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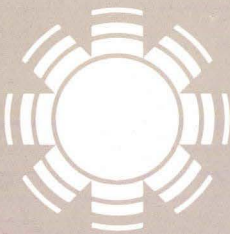
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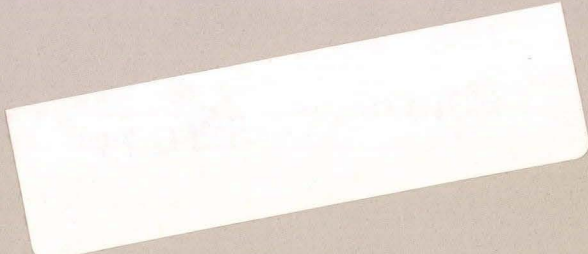
Wind Energy Activities at the Solar Energy Research Institute

American Section, International
Solar Energy Society
Annual Meeting

28-31 August 1978
Denver, Colorado



SERI



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ABSTRACT

Wind energy project activities at the Solar Energy Research Institute are collectively reviewed. Overall objectives of each major activity area are discussed in relation to the broader objectives of the Institute in furthering wind energy utilization. Also discussed is SERI's role in supporting the national Department of Energy program, interactions with the private sector in wind energy development, and efforts to promote information transfer throughout the wind energy community. Opportunities for cooperative projects with universities; with national laboratories and other research centers; and with existing or future business, manufacturing, and industrial capabilities are also indicated.

1. INTRODUCTION

The formation of the national Solar Energy Research Institute (SERI) was mandated by the United States Congress in 1974. Following a comprehensive planning and selection process which included studies by the National Academy of Sciences [1] and MITRE Corporation [2], the Midwest Research Institute was chosen in March 1977 to manage and operate SERI for the Department of Energy (DOE). SERI formally opened on July 5, 1977. Since then, the Institute has developed a broad range of programs in many phases of solar energy development [3,4]. This paper reviews activities

in one of those areas, Wind Energy Utilization. Before describing the SERI program in wind energy, it is useful to give a brief discussion of the operational divisions, their functions, and special capabilities.

The Research Division supports the national solar effort by assisting in the technical management of designated programs and the development of major experimental test facilities. It contributes by providing advanced technical options for solar energy conversion as well as the technical information needed for selection among these options. The Division helps identify and reduce technical and cost barriers to specific solar applications. It is organized into various branches that treat specific solar technologies, such as the Photovoltaics and Thermal Conversion Branches, and additional branches with more general responsibilities, such as the Materials and Energy Resource Assessment Branches.

The Information, Education and International Programs Division conducts substantial programs in solar energy information dissemination, education and training, and holds national conferences and workshops. In addition, it is the center for major international programs with many foreign countries. It has responsibility within SERI for establishing a comprehensive solar energy information data base to integrate all available data resources and solar information into a single national system. The Division also has primary responsibility for fostering and coordinating numerous creative approaches to solar research at universities.

The Analysis and Assessment Division performs the analytical investigations required to support development of national solar energy program plans and strategies. The Division makes economic feasibility analyses and studies the environmental, institutional,

and social factors that influence the utilization of all solar technologies. It reviews governmental policy options, undertakes program evaluations, and recommends changes or additions to the national effort to better achieve solar development goals. It also compares solar energy to other energy sources, provides a relative comparison of solar technologies, and evaluates the program emphasis within a single solar technology. The Division uses several branches, including the Policy Analysis and Program Evaluation Branches, in fulfilling its responsibilities.

The Technology Commercialization Division maintains extensive communication links with all sectors of the solar community and assesses the market readiness of different solar technologies. This division collects and distributes information on markets, standards, regulatory requirements, business risks, market barriers and constraints, and consumer attitudes. It supports SERI's primary goal of accelerating the widespread commercial production and use of solar energy conversion devices. Emphasis is placed on transferring technologies from the research stage to privately owned manufacturing and production facilities. The Division is organized into several branches including the Technology Evaluation and Market Development Branches.

SERI also employs several special offices within the Director's Office in addition to the operational divisions. The policy established by DOE concerning the administration of the federal program is to delegate authority and responsibility for the accomplishment of technical objectives to the DOE field offices and laboratories. In accordance with this policy, SERI is organized to meet these program objectives in part through subcontracted research. The Special Programs Office is responsible for the technical and administrative management of major programs selected by DOE for assignment to SERI. Programs in this category are in addition to management assistance with

subcontracts that directly support primary in-house SERI research. Technical assistance in the management of programs assigned to SERI by DOE is provided by the staff members of the operational divisions. Current plans are for the Special Programs Office to manage an important part of SERI's Wind Energy Utilization program, the Innovative Wind Systems effort.

In the remainder of this paper, I would like to treat the following subjects: the overall objectives of the SERI Wind Energy Utilization program, the DOE program structure and the function of SERI activities within the national effort, subcontracted studies in support of SERI's internal wind energy research and analysis needs, involvement with the private sector and foreign countries, information transfer and conferences, and SERI support of university research activities.

2. SERI OBJECTIVES IN WIND ENERGY RESEARCH AND ANALYSIS

The present DOE wind program is strong and diverse. Extensive technical capabilities [5] are being created in each of the key program elements. Major hardware designs based upon several years of effort are in development under the direction of the NASA-Lewis [6,7] and Sandia Laboratories [8]. A rapidly growing program to develop small wind machines is directed by Rockwell International [9], and broad-based research on wind characteristics is led by the Battelle Pacific Northwest Laboratories [10,11]. The USDA is assigned responsibility for farm and agricultural wind systems [12,13], and other important activities are also in progress. What is needed in order to help promote rapid utilization of wind energy is for us to build upon this solid base and, with a growing involvement of the private sector, to focus and apply the existing technological capabilities within the DOE national program. In

doing so, the products of all existing program elements can be drawn together and evaluated as they are applied to selected high-priority applications. The results of this process should not only hasten wind energy utilization nationwide, but also establish highly valuable information to be used in selecting future program initiatives.

Both the technical and nontechnical aspects of wind energy utilization are treated in the SERI program. There are several primary objectives of the effort. They are: to improve the wind energy resource data base, to determine the economic and environmental requirements for significant market penetration, to identify appropriate governmental policies and incentives that will promote such market penetration, to define the requirements of dispersed wind systems in small utility and nonutility applications, and to stimulate the development of innovative wind energy conversion devices. The four major tasks within the program are: (1) wind resource data improvement; (2) market, social, and environmental analysis; (3) dispersed applications and systems analysis; and (4) innovative wind systems program management.

The Wind Resource Data Improvement task involves field measurements, data analysis, and atmospheric modeling activities which address the specific siting and operational requirements of accelerated wind energy utilization. This activity is strongly concerned with meeting the data needs of a rapidly growing wind energy industry. It draws upon and uses capabilities developed within the DOE Wind Characteristics program element. The need for improved data and analysis methods has been identified [5] in four areas: (1) equipment design and performance evaluation, (2) mesoscale wind field properties, (3) equipment siting methodologies, and (4) power grid operations. Future research on wind characteristics must support the development, siting, and

operational aspects of different hardware designs for wind machine sizes from 1 kW to 2 MW deployed as single units or in "wind farms." A very broad range of spatial and temporal scales in meteorology [14] must be treated. Many of the problems in the wind resource area are associated with our present lack of extensive and varied experience in siting different machines and in operating one or more units under conditions characteristic of a specific site. Therefore, the development of improved national data acquisition procedures, of standardized wind energy measurements, and a continuing evaluation of procedures to interpret available data are important parts of this task.

The Wind Resource Data Improvement task will review and evaluate the quality and quantity of data required to support widespread commercial utilization of wind energy. In addition, it will examine wind resource data acquisition and interpretation procedures, conduct selected field studies, and recommend improved measurement methods to support research and commercial applications. Included within the effort is the development and use of a prototype field data acquisition system to provide measurements specific to identified wind energy needs. The activity will also apply, test, and evaluate resource mapping and siting methodologies (wind tunnel models, analytic and numerical models, field measurements, handbooks) through in-house and subcontracted work in specific applications. The effort will compile experimental results and meteorological data required to refine system simulation methods and to develop improved techniques for determining recoverable wind energy on a regional and local basis.

The objective of the Market, Social, and Environmental Analysis task is to develop the information needed to design government incentives and to plan information dissemination efforts that will accelerate the utilization of wind energy, especially in

nonutility applications or with the smaller utilities. This task makes use of knowledge developed within the Mission Analysis and the Legal/Social/ Environmental program elements of the DOE national program. Previous DOE activities have explored critical issues associated with the adoption of wind energy by utility companies [15]. Economic factors, legal, and institutional implications have also been studied [16]. However, the specific issues related to dispersed applications of small-scale wind energy devices have not been examined to an extent sufficient for accelerated commercialization of such products. This SERI task will complement ongoing DOE effort by selecting several promising applications for detailed market, social, and environmental analyses. Specific potential barriers to greater utilization of wind energy in these particular applications will be studied. It will examine the geographic market distribution and investment capability, assess product readiness, and review further requirements for technological development. Key institutional decisionmakers will be identified, and the important decision criteria in adopting wind energy devices will be determined. This effort will help formulate governmental policy options and develop a plan for widespread information dissemination.

The Dispersed Applications and Systems Analysis task addresses the following near-term applications of wind energy: (1) technical aspects of integrating units with small utilities; (2) applications matching of equipment in nonelectric usage with industry, agriculture, or other energy end-use sectors; and (3) performance and cost analysis of both electric and nonelectric wind energy conversion devices. Nonelectric applications in the power range of 50 to 200 kW will be examined and technically matched to selected end-uses. Performance and cost analyses will be based on software computer studies and laboratory models of typical equipment.

The Innovative Wind Systems program is an important part of the overall SERI Wind Energy Utilization program. Management responsibility for this effort is assigned to the SERI Special Programs Office with technical support from the Research Division. Research carried out on innovative wind systems may lead to technological breakthroughs or to other improvements which result in more cost effective designs for various applications. Subcontracted research in this area will probably exceed \$1 million in the coming year. Management of this program involves: (1) issuing solicitations for research proposals followed by proposal evaluation and funding, (2) continual review and assessment of subcontracted research in the context of the SERI management plan and the objectives of the DOE national wind program, (3) site visits and project reviews with individual research groups, and (4) conducting an annual workshop on innovative wind energy concepts at which recent project results will be presented and future programmatic activities discussed.

3. CONTRACTED STUDIES

It is recognized that the most efficient way to complete certain elements of the SERI technical program is to use the expertise and experimental capabilities of existing laboratories, businesses, and universities. The SERI Special Programs Office assists the technical staff in the administration of contracted research in support of in-house task objectives. The Office thus provides assistance with two types of contracted studies. The first are those assigned to SERI by DOE for technical management such as the Innovative Wind Systems program. The second are those directly related to internal SERI research objectives. Services provided by the Office include program planning assistance, procurement coordination, and administrative monitoring of contractor performance. These activities include solicitation for proposals,

evaluation of proposals in conjunction with the technical staff, and contract negotiations. The nature of the task to be contracted will determine whether a program opportunity notice (PON) or a request for proposal (RFP) is issued.

Accomplishment of tasks within SERI will be achieved by using the results of both the operational Divisions of SERI and results from work contracted to organizations outside of SERI. Some conceptual research programs will undoubtedly include studies by universities and not-for-profit research laboratories. The contractual agreements with such organizations should allow the researcher sufficient flexibility and freedom to be creative in his work, yet should also require him to meet a particular DOE/SERI objective within the time frame required for successful coordination with other activities. In areas of highly applied research or in systems demonstrations, the contractors' performance will be even more closely tied to the specific program objectives and the direction of the SERI management team. Contracted studies within the Wind Energy Utilization program that directly support internal task objectives may reach approximately \$500 thousand during the next year.

4. RELATED RESEARCH AND INFORMATION TRANSFER FUNCTIONS

The activities described above constitute the core of the Wind Energy Utilization program. The overall wind program supports and contributes to additional independent major efforts within SERI. These independent SERI activities, in turn, benefit the Wind Energy Utilization program. Complementary programs within SERI relevant to wind energy are discussed below and in the following sections.

In addition to the highly applied work necessary to promote near-term applications of wind energy, primary long-range studies must be conducted that are inherently more creative or speculative in nature. This is essential to assure that scientific progress is made in fundamental areas relevant to wind energy. Basic research on wind energy problems is conducted within the Basic and Applied Research program in recognition of these needs.

A major problem facing wind energy is the need for better scientific tools to extrapolate and interpolate wind data, including available historical records and additional specialized measurements. The general problem of optimally interpolating wind measurements from presently available measurement stations to intervening locations where data are needed to assess the local wind power potential is one of extreme importance. A second important need is for operational wind forecasts tailored to wind energy delivery systems. A third area of growing importance is analysis of the climatic variability of the practical wind energy resource, including the spacial distribution of temporal variability. Much remains to be done on each of these subjects. Recent advances in the application of principle components analysis to wind energy problems have indicated the great potential of this technique [17,18]. Further development of this method and applications to problems such as those stated above will be undertaken as a part of the Basic and Applied Research program.

An important part of SERI's work is an active involvement with the industrial sector. This involves continuing interaction with organizations such as the Electric Power Research Institute (EPRI), small businesses, major manufacturers, and trade-oriented groups such as the Association of Energy Engineers (AEE) and the American Wind Energy Association (AWEA). Interaction with the private sector also includes the development of technology

transfer plans for DOE. Responsibility for technology transfer planning rests with the SERI Technology Commercialization Division. Such work includes evaluating present technical information transfer procedures for all solar technologies, including wind energy, and incorporating the latest results into special descriptive reports for public use.

The entire solar energy field is developing very rapidly and wind energy is certainly no exception. It is essential for the early widespread utilization of wind energy that new ideas and new information emanating from research, development, or demonstration projects be disseminated very rapidly. Timely conferences, workshops, and seminars can serve to expedite information exchange. SERI in its first year has held about 50 conferences and special topical meetings. Within the Wind Energy Utilization program, several conferences and meetings are planned during the coming year. A major workshop on innovative wind systems is planned for the near future, and a conference on wind resource data problems will also be held during the coming year. Primary responsibility for the planning, coordination, and conduct of such professional conferences is assigned to the Conference Management Group at SERI. A fully-equipped conference center is being planned for the future permanent SERI facilities. It is hoped that the existence of conference management services at SERI will encourage many chairpersons to convene future wind energy meetings in the Denver area. This will enable the national and worldwide wind energy community to visit SERI and interact with its staff.

A major activity of SERI is the development of a comprehensive collection of solar energy information. This will provide a unique and valuable resource to the wind energy community. Until recently, solar energy information and data, when existent, were fragmented, widely scattered, and difficult to identify and

retrieve. Congress recognized the value of an efficient and well-organized data system and called for implementation of a Solar Energy Information Data Bank (SEIDB). SERI has been assigned responsibility for the development and operation of the SEIDB. Demands for information come not only from the technical community but also from groups and individuals at federal, state, and local agencies and from legislative bodies, manufacturers, the financial community, developers, and interested private citizens. A centralized and comprehensive system will be established to furnish both technical and nontechnical information. The SEIDB will be closely coordinated with other DOE activities and will focus entirely on solar energy information, including specialized data and reports of importance in wind energy development.

The ultimate SEIDB will evolve only after careful consideration of the available options; studies of the requests for information and data within the entire solar community; and detailed coordination with other DOE, federal, and private programs relating to solar energy information and data. Phased development and growth of the SEIDB is occurring parallel to these planning studies. By the end of 1978, the SEIDB, while not complete, will be an active, integrated operation providing a wide range of services to target audiences identified as warranting priority attention.

A national library, a solar data system and information dissemination service, and a solar energy computer service are being developed. The library will contain a comprehensive collection of technical and nontechnical solar energy publications supplemented by selected publications from many supporting disciplines. The files will be computerized and searchable from computer terminals throughout the country.

The National Computer System is developing a network which will provide broad access to bibliographical and numerical data files.

It will also incorporate systems for manipulation of data and standardized computational programs for modeling and simulation. Baseline computer models, tested and supported by the SERI technical staff, will be made available to researchers across the country. Baseline research models are those which have been defined by the SERI Research Division as a recognized standard for simulating and analyzing the scientific and engineering aspects of a solar technology. Economic baseline models will be defined by SERI's Analysis and Assessments Division as a standard measure of the economic viability of a particular solar technology within a specific economic scenario.

The Information and Data Systems group is concerned with the collection, processing, storage, and retrieval of textual and numeric data tailored to the needs of the solar community. The information dissemination program will assure wide dissemination of the information and data incorporated into the SEIDB. The SERI staff, in cooperation with DOE personnel, will monitor the needs of the solar community and will develop specialized programs and publications that are responsive to current needs.

5. INTERNATIONAL PROGRAMS

The entire world represents a potential market for solar energy technology and products. Wind energy is a solar technology with one of the best prospects for near-term, cost-effective applications and consequently has a great potential for use in foreign countries as well as our own. An important goal of SERI is to help the United States occupy a leadership role in the international development of all forms of solar energy. Cooperative programs are in progress with many nations, including Saudi Arabia, Spain, Iran, France, and work with the International Energy Agency. Future programs may be started with Japan, Mexico,

and less developed countries. Responsibility for these activities rest with the International Programs Branch within SERI. Separate tasks are designed to manage formal cooperative programs between the United States and other countries, to help the less developed countries improve their own solar capabilities, and to collect international information pertinent to the solar development activities of the United States. Areas of particular interest include the development of simple resource measuring equipment for use in remote areas and the testing of these techniques and equipment.

The SERI wind program is cooperating with Spain in the development of wind energy machines of intermediate size. The Spanish government is presently interested in the development of wind turbines with power ratings of approximately 100 to 500 kW for electric utility power generation. Several windy sites throughout Spain are of interest as deployment sites for equipment testing. SERI may assist Spain in the selection of hardware, meteorological instrumentation and measurements, siting problems, performance testing, and interactions with American manufacturers. The Wind Energy Utilization program has also provided advice to Saudi Arabia in regard to applications of wind energy within that country. Saudi Arabia has a very large program that will involve many forms of solar energy development including solar desalination. Applications of wind energy in irrigation, building cooling, refrigeration, and industrial or central-station power generation are under discussion.

6. UNIVERSITY RESEARCH PROGRAM

Historically, one of the most fertile resources for new concepts has been the academic community. It is essential for the evolution and healthy growth of any consumer industry, and

especially for one in its infancy, that it be supported by a vigorous conceptual research program. The specific objective of the University Solar Research Program within SERI is to support a large number of conceptual research projects, each at funding levels appropriate for an academic organization. The emphasis will be on a continuing multi-year program that will support the generation and development of new ideas. Several solicitations each year may be employed. SERI staff members will assist in the monitoring and peer review of proposals. It is hoped that a strong advisory role will be played by the academic community in deciding the relative allocation of available funds among the different solar technology areas. Research in these areas will be separate and distinct from any directed university research by either DOE or SERI in support of highly applied research projects. It is hoped that several creative breakthroughs leading to new solar technologies or to significant improvements in existing technologies will emerge from the program each year.

7. ACKNOWLEDGEMENTS

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