United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Investigations and Oversight, Committee on Science, Space, and Technology, House of Representatives

April 1993

ELECTRICITY SUPPLY

Efforts Under Way to Develop Solar and Wind Energy

149197

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Resources, Community, and
Economic Development Division

B-252296

April 16, 1993

The Honorable James A. Hayes
Chairman, Subcommittee on Investigations
and Oversight
Committee on Science, Space, and Technology
House of Representatives

Dear Mr. Chairman:

As requested, this report discusses barriers that discourage electric utilities from using wind and solar technologies and efforts made by the government, utility companies, and industry groups to foster wind and solar energy use. The report contains recommendations designed to make more effective use of the Department of Energy's programs and authorities for promoting the development and use of these technologies.

As agreed with your office, unless you publicly announce its contents earlier, we will make no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the appropriate congressional committees and the Secretary of Energy and will make copies available to others upon request.

This report was prepared under the general direction of Victor S. Rezendes, Director, Energy and Science Issues, who can be reached at (202) 512-3841 if you or your staff have questions. Major contributors to this report are listed in appendix III.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Wind and sunlight have the potential to help meet the nation's electricity needs without the adverse environmental effects associated with other energy sources, yet they currently supply less than 1 percent of the nation's electricity. The Chairman, Subcommittee on Investigations and Oversight, House Committee on Science, Space, and Technology, asked GAO to identify (1) economic and institutional barriers that discourage electric utilities from using wind or solar power; (2) efforts by government, utilities, and industry to foster the use of wind and solar power, and (3) ways in which the Department of Energy's (DOE) programs could further assist the development of wind and solar technologies.

Background

Wind generates electricity by turning the turbines attached to a generator. Solar energy generates electricity through the use of photovoltaics, in which light falling on a semiconductor surface directly produces an electrical current, and of solar thermal technologies, in which solar heat is used to make steam or is converted directly into electricity.

Investor-owned utilities provide more than 70 percent of the nation's electricity; the rest is provided by publicly, cooperatively, or federally owned electric utilities and by a growing number of non-utility generators. The majority of investor-owned utilities are monopolies, which operate in designated geographic service areas without retail competition. State regulatory commissions review the utilities' resource plans, which can include conservation measures and/or new power plants; determine the return that the utilities are allowed to earn on their investments; and set retail electricity rates.

DOE funds the research, development, and demonstration of fossil, nuclear, wind, solar, and other energy technologies, and disseminates information to utilities, regulators, and others. In its 1991 National Energy Strategy, DOE projected that wind and solar energy resources could supply a significantly higher portion of the nation's energy needs. DOE's fiscal year 1993 funding for wind and solar research and development is about $187 million.

Results in Brief

Utilities have been discouraged from using wind and solar energy technologies because (1) the availability of wind and solar resources varies, depending on geographic and climatic area; (2) the technologies are more costly than more conventional ones for a variety of reasons; and (3) the technologies, which are relatively new and untried, are perceived as riskier than conventional energy sources because approval by regulators and costs are both uncertain.

Government agencies, utilities, and industry groups are developing technologies and conducting marketing efforts to promote greater use of wind and solar energy. Wind energy developers have developed technology aimed at lowering the cost of wind-generated electricity; assisted by some state and federal initiatives, they are also working with utilities to create new markets for wind energy. A consortium of utility, industry, government, and consumer groups is identifying markets and improving manufacturing processes for photovoltaics. DOE, through joint ventures with utilities and others, is developing utility-scale models of two solar thermal technologies and planning their commercialization.

Opportunities for further DOE assistance include (1) funding additional research and development aimed at lowering the cost of wind and solar energy technologies, (2) developing methods to help utilities and regulators compare alternative resources more accurately, and (3) encouraging greater use of renewable energy by federal agencies.

Principal Findings

Barriers to Wind and Solar Energy Use

The use of wind and solar technologies depends on weather conditions that vary widely by geographic area—wind power is most practical in the Great Plains, solar power in the Southwest. Even in favorable climates, the resources are not available continuously. In addition, the most effective sites for wind and solar facilities may be far from population centers, which pose transmission difficulties.

With some exceptions, using wind and solar energy to produce electricity costs more than fossil energy and is therefore less attractive to utilities. For example, wind-generated power now costs about 5 to 9 cents per kilowatt-hour; solar thermal power, 9 to 10 cents; and photovoltaic power, 30 to 40 cents. By contrast, electricity produced by natural gas costs an average of about 4 cents per kilowatt-hour. In large part, costs are higher because the technologies are relatively new and may not have reached their potential in terms of scale economies.

The cost differences are also partly attributable to traditional utility planning and regulatory methods that may not account for all costs associated with each resource—for example, the costs of environmental impacts. The cost gap may also reflect, in part, the effects of past research and development funding allocations and tax benefits that were directed more toward conventional, nonrenewable energy sources.

Because wind and solar technologies are relatively new and more expensive than more conventional technologies, they are generally perceived as riskier investments. Specifically, utilities face the risk that regulators will find such investments to be imprudent if the investments are not demonstrably the lowest-cost option for meeting electricity demand and thus preclude the utility from recovering its investment cost from electricity customers.

Efforts to Foster Greater Use

The wind industry has taken the lead in developing new technology aimed at lowering the costs of wind-powered generation and in marketing the technology to utilities—including offering various project ownership and operating options to reduce utility investment risk. In addition, a number of states have adopted measures that encourage wind power developments, such as (1) set-asides (mandatory or voluntary goals to generate a specified amount of electricity using renewable resources), (2) requirements for considering environmental impacts in energy resource plans, and (3) tax incentives for renewable energy development.

A consortium of photovoltaic industry, utility, and state organizations has launched several efforts to expand utilities' use of photovoltaics. The strategy involves aggressive marketing of applications that are already cost-effective and opening new markets to increase production and achieve scale economies. In addition, DOE, working with utilities, private groups, and federal and state agencies, is involved in several efforts to advance solar energy technologies. These include a project designed to test and verify the performance of photovoltaic products in a utility setting and a joint venture to advance "central receiver" solar thermal technology, in which the sun's rays are focused on a central point to make steam for electricity generation.

Opportunities for Further DOE Efforts

The utility, industry, and state officials that GAO surveyed expressed strong support for DOE's recent efforts to work in partnership with them and share the costs of wind and solar projects. The officials also stated that additional research and development funding could help make wind and solar energy technologies more cost-competitive. While allocating research funds entails difficult choices, we noted in a 1992 report[1] that DOE's Office of Policy, Planning and Analysis concluded that the agency's renewable energy technology programs better met National Energy Strategy goals than did other research programs that have historically received higher funding—such as those for nuclear energy.

As resources that are relatively environmentally benign, wind and solar technologies could also benefit if utility planning and regulatory processes better accounted for the environmental and other impacts of energy resources—one of the goals of DOE's integrated resource planning program. Accelerated development of analytic tools to aid utilities and regulators in estimating costs for energy resources could help wind and solar technologies during the resource planning process.

Opportunities also exist for DOE to promote solar and wind energy use by federal agencies by (1) accelerating an effort to identify and include cost-effective photovoltaic applications in federal product supply catalogs and (2) accelerating efforts by two of DOE's power marketing administrations[2] to explore ways to help develop wind and solar resources within their service areas.

Recommendations to the Secretary of Energy

GAO recommends that the Secretary of Energy (1) reassess DOE's energy technology research and development funding for wind and solar energy technologies to ensure that it is commensurate with the technologies' potential to meet National Energy Strategy goals, (2) accelerate the development of analytical tools to help utilities and regulators assess the costs and benefits of developing and using each energy resource, and (3) consider increasing efforts to promote renewable energy use by federal agencies.

Agency Comments

GAO discussed the factual contents of this report with DOE's Associate Deputy Assistant Secretary for Utility Technologies, Office of Conservation and Renewable Energy, and with the Director, Office of Solar Energy Conversion, who agreed with the facts presented. However,

[1]Energy R&D: DOE's Prioritization and Budgeting Process for Renewable Energy Research (GAO/RCED-92-155, Apr. 29, 1992).

[2]The Bonneville and Western Area power administrations provide transmission and market federal power in most of the western United States, an area rich in solar and wind resources.

as requested, GAO did not obtain written comments on a draft of this report.

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Abbreviations

BPA	Bonneville Power Administration
DOE	Department of Energy
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute
IRP	Integrated resource planning
kW	kilowatt
kWh	kilowatt hour
MW	megawatt
NARUC	National Association of Regulatory Utility Commissioners
NRECA	National Rural Electric Cooperative Association
PG&E	Pacific Gas and Electric
PURPA	Public Utility Regulatory Policies Act of 1978
R&D	Research and development
SMUD	Sacramento Municipal Utility District
UPVG	Utility Photovoltaics Group
WAPA	Western Area Power Administration

Introduction

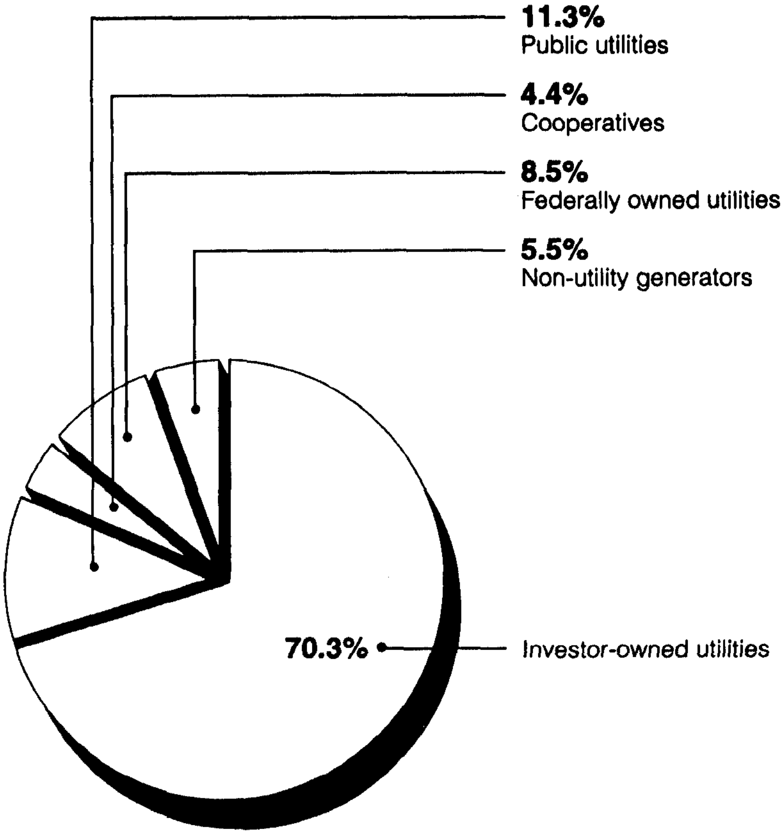
The Department of Energy's (DOE) 1991 National Energy Strategy estimates that, even with aggressive conservation and efficiency efforts, the nation's demand for electricity is expected to increase 28 percent over the current level by the year 2010. In addition, aging fossil fuel and nuclear power plants may need replacement. The development and use of renewable energy technologies to help meet the demand for electricity in the future could have both economic and environmental benefits. However, the development and use of these technologies has been slow.

Generation of Electric Power

The U.S. electric utility industry generally produces power at central generating stations and then distributes it over a network, or "grid," to meet customer demand. The amount of electricity required to meet the minimum round-the-clock need from customers is called "baseload" demand. "Peak" demand refers to the amount of electricity required to meet demand during brief periods of maximum customer need. A combination of privately, publicly, cooperatively, and federally owned electric utilities, and a growing number of non-utility generators, make up the electricity generating sector in the United States.

As shown in figure 1.1, privately owned electric companies—also referred to as investor-owned utilities—account for some 70 percent of the nation's electricity generation. Most investor-owned utilities are integrated monopolies which own and operate the facilities in all three stages of supplying electricity—generation, transmission, and distribution. As monopolies, electric utilities supply electricity within designated geographic retail service areas, without competition from other suppliers. In exchange for monopoly status, the utilities are required to serve all customers in the service area and are regulated by state regulatory commissions, which (1) determine the rate of return the utilities are allowed to earn on their investments, (2) set the retail electricity rates customers pay, and (3) review the utilities' plans for meeting electricity demand.

Figure 1.1: U.S. Electric Power Generation, 1990



Source: Energy Information Administration.

Public utilities and cooperatives are nonprofit, and therefore their rates of return are generally not subject to state regulation. However, states vary in their regulatory oversight of other aspects of these entities, such as resource planning. For the public utilities we contacted, plans for new generating capacity are generally reviewed only by their boards of directors.

Federally owned utilities include the Tennessee Valley Authority (TVA) and DOE's five power marketing administrations.[1] TVA is a

[1]The Alaska, Bonneville, Southeastern, Southwestern, and Western Area power marketing administrations.

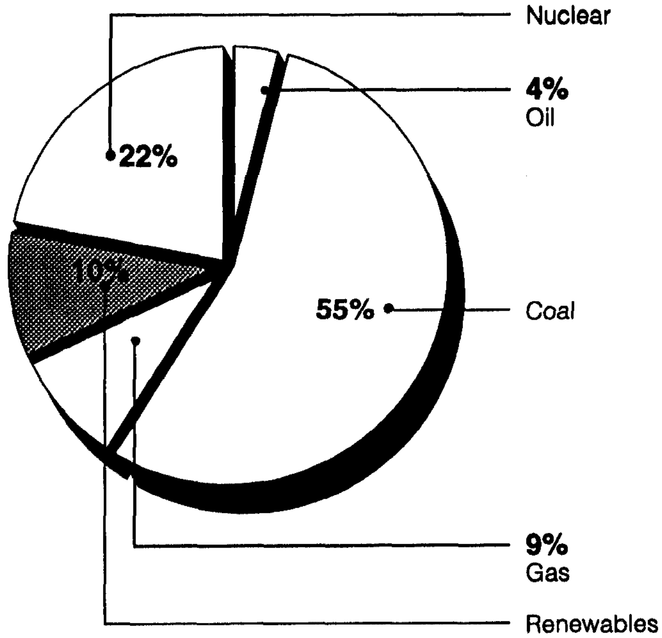
government-owned corporation that supplies power to electricity distributors in seven southeastern states. The power marketing administrations market and transmit electric power produced at federal hydroelectric projects and reservoirs to customer utilities. Unlike the other power marketing administrations, the Bonneville Power Administration (BPA) also has the authority to enter into long-term contracts to meet the needs of its customer utilities and to participate in resource development.

Non-utility generators include "qualifying facilities," which must meet certain fuel and technology requirements and may sell electricity to utilities at prices generally established by state regulators. Other non-utility sources, typically referred to as independent power producers, also generate and sell power to utilities but at prices they negotiate directly with the utilities.

Renewable Energy Technologies

Renewable resources are those which are continually replenished. In contrast, nonrenewable resources, such as fossil fuels, are gone forever once they are used. Renewable energy is derived directly from the sun's heat and light (solar) or through other natural processes such as wind flow, plant growth (biomass), river flow cycles (hydropower), and ocean temperature differentials. While arguably depletable, geothermal energy—energy from the heat of the earth—is also generally included as a renewable energy resource. Renewable resources contribute about 10 percent to the nation's electricity supply, mostly from hydropower (see fig. 1.2). As requested, this report focuses on wind and solar energy.

Figure 1.2: Electricity Supply by Source, 1991



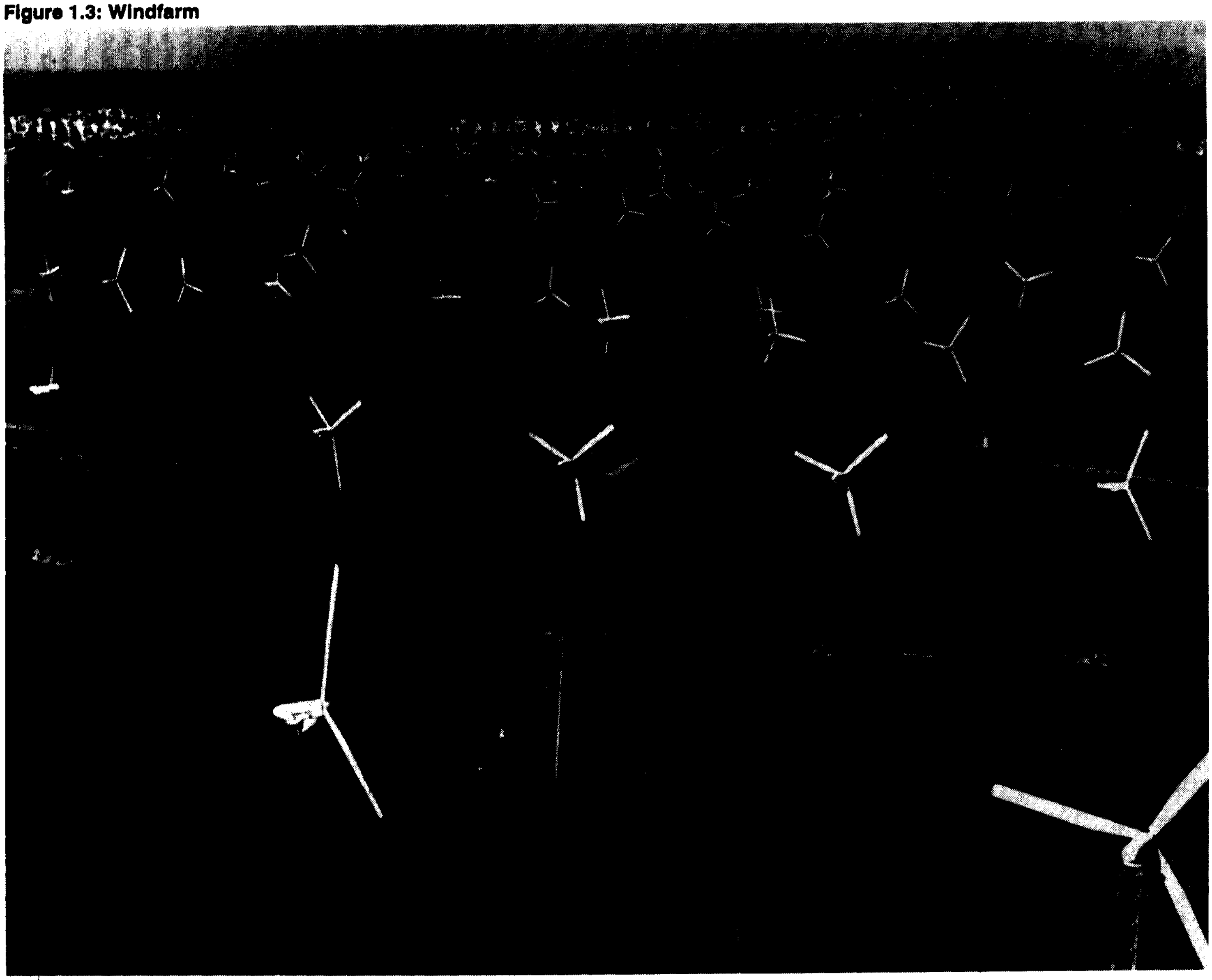
Source: Energy Information Administration.

Wind

The typical wind energy system is a "farm" of many medium-sized turbines (see fig. 1.3). There are two main turbine designs: horizontal-axis "propellers" somewhat like the traditional windmill, and "eggbeaters" with bow-shaped blades joined at top and bottom to a vertical axis. In 1990, U.S. wind generating capacity was about 1,950 megawatts (MW)—less than one percent of the nation's 725,000 MW total generating capacity.[2]

[2]A megawatt is 1 million watts, with a watt being the basic unit of measurement of electrical power.

Figure 1.3: Windfarm



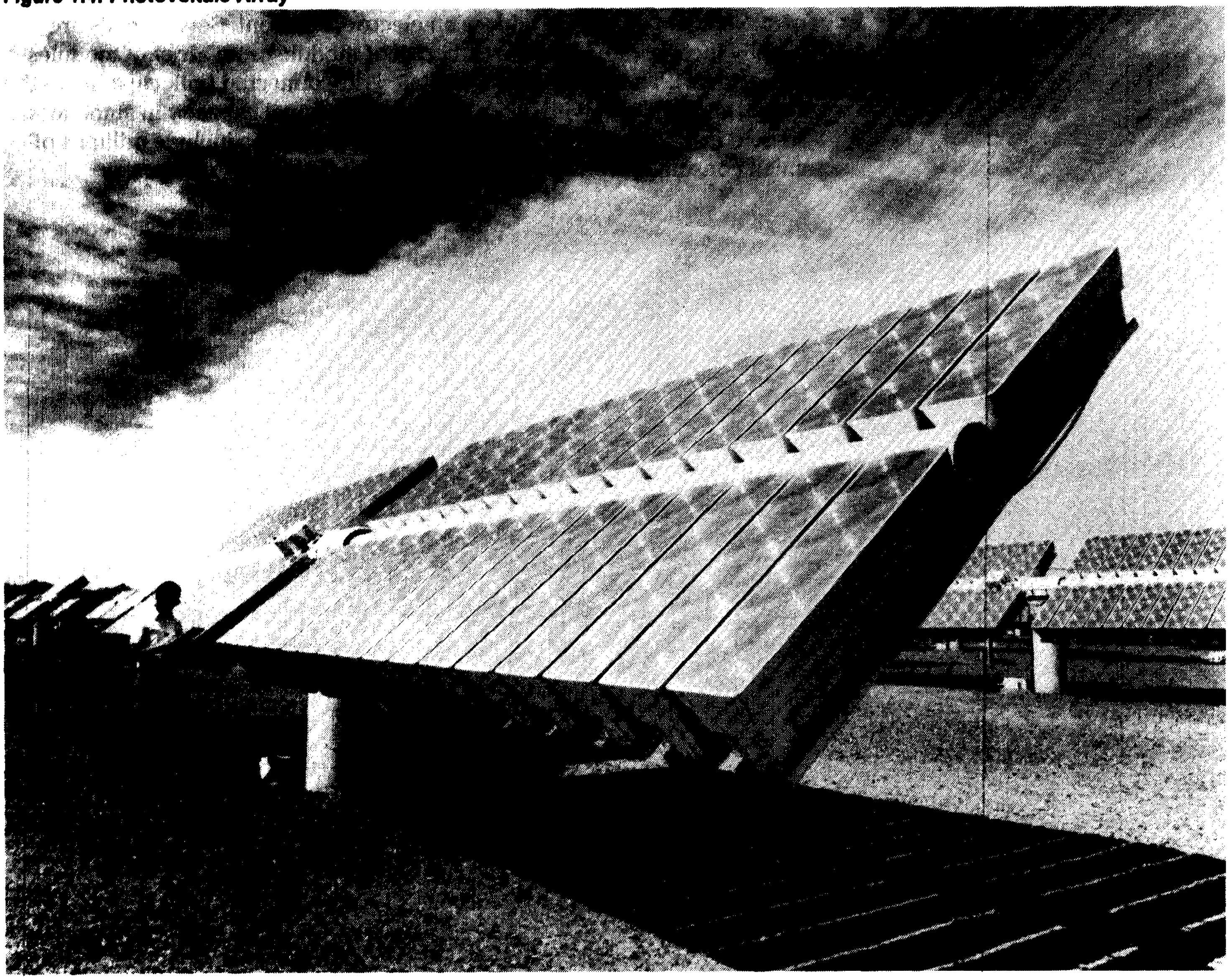
Note: About 190 horizontal-axis turbines have been installed at this site, each producing about 40 kilowatts of electrical power.

Source: Department of Energy.

Photovoltaics

In a photovoltaic cell, light falls on a semiconductor surface, usually made of silicon, and directly produces an electrical current. Several cells are usually incorporated into a weatherproof module or an array of modules (see fig. 1.4). The existing photovoltaic grid-connected bulk capacity in the U.S. is about 12 MW, with about 20 MW in additional capacity in stand-alone remote installations. Other photovoltaic applications include millions of small consumer products such as watches and battery rechargers.

Figure 1.4: Photovoltaic Array



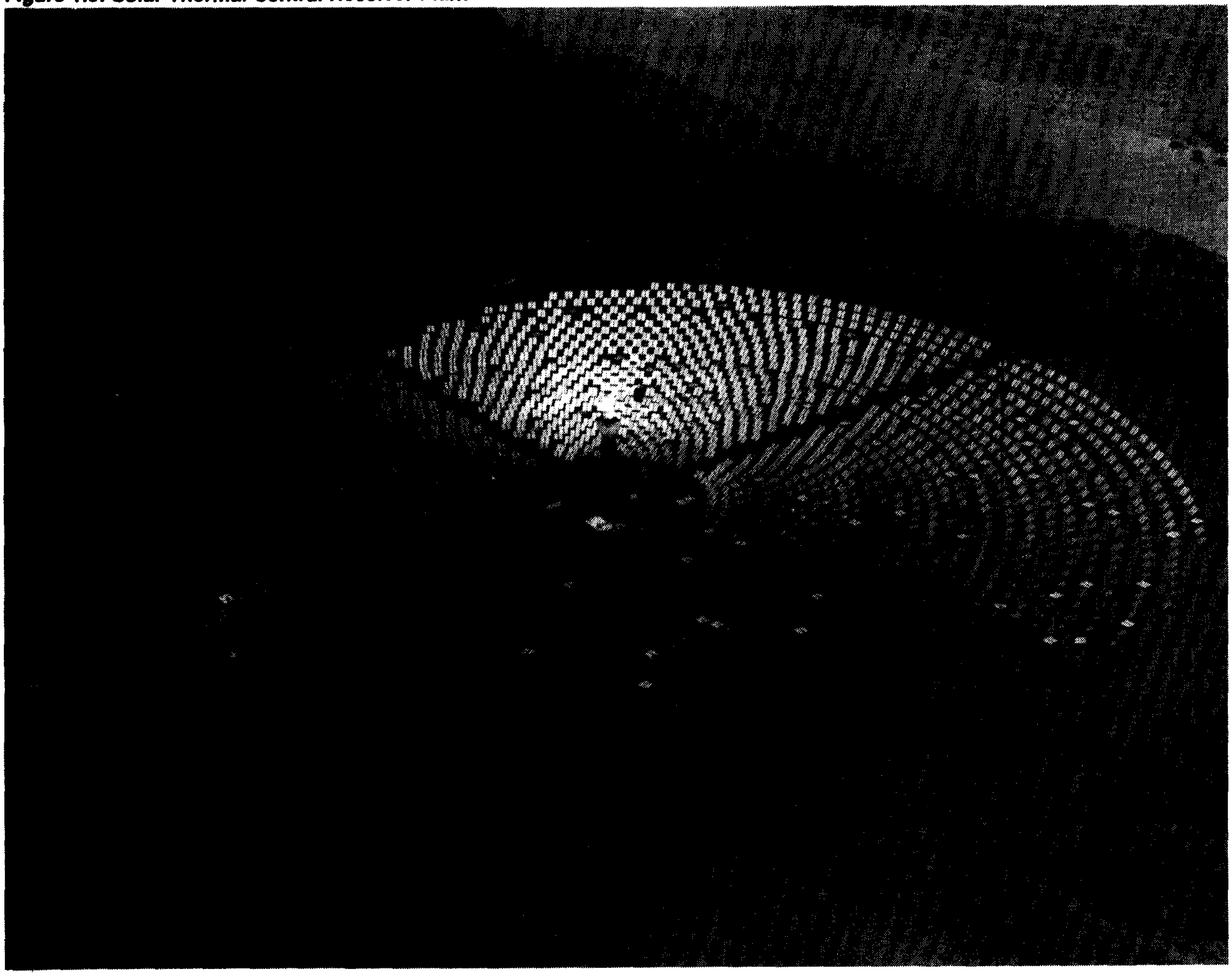
Note: Close-up view of one of the arrays in a photovoltaic plant generating 225 kilowatts of electricity.

Source: Department of Energy.

Solar Thermal

Solar thermal-electric equipment converts solar heat to electricity, usually at a central power plant. There are three types of solar thermal technology: trough, central receiver, and dish stirling. Trough technology uses reflective troughs to concentrate sunlight; central receiver technology uses tracking mirrors (heliostats) to focus heat from the sun (see fig. 1.5). In both cases, the solar energy is used to produce steam, which then drives a turbine generator. In contrast, dish stirling systems use sun-tracking parabolic dishes to focus heat onto an engine mounted on the dish, which directly converts collected solar heat into electricity. In 1990, U.S. solar thermal electric generating capacity was about 430 MW, primarily from the use of troughs.

Figure 1.5: Solar Thermal Central Receiver Plant



Note: Aerial view of a solar thermal central receiver plant comprised of more than 1,800 heliostats surrounding a central receiver installed on a high tower.

Source: Department of Energy.

The Federal Renewable Energy Program

The Arab oil embargo of 1973 sparked the establishment of a comprehensive federal energy program that included the promotion of renewable resources. During the 1970s, the federal renewable energy program grew rapidly to include research and development, including joint participation with the private sector in demonstration projects, commercialization, and information dissemination; market incentives such as business and residential tax credits; and encouragement of non-utility developers of solar-and wind-powered electricity under the Public Utility Regulatory Policies Act (PURPA) of 1978, as amended. Program support waned during the 1980s under the administration's emphasis on market-driven energy policy and generally declining energy prices. However, the sharp oil price drop in 1986 triggered growing oil imports, rekindling federal interest.

In 1991, DOE issued a National Energy Strategy that included several options designed to increase incentives for the development of renewable energy technologies. The Energy Policy Act of 1992 (P.L. 102-486) contains several provisions to encourage the use of renewable energy. Other federal programs and policies—including energy regulatory reform, environmental requirements, and congressional initiatives—have also helped renewable energy technologies.

Research and Development

DOE is responsible for overseeing federal research and development of a variety of electricity supply technologies, including those based on renewable, nuclear, and fossil energy sources. Program managers within DOE's Office of Conservation and Renewable Energy oversee groups of renewable energy technology research and development projects which are carried out by national laboratories, universities, and private industry. DOE's fiscal year 1993 budget provides about $187 million for wind and solar (including biofuel and ocean) energy technology research and development.

DOE's renewable research and development program contains an international component designed to develop and market export-ready technologies in developing countries where electrification efforts are being pursued. As chair of the Committee on Renewable Energy, Commerce and Trade, DOE works with 13 other federal agencies and the U.S. Export Council for Renewable Energy to stimulate cooperative federal/private sector deployment of renewable technologies to international markets.[3]

The Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989 authorized joint ventures between DOE and the private sector for commercial demonstration projects for energy efficiency and for certain renewable energy technologies. The act also established a committee to advise DOE on the development of the ventures. While the act has never received specific appropriations, DOE has adopted the joint venture approach in several areas. In January 1992 testimony, DOE's Assistant Secretary for Conservation and Renewable Energy noted that such partnerships leverage the impact of federal spending and increase the likelihood of commercial adoption of the technologies under development.

Tax Incentives

Since the late 1970s, several laws have provided various tax incentives for renewable energy development and/or use. These incentives, combined with the energy tax credits and standard investment credits available at the time, resulted in a negative effective tax rate for solar and wind projects in the early 1980s. In 1985, however, the business energy tax credit for wind, and residential energy tax credits for all categories of alternative energy resources, were allowed to expire. While tax credits for investments in solar technologies continued, they were reduced and subjected to annual renewal, creating uncertainty for potential investors.

To address concerns raised by investors and industry officials, the Energy Policy Act of 1992 permanently extended tax credits for investment in solar energy property. In addition, the act provided tax credits for electricity produced from alternative energy sources. With certain limits, qualified facilities may receive credits of 1.5 cents per kilowatt hour (kWh) of electricity generated over a 10-year period.

PURPA Incentives

The Public Utility Regulatory Policies Act of 1978 was enacted in part to encourage the development of alternative energy resources. PURPA requires utilities to purchase power output from non-utility facilities at prices established by state regulators if the facilities are (1) generators which produce electricity using solar, wind, waste, or geothermal energy sources,

[3]The Council is a consortium of nine renewable energy trade associations. For more information on the Committee on Renewable Energy, Commerce and Trade and this council, see Export Promotion: Federal Efforts to Increase Exports of Renewable Energy Technologies (GAO/GGD-93-29, Dec. 30, 1992).

or (2) cogenerators which produce both electricity and heat or steam for industrial or commercial purposes.

The states that established relatively high initial prices for this electricity saw a rapid expansion in the number of non-utility generators, mostly cogenerators. However, only a few states set prices high enough to benefit wind and solar projects, and most that did initially are no longer doing so.

Regulatory Reform

The stated objective of DOE's integrated resources planning (IRP) program (formerly "Least Cost Planning") is to encourage a market environment in which all viable demand-side and supply-side options can compete equally for utility resource investment. The program encourages state regulators to adopt policies directed at meeting electricity requirements at the lowest cost to society. According to the National Energy Strategy, technology and resource choices should be based on an improved understanding of total fuel-cycle costs—the entire costs of producing, transporting, dispensing, and using a given energy resource, including the costs of health and environmental impacts.[4] Because they are relatively environmentally benign, wind and solar energy technologies can benefit from planning and regulatory methods that incorporate such costs.

The analytic tools to accomplish the goals of IRP are still evolving. Utilities in at least 31 states have begun to develop IRP programs, but many are only beginning to address the regulatory changes necessary to implement IRP procedures. To date, IRP programs have been valuable in pointing out discrepancies in federal and state taxation and regulatory treatment of energy demand and supply investments, but most states and utilities are still grappling with how to incorporate demand-side management and alternative technologies into their planning processes.

Environmental Requirements

Environmental legislation, such as the Clean Air Act and its subsequent amendments, limit major air pollutants from power plants and thus encourage the development of non-polluting alternative energy resources. Over two-thirds of the electricity generated in the United States is produced by burning fossil fuels, accounting for significant portions of the sulfur dioxide, nitrogen oxide, and carbon dioxide emitted in the nation. Sulfur dioxide and nitrogen oxide are associated with acid rain, and evidence connects carbon dioxide emissions with global warming. In

[4]Because the costs of health and environmental impacts are not necessarily captured in energy prices, they are often referred to as external costs or "externalities."

general, wherever renewable energy systems displace fossil fuel use, they will also reduce emissions of pollutants that contribute to acid rain, urban smog, and global warming.

Direct Use by Federal Agencies

Requirements for direct use of renewable energy technologies by federal agencies have the effect of expanding the market for those technologies. For example, the House Committee on Appropriations has asked the Department of Defense to develop a plan for installing at least 100 MW of renewable-based generating capacity at its facilities by the end of 1996.[5] The Department's Photovoltaic Review Committee has identified 40,000 to 50,000 remote photovoltaic applications that are potentially cost-effective.

Objectives, Scope, and Methodology

Because growth in the development and use of renewable technologies has been slow, the Subcommittee on Investigations and Oversight, House Committee on Science, Space, and Technology, asked us to

- identify the economic and institutional barriers that discourage electric utilities from using wind, photovoltaic, and solar thermal technologies;
- identify the efforts made by government, utilities, and industry to foster a marketplace conducive to the use of these technologies; and
- identify ways in which DOE programs could further assist the development of wind and solar technologies.

To meet these objectives, we first conducted a search of the available literature. A partial bibliography is included at the end of this report.

To obtain information on the barriers and the efforts by government to overcome them, we contacted numerous government officials at both the federal and state levels. At the federal level, we contacted officials within the Department of Energy, including officals at the Office of Conservation and Renewable Energy, National Renewable Energy Laboratory, Sandia National Laboratory, Bonneville Power Administration, Western Area Power Administration, and Federal Energy Management Program. We also contacted officials from the Environmental Protection Agency and the Department of Defense. At the state level, we contacted the energy offices and public utility commissions in 34 states. We included states where significant efforts were being made to develop wind or solar power, or where good solar or wind resources exist but little development has occurred.

[5]House Report 101-605, "Military Construction Appropriations Bill, 1991" (July 19, 1990).

To obtain information on the barriers from the utilities' perspective, we contacted officials from 32 utilities. In selecting these 32 utilities, we chose some that were using wind or solar technologies and some that were not using them at the time, but which were located in areas with potentially good solar and wind resources. We also interviewed officials and obtained documents from various utility and energy related organizations. To obtain information concerning efforts by industry, we contacted various renewable energy technology industries and independent power producers. A listing of states, utilities, organizations, and industries contacted appears in appendix I.

To identify ways in which DOE could further assist the development of wind and solar technologies, we asked officials representing utilities, industry, federal and state agencies, and public interest groups representing environmental and energy organizations for their suggestions. We also drew upon our past reports on DOE research and development activities.

Our work was conducted from November 1991 through February 1993 in accordance with generally accepted government auditing standards.

Restricted Availability, High Cost, and Perceived Risk Pose Major Barriers

Development of wind, photovoltaic, and solar thermal technologies confronts several significant barriers. First, wind and solar resources vary by geographic region and daily weather conditions. Second, they are generally not cost-competitive with fossil fuels under traditional utility planning and regulatory approaches. Third, utility companies can be discouraged from developing renewable resources because they perceive these development projects as risky investments.

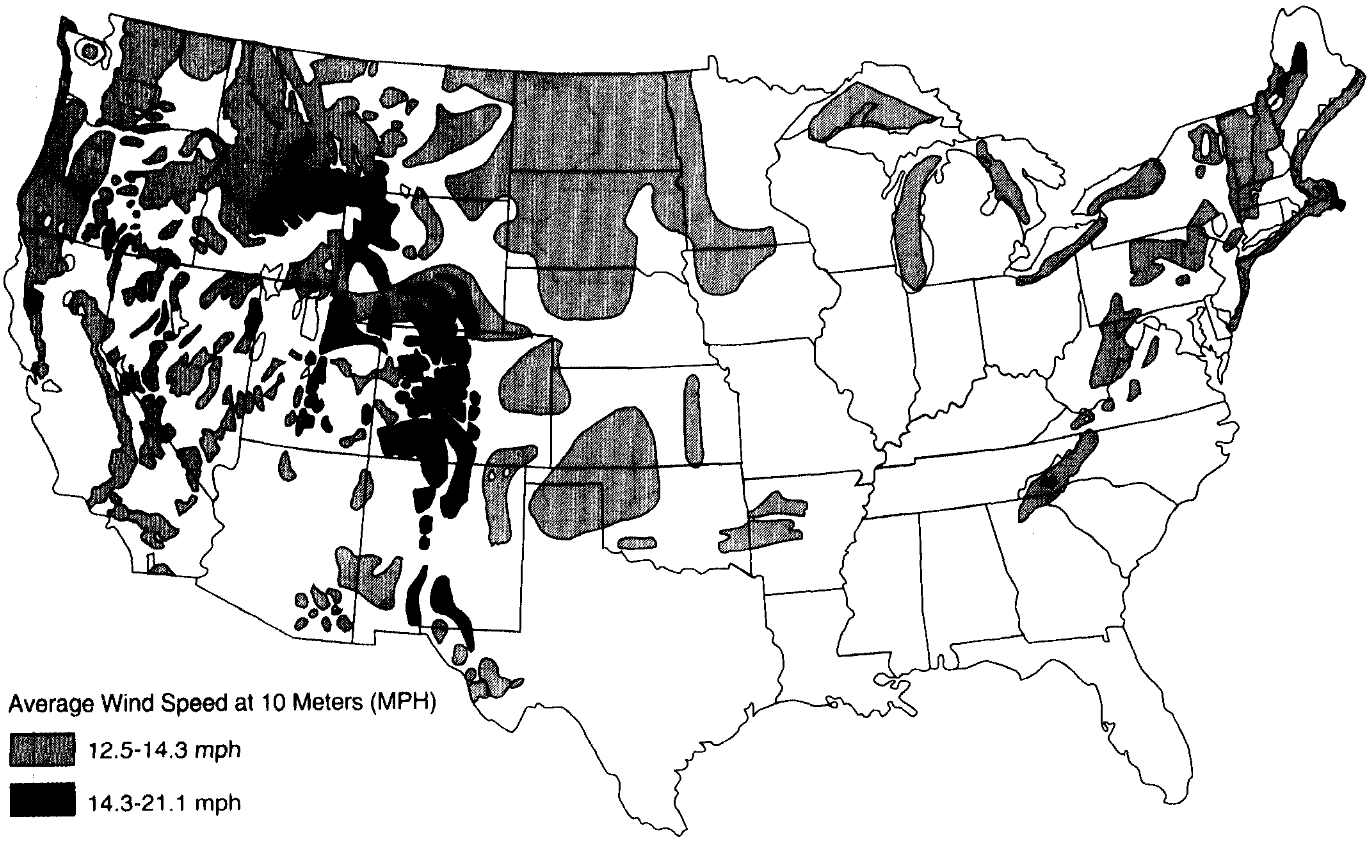
Use of Renewable Technologies Is Limited by Availability of Resources

Increasingly efficient technologies can be used in areas that are less and less windy or sunny. However, the availability of wind and solar energy resources varies by geographic location; even in locations where a resource is generally available, the ability to produce electricity is intermittent, changing with the weather. Furthermore, siting and transmission constraints may prevent constructing generating facilities in locations where the other conditions are favorable.

Resource Availability Varies Among Regions

The effect of geography on resource availability varies for wind, photovoltaic, and solar thermal technologies. Good wind resources exist at specific sites in several regions of the country (see fig. 2.1), while good solar resources are concentrated in the southwest (see fig. 2.2). Photovoltaics can generate electricity from diffuse as well as direct sunlight in any region of the country, but they have less potential in areas with the cloudiest climates. Solar thermal electricity generation requires direct clear sunlight, and thus is more limited to the southwestern sunbelt.

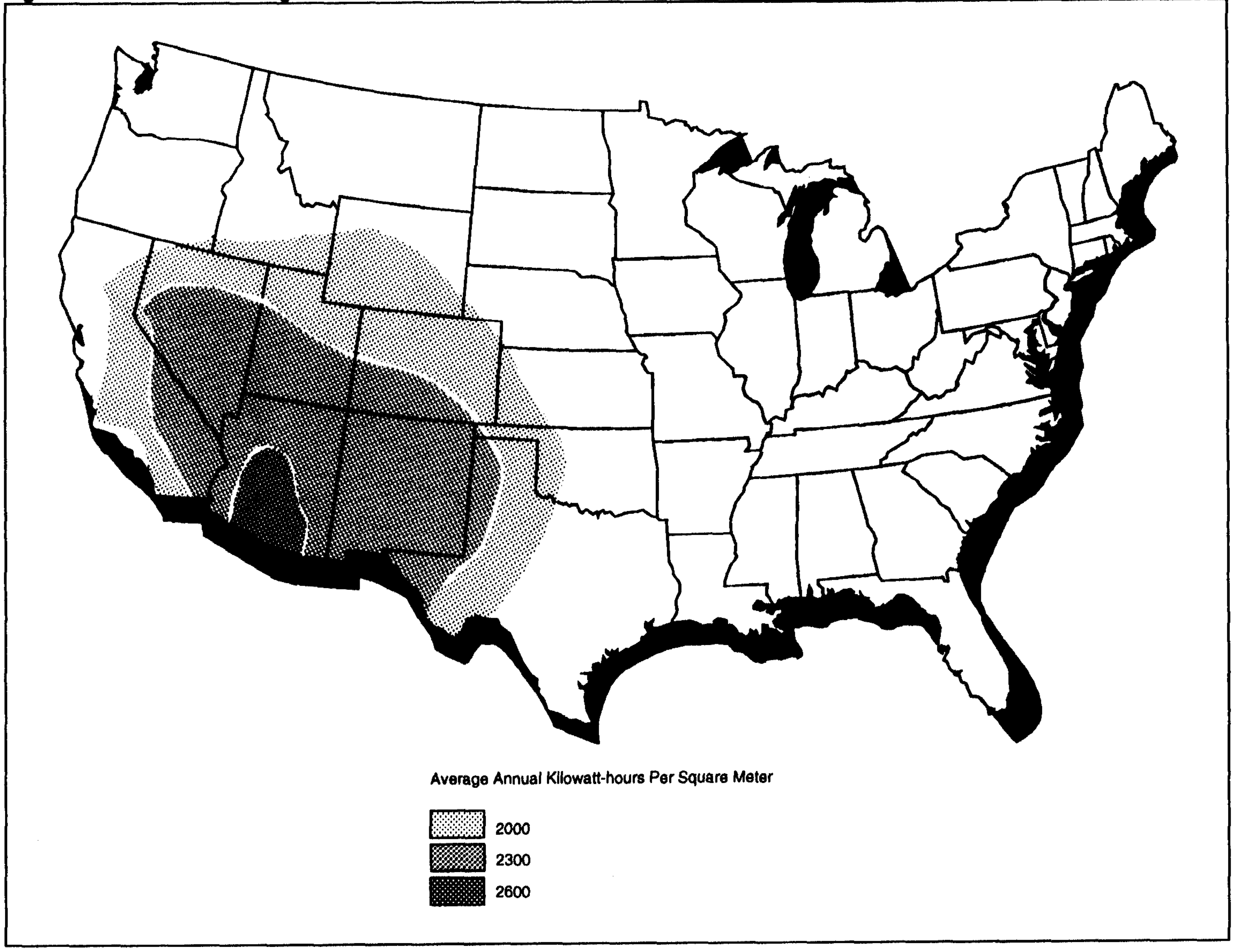
Figure 2.1: Areas With the Highest Wind Potential



Note: The Great Plains states extending from North Dakota and Montana down to New Mexico have much greater wind generation potential than the few California sites developed to date. The ability to back up wind-powered generation with hydropower makes the Northwest promising as well.

Source: Electric Power Research Institute.

Figure 2.2: Areas With the Highest Solar Potential



Note: The desert regions of the United States have the greatest potential for significant development of solar technologies, although photovoltaics can be cost-effective for remote low-power applications in virtually all parts of the country.

Source: Electric Power Research Institute.

Resources Permit Only Intermittent Electricity Production

Wind and solar energy are intermittent power sources, generally producing electricity only when the wind blows or the sun shines. This limitation makes them less attractive to utility companies, which generally prefer power sources to be dispatchable (that is, able to be turned on and used whenever needed). In addition, the time of peak availability of wind and solar resources in a given location may not coincide with the time of the utility's peak demand, foreclosing even the limited potential "peaking" market.

It is important to note that no power source is totally dispatchable all of the time. Virtually all power plants are periodically shut down for planned repairs and maintenance and are also subject to temporary emergency shutdowns. Nuclear power plants must be periodically shut down for refueling. Even hydropower is vulnerable to droughts, and fossil fuel plants are vulnerable to fuel supply interruptions. However, each of these sources are generally more dispatchable than wind- and solar-powered facilities.

Intermittent resources would be more attractive to utilities if cost-effective methods for storing electricity existed. Storage methods such as batteries and compressed air are currently being explored; in the longer term, the use of superconducting magnetic energy storage, or hydrogen as an energy storage medium, have potential.

Locations May Pose Siting And/or Transmission Problems

Electric generating facilities for wind and solar energy must be located at specific sites to maximize the amount of electricity generated; however, siting or transmission constraints may prevent this. For example, many good wind energy sites are on ridges or mountain passes at locations that pose siting and permitting difficulties, such as restrictions from land use regulations, aesthetic objections, bird kills, and harsh weather conditions. The siting and permitting process can take years, including at least a year for completing detailed plans for the project.

In addition, transmitting power from good resource sites to population centers where need is greatest often poses problems. For example, most good wind sites in the Northwest are east of the Cascade Mountains, but the major population centers are west of the mountains, and the existing transmission lines that cross the mountains are already heavily used. A similar constraint exists in transmitting power from potential wind sites in southern Wyoming to population centers in Colorado. Large wind resources in Montana and North Dakota are even further from major electricity markets. Likewise, the optimum sites for solar thermal plants stretch across the Southwest, but many are in low population areas, and transmission needs hinder power delivery from these sites to distant demand centers.

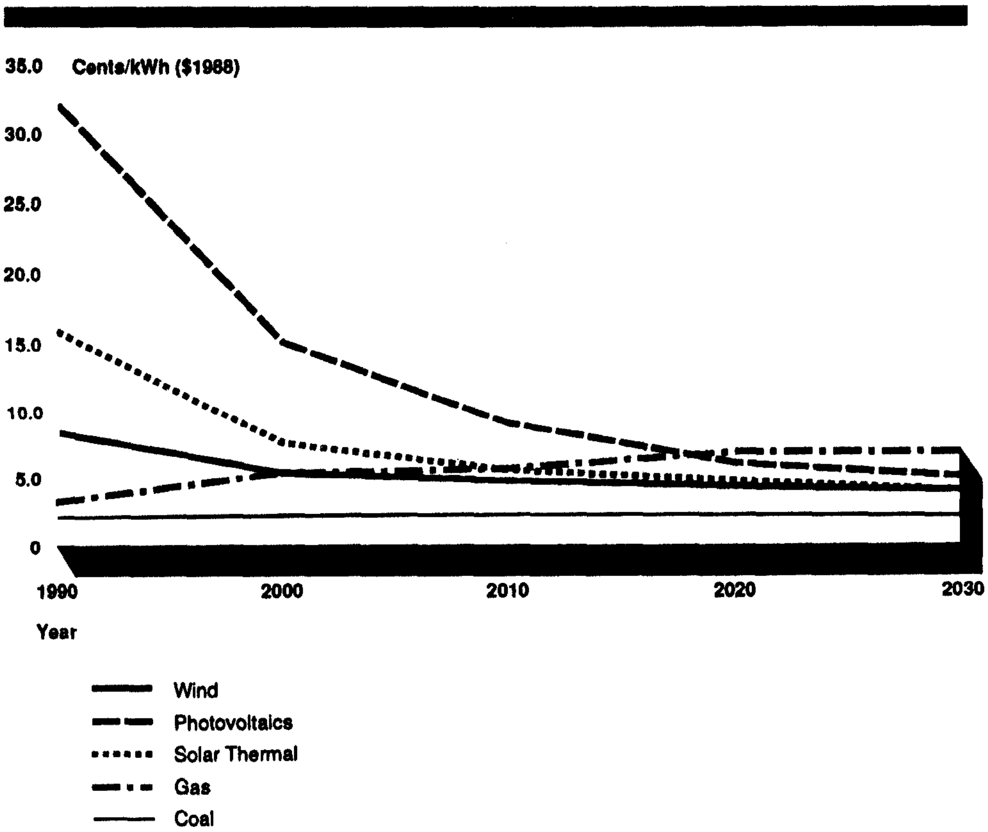
In Current Market, Renewable Energy Technologies Generally Cost More Than Alternatives

In today's bulk energy market, wind, photovoltaic, and solar thermal technologies generally cannot compete with the low cost of fossil fuel technologies. For example, the average cost of electricity generated from natural gas is currently about 4 cents/kWh, compared with 5 to 9 cents for electricity generated from wind, 9 to 10 cents for solar thermal trough technology, and 30 to 40 cents for photovoltaics. Because the costs of generating electricity vary throughout the country, the higher cost of renewable technologies poses more of a barrier to their adoption in some regions than in others.

Wind and Solar Technologies Are in Relatively Early Development Stages

In large part, the market costs of wind, photovoltaic, and solar thermal technologies are high because they are relatively new and have not reached their potential in terms of technical evolution and economies of scale. Under existing conditions and policies, the cost of electricity from these sources is expected to drop over time (see fig. 2.3). Currently, however, they are generally a higher cost investment for utilities than fossil fuel power sources.

Figure 2.3: Projected Levelized Costs of Various Energy Sources

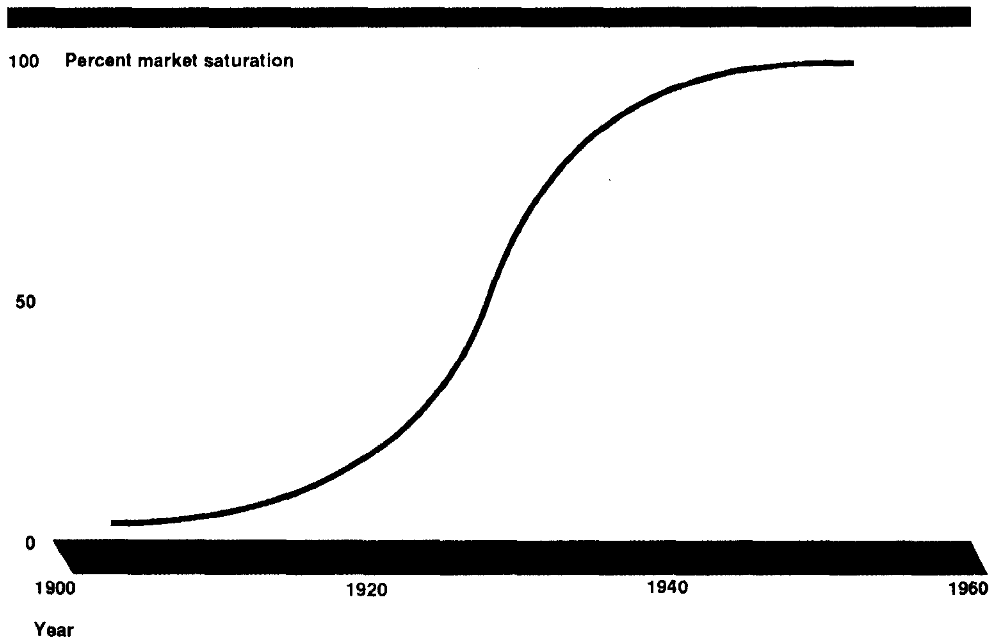


Source: Department of Energy.

Major technologies require a significant amount of time to be diffused through the economy—15 to 20 years on the average. Technologies for generating electricity from fossil fuels took over 50 years to evolve to maturity. Fossil fuel technologies are considered mature technologies because most efficiencies have been exhausted and generation costs are now closely tied to fuel prices.

In contrast, wind, photovoltaic, and solar thermal technologies are still in the incubation stages. Researchers have found that, as technologies evolve, they follow a pattern of market saturation that can be graphically represented by an "S"-shaped curve (see fig. 2.4). In the early stages, considerable outlays of funds and entrepreneurial effort are required; only after a fair amount of the market has been saturated can the technology benefit from economies of scale in production and competition among suppliers of component parts.

Figure 2.4: Pattern of Market Saturation for Fossil Fuels



Sources: Shimon Awerbuch, "Innovation and Economic Development: The Case for Public Investment in Photovoltaic Technology" and Ralph C. Lenz, "Forecasting the Rate of New Technology Adoption," TF Workshop, NYNEX Corporation.

Utility Planning and Regulatory Approaches May Not Capture All Costs

Traditional resource planning methods used by utility companies generally compare various electricity supply options on the basis of their "levelized cost," which is the total cost of building and operating a generating plant over its lifetime, converted to equal annual amounts. Although integrated resource planning has begun to change the situation, traditional methods of calculating the levelized cost may not capture all the costs associated with each option. Specifically, traditional methods may not (1) incorporate the costs of environmental impacts, (2) consider the price risks associated with conventional fuels, and (3) compare precisely the varying costs of generating electricity according to exactly when and where the power is needed. As a result, the projected cost gap between electricity generated from renewable energy sources and electricity generated from more conventional sources may be greater than it would be if these factors were considered.

Environmental Impacts

Each resource option considered in the resource planning process may have associated environmental impacts. For example, while wind and solar energy technologies are generally considered to be relatively environmentally benign, they can be unsightly and can require large amounts of land. While there is wide disagreement about how these environmental costs, or "externalities," should be valued, there is general agreement that (1) the external costs should be internalized and (2) the current system is inadequate.

For example, a 1990 study prepared by the Pace University Center for Environmental Legal Studies found that while environmental costs are difficult to quantify, a crude approximation of them is closer to an accurate accounting of resource costs than is a value of zero. The study estimated that "starting point" values for environmental costs—based only on nitrogen oxide and sulfur oxide emissions not mitigated by current federal and state regulations—would add at least 1 to 6 cents/kWh to the cost of fossil fuels, while adding no more than half a cent to wind or solar technologies. In reviewing the Pace study, however, DOE questioned the figures and concluded that specific values for the costs and benefits of health and environmental impacts should be determined on a site-specific basis.

In July 1990, the National Association of Regulatory Utility Commissioners (NARUC) reported that only 17 of the 51 state regulatory commissions had adopted explicit rules directing that environmental impacts be incorporated through various means unique to each state; in some cases, such rules applied only when comparing generating resource additions with measures to reduce electricity demand.[1] Another seven commissions were developing approaches but had not yet implemented any rules. (As of September 1992, one of these seven—Iowa—had implemented rules.) The remaining 27 state regulatory commissions had not taken any action toward formalizing requirements to consider environmental impacts.

Fuel Price Risks

Traditional utility planning and regulatory methods may emphasize the risks of investing in capital-intensive projects while minimizing future fuel price risk. As a result, wind, photovoltaic, and solar thermal resources, which have high capital costs and zero fuel costs, may be at a disadvantage

[1]See Electricity Supply: Utility Demand-Side Management Programs Can Reduce Electricity Use (GAO/RCED-92-13, Oct. 31, 1991).

compared with fossil fuel projects, which have lower capital costs but higher and unpredictable fuel costs. Table 2.1 shows a comparison of these costs developed by the California Energy Commission.

Traditional planning and regulatory processes place considerable risk on capital-intensive projects. Typically, regulated utilities request permission to recover, through retail electricity prices, the costs of a generating plant after it is built. Because regulators may decide, for a variety of reasons, that the project was an imprudent expenditure, they may not allow the utility to fully recover the cost. Thus, regulated utilities tend to view capital-intensive projects as risky.

Table 2.1: Comparison of Levelized Costs of Electricity for Various Energy Sources (cents/kWh)

Energy technology[a]	Capital costs	Fuel costs	Operating and maintenance costs	Total[b]
Coal (1995)	1.2-3.1	2.8-3.3	0.4-0.6	4.5-7.0
Natural gas (1995)	0.8-1.5	3.8-4.3	0.2-0.3	4.9-6.1
Wind (1995)	3.2-5.8	0.0	1.5	4.7-7.2
Photovoltaics (2000)	8.3-16.2	0.0	0.1-0.2	8.4-16.4
Solar thermal central receiver (2000)	3.0-4.6	0.0	2.5	5.6-7.0

[a]Costs for each technology are for planning purposes and thus are projected for the year provided in parentheses.

[b]Some totals do not add up due to rounding.

Source: California Energy Commission, Energy Technology Status Report, Appendix E (June 1991).

In contrast, traditional utility planning and regulatory processes minimize fuel price risk. Fuel costs can be highly unpredictable; for example, history has shown natural gas prices have fluctuated widely. In addition, fossil fuels such as coal bear the risk that future environmental regulation may increase the cost of fossil-fueled electricity generation. While future fossil fuel costs are therefore uncertain, most utilities are allowed to pass fuel price increases on to ratepayers through automatic fuel adjustment mechanisms.

There is increasing interest among utilities and state regulators about changing how risk is evaluated. Some have proposed using different discount rates to evaluate the cost of capital for different technologies. Others have emphasized diversification, in order to obtain a "portfolio" of various generating resources and thus minimize the risks associated with any one fuel or technology.

Cost Comparisons

Utilities typically compare average production costs across their entire grid (rather than at a specific location) when evaluating alternative energy sources. Because the marginal cost of producing energy can vary widely by location and over time, identifying precisely when and where on the grid the additional energy is needed can provide a more accurate cost comparison among different options.

For example, the marginal cost of energy during periods of highest usage, or "peak demand," can be much higher than the average cost of energy. A 1990 study estimated that for the New England Power Pool, peak power costs ranged from 37 to 52 cents/kWh, while average energy costs were about 10 cents/kWh.[2] A report by the California Energy Commission also showed significant although less dramatic differentials in that state. The study calculated that peaking costs ranged from 12.5 to 15.6 cents/kWh, while baseload costs ranged from 4.4 to 5.0 cents/kWh.[3]

In addition, the marginal cost of adding energy can be much higher in some locations than others if larger capacity transmission lines must be installed or if substations and transformers must be upgraded. Due to such distributional costs, photovoltaic systems are nearing cost-effectiveness for some grid-connected applications, and are already cost-effective for many remote (i.e., not grid-connected) applications.

Although the higher costs of meeting peak demand and of accommodating pockets of load growth on the grid are generally recognized, systematic analysis of such costs is a relatively new concept. Efforts to reevaluate traditional planning methods regarding distributional costs have been very limited. Pacific Gas & Electric (PG&E), a California utility, has done pioneering work in developing a technique for analyzing the distributive system benefits associated with use of photovoltaics for grid-enhancement. More research into this area is required before distributional costs can be accurately calculated and incorporated into the utility resource planning process.

[2]Shimon Awerbuch, "Innovation and Economic Development: The Case for Public Investment in Photovoltaic Technology," August 1990, pp. 6 and 14.

[3]California Energy Commission, Energy Technology Status Report: Report Summary, June 1990, p. 73.

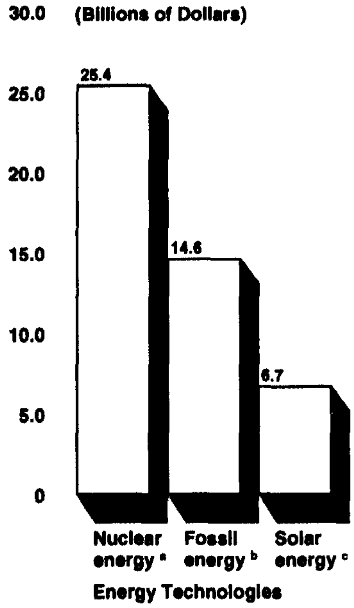
Subsidies Have Historically Benefitted Nonrenewable Energy Sources

According to a November 1992 DOE report,[4] identifying subsidies or other government policies that affect energy markets is difficult, as is quantifying their impacts. Still, government has consistently used various means to "tilt the playing field" to favor certain energy producers or consumers over others. The cost gap between renewable-powered and fossil-fuel electricity generation may also reflect, in part, the effects of research and development and tax policies that have historically been more directed toward conventional, nonrenewable energy sources.

Research and Development

As illustrated in figure 2.5 below, over the past 20 years, DOE has invested more than twice as much into the development of fossil fuels, and nearly four times as much into the development of nuclear energy, than it has invested in research and development of solar energy technologies.

Figure 2.5: DOE's Energy Supply R&D Funding, Fiscal Years 1973 to 1992
(Constant 1992 Dollars)



[a]Excludes fusion and nuclear waste R&D.

[b]Includes Clean Coal Technology program.

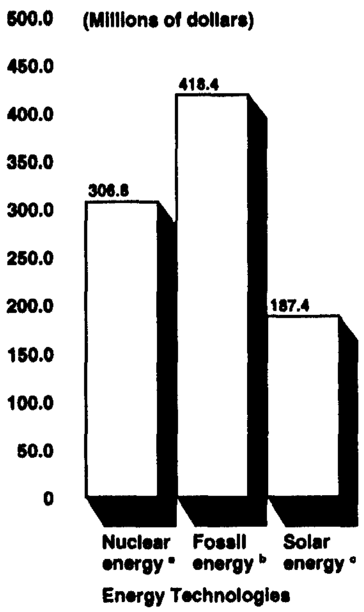
[c]Includes wind; also includes $705 million for biofuel and ocean energy technologies and related program direction and support.

Source: Congressional Research Service.

[4]Energy Information Administration, Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets, Report No. SR/EMEU/92-02, November 1992.

Although fossil fuel and certain nuclear energy technologies are considered mature and are currently in widespread use by utilities throughout the country, they still receive a greater share of DOE's research and development funding than the emerging solar energy technologies, as reflected in the funding levels for fiscal year 1993. (See fig. 2.6.)

Figure 2.6: DOE's Energy Supply R&D Funding, Fiscal Year 1993



[a]Excludes fusion and nuclear waste R&D.

[b]Includes Clean Coal Technology program.

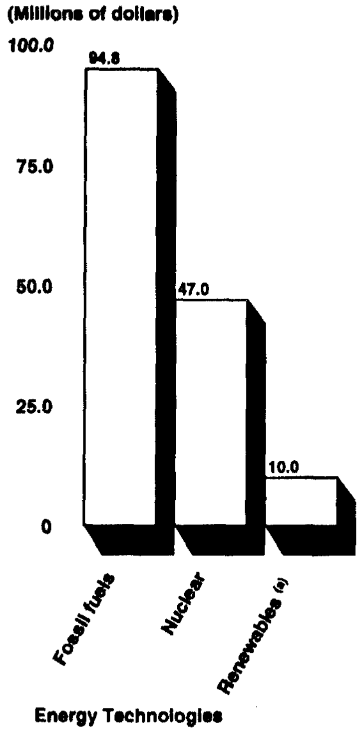
[c]Includes wind; also includes $49.4 million for biofuel and ocean energy technologies and related program direction and support.

Source: Department of Energy.

As with DOE, the Electric Power Research Institute (EPRI)[5] spends a far greater share of its research money on conventional energy sources than on renewables (see fig. 2.7). Decisions as to how EPRI allocates its research dollars are determined by a committee representing its 700 member utilities, many of whom are more interested in conventional rather than renewable-powered generation at this time.

[5]Established in 1973, EPRI is a large research organization funded by member utilities. The organization's work covers a wide range of technologies related to the generation, delivery, and use of electricity.

Figure 2.7: EPRI's 1992 Energy Supply R&D Budget



[a]Includes wind, solar, and biomass projects.

Source: EPRI.

Tax Policies

Until the 1970s, federal energy tax policy was focused on promoting oil and gas at the expense of alternative energy resources. There were two major provisions which embodied this policy. The first provision, introduced in 1918, allowed companies to expense intangible drilling costs and abandonment losses. The second provision, introduced in 1926, permitted use of the percentage depletion allowance to stimulate exploration of new reserves. Together these two tax subsidies have been worth billions of dollars to the oil and gas industry. For example, in 1975 alone the federal revenue loss resulting from these two provisions was an estimated $3 billion.

As noted in chapter 1, tax incentives were enacted in the late 1970s for alternative energy sources such as wind and solar projects. Also, new environmental taxes were imposed on oil and gas in 1978. According to the author of a Congressional Research Service report on energy tax issues[6] these taxes have mitigated the impact of the subsidies to a large extent, and since 1990, the oil and gas industries may have paid a net tax while alternatives may have enjoyed a net tax subsidy. The Energy Policy Act of 1992 calls for DOE to determine if conventional taxation and rate-making procedures result in economic barriers to, or incentives for, renewable energy use compared with the use of conventional energy sources.

Tax policies at the state and local level also affect electricity generation costs. Sales and property taxes can have a disproportionately greater impact on renewable projects which are capital intensive. A study that examined the tax burden in California found that a solar thermal plant without a property tax exemption would pay almost four times more in state and local taxes than a comparably-sized plant fueled by natural gas (see table 2.2).

Table 2.2: Comparison of California State and Local Taxes Paid by a Solar Plant Versus a Gas Plant

Type of tax	Gas-fired plant (80 MW)	Solar thermal plant (80 MW) with property tax exemption	Solar thermal plant (80 MW) without property tax exemption
Sales tax	$1,790,859	$6,960,937	$6,960,937
Annual property tax	532,900	83,800	2,073,800
Total property and sales tax (30-year present value)	**$6,814,459**	**$7,750,912**	**$26,510,472**

Source: Sandia National Laboratories.

Impact of Cost Barrier Varies by Region

The cost of generating electricity varies throughout the country based on a number of factors related both to supply and demand. The key supply factors are the cost and availability of fuel, which can vary significantly by region. For example, in 1991 the average cost of delivered coal was about 41 percent higher in the Northeast than it was in the western United States, while the average cost of delivered gas was about 13 percent higher in the Midwest than in the Southwest. In addition, some regions, like the Pacific Northwest, have abundant, low-cost hydropower available.

Key demand factors contributing to the variable cost of electricity are the amount of baseload and peak demand. While they tend to be large and expensive to build, baseload plants can spread fixed costs over many

[6]Congressional Research Service, A History of Federal Energy Tax Policy: Conventional As Compared to Renewable and Nonconventional Energy Resources, June 7, 1988.

hours of operation; as a result, the unit cost of electricity can be kept down. In contrast, peaking units operate only during certain times, so unit costs tend to be high. As a result, the higher the peaks, the higher the average cost of electricity. All these factors taken together result in a wide variation in the cost of electricity in the United States.

Renewable Technology Investments Are Perceived as More Risky

Even in situations where wind, photovoltaic, and solar thermal technologies are available and reach marginal competitiveness with certain fossil fuel applications, utilities may perceive investment in the renewable technologies as risky, and they may be reluctant to participate in their development. Investor-owned utilities, which generate most of the nation's electricity, must respond to several groups whose interests often conflict. Ratepayers may want clean energy but primarily want reliable service and low rates; shareholders want a good rate of return on their investment; and state regulators must balance these interests with the public interest.

Utilities can be reluctant to try anything that might be opposed by any one of these groups. They are particularly hesitant to invest in new technologies that are not "least-cost" by traditional planning methods, because state regulators could judge their expenses imprudent. Officials of several utilities told us of their reluctance to invest in renewable technologies. One utility official explained that there are no incentives for shareholders to invest in renewables: if shareholders take a risk and succeed, they gain no more reward than if they had invested in conventional sources, and if they do not succeed they are punished. An official at another utility stated that the utility is worried that, if it builds a wind or solar facility on a commercial scale and the project does not pan out, state regulators will not allow them to recover the costs.

Compounding the institutional disincentive, perceptions of "least cost" may be distorted by the lack of accurate, up-to-date information on the latest technological developments and potential applications of wind, photovoltaic, and solar thermal resources. According to NARUC, renewable energy interests are often underrepresented in the regulatory process. While various industry and trade organizations have tried to fill the gap, they do not have the funds to present a case for renewable energy at proceedings in every state, and if parties at these proceedings do not focus on renewable energy, reliable and current information is not likely to be considered. A NARUC task force concluded that the lack of information may leave utilities and state regulators influenced too much by early negative experiences when considering investment in renewables for the future.

Utilities that wish to promote the use of renewable energy for electricity, but are unwilling to risk direct investment, have two options: either treat renewable projects as research and development efforts and keep the projects small, or purchase the renewable-powered electricity from others. While each of these options generally allows a utility to pass the costs on to ratepayers with regulator approval, they do not allow any return on the investment. Utility officials raised additional concerns about these two options: (1) utilities may not have the funds to invest in expensive research and development projects and (2) relying on purchased power, rather than generating the power itself, poses another set of risks (regardless of the resources used to generate the purchased power), including reliability, cost, and financial concerns.[7]

[7]See Electricity Supply: The Effects of Competitive Power Purchases Are Not Yet Certain (GAO/RCED-90-182, Aug. 23, 1990) and Electricity Supply: Potential Effects of Amending the Public Utility Holding Company Act (GAO/RCED-92-52, Jan. 7, 1992).

Strategies to Overcome Barriers Include Both Technology and Market Development

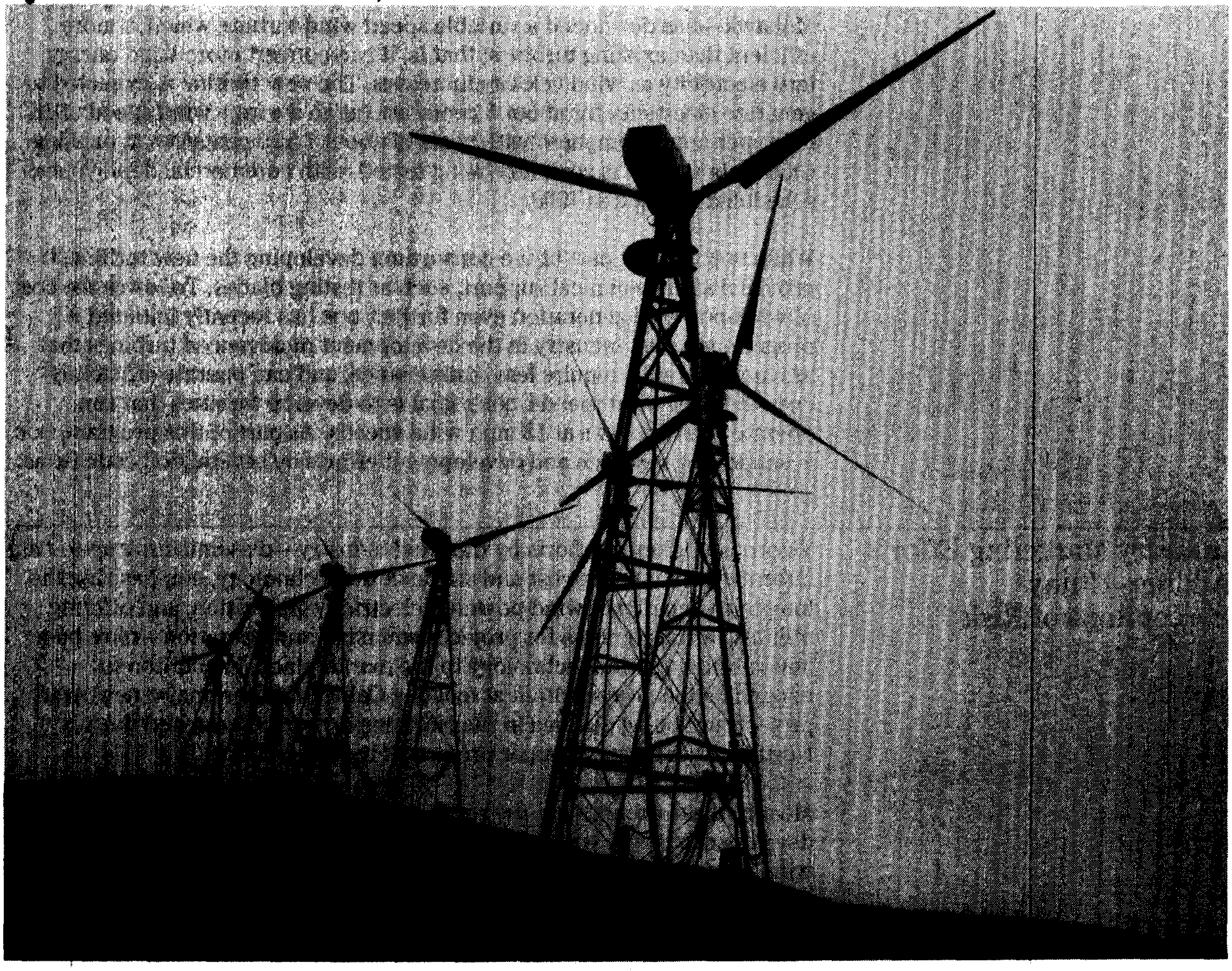
With varying degrees of success, proponents of renewable energy are beginning to overcome the barriers to increased use of wind, photovoltaics, and solar thermal technologies. The renewable energy industry, utilities, state governments, and DOE have been involved in the development and use of these technologies.

The mix of key proponents and strategies for further deployment are different for each technology, in part because of the technologies' different stages of development. Industry has taken the lead in advancing wind energy technology and, assisted by some state and federal initiatives, in working with utilities to create new markets. A new consortium of utility, industry, government, and consumer groups is working to promote greater utility use of photovoltaics. DOE is currently providing the leadership in advancing solar thermal technology toward future commercialization, through joint ventures with several utilities and companies.

Industry Efforts Are Expanding the Market for Wind-Powered Generation

While most of the wind power development to date has been at a few mountain passes in California (see fig. 3.1), major new wind projects are now being planned in several regions of the country, primarily as a result of efforts by the wind industry. California wind developers have taken the lead in advancing the technology and in creating markets in new regions. State support has also played a significant role. Potential funding assistance under a new DOE program and recent federal tax changes may make further projects financially feasible.

Figure 3.1: Windfarm at Altamont Pass, California



Note: This windfarm is comprised of about 4,200 wind turbines with an installed capacity of 420 MW.

Technology Advances Promise Lower Cost

Technology advances that enable turbines to operate at lower costs and/or lower wind speeds make wind-powered electricity generation a viable option at more sites across the country. U.S. Windpower, in consortium with EPRI and two utilities—California's PG&E and New York's Niagara Mohawk—has developed a variable speed wind turbine which is more efficient than existing turbines; that is, it can convert more wind energy into electricity as wind velocity increases. The new turbine is expected to generate electricity for about 5 cents/kWh (at an average wind speed of 16 miles per hour) compared with costs of about 7 to 9 cents/kWh at existing California sites. It is currently being tested, with commercial deployment scheduled to begin in 1993.

While DOE was not part of the consortium developing the new turbine, it provided some technical support, such as testing blades. To lower the cost of wind-powered generation even further, DOE has recently initiated a program to assist industry in the development of advanced turbines that are more durable, require less maintenance, and can operate efficiently even at lower wind speeds. DOE's goal is to develop turbines that can operate at 4 cents/kWh at 13 mph wind speeds. As part of this program, DOE is supporting research and development efforts by several domestic firms.

Industry Marketing Efforts Address Utility Perceptions of Risk

Vigorous marketing efforts by the wind industry—disseminating up-to-date information about the cost and status of the technology, emphasizing the long-term benefits of wind-powered electricity generation, and offering utilities various options for project ownership and operation—have been key to bringing wind technology to the marketplace. In addition to expanding the power output at existing California sites, major new wind projects are being planned in the Northwest, the Midwest, and the Northeast. (A listing of major projects is included in app. II.)

Most of these projects are the result of extensive efforts by wind developers to work with utilities to overcome perceptions of risk. While wind may not be a utility's cheapest option in the short run, developers emphasize that wind will likely be competitive in the long run as costs decrease and the risks associated with conventional fuels increase. For example, coal is currently plentiful and relatively cheap, but future air emission restrictions—especially on carbon dioxide—could increase its cost. In addition, although utilities may not need capacity now, many project that need will increase beyond the year 2000. Developers have pointed out that by investing now, utilities can gain experience with wind generating capacity for possible future expansion.

Offering a variety of ownership and operating options can also help utilities manage costs and risks. For example, U.S. Windpower has offered several options:

- The company can build, own, and operate the windfarms and sell the electricity to utilities. This option allows utilities to avoid investment risk by simply purchasing the electricity. This is the arrangement with PG&E at U.S. Windpower's largest facility at Altamont Pass in California.
- The company can sell completed windfarms to utilities for the utilities to operate, or for operation under contract to U.S. Windpower. This option enables utilities to own and control the facility, and allows them to earn a return on their investment. Such an arrangement is being planned by Puget Sound Power & Light in Washington.
- The company can enter into joint ventures, with the utilities providing investment capital and U.S. Windpower providing its technology and expertise. This option enables utilities to have some of the advantages of both the first two options: avoiding some risk, but also retaining some control and earning some return. Both Iowa-Illinois Gas and Electric and the Sacramento Municipal Utility District are pursuing this option.[1]

Other U.S. wind developers, such as Zond, Sea West, Cannon, and FloWind, have also built windfarms in California and are operating them. Since they operate windfarms rather than manufacture wind turbines, they are primarily interested in selling electricity to utilities. However, several are planning domestic turbine production as the market expands, and so may be able to offer utilities more options in the future.

States Have Provided Financial and Other Incentives

In nearly every location where utilities and wind developers are moving forward with wind energy projects, the state has adopted measures to encourage development of renewable energy resources. Measures providing the greatest incentives for wind development include set-asides, consideration of externalities in utility planning processes, and tax incentives.

Set-Asides

Set-asides are mandatory or recommended goals to generate a certain amount of electricity using specific resources. They are the most direct way a state can encourage increased use of renewable energy, and several states where prospective wind projects are planned have taken this

[1]The Sacramento Municipal Utility District project is planning to be the first large-scale commercial installation of the variable speed turbine. As a public utility, it is able to overcome the high capital cost of constructing a windfarm by using low interest tax-free revenue bonds, which can reduce the cost of a windfarm by 30 to 50 percent.

approach. For example, in California, 1991 legislation mandated the state's utilities to increase renewable energy resources in the utilities' resource plans. Southern California Edison, currently with 898 MW of wind capacity, has been called upon to add another 250 MW by 1998. PG&E, currently with 780 MW of wind capacity, has been called upon to add 150 MW by 1999.

Other states have enacted goals or devised incentives other than mandates. For example:

- Minnesota officials asked Northern States Power to develop a windfarm, even though cheaper coal power is readily available; at the urging of the state officials, the utility increased the size of the planned project from 10 MW to 100 MW.
- The Iowa legislature passed a law authorizing a higher-than-market rate—which the state established at 6 cents/kWh—for up to 100 MW of alternative energy statewide. A subsidary of Iowa-Illinois Gas and Electric told us this incentive is encouraging them to develop a major windfarm in that state as part of a joint venture with U.S. Windpower.
- Wisconsin regulators ordered a 10 MW windfarm to be developed, and set a goal of 811 MW of additional renewable energy development for the years 2006 to 2010. As a further incentive, the state established a high "benchmark" price for renewable energy-powered electricity—that is, it authorized utilities to pay a relatively high price when purchasing electricity generated from renewable resources. The state encourages utilities to be cost-effective by giving them a portion of the savings if they can develop or procure the renewable-powered electricity for less than the benchmark price.
- In Oregon, state regulators recommended that Portland General Electric acquire 10 to 30 MW of renewable-powered electricity; in accordance with this recommendation, the utility plans to participate in a wind project being planned by Puget Sound Power & Light.
- New York's 1992 State Energy Plan included a goal of 300 MW of renewable-powered electricity by 1998, even though the state currently has excess generating capacity. It wants state utilities to develop experience with renewables and to be ready for further deployment in the next decade, when increased capacity is needed. Niagara Mohawk, which had not planned any new capacity before the year 2000, indicated that New York's goal may hasten its plans for future wind development.

Consideration of Externalities

Several states where prospective wind projects are located have taken action to require the consideration of environmental and other externalities in their resource planning processes. Because wind and solar power plants produce no pollutants, they can appear more attractive when environmental impacts are taken into account.

For example, in the absence of federal action to cost environmental impacts, or to take any action to limit carbon dioxide emissions, some states have specified a method of quantifying the impact of environmental pollutants in resource planning. In California, state regulators have developed costs for five air pollutants, including carbon dioxide, to be factored in when considering various alternatives for new electric generating capacity. Massachusetts regulators have tried to encourage investment in renewables by developing relatively high costs for eight air pollutants, including carbon dioxide; the state also allows inclusion of other nonprice criteria (such as diversity, fuel price risk, and paying for imported fuel) in the resource selection process. In New York, to help identify economically acceptable projects to meet the goals of the 1992 State Energy Plan, the state asks utilities to value fuel source diversity, risk of fuel price increases, and the costs of impacts on air, land, and water.

In the Midwest, states have taken action to incorporate externalities into their planning processes and encourage the development of wind power because of environmental concerns over the region's reliance on coal power and a recognition that wind is a valuable indigenous resource. For example, Iowa state regulators add 0.7 cents/kWh to the cost of electricity from conventional powerplants to reflect environmental impacts and the economic cost of importing fuel from out-of-state. Wisconsin state regulators impose a $15 per ton cost of carbon dioxide emissions. Minnesota has ordered that quantitative costs for environmental impacts be established.

Tax Incentives

To address the potential tax disparities between renewable energy power plants and conventional fossil-fuel plants, or simply to provide additional incentives, some states have enacted sales and property tax exemptions for renewable energy projects or provided other counterbalancing tax incentives. Examples furnished by officials in each state were: (1) Minnesota offers both property and sales tax exemptions to developers of wind and photovoltaic projects, (2) Iowa offers a 5-year property tax exemption to renewable developers, and (3) Oregon offers a 35-percent business income tax credit to developers of renewable energy facilities.

Federal Financial Incentives May Further Expand Wind Applications

As part of a recent effort to put greater emphasis on partnerships with utilities and industry, DOE has initiated a 5-year program to help expand the domestic market for wind energy by co-funding demonstration projects with utilities. DOE estimates the program should be funded at $40 million; DOE's share has not been fully funded as of February 1993. Under the program, DOE, in cooperation with EPRI, shares the costs of demonstration projects using advanced wind turbines. According to the director of DOE's wind program division, projects using wind turbines currently being marketed—such as U.S. Windpower's variable speed turbine—can qualify for the program, as can projects testing new technologies.

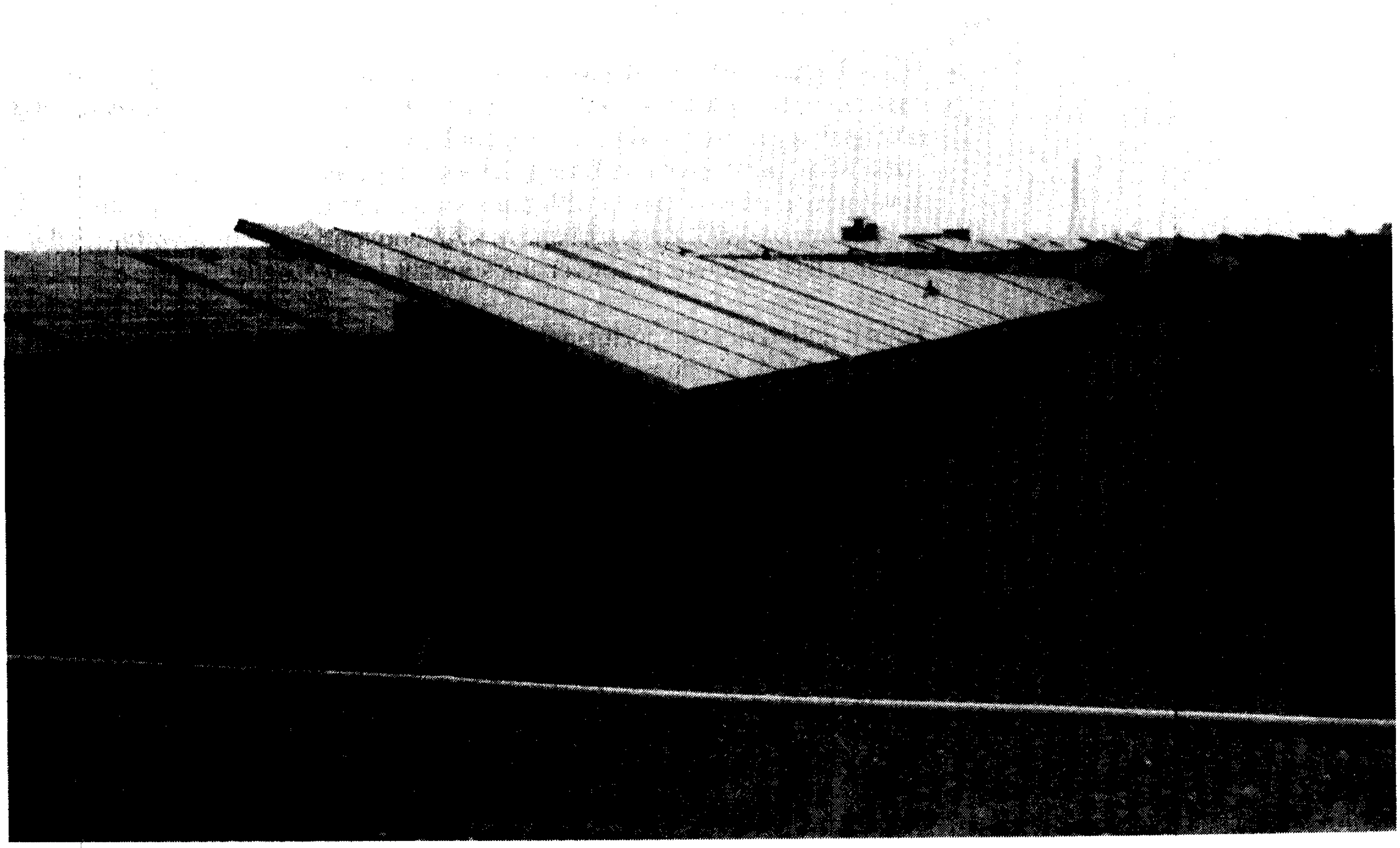
DOE's program is a commercialization effort, designed to encourage utilities contemplating wind projects but worried about the cost to go ahead with them. By giving the utilities experience in dealing with siting and permitting issues, such projects can help expand the market for wind-powered generation.

In addition, the Energy Policy Act of 1992 provides for a 10-year federal production tax credit for alternative energy producers. Developers and utilities contemplating wind projects told us that, by effectively lowering costs, the tax credit would play a significant role in making wind a competitive power source, even though some cannot take advantage of the tax credits for the first three years due to other tax provisions.

Utility-Industry-Government Consortium Is Promoting Photovoltaics

DOE and industry groups have several efforts underway to lower costs by advancing photovoltaic technology. In addition, as a result of a December 1991 conference in Tucson, Arizona, a consortium of photovoltaic industry, utility, and state organizations has launched several efforts to expand utilities' use of photovoltaics. The strategy involves lowering the cost of photovoltaics by opening up new markets and aggressively marketing applications that are already cost-effective. (See fig. 3.2)

Figure 3.2: Photovoltaic Array Near Sacramento, California



Note: This photovoltaic array, owned and operated by the Sacramento Municipal Utility District, has a generating capacity of 2 MW.

Technology Advances May Lower Costs

The installed cost of a photovoltaic generating station is currently about $9000 for each kilowatt of generating capacity, resulting in electricity that costs 30 to 40 cents/kWh. In order to be cost effective for most grid-connected applications, the installed cost must be reduced to about $3000/kW (although certain high-value applications, such as grid enhancement, may be cost-effective at $6000/kW). To advance photovoltaic technology and lower costs, industry and government efforts include developing new, less-expensive technologies; testing photovoltaic systems in a utility setting; and improving production processes.

Several initiatives to develop new lower-cost photovoltaic technologies are underway. For example:

- Texas Instruments is developing a new spherical cell technology which uses cheaper materials. Southern California Edison is a major investor and is targeting the cost of this new technology at $2000/kW.
- DOE's National Renewable Energy Laboratory has research and development subcontracts with nine companies developing thin-film technology, which is less expensive than conventional photovoltaic cells, but also less efficient in converting sunlight to electricity.

To test and verify the performance of photovoltaic products in a utility setting, PG&E is leading a joint effort called "Photovoltaics for Utility Scale Applications" (PVUSA). Participating in the project are eight utility companies, EPRI, the California Energy Commission, the New York Energy Research and Development Authority, the Department of Defense, and DOE, which is providing 50 percent funding. The project has identified potential problems faced by photovoltaic project developers, including gearing up to commercial scale production, meeting delivery schedules, and providing trustworthy balance-of-system equipment.

To improve the production processes of existing technology, DOE in 1990 initiated a cost-sharing partnership with industry called the "Photovoltaic Manufacturing Technology Initiative" (PV-MaT). Under this program, DOE will provide an estimated $55 million over 4 years to at least seven U.S. photovoltaic manufacturers. Siemens Solar, a major photovoltaic manufacturer, projects that it can lower the costs of its existing single crystal solar cell technology from the current cost of $9000/kW to $6000/kW through a combination of production improvements and increased production.

Utility Group Aims to Expand Market

Participants at the Tucson meeting concluded that lower costs would result from large-scale purchases by utilities, which would enable industry to scale up production and achieve better economies of scale. In October 1992, several Tucson participants—including 13 utilities, 3 utility trade associations, and EPRI—announced the formation of the Utility Photovoltaic Group (UPVG). The group's 5-year mission is to provide market assurance to photovoltaic suppliers through high-volume purchases that will lead to greater manufacturing economies and, hence, lower costs for even wider use of the technology.

UPVG, which hopes to expand to 80 utility members by the end of 1993, plans market promotion of cost-effective nongrid connected applications as well as high value grid-connected applications that will become more cost-effective as photovoltaic costs decrease.

Identifying Cost-Effective Non-Grid Applications

Many cost-effective non-grid connected photovoltaic applications have been identified, and a growing number installed by utilities, states, and federal agencies (see app. II). Examples include tower beacons, warning sirens, microwave relay stations, meteorological instruments, and remote lighting and water pumping. UPVG believes that disseminating information about these cost-effective "niche markets" can significantly expand the market for photovoltaics.

Only a small fraction of the estimated potential market for cost-effective photovoltaic applications has been tapped. EPRI estimates that only 200 of the nation's 3,200 utilities are using any photovoltaic applications, and many of these are just getting started. EPRI estimates the total U.S. market potential of such applications to be about 100 MW, using existing technology.

The UPVG is working to tap this potential through more effective information dissemination. Three major trade associations—the Edison Electric Institute (EEI), representing investor-owned utilities; the American Public Power Association, representing municipal and other public utilities; and the National Rural Electric Cooperative Association, representing cooperatively-owned utilities—and EPRI are disseminating information on photovoltaic applications to their member utilities. For example, in May 1992, EEI and PG&E officials made a presentation on photovoltaic applications to 150 transmission managers of major utilities.

Identifying High Value Grid-connected Applications

According to UPVG, the greatest potential for expanding photovoltaic markets and reducing costs is development of high value grid-connected applications. Such applications include distributed power generation to provide grid support, as well as reducing peak demand by installing photovoltaics on commercial or residential buildings. UPVG plans to assess the market for such applications at various cost ranges. An EPRI study, which was due for completion in late 1992, will be the first step in evaluating the national market potential of these photovoltaic applications.

Several initiatives to develop high value grid-connected projects are underway. For example, PG&E, a founding member of UPVG, gathered and analyzed extensive data to identify a high value application on its grid. Meeting demand for more power at a substation located in Kerman, California, would traditionally require improvements such as upgrading transformers and installing larger capacity transmission lines. Instead, the costs of these improvements were avoided by installing a photovoltaic power source. Several utilities are currently considering similar projects (see app. II).

Many utilities have expressed interest in rooftop photovoltaic applications, once costs come down. According to EPRI and PG&E officials, rooftop photovoltaics on commercial buildings will be the next cost-effective grid-connected application, because commercial building electricity demand (driven by lighting and air-conditioning needs) typically coincides with peak sunlight hours.

In the first major multi-year initiative by a utility, the Sacramento Municipal Utility District (SMUD) recently announced a commitment to procure 700 kW of photovoltaic capacity for grid-connected projects in 1993, 1 MW of capacity in 1994, and escalating purchases in years thereafter.[2] UPVG's goal is to encourage other utilities to assess their high-value application sites and make similar commitments.

Group Is Addressing Regulatory Barriers

Most current grid-connected photovoltaic projects have been treated as utility research and development expenditures. As such, they have not been subject to the "least cost" criteria of traditional utility planning and regulatory methods. However, in order for photovoltaic projects to compete in the future, the Tucson meeting participants concluded that (1) state regulatory structures need to be adjusted to capture the full costs and benefits of each power supply option, and (2) IRP processes have to be broadened, especially with respect to comparing costs based on precisely when and where electricity is needed.

As a result, the Tucson meeting participants have launched a coordinated effort to form state working groups, composed of regulatory, energy, and consumer agency representatives, to address planning and regulatory barriers within each state. As of October 1992, working groups were functioning in Arizona, California, Colorado, Delaware, Massachusetts,

[2]SMUD's 1993 request for proposals for 700 kW includes 200 kW for a Kerman-like grid enhancement application and 500 kW for rooftop systems.

New York, North Carolina, and Ohio. DOE's National Renewable Energy Laboratory has provided funding for an executive coordinator and for disseminating a comprehensive photovoltaic handbook to state regulators, major investor-owned utilities, state energy offices, and consumer groups.

States Provide Other Support

As is the case for wind energy systems, several states have provided information or otherwise supported photovoltaic projects. For example,

- Colorado and Arizona regulators have called on their utilities to provide customers with information on photovoltaics as an alternative to grid extensions.
- The Minnesota state energy office requested state agencies to identify cost-effective photovoltaic applications. So far nearly 6,000 applications have been identified.
- The Colorado Office of Energy Conservation helps identify photovoltaic applications and conducts photovoltaic training programs.
- The Arizona state energy office is working with utilities and state agencies to provide information on cost-effective photovoltaic applications.
- The Virginia state energy office conducted a workshop for all state agencies on photovoltaic and solar heating demonstration projects, and is assisting four agencies to set up photovoltaic projects.

DOE Has Assumed Leadership for Developing Solar Thermal Technology

Most solar thermal electricity generated to date has been from nine parabolic trough plants in southern California. Although the plants continue to operate, the company which built them (Luz International, Ltd.) has gone bankrupt. However, several industries and utilities are working with DOE to develop central receiver and dish stirling technologies (see fig. 3.3). DOE believes these technologies are potentially more cost-effective than troughs, and the agency has assumed a leadership role in promoting their development using the joint venture approach. State support is also encouraging utility involvement in these projects.

Figure 3.3: Research and Testing of Solar Thermal Systems

Note: This solar thermal central receiver test facility, located south of Albuquerque, New Mexico, is operated by DOE's Sandia National Laboratory.

Source: Department of Energy.

Consortium Is Developing Central Receiver Technology

DOE and Southern California Edison (SCE) are leading a joint venture, involving 11 other utilities, industries, and organizations, to advance central receiver technology (see table 3.1). The $39 million, 10 MW demonstration project, known as "Solar Two," is located near Barstow, California. Unlike previous central receiver plants, which used water or oil as the "working fluid" (the fluid that is heated by the sun and is then used to produce steam), Solar Two employs molten salt. The project is designed to test the salt's heat storage capabilities, which may enable the plant to provide electricity for up to 4 hours after sunset. The ability to generate electricity after sunset would be beneficial to a utility whose peak demand extends into the early evening hours.

Table 3.1: Solar Two Consortium Members and Contributions

Consortium member	Amount of contribution (in millions)
DOE (to provide 50-percent funding)	$19.50
Utilities	
Southern California Edison	6.00
Sacramento Municipal Utility District	1.25
Pacific Gas & Electric Company	1.00
Los Angeles Department of Water & Power	1.00
PacificCorp	1.00
Idaho Power Company	1.00
Arizona Public Service Company-Salt River Project	1.00
Others	
Supplier's Consortium	1.50
Bechtel Corporation	1.50
Electric Power & Research Institute	1.00
South Coast Air Quality Management District—City of Pasedena	0.20
California Energy Commission (tentative)	1.00
Subtotal	**$17.45[a]**

[a]An additional $2.05 million is needed to finance the $39 million project.

The project also includes efforts to lower operating costs and promote future commercialization of central receiver technology. Operation and maintenance costs currently account for about one-third of the projected price of electricity generated by central receivers. DOE's Sandia National Laboratory has undertaken a study which may identify ways of reducing the operating and maintenance costs of central receiver plants.

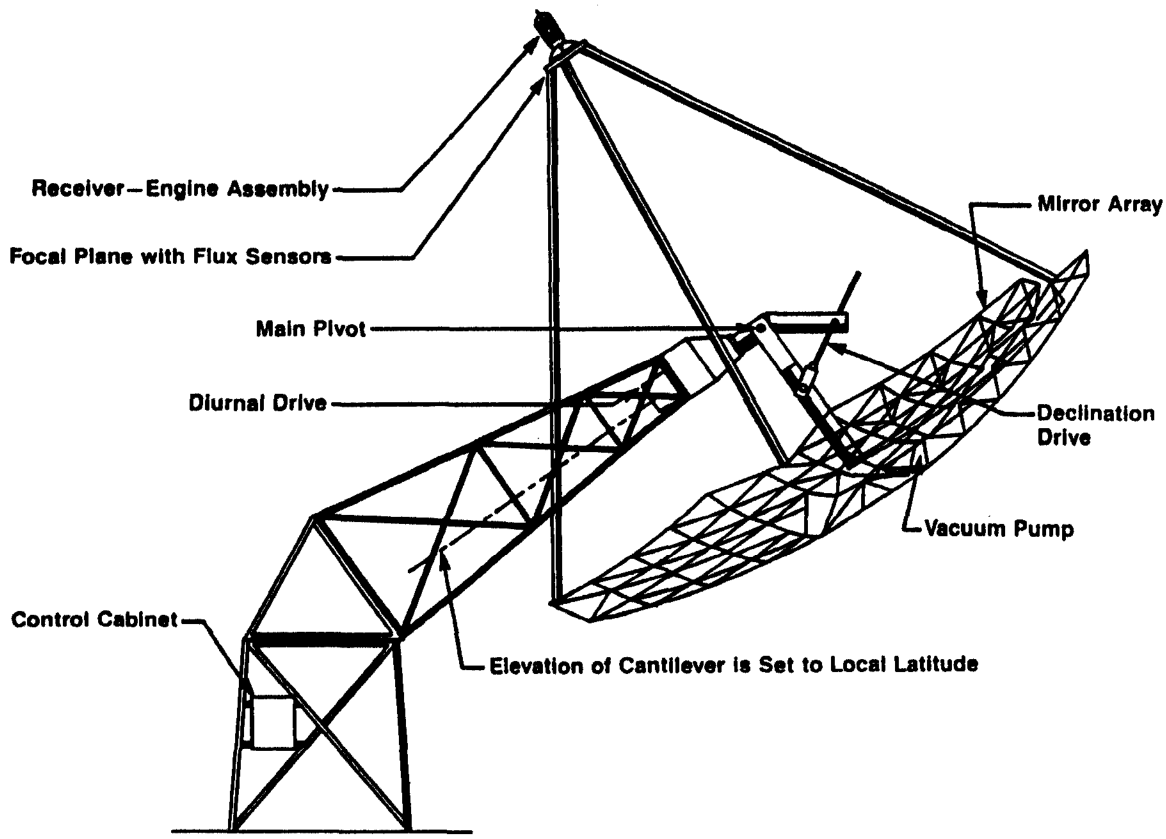
In addition, the project has contracted with an engineering and construction firm, Bechtel Corporation, to develop a plan for overcoming commercialization barriers. Bechtel's plan proposes establishing solar central receiver power plants as a commercially available technology for bulk electricity generation in three phases: (1) testing the molten salt technology, (2) constructing at least three plants with generating capacity of 100 megawatts, and (3) marketing 100- to 200-megawatt power plants in the United States and abroad by the year 2000.

DOE Joint Ventures Are Developing Dish Stirling Technology

Dish stirling systems focus the sun's radiation onto a stirling engine, which converts thermal energy directly to electricity (see fig. 3.4). According to an official of Cummins Power Generation, a company involved in developing dish stirling technology, the technology can be used for a broad range of electricity requirements, especially for needs between 5 kW and 100 MW. Needs less than 5 kW might better be served by a photovoltaic system, while needs in excess of 100 MW may be more economically met by a central receiver station.

At the present stage of the technology's development, cost remains the key barrier. Although costs have been estimated to be as low as 7 cents/kWh in a utility-scale setting, electricity generated from a dish stirling system in remote applications currently costs up to 20 cents/kWh. DOE has initiated two joint venture projects, both in early development stages, designed to advance dish stirling technology and lower its cost. The first is to test a small (7.5 kW) system at different locations around the country under differing climate conditions. The second is to develop and test a larger (25 kW) system.

Figure 3.4: Diagram of the Dish Stirling System



Note: In this dish/Stirling system, a free piston-stirling engine works in combination with a linear alternator to convert thermal energy into electrical energy. A microcomputer controls normal startups and shutdowns, and keeps the solar concentrators, which move in two axes, pointed directly at the sun.

Source: Cummins Power Generation, Inc.

DOE and Cummins are sharing the $14 million cost of developing and testing the 7.5 kW system. According to Cummins, the dish/ Stirling technology (1) offers the same environmental benefits as any renewable technology, (2) has the potential to be more energy efficient than other solar thermal technologies, (3) is modular, allowing flexibility in both planning and maintenance, and (4) can be used in a solar-natural gas hybrid system.

The project's goals include developing better manufacturing techniques and more durable elements for the solar concentrator, and reducing manufacturing costs. From mid-1991 to mid-1992, the prototype was developed and installed at two sites: the Pennsylvania Energy Office and Cummins dish/Stirling Development Center in Austin, Texas. Through 1994, additional units will be tested at Sandia National Labs in New Mexico and at host facilities in Georgia, California, and Arizona.

A 25 kW dish/Stirling generator was defined by industry as the size required for utility scale applications; it is also the maximum practical size for a dish. In June 1992, DOE issued a request-for-proposals to develop a 25 kW system through a joint venture approach, requiring the industry to assure test sites and obtain utility commitment for the project. Final selections will be made in late spring 1993.

State Support Encourages Utility Involvement

State support has helped encourage utilities to participate in the central receiver consortium and dish/Stirling joint ventures. For example, some state regulators have considered allowing private utilities participating in the projects to pass the costs on to ratepayers. In addition, state entities have provided direct financial support to the projects. For example, the city of Pasadena and the California Energy Commission are members of the "Solar Two" central receiver project consortium. Both Pennsylvania and California are hosting test sites for the 5 kW dish stirling joint venture at state facilities. Other support, such as incorporating environmental externalities into the utility resource planning and regulatory process and adopting tax incentives for renewable energy, give utilities encouragement that solar thermal technologies will become viable options in the future.

Opportunities for Further DOE Efforts to Encourage Wind and Solar Energy Technologies

The federal government has played an important role in the development of renewable energy, and it is participating in many of the market expansion initiatives for wind and solar technologies. However, if increasing the contribution that wind and solar energy make to our future energy supply becomes a national priority, more could be done.

Our discussions with utility, industry, and state and federal officials revealed several specific areas in which action by DOE could benefit the advancement of wind, photovoltaic, and solar thermal technologies. These include (1) expanding DOE's research and development funding for renewable energy technologies, (2) developing methods to more accurately cost and compare resource alternatives, and (3) encouraging greater use of renewable energy by federal agencies.

DOE Research and Development Budget

DOE currently devotes about 4 percent of its overall energy supply research and development budget to renewable energy resources. While utility, industry, and state officials expressed strong support for DOE's recent efforts to work in partnership with them by cost-sharing many of its research and development programs, many stated that allocating a greater share of its research budget to renewables would help advance renewable energy technologies.[1] For example, DOE is considering a cost-sharing program whereby it would subsidize utility investment in high-value grid-connected photovoltaic projects at the rate of perhaps $2000 per kW, with a steady phase out of the subsidy over 5 years. With such cost-sharing, the Sacramento Municipal Utility District estimated its total purchase of high-value photovoltaics could be as high as 100 MW by the year 2000, compared with an estimate of 35 MW without DOE's support.

In a previous GAO report, we concluded that weak federal research and development support substantially limited the development of renewable technologies because the private sector could not compensate for DOE's reductions.[2] Projections contained in a March 1990 white paper prepared by DOE's national laboratories estimated that if federal research and development funds were increased by $3 billion over the next two decades, the contribution of renewables to the national energy supply would nearly double by the year 2030, primarily as a result of technological improvements that private industry would otherwise pursue

[1]Also, utilities noted that they are still sometimes excluded from the partnerships. They feel that to effectively move technologies to the marketplace, utilities should always be involved.

[2]Energy R&D: Changes in Federal Funding Criteria and Industry Response (GAO/RCED-87-26, Feb. 1987), pp. 51 & 58.

independently at a much slower pace. According to recommendations prepared by a coalition of 32 energy-related organizations in March 1991, significantly increasing DOE's renewable energy research and development budget could help overcome barriers to the development of renewable energy technologies by (1) reducing up-front capital and lifecycle costs through technological and manufacturing advances, (2) transferring new technologies from the laboratory to the marketplace, and (3) validating large-scale projects on a cost-shared basis to inspire confidence by end-users and financiers.[3]

Allocating research funds entails policy decisions that frequently involve tradeoffs among policy goals, including the need for budget restraint in light of continuing federal budget deficits. However, increasing the renewable energy research and development budget need not increase DOE's overall budget, if increases are accompanied by decreased spending for research in other areas that may contribute less to policy goals. For example, as we noted in a 1992 report,[4] in preparing for DOE's fiscal year 1993 budget request, the Office of Policy, Planning and Analysis concluded that the agency's renewable energy technology programs better met National Energy Strategy goals than some other research programs, such as nuclear energy research, that have typically received higher funding levels. (DOE's fiscal year 1993 budget provides about $307 million for nuclear energy research programs—excluding nuclear fusion and nuclear waste R&D—and about $187 million for wind and solar energy.) The Office ranked 23 research program areas, representing various electricity supply and conservation efforts, on their contribution to the nation's energy supply, economic growth, environmental impact, and technological and market risk. On this basis, renewable energy technologies for electricity production were ranked fifth, while advanced nuclear technologies were ranked near the bottom.

In addition, research and development funds might be used more effectively if the geographic limitations of renewables were taken into account. Unlike conventional plants, as noted in chapter 2, powerplants using wind or solar resources must be located at specific sites to optimize the amount of electricity generated, and the availability of wind and solar energy resources varies by geographic location. DOE programs that support other energy technologies can discourage development in locations where

[3] Recommendations for the U.S. Department of Energy's Research and Development Budget for Renewable Energy Technologies FY 1992-1994 (March 13, 1991).

[4] Energy R&D: DOE's Prioritization and Budgeting Process for Renewable Energy Research (GAO/RCED-92-155, April 29, 1992)

wind or solar resources are the most promising. For example, we noted that a Nevada utility is seeking approval for a DOE-supported coal plant under the agency's clean coal technology program, even though Nevada has large solar, geothermal, and wind resources. DOE would provide $135 million for the project, an amount equal to 72 percent of the 1993 budget for the solar energy program (which funds all wind, photovoltaic, solar thermal, and biofuels projects). DOE planned to co-fund a similar coal project in Tallahassee, Florida, until voters there rejected the project in favor of greater reliance on solar energy.

Developing Methods to Cost Resource Alternatives

As discussed in chapter 2, new approaches to utility resource planning and regulation could help solar and wind technologies to better compete with traditional electricity sources. For example, because they are relatively environmentally benign resources compared with fossil fuels, renewable energy resources would benefit if utility planning and regulatory processes better incorporated the environmental impacts of resource alternatives. Consideration of other costs, such as fuel price risk and distributional costs, could also benefit renewable resources, as could consideration of the long-term benefits of investing now to develop resources that hold future promise of being clean, non-depletable, and cost competitive. Utilities and state regulators are exploring ways to incorporate these considerations into their resource planning processes, but find it very difficult to accomplish.

One of the goals of DOE's IRP program is to provide tools to assist utilities and regulators in determining appropriate methods for incorporating environmental and other externalities into the resource planning process. However, DOE has yet to develop methods to more accurately cost resource alternatives. In 1991, DOE launched a research effort with Oak Ridge National Laboratory and Resources for the Future to evaluate the costs and benefits of externalities associated with energy resources. Initial results of this research have focused on the risks associated with internalizing costs in ways that lead to economic inefficiency. In addition, one of DOE's IRP projects for fiscal year 1991 was aimed at preparing a handbook on various methods for evaluating and quantifying environmental externalities; however, controversy over the issue resulted in the project being put on hold for at least 6 months.

In addition, as also noted in chapter 2, renewable energy interests are often underrepresented in the regulatory process. Renewable energy technology companies and their trade organizations do not have the resources to present the potential for renewable energy at proceedings in every state, and they are reluctant to place themselves in an adversarial role with utilities which are their only potential customers. A more proactive DOE role in information dissemination could help ensure that accurate, up-to-date information is available to utilities and regulators and that wind and solar resources are considered equitably at proceedings during the resource planning process.

Use of Renewable Energy by Federal Agencies

DOE could more quickly promote federal agency use of wind and solar energy by giving greater priority to activities already required or underway. As discussed in chapters 1 and 3, federal agencies are either already required to, or have an opportunity to, directly utilize renewable resources under existing authorities. For example, the Federal Energy Management Program, established under the National Energy Conservation Policy Act as amended (42 U.S.C. 8201), requires DOE to apply energy conservation measures, including the use of renewable energy sources, to reduce the energy consumption of federal facilities from 1985 levels by at least 10 percent by 1995 and by at least 20 percent by 2000. Photovoltaic and dish stirling devices installed at the point of energy use could reduce the need for power to be supplied from other sources. While the Department of Defense has made some progress in identifying cost-effective photovoltaic applications for military facilities, DOE has not yet taken steps to identify similar applications for inclusion in the General Services Administration supply catalog for civilian federal agencies.

Under the 1980 Pacific Northwest Electric Power Planning and Conservation Act, as amended (16 U.S.C. 839), the BPA is authorized to cooperate with the Northwest states in developing a plan to meet the region's energy needs, with emphasis on conservation and the development of renewable resources. In addition, both BPA and the Western Area Power Administration (WAPA) have the authority to require their customer utilities to develop plans for conservation and use of renewables.[5] These two agencies provide transmission and market federal power in most of the western United States, an area rich in solar and wind resources. DOE officials stated that they are working with both Bonneville and Western to get them more involved in developing these resources. DOE

[5]WAPA, whose service area covers the western states other than the Pacific Northwest, generally does not have responsibility to meet the power needs of its customer utilities during dry years. However, as the result of a 1964 agreement, it is committed to provide power to California municipal utilities and irrigation districts even during dry years.

officials told us that they recently met with BPA officials concerning BPA's consideration of geothermal and photovoltaic energy sources.

Utilities in the Northwest told us that Bonneville's cooperation will be essential if wind energy sites are to be developed. In addition, an official from one state covered by Western that has abundant, undeveloped wind resources said that significant renewable projects would likely only result from a consortium effort initiated by Western. Most of the utilities served by Western are small and do not have the resources to develop larger-scale renewable projects on their own.

Conclusions

Wind and solar energy technologies are demonstrating the potential to contribute a greater share to the nation's electricity supply. Opportunities exist to improve or make more effective use of existing DOE programs and authorities for promoting these technologies. DOE's annual research and development resource allocations have continued to favor conventional electricity technologies, such as coal and nuclear energy, that according to the Department's own analysis show less potential for meeting National Energy Strategy goals than wind and solar energy technologies.

In the absence of methods to develop accurate life-cycle costs for comparing alternative resources, utilities and state regulators may continue to make resource decisions that do not take into account all costs, such as the costs of environmental impacts. DOE's integrated resource planning program can play a significant role in developing and promoting methods to better measure the costs of alternative resources. Because they are relatively environmentally benign, wind and solar technologies could benefit from such methods of resource comparison. These technologies could also benefit from additional efforts to promote their use by federal agencies under existing authorities and programs.

Recommendations to the Secretary of Energy

To help ensure effective use of DOE programs for encouraging wind and solar energy use, we recommend that the Secretary of Energy

- reassess DOE energy technology research and development funding for wind and solar energy technologies to ensure that it is commensurate with their potential to meet National Energy Strategy goals;
- accelerate the development of analytical tools to help utilities and regulators incorporate the costs and benefits, including environmental, of

developing and using each energy resource into the utility planning process; and

- consider assigning a higher priority to (1) identifying cost-effective applications of photovoltaics by federal agencies, and (2) efforts by the Bonneville and Western Area Power Marketing Administrations to assist customer utilities in identifying and installing renewable energy technologies where appropriate to help meet future energy needs.

States, Utilities, Organizations, and Industries Contacted

State Offices Contacted

Arizona
- Arizona Corporation Commission
- Arizona Energy Office

Arkansas
- Arkansas Public Service Commission
- Arkansas State Energy Office

California
- California Public Utilities Commission
- California Energy Commission

Colorado
- Colorado Public Utilities Commission
- Colorado State Office of Energy Conservation

Florida
- Florida Public Service Commission
- Florida Governor's Office of Community Affairs
- Florida Solar Energy Center

Georgia
- Georgia Public Service Commission
- Georgia Office of Energy Resources

Hawaii
- Hawaii Public Utilities Commission
- Hawaii Department of Business, Economic Development, and Tourism, Energy Division

Idaho
- Idaho Public Utilities Commission
- Idaho Department of Water Resources

Illinois
- Illinois Commerce Commission
- Illinois Department of Energy and Natural Resources

Iowa
- Iowa Department of Commerce, Utilities Division
- Iowa Department of Natural Resources, Energy Bureau

Kansas
- Kansas Corporation Commission (Kansas Energy Office was dissolved and merged with the Commission)

Kentucky
- Kentucky Public Service Commission

- Kentucky Natural Resources and Environmental Protection Cabinet, Division of Energy

Maine
- Maine Public Utilities Commission
- Maine Department of Economic and Community Development, Energy Conservation Division

Massachusetts
- Massachusetts Department of Public Utilities
- Massachusetts Division of Energy Resources

Minnesota
- Minnesota Public Utilities Commission
- Minnesota State Energy Office

Montana
- Montana Public Service Commission
- Montana Department of Natural Resources and Conservation

Nebraska
- Nebraska Energy Office (no state regulatory commission; all public utilities)

Nevada
- Nevada Public Service Commission
- Nevada Energy Office

New Jersey
- New Jersey Board of Public Utilities
- New Jersey Department of Environmental Protection and Energy

New Mexico
- New Mexico Public Service Commission
- New Mexico Energy, Minerals and Natural Resources Department

New York
- New York Department of Public Service
- New York State Energy Office
- New York State Energy Research and Development Authority

North Carolina
- North Carolina Utilities Commission
- North Carolina Department of Commerce, Energy Division

North Dakota
- North Dakota Public Service Commission
- North Dakota Department of Intergovernmental Assistance, State Energy Conservation Program

Oklahoma
- Oklahoma Corporation Commission
- Oklahoma Office of Cabinet Secretary of Energy
- Oklahoma Department of Commerce

Oregon	• Oregon Public Utility Commission • Oregon Department of Energy
Pennsylvania	• Pennsylvania Public Utility Commission • Pennsylvania Energy Office
South Dakota	• South Dakota Public Utilities Commission • South Dakota Governor's Energy Office
Tennessee	• Tennessee Public Service Commission • Tennessee Department of Economic and Commercial Development Energy Division
Texas	• Texas Public Utility Commission • Texas Governor's Energy Office • Texas General Land Office
Utah	• Utah Department of Commerce, Division of Public Utilities • Utah Division of Energy
Vermont	• Vermont Public Service Board • Vermont Department of Public Service
Virginia	• Virginia State Corporation Commission • Virginia Division of Energy
Washington	• Washington Utilities and Transportation Commission • Washington State Energy Office
Wisconsin	• Wisconsin Public Service Commission • Wisconsin Energy Bureau
Wyoming	• Wyoming Public Service Commission • Wyoming State Energy Office

Utilities Contacted[1]

Arizona Public Service Co. (AZ)
Austin Electric Utility Dept. (TX)
Basin Electric Power Cooperative (ND)
Central Maine Power Company (ME)

[1]States where utilities are headquartered are given in parentheses.

Eugene Water and Electric Board (OR)
Georgia Power Co. (GA)
Green Mountain Power Corporation (VT)
Hawaiian Electric Co. (HI)
Idaho Power Co. (ID)
Iowa-Illinois Gas & Electric Company (IA)
Los Angeles Dept. of Water and Power (CA)
Madison Gas & Electric (WI)
Nevada Power Co. (NV)
New England Power Co. (MA)
Niagara Mohawk Power Corporation (NY)
Northern States Power Company (MN)
Pacific Gas and Electric Company (CA)
PacifiCorp (OR)
Portland General Electric Company (OR)
Public Service Co. of Colorado (CO)
Puget Sound Power & Light (WA)
Sacramento Municipal Utility District (CA)
Salt River Project (AZ)
San Diego Gas & Electric Company (CA)
Sierra Pacific Power Company (NV)
Southern California Edison (CA)
Southwestern Public Service Co. (TX)
Tallahassee Electrical Dept. (FL)
Texas Utilities Electric Company (TX)
Virginia Electric Power Co. (VA)
Washington Public Utilities Districts Association (WA)
Wisconsin Electric Power Co. (WI)

Utility and Energy Related Organizations Contacted

American Public Power Association
American Wind Energy Association
Edison Electric Institute
Electric Power Research Institute
Energy Foundation
Hansen, McQuat & Hamrin, Inc.
Independent Energy Producers
National Association of Regulatory Utility Commissioners
National Assocation of State Utility Consumer Advocates
National Rural Electric Cooperative Association
Regulatory Assistance Project
Solar Energy Industries Association

Industries and Independent Power Producers Contacted

AT&T
Bechtel Corp.
Cummins Power Generation
Detroit Diesel Corp.
InterCoast Energy Co.
Minnesota Wind Power
Science Applications International Corp.
Sea West Energy Co.
Siemens Solar Industries
Texas Turbines Co.
Stirling Thermal Motors
U.S. Generating Co.
U.S. Windpower
Zond Systems

Major Wind and Photovoltaic Projects Planned or Underway

Wind Projects

California

- The Sacramento Municipal Utility District is planning a joint venture project with U.S. Windpower to develop 50 megawatts (MW) of wind, beginning with 5 MW in 1993.
- The Public Utilities Commission has ordered Southern California Edison to add 250 MW of wind capacity by 1998.
- The Public Utilities Commission has order Pacific Gas & Electric to add 150 MW of wind capacity by 1999.

Northwest

- Puget Sound Power & Light is negotiating with U.S. Windpower to build a 50-MW windfarm by 1996. Three other utilities (PacifiCorp, Portland General Electric, and Idaho Power Company) plan to participate in the project. Problems with obtaining site permits have not yet been resolved.
- PacifiCorp, a utility that operates in seven states, plans to install a total of 125 MW of wind power by 1996-97.
- The Bonneville Power Administration has issued a request for proposals to develop 50 MW of wind power by 1995 as part of its Resource Supply Expansion Program. Seven Washington state public utility districts have formed an organization to develop conservation and renewable energy projects, and this organization has submitted proposals in response to the Bonneville Power Administration's request.

Midwest

- Northern States Power has issued a request for proposals to develop 100 MW of wind power by 1997, with the first units in operation in 1993.
- InterCoast Energy Company, a subsidiary of Iowa-Illinois Gas & Electric, has formed a joint venture with U.S. Windpower to develop up to 250 MW of wind power. They are in the process of identifying sites and seeking other utilities to participate in the project.
- Wisconsin has ordered its utilities to come up with a plan for a 10-MW wind demonstration project by the year 2000.

Northeast

- In December 1991, the New England Power Company issued a request-for-proposals to procure up to 200,000 megawatt hours of renewable energy (referred to as the "Green RFP"). The company expects to purchase about 100,000 megawatt hours, with about half coming from a 20 MW wind facility beginning in 1995.

- Central Maine Power is negotiating with U.S. Windpower to develop 50 MW of wind power a year starting in 1994, totaling 250 MW by the end of the decade. This project is bidding on the New England Power solicitation and would sell power to other utilities in the region as well.
- Central Maine Power also has contracted with a local company, Endless Energy, to develop 15 MW of wind power by 1994.
- Green Mountain Power of Vermont has identified sites and plans to begin construction of 20 to 30 MW of wind capacity by 1995. The project will be scaled up to 50 MW if selected for the New England Power solicitation.

Photovoltaic Projects

Non-Grid Applications

- PG&E is using over 1,000 cost-effective photovoltaics application systems for its own use.
- Idaho Power Company has undertaken a $5 million, 3-year program to install and maintain photovoltaic systems for customers. It views the program as a business venture. The utility will, in effect, provide service without wire. A typical remote residential customer might pay a $160 monthly service charge—an attractive alternative when power line extensions may cost more than $20,000 per mile.
- The U.S. Coast Guard uses 10,000 photovoltaics-powered navigational aids, which operate reliably even in very harsh environments.
- The Department of Defense is planning to install several large remote systems, including a hybrid photovoltaics/diesel system on San Clemente Island that would provide 200 kW of Photovoltaics with 150 to 200 kW of diesel as backup during non-sunlight hours.

Grid-enhancement Applications

- The Sacramento Municipal Utility District plans to purchase 200 kW of photovoltaics for a substation grid-enhancement project, 400 kW of photovoltaics for residential rooftop systems, and 100 kW for one or two commercial rooftop systems in 1993.
- With DOE support, four utilities (Arizona Public Service, Salt River Project, City of Austin, and Plains Electric Generation and Transmission Cooperative) plan to identify grid-enhancement sites on their systems. Additional utilities are doing studies on their own to identify such sites.
- Southern California Edison plans 100 to 200 rooftop systems as a demonstration project by the end of 1993. It hopes that when large-scale production is implemented, 1 kW systems using Texas Instruments cells

will be able to be installed for $2,000, producing power at roughly 14 to 16 cents/kWh. According to an Edison official, it could be feasible to install such systems on 25,000 new homes a year in the utility's service territory.

- DOE is supporting a demonstration project by Niagara-Mohawk to evaluate rooftop photovoltaics on commercial buildings.
- EPA has plans to cost-share demonstration projects for rooftop photovoltaics on commercial and residential buildings for projects that are near commercial feasibility.

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