conducted by varying the amount of input data and comparing the results.

OUTPUT

A final report will be written summarizing the results of comparing simulated and observed wind fields. The report will discuss the special problems of modeling flow over complex terrain, the attributes as well as the limitations of the various models and the options for future research and development.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Evaluation of Inexpensive Meteorological Instrumentation
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.V. Ramsdell	**PERIOD OF PERFORMANCE** October 1978 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $19,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $19,000

PROJECT SUMMARY

BACKGROUND

Meteorological instrumentation with established reliability and accepted accuracy is relatively expensive to buy and more expensive to rent for long-term usage. A number of relatively inexpensive instruments are currently on the market. Some have laboratory type calibrations, but their reliability and accuracy under normal use have not been established.

OBJECTIVE

The objective of this work is to identify, test and evaluate inexpensive meteorological instrumentation for essential use in siting small wind energy conversion systems.

APPROACH

PNL will establish a meteorological instrument test facility at Hanford at which inexpensive instruments will be compared with standard instruments with established accuracy and proven reliability. Instrument accuracy will be initially evaluated under laboratory conditions, then tests will be conducted under actual atmospheric conditions. Reliability will be determined by allowing the instruments to operate continuously for an extended period. Several specimens of each instrument will be tested.

OUTPUT

A series of reports will document the test and evaluation program. The initial report will describe the program and the interpretation of individual instrument tests. Subsequent reports will contain the results of tests on specific instruments.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	International Model Verification
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR William T. Pennell	**PERIOD OF PERFORMANCE** March 1979 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $22,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $22,000

PROJECT SUMMARY

BACKGROUND

Through Annex II of the Implementing Agreement for a program of research and development on wind energy conversion systems of the International Energy Agency, an agreement was reached to undertake an international program of model verification. Numerical models have been suggested as techniques which can be used in screening WECS sites; however, the accuracy to which these models can simulate flow over terrain is unknown. This task is to provide some of this knowledge.

OBJECTIVE

The objective of this work is to evaluate the accuracy of numerical models in simulating the wind field over complex terrain.

APPROACH

PNL has been delegated the responsibility for planning, coordinating and reporting on this activity by DOE. A letter has been sent to each international participant inviting him to submit descriptions of models which have application to siting and data sets which could be used to verify these models. The data sets will be exchanged. The various models will be run on the suggested data sets by the individuals who developed the models. The observed and simulated fields will be compared in a manner similar to the domestic verification.

OUTPUT

A final report summarizing the results of comparing simulated and observed wind fields. The report will discuss the attributes as well as the limitations of various models and recommend what additional work may be needed.

2.1 WIND ENERGY PROSPECTINGS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Large WECS Siting Handbook
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR William T. Pennell	**PERIOD OF PERFORMANCE** January 1979 - April 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $42,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $97,000

PROJECT SUMMARY

BACKGROUND

In FY 1978 a document on siting considerations for large WECS was produced. Because of new information on siting techniques and siting requirements that was becoming available, it was clear that the document needed considerable review and updating.

OBJECTIVE

The objective of this work is to produce a document presenting a methodology for addressing the meteorological considerations in wind turbine siting. The document will describe siting techniques and discuss their applicability to the various steps in large wind turbine site selection.

APPROACH

Revisions in content and format will be made according to comments received by reviews of previous siting documents and by incorporating the results of recent work on site selection techniques.

OUTPUT

The output will be the completed document.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Siting Course for Small WECS
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.V. Ramsdell	**PERIOD OF PERFORMANCE** October 1978 - August 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $30,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $30,000

PROJECT SUMMARY

BACKGROUND

The Wind Characteristics Program Element (WCPE) has compiled technical information on siting in a number of studies.

OBJECTIVE

The objective of this task is to prepare a short course on WECS siting as a means of transferring the technical information compiled by the WCPE to SWECS dealers, agricultural extension agents and others who might be involved in assisting potential SWECS owners in siting.

APPROACH

PNL is developing a short course based on existing siting handbooks and other available information. It will be prepared for presentation by other organizations.

OUTPUT

The output of this task will be the materials needed for the short course, organized and presented in a manner that a non-meteorologist can conduct the course. The materials will include: an outline, lecture notes, problem sets, teaching guide, and audio-visual aids.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Update Small WECS Siting Handbook
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR Harry L. Wegley	**PERIOD OF PERFORMANCE** January 1979 - September 1979
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $19,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $73,000

PROJECT SUMMARY

BACKGROUND

In FY 1978 a handbook on siting procedures for small WECS was produced and given UC-60 distribution. Although UC-60 distribution makes the document publicly available, this distribution is, in reality, limited. Consideration must be given to finding ways of distributing the document more widely.

OBJECTIVE

The objective of this work is to revise the publication *A Handbook for Siting Small Wind Energy Conversion Systems* – as needed.

APPROACH

Comment on the handbook by potential users and representatives of the small WECS industry will be invited. Discussions will be held with the AWEA on how the small WECS handbook can be made more available. Criticisms and suggestions resulting from the review of the original handbook will be incorporated into the more widely disseminated document.

OUTPUT

The output will be the revised handbook.

2.1 WIND ENERGY PROPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: University of Alaska Arctic Environmental Information and Data Center 707 A Street Anchorage, AK 88501	Alaska Regional Assessment
	CONTRACT NO. B-87917-A-L
PRINCIPAL INVESTIGATOR James L. Wise Tunis Wentink	**PERIOD OF PERFORMANCE** September 1979 - September 1980
WORK LOCATION Anchorage and Fairbanks, AK	**FISCAL YEAR 1979 FUNDING** $150,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $150,000

PROJECT SUMMARY

BACKGROUND

The development and testing of wind resource assessment techniques in the Northwest region has set the stage for resource assessments in 11 other regions of the United States and its territories.

OBJECTIVES

The primary objective is to produce a regional assessment incorporating all relevant existing wind data within the region that provides the geographical, spatial and temporal resolution of the wind energy resource to be of use in decisions on the implementation of wind energy conversion systems.

APPROACH

The techniques developed by PNL for the Northwest region will be applied to each of the 11 other regions by contractors selected in a competitive procurement action. Training by, coordination with and careful monitoring by PNL staff will assure the comparability and compatability of the assessments from each region.

OUTPUT

The wind energy resource for each region will be described in an atlas of maps and graphs portraying the geographic distribution of annual and seasonal wind power density and various wind and wind power parameters computed from National Climatic Center data tapes. A final report will detail the application of PNL's technique to each region and document departures or improvements to these techniques.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: University of Virginia Charlottesville, VA 22903	Coastal Zone Wind Energy
	CONTRACT NO. EY-79-S-06-2344
PRINCIPAL INVESTIGATOR Michael Garstang	**PERIOD OF PERFORMANCE** September 1976 - March 1980
WORK LOCATION Charlottesville, VA	**FISCAL YEAR 1979 FUNDING** $95,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $255,000

PROJECT SUMMARY

BACKGROUND

This program began in September 1976, to study the wind power potential of the U.S. East Coast and Gulf Coast regions through extensive data analysis and application of a numerical sea-breeze circulation model.

OBJECTIVES

The objectives of this study are to establish quantitatively the space and time classifications of the East Coast and Gulf Coast zones for wind energy analyses, to investigate storm and interstorm contributions, to investigate the storm climatology using wind data and numerical modeling, and to verify the resource predicted by the assessment.

APPROACH

Regional and temporal classifications of the coastal zone have been developed using statistical analysis. The numerical model is being applied to the coastal zone to identify "speed-up" regions and the vertical distribution of winds. Wind data is being analyzed to characterize storm and interstorm contributions. From these analyses, power output for representative wind energy conversion systems (WECS) in coastal regions is being predicted. A short but intensive observational program will verify the model-predicted wind resource.

OUTPUT

A report on the current year's activity has been submitted. It details the results of the data analyses and model applications in the East and Gulf Coastal zones. Work on modeling activities and a field verification effort will continue into FY 1980.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Marlatt and Associates 3611 Richmond Drive Ft. Collins, CO 80521	Coordination of Large Area Analysis - National Fire Weather Data Library
	CONTRACT NO. B-50369-A-L
PRINCIPAL INVESTIGATOR W.E. Marlatt	**PERIOD OF PERFORMANCE** February 1978 - December 1979
WORK LOCATION Ft. Collins, CO	**FISCAL YEAR 1979 FUNDING** $26,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $43,000

PROJECT SUMMARY

BACKGROUND

The U.S. Forest Service fire weather data base has been identified as a potentially vast source of information for inclusion in large area analyses of wind energy potential. This consulting agreement was issued in January 1978 to assess the applicability of this data library and has been continued to assess this data of the other regions.

OBJECTIVES

The objectives of this study are to review the U.S. Forest Service wind data library to identify stations with usable records, so that an estimate of the seasonal and geographical wind energy in forest service regions can be developed for the entire United States.

APPROACH

The data has been obtained in magnetic tape format from the Forest Service's Rocky Mountain Forest and Range Experiment Station in Ft. Collins, Colorado. Statistical summaries have been developed from this tape for selected individual stations. The summaries have been screened for common windy areas. Frequency spectra of wind periods above certain threshold values have been developed. The analytical techniques, developed for the Pacific Northwest region, will be used for the other wind resource assessment regions.

OUTPUT

The final report discusses the analysis procedures and demonstrates the application of the analysis to the Pacific Northwest. The report provides guidelines on how the procedure can be applied to other areas of the United States where fire weather data exists. Application of these procedures to the other regions to yield wind speed and power estimates from sites within federal lands over the entire United States will continue into FY 1980.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: University of Hawaii at Manua Honolulu, HI 96822	Hawaii and the Trust Territories of the Pacific Islands Regional Assessment
	CONTRACT NO. B-87918-A-L
PRINCIPAL INVESTIGATOR Thomas A. Schroeder	**PERIOD OF PERFORMANCE** September 1979 - September 1980
WORK LOCATION Honolulu, HI	**FISCAL YEAR 1979 FUNDING** $44,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $44,000

PROJECT SUMMARY

BACKGROUND

The development and testing of wind resource assessment techniques in the Northwest region has set the stage for resource assessments in this and 10 other regions of the United States and its territories.

OBJECTIVES

The primary objective is to produce a regional assessment incorporating all relevant existing wind data within the region that provides the geographical, spatial and temporal resolution of the wind energy resource to be of use in decisions on the implementation of wind energy conversion systems.

APPROACH

The techniques developed by PNL for the Northwest region will be applied to each of the 11 other regions by contractors selected in a competitive procurement action. Training by, coordination with and careful monitoring by PNL staff will assure the comparability and compatability of the assessments from each region.

OUTPUT

The wind energy resource for each region will be described in an atlas of maps and graphs portraying the geographic distribution of annual and seasonal wind power density and various wind and wind power parameters computed from National Climatic Center data tapes. A final report will detail the application of PNL's technique to each region and document departures or improvements to these techniques.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: North American Weather Consultants Goleta, CA 93017	Innovative Techniques for Identifying and Screening Potential Wind Energy Conversion Sites
	CONTRACT NO. B-50365-A-E
PRINCIPAL INVESTIGATOR M.W. Edelstein	**PERIOD OF PERFORMANCE** February 1978 - January 1979
WORK LOCATION Goleta, CA	**FISCAL YEAR 1979 FUNDING** $10,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $56,000

PROJECT SUMMARY

BACKGROUND

Innovative techniques are required to further our understanding of the wind energy potential in regions where little or no surface wind data exists. This contract began in February 1978 to develop a technique for utilizing standard upper-air observations obtained by the National Weather Service to identify regions where surface wind energy potential is high.

OBJECTIVES

The objective of this study is to obtain quantitative estimates of the long-term mean wind speeds and of the frequency distribution of wind speed and direction at a height appropriate to wind energy conversion systems (WECS) in data-sparse areas.

APPROACH

Two test sites have been selected where some surface data is available for verification purposes. A climatology of three-hourly geostrophic winds is obtained over each of these sites using standard upper-air rawinsonde observations interpolated to the sites. By incorporating boundary layer relationships, a correlation between surface and geostrophic winds will be obtained, and a long-term surface wind climatology will be generated.

OUTPUT

A final report has been submitted summarizing the technique, including how the technique can be applied to other areas, and the usefulness of the technique for screening highwind areas for WECS inplementation.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: University of Wyoming Laramie, WY 82071	Locating Areas of High Wind by Remote Observations
	CONTRACT NO. EY-76-S-06-2342
PRINCIPAL INVESTIGATOR R.W. Marrs	**PERIOD OF PERFORMANCE** September 1976 - August 1979
WORK LOCATION Laramie, WY	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $186,000

PROJECT SUMMARY

BACKGROUND

This study was initiated in September 1976 to develop an efficient way to identify high wind energy sites by inferring wind characteristics from aeolian geomorphologic features mapped from LANDSAT imagery.

OBJECTIVES

The objective of this study is to identify characteristics of aeolian features which can be interpreted as indicators of wind characteristics. Methods for rapid assessment of the wind energy potential of large regions are to be defined by interpretation of wind characteristics from wind-formed surface features observable from satellite and aircraft imagery.

APPROACH

Extensive field observations, including measurements from an instrumented aircraft and study of dune and playa lake characteristics, have been made in the "wind corridor" of southern Wyoming. Based on data collected in this study area, techniques for interpreting wind characteristics are being tested and refined. An assessment of the regional applicability of the methodology has been made. The techniques are being demonstrated in arid regions of the Pacific Northwest.

OUTPUT

A handbook has been prepared which describes procedures for interpreting wind characteristics from aeolian features.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Geomet, Inc. Gaithersburg, MD 20760	Northeast Regional Assessment
	CONTRACT NO. B-23452-A-L
PRINCIPAL INVESTIGATOR Ken Pickering	**PERIOD OF PERFORMANCE** August 1979 - May 1980
WORK LOCATION Gaithersburg, MD 20760	**FISCAL YEAR 1979 FUNDING** $90,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $90,000

PROJECT SUMMARY

BACKGROUND

The development and testing of wind resource assessment techniques in the Northwest region has set the stage for resource assessments in this and 10 other regions of the United States and its territories.

OBJECTIVES

The primary objective is to produce a regional assessment incorporating all relevant existing wind data within the region that provides the geographical, spatial and temporal resolution of the wind energy resource to be of use in decisions on the implementation of wind energy conversion systems.

APPROACH

The techniques developed by PNL for the Northwest region will be applied to each of the 11 other regions by contractors selected in a competitive procurement action. Training by, coordination with and careful monitoring by PNL staff will assure the comparability and compatability of the assessments from each region.

OUTPUT

The wind energy resource for each region will be described in an atlas of maps and graphs portraying the geographic distribution of annual and seasonal wind power density and various wind and wind power parameters computed from National Climatic Center data tapes. A final report will detail the application of PNL's technique to each region and document departures or improvements to these techniques.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Global Weather Consultants San Jose, CA 95113	Southwest Regional Assessment
	CONTRACT NO. B-87920-A-L
PRINCIPAL INVESTIGATOR Richard L. Simon	**PERIOD OF PERFORMANCE** September 1979 - June 1980
WORK LOCATION San Jose, CA	**FISCAL YEAR 1979 FUNDING** $56,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $56,000

PROJECT SUMMARY

BACKGROUND

The development and testing of wind resource assessment techniques in the Northwest region has set the stage for resource assessments in this and 10 other regions of the United States and its territories.

OBJECTIVES

The primary objective is to produce a regional assessment incorporating all relevant existing wind data within the region that provides the geographical, spatial and temporal resolution of the wind energy resource to be of use in decisions on the implementation of wind energy conversion systems.

APPROACH

The techniques developed by PNL for the Northwest region will be applied to each of the 11 other regions by contractors selected in a competitive procurement action. Training by, coordination with and careful monitoring by PNL staff will assure the comparability and compatability of the assessments from each region.

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2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: University of Texas Austin, TX 78712	Wind Power Potential in a Coastal Environment
	CONTRACT NO. B-36379-A-E
PRINCIPAL INVESTIGATOR N.K. Wagner	**PERIOD OF PERFORMANCE** February 1978 - September 1979
WORK LOCATION Austin, TX	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $50,000

PROJECT SUMMARY

BACKGROUND

Innovative techniques for identifying high wind energy areas are important when little existing data is available in a region. This study began in February 1978 to test one promising technique–interviewing residents in a local area where high wind energy potential may exist and to apply the technique to a promising wind energy region, the western Gulf Coast of the United States.

OBJECTIVES

The objective of this study is to test oral interview techniques on fishing boat captains and pleasure craft operators in the western Gulf Coast and to compare the results of these interviews with available data and special measurements to further define the wind energy potential of this region.

APPROACH

Interview procedures for three specific coastal zones in the Port Aransas to Corpus Christi areas have been developed. These procedures cover the bay areas, the inshore areas, and the offshore areas. Existing meteorological data has been acquired and is being analyzed. Special short-term measurements of wind are being obtained to verify the results of the interviews.

OUTPUT

An interim report has been submitted which discusses the procedures for developing the interviews, the effectiveness of the interviews in producing additional information on wind energy potential in areas where little or no data exists, and the results of their application if furthering knowledge of wind energy potential in the western Gulf Coast region. A final report will be submitted comparing the results of the interviews with actual wind measurements.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Aerovironment, Inc. 145 Vista Avenue Pasadena, CA 91107	Assessing the Local Field with Instrumentation **CONTRACT NO.** B-92864-A-H
PRINCIPAL INVESTIGATOR Stel N. Walker	**PERIOD OF PERFORMANCE** December 1978 - January 1980
WORK LOCATION Pasadena, CA	**FISCAL YEAR 1979 FUNDING** $89,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $89,000

PROJECT SUMMARY

BACKGROUND

Several methods are under development for screening large areas and for identifying potential WECS sites. In any approach to siting, onsite measurements will be needed both in the initial screening of WECS sites and in determining the detailed wind characteristics required for final site selection.

OBJECTIVE

The primary objective of this research project is to identify cost effective measurement systems for evaluating the wind resource in and near a potential WECS site. The applicability of the systems and the methods for using them will be demonstrated in a realistic prototype field exercise. Emphasis is placed on efficient recovery and reduction of data and on the cost and manpower requirements for a typical application.

APPROACH

The general features of the wind field in the Tehachapi Mountains of Southern California is being investigated. The approach to data collection is in two phases. First a data and field survey is performed. This consists of an examination of existing data, land ownership, vegetation flagging, aeolian indicators, topographical layout, and preliminary measurements using hand held and kite anemometers. From this survey locations for a network of about 10 m towers are determined. These towers may be moved to optimize the useful information gained from the network as the data collection begins to demonstrate significant flow features. From analysis of seven months of data the wind characteristics of the Tehachapi Mountains will be deduced.

OUTPUT

The output of this project will be an assessment of the costs and effectiveness of the methods and instruments used in this project in their application to the evaluation of the wind resource at a potential WECS site.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: New Mexico State University Physical Science Lab Box 3 – PSL Las Cruces, NM 88003	Assessing the Local Wind Field with Instrumentation
	CONTRACT NO. B-23453-A-H
PRINCIPAL INVESTIGATOR Kenneth M. Barnett Ralph D. Raynolds	**PERIOD OF PERFORMANCE** December 1978 - January 1980
WORK LOCATION Las Cruces, NM	**FISCAL YEAR 1979 FUNDING** $106,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $106,000

PROJECT SUMMARY

BACKGROUND

Several methods are under development for screening large areas and for identifying potential WECS sites. In any approach to siting, onsite measurements will be needed both in the initial screening of WECS sites and in determining the detailed wind characteristics required for final site selection.

OBJECTIVE

The primary objective of this research project is to identify cost effective measurement systems for evaluating the wind resource in and near a potential WECS site. The applicability of the systems and the methods for using them will be demonstrated in a realistic prototype field exercise. Emphasis is placed on efficient recovery and reduction of data and on the cost and manpower requirements for a typical application.

APPROACH

Sierra Grande, a relatively isolated symmetrical peak standing 2000 feet above the surrounding plains, was instrumented. A mast was placed at the summit with sensors at 3 levels up to 30 m, and satellite masts with sensors at 10 m were deployed on four ridge shoulders 500 m away from the summit. Wind data are six-minute averages stored on cassette tapes retrieved monthly. From analysis of five months of data the wind characteristics at the summit of Sierra Grande will be deduced.

OUTPUT

The output of this project will be an assessment of the costs and effectiveness of the methods and instruments used in this project in their application to the evaluation of the wind resource at a potential WECS site.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Science Applications, Inc. P.O. Box 2351 La Jolla, CA 92038	Numerical Model Verification **CONTRACT NO.** EY-76-C-06-2440
PRINCIPAL INVESTIGATOR R.M. Traci	**PERIOD OF PERFORMANCE** May 1976 - June 1980
WORK LOCATION La Jolla, CA	**FISCAL YEAR 1979 FUNDING** $45,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $445,000

PROJECT SUMMARY

BACKGROUND

A 3-year program to develop, test and perform prototype applications of a wind energy conversion system site-selection methodology has been completed. Work is being extended to verify the computer codes developed in the program.

OBJECTIVES

The primary objective is to provide an improved siting methodology which makes use of mathematical wind field modeling to extrapolate data from measurement locations to other potentially windier sites throughout a mesoscale area, and to verify the wind field models by comparing their predictions with actual observations.

APPROACH

The siting methodology is based on the use of a pseudo-potential flow objective analysis scheme, and a three-dimensional primitive equation boundary layer model. The objective analysis scheme is used to initiate the boundary layer model and to generate wind statistics by calibrating a number of runs corresponding to differing, but typical boundary conditions. The boundary layer model is used to give a limited number of detailed "snapshots" of the area in question. These snapshots would correspond to the dominant climatological conditions observed in the area. The verification program is being conducted in cooperation with the Pacific Northwest Laboratory. Numerous simulations of the wind flow over various types of topography will be statistically compared with observations.

OUTPUT

All computer codes forming a part of this methodology have been documented so they can be applied by any competent user. Additionally, the siting methodology has been documented and demonstrated. The final report will contain the results of two model verification tests.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Colorado State University Fort Collins, CO 80523	Sites for Wind-Power Installations
	CONTRACT NO. EY-76-S-06-2438/A002
PRINCIPAL INVESTIGATOR Robert N. Meroney and Virgil A. Sandborn	**PERIOD OF PERFORMANCE** June 1976 - July 1979
WORK LOCATION Fort Collins, CO	**FISCAL YEAR 1979 FUNDING** $7,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $229,000

PROJECT SUMMARY

BACKGROUND

During the initial program, wind tunnel model studies were performed to study the influence of topography profile, surface roughness, and stratification on the suitability of various combinations of these variables for wind-power sites. For the range of cases examined (large turbulence integral scales with respect to surface feature scales) it was found that the flow is dominated by inviscid dynamics. Hence, the influence of hill shape, surface roughness, and mild stratification can be reliably estimated by simple prediction procedures.

OBJECTIVES

It is now appropriate to critique the potential of physical modeling via a simultaneous comparison of field, physical model and numerical model data. Results should provide a basis for immediate implementation of physical modeling as a siting tool, reevaluation of identified errors or trends via an extended program, or termination of the concept.

APPROACH

Many length and time scales of wind characteristics with respect to wind-power siting are not amenable to analytical or numerical methods. Physical modeling can thus provide guidance for siting handbooks, numerical model construction, and site specific information at a reasonable cost in a short time period. This program is constructed to exploit the advantages of wind tunnel simulation of the atmospheric shear layer as well as illuminate its limitations.

OUTPUT

Data provided by tests over a physical model of Kahuku Point and Oahu, Hawaii, have been compared with field measurements and numerical model programs. Results will be used to determine credibility of physical modeling and to select potential WECS sites in the Kahuku area.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Northwestern University Evanston, IL 60201	Stochastic Modeling of Site Wind Characteristics
	CONTRACT NO. EY-76-S-06-2342
PRINCIPAL INVESTIGATOR R.B. Corotis	**PERIOD OF PERFORMANCE** September 1976 - October 1979
WORK LOCATION Evanston, IL	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $173,000

PROJECT SUMMARY

BACKGROUND

This work began in October 1976 to develop stochastic and probabilistic methods for evaluating wind characteristics at potential wind turbine sites.

OBJECTIVES

The objective of this study is to develop and apply complete procedures for wind turbine site evaluation using probabilistic models and statistical methods and to establish the reliability of the characteristics.

APPROACH

New data sources have been tapped to test the models. These sources include data from the U.S. Forest Service fire weather network, data from candidate sites for testing large wind turbines, special hourly data and high speed data. The reliability of the various models is being investigated using these data. For locations where high cross-correlation exists among data stations, a statistical relationship will be developed to enhance short-term data.

OUTPUT

A report has been submitted documenting all pertinent analyses, techniques and calculated results. The report discusses the reliability of the models and shows results of a study to enhance short-term data from nearby long-term records.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: FWG Associates, Inc. R.R. 3, Box 331 Tullahoma, TN 37388	Technology Development for Assessment of Small-Scale Terrain Effects on Available Wind Energy
	CONTRACT NO. EY-76-C-06-2443
PRINCIPAL INVESTIGATOR Dr. Walter Frost	**PERIOD OF PERFORMANCE** August 1976 - December 1979
WORK LOCATION Tullahoma, TN	**FISCAL YEAR 1979 FUNDING** $51,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $306,000

PROJECT SUMMARY

BACKGROUND

Reliable information regarding the effect of small-scale terrain features on the wind near the surface is needed to evaluate the suitability of specific sites for wind energy conversion system (WECS) installations.

OBJECTIVES

The project objective is to characterize and catalog the effect of microscale terrain features on the near-surface wind.

APPROACH

Existing knowledge in the disciplines of fluid mechanics and meteorology of flow over two- and three-dimensional obstacles is being surveyed from the standpoint of its usefulness to WECS siting. This information is then to be compiled as guidelines and rules-of-thumb that would enable a user to determine the probable effect of local terrain on the wind. An experimental field program is being designed to verify the accuracy of these guidelines. The instrumentation required for these experiments is also being identified.

OUTPUT

A handbook will be produced to provide methods for an engineer to use in selecting an optimum site (from the standpoint of wind power) for a WECS within a small area. The performance of an inexpensive wind profiling system will also be tested.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Oregon State University Corvallis, OR 97331	Vegetation as an Indicator of High Wind Velocities
	CONTRACT NO. EY-76-S-06-2227
PRINCIPAL INVESTIGATOR E.W. Hewson	**PERIOD OF PERFORMANCE** June 1976 - June 1980
WORK LOCATION Corvallis, OR	**FISCAL YEAR 1979 FUNDING** $100,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $314,000

PROJECT SUMMARY

BACKGROUND

This program was initiated to examine the feasibility of using the growth and appearance of vegetation as an aid to locating favorable wind energy areas.

OBJECTIVES

The objective of this work is to calibrate in terms of mean wind velocity the type and degree to which vegetation has been deformed by the wind.

APPROACH

Five indices of the effect of wind on conifers were identified in the first year of the study. At a number of sites in the region of the Columbia Gorge, wind data has been gathered over the course of the past 2 years. Two of the five indices that have been successful for conifers are being extended to deciduous trees. A study is also underway to determine if wind-flagged trees can be located by aerial photography.

OUTPUT

Published reports of the calibration results should prove valuable in providing an initial screening tool to those who are doing preliminary site survey work with similar vegetation. A handbook on the use of this technique has been published.

2.1 WIND ENERGY PROSPECTING

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Flow Industries, Inc. 21414 68th Avenue Kent, WA 98031	Wind Turbine Wake Flow
	CONTRACT NO. B77495
PRINCIPAL INVESTIGATOR James V. Riley	**PERIOD OF PERFORMANCE** August 1979 - January 1980
WORK LOCATION Kent, WA	**FISCAL YEAR 1979 FUNDING** $29,000
CONTRACTING OFFICE Pacific Northwest Laboratory	**CUMULATIVE FUNDING** $29,000

PROJECT SUMMARY

BACKGROUND

An important issue in the design of WECS farms will be the spacing and orientation of the machines with respect to each other. It is desirable to optimize the total power output of a WECS farm by achieving an optimum arrangement of machines.

OBJECTIVES

The objectives of this project are to define the critical technical issues related to the problem of wake effects in wind farms and to determine the current state of knowledge of wake characteristics and how to model them. A final objective is to recommend further research necessary to solve the problems in this field.

APPROACH

A preliminary review of all aspects of the problem of wake effects, including atmospheric boundary layer effects, propeller efficiencies, structural characteristics and wind machine wakes, will define the critical issues of the problem. Second, there will be a comprehensive review of all previous work relevant to the problem of wakes. This review will encompass all approaches to the problem, including theoretical, numerical and laboratory modeling, and field studies. This review will define the state-of-the-art in these problem areas. From these reviews, recommendations for future research will be made.

OUTPUT

This project will result in a review of the literature and description of the state-of-the-art in the areas relevant to machine wake effects. It will provide recommendations, and the reasoning behind them, for future work needed to resolve the outstanding questions. An annotated bibliography of the most significant papers related to wind machine wake effects will also be provided.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Environmental Design Criteria for WECS
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** October 1978 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $87,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $205,000

PROJECT SUMMARY

BACKGROUND

PNL receives frequent requests from DOE and DOE contractors for information on special wind characteristic parameters that are driving a WECS design and on topics such as gust rise rates, discrete gusts, wind direction changes, etc. PNL responds to these requests as well as performs limited in-house research to provide the needed information.

OBJECTIVES

The objective of this study is to provide new or improved wind characteristics information expediently, needed by designers of WECS as those needs become known.

APPROACH

Documentation of velocity change, angular change and wind shear fluctuations will be performed. A discrete gust model will also be developed.

OUTPUT

The output of this contract will be reports, direct technology transfer, and position papers describing the wind characteristic parameters of concern. One report was completed in May 1979.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Flow Through a Vertical Plane
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** January 1977 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $146,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $309,000

PROJECT SUMMARY

BACKGROUND

Rotating blades, especially of the larger WECS, experience wind characteristics which vary both in space and time. In contrast to this, wind measurements are usually made at hub height and possibly at one or two additional heights along the same vertical line. The vertical plane array measurements provide the data by which to estimate what wind that rotating blade experiences and to relate that to hub-height wind, disc averaged wind, etc.

OBJECTIVES

The objective of this study is to characterize the flow field (in the disk of rotation) that a WECS would encounter during operation.

APPROACH

A set of 13 3-D anemometers is arranged on two concentric circles in a vertical plane. The center is 36 m above the ground. The outer diameter is 49 m. The data are recorded at 0.1 second intervals. The terrain is fairly level with low sage brush. Strong and moderate wind cases are analyzed to provide needed wind characteristics using numerical and graphical methods.

OUTPUT

Reports will be written which describe properties of measured velocity differences (gust accelerations), synthetic wind traces simulating the wind field experienced by a rotating blade, and time and spacial averaging effects on such wind characteristics as velocity change, spectra and wind shear and gusts.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	International Forecast Verification Program
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR H.L. Wegley	**PERIOD OF PERFORMANCE** May 1979 - June 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $5,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $5,000

PROJECT SUMMARY

BACKGROUND

In June 1977 a program of international cooperation for research and development of WECS was approved. Fourteen nations, including the United States, are included in the agreement. Annex I, Area B, Sub Task B.1 of the implementing agreement states that each participating nation will test wind forecasting techniques to develop a data base for the determination of uncertainty levels of wind forecasts for WECS operations.

OBJECTIVES

The primary objectives of this study are to define criteria for an objective wind forecast verification scheme and to provide wind forecasts and observations for input into the verification scheme.

APPROACH

The required wind verification statistics will be identified by technical consultation with experts from participating nations. The wind data supplied by the United States for input into the international verification effort will be produced by objective and subjective forecasting techniques. Forecast and observed wind data for selected sites in different topographical and climatological regimes will be placed on magnetic tape for verification using the scheme developed by the operating agent for Sub Task B.1, Sweden.

OUTPUT

The following information developed in this study will be provided to the operating agent for inclusion in a final report on wind forecasting reliability:

1. Well-documented wind forecast verification tables.
2. Forecast uncertainty analysis (in a standardized format),
3. Detailed description of each forecasting technique employed.
4. A description of each site to include topography, terrain roughness, and climatological regime.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Upgrade – Specialized Wind Forecasts
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR A.H. Miller	**PERIOD OF PERFORMANCE** August 1979 - September 1981
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $5,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $5,000

PROJECT SUMMARY

BACKGROUND

Present forecast techniques and products are lacking in the area of WECS operating strategies. As more and more WECS penetrate the utilities networks, tailored forecasts and products will be needed.

OBJECTIVES

The objective of this study is to upgrade or tailor wind forecasting techniques to meet the needs of WECS users.

APPROACH

Initially, a survey of operating strategies of utilities either with or contemplating on-line WECS was made to determine how forecasting can effect operations. The results of this survey were used to direct the research to develop better forecasts for WECS users. In light of other ongoing research in subjective forecasting, a further look into objective techniques was undertaken. After some consideration a modeling technique was chosen to be developed. The starting point is the U.S. Air Force, Global Weather Center, Boundary Layer Model. This Model is operationally used to forecast winds (terminal) for Air Force operations and has all the attributes and refinements of a state-of-the-art model and should be easily modified for use in the wind energy program.

OUTPUT

A final report will be written containing a complete description of the techniques employed, a comprehensive documentation of any computer codes and input data required to reproduce the wind forecasts, and a statistical analysis of the reliability of each technique.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Wind Forecast Verification
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR A.H. Miller	**PERIOD OF PERFORMANCE** May 1979 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $33,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $33,000

PROJECT SUMMARY

BACKGROUND

Power company electrical dispatchers have stated that they would need reliable 24-hour forecasts of wind power to effectively factor wind turbine generators into power grids. Currently insufficient data exist to determine the reliability of 24-hour, hourly average windspeed forecasts. Once this data is generated it must be analyzed to determine the reliability of state-of-the-art wind forecasts for WECS operations.

OBJECTIVE

The objective of this study is to determine the reliability of existing wind forecasting techniques in predicting hourly average windspeeds for a 24-hour period.

APPROACH

Subjectively and objectively derived 24-hourly average wind speed forecasts are being compared to the observed wind speeds. Overall reliability as well as specific strengths and weaknesses of each forecast technique will be determined by statistical analysis.

OUTPUT

A final report will be written containing an analysis of the reliability of all forecast techniques tested for each site including all forecast verification statistics.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Wind Characteristics at Singular Topographic Features
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** January 1979 - September 1980
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $48,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $48,000

PROJECT SUMMARY

BACKGROUND

Many WECS may be sited in non-uniform terrain where some very good wind resources may be found. Present designs are based upon classical-wind characteristics measured over uniform terrain. Since non-uniform terrain will have more severe winds, their characterization is important to achieve safe and economical WECS. The characterization of wind at a singular topographic feature is required to eliminate complexities and permit more general applicability of results.

OBJECTIVES

The objective of this study is to characterize the wind at a singular topographic feature for use in design and performance evaluation of WECS for operation in non-uniform terrain such as mountains or ridges.

APPROACH

The wind is measured at three or four levels within the boundary layer on and near an isolated mountain using 3-dimensional fast response anemometers. Mean and fluctuation properties of the wind are calculated to provide gust, turbulence, mean wind and wind shear characteristics.

OUTPUT

A report will be written containing useful wind characteristics and guides to possible methods of generalizing the results to other mountain sites as a function of location, meteorological conditions and time of day. The subcontract has resulted in the placement of a meteorological tower at the remote site atop a singular mountain.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: NOAA Wave Propagation Laboratory Boulder, CO 80303	Characteristics of Strong Down-Slope Wind
	CONTRACT NO. DE-A106-79ET23115
PRINCIPAL INVESTIGATOR Dr. Chandran Kaimal	**PERIOD OF PERFORMANCE** March 1979 - April 1980
WORK LOCATION Boulder, CO	**FISCAL YEAR 1979 FUNDING** $80,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $80,000

PROJECT SUMMARY

BACKGROUND

The environmental input for WECS design is generally limited to results obtained from low level (30 m or lower) wind measurements taken over uniform terrain. Also, at present no conditional sampling results investigating discrete gusts in the atmosphere are available for WECS design. The Boulder area has a unique wind condition which permits the measurement of more intense gusts. The upwind topographic conditions change as the wind direction changes. The gust characteristics as well as the effect of upwind topography need to be described for use in assessing acrodynamic loads on WECS.

OBJECTIVES

The objective of this study is to provide experimental measures of gust amplitudes and time scales and also provide experimental measures of the probability density distributions of wind accelerations averaged over specific times.

APPROACH

High resolution wind measurements are taken at the 300-m tower near Boulder, CO. These measurements are taken at many heights on the tower. These measurements will be analyzed for spectral and probability distributions of wind fluctuations.

OUTPUT

A report detailing the wind characteristics in strong winds measured at a 300-m tower near Boulder, CO. These results will also be interpreted with regard to their general applicability at other sites.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: FWG Associates, Inc. R.R. 2, Box 271-A, Lakewood Drive Tullahoma, TN 37388	Error Band Analysis
	CONTRACT NO. B23461-A-P
PRINCIPAL INVESTIGATOR Dr. Walter Frost	**PERIOD OF PERFORMANCE** February 1979 - September 1979
WORK LOCATION Tullahoma, TN	**FISCAL YEAR 1979 FUNDING** $27,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $27,000

PROJECT SUMMARY

BACKGROUND

Most meteorological parameters for use in WECS design are defined by empirical equations or curves derived from field data. These data usually show significant scatter about the empirical fit to them. The designer must know the risk of exceeding his design criteria which come from empirical relations. This task provides the required measures of reliability of wind characteristics information for the designer to examine the sensitivity of his design to the particular characteristic. It provides a measure of the spread to be expected in the actual wind characteristics experienced by a WECS.

OBJECTIVES

The objective of this study is to assess the data spread, variance and/or statistical confidence intervals associated with equations and curves derived from meteorological data for selected wind characteristics.

APPROACH

The contractor is performing error estimate calculations for a set of four wind characteristics reported in the NASA handbook for design of wind turbines.

OUTPUT

A report will be written which gives estimates of error and reliability of recommended equations, curves and numerical tabular relations for wind characteristics useful in the design of WECS.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Oregon State University Dept. of Atmospheric Sciences Corvallis, OR 97331	Measurement Methods for Performance Evaluation **CONTRACT NO.** DE-AM06-76RL02227
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** July 1979 - February 1981
WORK LOCATION Corvallis, OR	**FISCAL YEAR 1979 FUNDING** $130,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $130,000

PROJECT SUMMARY

BACKGROUND

Any evaluation of the effectiveness of a WECS in extracting power from the wind in which the WECS is immersed requires a thorough understanding of the wind characteristics and the machine response to those characteristics. Evaluation of stresses on WECS components also requires knowledge of the aerodynamic forces on the winds which cause them. It is not always a simple matter to know where or with what to measure the winds or how to analyze the wind measurements to properly characterize it. There is a need to describe the methods of which analysis are useful, the ways in which adequate measurements of wind can be made and the accuracy limits to be expected for each method.

OBJECTIVES

To provide suitable methods of measuring and analyzing wind near a WECS for the purpose of evaluating the performance of the WECS.

APPROACH

Combined aerodynamic theory and empiricism, and field tests employing a variety of wind property measurement methods and configurations will be used to determine the accuracy and completeness of the methods. The subcontractor will develop a model of a WECS with wind input and test the model against WECS performance measurements at turbine sites.

OUTPUT

Topical reports describing instruments, measurement methods, instrument location, methods of analysis and accuracy of results when using wind characteristics in evaluation of WECS performance will be written. The subcontractor will provide a computer model of a WECS dynamical response to wind suitable for estimating what wind characteristics are important in performance evaluation.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Colorado State University Dept. of Mechanical Engineering Ft. Collins, CO 80523	Measurement Methods for Performance Evaluation
	CONTRACT NO. DE-AC06-79ET-23164
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** September 1979 - June 1980
WORK LOCATION Ft. Collins, CO	**FISCAL YEAR 1979 FUNDING** $25,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $25,000

PROJECT SUMMARY

BACKGROUND

Any evaluation of the effectiveness of a WECS in extracting power from the wind in which the WECS is immersed requires a thorough understanding of the wind characteristics and the machine response to those characteristics. Evaluation of stresses on WECS components also requires knowledge of the aerodynamic forces on the winds which cause them. It is not always a simple matter to know where or with what to measure the winds or how to analyze the wind measurements to properly characterize it. There is a need to describe the methods of analysis which are useful – the ways in which adequate measurements of wind can be made and the accuracy limits to be expected for each method.

OBJECTIVES

The objective is to provide suitable methods of measuring and analyzing wind near a WECS for the purpose of evaluating the performance of the WECS.

APPROACH

Aerodynamic theory combined with field tests of a variety of wind property measurement methods and configurations will be used to determine the accuracy and completeness of the methods. The subcontractor will develop computer algorithms for real time evaluation of WECS performance using measurements of wind and turbine parameters.

OUTPUT

Topical reports describing instruments, measurement methods, instrument location, methods of analysis and accuracy of results when using wind characteristics in evaluation of WECS performance will be written. The subcontractor will provide algorithms for use with a "smart" data acquisition system to be used in studies by PNL of appropriate measurements and analysis of wind for performance evaluation.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Virginia Polytechnic Institute Dept. of Engineering Science and Mechanics P.O. Box 60220 Blacksburg, VA 24061	Meteorological Guidelines for WECS Design
	CONTRACT NO. DE-AC06-79ET-23114
PRINCIPAL INVESTIGATOR Dr. Robert Akins	**PERIOD OF PERFORMANCE** June 1979 - April 1980
WORK LOCATION Blacksburg, VA	**FISCAL YEAR 1979 FUNDING** $26,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $26,000

PROJECT SUMMARY

BACKGROUND

There is a strong need for accurate, concise documents which provide basic information about wind characteristics and other atmospheric characteristics for design of WECS. The documents must have sufficient depth of information, in the form of topical reports, for all anticipated needs, and be available for timely use.

OBJECTIVES

The objective of this study is to develop a set of reference documents, or topical reports, which contain the current best estimates of characteristics of the atmosphere for use in design of WECS.

APPROACH

Present best estimates of specific atmospheric characteristics will be derived from the literature and analysis of measurements. The subcontract is for gust and mean wind analysis at an East Coast island tower.

OUTPUT

A set of topical reports will be written which contain the current best estimates of atmospheric characteristics for use in WECS design. The subcontract will result in two reports. One is to be a gust analysis. The other is to be on mean wind probabilities, wind shear magnitude, and wind speed spectra.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Desert Research Institute P.O. Box 60220 Reno. NV 89506	Meteorological Guidelines for WECS Design **CONTRACT NO.** B-87938
PRINCIPAL INVESTIGATOR Dr. Thomas Hoffer	**PERIOD OF PERFORMANCE** September 1979 - August 1980
WORK LOCATION Reno, NV	**FISCAL YEAR 1979 FUNDING** $19,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $19,000

PROJECT SUMMARY

BACKGROUND

There is a strong need for accurate, concise documents which provide basic information about wind characteristics and other atmospheric characteristics for design of WECS. The documents must have sufficient depth of information, in the form of topical reports, for all anticipated needs, and be available for timely use.

OBJECTIVES

The objective of this study is to develop a set of reference documents, or topical reports, which contain the current best estimates of characteristics of the atmosphere for use in design of WECS.

APPROACH

Present best estimates of specific atmospheric characteristics will be derived from the literature and analysis of measurements. The subcontract is for estimation of icing conditions as a function of physical parameters of the atmosphere and topography.

OUTPUT

A set of topical reports will be written which contain the current best estimates of atmospheric characteristics for use in WECS design. The subcontract will result in one report on two icing types: freezing rain and rime-icing. The report will have a section dealing with icing at the MOD-2 test site.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Science Applications, Inc. 1200 Prospect St. La Jolla, CA 92038	Physical Analysis of Wind Speed Distribution Functions **CONTRACT NO.** DE-A106-79ET23115
PRINCIPAL INVESTIGATOR Dr. Eugene Buell	**PERIOD OF PERFORMANCE** October 1978 - September 1979
WORK LOCATION Colorado Springs, CO	**FISCAL YEAR 1979 FUNDING** $31,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $31,000

PROJECT SUMMARY

BACKGROUND

Probability density function (PDF) formulas generally used to estimate actual PDFs of hourly mean winds do not fit well many real measurements of PDF. There is a need to develop better PDF formulas based upon the actual physical boundary conditions and physical processes of the atmosphere in order to better estimate the power in the accessible wind at various sites.

OBJECTIVES

The objective of this study is to provide a formula for reliably estimating the probability density function for hourly mean winds for a variety of locations whose more general atmospheric physical properties can be described.

APPROACH

Joint frequency distributions of wind speed and direction completed from measured winds will be used to generate scalar PDFs. Generic shapes for the joint frequency distribution will be used to yield a closed form scalar PDF. The effect of height above grade level will also be examined and the effect of height and geographic location on the PDF will be assessed.

OUTPUT

A report will be written detailing a recommended PDF of wind speed as a function of location within the United States.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Pennsylvania State University University Park, PA 16802	Turbulence Characteristics Over Nonuniform Terrain
	CONTRACT NO. ET-78-S-06-1110
PRINCIPAL INVESTIGATOR H.A. Panofsky	**PERIOD OF PERFORMANCE** September 1978 - September 1980
WORK LOCATION University Park, PA	**FISCAL YEAR 1979 FUNDING** $12,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $71,000

PROJECT SUMMARY

BACKGROUND

While a fair amount of information concerning turbulence over smooth terrain is available, much less is known about the behavior of the wind over rougher terrain. Since many potentially attractive wind energy conversion system (WECS) sites are found in such areas, studies of wind characteristics, especially turbulence, are needed for proper and efficient WECS design.

OBJECTIVES

The objective of this study is to develop a model relating the fluctuation variance or turbulent intensity to parameters such as wind speed, surface roughness, stability and mixing depth. A model will also be formulated to specify the dependence of spectral density shape on such parameters. Separately, a study is being made of how non-normal are the distribution of gust accelerations.

APPROACH

Data from a number of sources, in various terrain configurations, will be analyzed. The results will be compared to models reported in the literature. The results of these analyses and comparisons will be used to develop the model.

OUTPUT

The output will consist of two reports. One report will describe the wind speed spectra observed in rough terrain as a function of meteorological parameters. The other report will describe the quantitative differences between actual gust rise (or velocity difference) probability distributions and the hypothetical Gaussian distributions.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Georgia Institute of Technology Atlanta, GA 30332	Turbulence Effects on WECS Output
	CONTRACT NO. EY-76-S-06-2439
PRINCIPAL INVESTIGATOR C.G. Justus	**PERIOD OF PERFORMANCE** May 1976 - April 1979
WORK LOCATION Atlanta, GA	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $238,000

PROJECT SUMMARY

BACKGROUND

This work began in May 1976 to examine the power production characteristics of simulated large-scale arrays of wind turbines in various geographic regions of the United States and to develop and verify a simplified array simulation model.

OBJECTIVES

The objectives of this project are to continue to study the benefits of wind diversity for multiple turbine units and turbine arrays and to develop methodologies for simple modeling of array wind statistics and effects on energy production. In addition, this study is to evaluate probabilities and time and spatial correlations relating to year-to-year and month-to-month variations of mean wind speed, and to test the feasibility of adjustment of short-term "candidate site" data with long-term nearby data. Also the effects of turbulence on a wind turbine's performance are to be evaluated experimentally.

APPROACH

Wind performance statistics for arrays having maximum diversity have been evaluated. Development of simplified methods for simulating array performance from single site statistics has continued. The annual variability of wind power at 40 National Weather Service Stations with mean wind speed greater than 5 m/s has been studied. Simple models of wind gusts and shear on the power output are being investigated, along with parallel studies with a Grumman Windstream 25.

OUTPUT

A report will be submitted detailing the computer program which is used in the array analyses. Another report will describe the effects of turbulence on wind turbine performance.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Western Scientific Services, Inc. 328 Airpark Drive P.O. Box 965 Ft. Collins, CO 80522	Wind Characteristics at Singular Topographic Features
	CONTRACT NO. B-92891-A-K
PRINCIPAL INVESTIGATOR J.R. Connell	**PERIOD OF PERFORMANCE** September 1979
WORK LOCATION Big Southern Butte, ID	**FISCAL YEAR 1979 FUNDING** $44,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $44,000

PROJECT SUMMARY

BACKGROUND

Many WECS may be sited in non-uniform terrain where some very good wind resources may be found. Present designs are based upon classical-wind characteristics measured over uniform terrain. Since non-uniform terrain will have more severe winds, their characterization is important to achieve safe and economical WECS. The characterization of wind at a singular topographic feature is required to eliminate complexities and permit more general applicability of results.

OBJECTIVES

The objective of this study is to characterize the wind at a singular topographic feature for use in design and performance evaluation of WECS for operation in non-uniform terrain such as mountains or ridges.

APPROACH

The wind is measured at three or four levels within the boundary layer on and near an isolated mountain using 3-dimensional fast response anemometers. Mean and fluctuation properties of the wind are calculated to provide gust, turbulence, mean wind and wind shear characteristics.

OUTPUT

A report will be written containing useful wind characteristics and guides to possible methods of generalizing the results to other mountain sites as a function of location, meteorological conditions and time of day. The subcontract has resulted in the placement of a meteorological tower at the remote site atop a singular mountain.

2.2 SUPPORT FOR DESIGN AND OPERATIONS

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Oregon State University Dept. of Atmospheric Sciences Corvallis, OR 97331	Wind Shear in the Nocturnal Boundary Layer
	CONTRACT NO. DE-A106-ET23116
PRINCIPAL INVESTIGATOR Larry J. Mahrt	**PERIOD OF PERFORMANCE** February 1979 - September 1980
WORK LOCATION Corvallis, OR	**FISCAL YEAR 1979 FUNDING** $61,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $61,000

PROJECT SUMMARY

BACKGROUND

Strong nocturnal wind shears are frequent over the high plains region since strong radiational cooling causes the boundary layer to be thin and the nocturnal jet low. These shears are roughly a factor of two larger than those predicted by the 1/7 power law. With baroclinic contributions they can exceed the shears predicted from conventional frictional-inertial theory by an order of magnitude. Such large shears can lead to excessive wind machine fatigue, therefore, an understanding of the frequency and characteristics of nocturnal shears is necessary for WECS design. Diurnal wind power variations by season and geographical location are appropriate considerations for both WECS design and siting.

OBJECTIVES

The principal objectives are to determine the statistics of strong nocturnal wind shears and to investigate the diurnal variation of wind power potential due to the low level jet for different locations, seasons and synoptic conditions.

APPROACH

Data from Colorado, Oklahoma, Nebraska, Pacific Northwest, Australia and Denmark will be analyzed. Cumulative frequency distributions for velocity shears in the vertical will be computed for layers appropriate to WECS for different times of day, season and geographical location. Similarity variations in wind power will be computed. Preliminary attempts to identify a simple parameter set with which to model these shears will be made.

OUTPUT

Documentation on the frequency and characteristics of strong noctural wind shears will be provided. Suggestions on how such shears might be modeled or predicted from a limited data set, as might be available to a site evaluation time, will be made.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: NOAA - Technique Development Laboratory National Weather Service Silver Spring, MD 20910	Development of Wind Forecasts for WECS Operations by MOS **CONTRACT NO.** B-23451-A-P
PRINCIPAL INVESTIGATOR Dave Gilhausen	**PERIOD OF PERFORMANCE** June 1979 - June 1980
WORK LOCATION NOAA/NWS/TDL Washington, DC	**FISCAL YEAR 1979 FUNDING** $40,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $40,000

PROJECT SUMMARY

BACKGROUND

The feasibility of using wind forecasts to make more efficient use of wind energy conversion systems (WECS) depends directly upon the reliability of the wind forecast. Consequently, one of the primary objectives of the Wind Characteristics program area is to determine the reliability of wind forecasts produced for wind turbine users, using state-of-the-art techniques.

Two general types of forecasting techniques are currently used to produce operational wind forecasts: subjective and objective. In an attempt to locate weather forecasting organizations producing operational wind forecasts by objective techniques, Pacific Northwest Laboratory (PNL) contacted all forecasting firms certified by the American Meteorological Society as well as the military and national weather services. TDL was the only organization producing such forecasts.

OBJECTIVES

The objective of this study is to examine the reliability of both deterministic and probabilistic objective wind forecasts produced by using model output statistics.

APPROACH

Both deterministic and probabilistic wind speed and direction forecasting equations are to be developed using Model Output Statistics (MOS). These equations shall be developed for nine selected DOE candidate sites. Twelve months of on site data will be used to develop the equations and an additional 12 months of data used to verify the forecasts.

OUTPUT

The wind forecast verification statistics will form part of the data base for evaluating the reliability of the forecasts for the operation of WTGs.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Weather Services Corporation Bedford, MA 01730	Historical Subjective Forecasting
	CONTRACT NO. B23451-A-P
PRINCIPAL INVESTIGATOR J.P. Murphy	**PERIOD OF PERFORMANCE** March 1979 - August 1979
WORK LOCATION Bedford, MA	**FISCAL YEAR 1979 FUNDING** $34,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $34,000

PROJECT SUMMARY

BACKGROUND

In order to assess the reliability of wind forecasts for the efficient operation of wind energy conversion systems (WECS) within a utility power grid system, both subjective and objective wind forecasts must be examined. However, a survey of existing subjective wind-forecasting products revealed that little or no data are available to evaluate these wind forecasts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts, using a historical data base.

APPROACH

Using existing forecasting techniques and a historical data base, the contractor will produce hourly wind speed forecasts for DOE candidate sites for a period of 12 months. Site wind data are supplied to the forecaster for the previous 18-hour period to simulate a real-time operational forecast mode.

OUTPUT

The contractor will provide a computer compatible data tape of hourly wind speed forecasts for the period of 12 months as a part of the data base for evaluating the reliability of wind forecasts for the operation of WTGs.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Accu-Weather 619 West College Ave. State College, PA 16801	Real Time Subjective Wind Forecasts
	CONTRACT NO. B-23098-A-P
PRINCIPAL INVESTIGATOR Multiple	**PERIOD OF PERFORMANCE** May 1979 - October 1979
WORK LOCATION Site	**FISCAL YEAR 1979 FUNDING** $53,000*
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $53,000*

PROJECT SUMMARY

BACKGROUND

A primary source of state-of-the-art subjective forecasting exists in the private sector of the meteorological community. A survey of all the organizations active in this endeavor was made. An RFP to produce real-time hourly forecasts for 11 DOE candidate sites for six months was sent to all such organizations expressing an interest in undertaking such a task. Five organizations were awarded contracts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts using only real-time data typically available to the operational forecaster.

APPROACH

Using existing forecasting techniques and near-real-time data, the contractor makes hourly wind speed and direction forecasts which are transmitted to the PNL prior to the first hour forecast. The forecasts are transmitted on farms which contain not only the 24 hourly forecasts but sufficient ancillary data to allow a thorough statistical analysis keyed to company, forecaster, time, site, etc. As the project progresses, site data will be made available to all forecasters so that they might benefit from their experience.

OUTPUT

This subcontract is one of five which were let so that all 11 sites would have three forecasts per hour. At the termination of the contract, each contractor will write a report detailing the methods used to forecast for each site as well as documenting the changes elicited by the data updating. A statisitical analysis of the results is anticipated in another contract.

*Total for five subcontracts

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Freeze-Notis 1453 Northeast 66th Ave. Des Moines, Iowa 50313	Real Time Subjective Wind Forecasts
	CONTRACT NO. B-87037-A-P
PRINCIPAL INVESTIGATOR Multiple	**PERIOD OF PERFORMANCE** May 1979 - October 1979
WORK LOCATION Site	**FISCAL YEAR 1979 FUNDING** $53,000*
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $53,000*

PROJECT SUMMARY

BACKGROUND

A primary source of state-of-the-art subjective forecasting exists in the private sector of the meteorological community. A survey of all the organizations active in this endeavor was made. An RFP to produce real-time hourly forecasts for 11 DOE candidate sites for six months was sent to all such organizations expressing an interest in undertaking such a task. Five organizations were awarded contracts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts using only real-time data typically available to the operational forecaster.

APPROACH

Using existing forecasting techniques and near-real-time data, the contractor makes hourly wind speed and direction forecasts which are transmitted to the PNL prior to the first hour forecast. The forecasts are transmitted on farms which contain not only the 24 hourly forecasts but sufficient ancillary data to allow a thorough statistical analysis keyed to company, forecaster, time, site, etc. As the project progresses, site data will be made available to all forecasters so that they might benefit from their experience.

OUTPUT

This subcontract is one of five which were let so that all 11 sites would have three forecasts per hour. At the termination of the contract, each contractor will write a report detailing the methods used to forecast for each site as well as documenting the changes elicited by the data updating. A statistical analysis of the results is anticipated in another contract.

*Total for five subcontracts

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: General Weather Center 910 Fisher Bldg. Detroit, MI 48202	Real Time Subjective Wind Forecasts
	CONTRACT NO. B-87038-A-P
PRINCIPAL INVESTIGATOR Multiple	**PERIOD OF PERFORMANCE** May 1979 - October 1979
WORK LOCATION Site	**FISCAL YEAR 1979 FUNDING** $53,000*
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $53,000*

PROJECT SUMMARY

BACKGROUND

A primary source of state-of-the-art subjective forecasting exists in the private sector of the meteorological community. A survey of all the organizations active in this endeavor was made. An RFP to produce real-time hourly forecasts for 11 DOE candidate sites for six months was sent to all such organizations expressing an interest in undertaking such a task. Five organizations were awarded contracts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts using only real-time data typically available to the operational forecaster.

APPROACH

Using existing forecasting techniques and near-real-time data, the contractor makes hourly wind speed and direction forecasts which are transmitted to the PNL prior to the first hour forecast. The forecasts are transmitted on farms which contain not only the 24 hourly forecasts but sufficient ancillary data to allow a thorough statistical analysis keyed to company, forecaster, time, site, etc. As the project progresses, site data will be made available to all forecasters so that they might benefit from their experience.

OUTPUT

This subcontract is one of five which were let so that all 11 sites would have three forecasts per hour. At the termination of the contract, each contractor will write a report detailing the methods used to forecast for each site as well as documenting the changes elicited by the data updating. A statistical analysis of the results is anticipated in another contract.

*Total for five subcontracts

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Global Weather Services P.O. Box 6053 Leawood, Kansas 66206	Real Time Subjective Wind Forecasts **CONTRACT NO.** B-87039-A-P
PRINCIPAL INVESTIGATOR Multiple	**PERIOD OF PERFORMANCE** May 1979 - October 1979
WORK LOCATION Site	**FISCAL YEAR 1979 FUNDING** $53,000*
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $53,000*

PROJECT SUMMARY

BACKGROUND

A primary source of state-of-the-art subjective forecasting exists in the private sector of the meteorological community. A survey of all the organizations active in this endeavor was made. An RFP to produce real-time hourly forecasts for 11 DOE candidate sites for six months was sent to all such organizations expressing an interest in undertaking such a task. Five organizations were awarded contracts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts using only real-time data typically available to the operational forecaster.

APPROACH

Using existing forecasting techniques and near-real-time data, the contractor makes hourly wind speed and direction forecasts which are transmitted to the PNL prior to the first hour forecast. The forecasts are transmitted on farms which contain not only the 24 hourly forecasts but sufficient ancillary data to allow a thorough statistical analysis keyed to company, forecaster, time, site, etc. As the project progresses, site data will be made available to all forecasters so that they might benefit from their experience.

OUTPUT

This subcontract is one of five which were let so that all 11 sites would have three forecasts per hour. At the termination of the contract, each contractor will write a report detailing the methods used to forecast for each site as well as documenting the changes elicited by the data updating. A statisitical analysis of the results is anticipated in another contract.

*Total for five subcontracts

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Murray & Trettel 414 West Frontage Road Northfield, Illinois 60093	Real Time Subjective Wind Forecasts **CONTRACT NO.** B-87040-A-P
PRINCIPAL INVESTIGATOR Multiple	**PERIOD OF PERFORMANCE** May 1979 - October 1979
WORK LOCATION Site	**FISCAL YEAR 1979 FUNDING** $53,000*
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $53,000*

PROJECT SUMMARY

BACKGROUND

A primary source of state-of-the-art subjective forecasting exists in the private sector of the meteorological community. A survey of all the organizations active in this endeavor was made. An RFP to produce real-time hourly forecasts for 11 DOE candidate sites for six months was sent to all such organizations expressing an interest in undertaking such a task. Five organizations were awarded contracts.

OBJECTIVES

The objective of this contract is to produce and evaluate subjective wind forecasts using only real-time data typically available to the operational forecaster.

APPROACH

Using existing forecasting techniques and near-real-time data, the contractor makes hourly wind speed and direction forecasts which are transmitted to the PNL prior to the first hour forecast. The forecasts are transmitted on farms which contain not only the 24 hourly forecasts but sufficient ancillary data to allow a thorough statistical analysis keyed to company, forecaster, time, site, etc. As the project progresses, site data will be made available to all forecasters so that they might benefit from their experience.

OUTPUT

This subcontract is one of five which were let so that all 11 sites would have three forecasts per hour. At the termination of the contract, each contractor will write a report detailing the methods used to forecast for each site as well as documenting the changes elicited by the data updating. A statistical analysis of the results is anticipated in another contract.

*Total for five subcontracts

CONTRACTOR Pacific Northwest Laboratory Subcontractor: Simpson Weather Association P.O. Drawer 5508 Charlottesville, VA 22903	**TITLE** Wind Characteristics for Solar-Wind Desalting **CONTRACT NO.** DE-AC06-79ET23112
PRINCIPAL INVESTIGATOR Dr. M. Garstang	**PERIOD OF PERFORMANCE** July 1979 - August 1980
WORK LOCATION University of Virginia Charlottesville, VA	**FISCAL YEAR 1979 FUNDING** $13,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $13,000

PROJECT SUMMARY

BACKGROUND

Most WECS research is aimed at the end product of energy in the form of either heat or electricity. Apparently a large part of the available wind energy resource exists in areas where there is high solar insolation and a need for potable water. Frequently contaminated water (e.g., sea water) is readily available.

OBJECTIVES

The research objectives are threefold:

1) To determine the feasibility of a solar-wind desalting system where all requirements for heat balance and energy flow are defined through detailed calculations.
2) To determine geographical/climatological locations where the system can be most profitably utilized.
3) To recommend whether or not a test unit should be constructed.

APPROACH

The system to be studied elevates the temperature of impounded saline water by utilizing solar radiation. Water vapor from the surface is condensed by passing it through cooling coils powered by the wind. The latent and mechanical heat produced is returned to the impounded water. Detailed calculations of the physics, meteorology and economics will delineate the feasibility. Available climatology of both solar insolation and wind will be used to determine sites where such a system could be most profitably utilized. Feasibility will be further delineated by size – a single family, a small community, such as a hotel or school or resort, and a small municipality of hundreds to a few thousand people.

OUTPUT

A comprehensive final report, which describes in detail all analyses, calculations, assumptions and results shall be submitted. It shall include in detail the recommendation whether or not to construct a test unit.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Data Analysis and Reporting
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR W.F. Sandusky	**PERIOD OF PERFORMANCE** October 1978 - September 1982
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $114,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $114,000

PROJECT SUMMARY

BACKGROUND

Wind characteristic at candidate wind turbine sites must be continuously documented and updated for use in the wind turbine installation site selection process. At those sites where turbines have been installed, an update on the wind characteristics at the site is needed for operational strategy and performance evaluation studies as well as analysis of turbine parameters collected with the wind data.

OBJECTIVE

The objective of this study is to develop data analysis procedures for use in the site selection and machine R&D efforts, and to present these analyses in a useful format for each site via monthly data reports. Computer generated graphical plots will be prepared for presentation of the turbine parameter data.

APPROACH

Computer programs will be developed that will read the nine-track data tape submitted to PNL for each candidate and installation site, and that will process the data to produce the necessary analyses. Coordination with DOE/NASA, machine manufacturers, and DOE will ensure that the format of the analysis is appropriate. As new analyses are needed, the computer programs will be updated.

OUTPUT

Quarterly data reports for each candidate and installation site have been published and submitted to NASA and DOE. Each participating utility receives a report for his use. Graphical plots of turbine parameter data at three MOD-0A 200-kW wind turbine sites (Clayton, NM; Block Island, RI; and Culebra, PR) are being submitted to NASA for review.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Evaluation of Wind Turbine Installation Sites
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR D.S. Renne	**PERIOD OF PERFORMANCE** October 1973 - September 1982
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $35,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $35,000

PROJECT SUMMARY

BACKGROUND

Although the meteorological measurements obtained from the DOE tower installed at each wind turbine site provide an extensive data base on the wind characteristics in the vicinity of the turbine, at some sites unique meteorological phenomena will occur which could have important influences on the operational strategy and performance of the turbine. Because of the location of the tower and the type of sensors used, a special measurement program may be needed to address these phenomena.

OBJECTIVES

The objectives of this program are to identify pertinent meteorological characteristics at wind turbine installation sites, and develop fast response short-term field measurement programs to quantify the characteristics.

APPROACH

For these special types of studies, a number of measurement platforms, including kites, balloons, aircraft and photographic measurements may be used. As a study is identified, contracts to consultants, who have demonstrated expertise in the use of this equipment, will be issued and measurements will be performed under a variety of synoptic conditions that are representative of the climatology of the site.

OUTPUT

A special field program was undertaken at the Boone, NC, MOD-1 site in March 1979 to determine in detail the vertical structure of the airflow characteristics during power producing winds. Extensive profiles of wind speed and direction, vertical component of the wind, temperature and humidity were made during a two-week period. A clear understanding of the characteristics of the strong vertical shear that exists over the site resulted from these studies.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Support to DOE's Selection of New Candidate Wind Turbine Sites
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR D.S. Renne	**PERIOD OF PERFORMANCE** October 1978 - September 1979
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $32,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $32,000

PROJECT SUMMARY

BACKGROUND

The technology necessary for the successful design, fabrication and operation of large wind turbine systems can be developed most effectively by operation of several prototype systems in typical user environments. To assure appropriate utility participation, a Program Opportunity Notice will be issued in FY 1979 to all interested utilities, requesting proposals for sites. Meteorological measurement equipment will be installed in FY 1980 on the most promising sites for additional documentation of wind energy potential. Periodically, machine installation sites will be selected from these candidate sites.

OBJECTIVES

The objective of this program is to provide technical assistance to DOE in announcing the objectives of the program to prepare a Program Opportunity Notice for utility response, and to prepare the appropriate supporting documents such as Evaluation Procedures, Letters of Announcement of the Program Opportunity Notice to the utilities, and Commerce Business Daily advertisements. The ultimate objective is to provide necessary assistance to DOE via support to the Evaluation Panel and Site Selection Board for final selection of the candidate sites.

APPROACH

A Program Opportunity Notice and supporting Evaluation Procedures documents will be drafted incorporating the pertinent features of the earlier RFP for candidate sites (E49-8-2283 released March 1976), and including requests for information on wind characteristics pertinent to the next generation of machine technology.

In addition, procedures will be established to screen the utility proposals and provide fast response assistance to the federal Evaluation Panel and Site Selection Board in their deliberations.

OUTPUT

A Commerce Business Daily announcement was published announcing two phases of the program: candidate sites (and ultimately, an installation site) for the MOD-2, 2,500-kW wind turbine generator, and candidate sites for future wind turbine systems. In addition, approximately 3,100 electric service organizations were notified of this program. A PON for both candidate site selections and one for the MOD-2 installation site were prepared and distributed to electric service organizations. Technical and documentation assistance were provided to the federal Evaluation Panel and DOE's Site Selection Board in reviewing and evaluating proposals submitted in response to the PONs.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Battelle Boulevard Richland, WA 99352	Support to DOE's Turbine Installation Site Selection Program
	CONTRACT NO. EY-76-C-06-1830
PRINCIPAL INVESTIGATOR D.S. Renne	**PERIOD OF PERFORMANCE** October 1978 - September 1982
WORK LOCATION Richland, WA	**FISCAL YEAR 1979 FUNDING** $80,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $80,000

PROJECT SUMMARY

BACKGROUND

As the need is established to identify a specific site on which to install a wind turbine for testing purposes, wind characteristics information for all the sites must be presented to the Evaluation Panel and Site Selection Board in a suitable format for their delibrations.

OBJECTIVE

The objective of this program is to support DOE's wind turbine installation site selection process.

APPROACH

Summaries of pertinent wind characteristics will be prepared for each candidate site. The summaries will address the Evaluation Procedures established by the Evaluation Panel for wind turbine installation site selections. Site visits may be made to provide additional information on potential unique wind characteristics that may exist at each site. Presentations of this information will be made to the evaluation panel during their formal deliberations.

OUTPUT

During FY 1979 emphasis was placed on providing technical and documentation assistance to DOE in selecting a site for receiving three MOD-2, 2,500-kW wind turbine generators. The selection process was completed by reviewing proposals received in response to a PON (see Support to DOE's Selection of New Candidate Wind Turbine Sites), providing technical assistance to the federal Evaluation Panel and DOE's Site Selection Board, and documenting the presentation to the Site Selection Official.

CONTRACTOR Pacific Northwest Laboratory Subcontractor: SRI-International 333 Ravenswood Avenue Menlo Park, CA 94025	**TITLE** Estimating Wind Characteristics at Candidate Sites **CONTRACT NO.** B-23149-A-E
PRINCIPAL INVESTIGATOR Dr. Chandrakant Bhumralkar	**PERIOD OF PERFORMANCE** April 1979 - February 1980
WORK LOCATION Menlo Park, CA	**FISCAL YEAR 1979 FUNDING** $69,000
CONTRACTING OFFICE DOE Richland Operations Office Richland, WA	**CUMULATIVE FUNDING** $69,000

PROJECT SUMMARY

BACKGROUND

To assist in the wind turbine site selection process, it is necessary to have an estimate of the wind characteristics at a candidate site even if on-site measurements are unavailable. One way to achieve this is to utilize a model that incorporates nearby National Weather Service data.

OBJECTIVE

The objective of this study is to refine a previously developed numerical wind flow model which utilizes nearby National Weather Service data, and to apply the model to eight candidate wind turbine sites. The model will be validated by comparing results with actual on-site wind measurements.

APPROACH

A model, developed in an earlier study within the Wind Characteristics program element, will be refined by incorporating spatial and temporal variations in the boundary layer. Nearby National Weather Service data for the year 1977 will be acquired for eight candidate wind turbine sites. Results of the model using these data will be compared with actual on-site data taken during the same period.

OUTPUT

The model has been refined in a number of ways, including allowances for variation in boundary layer thicknesses. Digital terrain types are used as model input. The refined model version has been applied to four DOE candidate sites to test the refinements and is being verified against data collected from three additional candidate sites.

CONTRACTOR	TITLE
Pacific Northwest Laboratory Subcontractor: Environmental Systems Corporation (ESC) P.O. Box 2525 Knoxville, TN 37901	Meteorological Measurements at Candidate Sites/ Meteorological Measurements at Wind Turbine Sites
	CONTRACT NO. B-23454-A-E
PRINCIPAL INVESTIGATOR T.B. Carlson	**PERIOD OF PERFORMANCE** July 1978 - January 1980
WORK LOCATION Knoxville, TN	**FISCAL YEAR 1979 FUNDING** $686,000
CONTRACTING OFFICE Pacific Northwest Laboratory Richland, WA	**CUMULATIVE FUNDING** $844,000

PROJECT SUMMARY

BACKGROUND

There is a need for utility participation if effective operation of several prototype large wind turbine systems in typical user environments is to be demonstrated. However, it is unrealistic to expect that all interested utilities will have appropriate on-site wind data for use in determining which sites will receive machines for testing purposes. Collection of on-site data will provide an incentive for utilities to pursue wind energy utilization even if they are not awarded a machine from the federal government.

OBJECTIVE

The objective of this program is to obtain sufficient wind data to accurately assess the wind energy of various sites as an evaluation factor in the selection of sites for future wind turbine installations. The second objective is to continue collection of on-site data at sites where machines are installed, modifying the measurement system to support the R&D effort.

APPROACH

Meteorological towers 150 feet in height will be installed at all candidate sites selected through the RFP released in March 1976 and the PON released in FY 1979. Continuous collection of wind data at two or more levels on the tower will proceed for a long period of time for use in installation site selections. Once a turbine is installed on a site, the measurement program will be modified to collect turbine parameters data to support operational strategies and performance evaluations.

OUTPUT

Cassette data tapes collected at each site are forwarded to ESC by the utility. From these cassette tapes a 9-track tape is provided to PNL each month for use in PNL's preparation of monthly data reports. Equipment at the sites is maintained by ESC. As new candidate sites are selected, a subcontractor to PNL will continue to perform these functions after making arrangements to have the equipment installed at the sites.

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3.0 TECHNOLOGY DEVELOPMENT PROJECT SUMMARIES

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO 80401	Technical and Management Support for the Development of Small Wind Systems
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Terry Healy	**PERIOD OF PERFORMANCE** April 1976 - continuing
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $11,800,000
CONTRACTING OFFICE DOE Albuquerque Operations Office Albuquerque, NM	**CUMULATIVE FUNDING** $20,688,000 (total program)

PROJECT SUMMARY

BACKGROUND

While small (less than 100 kW) wind systems are commercially available, they are not yet cost-competitive with conventional power sources in most applications and locations. To reduce these costs and alleviate other barriers to the commercialization of wind systems, a Small Wind Systems Test and Development Center has been established at the DOE Rocky Flats Plant near Golden, Colorado. Most of the funding for this operation will be passed on to private industry through the purchase of test and prototype machines and research and development services.

OBJECTIVES

The overall objectives are to reduce the cost of energy generated by small wind systems and advance their commercialization and use. Specific objectives during FY 1979 were to: 1) reduce the uncertainties of performance and energy costs through instrumented testing of small wind energy conversion systems (SWECS); 2) determine and achieve technical and cost goals through the development of advanced SWECS and the conduct of supporting research and technology projects; 3) help reduce institutional barriers to SWECS commercialization through the operation of the DOE Field Evaluation Program for SWECS and the conduct of special studies; 4) increase consumer knowledge and manufacturer capability; and 5) assist private industry in the development of standards.

APPROACH

To meet its objectives, the Rocky Flats Wind Systems Program was organized into ten technically related task areas, including 1) test center development; 2) test operations; 3) systems development; 4) supporting research and technology; 5) field evaluation; 6) special studies; 7) technical support; 8) planning; 9) standards; and 10) information dissemination.

OUTPUT

The output of the Rocky Flats effort includes test data on commercially available and advanced prototype wind machines together with a series of advanced designs created to meet specific performance and cost goals. Technical reports will contribute to the resolution of institutional barriers to SWECS commercialization and increased consumer awareness of wind power potential and will provide information to manufacturers on SWECS design, performance, applications, and cost. Subcontracted systems development efforts will help stimulate the development of the SWECS industry.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO, 80401	**TITLE** Rocky Flats Small Wind Systems Test Center **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Andrew R. Trenka	**PERIOD OF PERFORMANCE** April 1976 - continuing
WORK LOCATION DOE Rocky Flats Plant and DOT Testing Facility, Pueblo, CO	**FISCAL YEAR 1979 FUNDING** Included in total program funding
CONTRACTING OFFICE DOE Albuquerque Operations Office Albuquerque, NM	**CUMULATIVE FUNDING** Included in total program cumulative funding

PROJECT SUMMARY

BACKGROUND

A major objective of the DOE Rocky Flats Plant Wind Systems Program is to test small wind systems over a wide range of environmental conditions and under various simulated conditions. A test facility was established in 1976 and has been continually expanded since that time to meet this program objective. Work under this task is performed as a part of the overall Rocky Flats program effort.

OBJECTIVES

The objectives of this project are to establish, develop and operate a test facility and to provide data obtained at this facility to meet the needs of various audiences.

APPROACH

Commercially available SWECS and advanced SWECS developed under subcontract to various government agencies as well as those developed by private monies are tested at Rocky Flats. To meet objectives, several types of testing capability have been developed, including: 1) atmospheric (free wind) testing; 2) controlled velocity testing, which is performed using a propelled railroad flatcar at the U.S. Department of Transportation (DOT) test facility in Pueblo, Colorado; and 3) vibration testing of SWECS and SWECS components. A fourth capability, dynamometer testing of SWECS generators and transmissions, is under development. Seventeen commercially available SWECS were tested under atmospheric conditions during FY 1979. Selected units were tested under controlled velocity conditions and subjected to vibration testing.

OUTPUT

Engineering and performance data on commercially available SWECS are being provided to meet the needs of the SWECS industry, government agencies, various institutions, utilities and the general public. Test data on advanced systems will be used to verify design analyses and system integrity and to support design modifications to reduce SWECS cost, optimize their performance and increase their reliability.

3.1 SMALL SYSTEMS TECHNOLOGY

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO 80401	SWECS Noise Assessment
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR A. Craig Hansen/Margaret Hickey	**PERIOD OF PERFORMANCE** October 1978 - June 1980
WORK LOCATION Rocky Flats Plant Bolden, CO 80401	**FISCAL YEAR 1979 FUNDING** $14,400
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $14,400

PROJECT SUMMARY

OBJECTIVES

The specific objectives of this effort are to: 1) measure in a controlled and systematic manner the noise generated by commercially available and prototype machines being tested at Rocky Flats; 2) make a limited effort to locate the source of noise from each machine; and 3) compare the noise generated with the existing range of federal and community standards.

APPROACH

Noise measurements will be made (in an area free of WTG noise) as a function of wind speed. A noise level map will be generated around representative turbines in light, "rated" and high winds. A survey will be made of EPA regulations, codes and acoustics literature to allow a comparison of noise data with acceptable noise levels in community situations. The significance of the measurements to noise nuisance potential will be assessed.

OUTPUT

Noise data will be included in Test Center reports and compared with federal, state and community standards. A stand-alone noise assessment report will provide information to SWECS designers, consumers, state and local agencies, planning and zoning boards, and building code developers.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO 80401	**TITLE** SWECS – Rotor Wake Investigations **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR A. Craig Hansen	**PERIOD OF PERFORMANCE** June 1979 - continuing
WORK LOCATION Rocky Flats Wind Systems Test Center	**FISCAL YEAR 1979 FUNDING** $44,000
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $44,000

PROJECT SUMMARY

BACKGROUND

Knowledge of the extent and nature of the disturbance a WTG causes in the ambient flow field is important for a variety of reasons. Wake vortex trajectories determine the induced velocity distribution near the rotor – an important input to load and performance calculations. Though virtually all performance models require tabulation of the induced velocity field, no actual measurements have been made to validate the velocity field calculated. Complete testing and validation of load prediction models will not be possible without wake measurements in the natural wind.

OBJECTIVES

The purpose of this project is to measure the wake around a horizontal-axis wind turbine.

APPROACH

Sonic anemometer arrays will be used for the velocity measurements. These anemometers offer two-component measurement with adequate spatial resolution, frequency response much greater than vortex passage frequencies, high wind survivability and ease of operation and calibration. Emphasis will be placed on measuring the wake persistance and vortex location.

OUTPUT

Quantitative measurements of the flow field around a SWECS in the field will be made. A technical report describing the work performed and data acquired will be prepared.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO 80401	**TITLE** Synthesis of Tower Dynamics Analysis Methods **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR D. Chris Shepherd	**PERIOD OF PERFORMANCE** November 1978 - continuing
WORK LOCATION Rocky Flats Plant	**FISCAL YEAR 1979 FUNDING** $15,000
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $15,000

PROJECT SUMMARY

BACKGROUND

Matching of rotors and towers to avoid vibration problems requires accurate prediction of tower vibration frequencies and modes. At present, there is a variety of structural dynamics models covering a wide range of complexity, cost and application. Some models provide capabilities beyond those needed by the SWECS designer, while other models will meet all of the needs of the industry. An in-house examination of available models is being performed at Rocky Flats to determine which model or models are most appropriate in complexity, cost and accuracy for use by the SWECS designer.

OBJECTIVES

The purpose of this project is to identify and evaluate available structural dynamics computer codes.

APPROACH

A variety of analysis codes which cover a wide spectrum of sophistication will be examined. Selected programs will be entered and run on the Rocky Flats computer system. Towers which will be tested at the RF WSTC will be analyzed with the models to determine the models' limitations and applicability.

OUTPUT

A guide to the selection and use of available computer models for a variety of tower types for use by SWECS designers.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Wind Systems Program P.O. Box 464 Golden, CO 80401	**TITLE** Tower Dynamics Response Characteristics **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR D. Chris Shepherd	**PERIOD OF PERFORMANCE** November 1978 - continuing
WORK LOCATION Rocky Flats Plant	**FISCAL YEAR 1979 FUNDING** $25,000
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $25,000

PROJECT SUMMARY

BACKGROUND

Tower design affects wind turbine system characteristics through the aerodynamic interference introduced at the blading (tower shadow), the motion of the turbine arising from tower oscillations, and the addition of a mass/elastic contribution that could participate in mechanical and aeroelastic instabilities. Little information on the vibration characteristics of various tower designs has been released for use by the SWECS designer.

OBJECTIVES

The purpose of this project is to acquire and assemble a data base on tower vibration frequencies and mode shapes for use in validating theoretical models.

APPROACH

Dynamic characteristics of several towers located at the Rocky Flats WSTC will be measured using accelerometers and a HP Modal Analyzer. Parameters to be varied during the test sequence are guy wire tension and mass atop to tower.

OUTPUT

A test data package will be generated for several towers at the test center. This data package will catalog the measured parameters in a graphical format and provide an analysis of the resulting data. A separate package will be provided which would detail the test procedures, data reduction methodology and analysis techniques employed.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Systems Control, Inc. 1801 Page Mill Rd., Palo Alto, CA 94304	**TITLE** Dispersed Small Wind Systems Interconnected with a Utility Distribution System **CONTRACT NO.** PF-94445-L
PRINCIPAL INVESTIGATOR Fred S. Ma	**PERIOD OF PERFORMANCE** April 1979 - May 1980
WORK LOCATION Palo Alto, CA	**FISCAL YEAR 1979 FUNDING** $112,000
CONTRACTING OFFICE DOE Rocky Flats Plant, P.O. Box 464 Golden, CO 80401	**CUMULATIVE FUNDING** $112,000

PROJECT SUMMARY

OBJECTIVES

The goals of this study are to identify concerns associated with the intertie of SWECS with a utility, recommend procedures for alleviating the identified problems, and assess the technical feasibility of intertying dispersed SWECS with utility systems. Various operational situations shall be studied for which SWECS would have an impact on utility load dispatching, the integrity of the grid systems, the safety of utility personnel and the operation and condition of electrical equipment powered by the utility.

APPROACH

Tasks will include: 1) scenario and case study definitions; 2) personnel safety assessment; 3) distribution operations assessment; 4) bulk generation and transmission operation assessment; 5) utility impact evaluation; and 6) technical feasibility assessment.

OUTPUT

An interim report will assess current interconnect hardware. The final report will identify and assess the technical problems of implementing dispersed SWECS, determine the feasibility of intertying a significant number of wind turbines throughout a utility distribution system, and document all work performed under the contract. Deficiencies in the state-of-the-art hardware will be identified and recommendations made for SWECS hardware development.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: New Alchemy Institute Woods Hole, MA 02543	**TITLE** Matching SWECS Rotor Capabilities to Driven Loads **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Joseph B. Seale	**PERIOD OF PERFORMANCE** August 1979 - August 1980
WORK LOCATION Woods Hole, MA	**FISCAL YEAR 1979 FUNDING** $16,233
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $16,233

PROJECT SUMMARY

BACKGROUND

The SWECS industry has too often experienced cases of rotor-load mismatch. The result is generally failure of the rotor to reach its optimum tip speed ratio (and hence its optimum efficiency). If the load requires excessive starting torque, the rotor will not operate at all. These extreme situations have often occurred in spite of the obvious need to avoid them. No consistent methodology has been developed for use by the SWECS designer in matching the rotor torque/rpm output characteristics with the torque/rpm input characteristics of an energy conversion unit.

OBJECTIVES

The primary goal of the study is to provide the SWECS designer with information needed to successfully match rotor output characteristics to the input characteristics for a variety of load types early in the system design phase.

APPROACH

This project will be conducted in two phases. In Phase I the contractor will gather characteristics data on a variety of rotors and loads and condense it into workable form. In Phase II the contractor will develop methods to use the rotor/load characteristics data and recommend approaches for matching specific rotors and loads.

OUTPUT

A handbook which provides 1) details on the torque vs rpm characteristics of a variety of loads and rotors, and 2) an analytical procedure for matching rotor/load characteristics will be prepared.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Agricultural Research Northeastern Region Beltsville, MD 20705	Program Management, Rural and Remote Areas of Wind Energy Research
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L.A. Liljedahl	**PERIOD OF PERFORMANCE** August 1975 - September 1979
WORK LOCATION Beltsville, MD	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Headquarters Washington, DC	**CUMULATIVE FUNDING** $2,467,000

PROJECT SUMMARY

BACKGROUND

Agricultural power use is geographically dispersed, as is wind power availability, and historically agriculture has made considerable use of wind power, yielding heuristic arguments that agriculture might beneficially use wind power in the future. However, agricultural practices and power requirements have changed drastically since the time when the use of windmills was widespread.

OBJECTIVES

The objective of this project is to determine agricultural applications that indicate high potential for wind power use, define agricultural markets for wind energy conversion systems and their economic thresholds, and specify research and development needs which will meet these objectives.

APPROACH

Research literature on agricultural power and energy use and wind power technology will be reviewed, from which preliminary definitions of wind power applications will be formulated. Plans for needed research and development to assess the value of these applications will be submitted periodically to DOE, and research and development projects assigned to the U.S. Department of Agriculture by DOE will be managed, reviewed and reported to DOE.

OUTPUT

Management of the program will yield annual program development plans, requests for proposals for externally executed work and reports of completed work suitable for distribution by DOE.

CONTRACTOR U.S. Department of Agriculture Science and Education Administration	**TITLE** Dairy Milk Cooling/Water Heating – Feasibility Study
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L.A. Liljedahl	**PERIOD OF PERFORMANCE** 1976 - 1981
WORK LOCATION Beltsville, MD	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $113,000

PROJECT SUMMARY

BACKGROUND

Dairy milk cooling is a candidate use of wind power in agriculture. The use of electrical power transmission between the wind turbine and the refrigeration equipment adds to the system cost and restricts the wind power which can be captured. There is a need to test the practicality and measure the performance of a wind turbine which is mechanically coupled to the refrigeration equipment.

OBJECTIVES

The objectives are to 1) develop the design procedure for a wind turbine system used to directly drive (through a mechanical transmission system) a heat pump system used for dairy milk cooling, having an intermediate ice storage system, and also used for preheating of sanitation wash water; and 2) evaluate possible operating difficulties.

APPROACH

A wind-powered, mechanically-driven refrigeration system for a typical 200-cow dairy, having intermediate ice storage and using condensor heat for water heating will be designed. Its performance will be analyzed and evaluated for potential difficulties in the operation of the refrigeration system when operated over a wide range of compressor speeds. The performance of alternative schemes for matching refrigeration load to wind power availability will be analyzed, and the vibration of structures and drive systems will be evaluated.

OUTPUT

A report on design procedure and feasibility analysis will be prepared.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration	Evaluation of Pumps for Wind-Driven Irrigation Proof-of-Concept Experiment
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR TBD	**PERIOD OF PERFORMANCE** 1979 - 1980
WORK LOCATION TBD	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $50,000

PROJECT SUMMARY

BACKGROUND

Commercially available irrigation pumps are designed to operate at constant speed, since previous power sources such as engines and electric motors maintain a nearly constant speed. They are thus not well suited for direct, independent operation by a wind turbine, which may operate intermittently and at varying speeds.

OBJECTIVES

The objective is to assess deep-well and shallow-well pumps for characteristics of value for wind-powered irrigation pumping.

APPROACH

The operating characteristics of all types of pumps customarily used for pumping water will be reviewed, formance data. From analysis, and if necessary, computer simulation, the performance of such pumps, operated at varying speeds over a wide range of speeds, will be computed. From this research, the advantages and disadvantages of each type of pump will be assessed for its value in a wind-powered irrigation system.

Modifications in the design and construction of these pumps, to make them suitable for use with wind power, will be investigated and analyzed. Recommendations will be made for future development. Such developments might involve the use of adjustable stators and/or rotors to maintain constant pressure at variable speeds, or the development of high capacity positive displacement pumps.

OUTPUT

1. Report on selection criteria and design procedure when pumps are to be independently wind driven.
2. Report on evaluation of pump types most suitable for independent wind driven operation and recommendations for needed research and/or development.

3.1 SMALL SYSTEMS TECHNOLOGY

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: USDA Wind Erosion Laboratory, Manhattan, KA	Low Lift Pumping Proof-of-Concept Experiment
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L. Hagen	**PERIOD OF PERFORMANCE** 1978 - 1980
WORK LOCATION Manhattan, Kansas	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $124,000

PROJECT SUMMARY

BACKGROUND

Several methods of using wind power for irrigation pumping have been proposed. One method uses a wind turbine mechanically coupled to a centrifugal pump for low lift pumping from water sources with little response to varying pumping rates. This concept requires verification and measurement of the performance of such a system.

OBJECTIVES

The objective is to obtain actual operating data on performance of a windmill driving a low-lift irrigation pump and identify operating problems.

APPROACH

A windmill of approximately 20-foot diameter has been installed and directly coupled, through an appropriate transmission system, to an irrigation pump operating at a low-lift. The pumping rate and wind velocities will be recorded to determine performance as a function of wind velocities. The system will be operated through at least one growing season, and if successful, it is likely that the operation will continue through a second growing season to accumulate a broader data base for predicting feasibility.

OUTPUT

1. Report describing design criteria and design procedure.
2. Report describing performance results.

3.1 SMALL SYSTEMS TECHNOLOGY

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: USDA Southwestern Great Plains Research Center, Bushland, Texas	Wind-Powered/Engine-Powered Hybrid-Drive Pumping Proof-of-Concept Experiment
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR N. Clark	**PERIOD OF PERFORMANCE** 1978 - 1980
WORK LOCATION Bushland, TX	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $543,000

PROJECT SUMMARY

BACKGROUND

Several methods of using wind power for irrigation pumping have been proposed. One method uses a wind turbine mechanically coupled, through an over running clutch, to a deep well pump driven with a conventional power source which provides a constant speed of operation. This concept requires verification and measurement of the performance of such a system.

OBJECTIVES

The objective is to obtain actual performance data on the operation of an irrigation pumping system driven by a drive system combining a windmill and an internal combustion engine or electric motor and identify operating problems.

APPROACH

A 50-foot diameter windmill will be installed and connected to a dual drive pump to permit hybrid operation with an internal combustion engine or electric motor and operated in this manner for two irrigation seasons. The pumping rate, wind velocity, torque and fuel consumption will be recorded, from which the windmill performance characteristics and the fuel savings can be computed as a function of the wind velocity distribution.

OUTPUT

1. Report describing design criteria and design procedure.
2. Report describing performance results.
3. Report in 1979 workshop proceedings.

3.1 SMALL SYSTEMS TECHNOLOGY

CONTRACTOR U.S. Department of Agriculture Science and Education Administration Subcontractor: Virginia Polytechnic Institute Department of Aerospace and Ocean Engineering Blacksburg, VA 24061	**TITLE** Apple Storage Cooling Proof-of-Concept Experiment **CONTRACT NO.** Interagency Agreement EX-76-A-29-1026 (Amendment 3)
PRINCIPAL INVESTIGATOR Joseph Schetz	**PERIOD OF PERFORMANCE** November 1976 - October 1979
WORK LOCATION Blacksburg, VA	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $242,000

PROJECT SUMMARY

BACKGROUND

Refrigeration of agricultural products is a possible use of wind power because of the generally high annual hours of load, the economy of intermediate term energy storage in ice builders, and the possibility of system fabrication using commercially available components.

OBJECTIVES

The objective of this project is to obtain actual operating data on the performance of a windmill used for refrigeration of an apple storage warehouse.

APPROACH

A 6-kW wind turbine was installed and coupled, through a small battery bank and direct current motor, to the compressor of a refrigeration system for an apple storage warehouse. The wind velocity, ambient temperatures, cooling supplied to the building and the cooling load of the building are measured. The measurements will be analyzed to provide empirical performance characteristics of such a system as a function of environmental conditions and wind velocities.

OUTPUT

A final report on the performance of the system, the technical feasibility of this use of wind power and the estimate of its economic value to farmers will be submitted to DOE in 1980.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Cornell University Agricultural Engineering Department Ithaca, New York	Direct Hydraulic Dissipation to Heat – Proof-of-Concept Experiment
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR W.W. Gunkel	**PERIOD OF PERFORMANCE** 1978 - 1980
WORK LOCATION Ithaca, NY	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $206,000

PROJECT SUMMARY

BACKGROUND

Heating of DHW is a candidate use of wind power in agriculture. The use of an electric generator and resistance heating may increase the cost of the system. Joule's famous experiment of converting mechanical work to heat suggests that hydraulic frictional dissipation may be a cheaper means of heating water with wind power.

OBJECTIVES

The objectives are to obtain performance data on a system converting wind power to heat through hydraulic dissipation, and to identify operating problems.

APPROACH

A hydraulic churn for energy dissipation will be directly coupled to an appropriately sized wind turbine. The wind velocity and heat production will be measured. Analysis of the measurements will provide heat yield and conversion efficiency as a function of wind velocity.

OUTPUT

A final report, describing operating performance and operating limitations, if any, will be prepared.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Iowa State University 213 Davidson Hall Ames, IA 50010	Wind-powered Farmhouse Heating Proof-of-Concept Experiment
	CONTRACT NO. Interagency Agreement EX-76-A-29-1026 (Amendment 3)
PRINCIPAL INVESTIGATOR Leo H. Solderholm	**PERIOD OF PERFORMANCE** August 1975 to September 1979
WORK LOCATION Ames, IA	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Headquarters Washington, DC	**CUMULATIVE FUNDING** $159,000

PROJECT SUMMARY

BACKGROUND

Heating of buildings is a major use of energy in farming. The use of wind power has been proposed for this because of the correlation of wind speeds to heating loads and the simplicity of retrofit. There is a need for actual performance measurements upon which to base realistic assessments of technical and economic feasibility.

OBJECTIVES

The equipment and techniques that can be used for heating rural structures with wind energy at maximum efficiency and minimum cost will be determined.

APPROACH

A wind-powered alternator with a voltage and frequency which varies with wind velocity is being used to drive an electric resistance heating system using a water storage tank as an energy storage medium. Heated water will be circulated through a heat exchanger in a controlled flow to supply structural heat. An air-to-air heat pump modified to heat the water storage medium will provide supplementary heat to this complete heating system. The wind velocity, energy output of the wind system, thermal characteristics of the heating system, the utility power requirements, heat output of the heat pump and ambient temperatures are being recorded and analyzed to characterize the performance of the system.

OUTPUT

The performance measurements recorded will be analyzed to estimate the economic value of wind power for heating farm structures and to assess other advantages and disadvantages of this use of wind power.

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Colorado State University Dept. of Civil Engineering Fort Collins, CO	Wind-Powered Heat Pump in a Dairy Operation
	CONTRACT NO. EX-76-A-29-10026
PRINCIPAL INVESTIGATOR R. Meroney	**PERIOD OF PERFORMANCE** 1978 - 1981
WORK LOCATION Fort Collins, CO	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $242,000

PROJECT SUMMARY

BACKGROUND

Milk cooling and water heating are major uses of energy on dairy farms. It is a uniform load throughout the year, and has an inherent storage associated with it. It is a good candidate for wind power. There is a need for testing the performance of a wind turbine electrically connected to a refrigeration compressor.

OBJECTIVES

The objectives are to gain more experience from operating a windmill system, and to determine the technical and economical feasibility of a windmill-driven heat pump in a dairy operation.

APPROACH

A vertical-axis windmill has been constructed, and connected electrically to a milk cooling/water heating system at the Colorado State University dairy farm under a previous contract. It has been instrumented and some data collected. Data will be continuously taken, and modifications and maintenance as needed will be performed.

OUTPUT

A report on performance of the wind system will be prepared.

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	MOD-0 Operations and Tests Dissemination
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR Donald Cooksey and John C. Glasgow	**PERIOD OF PERFORMANCE** 1974 - 1983
WORK LOCATION Lewis Research Center Sandusky, OH	**FISCAL YEAR 1979 FUNDING** $700,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $4,600,000

PROJECT SUMMARY

BACKGROUND

The MOD-0 100 kW wind turbine was designed in 1974 and became operational in 1975. It has been used to test wind turbine design concepts and to supply data for computer code verification. Tests have been conducted in support of MOD-0A, MOD-2, MOD-5, MOD-6 and other government agency wind turbine development projects.

OBJECTIVES

The objectives are (1) to identify and resolve problems encountered in the operation of large wind turbines and develop an understanding of the operation of large wind turbines; (2) to investigate the feasibility of advanced design concepts and subsystems; and (3) to provide experimental data to verify aerodynamic performance, structural dynamics, power train dynamics and system dynamics computer codes.

APPROACH

The emphasis in FY 1979 was on tests to support the MOD-2 project. Tests were also conducted to support advanced design concepts such as teetered tip control rotor, soft tower, expanded capability microprocessor, hydraulic drive and free yaw, and induction generator. Performance and loads and noise data are collected. Tests are also planned to support various aspects of the new wind turbine projects, including the MOD-5, MOD-6 and other government agency wind turbine development projects.

OUTPUT

The evaluation of the steel spar blades is complete and will be reported in FY 1980. The soft tower base was installed and tested. The teetered, tip-controlled rotor tests were begun in FY 1979 and will be completed and reported in FY 1980. The hydraulic yaw and free yaw tests begun in December 1979 will be completed in FY 1980. The MOD-0 will be operated in support of noise tests in late FY 1980. Results will be reported in articles, presentations, papers and formal reports.

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	MOD-02 – Design - Standards Second Generation Experimental 200 kW Wind Turbine (WT)
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR J. Savino	**PERIOD OF PERFORMANCE** 1978 - 1981
WORK LOCATION Lewis Research Center	**FISCAL YEAR 1979 FUNDING** $200,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $350,000

PROJECT SUMMARY

BACKGROUND

MOD-0 is a very useful experimental tool and has operated in more than 50 configurations. However, there is a need to update the basic configuration to make it closer to the advanced WT designs. In addition, there is a need to integrate the experience obtained as a result of MOD-0 and MOD-0A operations; MOD-1, MOD-1A and MOD-2 design and tradeoff studies; and rotor, power train and control studies. This experience indicates there is potential to reduce costs but a wind turbine design study (similar to the 1978 MOD-X study, NASA TM-79032) is required to determine the magnitude of the reduction. This task would address both these needs.

OBJECTIVES

The objective of the MOD-02 Project is to develop a low cost 200 kW wind turbine design which integrates NASA wind turbine experience and provides the basis for both an advanced production WT and for a second generation experimental WT for Plum Brook.

APPROACH

Using the MOD-X design as a starting point, the approach is to conduct a sequence of in-house design and cost study iterations until an acceptably low cost design has been achieved. Each iteration consists of a design effort in which the expensive subsystems are eliminated, redesigned, or replaced by a lower cost alternative, and then assessed for its potential low cost effectiveness. Appropriate industries have been and will continue to be used to provide costs for fabrication, assembly and erection. When the MOD-02 design has been developed, the design will be documented, and a proposal will be submitted to DOE to build and test a WT at Plum Brook.

OUTPUT

One design and cost iteration has been completed in 1979. This iteration showed that a number of features of the MOD-X design, such as the precast concrete vault foundations, are cost effective, and others such as the rotating tower, are not. A second iteration was started in 1979 and will be completed in 1980.

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	One Blade Rotor for Test on MOD-0 Cost Analysis, WTG
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR J.C. Glasgow	**PERIOD OF PERFORMANCE** 1979 - 1981
WORK LOCATION Lewis Research Center	**FISCAL YEAR 1979 FUNDING** $20,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $20,000

PROJECT SUMMARY

BACKGROUND

A one-bladed rotor operates at about 30% higher rpm than a two bladed rotor with a consequent reduction in gear box size and weight. In addition, the tower weight may be lower because the blade is shielded by the tower in hurricane winds and the loads transmitted to the tower are reduced. The rotor cost will be less. The one blade rotor captures 15% less energy than a two blade rotor of the same diameter and it may introduce system dynamic problems. Work is needed to define the performance, system dynamics and wind turbine control and operating characteristics.

OBJECTIVES

The objective of the project is to provide information for WT design studies to determine if the cost of energy can be reduced by using a one-bladed rotor. The specific objective of this FY 1979 research task is to design and initiate procurement of a rotor and pitch control system for a one blade rotor test on MOD-0.

APPROACH

A cost tradeoff analysis for a one-bladed wind turbine will be conducted. The one-bladed rotor may be lower in cost than the two-bladed rotor, the increased rpm may reduce drive train costs, and the lower loads during hurricane winds may reduce rotor and tower costs. However, the one-bladed rotor introduces dynamics problems. A counter weight will be designed to attach to the teetered hub used for the tip control tests. The blade will be the MOD-0 tip control blade.

OUTPUT

Preliminary design of the rotor and counter weight was started at the close of FY 1979 and will be completed in FY 1980. Final design will be completed in FY 1980, and fabrication and testing will be completed in FY 1981. The test results will be used to verify the analysis techniques and will be factored back into conceptual design/cost tradeoff studies in FY 1981 and 1982. The results of the studies supported by WT test data will establish the role of the one-bladed rotor in the future of large wind turbine development.

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	Operating WT Evaluation – Performance – Operations – Maintenance and Reliability – Standards
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR D. Spera	**PERIOD OF PERFORMANCE** 1979 - 1983
WORK LOCATION Lewis Research Center	**FISCAL YEAR 1979 FUNDING** $80,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $80,000

PROJECT SUMMARY

BACKGROUND

The large wind turbine field test program currently consists of four MOD-0A's, one MOD-1 and one to four MOD-2 wind turbines. Other wind turbines in the 200 kW and multi-megawatt size are in the planning stage. There is a need for a WT evaluation group to assure that the data from operating wind turbines is collected, analyzed and reported in a consistent manner.

OBJECTIVES

The objective is to provide a means for evaluating all the operating WT's in a consistent manner and for factoring this information into future wind turbine designs and into the research program.

APPROACH

Information on operating WT's is collected by the operations staff. In general, this task will not require that new information be collected. The WT performance, operation, maintenance and reliability data collected by the operations staff will be integrated into a data bank with data from all other operating WT's. Data will be compiled on component and overall WT/utility performance. Items to be considered are utility compatibility and acceptance, power vs wind speed, loads, component, performance and reliability, wear, deterioration and O&M history. Problems will be logged. If chronic problems are identified, research tasks will be defined to provide a long-term solution. This effort will consist of several people part-time from R&QA and the Wind Energy Program Office.

OUTPUT

The output of this task should be periodic reports that present operating data from each wind turbine and summarizes the experience to date. The first report on *"Preliminary Analysis of Performance and Loads Data from the 2-Megawatt Mod-1 Wind Turbine Generator"* by Spera et al was published in December (DOE/NASA/1010-79/5, NASA TM-81408).

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	Power Train Design - Cost/Analysis
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR J.M. Savino and R.C. Seidel	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Lewis Research Center	**FISCAL YEAR 1979 FUNDING** $40,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $40,000

PROJECT SUMMARY

BACKGROUND

New drive train concepts are required to reduce costs, reduce cyclic loads, increase reliability and improve power quality. There is a need to improve the techniques for dynamic drive train analysis to calculate loads, stability and power quality; and to analyze drive train concepts in a consistent manner to assure the validity of the results of trade-off studies which are intended to identify the most promising concepts.

OBJECTIVES

The objective is to identify drive train concepts which will result in a net reduction in the cost of energy (COE).

APPROACH

This work will be performed in support of previous designs and of future designs such as MOD-5 and MOD-6. Several drive train configurations will be analyzed and tested: rotor on gear box, epi-cyclic gears, phase shifting dampers, two speed rotors and other concepts. Drive trains will be conceptually designed, weight estimates made and dynamic characteristics determined. The dynamics of the drive train will be analyzed using codes that have been verified by MOD-0. The results will be incorporated into the WT system studies to determine the net benefit.

OUTPUT

A phase shift damper system for the MOD-0 has been analyzed, bench tested and checked out. It will be tested on the MOD-0 in 1980. An over-running clutch was tested in the high speed shaft of the MOD-0 to determine if it would be useful in reducing the energy loss due to start-stop cycles in low and variable winds. The overrunning clutch has been used on MOD-0 for 6 months without problems and has shown that it can significantly reduce the number of start-stop cycles. A two speed induction generator was purchased for a two speed rotor test in 1980.

CONTRACTOR	TITLE
NASA Lewis Research Center 21,000 Brookpark Rd. Cleveland, OH 44135	Teetered Tip-Controlled Rotor for MOD-0 Test Design, Evaluation, Test
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR John C. Glasgow	**PERIOD OF PERFORMANCE** 1978 - 1979
WORK LOCATION Lewis Research Center	**FISCAL YEAR 1979 FUNDING** $160,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $360,000

PROJECT SUMMARY

BACKGROUND

Design trade-off studies for large wind turbines indicate the use of a teetered, tip control rotor reduces COE. The MOD-2 WT has an up wind, teetered hub, tip control rotor. There is a need to test such a rotor on MOD-0 prior to use on MOD-2.

OBJECTIVES

The objective is to verify the teetered tip control analysis techniques, primarily those being used to design MOD-2.

APPROACH

The approach is to calculate the performance of a teetered tip control rotor for MOD-0, calculate loads and control rates, design blades and tip control, fabricate blades, test, and evaluate the results and analytical techniques.

OUTPUT

The output will be 1) a design and a design procedure using developed Wind Energy Program Office computer codes, 2) a teetered tip control blade and a comparison of MOD-0 experimental results with analytical predictions, and 3) an evaluation of the computer codes and design techniques. The design of the teetered, tip-controlled rotor was completed in FY 1978. Fabrication and installation were completed in FY 1979 and testing commenced on the MOD-0. Measurements agree with calculations and indicate that blade loads are not significantly reduced, but significant reductions in nacelle and yaw loads are possible with the teetered rotor when compared with the two-bladed rigid rotor. The measured mean teeter angle of 1 to 3 degrees agreed with the calculated angles. Transient teeter angles of 6 degrees were observed in variable winds. The teetered rotor test program will continue in FY 1980. Reports presenting test results will be completed in FY 1980 and 1981.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Kaman Aerospace Corporation Old Windsor Road Bloomfield, CT 06002	100 Foot Fiberglass Composite Blades MOD-1-Fabricate-Test
	CONTRACT NO. DEN 3-131
PRINCIPAL INVESTIGATOR H.W. Gewehr	**PERIOD OF PERFORMANCE** 1979 - 1981
WORK LOCATION Lewis Research Center, Cleveland Ohio Kaman, Bloomfield, CT	**FISCAL YEAR 1979 FUNDING** $1,100,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,100,000

PROJECT SUMMARY

BACKGROUND

It is currently not economically feasible to develop and test large wind turbine blades prior to use on the wind turbine. The field test wind turbines are used to test all components including blades. The 150-foot blades have been designed and statically tested. Their design concept will be tested by building two 100-foot blades for use on MOD-1.

OBJECTIVES

The objectives is to qualify the FRP technology by fabricating and testing two 100-foot blades on the MOD-1 wind turbine.

APPROACH

Two 100-foot blades will be fabricated on the MOD-1 wind turbine. These blades would use the transverse filament tape composite technology developed in the 150-foot blade project. Small and full scale static and fatigue tests would be run on key elements of the design and each blade would be static tested prior to shipment to the MOD-1 site.

OUTPUT

The output will be two 100-foot blades which are compatible with the MOD-1 wind turbine, and a report which describes the design procedure, stress calculations and presents the results of the small scale and full scale tests. The blade design was completed in November 1979 and fabrication of components was started. Blade assembly and static tests will be completed in 1980 for installation on MOD-1 early in 1981.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Kaman Aerospace Corporation Old Windsor Road Bloomfield, CT 06002	150-Foot Wind Turbine Blade Project Cost Analysis, Fabrication, Tests
	CONTRACT NO. EX-76-I-01-1028
PRINCIPAL INVESTIGATOR H.W. Gewehr, Kaman O. Weingart, SCI	**PERIOD OF PERFORMANCE** 1977 - January 1980
WORK LOCATION Lewis Research Center: Cleveland, OH Kaman: Bloomfield, CT SCI: Azusa, CA	**FISCAL YEAR 1979 FUNDING** $357,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $2,350,000

PROJECT SUMMARY

BACKGROUND

Wind turbine system studies indicate that large wind turbines with rotors of approximately 300-foot diameter would produce the lowest cost electricity. A competitive procurement was initiated to develop a 150-foot prototype blade for evaluation and test.

OBJECTIVES

The objective of this project is to evaluate a blade for a 300-foot diameter rotor which has potential for low cost.

APPROACH

To achieve this objective, a contract for the design, development, fabrication and test of a 150-foot blade was awarded to Kaman Aerospace Company. The blade spar was fabricated by Structural Composite Industries, Inc., (SCI), Azusa, California, under a Kaman subcontract, using the transverse filament tape method. Kaman assembled the root end, spar and aft panels and tested the blade.

OUTPUT

Blade fabrication was completed in August 1978 and tests started in September. The buckling test showed the inboard third of the blade had a strength of 105% of design limit load and the outboard two-thirds had a buckling strength which varied from 150 to 290% of design limit load. Analysis of the test data indicated several changes in the fabrication procedure would increase buckling strength of the inboard third to that of the outboard part of the blade without increasing weight or cost. Small scale fatigue tests of the root end attachment demonstrated adequate fatigue life. The manufacturing cost of the first blade was $10 per pound and the estimated cost of the second and hundredth blade are $9/lb and $5/lb respectively. Manufacturability was demonstrated. SCI received the Grand Award from Materials Engineering Magazine for fabricating the spar and Kaman received an Award of Merit for fabricating the finished blade.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Wichita State University College of Engineering Wind Energy Lab Wichita, Kansas 67208	Analysis and Conceptual Design of Spoiler (Blade) Control – Large WTG
	CONTRACT NO. Grant No. NSG - 3277
PRINCIPAL INVESTIGATOR W. Wentz	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Lewis Research Center, Cleveland, OH Wichita State Univ., Wichita, KA	**FISCAL YEAR 1979 FUNDING** $25,600
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $25,600

PROJECT SUMMARY

BACKGROUND

Pitch control systems are normally required to perform three functions – start-up, shut-down, and rpm and power control. Spoilers and flap controls can control rpm and power and can shut-down the WT. They do not work as well for WT start-up control, but this may not be important if yaw or motor start-up are used. Spoilers and flaps have potential advantages relative to full blade or partial span pitch control; the movable surfaces are smaller, the power requirements are lower, and the blade main spar is continuous.

OBJECTIVES

The objective of this project is to determine the feasibility of using spoiler and flap for the control of large wind turbines.

APPROACH

The approach is to compile spoiler and flap performance data applicable to wind turbines, integrate this data into a rotor performance computer program and calculate the performance of fixed pitch rotors with spoiler and flap controls, develop preliminary designs of spoiler controls for existing MOD-0 blades, and estimate the weight and power requirements.

OUTPUT

The output is 1) a modification to the PROP computer code which can be used to calculate spoiler and flap control performance and 2) a report which describes the analysis of WT performance with spoiler and flap control, presenting a preliminary design and discussing the advantages and disadvantages of spoiler and flap control systems.

Results of the performance analysis show that a 20% chord aileron on the outboard 30% of the blade span will provide adequate control of the MOD-0 100 kW wind turbine. This concept will be tested on the MOD-0 in 1980.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: University of Toledo (U of T) Department of Mechanical Engineering 2801 West Bancroft Toledo, Ohio 43606	Analytical Services
	CONTRACT NO. DEN 3-26
PRINCIPAL INVESTIGATOR D. Spera	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Lewis Research Center, Cleveland, OH U of T, Toledo, OH	**FISCAL YEAR 1979 FUNDING** $133,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $403,000

PROJECT SUMMARY

BACKGROUND

The expanding wind turbine program and the limited in-house manpower requires that analytical support services be procured.

OBJECTIVE

The objective is to provide analytical support services to the Wind Energy Project Office (WEPO) analytical group to enable them to carry out their supporting analysis in a timely manner.

APPROACH

The grant with the University of Toledo for aeroelastic stability analysis services will be extended. Other calculation services will be procured as required.

OUTPUT

Verification of the MOSTAS code (rigid hub version) was completed at NASA and reported in NASA TM-79101 by Kaza et al. MOSTAS has now been extended to include teetered rotor analysis, and further verification studies are underway.

Two units of the WEST (Wind Energy System, Time-Domain) analog/digital simulator were delivered and verification testing has begun.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Paragon Pacific Inc. (PPI) 1601 East El Segunda Boulevard El Segunda, CA 90245	Analytical Services
	CONTRACT NO. DEN 3-79
PRINCIPAL INVESTIGATOR D. Spera	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Lewis Research Center, Cleveland, OH PPI, Los Angeles, CA	**FISCAL YEAR 1979 FUNDING** $133,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $403,000

PROJECT SUMMARY

BACKGROUND

The expanding wind turbine program and the limited in-house manpower requires that analytical support services be procured.

OBJECTIVE

The objective is to provide analytical support services to the Wind Energy Project Office (WEPO) analytical group to enable them to carry out their supporting analysis in a timely manner.

APPROACH

Contracts with Paragon Pacific, Inc. will be written to provide maintenance services on computer programs, to update the codes and user manuals, and to develop an analog/digital simulator for the dynamic systems of a wind turbine. Other calculation services will be procured as required.

OUTPUT

Verification of the MOSTAS code (rigid hub version) was completed at NASA and reported in NASA TM-79101 by Kaza et al. MOSTAS has now been extended to include teetered rotor analysis, and further verification studies are underway.

Two units of the WEST (Wind Energy System, Time-Domain) analog/digital simulator were delivered and verification testing has begun. The hardware in one of the simulators has been extended to model a gimbal hub, as reported by Paragon Pacific in their report, PPI-1640-3, by Hoffman. Additional documentation on the WEST system was published in NASA CR-159737, by Hoffman.

3.2 INTERMEDIATE AND LARGE SYSTEMS TECHNOLOGY

CONTRACTOR NASA Lewis Research Center Subcontractor: Power Technologies, Inc. P.O. Box 1058 Schenectady, NY 12301	**TITLE** Cluster/Grid/Farm Wind Turbine Stability Study Computer/Modeling **CONTRACT NO.** PTI – DEN3-134
PRINCIPAL INVESTIGATOR E.N. Hinrichsen, Power Technologies, Inc.	**PERIOD OF PERFORMANCE** 1979 - 1980
WORK LOCATION Lewis Research Center, Cleveland, OH Power Technologies Inc. Schenectady, NY	**FISCAL YEAR 1979 FUNDING** $57,500
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $57,500

PROJECT SUMMARY

BACKGROUND

MOD-0A and MOD-0 operations have demonstrated that single wind turbines of 200 kW capacity operate well on both large grids and small diesel grids. The 2000 kW MOD-1 will begin operation in the summer of 1979 and will establish the operating characteristics of a single large wind turbine on a grid. A cluster of several 2500 MW MOD-2 wind turbines will be connected to a grid in 1980.

OBJECTIVES

The objective of the procurement is to provide design information for WT's and the utility interface to permit significant numbers of machines to be incorporated effectively into the power system. More specifically this task should supply information to assure that MOD-2 wind turbines are electrically stable when connected to utility grids in groups of three.

APPROACH

Wind turbine and grid systems will be defined and modeled, and parametric analyses will be conducted to determine operating limits of the individual WT's as well as the machine clusters. Detailed models will be used until the validity of simplified models is established. The content of the study was defined by T. Reddoch of the University of Tennessee and by NASA, and a contract was awarded to Power Technologies Inc. on May 21, 1979.

OUTPUT

Power Technologies Inc. (PTI) modeled a single MOD-2 WT and demonstrated that the WT was stable and that the soft drive train effectively decoupled the mechanical dynamics from the electrical dynamics. PTI also modeled two MOD-2 WT's and analyzed effects of gusts and faults and found no evidence of objectionable interaction between WT's or between the WT's and the grid. The contract is about two-thirds completed. A final report of study results and conclusions will include 1) specific design requirements to achieve stable operation of the WT experiencing wind gusts and load changes, and 2) specific utility interface design to coordinate the protection, switching and voltage regulations of the power system with the WTG.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Gougeon Brothers, Inc. 705 Martin St. Bay City, MI 48706	Low Cost Blade Design and Fabrication Contracts
	CONTRACT NO. DEN 3-101
PRINCIPAL INVESTIGATOR M. Gougeon	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Bay City, MI	**FISCAL YEAR 1979 FUNDING** $1,484,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,684,000*

PROJECT SUMMARY

BACKGROUND

From the start of the large wind turbine program the development of blades that have adequate life and are low cost has been recognized as one of the most pressing problems. There is need to design, fabricate, test and demonstrate the adequacy of candidate low cost blades for large wind turbines.

OBJECTIVES

The objective of this task is to identify and develop low cost wind turbine (WT) blade fabricator methods and to qualify the methods by building, static testing and operating the candidate blades on a wind turbine.

APPROACH

This task was initiated in FY 1978 by the issuance of an RFP to potential offerors. The effort included full-scale (MOD-0A) blade design and fabrication phases. A contract was awarded to Gougeon Bros. for a laminated wood saturated epoxy blade.

OUTPUT

The expected output includes: three new blade design concepts with credible cost estimates; blade production costs significantly lower than the costs of blades procured to date; several new qualified blade designers and fabricators; a minimum of three sets of blades for MOD-0 or 0A wind turbine facilities; new large blade designs; and an improved estimate of the feasibility of achieving low cost blade goals. The first set of blades from Gougeon Bros. should be delivered in March 1980. A supporting fatigue test program has been completed.

*Total of four related subcontracts.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Structural Composites Industries, Inc. 6344 North Irwindale Ave. Azusa, CA 91702	Low Cost Blade Design and Fabrication Contracts
	CONTRACT NO. DEN 3-100
PRINCIPAL INVESTIGATOR O. Weingart	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Azusa, CA	**FISCAL YEAR 1979 FUNDING** $1,484,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,684,000*

PROJECT SUMMARY

BACKGROUND

From the start of the large wind turbine program the development of blades that have adequate life and are low cost has been recognized as one of the most pressing problems. There is need to design, fabricate, test and demonstrate the adequacy of candidate low cost blades for large wind turbines.

OBJECTIVES

The objective of this task is to identify and develop low cost wind turbine (WT) blade fabricator methods and to qualify the methods by building, static testing and operating the candidate blades on a wind turbine.

APPROACH

This task was initiated in FY 1978 by the issuance of an RFP to potential offerors. The effort included full-scale (MOD-0A) blade design and fabrication phases. A contract was awarded to SCI for a fiberglass composite and foam blade.

OUTPUT

The expected output includes: three new blade design concepts with credible cost estimates; blade production costs significantly lower than the costs of blades procured to date; several new qualified blade designers and fabricators; a minimum of three sets of blades for MOD-0 or 0A wind turbine facilities; new large blade designs; and an improved estimate of the feasibility of achieving low cost blade goals. The final design review for SCI blades is in May 1980 with blade delivery in the last quarter of 1980.

*Total of four related subcontracts.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: The Budd Co. 375 Commerce Drive Ft. Washington, PA 19034	Low Cost Blade Design and Fabrication Contracts
	CONTRACT NO. DEN 3-129
PRINCIPAL INVESTIGATOR W. Eggert	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Fort Washington, PA	**FISCAL YEAR 1979 FUNDING** $1,484,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,684,000*

PROJECT SUMMARY

BACKGROUND

From the start of the large wind turbine program the development of blades that have adequate life and are low cost has been recognized as one of the most pressing problems. There is need to design, fabricate, test and demonstrate the adequacy of candidate low cost blades for large wind turbines.

OBJECTIVES

The objective of this task is to identify and develop low cost wind turbine (WT) blade fabricator methods and to qualify the methods by building, static testing and operating the candidate blades on a wind turbine.

APPROACH

This task was initiated in FY 1978 by the issuance of an RFP to potential offerors. The effort included full-scale (MOD-0A) blade design and fabrication phases.

OUTPUT

The expected output includes: three new blade design concepts with credible cost estimates; blade production costs significantly lower than the costs of blades procured to date; several new qualified blade designers and fabricators; a minimum of three sets of blades for MOD-0 or 0A wind turbine facilities; new large blade designs; and an improved estimate of the feasibility of achieving low cost blade goals. The preliminary design review for the Budd blade has been successfully completed. Fatigue tests of spot-welded stainless steel spar test specimens and vibration tests on a full-scale cross section of the blade are being conducted.

*Total of four related subcontracts.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: IIT Research Inst. 10 West 35th Street Chicago, Illinois 60616	Low Cost Blade Design and Fabrication Contracts
	CONTRACT NO. DEN 3-182
PRINCIPAL INVESTIGATOR K. Hofer	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Chicago, IL	**FISCAL YEAR 1979 FUNDING** $1,484,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,684,000*

PROJECT SUMMARY

BACKGROUND

From the start of the large wind turbine program the development of blades that have adequate life and are low cost has been recognized as one of the most pressing problems. There is need to design, fabricate, test and demonstrate the adequacy of candidate low cost blades for large wind turbines.

OBJECTIVES

The objective of this task is to identify and develop low cost wind turbine (WT) blade fabricator methods and to qualify the methods by building, static testing and operating the candidate blades on a wind turbine.

APPROACH

This task was initiated in FY 1978 by the issuance of an RFP to potential offerors. The effort included full-scale (MOD-0A) blade design and fabrication phases. A contract was also awarded to IITRI for fatigue testing to support the composite blades. If the blade concepts prove to have significant potential then the design phase would be expanded to include blades over 60 ft. in length.

OUTPUT

The expected output includes: three new blade design concepts with credible cost estimates; blade production costs significantly lower than the costs of blades procured to date; several new qualified blade designers and fabricators; a minimum of three sets of blades for MOD-0 or 0A wind turbine facilities; new large blade designs; and an improved estimate of the feasibility of achieving low cost blade goals.

*Total of four related subcontracts.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: EMR Telemetry Inc. P.O. Box 3041 Sarasota, Florida 33578	Coordination Wind Energy Remote Data System Operatonal Data, Installation
	CONTRACT NO. EX-77-A-29-1010
PRINCIPAL INVESTIGATOR Harold Neustadter	**PERIOD OF PERFORMANCE** December 1976 - October 1984
WORK LOCATION Various Wind Turbine Sites	**FISCAL YEAR 1979 FUNDING** $345,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $1,600,000

PROJECT SUMMARY

BACKGROUND

Each wind turbine that is brought into operation has an initial requirement for highly reliable on-line data processing of information from over 90 separate transducers. In addition, there is a long term monitoring requirement for about 40 of these parameters. The Wind Energy Mobile Data System has supported the initial start-up of 3 MOD-0A machines and MOD-1, and is committed to support the start-ups of MOD-2 and the first Water and Power Resources Service machine. In addition it provides long term data support for the 3 operational MOD-0A's and MOD-1.

OBJECTIVES

The objective of this task is to acquire, process and analyze the engineering data generated during all wind turbine operations (including MOD-0 in the near future) and to convert these data into useful information.

APPROACH

NASA opted for a balanced mix of mobile and stationary data systems. This allowed for the acquisition of the full range data processing capability required to support each machine as it is assembled and brought into operation, without incurring the high cost of duplicating this equipment at each site. In addition, a minimum of data equipment is retained at each site over the long term to monitor the continuing performance of each wind turbine. The operation and maintenance of the remote portions of this data system is performed by EMR Telemetry personnel under NASA direction. This provides a fully integrated operational data system serving the needs of the WEPO from the initial start-up through the long term evaluation of all designated wind turbines.

OUTPUT

The output is the engineering level information required on line (real time) by field engineers to bring a new machine into operation, by project managers to assess machine status and performance, and by design engineers for development evaluations.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: Purdue University West Lafayette, IN 47907	Wind Turbine Clusters/Grid Simulator
	CONTRACT NO. NSG-3237 Purdue
PRINCIPAL INVESTIGATOR D.M. Triezenberg, Purdue University	**PERIOD OF PERFORMANCE** 1979 - 1980
WORK LOCATION Lewis Research Center, Cleveland, OH Purdue University, West Lafayette, IN	**FISCAL YEAR 1979 FUNDING** $49,870
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $49,870

PROJECT SUMMARY

BACKGROUND

Current analysis of the interaction of WTs on a grid are conducted using digital computer codes. There is a need for an analog simulator which will permit simulations to be carried out in reasonable times and will permit the factors which could affect stability to be studied more expeditiously.

OBJECTIVES

The objectives are 1) develop the capability to do real time mechanical and electrical dynamics analysis of WTs connected to an electric grid, and 2) establish the stability of up to four MOD-2 WTs connected to a utility grid.

APPROACH

Current digital simulations of WTs on grids require large amounts of computer time and consequently are very expensive. Analog simulations are 100 times faster and are significantly less expensive to run. The wind turbine grid system will be modeled on an analog simulator in four parts: rotor, drive train and tower and grid. The rotor simulator and drive train and tower simulator will be simplified by NASA. A detailed simulation of the WT electrical system will be procured by grant to Purdue University. These simulators will be used to analyze the MOD-2 wind turbine farm. Results are required to support MOD-2 first rotation in 1980.

OUTPUT

The study was completed in December 1980. Detailed analog computer models of the MOD-2 WT will be established at NASA and at Purdue. As part of this study a seminar on wind turbine modeling was held at NASA and a final report for the grant was prepared by Purdue. During the period of performance of the grant two papers describing the model and its performance were presented by NASA at wind energy conferences. Exercise of the computer simulation indicated that a cluster of two WTs synchronized to a utility transmission line was stable. This work is being continued at Purdue University under the direction of the Electric Energy division of DOE.

CONTRACTOR	TITLE
Sandia Laboratories Subcontractor: Texas Tech University Department of Mechanical Engineering Lubbock, TX 79409	Aerodynamic Model-VAWT-Wake-Flow-Computer Modeling-Codes
	CONTRACT NO. SAND-13-5602
PRINCIPAL INVESTIGATOR J. H. Strickland	**PERIOD OF PERFORMANCE** April 1979 - January 1981
WORK LOCATION Sandia Lab Lubbock, TX	**FISCAL YEAR 1979 FUNDING** $39,890
CONTRACTING OFFICE Sandia Laboratories Albuquerque, NM	**CUMULATIVE FUNDING** $39,890

PROJECT SUMMARY

BACKGROUND

There is a need to improve upon the capabilities of multiple streamtube models, which are currently used to predict aerodynamic performance and loads generated by Darrieus turbines. These models perform calculations which apply in a spatially average sense rather than locally. Knowledge of local contributions to total loads are required in order to optimize aerodynamic and structural design.

OBJECTIVES

The objective of this project is to develop a theoretical aerodynamic model which predicts experimental results more accurately than present multiple streamtube models. This new model would: 1) include blade mutual interference effects; 2) be programmable to run at reasonable computing costs; and 3) be verifiable through laboratory experimentation.

APPROACH

A computer code has been developed at Texas Tech for the simulation of turbine blades and wakes by time-dependent vortices. This is to be modified by the use of approximations which shorten computing time by an order of magnitude. Necessary laboratory experiments would include strain-gaged blades and quantitative flow techniques for small-scale turbines operating in a water tow tank.

OUTPUT

The final report will include computer codes written in ANSI FORTRAN with detailed instructions for their use. These codes will provide a capability for better estimating the vertical-axis wind turbine performance characteristics and aerodynamic loads.

CONTRACTOR	TITLE
Sandia Laboratories Subcontractor: Oregon State University P.O. Box 1086 Corvallis, OR 97330	Aerodynamic Performance Tailoring of the VAWT
	CONTRACT NO. SAND42-2967
PRINCIPAL INVESTIGATOR Robert Wilson	**PERIOD OF PERFORMANCE** August 1979 - September 1980
WORK LOCATION Corvallis, OR	**FISCAL YEAR 1979 FUNDING** $29,999
CONTRACTING OFFICE Sandia Laboratories Albuquerque, NM	**CUMULATIVE FUNDING** $29,999

PROJECT SUMMARY

BACKGROUND

Research and development of the Darrieus turbine has been pursued at Sandia Laboratories since 1975. Of key importance is the economic performance of the Darrieus which is affected not only by peak aerodynamic efficiencies but also by the variation of efficiency with wind speed.

OBJECTIVES

Tailoring of the efficiency between (Cp) max and (Cp/λ^3) max for improved economics is to be investigated using passive rotor schemes.

APPROACH

The principal tools to be used in assessing aerodynamic performance are the Sandia Optimization Program and the Vortex Aerodynamics Program. The study will consider the affects of blade camber, offset, and any other tailoring mechanisms which can be developed.

OUTPUT

A final report following completion of the work will be provided.

CONTRACTOR	TITLE
Sandia Laboratories Subcontractor: Hibbitt & Karlsson North Scituate, RI 02857	Develop Finite Element Analysis Structural Dynamics VAWT - Computer/Modeling
	CONTRACT NO. 13-5039
PRINCIPAL INVESTIGATOR H.D. Hibbitt	**PERIOD OF PERFORMANCE** May 1979 - March 1980
WORK LOCATION Sandia Lab North Scituate, RI	**FISCAL YEAR 1979 FUNDING** $48,500
CONTRACTING OFFICE Sandia Laboratories Albuquerque, NM	**CUMULATIVE FUNDING** $48,500

PROJECT SUMMARY

BACKGROUND

There is a current need to improve structural analysis techniques for the study of Darrieus wind turbine dynamics. By matching turbine structure to minimum dynamic response requirements, a substantial savings in weight and cost is possible.

OBJECTIVES

The approach will be to develop a computer capability for the prediction of stress, deflection and structural vibration of Darrieus turbines. The program is to model the turbine using finite element, nonlinear analysis.

APPROACH

The approach will be to develop a computer capability for the prediction of stress, deflection and structural vibration of Darrieus turbines. The program is to model the turbine using finite element, nonlinear analysis.

OUTPUT

The final report will include the computer code in Fortran with detailed user instructions.

CONTRACTOR	TITLE
Sandia Laboratories Subcontractor: University of New Mexico P.O. Box 188 Albuquerque, NM 87131	Guy Cable Anchor and Foundation Design
	CONTRACT NO. 13-8731
PRINCIPAL INVESTIGATOR P. F. Lodde	PERIOD OF PERFORMANCE September 1979 - March 1980
WORK LOCATION University of New Mexico Albuquerque, NM	FISCAL YEAR 1979 FUNDING $8,449
CONTRACTING OFFICE Sandia Laboratories Albuquerque, NM	CUMULATIVE FUNDING $8,449

PROJECT SUMMARY

BACKGROUND

Vertical-Axis Wind Turbine (VAWT) foundation and guy cable anchor design is a significant part of the total cost of the VAWT. This design should be matched to the design of the VAWT and the earth at the building site, similar to the building of any structure, with the dynamic response of the VAWT and civil engineering principles also considered.

OBJECTIVES

The objectives are to minimize the cost of the VAWT foundation and guy anchor designs, and to achieve a design compatible with the static and dynamic requirements of the VAWT and the earth at the selected site.

APPROACH

The approach is to investigate the load capability and cost of five types of foundations and guy anchors for five sizes of VAWTs and six types of site soils. This gives the proper foundation and guy anchor design for a given size of VAWT on a given soil. In addition, this study investigates the effect of variation in the vibration criteria.

OUTPUT

The final report will outline the preferred anchor designs, the recommended sizes for average soil and poor soil, and the costs of these anchors as a function of cable tension and vibration criteria.

CONTRACTOR	TITLE
Grumman Aerospace Corporation South Oyster Bay Road Bethpage, NY 11714	Tornado-Type Wind Energy Systems (Phase II)
	CONTRACT NO. EX-76-C-01-2555
PRINCIPAL INVESTIGATOR James T. Yen	**PERIOD OF PERFORMANCE** March 1976 - June 1980
WORK LOCATION Bethpage, NY Golden, CO	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Irwin E. Vas – SERI	**CUMULATIVE FUNDING** $434,731

PROJECT SUMMARY

BACKGROUND

This concept incorporates a tall cylindrical tower with an open top, slotted side openings with guide vanes to create a swirling, tornado-like vortex flow in the tower. Outside air enters the base of the tower and is drawn upward through the rotor at the bottom of the tower causing the rotor blades to spin and drive the generator.

OBJECTIVES

The major objective is to determine the cost effectiveness and practicality of the Tornado-Type Wind Energy Systems (TTWES) in its ability to demonstrate multi-megawatt unit capacity and be energy cost-competitive with a lifetime of 30 years.

APPROACH

Both theoretical and experimental investigations are to be carried out. A multi-vaned tower model of up to six feet in height will be made and tested. Turbines of up to one foot in diameter will be designed, manufactured and installed in the model. Theoretical analyses will take into account the complex effects of turbulence on the complicated interactions among the vortex, the turbine flow and the boundary layers. Scaling and cost estimates will be improved. Small high speed models of one foot diameter with a four inch turbine are to be designed, constructed and tested. An 18 foot high, six foot diameter model is to be designed and constructed.

OUTPUT

A better understanding and design capability for the TTWES will be established. Details of the inlet-vane design will be obtained; detailed tests of the turbine and total systems will be conducted; improved scaling and cost estimates will be acquired; and experimental comparisons between spiral and multi-vane towers will be documented.

3.4 INNOVATIVE CONCEPTS

CONTRACTOR	TITLE
Polytechnic Institute of New York Route 110 Farmingdale, NY 11735	Vortex Augmentors for Wind Energy Conversion
	CONTRACT NO. ET-77-C-01-2358
PRINCIPAL INVESTIGATOR Pasquale M. Sforza	**PERIOD OF PERFORMANCE** May 1976 - August 1979
WORK LOCATION Farmingdale, NY	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Irwin E. Vas – SERI	**CUMULATIVE FUNDING** $379,927

PROJECT SUMMARY

BACKGROUND

Appropriate interaction of properly designed aerodynamic surfaces with natural wind of low power density can generate discrete vortical flow of relatively high power density. Suitable turbines may then be used to extract the energy from this compacted vortical field. This idea for energy concentration in natural flows is termed the vortex augmentor concept (VAC).

OBJECTIVES

The objective of this project is to determine the technical feasibility, performance and economic potential of the delta wing VAC for wind energy conversion.

APPROACH

The VAC field test prototype instrumentation will be refined to provide detailed information on torque, speed and power output under actual field conditions. Stability, control and safety aspects of the prototype VAC system will be determined under power generation. Performance maps, power control flaps and additional laboratory testing, as well as economic studies will be generated.

OUTPUT

Results of field tests and economic studies will be utilized to determine the potential of the vortex augmentor concept for implementation in the Federal Wind Energy Program.

CONTRACTOR South Dakota School of Mines & Technology Rapid City, SD 57701	**TITLE** Energy from Humid Air
	CONTRACT NO. DE-AC01-79ET-23052
PRINCIPAL INVESTIGATOR Thomas K. Oliver	**PERIOD OF PERFORMANCE** October 1976 - March 1980
WORK LOCATION Rapid City, SD Golden, CO	**FISCAL YEAR 1979 FUNDING** $68,975
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Irwin E. Vas – SERI	**CUMULATIVE FUNDING** $168,522

PROJECT SUMMARY

BACKGROUND

A vast amount of energy is contained in the latent heat of vaporization of water vapor in humid air. Humid air at specific locations could possibly have the potential to provide useful energy.

OBJECTIVES

The objective of this project is to find a cost-effective way to convert the latent heat energy in humid air into mechanical work. This would then be used to drive an electrical generator or alternator. The objective includes the investigation and assessment of the expansion-compression technique.

APPROACH

Studies have been conducted by computer modeling. For humid air, which is made up of dry air plus water vapor, the dry air component is treated as an ideal gas. Properties of the water vapor component have been taken from a computer subroutine for the international steam tables. The expansion-compression technique has been modeled and extensive parametric studies conducted to determine optimum size system.

OUTPUT

A one-machine mechanization of an expansion-compression cycle making use of vortex flow is to be assessed as to whether it is a cost-effective method based to extract energy from humid air.

CONTRACTOR	TITLE
University of Dayton Research Institute 300 College Park Avenue Dayton, OH 45469	An Analysis of the Madaras Rotor Power Plant
	CONTRACT NO. EX-76-S-01-2554
PRINCIPAL INVESTIGATOR Dale H. Whitford	**PERIOD OF PERFORMANCE** October 1978 - May 1979
WORK LOCATION Dayton, OH	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Irwin E. VAS – SERI	**CUMULATIVE FUNDING** $143,170

PROJECT SUMMARY

BACKGROUND

This concept utilizes rotating cylinders, vertically mounted on flat cars, to extract the energy in the wind. The rotating cylinders, which generate a lift force ten times that of an airfoil, propel an endless train of cars around a closed track at constant speed. Alternators geared to the wheels of each car generate the electrical power.

OBJECTIVES

The objective of this project is to demonstrate the degree to which Madaras power plants in the 100 MW to 200 MW range are cost competitive with conventional horizontal axis wind turbines.

APPROACH

Theoretical and experimental studies are to be conducted of rotating cylinders. The structural, electric and mechanical components of the systems are to be evaluated utilizing modern technology. An economic evaluation and performance simulation of the system for various plant sizes is to be performed.

OUTPUT

A report will be submitted by the subcontractor detailing the system, the analysis method used, and the results of the analysis.

CONTRACTOR West Virginia University Morgantown, WV 26506	**TITLE** Innovative Wind Turbines
	CONTRACT NO. EY-76-C-05-5135
PRINCIPAL INVESTIGATOR Richard E. Walters	**PERIOD OF PERFORMANCE** March 1976 - December 1979
WORK LOCATION Morgantown, WV	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE DOE Wind Systems Branch Technical Mgr. Irwin E. Vas – SERI	**CUMULATIVE FUNDING** $412,641

PROJECT SUMMARY

BACKGROUND

Innovative wind turbine designs are being investigated as possible alternatives to conventional horizontal axis propeller-type turbines. For vertical axis turbines, blades with high lift airfoils are being considered to improve performance. One such airfoil is the circulation-controlled airfoil. Previous work on this airfoil at West Virginia University resulted in the development of a successful STOL aircraft which utilized a circulation-controlled flap design.

OBJECTIVES

The project objective is to investigate the potential of using circulation-controlled blades on a straight bladed vertical axis wind turbine. This includes turbine configuration, structural and aerodynamic analyses, as well as a system component cost study.

APPROACH

Both theoretical and experimental methods will be used to study the performance. The major efforts will be to modify the existing vertical axis wind turbine test model to allow direct measurements of blade aerodynamic parameters of lift, drag and moment coefficients. Indoor tests will be performed with both conventional and circulation-controlled blades installed on the single-bladed indoor test apparatus.

OUTPUT

Test data will be analyzed to determine turbine performance gains which result from blades of circulation-controlled airfoil sections. Turbine power coefficients will be estimated from the blade aerodynamic data. Preliminary estimates of the cost benefits of the circulation-controlled turbine will be made. If results appear encouraging, future outdoor free-wind tests may be performed.

3.4 INNOVATIVE CONCEPTS

CONTRACTOR Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	**TITLE** Engineering Analysis and Cost Estimating of Innovative WECS
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Irwin E. Vas	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $174,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $174,000

PROJECT SUMMARY

BACKGROUND

Design studies of conventional horizontal axis and vertical axis wind turbines have provided the basis for the cost estimating and engineering analysis of innovative wind turbines. A body of literature is growing that relates to work on innovative wind turbines. Detailed designs, for which blueprints and cost dossiers were generated, have been completed for conventional wind turbines by Kaman Aerospace Corporation, General Electric Company, NASA Lewis Research Center and Sandia Laboratories. Design study information has been supplemented with data on wind turbines that have been built. These studies form the major portion of the data base used for the task work of developing techniques of evaluating the potential cost of energy produced by innovative wind turbines.

OBJECTIVE

The objectives are to establish costing methodologies suitable for innovative WECS (I WECS) in their conceptual, developmental and production phases and to estimate their cost of energy.

APPROACH

The research approach to the task is to develop several cost methodologies suitable for determining system costs of innovative systems. Initially a screening methodology is required to review proposals in their early concept stage. Later the task will develop two parallel and complimentary efforts. The continuation of costing methodology development and an engineering analysis of one or perhaps two innovative wind systems.

OUTPUT

The task will provide methodologies suitable for estimating the life-cycle cost of an innovative wind system. Life-cycle cost is assumed to include development costs, production costs and operation and maintenance costs.

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	Wind Energy Innovative Systems (WEIS)
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Irwin E. Vas	**PERIOD OF PERFORMANCE** 1979 - 1982
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $750,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $750,000

PROJECT SUMMARY

BACKGROUND

Studies have been carried out of innovative/advanced wind systems under the auspices of NSF, ERDA and DOE. The Darrieus and Giromill projects have advanced from this program to the test and demonstration stage. Additional projects may well qualify for demonstration while others may not prove to be cost effective and therefore are dropped from the program.

OBJECTIVES

The objective is to conduct research and development studies aimed at determining the technical and economic feasibility of innovative systems that have the potential of providing energy at a cost which is competitive with conventional energy systems.

APPROACH

Research and development studies are solicited for innovative systems that have the potential of competing with conventional systems. These studies together with ongoing studies are monitored, reviewed and assessed on a continuing basis to determine concurrence with program objectives. A workshop is conducted to review project efforts, to provide a line of communication with the interested technical public, to provide input to the program and to develop programmatic objectives.

OUTPUT

Specific R&D studies that show the potential of providing cost effective energy will be supported in the concept analytical/experimental and verification phases. Results of the studies are to be presented in technical reports by the subcontractors and at conferences/workshops aimed at disseminating the information. Successful cost effective innovative concepts would have the opportunity of competing for a proof-of-concept phase.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Aerovironment, Inc. 145 Vista Avenue Pasadena, CA 91107	A Definitive Generic Study of Augmented Horizontal Axis WES
	CONTRACT NO. XH-9-8003-1
PRINCIPAL INVESTIGATOR Peter Lissaman	**PERIOD OF PERFORMANCE** February 1979 - May 1979
WORK LOCATION Pasadena, CA	**FISCAL YEAR 1979 FUNDING** $21,827
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $21,827

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost projects of augmented horizontal axis wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of augmented horizontal axis wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by a critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of augmented horizontal axis wind energy systems. For each wind energy system considered, a comparison will be provided with a conventional, unaugmented wind system. For purposes of comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Tetra-Tech, Inc. 911 Fort Myer Dr. Suite 601 Arlington, VA 22206	A Definitive Generic Study of Augmented Horizontal Axis WES
	CONTRACT NO. AH-9-8003-3
PRINCIPAL INVESTIGATOR Mark Harper	**PERIOD OF PERFORMANCE** January 1979 - June 1979
WORK LOCATION Arlington, VA	**FISCAL YEAR 1979 FUNDING** $24,677
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $24,677

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost project of augmented horizontal axis wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of augmented horizontal axis wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics, and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by a critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of augmented horizontal axis wind energy systems. For each wind energy system considered, a comparison will be provided with a conventional, unaugmented wind system. For purposes of comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: New York University Dept. of Applied Science New York, NY 10003	A Definitive Generic Study of Augmented Vertical Axis WES
	CONTRACT NO. AH-9-8003-4
PRINCIPAL INVESTIGATOR Martin Moffert	**PERIOD OF PERFORMANCE** January 1979 - May 1979
WORK LOCATION New York, NY	**FISCAL YEAR 1979 FUNDING** $24,951
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $24,951

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost project of augmented vertical axis wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of augmented vertical axis wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by a critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of augmented vertical axis wind energy systems. For each wind energy system considered, a comparison will be provided with a conventional, unaugmented wind system. For purposes of comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Aerovironment, Inc. 145 Vista Avenue Pasadena, CA 91107	A Definitive Generic Study of High Lift Device WES
	CONTRACT NO. XH-9-8003-2
PRINCIPAL INVESTIGATOR Peter Lissman	**PERIOD OF PERFORMANCE** February 1979 - June 1979
WORK LOCATION Pasadena, CA	**FISCAL YEAR 1979 FUNDING** $22,772
CONTRACTING OFFICE Solar Energy Reserach Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $22,772

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost projects of high lift wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of high lift wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of high lift wind energy systems. For each wind energy system considered a comparison will be provided with a conventional, unaugmented wind system. For purposes of the comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Washington University Technology Assoc. Dept. of Mechanical Engineering St. Louis, MO 63130	A Definitive Generic Study of Sail Wing WES
	CONTRACT NO. AH-9-8003-5
PRINCIPAL INVESTIGATOR K.H. Hohenemser	**PERIOD OF PERFORMANCE** January 1979 - December 1979
WORK LOCATION St. Louis, MO	**FISCAL YEAR 1979 FUNDING** $22,500
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $22,500

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost projects of sail wing wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of sail wing wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by a critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of sail wing wind energy systems. For each wind energy system considered, a comparison will be provided with a conventional, unaugmented wind system. For purposes of comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

CONTRACTOR Solar Energy Research Institute Subcontractor: JBF Scientific Corporation 2 Jewel Drive Wilmington, MA 01887	**TITLE** A Definitive Generic Study of Vortex Extraction WES **CONTRACT NO.** AH-9-8003-6
PRINCIPAL INVESTIGATOR Theodore R. Kornreich	**PERIOD OF PERFORMANCE** February 1979 - June 1979
WORK LOCATION Wilmington, MA	**FISCAL YEAR 1979 FUNDING** $24,950
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $24,950

PROJECT SUMMARY

BACKGROUND

The purpose of this procurement is to provide definitive short studies of generic wind energy systems aimed at evaluating the technical status, performance characteristics and cost projects of vortex extraction wind energy systems.

OBJECTIVES

The objective of this contract is to provide a critical study of vortex extraction wind energy systems. The study includes an evaluation of the technical aspects, performance characteristics and an economic assessment of the system for each wind energy system within this generic group. The major purpose of the study is to determine, by a critical evaluation, whether the system has the potential of being a cost effective energy resource.

APPROACH

A critical review is to be provided for the study of vortex extraction wind energy systems. For each wind energy system considered, a comparison will be provided with a conventional, unaugmented wind system. For purposes of comparison, the systems will be analyzed using a specified wind speed duration and variation, and a cost projection.

OUTPUT

A report will be submitted by the subcontractor detailing the results of the analysis, describing the systems studied, and the approach used.

3.4 INNOVATIVE CONCEPTS

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Aerovironment, Inc. 145 Vista Avenue Pasadena, CA 91107	Advanced and Innovative Wind Energy Concept Development – Dynamic Inducer
	CONTRACT NO. XH-9-8085-1
PRINCIPAL INVESTIGATOR Peter Lissaman	**PERIOD OF PERFORMANCE** October 1979 - October 1980
WORK LOCATION Pasadena, CA	**FISCAL YEAR 1979 FUNDING** $121,835
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $121,835

PROJECT SUMMARY

BACKGROUND

Dynamic induction involves the use of additional lifting surfaces, inducer vanes, attached to the power blades of a wind turbine, which by their motion dynamically induce additional flow through the power blade disk. This provides additional energy flux which may be absorbed by the power blades.

OBJECTIVE

The objective of this project is to determine the performance and cost effectiveness of tip vane power augmentation on an actual 4m diameter wind turbine operating in the field.

APPROACH

The optimal tip vane geometry with wind tunnel testing without blades is to be determined. The power output and torque for dynamic inducer with blades is to be established in the wind tunnel and field tests conducted. An analysis of the performance and cost effectiveness of the dynamic inducer is to be performed.

OUTPUT

A final report is to be submitted by the subcontractor detailing the concept, test results, the analysis methods used, and the results of the testing and analysis of the system.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: University of Dayton Research Institute Dayton, OH 45469	Electrofluid Dynamic (EFD) Wind Generator Program
	CONTRACT NO. XH-9-8074-1
PRINCIPAL INVESTIGATOR John E. Minardi	**PERIOD OF PERFORMANCE** September 1976 - March 1980
WORK LOCATION Dayton, Ohio Golden, CO	**FISCAL YEAR 1979 FUNDING** $117,523
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $314,818

PROJECT SUMMARY

BACKGROUND

Research conducted by the United States Air Force in the early 1970s demonstrated the Electrofluid Dynamic (EFD) generator concept and provided the scaling laws. Research at the University of Dayton provided EFD wind generator theory and experimentally confirmed the basic principle of EFD power generation.

OBJECTIVES

The primary objectives are: 1) to provide a sufficient density of charged water droplets of low mobility so that EFD generator geometries can be experimentally evaluated; and 2) to provide a system with low energy costs, satisfactory levels of density of charged water droplets of low mobility for wind generator applications.

APPROACH

Charge droplet production methods and performance of generator designs are being investigated in wind tunnels. Theoretical investigations of EFD theory are extended and compared with data.

OUTPUT

Output current and voltage are measured and compared with theoretical predictions to establish research progress and direction of new efforts to lead to the development of practical EFD wind generators.

CONTRACTOR Solar Energy Research Institute Subcontractor: Grumman Aerospace Corporation South Oyster Bay Road Bethpage, NY 11714	**TITLE** Further Investigations of Diffuser Augmented Wind Turbines **CONTRACT NO.** XH-9-8073-1
PRINCIPAL INVESTIGATOR K.M. Foreman	**PERIOD OF PERFORMANCE** June 1975 - December 1979
WORK LOCATION Bethpage, NY Golden, CO	**FISCAL YEAR 1979 FUNDING** $89,293
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $557,224

PROJECT SUMMARY

BACKGROUND

A diffuser creates a low subatmospheric pressure behind a turbine rotor. A consequence of this suction is the capture of significantly more wind through a diffuser augmented wind turbine (DAWT) than a conventional wind turbine. The resulting increased mass flow increases the output power and has the potential to reduce the busbar cost. This allows smaller, cheaper turbine blades to be used for the DAWT than for a conventional wind energy conversion system of equal rating.

OBJECTIVES

This project is to refine the performance and engineering design of a compact diffuser in order to improve confidence in scaled up designs and the cost/benefit ratio of the DAWT concept.

APPROACH

This continuing program employs wind tunnel testing, engineering design and producibility analyses to increase the relative power coefficient of the concept and to estimate the cost of field demonstrations and commercialized models that can become economically viable.

OUTPUT

Wind tunnel model tests will provide performance data that will be extrapolated to full scale field test conditions. Manufacture cost estimates will be obtained for a prototype engineering design of a candidate diffuser configuration. Busbar energy costs will be determined for power ratings and production quantities that are considered commercially practical. A meaningful field demonstration model will be sized and its cost determined.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Marks Polarized Corporation 15 3-16 Tenth Avenue Whitestone, NY 11357	Tests and Devices for Wind/Electric Power Charged Aerosol Generator
	CONTRACT NO. XH9-8128-1
PRINCIPAL INVESTIGATOR Alvin M. Marks	**PERIOD OF PERFORMANCE** July 1976 - April 1980
WORK LOCATION Whitestone, NY	**FISCAL YEAR 1979 FUNDING** $64,007
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $263,255

PROJECT SUMMARY

BACKGROUND

Under previous Department of Energy, Energy Research and Development Administration and National Science Foundation funds, a wind tunnel test facility was developed, methods were identified and evaluated, and tests conducted on four methods of electrofluid dynamic (EFD) aerosol charging. Resulting data demonstrated the feasibility of and potential of one of these methods. The key technical problem is to develop this method for efficiently charging the aerosol.

OBJECTIVES

The objectives are to investigate experimentally the induction charging (waterjet method for an EFD machine) and to compare the results with existing theories.

APPROACH

The research approach includes the design and manufacture of specific orifices and the performance of parametric tests using the induction charging/waterjet method. The environmental test data on these devices are to include variation in velocity, air temperature and relative humidity. The result of the testing will establish optimum geometric configurations, orifice sizes and performance.

OUTPUT

Experimental equipment and orifices were designed and constructed and experimental data is to be obtained on the critical parameters and constraints of the induction charging/waterjet technique.

3.4 INNOVATIVE CONCEPTS

CONTRACTOR Solar Energy Research Institute Subcontractor: Washington University Technology Assoc. Department of Mechanical Engineering St. Louis, MO 63130	**TITLE** The Yawing of Wind Turbines with Blade Cyclic Pitch **CONTRACT NO.** XH-9-8085-3
PRINCIPAL INVESTIGATOR K.H. Hohenemser	**PERIOD OF PERFORMANCE** September 1979 - October 1980
WORK LOCATION St. Louis, MO	**FISCAL YEAR 1979 FUNDING** $106,318
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $106,318

PROJECT SUMMARY

BACKGROUND

Large wind turbines have all used some combination of yaw drive and damping to control the large aerodynamic forces and moments due to skewed flows acting on the rotor. The use of collective pitch for speed control also precludes the development of pitch control strategies designed to take advantage of wind shear or other regular atmospheric flow variations. The study of cyclic pitch control for yawing and turbine control are to be addressed.

OBJECTIVE

The objective of this project is to determine the potential for wind energy conversion using a horizontal axis rotor with blade cyclic pitch variation.

APPROACH

The yaw control systems characteristics of a small scale wind rotor using blade cyclic pitch are to be determined by tests and analyses. The yaw characteristics, power output and loads are to be determined for a specific HAWT and a medium sized machine. The analytical results are to be verified with free atmospheric testing of a small scale machine.

OUTPUT

A final report is to be submitted by the subcontractor detailing the concept, test results, the analysis methods used and other results of the testing and analysis of the systems.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: United Technologies Corporation Silver Lane East Hartford, CT 06108	Oscillating Vane Concept
	CONTRACT NO. XH-9-8085-2
PRINCIPAL INVESTIGATOR R.L. Bielawa	**PERIOD OF PERFORMANCE** September 1979 - October 1980
WORK LOCATION East Hartford, CT	**FISCAL YEAR 1979 FUNDING** $119,900
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO - Technical Mgr. Irwin E. Vas	**CUMULATIVE FUNDING** $119,900

PROJECT SUMMARY

BACKGROUND

This concept employs the flutter principal as its energy conversion mechanism. This concept may have cost advantages over turbine type wind energy systems due to a simplification of the aerodynamic element and a reduction in support structure costs.

OBJECTIVE

The objective of this project is to evaluate the feasibility of the oscillating vane concept as applied to wind energy conversion.

APPROACH

A 4-foot wind tunnel model is to be designed, constructed and tested to establish performance. A full scale oscillating vane WECS is to be designed.

OUTPUT

A final report is to be submitted by the subcontractor detailing the concept, test results, the analysis methods used and the results of the testing and analysis of the concept.

4.0 ENGINEERING DEVELOPMENT PROJECT SUMMARIES

4.1 SMALL SYSTEMS DEVELOPMENT

CONTRACTOR	TITLE
Aluminum Company of America Alcoa Laboratories Alcoa Center, PA 15069	Low Cost Vertical-Axis Wind Turbine Fabrication
	CONTRACT NO. DE-AC04-78AL04272
PRINCIPAL INVESTIGATOR Marvin Williams	**PERIOD OF PERFORMANCE** April 1978 – September 1981
WORK LOCATION Alcoa Center, PA	**FISCAL YEAR 1979 FUNDING** $996,400
CONTRACTING OFFICE DOE Albuquerque Operations Office* Albuquerque, NM	**CUMULATIVE FUNDING** $1,214,693

PROJECT SUMMARY

BACKGROUND

The future commercial value of the Darrieus vertical-axis wind turbine used to produce electrical energy depends on the ability to fabricate such systems at low cost. Studies can be utilized to obtain approximate cost estimates and to determine feasibility. However, better estimates can be derived from an actual design and fabrication effort.

OBJECTIVES

A major objective of the project is to obtain realistic fabrication cost data based on current technology for a system designed with the goal of minimizing costs. Another objective is to provide a low-cost system design which is suitable for continued production and/or to serve as a baseline for further cost reduction efforts.

APPROACH

The best way to accomplish these objectives is to have private, fabrication-oriented industry design and fabricate the systems with DOE providing technical support in the unique aspects of structural and systems design associated with the vertical-axis wind turbine. One to four turbines are planned for production, the first of which will be installed and tested at the Rocky Flats test site.

OUTPUT

The project will generate complete design and cost estimates, low-cost turbines for testing and actual design and cost data.

*Technical monitoring performed by Sandia Laboratories.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Aerospace Systems, Inc. Pinson Energy Corporation	Development of a 1 kW High Reliability Wind Turbine Generator
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Jon Zvara/Herman Drees	**PERIOD OF PERFORMANCE** January 1978 - May 1980
WORK LOCATION Burlington, MA, Marstons Mills, MA and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $273,100
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $484,100

PROJECT SUMMARY

BACKGROUND

The high reliability machine being developed under this subcontract is a vertical-axis, 3-bladed Cycloturbine. The design features cyclic and collective pitch control to permit self-startup, rotor rpm control during operation and shutdown in high winds. The rotor will be 8 feet high and 15 feet in diameter. The system is rated at 1 kW, at a wind speed of 9 m/s (20 mph).

OBJECTIVES

The objective of this project is to accelerate the development of durable, high reliability wind turbine generators in the 1-2 kW size range, and stimulate their use in rural and remote applications such as repeater and seismic monitoring stations, offshore navigation aids, and remote cabins and houses. The cost goal for this system is $1,500 per kW (1977 dollars), excluding tower and storage equipment.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, three prototype units will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 1-kW system and three prototype units ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for remote site applications and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Enertech P.O. Box 420, Norwich, VT 05005	Development of a 2-kW High Reliability Wind Machine **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Bill Drake	**PERIOD OF PERFORMANCE** January 1978 - May 1980
WORK LOCATION Norwich, VT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $219,500
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $318,300

PROJECT SUMMARY

BACKGROUND

Enertech's high reliability machine design features a 16.4-foot diameter, 2-bladed downwind horizontal-axis rotor. A new generator (utilizing a proven design) and an innovative hub design, which will pitch the rotor blades to stall in the control and shutdown mode, are specified for the system. The system is rated at 2 kW at a wind speed of 9 m/s (20 mph).

OBJECTIVES

The objective of this project is to accelerate the development of durable, high reliability wind turbine generators in the 1-2 kW size range, and stimulate their use in rural and remote applications such as repeater and seismic monitoring stations, offshore navigation aids, and remote cabins and houses. The cost goal for this sytem is $1,500 per kW (1977 dollars), excluding tower and storage equipment.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, three prototype units will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 2 kW system and three prototype units ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for remote applications and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: North Wind Power Company Box 315, Warren, VT	Development of a 2-kW High Reliability Wind Machine
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Don Mayer	**PERIOD OF PERFORMANCE** January 1978 - May 1980
WORK LOCATION Warren, VT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $220,100
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $415,300

PROJECT SUMMARY

BACKGROUND

The horizontal-axis North Wind design features a 3-bladed, upwind rotor 16.4 feet in diameter. It is rated at 2 kW at a wind speed of 9 m/s (20 mph). An automatic tiltback mechanism is used to rotate the complete rotor assembly to a horizontal (helicopter) orientation for protection in high winds.

OBJECTIVES

The objective of this project is to accelerate the development of durable, high reliability wind turbine generators in the 1-2 kW size range, and stimulate their use in rural and remote applications such as repeater and seismic monitoring stations, offshore navigation aids, and remote cabins and houses. The cost goal for this system is $1,500 per kW (1977 dollars), excluding tower and storage equipment.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, three prototype units will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 2-kW system and three prototype units ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for remote site applications and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Aluminum Company of America Alcoa Laboratories, Alcoa Center, PA 15069	8-kW Wind Turbine Generator Development
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Thomas Stewart	**PERIOD OF PERFORMANCE** November 1977 - (Contract cancelled during FY 1979)
WORK LOCATION Alcoa Center, PA and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $1,000*
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $320,600

PROJECT SUMMARY

BACKGROUND

The Alcoa design is for a 33 x 33.7 foot, 3-bladed Darrieus system rated at 11 kW in a 9 m/s (20 mph) wind and up to 20 kW at higher wind speeds.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 8 kW size range, and stimulate their use in providing power for homes and farm buildings. The cost goal for this system is $750 per kW installed (1977 dollars), excluding secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 8-kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for residential and rural building applications, and will advance private industry's technical knowledge and capability.

*This project is being terminated as the design did not show reasonable potential for being cost effective. Alcoa is pursuing other more promising Darrieus designs both internally and under contract with Sandia Laboratories.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Grumman Corporation, 4175 Veterans Memorial Hwy., Ronkonkoma, NY 11777	8-kW Wind Turbine Generator Development
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Frank Adler	**PERIOD OF PERFORMANCE** January 1977 - September 1979
WORK LOCATION Ronkonkoma, NY and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $398,400
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $662,900

PROJECT SUMMARY

BACKGROUND

This Grumman system design has a 3-bladed, horizontal-axis, downwind rotor 33.25 feet in diameter. The system is rated at 11 kW in a wind of 9 m/s (20 mph) and up to 18.5 kW at higher wind speeds.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 8 kW size range, and stimulate their use in providing power for homes and farm buildings. The cost goal for this system is $750 per kW installed (1977 dollars), excluding secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 8-kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for residential and rural building applications, and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: United Technologies Research Center River Lane, East Hartford, CT 06108	8-kW Wind Turbine Generator Development
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR M.C. Cheney, Jr.	**PERIOD OF PERFORMANCE** October 1977 - April 1980
WORK LOCATION East Hartford, CT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $324,400
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $711,000

PROJECT SUMMARY

BACKGROUND

The 31-foot diameter, horizontal-axis, downwind rotor of the United Technologies Research Center design incorporates a flex beam which enables blade-pitch control without the use of bearings. The basic concept for this design was refined during projects funded by the Federal Wind Energy Program in 1976 and 1977. The system is rated at 9 kW in a wind of 9 m/s (20 mph).

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 8-kW size range, and stimulate their use in providing power for homes and farm buildings. The cost goal for this system is $750 per kW installed (1977 dollars), excluding secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 8-kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for residential and rural building applications, and will advance private industry's technical knowledge and capability.

4.1 SMALL SYSTEMS DEVELOPMENT

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Windworks, Inc. Box 329, Rt. 3, Mukwonago, WI 53149	8-kW Wind Turbine Generator Development
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR Hans Meyers	**PERIOD OF PERFORMANCE** October 1977 - April 1980
WORK LOCATION Mukwonago, WI and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $324,500
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $599,200

PROJECT SUMMARY

BACKGROUND

The Windworks design incorporates a direct-drive permanent magnet alternator, a hydraulic blade-pitch control system and free-flapping blades fabricated of aluminum and fiberglass. The 3-bladed, horizontal-axis, downwind rotor is 33 feet in diameter. The system is rated at 8 kW in a 9 m/s (20 mph) wind and is connected to a utility network through a synchronous inverter.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 8-kW range, and stimulate their use in providing power for homes and farm buildings. The cost goal for this system is $750 per kW installed (1977 dollars), excluding inverter and other secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 8-kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for residential and rural building applications, and will advance private industry's technical knowledge and capabiltiy.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Enertech P.O. Box 420, Norwich, VT 05005	**TITLE** Development of a 15 kW Wind Turbine Generator **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR K. Rajarama Shenoy	**PERIOD OF PERFORMANCE** August 1979 - September 1981
WORK LOCATION Norwich, VT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $20,000
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $20,000

PROJECT SUMMARY

BACKGROUND

Enertech's basic concept consists of a 3-blade, horizontal-axis, downwind, 13.4 m (44 ft) diameter laminated wood rotor with free yaw control. The 3-phase induction generator will be capable of producing 15 kW of output at 9 m/s (20 mph). The system is expected to produce 50,000 kilowatt hours (kWh) annually in areas with an average mean wind of 5.4 m/s (12 mph) at an energy cost of 3¢/kWh.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 15 kW size range, and stimulate their use in providing power (including heating) for industry, homes and farms. The cost goal for this sytem is 3¢/kWh for the 10,000th production system.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 15 kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size can provide reliable power for industrial, residential and rural building applications, and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: United Technologies Research Center River Lane, East Hartford, CT 06108	Development of a 15 kW Wind Turbine Generator **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR M.C. Cheney, Jr.	**PERIOD OF PERFORMANCE** September 1979 - August 1981
WORK LOCATION East Hartford, CT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $20,000
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $20,000

PROJECT SUMMARY

BACKGROUND

UTRC designed their 15 kW machine with a 2-bladed, horizontal-axis, downwind rotor that is 14.6 m (48 ft) in diameter. The blades are made of a pultruded fiberglass. This machine will be capable of producing 15 kW of output at 9 m/s (20 mph). This system is expected to produce 60,000 kilowatt hours (kWh) annually in an area which has a 5.4 m/s (12 mph) mean annual wind speed. The energy cost from a system located in such a wind regime is anticipated to be 3¢/kWh.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 15 kW size range, and stimulate their use in providing power (including heating) for industry, homes and farms. The cost goal for this system is 3¢/kWh for the 10,000th production system.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase III, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 15 kW system and a prototype system ready for testing. The machine will help demonstrate how wind systems of this size can provide reliable power for industrial, residential and rural building applications, and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Kaman Aerospace Corporation Old Windsor Road, Bloomfield, CT 06002	Development of a 40 kW Wind Turbine Generator **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR H. Howes	**PERIOD OF PERFORMANCE** July 1978 - February 1980
WORK LOCATION Bloomfield, CT and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $1,064,300
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $1,267,500

PROJECT SUMMARY

BACKGROUND

Only the electrical output prototype of the Kaman system design will be built. The basic system features a 2-bladed, downwind, horizontal-axis rotor 64 feet in diameter. It is rated at 40 kW in a 9 m/s (20 mph) wind.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 40 kW size range, and stimulate their use in such applications as deep-well irrigation pumping and providing power to small isolated communities and small factories. The cost goal for this system is $500 per kW (1977 dollars), excluding inverter (if required) and other secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 40 kW system and two prototype systems ready for testing. The machine will help demonstrate how wind systems of this size range can provide reliable power for irrigation, remote community and small factory applications, and will advance private industry's technical knowledge and capability.

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: McDonnell-Douglas Aircraft Corporation P.O. Box 516, St. Louis, MO 63166	**TITLE** Development of a 40 kW Wind Turbine Generator **CONTRACT NO.** DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR John Anderson	**PERIOD OF PERFORMANCE** September 1978 - June 1980
WORK LOCATION St. Louis, MO and Rocky Flats, CO	**FISCAL YEAR 1979 FUNDING** $1,114,500
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $1,114,500

PROJECT SUMMARY

BACKGROUND

The vertical-axis McDonnell design incorporates the gyromill configuration refined under previous Federal Wind Energy Program contracts. The system is rated at 40 kW in a 9 m/s (20 mph) wind. Its rotor is 42 feet high by 58 feet in diameter. The prototype will be designed for electrical output. However, a changeover kit will be provided to convert the system to mechanical power output.

OBJECTIVES

The objective of this project is to accelerate the development of cost-competitive wind turbine generators in the 40 kW size range, and stimulate their use in such applications as deep-well irrigation pumping and providing power to small isolated communities and small factories. The cost goal for this system is $500 per kW (1977 dollars), excluding inverter and other secondary components.

APPROACH

The project will be accomplished in two phases. During Phase I, the contractor will perform design and analysis to finalize a design. During Phase II, a prototype system will be fabricated, checked out and shipped to Rocky Flats for testing. The contractor will provide technical support and monitoring during these tests.

OUTPUT

The project will provide documentation and detail drawings of an advanced 40 kW system and a prototype system ready for testing. A conversion kit will also be furnished to convert the system from electrical to mechanical output. The machine will help demonstrate how wind systems of this size range can provide reliable power for irrigation, remote community and small factory applications, and will advance private industry's technical knowledge and capability.

CONTRACTOR	TITLE
NASA-Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135	Design, Fabricate, Test Advanced, Multi-Purpose, Medium Scale Wind Turbine: MOD 6H
	CONTRACT NO. DE-AI-01-79ET-23140
PRINCIPAL INVESTIGATOR W.H. Robbins Richard Puthoff	**PERIOD OF PERFORMANCE** May 1980 - January 1985
WORK LOCATION Cleveland, OH	**FISCAL YEAR 1979 FUNDING** $2,900,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $2,900,000*

PROJECT SUMMARY

BACKGROUND

The development of large megawatt size wind turbines is progressing satisfactorily. However, medium size machine development requires substantial improvement. Conceptual studies have indicated that the cost of energy of a medium size machine is probably less than 4-6 cents/kWh as compared to 30-35 cents/kWh of the current MOD-0A 200-kW machines.

OBJECTIVE

The objective of this project is to develop the design, and then validate the performance of a medium size wind turbine optimized for minimum cost of energy and adapted for utility, farm and industrial applications.

APPROACH

The NASA Lewis Research Center will manage the project, including contracting activities for DOE. A contractor will be selected by competitive bid to perform this work. Three discrete phases will be accomplished: design, fabrication, installation and operation.

OUTPUT

An advanced multi-purpose medium size wind turbine will be built and installed on a user's system and tested. A design report will be published at completion of design and fabrication, and an operations report will be published following completion of 24 months of operation. Design, cost, and performance data for medium size systems will be provided.

*Total for MOD6H and MOD6V programs.

CONTRACTOR	TITLE
NASA Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135	Design, Fabricate, Test Advanced, Multi-Purpose, Medium Scale Wind Turbine: MOD 6V
	CONTRACT NO. DE-A1-01-79ET-23140
PRINCIPAL INVESTIGATOR W.H. Robbins Richard Puthoff	**PERIOD OF PERFORMANCE** May 1980 - January 1985
WORK LOCATION Cleveland. OH	**FISCAL YEAR 1979 FUNDING** $2,900,000*
CONTRACTING OFFICE NASA Lewis Research Center Cleveland. OH	**CUMULATIVE FUNDING** $2,900,000*

PROJECT SUMMARY

BACKGROUND

The development of large megawatt size wind turbines is progressing satisfactorily. However, medium size machine development requires substantial improvement. Conceptual studies have indicated that the cost of energy of a medium size machine is probably less than 4-6 cents/kWh as compared to 30-35 cents/kWh of the current MOD-0A 200-kW machines.

OBJECTIVE

The objective of this project is to develop the design, and then validate the performance of a medium size wind turbine optimized for minimum cost of energy and adapted for utility, farm and industrial applications.

APPROACH

The NASA Lewis Research Center will manage the project, including contracting activities for DOE. A contractor will be selected by competitive bid to perform this work. Three discrete phases will be accomplished: design, fabrication, installation and operation.

OUTPUT

An advanced multi-purpose medium size wind turbine will be built and installed on a user's system and tested. A design report will be published at completion of design and fabrication, and an operations report will be published following completion of 24 months of operation. Design, cost, and performance data for medium size systems will be provided.

*Total for MOD-6H and MOD-6V programs.

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractors: Westinghouse Electric Corporation Lockheed Aircraft Corporation Gougeon Brothers Inc.	Field Tests Experimental 200-kW Wind Turbine Designs (MOD-0A Project)
	CONTRACT NO. DE-AB-29-76ET-20370
PRINCIPAL INVESTIGATOR W.H. Robbins Arthur Birchenough	**PERIOD OF PERFORMANCE** June 1975 - May 1982
WORK LOCATION Clayton, NM Oahu, HI Block Island, RI Culebra Island, PR	**FISCAL YEAR 1979 FUNDING** $2,100,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $12,200,000

PROJECT SUMMARY

BACKGROUND

One phase of the Federal Wind Energy Program is to develop the technology necessary for the successful design, fabrication and operation of large, horizontal-axis wind turbine systems. The four 200 kilowatt wind turbines in this project comprise the first system under development.

OBJECTIVES

The overall objective is to obtain early operation and performance data while gaining initial experience in the operation of large wind turbines in typical user environments.

APPROACH

The MOD-0A wind turbines were designed by NASA. The majority of machine assembly and installation work was contracted to Westinghouse. Lockheed designed and furnished aluminum blades for three machines and Gougeon Brothers will design and furnish wood blades for the fourth machine.

Utility companies were involved in the program not only to provide test sites, but to identify their requirements while gaining direct operational experience. The Clayton, Culebra, Block Island and Hawaiian installation sites were chosen from among 17 utility company sites selected for further wind data collection and evaluation.

OUTPUT

The field tests will provide valuable data and information to allow optimization of wind turbine design features for durable and economical operation. Utility operation of the machines will enable identification of electrical system stability and control requirements.

4.3 LARGE SYSTEMS DEVELOPMENT

CONTRACTOR	TITLE
NASA Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135	Design, Fabricate, Install Advanced Multi-Megawatt Wind Turbine – AMMWT (MOD-5)
	CONTRACT NO. DE-A1-01-79ET-23139
PRINCIPAL INVESTIGATOR W.H. Robbins - John Sholes	**PERIOD OF PERFORMANCE** February 1980 - February 1985
WORK LOCATION Cleveland, OH	**FISCAL YEAR 1979 FUNDING** $3,800,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $3,800,000

PROJECT SUMMARY

BACKGROUND

The Federal Wind Energy Program has been established to develop reliable, safe and economically viable wind energy systems. The second generation MOD-2 design provides energy at 4 cents/kWH which is economically viable in areas of high fuel costs.

OBJECTIVES

The objective of this project is to develop the design and then validate the performance of a multi-megawatt wind turbine that will deliver energy for 3 cents/kWh or less (1977 dollars) when produced in quantity, and installed at a site with an annual mean wind speed of 6.3 M/S (14 mph). The wind turbine must operate safely and reliably and be compatible with existing utility networks.

APPROACH

The NASA Lewis Research Center will manage the project, including contracting activities for DOE. A contractor will be selected by competitive bid to perform this work. Three discrete phases will be accomplished: concept formulation, engineering development and fabrication and test.

OUTPUT

An AMMWT System will be built and installed in a user's system and tested. A design report will be published at completion of design and manufacturing, and an operations report will be published following completion of 24 months of operation. Design, cost and performance information for large megawatt size wind systems will be provided.

4.3 LARGE SYSTEMS DEVELOPMENT

CONTRACTOR	TITLE
NASA Lewis Research Center Subcontractor: General Electric Company P.O. Box 8661 Philadelphia, PA 19101	Field Tests of Experimental 2 MW Wind Turbine Design (MOD-1 Project)
	CONTRACT NO. EX-77-A-29-1010
PRINCIPAL INVESTIGATOR W.H. Robbins - John Collins	**PERIOD OF PERFORMANCE** November 1974 - August 1982
WORK LOCATION Boone, NC	**FISCAL YEAR 1979 FUNDING** $3,800,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $22,500,000

PROJECT SUMMARY

BACKGROUND

General Electric is the primary subcontractor responsible for developing a 2-megawatt horizontal-axis, propeller-type experimental wind turbine generator with two rotor blades 200 feet in diameter. The system has been optimized for an 18 mph average wind site. Boone, North Carolina, has been selected as the site.

OBJECTIVES

The primary objectives of the project are to: (1) determine the operating and economic characteristics of a utility-operated, megawatt-scale wind turbine; (2) involve industry in the design, fabrication and installation of large wind systems; and (3) involve potential users of wind systems so that institutional, operational and technical interface requirements can be clearly defined.

APPROACH

A MOD-1 experimental wind turbine generator has been installed and is now being operated at Howard's Knob in Boone, North Carolina. It is being operated on the Blue Ridge Electrical Membership Corporation's utility grid providing power to their customers.

OUTPUT

Field testing of the turbine will provide engineering and performance data for use in refining the design features of future systems, and will contribute valuable information to wind energy applications.

CONTRACTOR NASA Lewis Research Center Subcontractor: The Boeing Engineering and Construction Company P.O. Box 3707 Seattle, WA 98124 Contract: DEN 3-2	**TITLE** Design, Fabricate, and Test Three Experimental 300-Foot Diameter Wind Turbines (MOD-2 Project) **CONTRACT NO.** DE-AI01-79-ET-20305
PRINCIPAL INVESTIGATOR W.H. Robbins - Jim Couch	**PERIOD OF PERFORMANCE** August 1977 - August 1983
WORK LOCATION Cleveland, OH Seattle, WA Goodnoe Hills near Goldendale, WA	**FISCAL YEAR 1979 FUNDING** $11,500,000
CONTRACTING OFFICE NASA Lewis Research Center Cleveland, OH	**CUMULATIVE FUNDING** $21,400,000

PROJECT SUMMARY

BACKGROUND

The Boeing Engineering and Construction Company has developed a 2.5 MW, horizontal-axis wind turbine generator with a rotor diameter of 300 feet. This system's features are optimized to generate electricity at a cost that is competitive with conventional systems while operating at sites with a mean wind speed of 14 mph. Projected cost of the 100th production wind turbine is 3.3 cents/kWh in 1977 dollars.

OBJECTIVES

The objective of this project is to establish the design and to determine the performance, present cost, future production cost, operation and maintenance cost, and practicality of manufacturing a large wind turbine, with a minimum rotor diameter of 300 feet, installed at a site with a mean wind speed of 14 mph at 30 feet. It is also the objective of this project to demonstrate the feasibility of such wind turbines operating in a cluster in a utility network.

APPROACH

NASA is managing this project which established a baseline design for the MOD-2, determined the cost sensitivity of the design to various configuration alternatives, up-dated cost estimates at several NASA/DOE design review stages, and following approval of design will build and install three experimental wind turbines on a single user site at Goodnoe Hills near Goldendale, WA. The participating utility is the Bonneville Power Administration.

OUTPUT

Three MOD-2 systems are being built and installed for testing. A detailed design report was published at completion of the design phase. Design and cost information and performance models for very large wind systems will be provided.

5.0 IMPLEMENTATION AND MARKET DEVELOPMENT PROJECT SUMMARIES

5.1 SMALL SYSTEMS IMPLEMENTATION AND MARKET DEVELOPMENT

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant	Field Evaluation Program
	CONTRACT NO. DE-AC04-76DP03533
PRINCIPAL INVESTIGATOR M.E. Nightengale	**PERIOD OF PERFORMANCE** January 1978 - June 1982
WORK LOCATION Boulder, CO	**FISCAL YEAR 1979 FUNDING** $3,489,200
CONTRACTING OFFICE DOE Rocky Flats Plant Golden, CO	**CUMULATIVE FUNDING** $3,489,200

PROJECT SUMMARY

BACKGROUND

The institutional barriers to widespread use of utility interconnected SWECS and the means by which costs or benefits are passied on to the SWECS customer are important to the eventual commercialization of SWECS. The technical issues of interconnection arise from the introduction of an unpredictable bi-directional power source to the utility system. The issues of safety for utility personnel and equipment, power quality and operational control over a dispersed generation source are of primary importance.

OBJECTIVES

- Provide data to establish procedures for SWECS interconnected to a utility system and establish a basis for evaluation of cost of service for these applications.
- Assist and support state and local governments in the reduction of institutional barriers to private SWECS use.
- Prepare consumer information regarding the performance and reliability of commercially available SWECS and the procedures and costs for interconnecting SWECS with utility networks.

APPROACH

The Field Evaluation Program entails the technical selection of users, in cooperation with state energy offices, in the United States and territories. Selected users will be awarded a commercially available wind system for field evaluation. The wind system, instrumentation and ancillary equipment will be the property of DOE until the program data collection activities are completed, at which time it may become the property of the user.

OUTPUT

- Direct involvement of state agencies in the program activities in their state.
- 120 SWECS installations in the states and territories that are interconnected to utility lines.
- General technical safety, and legal requirements for the interconnection of SWECS with a utility line.
- Assessment of the institutional barriers encountered in the field evaluation program and recommendations for removing these barriers.
- User guides for dealing with questions raised by local building and zoning boards, utility regulatory commissions and utilities on the legal, safety, and technical aspects of interconnected SWECS.

5.1 SMALL SYSTEMS IMPLEMENTATION AND MARKET DEVELOPMENT

CONTRACTOR Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: JDB & Company 1629 K Street, N.W., Suite 700 Washington, D.C. 20006	**TITLE** Financial Problems Facing the Manufacturer of Small Wind Energy Conversion Systems
	CONTRACT NO. PF-97897-L
PRINCIPAL INVESTIGATOR Thomas G. Bolle	**PERIOD OF PERFORMANCE** June 1979 - November 1979
WORK LOCATION Washington, D.C.	**FISCAL YEAR 1979 FUNDING** $800,000
CONTRACTING OFFICE DOE Rocky Flats Plant, P.O. Box 464 Golden, CO 80401	**CUMULATIVE FUNDING** $80,000

PROJECT SUMMARY

OBJECTIVES

The objectives of this study are to identify and assess the issues which affect the availability of venture capital and loans to SWECS manufacturers, and recommend strategies to resolve these issues.

APPROACH

Tasks will include: 1) a description of the financial resources available for financing manufacturers of SWECS, 2) interviews to identify regulations, data requirements and practices, 3) documentation of issues, 4) an analysis of the issues aimed at prescriptive action, and 5) suggested strategies to aid the acquisition of financing for manufacturers of SWECS.

OUTPUT

The report will cover the tasks outlined and will include a directory of financing resources, a discussion and analysis of financing problems, and issues and recommendations for institutions for making financing more available to SWECS manufacturers.

CONTRACTOR	TITLE
Rockwell International Energy Systems Group DOE Rocky Flats Plant Subcontractor: Windworks, Inc. Box 44A, Route 3, Mukwonago, WI	Review of SWECS Interconnected with Utility Networks
	CONTRACT NO. PF-96324-L
PRINCIPAL INVESTIGATOR Hans Meyer	**PERIOD OF PERFORMANCE** December 1978 - December 1979
WORK LOCATION Mukwonago, WI	**FISCAL YEAR 1979 FUNDING** $22,000
CONTRACTING OFFICE DOE Rocky Flats Plant, P.O. Box 464 Golden, CO 80401	**CUMULATIVE FUNDING** $22,000

PROJECT SUMMARY

OBJECTIVES

The objective of the study is to determine and report the technical economic and institutional problems and difficulties encountered by SWECS owners who have interconnected their machines with an electric utility system.

APPROACH

- Compile a listing of interconnected SWECS and the utilities and regulatory agencies involved.
- Solicit information on primary technical, economic and institutional issues encountered by users.

OUTPUT

The final report will detail the data collected and contain a summary of responses relative to each of the issues identified.

5.1 SMALL SYSTEMS IMPLEMENTATION AND MARKET DEVELOPMENT

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: American Wind Energy Association (AWEA) 1621 Connecticut Avenue, NW Washington, D.C. 20009	(Wind Energy TID) Capital Formation and the SWECS Industry
	CONTRACT NO. AM-8-8298-1
PRINCIPAL INVESTIGATOR Ben Wolff	**PERIOD OF PERFORMANCE** September 1979 - June 1980
WORK LOCATION Washington, D.C.	**FISCAL YEAR 1979 FUNDING** $20,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO Project Mgr. Pat Weis	**CUMULATIVE FUNDING** $20,000

PROJECT SUMMARY

BACKGROUND

The acquisition of adequate capital is a persistent problem for small business. Most manufacturers of small wind turbines classify as small business and could benefit from increased familiarity with the nature and sources of capital.

OBJECTIVE

The objective of this task is to familiarize SWECS manufacturers and the financial community with issues of capital acquisition for the industry.

APPROACH

Representatives of the SWECS industry and the financial community met for a 2-day workshop on capital acquisition. The results of that meeting will be reported in a guide to capital acquisition for SWECS manufacturers.

OUTPUT

A handbook on capital acquisition for distribution to SWECS companies.

5.4 USER OUTREACH PROGRAM

CONTRACTOR U.S. Department of Agriculture Science & Education Administration	**TITLE** USDA Extension Circular – *Wind Power and Windmills*
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L. Liljedahl	**PERIOD OF PERFORMANCE** 1979
WORK LOCATION Washington, DC	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $4,000

PROJECT SUMMARY

BACKGROUND

No federal publication directed toward farmers is now in print which gives practical directions on the use of wind power in agriculture. A need exists for such a publication in answering correspondence by the Department of Agriculture and by the agriculture extension engineers in the state extension service.

OBJECTIVES

The objective is to provide information to the farmer needed to select and properly size a water pumping windmill or a wind powered electric generator.

APPROACH

An existing state extension circular will be rewritten to enlarge its scope to the entire United States. This manuscript will be submitted to the USDA-SEA Information Division for final preparation and publication.

OUTPUT

An 8-page USDA Extension Circular will be published in February 1980.

5.4 USER OUTREACH PROGRAM

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration	USDA Production Research Report: *Agricultural Use of Wind Power*
	CONTRACT NO. DX-76-A-29-1026
PRINCIPAL INVESTIGATOR L. Liljedahl	**PERIOD OF PERFORMANCE** 1979
WORK LOCATION Washington, DC	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $4,000

PROJECT SUMMARY

BACKGROUND

A general description of the agricultural wind energy research program is available only in the DOE reports describing the overall DOE program. There is no federal publication describing the agricultural wind energy research program in the detail needed by potential wind mill manufacturers, agricultural equipment dealers, agricultural extension engineers and innovative farmers. A need exists for such a publication to answer correspondence in the USDA and for distribution by the state agricultural extension service.

OBJECTIVE

The objective is to communicate the results conducted under the USDA program to the potential equipment manufacturers and the agricultural industry.

APPROACH

A manuscript for the publication will be drafted by USDA program personnel and submitted to the USDA-SEA Information Division editorial staff for final preparation and publication.

OUTPUT

A 16-20 page USDA Production Research Report will be published in 1980.

5.4 USER OUTREACH PROGRAM

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration	USDA Program Aid: *USDA-DOE Research on Use of Wind Power*
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L. Liljedahl	**PERIOD OF PERFORMANCE** 1979
WORK LOCATION Washington, DC	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $3,000

PROJECT SUMMARY

BACKGROUND

General description of the agricultural wind energy research programs are available only in the DOE reports describing the overall DOE program. There is no brief popular publication describing the agricultural wind energy research program. A need exists for such a publication to answer correspondence in the USDA and DOE.

OBJECTIVES

The objective is to communicate the results conducted under this program to the general public.

APPROACH

A manuscript for the publication is being drafted by USDA-SEA Information Division editorial staff for final preparation and publication.

OUTPUT

A 4-page, Program Aid, will be published in 1980.

5.4 USER OUTREACH PROGRAM

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: USDA Office of Information Motion Picture Service	USDA Film – *Gusts of Power* **CONTRACT NO.** EX-76-A-29-1026
PRINCIPAL INVESTIGATOR L. Liljedahl	**PERIOD OF PERFORMANCE** 1979
WORK LOCATION Washington, DC	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $25,000

PROJECT SUMMARY

BACKGROUND

A need exists for a short film describing how wind power might be used in agriculture and the research now devoted to this possible use. The film could be used by extension engineers for presentations to farmer groups and agricultural industry groups.

OBJECTIVE

The objective is to communicate the results conducted under the USDA program to the agricultural industry and the general public.

APPROACH

The USDA Motion Picture Service will film all of the current USDA experimental projects. Narration and interviews with researchers will provide descriptions in the film sound track. After editing, a negative will be made from which USDA, DOE, NAC and other interested groups may make prints of the film.

OUTPUT

A 14-minute, sound film will be released in April 1979. In addition, two, 1 minute, sound films on individual projects were released in July 1979.

5.4 USER OUTREACH PROGRAM

CONTRACTOR	TITLE
U.S. Department of Agriculture Science and Education Administration Subcontractor: Iowa State University	1979 Workshop on Wind Energy Applications in Agriculture
	CONTRACT NO. EX-76-A-29-1026
PRINCIPAL INVESTIGATOR H. Klueter	**PERIOD OF PERFORMANCE** 1979
WORK LOCATION Ames, Iowa	**FISCAL YEAR 1979 FUNDING** 0
CONTRACTING OFFICE U.S. Department of Agriculture Beltsville, MD	**CUMULATIVE FUNDING** $4,000

PROJECT SUMMARY

BACKGROUND

No detailed public presentation of the Agricultural Wind Energy Research Program has been made since its inception. A need exists for such a presentation where potential manufacturers and users of wind power equipment can obtain a detailed exposition of the work to date, ask questions concerning progress and application of the work, and make recommendations concerning future work.

OBJECTIVES

The objectives are to present the findings of the research program to date and to obtain recommendations concerning future work.

APPROACH

A state agricultural college will be invited to host the workshop and to sponsor it jointly with USDA, DOE, and the American Society of Agricultural Engineers. USDA-DOE funded projects will be presented in half-hour talks on the work to date. A small number of non-federally supported projects will also be presented. Attendees will be asked to participate in discussion groups to review the federal program and make recommendations.

OUTPUT

The *Proceedings of the Workshop on Wind Energy Applications in Agriculture*, held in May 1979, at Ames, Iowa, will be published in 1980.

5.4 USER OUTREACH PROGRAM

CONTRACTOR	TITLE
Solar Energy Research Institute 1617 Cole Blvd. Golden, CO 80401	Wind Energy Technical Information Dissemination
	CONTRACT NO. EG-77-C-01-4042
PRINCIPAL INVESTIGATOR Patricia Weis	**PERIOD OF PERFORMANCE** October 1978 - October 1979
WORK LOCATION Golden, CO	**FISCAL YEAR 1979 FUNDING** $200,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO	**CUMULATIVE FUNDING** $200,000

PROJECT SUMMARY

BACKGROUND

As wind energy technology becomes more developed the need to communicate information effectively to a number of audiences affecting commercialization increases.

OBJECTIVE

The objective of this is to make the results of the federal R&D program available to a wider audience including researchers, developers and users in order to accelerate commercialization of WECS.

APPROACH

The approach is to develop materials for specific audiences and to devise and implement distribution strategies for publications of the program.

OUTPUT

The development and production of materials to raise public awareness and to use in responding to inquiries will include: a poster on the DOE Wind Energy Program; the Wind Energy Information Directory and; a multi-media show and pamphlet on wind energy. Some 5,000 posters and 10,000 directories will be distributed to RSECs, DOE labs and in response to inquiries. Thirty-two multi-media shows will be used in state fairs and circulated at the regional level.

CONTRACTOR	TITLE
Solar Energy Research Institute Subcontractor: Regional System Service Group 5680 South Syracuse Circle, Suite 514 Englewood, CO 80111	(Wind Energy TID) Planning Guide for Community
	CONTRACT NO. XH-9-8304-1
PRINCIPAL INVESTIGATOR Wayne Stafford	**PERIOD OF PERFORMANCE** October 1979 - October 1980
WORK LOCATION Englewood, CO	**FISCAL YEAR 1979 FUNDING** $25,000
CONTRACTING OFFICE Solar Energy Research Institute Golden, CO Project Mgr. Pat Weis	**CUMULATIVE FUNDING** $25,000

PROJECT SUMMARY

BACKGROUND

Increasing conventional energy costs have encouraged many communities to explore alternative methods of meeting their energy needs. A great deal of valuable information has been developed by the Federal Wind Energy Program, but it is difficult for communities to assemble all the information they need quickly and efficiently.

OBJECTIVE

The objective is to bring together existing information from DOE reports into a readable guide for communities considering wind energy.

APPROACH

Existing information will be assembled with the assistance of a manufacturer of SWECS, a community planner, a wind economist and an engineer. A step by step guide for a community group to conduct a preliminary feasibility study will be developed. A peer and community level review will be conducted to revise the guide as necessary.

OUTPUT

A completed guide for a feasibility study of a municipally owned wind energy system will be prepared.

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PART VI
SELECTED REPORTS BIBLIOGRAPHY

SELECTED REPORTS BIBLIOGRAPHY

The entries in this partial bibliography include reports generated by the Federal Wind Energy Program as of September 1979. Unless otherwise indicated, these reports are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, (703)557-4650. Reports available only from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, (202)783-3238 are specifically indicated within the reference. Many progress or partial-year reports are also available and numerous additional final reports will be published in the coming months. Report identification numbers are listed in parentheses at the end of each entry.

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PART VIII
REQUIREMENTS FOR UNSOLICITED PROPOSALS

REQUIREMENTS FOR UNSOLICITED PROPOSALS

Most projects supported by the Office of Solar Power Applications are selected as a result of competitive solicitations because of the widespread interest in solar energy programs and the similarities among many proposed concepts and research and development ideas. However, the unsolicited proposal is recognized as a valuable means by which unique or innovative methods or approaches can be made available to the Office of Solar Power Applications in the fulfillment of its mission.

Unsolicited proposals are evaluated using several criteria, including technical merit, cost-effectiveness, applicability to the DOE plan, and funding availability. Procurement regulations prohibit consideration of any unsolicited proposal if the proposal substantially includes work covered by any other solicitation mechanism. If an unsolicited proposal receives a favorable evaluation and the substance of the proposal is not available to DOE without restriction from another source, the procurement may proceed.

Individuals or organizations who are interested in submitting unsolicited proposals are encouraged to make preliminary inquiries of program managers before expending extensive effort preparing a detailed technical proposal. Potential proposers should also obtain a copy of the publication *Guide for the Submission of Research and Development Proposals by Individuals and Organizations Other than Educational Institutions* from:

Director of Procurement
U.S. Department of Energy
Washington, DC 20545

or "Guide for the Submission of Research Proposals from Educational Institutions," from the Division of Institutional Programs.

Since unsolicited proposals may form the basis for technical evaluation or contract negotiations, each should contain detailed information on the purpose and objective of the proposed work; an indication of the offeror's background and related experience; a concise statement of work; information relating to organization, facilities, and qualifications; other pertinent data; and a detailed cost estimate.

By their very nature, demonstration projects for solar energy technology do not lend themselves to consideration on an unsolicited basis. In addition, innovative concepts submitted on an unsolicited basis should promise a clear benefit to the solar energy program by offering a potential for improvement in cost or performance over other approaches.

Unsolicited proposals may be submitted to:

Unsolicited Proposal Management
Division of Procurement
U.S. Department of Energy
Washington, DC 20545

In addition, proposers should consider addressing their proposals directly to the lead laboratories and agencies responsible for the various elements of the wind energy program as described in this report.

Note to Inventors:
The National Bureau of Standards operates a program to evaluate all promising energy-related inventions, particularly those submitted by individuals and small companies. If you have an innovative idea for a wind system, you are encouraged to contact:

Office of Energy-Related Inventions
National Bureau of Standards
Washington, DC 20234

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