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The Electric Power Research Institute

Chauncey Starr

Growing awareness of research needs, coupled with the threat of federal intervention, galvanized the leaders of the electric utility industry in the early 1970's. By January 1973, the Electric Power Research Institute (EPRI) was in business—in spite of skepticism from inside and outside the industry.

As EPRI's first president, I began with a budget of $61 million pledged by the industry for 1973 and imputations from many quarters that EPRI was a sham, that the utility industry was not serious about its technical responsibilities, and that this new entity would not get anywhere. This early history of the institute and of the legislation proposed by the Senate Commerce Committee as a result of the 1965 blackout in the Northeast have been recounted elsewhere (*1*).

National investments in research and development (R & D) are indirectly provided by the public through taxation, cost of goods, or direct contribution. EPRI is supported through the cost of electricity and represents a novel form of institutional intermediary between the consuming public, the utilities, and the researchers. Because many scientists in fields outside of energy research have had little contact with EPRI, I shall describe its scope, organization, and philosophy.

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Organization

EPRI is a nonprofit organization whose purpose is to manage a coordinated national R & D program for the electric power industry. EPRI selects and funds research projects designed to develop or improve technologies that will help the utility industry meet present and future electric energy needs in environmentally and economically acceptable ways. EPRI's activities are coordinated with those of government agencies, individual utilities, manufacturers and vendors, and comparable organizations in many other countries.

Of the roughly 3000 electric utilities in the United States, almost all the largest are voluntary supporting members of EPRI. In 1982, the 571 members were 160 investor-owned utilities, including their affiliates and service organizations; 177 municipal or regional government utilities; 232 rural electric cooperatives; and two federal systems—Tennessee Valley Authority and the Bonneville Power Administration. About 150 nonmember utilities also contributed some measure of support. Collectively, the contributors represent about 70 percent of the total electricity generated in the United States. EPRI also has 16 foreign utility associates with which information is exchanged.

In 1982, members paid 0.0236 cents per kilowatt-hour of electricity sold in 1980, or about 0.3 percent of member utilities' gross revenue, of which EPRI manages 80 percent and utilities retain and manage 20 percent for specific R & D needs. EPRI had a total budget of about $300 million in 1982, of which $260 million covered external R & D contract activities. Aside from membership payments from the Tennessee Valley Authority and Bonneville Power Administration, no federal funds come to EPRI, although many joint programs with federal agencies have been undertaken.

EPRI's primary areas of research are organized into six technical divisions (Fig. 1).

Since its founding, EPRI has initiated more than 1800 research projects (*2*). There are currently about 1400 active R & D projects under EPRI management. The 5-year funding plan (1982 to 1986) for these projects totals $1.8 billion. Cofunding and cost-sharing by contractors and other organizations increase

that figure to about $2.8 billion. Near-term R & D (industrially usable results within 10 years) accounts for approximately 60 to 70 percent of EPRI's program funding; intermediate R & D (10 to 25 years until industrial availability), 25 to 30 percent; and long-term R & D (25 years or more), about 5 percent. EPRI's role is to fill a void between the immediate operating problems handled by utilities and vendors and the very long-term scientific R & D appropriate for federal funding. The broad objective established by the utility industry is to improve the quality of service to consumers. More than improvements in technology must be considered; consumers' many economic, environmental, and social values eventually influence utility perceptions of their operating needs and priorities. Consequently, EPRI's technical program reflects these perceptions (Fig. 2).

Summary. The Electric Power Research Institute, now 10 years old, was formed by the electric utility industry in response to the threat of federal legislation to create a government agency, funded by a 1 percent tax on utility gross revenue, to undertake research and development. Legislation was proposed in the early 1970's by the Senate Commerce Committee as a result of the massive 1965 Northeast blackout and subsequent public criticism. In March 1972, the Senate was persuaded to give the electric utility industry 1 year to establish an industry-managed and supported substitute to the proposal. This article describes the subsequent history and the program today.

Prior History

In undertaking a comprehensive program to develop and apply advanced electricity technologies EPRI would have to use effectively the existing national institutions that could assist. Universities and engineering schools have always carried out basic research, and federal agencies have been the principal supporters of the very long-term programs, such as fission, fusion, coal conversion, and solar technology through the Atomic Energy Commission, the Office of Coal Research, the National Science Foundation, the Department of the Interior, the Department of Energy, and others.

The utilities' near-term technical needs had been met traditionally by the large equipment vendors, most established a century ago when inventors like Edison, Westinghouse, and others set up engineering and manufacturing firms to serve the fledgling electric light and power companies. By the turn of the century, the larger private vendors had also established their own R & D laboratories. Not only did some of that research turn out to be first-rate science (as, for instance, that of Nobel Laureate Irving Langmuir and William Coolidge at General Electric), it also offered an alternative career path for many scientists.

By the 1960's, the electrical industry was beginning to face problems, notably in the environmental area, that began to strain the resources of even the largest vendors. At the same time the utility industry was reaching a plateau in new electricity generation technology. Expectations for improvements in fossil fuel generation efficiency leveled off, much more work with nuclear fission was needed, and exotic concepts, such as fusion, loomed as tremendously long-range and high-risk undertakings. Vendors could simply not be expected to make the huge investments needed in some areas. In addition, equipment had not been developed that could at once conform to the mounting number of environmental regulations and perform reliably.

During this period, the utility systems were getting larger and more tightly interconnected. The vendors continued to supply the hardware and to give counsel on system interconnections, but improvement of the technical performance of the systems—their overall reliability—was becoming more and more the responsibility of the operating utilities.

It is important to recognize that utilities must operate differently from private industry. Utilities are local or regional public service monopolies, each independently managed and state regulated if investor-owned, or politically regulated if publicly owned. Because rates are closely controlled and usually adjusted to minimize consumer costs, it is difficult for even the largest utilities to justify to stockholders especially the costs and risks associated with any major new development. Regulation seriously diminishes the incentives to improve performance that motivate private business.

By the late 1960's, the need for new R & D efforts was recognized by both the industry and the Senate Commerce Committee. The implications of a federally managed R & D program alarmed the industry leaders for many reasons, but underlying their alarm was a fundamental concern—that research carried out by organizations that are not under the pressure of meeting an operational need tends to be open-ended. At the federal level, there are rare examples of effective applied research. The activities of the National Aeronautics and Space Administration represent a noteworthy example of the successful transfer of federal agency research to industry for commercial purposes; success was based on a carefully managed relationship and selection of research areas (*3*).

Even in the best of circumstances, as with narrowly focused research groups

Advanced Power Systems Division
- Clean Gaseous Fuels
- Clean Liquid and Solid Fuels
- Engineering and Economic Evaluation
- Fusion Power Systems
- Geothermal Power Systems
- Power Generation
- Solar Power Systems

Coal Combustion Systems Division
- Air Quality Control
- Coal Quality
- Desulfurization Processes
- Fluidized Combustion and Alternate Fuels
- Fossil Plant Performance and Reliability
- Heat, Waste, and Water Management

Electrical Systems Division
- Distribution
- Overhead Transmission Lines
- Power System Planning and Operations
- Rotating Electrical Machinery
- Transmission Substations
- Underground Transmission

Energy Analysis and Environment Division
- Demand and Conservation
- Ecological Studies
- Environmental and Occupational Health
- Environmental Physics and Chemistry
- Economic and Environmental Integration
- Supply

Energy Management and Utilization Division
- Electric Transportation
- Energy Storage
- Fuel Cells and Chemical Energy Conversion
- Industrial Applications
- Residential and Commercial Applications

Nuclear Power Division
- Analysis and Testing
- Chemistry, Radiation, and Monitoring
- Code Development and Validation
- Developing Applications and Technology
- Materials and Corrosion
- Risk Assessment
- System Integrity
- System Performance

Fig. 1. EPRI research and development program.

within commercial enterprises, the development of useful products from research is an uncertain process. When the research customers are disparate units providing public services, as in health, transportation, housing, and energy, technology transfer becomes a severe problem. This is particularly true of the utility industry, which consists of many separate organizations, with different geographical and institutional problems, separate public regulatory mechanisms, and different equipment, fuel, and customer mixes.

Although the Electric Research Council (ERC), established in 1965 by utility-industry trade associations, was projecting the need for $32 billion (an average of more than $1 billion per year, 1971 dollars) to sponsor a national R & D program for the remainder of the century, there was no consensus among the utilities in the early 1970's as to whether a coordinated effort to address the industry's needs over a long period would be of value. At the time, about $7 to $10 million was being expended annually on ERC studies. It took extraordinary efforts on the part of a few farsighted utility leaders with support from the National Association of Regulatory Utility Commissioners (NARUC) to push through the new R & D institution. NARUC, which oversaw many of the important functions of the regulated industry, laid the way for allowing the utilities to recover the cost through rates charged to customers.

A key objective in establishing EPRI was the pooling of resources. Although the cost per participant would be relatively low, pooling would permit large-scale programs to be carried out. In addition, it was understood that the equipment manufacturers' and vendors' traditional R & D role would be vigorously maintained, and perhaps expanded. How to prevent competition between EPRI and other organizations, and how to coordinate resources of the nation's scientists and engineers, national laboratories, universities, federal agencies, and others were the major issues the new organization had to face.

Philosophy and Function

Once EPRI was inaugurated, it became important to build a critical level of support from the participating utilities to recruit a technical research staff and to establish a sufficient breadth of R & D programs to ensure results. Because support is voluntary and the community so diverse, continuous efforts must be made to maintain and increase support. The contributions to the EPRI program represent R & D costs to the utilities, and as such they form part of the operating expenses that must be approved by state public utility commissions or other regulatory bodies. This relationship makes EPRI a quasi-public trustee, so that from the beginning, the institute had to establish itself as a reliable technical resource to both utilities and public bodies, through emphasis on objectivity, technical thoroughness, and intellectual integrity.

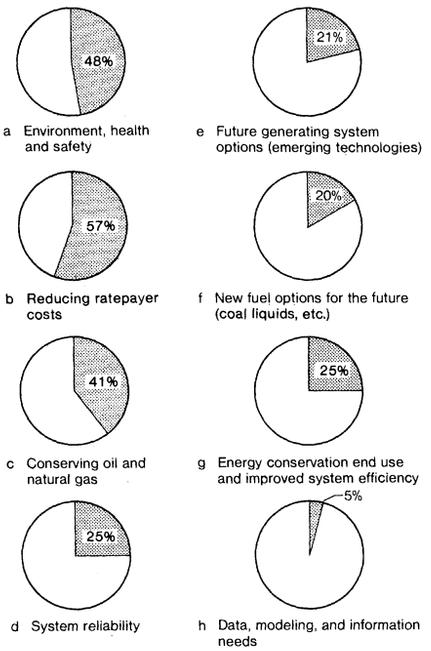

Fig. 2. Percentage of EPRI research and development program by program objective.

To use its funding most effectively, EPRI staff realized that it was important to draw on expertise and facilities in the universities and in manufacturers' and government laboratories, as well as on the resources of the utilities. To duplicate such facilities would take billions of dollars and at least a decade. EPRI thus plans and manages R & D contracts with a range of contractors (Fig. 3). In assembling the technical staff to manage these contracts, the assumption was made that professionals in technical fields could be taught the art of project management more easily than a professional manager could be taught technology. As a result, the EPRI administrative functions have been carefully tailored to serve the needs of scientists and engineers.

In addition to contracting R & D, EPRI has also established seven specialized test centers that are managed under long-term contract: the Nondestructive Evaluation Center in Charlotte, North Carolina; the Battery Energy Storage Test Facility in Hillsborough Township, New Jersey; the Coal Cleaning Test Facility in Homer City, Pennsylvania; the Transmission Line Mechanical Research Facility in Haslet, Texas; the Underground Cable Test Facility in Waltz Mill, Pennsylvania; the High Voltage Laboratory in Pittsfield, Massachusetts; and the Emissions Control and Test Facility in Denver, Colorado. These centers demonstrate, test, and evaluate new techniques and hardware, train personnel, and assess the reliability, efficiency, and performance of new components and systems.

The substantial changes in the electric utility industry in the last decade—fuel sources, finances, public perceptions, health and safety issues, rate structures, growth forecasts, and so on—have required that EPRI R & D provide a mix of current technology improvements, on which utilities must depend for several decades, stability in long-term projects, and flexibility in handling emergencies or new problems. For example, after the 1979 Three Mile Island accident, the Nuclear Safety Analysis Center was formed to provide the utilities with technical advice on operational issues; although generic reactor safety has always been a central part of EPRI's nuclear programs.

As EPRI has evolved, its program emphasis has broadened from chiefly long-term projects to include those aimed at achieving relatively near-term results. There were a number of fundamental reasons for this: the oil crisis, which quickly raised fuel costs; a need for energy conservation and increased end-use efficiency; and the increasing cost of new capital, which made it economic to extend the life of older plants and equipment. Some important scientific and technical issues also brought about this change. The temperature and pressure limits reached by increasingly sophisticated utility systems and the efforts directed at cleaning up undesirable effluents affected system performance and lifetime, and problems at the frontiers of basic science now occur with increasing frequency—problems which typically did not often arise in older generating equipment because their smaller size permitted much more engineering conservatism to be built into them. Thus, the industry faced a set of generic problems that needed near-term remedies as well as fundamental scientific work best carried out in a university-like situation.

EPRI contracts out about 9 percent (about $25 million per year) of its R & D to the university community (Fig. 3).

EPRI does not support pure science directly but does support exploratory and applied scientific research in materials, corrosion, basic electrochemical problems, and studies of environment, and in epidemiology, geology, meteorology, the basic character of coal, and so on. There is no doubt that some of the results of these studies are or will be of importance to the scientific community at large.

EPRI reports on current projects are being produced at about the rate of two a day, or about 700 per year. These reports flow steadily to the utility users, universities, vendors, architect-engineers, and government agencies (*2*). In the past few years, many hardware developments, computer models, and codes have found increasing utility applications, with well-documented financial benefit. The growing utility use of EPRI results clearly shows that in the long run, the cumulative benefits of the R & D program will be large in comparison with the cost. Each member utility has access to the results of a $300 million annual R & D program for a small percentage of this cost. In economic terms, this form of R & D structure appears to be successful.

A question has been raised from time to time as to why EPRI is not actively and aggressively involved in legislative and regulatory issues, particularly those which pertain to electric power, energy supply, and environmental matters. EPRI does not conduct lobbying activities for three reasons: (i) to maintain respect as an objective and credible technical organization, (ii) to maintain its nonprofit tax exempt status, and (iii) because supporters are well served by other organizations. At the invitation of legislative and regulatory representatives, however, EPRI staff do occasionally provide information or testify on technical matters.

The Advisory Structure

EPRI draws advisors from industry, federal agencies, foreign utilities, and public and regulatory groups for its task forces in the major areas of the R & D program (Fig. 1). In managing R & D projects in 40 major program areas, EPRI interacts with this advisory structure, to identify broad industry R & D needs, suggest appropriate balance and emphasis, guide technical policy, and help transfer results to industry.

The broadest group, the 25-member advisory council appointed by the EPRI board of directors, provides a cross section of public views on EPRI. NARUC has seven regulators on this council, and

	Percent
Industrial, commercial	62
Consultant	13
University	9
Utility	7
Architect, engineer	6
Government labs	3
Total	100

Fig. 3. Funding by contractor type.

EPRI management use the council to review and comment on key issues and priorities. It was this council that was instrumental in broadening the program on specific environmental issues that were just becoming of public concern.

To maintain relevance, each major element of the permanent EPRI technical staff has a counterpart advisory group made up of full-time employees of electric utilities. There are 25 chartered industry advisory groups, with 10 to 25 members, who review all EPRI-managed projects. Thus, the projects and programs must be continually justified by the EPRI staff in terms of both near-term and long-term applicability and end-use value. Technology transfer, a common problem between science laboratories and users, generally takes place continuously, with operating utilities volunteering as the test and demonstration centers for large-scale developments.

The top industry group, appointed by EPRI board of directors, is the research advisory committee, which reports to and advises the president and board. At the next level, the directors and senior staff of each of the six technical divisions are advised by a divisional committee. Finally, advice at the department and program levels is provided by 18 task forces. This structure numbers about 600 advisors. Members are appointed by the next higher advisory level, selected from candidates nominated by individual utilities.

Through its chairman, each task force may appoint one or more subgroups to help task force responsibilities. These are not chartered groups, and the members, whose terms are not fixed, can be chosen from universities, national laboratories, and equipment manufacturers, as well as electric utility organizations. The cumulative membership of such groups is approximately 500, some of whom serve also on task forces.

As a general EPRI policy, appointments to advisory committees and task forces are normally for 3 years and are not renewable. In this way, the number of people who become involved in the selection and direction of EPRI's R & D program grows steadily. These people, who are aware of the research going on, may subsequently become active proponents of its application.

This extensive advisory structure has been surprisingly beneficial in providing two-way communication with the utility industry. It has also maintained a continuous and constructive critique of the R & D program, forcing the EPRI staff to continually justify decisions. Although the final program authority resides in EPRI's top management and its board, the recommendations of the industry advisors are very influential. The balance between judicious review and flexible, rapid response is difficult to achieve in any R & D organization, and the industry review process at EPRI is more extensive than that of any research organization or government agency that I know of. This elaborate advisory and review structure can draw heavily on the time of EPRI's professional staff as well as slow EPRI's response time to new or changing R & D situations. For this reason, EPRI's senior management retains separate budgetary flexibility for initiating studies or early work on projects still in the review process.

The success of EPRI in contributing to the performance of the utilities is difficult to measure quantitatively. The rough estimate by utilities of their annual savings from EPRI research now totals about $700 million annually. This does not include the intangible savings from operational improvements arising from information exchange and new methodologies, and the R & D pipeline of EPRI projects is only now approaching a steady output.

EPRI Contractors

EPRI deals with the full spectrum of R & D participants—large and small equipment manufacturers, commercial research and consulting organizations, architect-engineers, universities and their faculty members, and private consultants. It has also engaged in many joint projects with national and foreign government agencies and private companies. In addition, EPRI has information exchange agreements with foreign institutions in a dozen nations, including one with the Soviet Union on biological field effects.

The basic EPRI contract principles are

similar to those followed by government agencies, such as the Department of Energy, with some variations. R & D programs operate on 5-year plans that are updated annually. Contracts are primarily for cost reimbursement, with an agreed upon task statement, R & D plan, budget, performance schedule, and reporting requirements. The basic terms have seldom prevented contracts from being fulfilled, and disagreements appear to be diminishing in number.

The most common area of difficulty with new contractors is the subject of proprietary rights. EPRI wishes to encourage contractor participation and eventual commercial development. Therefore, EPRI's basic constraints are few: (i) EPRI funds must not be used to create or strengthen a monopoly resulting from ownership of proprietary rights obtained with EPRI support, and (ii) EPRI will negotiate the disposition of proprietary rights on the basis of the contribution of its funding. These terms are often the most arduous to negotiate with new contractors because of the understandable differences in perspective on the values being contributed.

EPRI encourages investigators to publish final results in professionally reviewed journals but does ask that work in progress not be published without agreement and review by EPRI staff before submission for publication. As a practical matter, most investigators are usually urged to present progress papers at professional meetings as well as to publish final papers. In case of a fundamental disagreement between EPRI and the contractor, the contractor may publish independently if no reference is made to EPRI's sponsorship. Publication issues have not to date been a problem.

One of EPRI's objectives is to increase the total amount of electricity R & D by supplementing, rather than replacing, vendor R & D. To do this, EPRI has sought to stimulate its contractors to contribute as partners in most R & D in return for an enhancement of their proprietary and leadership positions. In many projects, even the largest companies hesitate to provide the critical funding needed to proceed. EPRI encourages them to make their investment by its participating. Of course, with some R & D contractors, such as universities, jointly funded projects may not be feasible.

The EPRI Model: Is It Transferable?

Is EPRI a viable form of industrial R & D institution more suited for the U.S. private sector than the government agency role that has become common in the past few decades? And, if so, which segments of the private sector are most suited for this kind of organization? The utility industry was well suited for the experiment in R & D management and the pooling of resources that EPRI represents. The industry has a long-term R & D perspective and is bound both by its responsibilities and by regulation to have a long planning horizon. Furthermore, individual utilities generally do not face competition from other electricity suppliers, particularly with regard to proprietary rights to technology. These characteristics are also found among gas utilities which, later in the 1970's, followed the EPRI pattern to form the Gas Research Institute (*4*). The two organizations have many common technology interests and work cooperatively, in spite of the active sales competition between the two energy forms in the marketplace.

Do other industries have a common interest in developing advanced technologies basic for their future progress? I believe that most do. Even very competitive companies are now pooling funds to support research. For example, the not-for-profit Semiconductor Research Cooperative supports basic research to improve the competitive status of U.S. technology in integrated circuits. On the West Coast, this industry also supports the Center for Integrated Systems at Stanford University. In both instances, the research is focusing on basic phenomena, material behavior, and new techniques. The companies will continue to compete in the application of such knowledge in the development of new devices or systems. A similar arrangement is the Chemical Industry Institute of Toxicology founded in 1974 to study toxicology issues generic to that industry. Even among companies eager for competitive technical advantages there is still room for shared efforts. The automobile and oil companies cooperate on research in air pollution, lubrication, and so on (*5*).

The voluntary nature of such industry pooling requires that the participants be convinced that there is a shared value that merits their contributions. This shared value arises from the fact that superior scientists are limited in number, that the research is expensive and the outcomes unpredictable, that effective results require long-term support, and that skillful research managers are also scarce. Only a few companies, such as IBM or Bell Labs, can afford this by themselves. The potential for shared values is present in most U.S. industries. Competition is, of course, maintained in product development, manufacturing, and marketing.

An awareness of the benefits from pooling resources and sharing results is gradually developing especially in industries facing international competition from countries that have encouraged their companies to conduct joint technical development. The alternative to industry initiatives in an EPRI pattern is government-sponsored programs in federal agencies. The antitrust issues, as perceived by company lawyers interpreting the current attitudes of the Justice Department, have tended to reinforce the habit of turning over industrywide problems to the government. However, the difficulties in accommodating to antitrust issues may be considerably less than those of conducting useful industry-oriented research in a government setting. History has shown that, with a few exceptions, federal programs have been ineffective for promoting commercial developments. Federal agencies serve Congress, and the industrial user is usually aided only indirectly. Further, the whimsicalities of the annual congressional budget manipulations tend to interfere with the content and continuity of even worthwhile projects. Because congressional committees have not demonstrated a competence to direct R & D programs, the private sector should consider a structure like EPRI for directing the applied science and technology crucial to the efficiency and international competitiveness of U.S. industry.

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