

August 1996

# FEDERAL RESEARCH

## Changes in Electricity-Related R&D Funding







United States  
General Accounting Office  
Washington, D.C. 20548

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**Resources, Community, and  
Economic Development Division**

B-272317

August 16, 1996

The Honorable George E. Brown, Jr.  
Ranking Minority Member  
Committee on Science  
House of Representatives

Dear Mr. Brown:

In fiscal year 1996, the Congress appropriated to the Department of Energy (DOE) about \$1 billion for electricity-related research and development (R&D). Along with the electric utilities, states, and manufacturers, the federal government has traditionally played a major role in this R&D. Electricity R&D includes such technologies as solar energy, fossil-fueled generating systems, and electric automobiles.

The electric utility industry is being deregulated and moving toward a more competitive market. At the same time, reductions have occurred in funding from the major sources of electricity-related R&D. Consequently, you asked us to determine (1) what changes have occurred in the amount of electricity-related R&D funding and the primary reasons for these changes and (2) what has been the impact of these changes on the types of R&D being funded. As agreed with your office, we are providing information on the impact of reducing funding for six technologies—fuel cells, coal gasification, advanced gas turbines, wind power, photovoltaics, and electricity storage—in which DOE participated. You also wanted to know, given these changes, what alternate funding sources R&D managers and others have proposed. We did not attempt to determine whether changes in funding levels or proposals for alternate funding sources were appropriate.

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## Results in Brief

DOE's 1993 appropriation for electricity-related R&D was about \$1 billion.<sup>1</sup> For fiscal year 1995, the appropriation had increased by 15 percent to \$1.3 billion. However, DOE's 1996 appropriation was reduced to about the same level as 1993. DOE's 1997 request is a 14-percent increase over its 1996 appropriation. During calendar years 1993 through 1996, however, funding by electric utilities decreased about 33 percent to \$476 million, and further reductions are expected. The state programs that we reviewed have also reduced their funding. Data on R&D spending by electric equipment

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<sup>1</sup>References to dollars over multiple years are in 1995 constant dollars throughout this report unless otherwise noted.

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manufacturers are unavailable because the data are proprietary. The primary reason for DOE's reduction in fiscal year 1996 is the Congress's overall effort to reduce the federal budget. Utilities, in an effort to cut costs in anticipation of a shift from a regulated electric power industry to a deregulated environment, are also reducing their R&D budgets, according to R&D managers, because of the expected increase in competition in the electricity market. The declines in state programs are due to reductions in major funding sources, including utilities' contributions.

Concurrent with the reduction in funding, a shift in the types of R&D funded by electric utilities has occurred, primarily resulting in a decrease in collaborative and longer-term projects. Many utilities are shifting away from such projects, which may benefit all electric utilities, to those they believe will help them competitively in the near term, that is, proprietary R&D with a short-term payback. Utility R&D managers view this shift as part of the effort to recast the utility companies as businesses rather than regulated providers of public services. The projects that we reviewed in six technologies in which DOE participated were often delayed, scaled down, or canceled. Given the inherent difficulties in measuring the benefits of R&D, the economic consequences of these program changes are unclear.

Utility R&D managers and industry and government officials who expressed concerns about the funding levels of electricity-related R&D suggested alternative funding sources. These sources include a (1) state surcharge on all in-state retail sales of electricity and (2) nationwide charge on all electricity entering the transmission system—a "wires" charge.

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## Background

Electricity-related R&D encompasses both basic and applied research and includes all aspects of electricity generation, including nuclear, fossil, and renewable energy technologies; transmission and distribution technologies; energy storage technologies; and environmental studies of electricity-related issues, according to DOE's Deputy Assistant Secretary for Utility Technologies.<sup>2</sup>

Electricity-related R&D is funded from several sources. For the last 4 years, DOE has provided about \$4.6 billion in funding at its national laboratories, at universities, and in co-funded collaborative research with utilities and manufacturers. Over the same period, electric utilities, primarily private

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<sup>2</sup>Because DOE does not define electricity-related R&D but includes it within energy R&D, we used this definition as the basis for the information we present.

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and investor-owned, have spent about \$2.3 billion; over the last 3 years, state programs have spent about \$200 million.<sup>3</sup> Manufacturers of electric utility equipment have also funded electricity-related R&D; however, current estimates of such funding are unavailable.

As the electric power industry moves toward deregulation and increased competition, utilities face significant changes. Historically, utilities have operated as monopolies in protected geographic areas. Many of these utilities were regulated by state public utility commissions that approved the inclusion of electricity R&D expenditures in the rate base. By including these expenditures in the rate base, the utilities have been allowed to earn a fixed rate of return on these expenditures. Driven by a combination of factors, the move toward deregulation gained impetus with the Energy Policy Act of 1992, which promotes increased competition in the wholesale power market. Other factors spurring the move toward competition include large differences in electricity rates among utilities; new low-cost electricity generation technologies; and recent experiences in reduced regulation in other industries, such as telecommunications and natural gas.

In April 1996, as a result of the Energy Policy Act of 1992, the Federal Energy Regulatory Commission issued a final rule that now requires electric utilities to make their transmission lines accessible to other utilities or power producers for the transmission of wholesale power. It requires that this open access be made available at the same cost that these public utilities incur to transmit their own power. Regulatory commissions in 44 states and the District of Columbia had adopted or were evaluating deregulation alternatives as of June 30, 1996.

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## Electricity-Related R&D Funding Is Declining Due to Budget Reductions and Deregulation Prospects

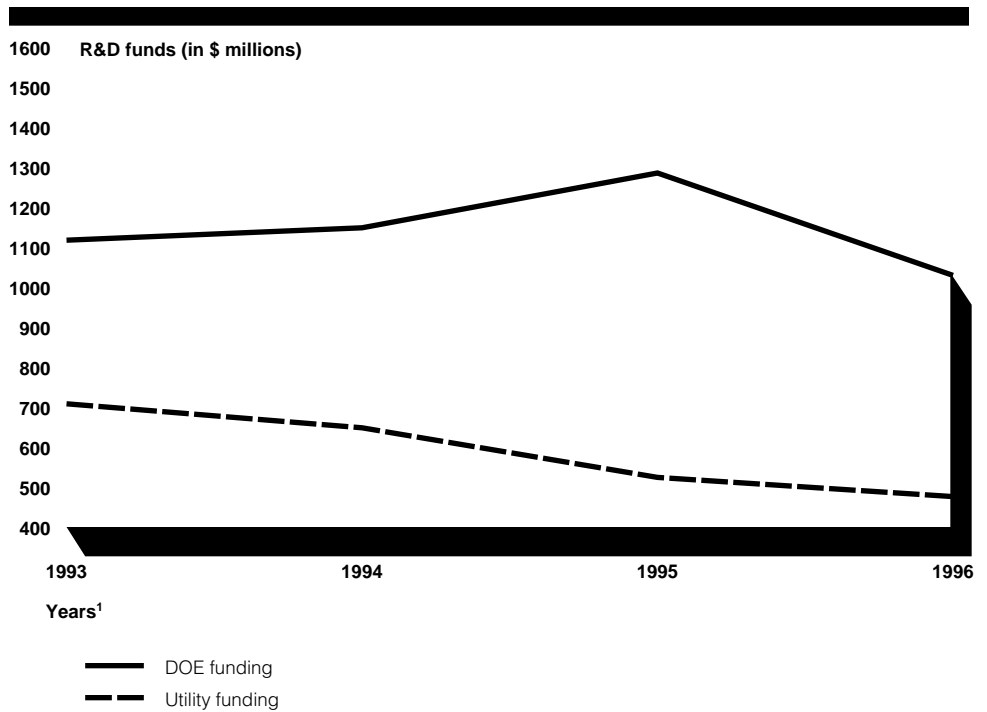
Electricity-related R&D funding was generally reduced in 1996 by the federal government, the electric utility industry, and most states that we reviewed. Since fiscal year 1993, DOE's electricity-related R&D budget has increased, except for fiscal year 1996 when it was reduced to near its 1993 level. Meanwhile, the electric utilities began making reductions 3 years ago. Most state programs we reviewed are also experiencing reductions. The primary reasons for the funding declines are overall reductions in federal and state funding and the increased competition expected from the deregulation of the utilities. Current data on the manufacturers' R&D spending were unavailable.

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<sup>3</sup>Comparable funding estimates are difficult to compile because the states use different time frames for their data.

Figure 1 shows the funding for the two largest sources of R&D for which we have data for the last 4 years. DOE's 1993 and 1996 budget amounts are similar, while the 1994 and 1995 budgets experienced increases. Meanwhile, the utilities' investments have decreased each year.

**Figure 1: DOE's and Investor-Owned Utilities' Investments in Electricity R&D, 1993-96**



DOE time periods are fiscal years; utility time periods are calendar years.

Note: Millions of 1995 constant dollars

Source: GAO's presentation of data from DOE's budgets, the Federal Energy Regulatory Commission, and selected electric utility companies.

## DOE's R&D Budget Reduced

After approving increases in previous years, the Congress reduced DOE's electricity-related R&D budget by about 20 percent in fiscal year 1996 compared to 1995. The reductions occurred in electricity-related R&D activities under both of DOE's appropriations—Energy and Water Development and Interior and Related Agencies. DOE's 1997 budget request for electricity-related R&D is about 14 percent higher than the 1996 appropriation. Table 1 presents the major R&D program budgets over 5 years.

**Table 1: Appropriations for Major Electricity-Related R&D Programs (Fiscal Years 1993-97)**

Millions of 1995 constant dollars

<b>Budget item</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997 request</b>
Renewable & energy efficiency	\$380,968	\$460,483	\$533,441	\$415,806	\$562,217
Nuclear	129,813	97,838	106,978	67,157	75,441
Fossil	372,528	364,824	353,300	304,293	272,452
Energy research, including fusion <sup>a</sup>	100,084	95,930	181,957	138,510	153,268
Biological & environmental R&D <sup>b</sup>	129,653	128,562	102,852	99,622	100,330
Policy office <sup>c</sup>	3,559	•	6,070	3,922	4,831
<b>Total</b>	<b>\$1,116,605</b>	<b>\$1,147,637</b>	<b>\$1,284,598</b>	<b>\$1,029,309</b>	<b>\$1,168,539</b>

Note: DOE's Office of Energy Efficiency and Renewable Energy developed an estimate of DOE's budget for utility-related activities for fiscal year 1993, which we used together with other budget data to estimate DOE's budget for electricity-related R&D activities.

<sup>a</sup>DOE's Office of Energy Research noted that fusion energy had a goal of energy production through fiscal year 1995 and was oriented toward a technology program; however, for fiscal years 1996 and 1997, the program's goal was reoriented to a science program. Reflecting this reorientation, the Deputy Associate Director of the Fusion Energy Sciences program provided us with estimates of about \$83 million for fiscal year 1996 and about \$84 million for the fiscal 1997 request.

<sup>b</sup>Includes R&D on the effect of carbon dioxide on the earth's atmosphere and on people.

<sup>c</sup>Includes environmental policy studies, analysis of DOE's R&D activities, and evaluation of the proposed regulations' effect on the energy system.

Source: GAO's presentation of data from DOE's budgets.

According to the House and Senate Appropriations Committees' reports on DOE's fiscal year 1996 appropriations, the primary reason for the decline was to meet overall budget constraints. For example, the House and Senate Appropriations Committees' reports on Energy and Water Appropriations made repeated references to budget constraints and budget realities in their reports on DOE's fiscal year 1996 budget for energy supply R&D activities. Compared to DOE's request, the House Committee recommended a 24-percent decrease, and the Senate Committee recommended an 18-percent decrease.

In separate reports, the House and Senate Appropriations Committees responsible for the Interior and Related Agencies Appropriations recommended reducing DOE's fiscal year 1996 appropriation for fossil energy R&D programs by about 10 percent below the fiscal year 1995 level

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and stated their intent to continue reducing this program by a similar percentage each year for the next several years. According to these reports, the reductions will permit the agency to gradually phase down to a funding level more in line with the recommendations of the legislative committee of jurisdiction in the House.

DOE's fiscal year 1997 overall budget request for electricity-related R&D is greater than the 1996 appropriations; however, the budget request for some technologies decreased. For example, the request for the renewable energy and energy-efficiency programs is \$146.4 million (or 35 percent) greater, whereas the request for the fossil energy programs is \$31.8 million (or 10 percent) less. DOE's budget attributes the reductions in the fossil energy programs to congressional guidance to reduce these programs by 10 percent per year.

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## Utilities Are Reducing R&D to Prepare for Increased Competition

R&D spending by the nation's investor-owned utilities has declined by nearly one-third in 3 years (from 1993 to 1996) after being level in real dollars for the previous 10 years. We gathered data from 80 companies representing the 112 largest operating utilities<sup>4</sup> from a total of 3,000 utilities.<sup>5</sup> These 112 investor-owned utilities, which are privately owned, account for over 93 percent of all nonfederal<sup>6</sup> utility R&D spending and are responsible for about three-quarters of all electricity sales. They reduced their spending for R&D from about \$708 million in 1993 to about \$476 million in 1996.

In 1992, the National Association of Regulatory Utility Commissioners recommended that utilities devote 1 percent of their revenues to R&D. In 1993, 6 of the 112 investor-owned utilities met that target, but since then all 6 have substantially cut back their R&D spending. In 1994, utilities on average devoted about 0.3 percent of their revenues to R&D.

Utility R&D managers told us that this average will most likely continue to decline. Of the 80 companies we contacted, the R&D managers of 38 companies predicted cutbacks in R&D spending after 1996, while the managers of only 2 companies predicted increases. The managers from the

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<sup>4</sup>Some companies own more than one utility.

<sup>5</sup>The remaining utilities consist primarily of municipal utilities and rural cooperatives, and the combined total of their R&D spending last fiscal year was about \$5 million.

<sup>6</sup>Federally owned utilities include TVA and DOE's five power marketing administrations.



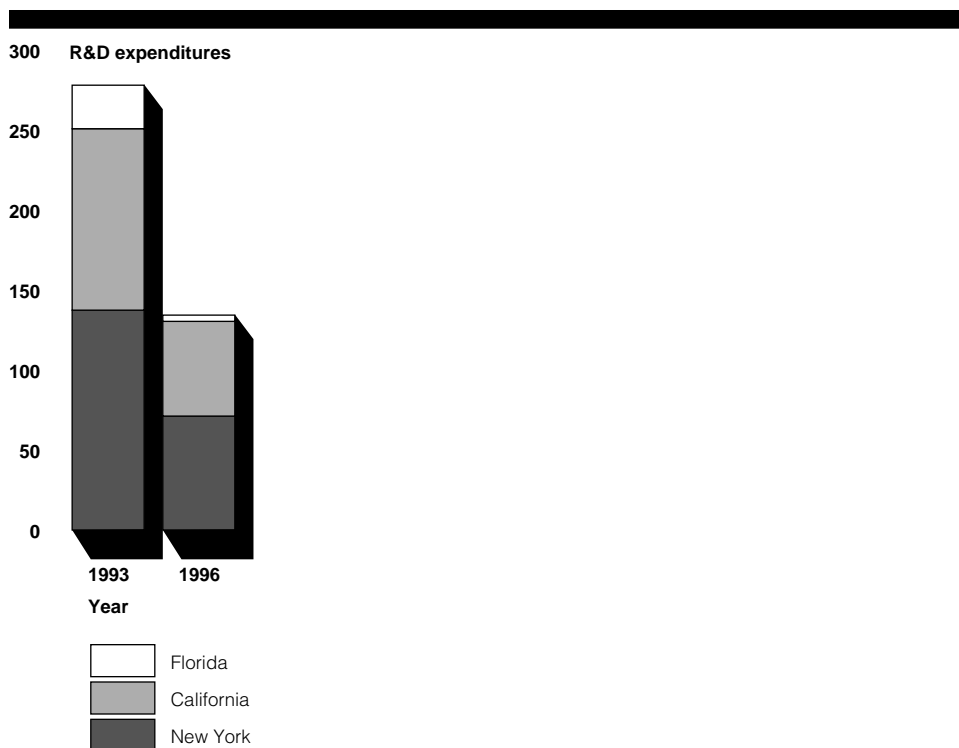
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remaining 40 companies were either unsure, thought their expenditures would remain about the same, or did not provide the information.

According to utility R&D managers who were asked why their budgets were being reduced, the main reason was that their companies are preparing for deregulation and competition by cutting costs wherever they can. In the past, utilities were allowed to earn a fixed rate of return on all R&D projects that the public utility commission allowed in the rate base. In a more competitive marketplace, utilities will be forced to price electricity to compete with other utilities and independent power producers. As a result, R&D managers evaluate potential R&D projects on the basis of their likelihood of providing a near-term return to the utility that will allow them to reduce electricity rates.

Increased competition was cited as the primary reason for the biggest cutbacks to date by utilities in California, New York, and Florida. The 13 investor-owned utilities in these states have been among the leaders in R&D investments, accounting for 39 percent of the R&D funded by investor-owned utilities in 1993. But they have reduced their R&D spending by 52 percent since 1993. According to utility R&D managers in New York and California, they currently charge customers considerably more than the average price for electricity, and they are under pressure to cut costs in order to be able to compete in a deregulated market. Florida's major utilities have eliminated nearly all of their R&D funding in order to be cost-competitive with each other and with other electricity suppliers in the region.

**Figure 2: R&D Spending by Major California, New York, and Florida Investor-Owned Utilities (1993 and 1996)**



Note: Millions of constant 1995 dollars

Source: GAO's presentation of data from the Federal Energy Regulatory Commission and selected utilities.

Other reasons given by 10 companies' R&D managers for reductions in their R&D were that no new DOE co-funded projects were being initiated and ongoing projects were either reaching completion or being cut back. These projects included coal technology development, renewable energy, and other projects for advanced electricity generation technology.

**Some State R&D Programs Are Being Reduced Because of Funding Constraints**

The electricity-related R&D programs that we reviewed at the state level are also experiencing reductions. Of the 11 large programs in the nine states that we reviewed, 7 have been reduced in the past 3 years.<sup>7</sup> Overall the programs have seen a 30-percent reduction in funding, from \$83 million to

<sup>7</sup>The 11 programs represent the major state programs involved in electricity-related R&D, according to the available data and discussions with key state program officials. The states and their programs are identified in appendix I.

\$58 million, since 1993. Most of these programs involved energy-efficiency R&D, and some involved generation technologies of particular interest to that state, such as coal power and renewable energy.

The state program officials attributed the declines in these programs to the decreases in major funding sources: (1) utilities' contributions; (2) oil overcharge revenues;<sup>8</sup> (3) co-funding available for R&D projects from DOE, the Electric Power Research Institute<sup>9</sup> (EPRI), utilities, and industry; and (4) state appropriations. For example, the budget of the Empire State Electric Energy Research Corporation, funded by voluntary contributions from New York utilities, was cut nearly in half, from \$19 million to \$10 million, between 1993 and 1996.

The California Institute for Energy Efficiency, which has funded energy-efficiency R&D at Lawrence Berkeley National Laboratory and various California universities, has also been affected by cost-cutting. The Institute's primary source of funding was about \$4 million per year from California utilities. By late 1994, the utilities no longer provided funding. The Institute is maintaining a skeleton operation using carryover funds but will be unable to continue if another source of funding is not found by the end of 1996.

## Amount of Manufacturers' R&D Spending Is Unavailable

Information on spending on electricity-related R&D by the manufacturers of electric utility equipment is unavailable. Data from manufacturers are considered proprietary and therefore difficult for organizations that collect and analyze R&D financial information to obtain. The organizations, which include the National Science Foundation and DOE's Energy Information Administration, said that they had data on the manufacturers' energy R&D but could not isolate the electricity-related R&D spending. The most recent such information available was an EPRI study that estimated a 1988 total for all U.S. manufacturers of \$200 million.<sup>10</sup>

In a restructured industry in which other companies are reducing R&D spending, manufacturers may take on the development of new products. In the absence of current data, the degree to which this is occurring, if at all, is uncertain. Utility, EPRI, and DOE officials told us that on the one hand,

<sup>8</sup>These funds were allocated to the federal government by courts as a result of lawsuits in which oil companies were found to have overcharged for oil.

<sup>9</sup>EPRI was founded by the utility industry in 1972 to do R&D. It is funded by the utilities' contributions.

<sup>10</sup>Research and Development in the 1980s: An Overview, Electric Power Research Institute, June 1990.

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the manufacturers are increasingly being relied on to meet technology needs, especially by independent power producers, which are producing a growing portion of the nation's electricity but are generally not investing in R&D themselves because they operate on a thin profit margin. On the other hand, officials from these organizations told us that electricity-related manufacturers may not invest in new technology R&D for the following reasons: (1) the cutbacks in the availability of co-funding to help support projects; (2) the restructuring of the electricity industry, which has created uncertainties in the domestic market; and (3) the difficulty of competing in international markets where foreign competitors have the strong backing of their governments.

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## Collaborative and Longer-Term Projects Are Being Reduced

Concurrent with the declines in funding, a shift in the types of R&D being funded has also occurred, primarily resulting in a decrease in collaborative and longer-term projects. Many utilities are shifting their R&D from such projects to proprietary R&D and to projects with a short-term payback. In addition, as a result of these changes and last year's reductions in DOE's funding, advanced technology projects in the six technology areas we reviewed were often delayed, scaled back, or canceled. Given the inherent difficulties in measuring the benefits of R&D, the economic consequences of these program changes are unclear.

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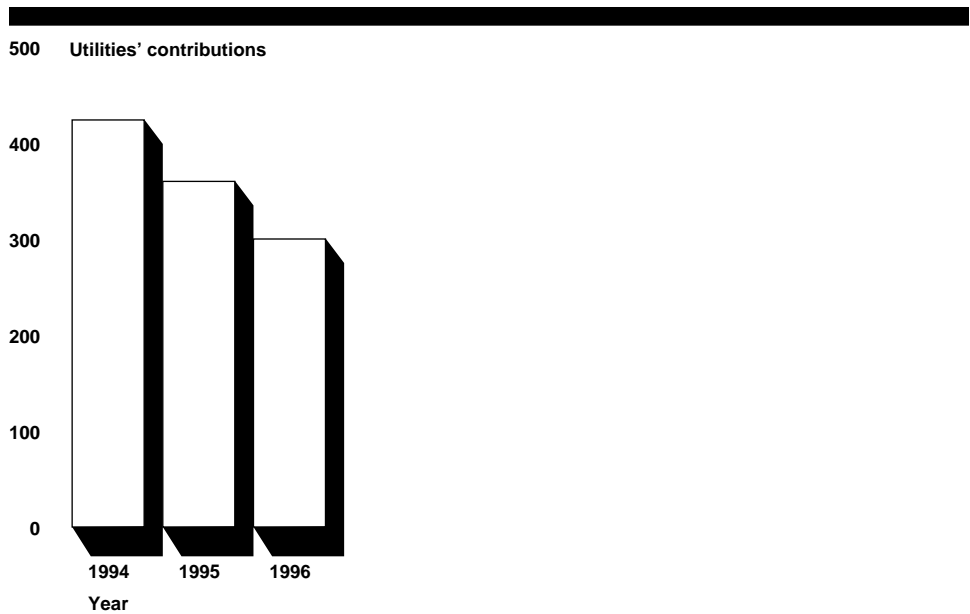
## Utilities Are Shifting Away From Collaborative R&D

According to many utility R&D managers, their companies have been shifting the focus of their R&D from collaborative projects benefiting all utilities, to proprietary R&D, giving their individual companies a competitive edge. R&D managers at more than half of the 80 utilities we contacted reported reducing funding for collaborative R&D. Some R&D managers said they believe that continued investment in R&D that could benefit all companies would put their company at a competitive disadvantage in comparison with other utilities and with independent power producers that are not making such investments.

This shift is reflected in the declining support for EPRI, which is the utilities' main vehicle for collaborative R&D. According to a National Rural Electric Cooperative Association official, many of his members belong to EPRI and look to it for larger, industrywide innovations. Traditionally amounting to more than half of the utilities' R&D dollars, the utilities' contributions to EPRI over the last few years have declined faster than the utilities' R&D spending overall. Between 1994 and 1996, membership contributions to EPRI declined by nearly 30 percent, from \$424 million to

\$300 million, and EPRI officials expect a further decline in 1997 (see fig. 3). Of the 80 utility companies we contacted, 12 dropped out of EPRI between 1994 and 1996, but most remained members and simply decreased their contributions.<sup>11</sup>

**Figure 3: Decline in Utilities' Contributions to EPRI (1994-96)**



Note: Millions of dollars

Source: GAO's presentation of EPRI's data.

To address the changes that are occurring, EPRI has tried to encourage membership for independent power producers—which an EPRI official estimates will account for more than 35 percent of future generating capacity—but such efforts have been unsuccessful. In addition, EPRI plans to establish a taxable subsidiary that can participate in proprietary R&D.

### Utilities Are Shifting Away From Long-Term, Advanced-Technology R&D

According to many utility R&D managers, their companies are also shifting the focus of their R&D away from long-term, advanced-technology R&D, like the advanced gas turbine and new fuel cells, to short-term projects that will be profitable and provide a competitive edge in the near term. The R&D

<sup>11</sup>In addition, four of the six utilities that dropped out of EPRI prior to 1994 rejoined.

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managers at about half of the 80 utility companies we contacted reported such a change. In fact, the R&D managers at the nation's two largest utilities, Pacific Gas & Electric and Southern California Edison, said that their advanced-technology R&D programs have been eliminated.

R&D managers from 52 of the 80 utility companies we contacted expressed concern that if the trend in funding decreases continued, it would result in slowing technology development, sacrificing future prosperity to meet short-term goals, and failing to meet national energy goals.<sup>12</sup> In addition, DOE officials said that the reductions in the renewable and fossil energy programs will delay penetration of technologies into the market and change the way that some projects are being carried out.

With the move toward deregulation, some R&D managers said that they are more concerned with whether their companies will continue to exist in the face of widespread restructuring and mergers than with the potential long-term benefits from advanced technology that may take 8 or more years to develop and market. They also said that they view the shift to short-term R&D as part of the recasting of utility companies as businesses rather than regulated public-service providers. A 1996 DOE study<sup>13</sup> found that private industry in general is shifting its R&D priorities away from the longer-term benefits of basic and applied research to an emphasis on product development and process enhancements supporting shorter-term market strategies and "bottom lines."

The R&D managers at some utilities told us that their companies are shifting from R&D activities related to long-term, advanced-technology power generation R&D because, under restructuring, they will become transmission and distribution companies and will no longer be involved in power generation. Thus, some utilities see themselves purchasing new power rather than adding generating facilities. Additional reasons for the shift mentioned by some utilities' R&D officials were that there is no immediate need for additional electricity supplies, the available gas-turbine technology is adequate as long as natural gas is plentiful and relatively inexpensive, and market uncertainties are associated with deregulation.

EPRI's R&D programs for advanced power generation have also been affected by cutbacks in the utilities' contributions. For example, the budgets for fuel cells, coal gasification, advanced gas turbines, and wind

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<sup>12</sup>Only two R&D managers said they were not concerned; the rest did not comment.

<sup>13</sup>Corporate R&D in Transition, DOE, Mar. 1996.

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and solar power have declined by a total of 66 percent, from \$40.7 million to \$13.9 million, within the past 3 years. EPRI program managers said that they no longer have funds to initiate new projects; instead, their role is increasingly one of information transfer rather than R&D funding.

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### Some DOE Projects Are Being Delayed, Scaled Down, or Canceled

The projects that we reviewed in six technologies in which DOE participated were beginning to be delayed, scaled down, or canceled as a result of funding reductions, according to DOE, state, and industry officials that we contacted. We chose to review these areas because, according to the 1995 DOE Task Force study,<sup>14</sup> the projects in these areas have a high or medium long-term potential for meeting the national energy goals and because they were significantly reduced in the utilities' budgets. The technologies reviewed were fuel cells, coal gasification, advanced gas turbines, wind power, photovoltaics, and electricity storage (see app. II for details).

The reductions in DOE's funding are delaying the development of several technologies, according to DOE officials. For example, the unavailability of DOE and EPRI co-funding is delaying the development of a fuel-cell system—whose goal is the highly efficient, environmentally benign conversion of fossil fuel to electricity. Funding reductions are also delaying the development of one of DOE's fuel-cell vehicle programs and a demonstration of superconducting magnetic energy storage, whose goal is a highly efficient new technology for storing electricity.

The funding reductions by DOE, utilities, and EPRI are resulting in the scaling down of collaborative projects with industry for the development of cost-efficient photovoltaic systems, which convert sunlight directly to electricity. Several projects are being scaled down, such as (1) a program to reduce the cost of photovoltaic manufacturing and (2) a center that aids in designing new photovoltaic applications.

The funding reductions are also resulting in the cancellation of two programs to encourage wind-power development. A collaborative program involving DOE, utilities, and EPRI to test new wind turbines in utility settings will be terminated following the completion of the three projects currently under way. A program to support utilities' wind turbine purchases to reduce the utilities' perceived risk of introducing a new and unfamiliar technology has also been eliminated.

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<sup>14</sup>Energy R&D: Shaping our Nation's Future in a Competitive World, Final Report of the Task Force on Strategic Energy Research and Development, Secretary of Energy Advisory Board, June 1995.

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## R&D Managers Propose Alternative Funding Mechanisms

Utility R&D managers and industry, DOE, and state government officials who expressed concerns about the funding of electricity-related R&D suggested alternative funding sources. They are (1) a state-administered surcharge on all retail sales of electricity within the state and (2) a nationwide non-bypassable wires charge that could provide an alternative funding source for EPRI.

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## State Surcharge Proposals

Several states that are considering deregulating their utilities have proposed surcharges to fund public-benefit R&D; the states include California, New York, Massachusetts, and Rhode Island. For example, in January 1996 the California Public Utilities Commission published its deregulation proposal. It recognized that California utilities' R&D budgets have decreased significantly in the transition to a competitive market. The Commission's proposal calls for a non-bypassable surcharge to be instituted no later than January 1, 1998, on all retail electricity sales to fund public-benefit R&D and energy-efficiency activities. The surcharge would fund R&D that served a broad public interest which might otherwise be lost in the transition to a more competitive market place. The proposal calls for establishing a consortium or public authority to administer the funds but does not specify a funding level.

However, some utility R&D managers and state and EPRI officials pointed out weaknesses in the state-by-state administration of surcharges. These officials believe that although surcharges may be suitable for programs that focus on locally available natural resources, local conditions, and partnerships with local industries, the states' administration of more broadly based programs would likely be inefficient, uncoordinated, and duplicative and not achieve the critical mass necessary for projects of nationwide scope. Also, they are concerned that if some states implemented a surcharge and others did not, the problem of "free riders" would continue, where some would receive the benefits without helping to pay for the R&D, putting states that did pay at a competitive disadvantage.

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## Nationwide Wires Charge Proposal

Some utility R&D managers and state and EPRI officials suggested that a non-bypassable national wires charge could provide an alternative funding mechanism for EPRI and longer-term collaborative R&D. It would ensure that those who do not fund R&D do not achieve a competitive advantage over those who do. Under this proposal, a small charge would be assessed on all electricity entering the transmission grid, whether it be interstate or intrastate.



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Furthermore, the National Association of Regulatory Commissioners in November 1994 adopted a resolution recognizing the need for a system of support for public benefits, which include electricity-related R&D in the restructured electricity industry. Subsequently, an Association official told us that in commenting on the Federal Energy Regulatory Commission's open-access rulemaking, the Association recognized that a nationwide wires charge was one possible technique to fund public benefits.

The Gas Research Institute, the R&D counterpart to EPRI for the natural gas industry, is funded by a somewhat similar charge on gas flowing through interstate pipelines. This pipeline charge has enabled funding for the Institute to be maintained despite reduced regulation. Recently, the Institute has encountered problems with this funding mechanism because individual pipeline companies are allowed to reduce their payments to the Institute if their rates are discounted due to competition from other pipeline companies. As a result, the Institute experienced a 21-percent shortfall in its 1996 R&D budget. In an order issued on May 3, 1996, the Federal Energy Regulatory Commission approved an amended R&D program for the Institute.

Many utility R&D managers with whom we spoke, although generally reluctant to support any additional charges for electricity, said that a non-bypassable wires charge would be a more equitable way to provide funding than the current system, to which some utilities and independent power producers were not contributing. The managers also said that if there were a wires charge, they would like to have considerable say over how the money was spent.

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## Agency Comments

We transmitted a draft of this report to the Secretary of Energy for review and comment. We received written comments from DOE's Assistant Secretary, Energy Efficiency and Renewable Energy, who stated that the agency had only minor editorial comments on the draft. We incorporated these suggestions where appropriate.

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We conducted our work from October 1995 through July 1996 in accordance with generally accepted government auditing standards. Appendix I describes the objectives, scope, and methodology of our review in detail. Appendix III lists the major contributors to this report.

As arranged with your office, unless you publicly announce its contents earlier, we plan 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, federal agencies, and other interested parties. We will also make copies available to others on request.

If you have any questions about this report, call me at (202) 512-3841.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Victor S. Rezendes". The signature is fluid and cursive, with the first name "Victor" being the most prominent.

Victor S. Rezendes  
Director, Energy, Resources,  
and Science Issues

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# Contents

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<b>Letter</b>		1
<b>Appendix I</b>		20
<b>Objectives, Scope, and Methodology</b>		
<b>Appendix II</b>		22
<b>Impact of Changes on Six DOE Technologies</b>	Fuel Cells	22
	Coal Gasification	24
	Advanced Gas Turbines	25
	Wind Power R&D	27
	Photovoltaic R&D	29
	Electricity Storage Technologies	30
<b>Appendix III</b>		33
<b>Major Contributors to This Report</b>		
<b>Related GAO Products</b>		36
<b>Table</b>	<b>Table 1: Appropriations for Major Electricity-Related R&amp;D Programs</b>	5
<b>Figures</b>	<b>Figure 1: DOE's and Investor-Owned Utilities' Investments in Electricity R&amp;D, 1993-96</b>	4
	<b>Figure 2: R&amp;D Spending by Major California, New York, and Florida Investor-Owned Utilities</b>	8
	<b>Figure 3: Decline in Utilities' Contributions to EPRI</b>	11

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## Abbreviations

DOE	Department of Energy
EPRI	Electric Power Research Institute
GAO	General Accounting Office
R&D	research and development

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# Objectives, Scope, and Methodology

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Our objectives were to determine (1) what changes have occurred in the amount of electricity-related research and development (R&D) funding and the primary reasons for these changes and (2) what has been the impact of these changes on the types of R&D being funded. For the impact of changes to the Department of Energy's (DOE) R&D, we agreed to provide information on six technologies. You also wanted to know, given these changes, what alternate funding approaches R&D managers and others have proposed.

To obtain information on the federal electricity-related R&D programs, we contacted DOE officials and program managers and extracted electricity-related R&D data from DOE's budget documents. Because DOE does not separately identify electricity-related R&D, we relied heavily on an analysis of utility-related activities for fiscal year 1993 performed by DOE's Office of Energy Efficiency and Renewable Energy. We used this analysis together with other budget data to estimate DOE's budget for electricity-related R&D activities for fiscal years 1993 through 1997. We did not gather data on possible electricity-related R&D funding by other federal agencies, such as the Department of Defense, National Aeronautics and Space Administration, and Department of Commerce.

To determine changes in electric utilities' R&D spending, we analyzed data on R&D expenditures collected by the Federal Energy Regulatory Commission from investor-owned utilities through 1994. These utilities accounted for about 93 percent of nonfederal utilities' R&D spending. For information for 1994 through 1996, future trends, and other responses, we interviewed and obtained data from utility R&D managers or other corporate officials at 80 companies representing 112 investor-owned electric utilities, which accounted for over 99 percent of investor-owned utilities' R&D. We also interviewed and collected information from corporate officials, program managers, and officials of the Electric Power Research Institute (EPRI), and officials of trade associations representing municipal utilities and rural electric cooperatives.

To gather information on state-sponsored electricity-related R&D programs, we interviewed and obtained data from officials involved with 11 state programs of significant size from 9 states—California, Florida, Illinois, Iowa, New York, North Carolina, North Dakota, Ohio, and Wisconsin. The 11 programs include the Empire State Electric Energy Research Corporation, New York State Energy Research and Development Authority, Florida Solar Energy Center, Ohio Coal Development Office, California Energy Commission's Energy Technology Advancement Program, California Institute for Energy Efficiency, Energy Center of

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Wisconsin, North Carolina Alternative Energy Corporation, North Dakota Lignite Energy Council, Illinois Clean Coal Institute, and Iowa Energy Center.

To obtain information on industry spending on electricity-related R&D, we contacted manufacturers' trade associations and private nonprofit research organizations, including EPRI. We also interviewed officials from several companies involved with specific technologies we selected to examine. In addition, we reviewed studies published by and contacted officials at other organizations, including DOE, the National Science Foundation, the Industrial Research Institute, and the Energy Information Administration.

To determine the effects of the changes on the types of R&D being funded, we interviewed and obtained information from EPRI and DOE program managers, utility R&D managers, and industry and state officials. To determine the impact of changes to DOE's R&D, we selected six technologies—fuel cells, coal gasification, advanced gas turbines, wind power, photovoltaic, and electricity storage. We selected these technologies because the Secretary's 1995 Task Force study designated them as having high and medium long-term potential for meeting national energy goals and they have experienced funding reductions by utilities and EPRI. These technologies are advanced electricity generation technologies, except for electricity storage, which EPRI officials predict will be of increasing importance in an era of deregulation.

To obtain information on alternative funding approaches, we relied on interviews and documents from utility R&D managers and state, DOE, EPRI, and industry officials, as well as the National Association of Regulatory Utility Commissioners. We also discussed the Gas Research Institute's fuel line charge with Institute and Federal Energy Regulatory Commission officials. We did not determine whether the changes and trends in funding levels are appropriate and therefore whether the alternative funding proposals are necessary.

We conducted our work from October 1995 through July 1996 in accordance with generally accepted government auditing standards.

# Impact of Changes on Six DOE Technologies

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We reviewed the following six technologies—fuel cells, coal gasification, advanced gas turbines, wind power, photovoltaic, and electricity storage. Projects in these six technologies are beginning to be delayed, scaled down, or canceled as a result of funding reductions, according to DOE, state, and industry officials that we contacted.

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## Fuel Cells

Fuel cells is a new generating technology that converts the energy of chemical reactions directly into electricity. It is intended to be the most efficient, environmentally benign of the fossil-fueled technologies. As fuel cell applications are being tested, developers are seeking ways to bring down the cost so that the systems can compete with other technologies. The various fuel cell technologies—phosphoric acid, molten carbonate, solid oxide, and proton exchange membrane fuel cells—are at different stages of development.

Phosphoric acid fuel cell technology is on the market as relatively small power plants in hospitals, research laboratories, and remote sites. Neither EPRI nor DOE is any longer involved with this R&D. However, DOE is cooperating with the Department of Defense on a buy-down program aimed at decreasing the unit cost by increasing production and sales. Defense is providing \$15 million to reduce the purchase price, with preference given to Defense sites.

For molten carbonate fuel cells, two manufacturers are currently building and testing demonstration plants. The demonstrations involve scaling up the technology into commercial-size powerplant systems. The projects were co-funded by DOE, EPRI, the Gas Research Institute, and several utility companies. Both manufacturers have experienced significant problems in scaling up their systems to demonstration plant size. Because extensive system modifications are being made, another generation of demonstration plants will likely be needed before the systems are market ready. The availability of funding for a second round of demonstration plants is questionable.

Solid oxide fuel cell systems are currently being developed by several companies. DOE is co-funding the development by Westinghouse Electric Corporation of a tubular system, while several smaller companies are working on developing planar systems. While Westinghouse's tubular system is more fully developed, planar technology may prove simpler and cheaper. The developers, along with EPRI, are seeking funding to scale up the technology into larger systems.



Proton exchange membrane fuel cells operate at low temperatures and thus can be turned on and off readily, making them suitable for transportation vehicles. Several auto makers, with DOE co-funding, are investigating whether this technology can meet the cost and performance standards under the Partnership for a New Generation of Vehicles program, an effort to spur the development of more efficient and lower emission vehicles.

The stationary fuel cell budget for 1995 was \$48.2 million, which according to DOE's program manager was more than two-thirds of total U.S. fuel cell R&D expenditures. In fiscal year 1996, the program operated at a reduced level under a continuing resolution for most of the year. The program manager expects that the Congress will reduce the budget by about \$5 million per year for the next 4 years, which would reduce DOE's ability to co-fund demonstration projects. Even without these cuts, DOE lacks the funds to support the development of planar solid oxide systems unless it were to drop funding for other on-going projects, according to the program manager. EPRI is trying to get a consortium of utilities to invest in the development of a planar solid oxide system but is finding it difficult. The program manager also said that the lack of DOE or EPRI/utility support will delay efforts by the developer, a small company, to scale up its technology into a marketable system.

DOE's transportation fuel cell budget for fiscal year 1995 was \$25 million. The program manager expects the fiscal year 1996 budget to be reduced by 14 percent and expects additional reductions in 1997. For 1996, DOE eliminated programs for the transportation applications of phosphoric acid fuel cells, such as in buses and locomotives. For proton exchange membrane fuel cells, DOE reduced by 50 percent its support for General Motors' fuel cell vehicle program, which according to DOE's program manager will delay the program. DOE is maintaining its support for the Ford and Chrysler fuel cell vehicle programs, which are not as far along.

The program manager said that further budget cuts in the transportation fuel cell program will jeopardize advanced concept research, such as work at Los Alamos National Laboratory to develop direct methanol oxidation, which could potentially eliminate the need for a heavy on-vehicle fuel reformer. He is also concerned that delays due to budget cutbacks could keep fuel cell vehicle development from meeting the time frames for selection under the Partnership for a New Generation of Vehicles program.

EPRI's fuel cell budget has dropped 67 percent, from \$9 million to \$3 million, in the past 2 years and is likely to decrease further in the future. EPRI officials are concerned that they will no longer be able to support fuel cell demonstration projects and that fewer funds will be available for exploratory research on advanced fuel cell concepts. In addition, the largest California utilities, which have supported fuel cell development, have discontinued funding for the advanced generation technologies.

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## Coal Gasification

Coal gasification is an advanced electricity generation technology that converts coal into gaseous fuel and cleans the fuel of pollutants in certain powerplants. Three powerplants to demonstrate the currently available technology are under construction as a part of another DOE program.

The program was to consist of the Gasification Product Improvement Facility in West Virginia and the Power System Development Facility in Alabama. The West Virginia facility was designed to do R&D on advanced concepts to increase efficiency and lower costs. The Alabama facility, for which DOE provides 80 percent of the funding, was designed to test high-temperature particulate filters, but it has the potential to do some of the advanced concept R&D work planned for the West Virginia facility.

DOE's budget for coal gasification-related R&D was reduced by 23 percent from \$26.7 million in fiscal year 1995 to about \$20.6 million in fiscal year 1996. To achieve this cutback, DOE has decided to eliminate the Gasification Product Improvement Facility. DOE, however, is preserving funding for the Power System Development Facility. For fiscal year 1996, DOE's funding for the project is \$12 million. Also contributing funding are EPRI and the Southern Company, the host utility. DOE expects some cost sharing from filter manufacturers and developers and more participation from industry once the facility is in operation. DOE is also funding related research projects at the Morgantown Energy Technology Center and other locations.

EPRI's budget for advanced coal technology has dropped 71 percent, from \$8.7 million in 1993 to \$2.5 million in 1996, of which \$1.6 million is for the Alabama facility. The EPRI program manager said that if funding keeps shrinking, EPRI may not be able to continue funding the facility. Although EPRI has supported the three demonstration projects, EPRI's continued support is jeopardized because one of the host utilities, Tampa Electric, has dropped out of EPRI and another, Cinergy, has stopped funding EPRI's advanced fossil business unit.

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The outlook for industry's potential contribution, according to EPRI and DOE officials, is mixed. Many of the companies are small and not capable of doing much R&D on their own. However, some of the large oil and gas companies, which have more resources, may become more involved, especially in international markets.

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## Advanced Gas Turbines

The potential benefits of advanced gas turbines, another electricity generating technology, is greater energy efficiency and economy and reduced emissions. The turbines can be fueled by natural gas, oil fuels, coal-derived gas, or biomass gas. Gas turbines for utility applications are typically combined with steam turbines to form a combined-cycle system. The waste heat from the gas turbine is used to generate steam, which is converted into additional electricity.

DOE is cost-sharing with industry, developing both large and small advanced gas turbines. DOE is to fund no more than 65 percent of the \$700 million, 8-year program to develop advanced turbines by the year 2000; industrial participants will contribute at least 35 percent. DOE's Fossil Energy Office is responsible for developing the large-scale turbine, while DOE's Office of Energy Efficiency and Renewable Energy is responsible for the small-scale turbine for distributed, industrial, and co-generation applications. On a four-phase schedule, both programs are now in phase III, which involves full-scale component development and a steep increase in expenditures, according to DOE officials. Two manufacturers are independently developing turbine systems under each program—General Electric and Westinghouse are the developers of the large turbine systems and Allison Engines and Solar Turbines are the developers of the small turbine systems.

Meanwhile a collaborative initiative, including several utilities and EPRI, is seeking to develop a mid-sized (about 100 megawatt) advanced turbine using aeroderivative technology developed for jet aircraft, such as the wide-bodied Boeing 777. Organized in 1991 by Pacific Gas & Electric, other California utilities, and the state of California, the collaborative has been managed by EPRI and supported by the Gas Research Institute since 1994 when Pacific Gas & Electric dropped out. Now, more than 50 percent of its funding comes from overseas members, including Canadian, British, French, Danish, Dutch, and Italian power companies. Although DOE was an early participant in the collaborative, DOE officials believe that more of a market, albeit overseas, exists for the big plants and may provide benefits to the United States in terms of exports and job creation.

The collaborative is seeking to encourage a manufacturer to develop a mid-sized system by getting potential customers to step forward and ensure a sufficient initial market. The collaborative has requested federal seed money for this marketing activity, which, if successful, would result in a largely private-sector system development effort. The collaborative has received no response from DOE or the White House Office of Science and Technology Policy. If such federal funds are not forthcoming, a program official said the collaborative will try to raise the funds from other sources, such as from utilities or independent power producers.

DOE's budget requests for big and small turbines increased from fiscal year 1995, but approval for smaller increases is expected. DOE's fiscal year 1995 budget for the big turbine project was \$36.6 million. DOE requested \$44 million for fiscal year 1996, but \$36.7 million was approved. While the projects may be slowed somewhat as a result, they were delayed about 9 months in the solicitation process; therefore, the budget impact will likely occur in fiscal year 1997. According to the DOE program manager, General Electric is cost-sharing at 65 percent and Westinghouse at 40 percent, both above the minimum 35 percent for phase III called for in the program plan. The program manager also said that if future federal funds are not available for the program, the manufacturers will likely forgo the development of machines for the domestic market and participate with international partners in developing machines for overseas markets.

DOE's fiscal year 1995 budget for the small turbine project was \$18.8 million. DOE requested \$27.5 million for fiscal year 1996, but \$22.1 million was received. According to the DOE program manager, Allison Engines and its partners and subcontractors, which include EPRI and Indianapolis Power & Light, are cost-sharing 40 percent, and Solar Turbines and its partners and subcontractors, which include the California Energy Commission and the Gas Research Institute, are cost-sharing 60 percent. The DOE manager does not believe either group can afford a bigger share and that budget reductions are likely to delay by 2 years the completion of the projects.

In the past 3 years, EPRI's budget for advanced gas turbines has been cut 67 percent, from \$15 million to \$5 million. As a result, EPRI has started no new innovations and is forgoing several areas of research. For example, EPRI is no longer doing any control or balance of plant R&D. According to the program manager, EPRI's ability to monitor the performance of new technology in utility settings and identify problems has been reduced, and no one is picking up the slack from the cutbacks in EPRI's program.

The Department of Defense and the National Aeronautics and Space Administration are continuing to be involved in turbine R&D. However, according to DOE, EPRI, and industry officials, cutbacks in these R&D programs and the shifting of funds from turbine R&D to other activities will mean that less turbine technology will flow from these programs to the U.S. turbine industry than in the past.

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## Wind Power R&D

DOE's wind program seeks to assist the wind industry in designing, developing, and testing technologically advanced wind turbines that can compete with conventional electricity generation. Wind energy is a renewable resource that does not use fossil energy supplies; has no air pollutant emissions; and is compatible with other land uses, such as farming and recreation. While good wind resources exist in many areas of the country, over 90 percent of the usable wind resource is in the Great Plains, stretching from Montana, North Dakota, and Minnesota south to Texas. Over 1,700 megawatts of wind power capacity are currently installed in the United States, mostly in California.

DOE is providing funds for several wind power projects. Since 1992, DOE has provided funds under its near-term product development and prototype testing program to three companies to develop turbines capable of generating electricity at a cost of 5 cents per kilowatt-hour (kwh). Also, in 1994 DOE began co-funding R&D projects by five companies on subsystems that could be incorporated into advanced turbine systems capable of generating electricity at a cost of 4 cents per kwh from 13-mile-per-hour winds. In addition, DOE is negotiating contracts with two companies to develop advanced turbine systems over the next 3 to 5 years. Scheduled to commence in September 1996, the contracts are expected to total \$33.7 million; DOE's share will be approximately \$19.7 million. One developer is covering 50 percent of the cost and the other is covering 30 percent.

In 1993, DOE and EPRI began the Utility Wind Turbine Performance Verification Program to promote utilities' participation in wind power projects and evaluate the latest commercial prototype wind turbines in typical utility operating environments. The program also provides a limited market for newly designed wind turbines prior to their achieving fully commercial status and documents and communicates the project's experiences and lessons learned to interested U.S. utilities and turbine manufacturers. DOE has provided \$2.75 million of the total program cost of \$22.4 million. The two utility companies involved in the program (Central

& SouthWest in Texas and Green Mountain Power in Vermont) are covering 50 percent and 65 percent of the cost, respectively, and EPRI is contributing the balance. The Texas project has been built and plant performance evaluation is under way. Construction of the Vermont project is scheduled for summer 1996.

To further encourage the utilities' involvement, in 1994 DOE initiated the Wind Energy Deployment Project under which DOE would contribute up to 20 percent of the cost of constructing 25-megawatt wind powerplants. In fiscal year 1995, DOE selected one project in Wyoming and two projects in Iowa under this program.

DOE's wind program budget was reduced 34 percent, from \$45.4 million in fiscal year 1995 to \$30 million in fiscal year 1996. The previous year's budget was increased from the fiscal year 1994 level of \$28.6 million, primarily to fund the Wind Energy Deployment Project. As a result of the reduction in 1996, DOE canceled further funding of the project. In addition, because of DOE's, EPRI's, and utilities' budget reductions, no further funding in fiscal year 1996 was provided for the Turbine Verification Program, beyond the two projects already under way. DOE, however, is sustaining funding for the advanced turbine contracts, which DOE officials believe are of increased importance because the industry needs outside support to ride out the current domestic utility market stagnation and continue developing new technology. Because the projects require multiyear funding, however, the budget reductions in fiscal year 1997 would require cutbacks, potentially not allowing completion of the turbine development program.

According to EPRI's program manager for wind and solar projects, the wind budget has declined from \$2.3 million to \$2 million since 1993. The 1996 budget will be used primarily to complete the two turbine verification projects under way.

According to DOE and EPRI officials, the domestic market for wind turbines is currently depressed because of utilities' uncertainty about electric power market restructuring. Additionally, even though the cost of wind power is coming down, the target price for power generation has declined further due to the availability of cheap natural gas and turbines. A further setback occurred in 1995 when the Federal Energy Regulatory Commission nullified a California set-aside plan under which California utilities would have purchased over 1,000 megawatts of additional wind power. According to DOE, the U.S. wind industry is badly lagging in sales

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and behind in technology development compared to European competitors, who have expanded R&D funding for wind energy since 1985, much faster than any other renewable technology. These countries are currently spending over \$150 million annually, according to DOE.

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## Photovoltaic R&D

Photovoltaic technology uses various devices to convert sunlight directly into electricity without any moving parts. Photovoltaic systems are aimed at providing an alternative to fossil fuel-based electricity generation and its residual environmental impacts. Hundreds of photovoltaic applications are currently cost-effective for off-grid electric power needs, and research is directed at making more applications cost-effective.

DOE has several programs to assist the photovoltaic industry. DOE's Photovoltaic Manufacturing Technology Project, a DOE-industry partnership, is aimed at reducing manufacturing costs and increasing production capacity. DOE also provides U.S. manufacturers with some international marketing assistance. Another research program that DOE funds is in advanced materials and devices, the major focus of which is developing more efficient and durable thin-film photovoltaic technology, which is cheaper to manufacture. Under this program, DOE funds research at national laboratories and universities and co-funds selected industry research projects.

DOE also has several programs to encourage utilities to use photovoltaics. DOE provides funds to operate Photovoltaics for Utility Scale Applications, which tests the performance of new systems in a utility setting. Through another program, DOE helps to buy down the cost for utilities purchasing photovoltaic systems. DOE also funds the Design Assistance Center at Sandia National Laboratory, which provides information and technical assistance to utilities and other entities to design photovoltaic projects.

DOE's budget for photovoltaics was reduced by 29 percent, from \$84.6 million in fiscal year 1995 to \$60.1 million in fiscal year 1996. Specific reductions include (1) 57 percent, from \$14 million to \$6 million, to buy down the cost for utilities purchasing photovoltaic systems; (2) 57 percent, from \$10 million to \$4.3 million, to provide information and technical assistance to federal agencies, utilities, and other entities to design photovoltaic projects; (3) 49 percent, from \$5 million to \$2.6 million, to support the development and testing of new equipment designs and applications; (4) 33 percent, from \$3 million to \$2 million, to support

international marketing; and (5) 23 percent, from \$11 million to \$8.5 million, to fund the Photovoltaic Manufacturing Technology Project.

According to DOE officials, the effect of these reductions on market expansion programs will be magnified because in most cases the cost-shared contributions from utilities and industry will also be reduced. Furthermore, according to the DOE program manager, the result of this reduction is that efforts to improve cost-effectiveness in manufacturing are slowing down and the goals are being extended.

EPRI's solar budget has declined 75 percent, from \$5.7 million in 1993 to \$1.4 million in 1996. EPRI is continuing to fund some thin-film research and is assisting a manufacturer in the marketing of its photovoltaic concentrator technology that was developed with past EPRI assistance.

DOE officials do not believe that industry will pick up the slack from DOE's reductions, since only a few of the 19 U.S. photovoltaic manufacturers are profitable or close to making a profit. Furthermore, according to an industry spokesperson, DOE's 23-percent reduction in the Photovoltaic Manufacturing Technology Project will affect the manufacturers' initiatives. Some of the manufacturers have reinvested their revenues and have been able to attract venture capital to develop new automated processes and equipment for manufacturing photovoltaic modules on the expectation that the government would follow through in assuming some of the technology development risk.

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## Electricity Storage Technologies

Electricity storage technologies store electrical energy for stationary or transportation applications and can absorb or release energy upon demand. Advanced batteries for electric vehicles and superconducting magnetic energy storage are examples of such technologies that could provide economic and environmental benefits. EPRI officials believe that electricity storage will become increasingly important as utilities are deregulated and more entities are involved in electric power.

The U.S. Advanced Battery Consortium, which includes DOE, automakers, battery manufacturers, EPRI, and several utility companies, is spearheading efforts in this country to develop advanced batteries whose performance, weight, durability, and cost will enable electric vehicles to compete in the marketplace. Begun in 1991, the consortium has funded the development of several batteries expected to be in production in 2000 and beyond. For stationary applications, DOE and EPRI have agreed to each sponsor the



development of a transportable battery storage system that could be moved to utility sites to demonstrate and quantify the extent of reliability improvements, network stability enhancements, and other system benefits. Several companies have bid on the development contract. Planned completion of the project is scheduled for mid-1997. According to DOE, completion of the project is questionable if funds are cut further.

Superconducting magnetic energy storage is the only storage technology that stores electricity as electricity. It is about 90 percent efficient, compared to other storage systems that are about 70 percent efficient. It uses a large coil of conductor maintained at a superconducting low temperature. DOE and EPRI funded early research in the 1980s. DOE-funded Los Alamos National Laboratory was involved in the research. Several U.S. companies have also pursued the technology. EPRI has proposed the construction of a pilot plant for a system that would enable greater utilization of existing transmission capacity and forgo the need for the construction of additional transmission lines. The estimated cost of the project is \$80 million, but funding for this project has not been found. EPRI's only active project is a cooperative program with the Navy under which the Navy is seeking to identify potential applications in the military and EPRI is doing the same for utilities and private industry.

The Department of Defense has provided some funds for a smaller project designed to show how superconducting magnetic energy storage can meet the specific needs of a utility. The project would provide stored power to Anchorage Municipal Power & Light for a short period if a turbine plant went down until the utility got backup power going from its reserve. Full funding for this project has not yet been secured, and continued Defense funding is unlikely unless a concrete military application is identified.

A limited amount of research is ongoing at several national laboratories and universities to develop flywheels and ultracapacitors. The Department of Defense and DOE are funding these efforts. Flywheels, which involve storing energy in a heavy wheel spun very fast, potentially have both stationary and transportation applications. Ultracapacitors also enable the rapid storage and release of large amounts of energy. Ultracapacitors are electrochemical double-layer energy storage devices that use electrodes with a very high surface area per unit volume; they have potential transportation applications.

DOE's budgets for transportation and stationary applications have declined 17 percent, from \$34.5 million to \$28.6 million. Specifically, DOE's budget

for transportation applications declined 7 percent, from \$28.7 million in fiscal year 1995 to \$26.6 million in fiscal year 1996. However, some major shifts were made within the program, specifically shifting funding from the advanced battery program to high-power energy storage for vehicles. For example, DOE's funding for high-power energy storage for hybrid vehicles was increased from \$470,000 to \$9.6 million. Hybrid vehicles use piston engines, gas turbines, or fuel cells to produce electricity that is stored and used to run the vehicle. Meanwhile, DOE's funding for the advanced battery consortium was reduced 43 percent, from \$26.4 million to \$15.1 million. Several utility consortium members have also dropped out or are considering dropping out because of cutbacks in their R&D programs. To accommodate these cuts, the program is narrowing to funding only one mid-term and one advanced battery technology, deemed the most promising for meeting the consortium's goals. According to the DOE program manager, steady funding at this level will be needed for the next 3 to 4 years to continue developing these technologies.

Finally, the program continues to fund nearly \$1.9 million in exploratory and applied research, most of which is at the national laboratories and universities. According to the head of the exploratory research program, the program has been cut back significantly because the cooperative R&D agreements have been eliminated.

DOE's stationary energy storage program budget has decreased 66 percent, from \$5.8 million in fiscal year 1995 to \$2 million in fiscal year 1996, and EPRI's budget has decreased 67 percent in the past 2 years, from \$6 million to \$2 million. As a result, neither EPRI nor DOE is funding pilot projects to demonstrate newly developed superconducting magnetic energy storage technology. EPRI and DOE have funded separate stationary battery storage projects, but neither has funds to explore the demonstration and testing of new advanced batteries in stationary utility applications. DOE focuses on benefits to the nation's utility networks that can result from storage systems employing currently available batteries.

# Major Contributors to This Report

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Resources,  
Community, and  
Economic  
Development  
Division, Washington,  
D.C.

Bernice Steinhardt, Associate Director  
Peg Reese, Assistant Director  
James M. Kennedy, Evaluator-in-Charge  
Casandra D. Joseph, Adviser

---

San Francisco  
Regional Office

Donald J. Porteous, Senior Evaluator  
Margie K. Shields, Senior Evaluator

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# Related GAO Products

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Electric Vehicles: Efforts to Complete Advanced Battery Development Will Require More Time and Funding (GAO/RCED-95-234, Aug. 17, 1995).

Electricity Supply: Consideration of Environmental Costs in Selecting Fuel Sources (GAO/RCED-95-187, May 19, 1995).

Electric Vehicles: Likely Consequences of U.S. and Other Nations' Programs and Policies (GAO/PEMD-95-7, Dec. 30, 1994).

Fossil Fuels: Lessons Learned in DOE's Clean Coal Technology Program (GAO/RCED-94-174, May 26, 1994).

Electricity Supply: Efforts Under Way to Develop Solar and Wind Energy (GAO/RCED-93-118, Apr. 16, 1993).

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

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