A Special Issue

EPRI's 20th ANNIVERSARY

ELECTRIC POWER RESEARCH INSTITUTE

EPRI JOURNAL

JANUARY/FEBRUARY 1993

EPRI JOURNAL is published eight times each year (January/February, March, April/May, June, July/August, September, October/November, and December) by the Electric Power Research Institute.

EPRI was founded in 1972 by the nation's electric utilities to develop and manage a technology program for improving electric power production, distribution, and utilization.

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Growth in Size and Purpose

I was fortunate enough to join EPRI in its first year of operation. The handful of us from those early days under Chauncey Starr's leadership had a feeling we were involved in something special—something that would make a real difference to the industry and society. But I had no idea how rich, challenging, and fulfilling the Institute's work would be. We discovered quickly that the utility industry, in its growing complexity, would stretch us to the limit, that changes and crises in the industry would require more expertise in more areas than we had anticipated. As a result, we grew—both in size and in purpose. And Chauncey's insistence on acquiring the best minds and talent from every field of research ensured that we met the challenge.

In effect, we were working through a central truth of modern society; change is very much the natural order of things. The accelerated pace of change in science and technology really makes it impossible for individual utilities to stay abreast of and integrate all the developments and opportunities that arise. This is one of the reasons an organization like EPRI makes sense, and I think there will be a continuing effort in our industry, as well as in others, to look for collaborative opportunities, where costs and benefits can be shared.

We also see fundamental changes coming for the industry itself. The ramifications of some of these are clear, and the Institute has been careful to prepare the technological groundwork utilities will need to cope with them. Other changes are understood less clearly. These will present some of EPRI's major challenges in the coming years. Rest assured that as we enter our third decade of service to the industry, we will bring the best of our capabilities to bear on these issues.

I have been proud to be able to lead this organization in recent years, and I'm particularly gratified to have had a hand in many of its successes. A number of EPRI's accomplishments are highlighted in this special anniversary issue of the *Journal*, along with our history and some speculations on the future. I hope what we tell and show you here will help you know us better. And I hope you will join us in celebrating this year not just as our twentieth birthday but also as the beginning of a new decade of fruitful collaboration.

Richard E. Balzhiser
President and Chief Executive Officer

DELIVERING VALUE

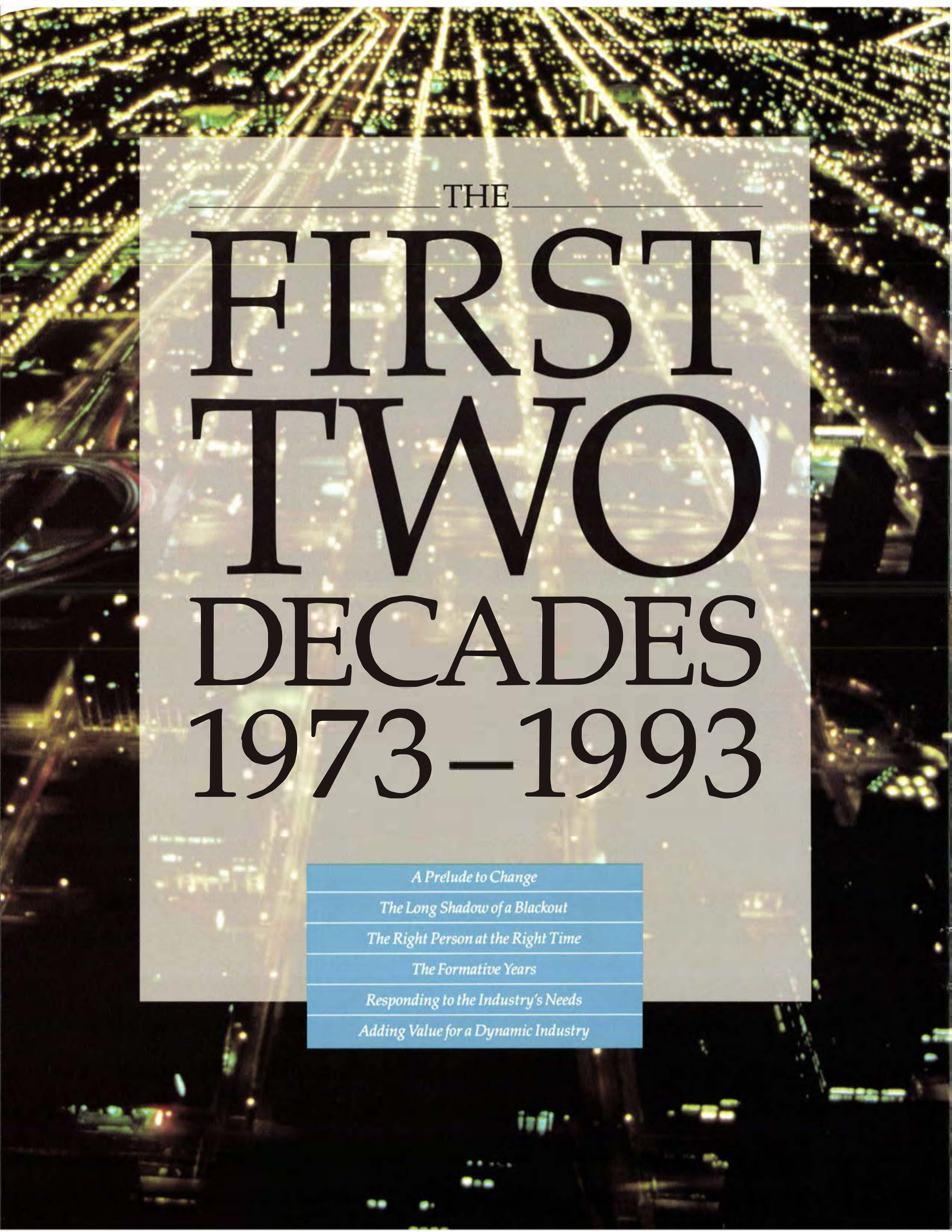
EPRI 20

1973 • 1993

EPRI JOURNAL

Volume 18, Number 1   January/February 1993

A Special Issue



THE FIRST TWO DECADES 1973–1993

A Prelude to Change

The Long Shadow of a Blackout

The Right Person at the Right Time

The Formative Years

Responding to the Industry's Needs

Adding Value for a Dynamic Industry

A Prelude to Change

Glimpses of an industry future very different from the past spark the beginnings of cooperative research.

Throughout most of the 1960s, the decade before the one in which EPRI was established, the electric utility industry grew at a rate that was virtually unequaled in its then less-than-100-year history. Sustained economic and population expansion fueled a rapidly rising demand for electricity. Some utilities were experiencing demand growth of as much as 8% a year and were building new and bigger power plants to keep up. Massive, multiunit coal-fired plants were being built near mines, with high-voltage transmission lines carrying the power back to urban centers. Gas turbines were brought into New York harbor on barges to help meet power demand in the country's largest metropolitan area. The commercial use of nuclear power for generating electricity was fast approaching, after the success of a series of small, government-funded demonstration reactors.

As individual power systems grew and expanded, utilities began to provide interconnections between them and to forge operating agreements for limited power exchange and backup. Transmission circuits of higher voltage rating were built into existing networks to move larger amounts of power over longer distances. At generating plants, turbine and generator ratings climbed in step with the higher steam pressures and temperatures of bigger boiler units.

But the 1960s was the last of many decades in which the real price of electricity declined as larger generating systems produced ever more kilowatt-hours from a given amount of fuel. In the 1970s, an extended period of rising fossil fuel prices driven by oil market gyrations combined with a broad wave of price inflation, economic recession, and major overruns in the cost of constructing new power plants to reverse the falling cost of electricity. Another important factor in the reversal was the cumulative cost impact of new environmental requirements that often resulted not only in higher capital costs for plant retrofits and new units but also in impaired operating efficiencies.

Traditionally, the major vendors (such as General Electric and Westinghouse) and architect-engineering firms not only supplied power plants and transmission and distribution equipment, they also performed much of the early utility power system engineering. Their volume of business justified substantial corporate R&D programs to ensure that they maintained their market share and profitability during a period of rapid growth in generating capacity.

Longer-term research or research on advanced concepts was done, if at all, under government-sponsored programs, such as that of the Atomic Energy Commission. Indeed, the AEC was the principal sponsor of energy-related research in the 1960s, and most of that research, not surprisingly, was in nuclear power development, including work on advanced technologies like the fast breeder reactor and nuclear fusion.

Meanwhile, in the world of utility operations—which was still based mainly on fossil-fuel-fired steam and hydroelectric generation—the pressure and temperature limits of available materials and systems were becoming apparent. As a result, utilities began to think that perhaps a plateau had been reached in the development of the technology they relied on to fulfill their obligation to reliably supply the electricity that customers demanded. In the 1970s, the traditional objective of building larger and more-efficient generating plants gave way to the deployment of emissions control systems mandated by a rapidly developing environmental legislative and regulatory agenda.

By the 1970s, too, the new rise in the real cost of electricity slowed the growth in electricity consumption and led to a decrease in orders for boilers and turbine generators. Also, the development and integration of environmental control technology, particularly flue gas scrubbers, fell outside the capabilities of the traditional vendors, forcing utilities to pay closer attention to their technological future. Utility engineers increasingly found themselves with operating responsibilities for complex systems in which only the individual components—not the overall system—had been engineered for high reliability.

The earliest presentation of the idea that the electric utility industry needed and should have its own R&D organization came in a 1954 paper given at a meeting of the American electrical engineering professional society. The two men who presented the paper were, coincidentally, from the area that would later become the location of EPRI's headquarters. William Lewis was a consulting electrical engineer in Palo Alto, California, and Jesse Hobson was the director of the Stanford Research Institute (now SRI International).

Little came of their gadfly effort until 1963, when their idea was picked up by Joseph Swidler, chairman of the Federal Power Commission. In a speech to the Edison Electric Institute (EEI), the trade association of investor-owned utilities, Swidler suggested that there was a serious need for a permanent, organized research program.

The electric utility industry would spend approximately $140 billion over the next two decades, Swidler projected, most of it for "equipment of more advanced design than anything that has yet been built. . . . Adequate research and development is the best means of ensuring that the industry and its consumers will get their money's worth for the vast sums which the industry will invest." He noted that earlier in the year President John Kennedy had ordered an interdepartmental review of the allocation of federal R&D spending in the energy field—spending that focused almost entirely on the development of nuclear energy. Although Swidler thought that this review held "great potential importance for the future of the electric power industry," he felt that utilities still needed to organize and support long-range research on their own.

Despite growing acknowledgment of the need for research that was beyond the means or interests of electrical equipment manufacturers, utilities hesitated to translate their interest into a planned program. But after a couple of years of persistent prodding from Swidler, something happened that, for the time, was remarkable. The private (investor-owned) and public (municipal and rural co-op) sectors of the utility industry, which had been bitter rivals off and on since the 1920s, joined with the government power agencies, including the Tennessee Valley Authority, the Bonneville Power Administration, and the Department of the Interior, to create the Electric Research Council (ERC).

Organized in the spring of 1965, the ERC brought together all segments of the electric utility industry to sponsor cooperative research of industrywide importance. The ERC's R&D Goals Task Force prepared a comprehensive plan (see sidebar) for a utility industry research program that focused mainly on intermediate and long-term needs. Some modest research projects were initiated with the limited funding that was then available. (Early attempts to raise funds for individual projects on an ad hoc basis had fallen far short of the perceived needs.) The ERC's early projects were largely managed by EEI (which had run a limited research program since the 1950s for the investor-owned sector) and conducted by individual utilities or university professors because the ERC itself had virtually no staff.

THE LONG SHADOW OF A BLACKOUT

With concerns over system reliability prompting government action, utilities draw up plans for their own collaborative R&D organization.

Later in the same year that the ERC was set up, an event occurred that shocked the nation and the utility industry. It would also profoundly affect the ERC's research agenda and have a major impact on the future of electricity-related R&D. On November 9, 1965, a blackout plunged New York City and much of the northeastern United States and eastern Canada into darkness for 12 hours. The blackout occurred when a fault-current relay opened at Niagara Falls, overloading other transmission lines and creating a cascading instability. Transmission system interconnections were not adequately protected against such a disturbance and allowed the instability and resulting blackout to spread over a wide area.

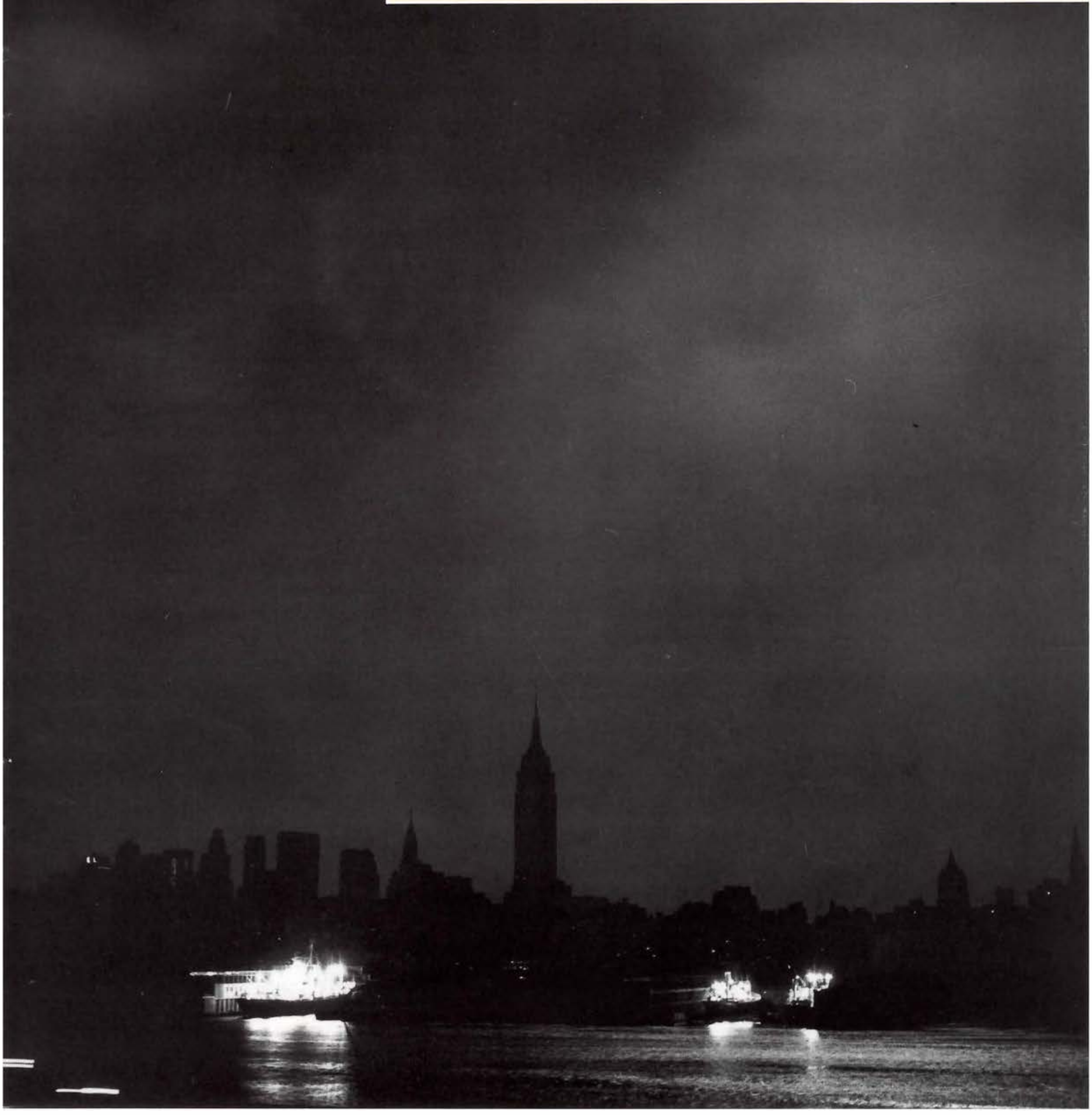
Although power was restored in affected areas by the following day, the 1965 blackout cast a shadow over the electric utility industry for many years. Millions of dollars worth of manufacturing and economic production was idled, public services were paralyzed, and people's lives were jeopardized. A second blackout two years later affected a smaller area in the mid-Atlantic states. The resulting concerns about power system reliability prompted congressional hearings in which the utility industry was criticized by members of the government as well as the public for perceived inadequacies in system protection. The hearings revealed that no group had overall responsibility for the technical performance of the country's interconnected power systems.

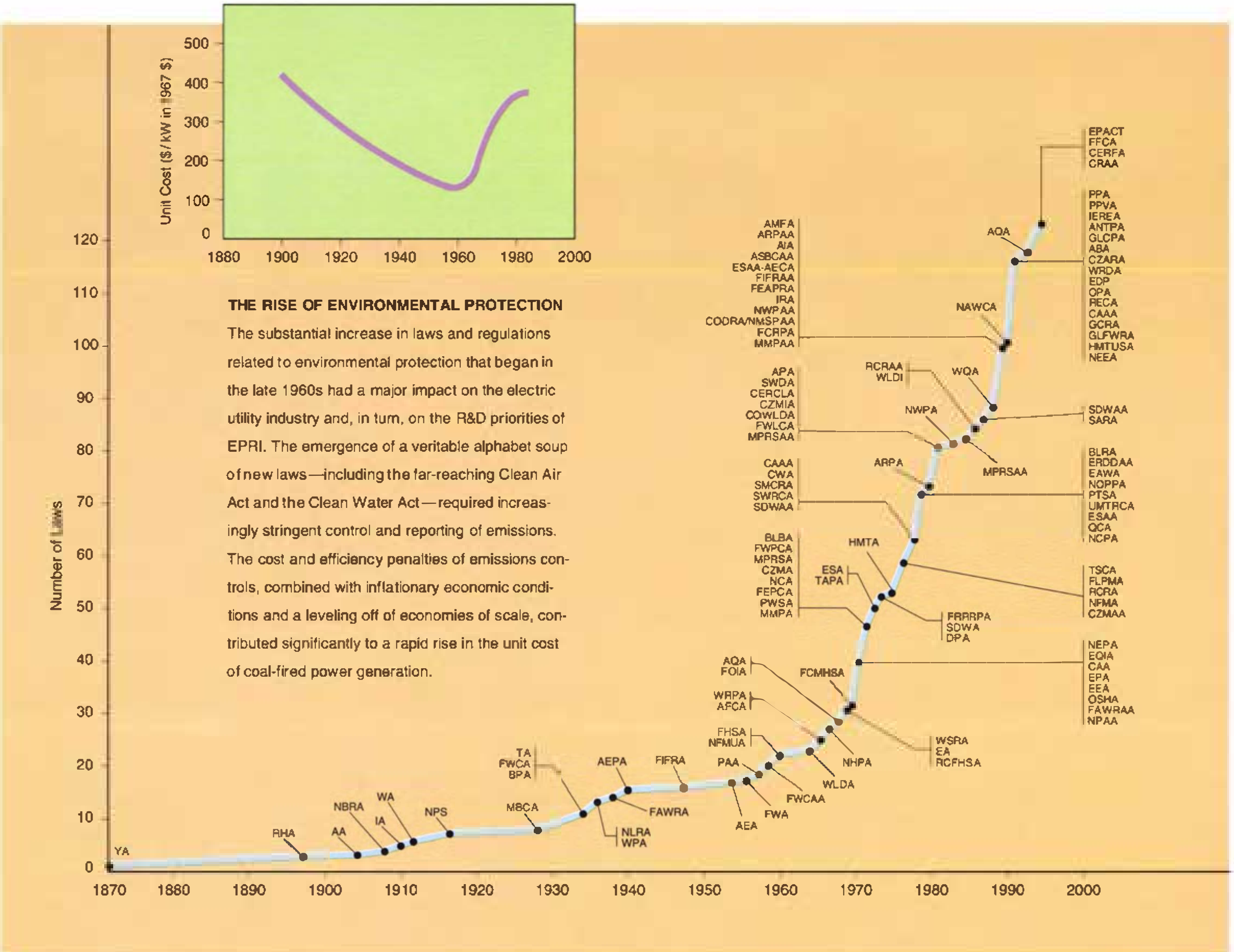
There were several responses to the blackout over the next few years. The utility industry's own most immediate response led to the establishment in 1968 of the North American Electric Reliability Council, an association of regional councils that coordinates and promotes the reliability of utility generation and transmission systems in the United States and Canada at the operations, engineering, and planning levels. With its regional operating councils and a small headquarters staff based in Princeton, New Jersey, NERC remains today the major utility organization devoted to addressing reliability issues and continually assessing the adequacy of the bulk power supply system.

Besides the blackout, other developments in the 1960s substantially broadened the scope of issues that faced the electric utility industry. The 1967 Arab-Israeli war highlighted the fact that energy in the form of oil, on which many utilities depended heavily, could be a political weapon. "Energy in all forms moved into the political spotlight," remembers John Ellis, chairman and CEO of Puget Sound Power & Light Company and current chairman of EPRI's Board of Directors.

The National Environmental Policy Act of 1969 institutionalized environ-

New York–Northeast blackout, 1965





THE RISE OF ENVIRONMENTAL PROTECTION

The substantial increase in laws and regulations related to environmental protection that began in the late 1960s had a major impact on the electric utility industry and, in turn, on the R&D priorities of EPRI. The emergence of a veritable alphabet soup of new laws—including the far-reaching Clean Air Act and the Clean Water Act—required increasingly stringent control and reporting of emissions. The cost and efficiency penalties of emissions controls, combined with inflationary economic conditions and a leveling off of economies of scale, contributed significantly to a rapid rise in the unit cost of coal-fired power generation.

1960	1961	1962	1963	1964	1965	1966
• OPEC formed in Baghdad		• Federal Power Commission (FPC) launches National Power Survey	• FPC Chairman Swidler urges utility R&D program		• Electric Research Council (ERC) formed • New York–Northeast blackout	

mental protection for the first time in energy-related laws and regulations, beginning a wave of more than a decade of legislation and technical and procedural rulemaking that drives an increasing part of the utility industry's technological development. Another measure passed in the same period opened the door to intervenor lawsuits and to the participation of activists in many policy, rulemaking, and licensing arenas that involve the utility business.

Meanwhile, Senator Warren Magnuson of Washington, then chairman of the Senate Commerce Committee, and Senator Ernest Hollings of South Carolina introduced legislation in 1971 to create a federal agency to conduct electricity-related research and development. It was to be funded by a small tax on every kilowatthour sold. The proposal reflected the perception of many policymakers that long-range R&D in electric power, which was increasingly vital to the nation's economic health, was not being adequately addressed.

At most utilities, accustomed to mainly state-level regulatory oversight, the idea of a mandated, federally managed research program in their traditional area of responsibility was not warmly welcomed. Among those who testified on behalf of the utility industry against the proposal and in favor of an industry-organized effort was a young lawyer named John Ellis. "The specter of government control loomed—it was anathema to the fiercely independent utilities," recalls Ellis.

Senator Magnuson signaled that he was more interested in seeing an electric power research capability created than just another federal agency. Although he and Hollings were publicly skeptical that the industry itself would do what it should about R&D, they agreed at the request of key utility executives representing the industry to suspend their legislative effort for one year—1972—to give utilities an opportunity to develop an alternative to the proposed agency.

One of the men who received the ultimatum was Shearon Harris, president and chief executive of Carolina Power & Light Company and, at the time, president of EEI. He promised Magnuson that if the industry could not get an alternative research venture off the ground within a year, he would return before the committee to personally endorse the federal agency proposal. Over the next weeks and months, Harris made personal visits to many of his fellow chief executives to enlist support for an expanded, formal industry R&D program.

Before his death in 1980, Harris recalled how, even under the threat of a federal mandate, few utility executives could at first see the value of a collaborative research program that would address the full range of the industry's long-term technological needs. "Everyone was thinking, 'If I put a million dollars in, how quickly am I going to get something visible that will be understood and appreciated by my consumers?' " he remembered.

Yet there was growing recognition that if utilities did not take control of their technical destiny, the government would. "Utilities realized that they could no longer be beholden to a couple of manufacturers, and that their industry really deserved a major research arm not unlike what the AT&T system had in Bell Laboratories," says Robert Bell, vice president for research and development at Consolidated Edison Company of New York. "That was the carrot, but the Magnuson bill was the stick." Bell served on the ERC's R&D Goals Task Force, which drew up the first blueprint for an electric power research program.

State utility regulatory commissions had already been primed for the idea of collaborative research by the work of the task force. Armed with the ERC's Green Book (the research plan was so named for the color of its cover), Harris enlisted the support of the president of the National Association of Regulatory Utility Commissioners, George Bloom of the Pennsylvania commission, for a full-

1967	1968	1969	1970	1971	1972
				• ERC Green Book report on R&D goals published	• EPRI incorporated in Washington, D.C.
	• North American Electric Reliability Council established • Oil discovered on Alaska's North Slope	• National Environmental Policy Act	• Clean Air Act (original) • First Earth Day		

blown utility research organization supported by member dues that would be recovered through customer rates. NARUC pledged its institutional support for an expanded research effort at its annual convention in late 1971.

But while Harris huddled with fellow executives and persuaded more of them of the importance of creating a research organization that was attuned and answerable directly to utilities, the skepticism in Congress persisted. At one of the Senate hearings, an expert witness from the Nixon administration was sympathetic to the utilities. "I remember a senator asking me, 'Don't you think that if we let the utilities set up their own research program, they'll just work on things that will use more electricity, like electric vehicles?' " recalls Richard Balzhiser, EPRI's current president, who was then a University of Michigan engineering professor serving a stint as assistant director of the White House Office of Science and Technology. "As if that would not have been in the public interest," he adds, considering the present push for alternative vehicles.

More in anticipation of what would come than as a real beginning, the Electric Power Research Institute was incorporated on April 5, 1972, in the District of Columbia. "The federal threat was forcing a cesarean delivery," recalls Chauncey Starr. It would not be until about a year later that the Institute truly existed, in the mind and plans of Starr, its founding president and first employee.

THE RIGHT PERSON AT THE RIGHT TIME

An engineer of uncommon vision is chosen to build and lead the fledgling Institute.

Already brimming with accomplishment, Chauncey Starr's career up to the time he was chosen to head the embryonic EPRI looks as if he had been preparing most of his adult life to found and mold a major technological research organization. His experience and background gave him unusual confidence in his own vision of what EPRI should be and exactly what he would do to put it on that course. Starr was formerly the longtime head of research, general manager, and president of Atomics International (part of North American Aviation, which later became Rockwell International); an engineer with the wartime Manhattan Project to develop atomic weapons in the early 1940s; and a young research associate at the Massachusetts Institute of Technology in the 1930s. When he first came to the attention of Shearon Harris and a few others in the utility industry, he was dean of the School of Engineering and Applied Science at the University of California, Los Angeles.

Starr had published an article in the September 1971 issue of *Scientific American* titled "Energy and Power," which pointed to the need for careful planning and a thorough assessment of available options for meeting the projected need for energy in the future, given the risks and environmental costs that were entailed by the present rate of consumption. "Man's expanding need for energy creates difficult economic, social, and environmental problems," ran the article's subtitle. "The solutions call for sensible choices of technological alternatives by the market and political process." Starr's broad survey of energy use in various societies through history pointed out, among other things, that the world's population growth rate could not be sustained indefinitely and that the health and environmental impacts of energy conversion would become a major factor in subsequent national debates about energy policies and priorities.

"Perhaps the most fundamental question of national policy is how we should allocate our present resources for the benefit of future generations," wrote Starr. "The development of new speculative energy resources is an investment for the future, not a means of remedying the problems of today. It is equally clear that the quality of life of the peoples of the world depends on the availability *now* of large amounts of low-cost energy in useful form. This being so, we must emphasize an orderly development of the resources available to us with present technology, and these are primarily power plants based on fossil fuels and nuclear fission."

In the spring of 1972, within a few days of EPRI's incorporation, Harris, who had already been quoting Starr's article in his own speeches, met him at a seminar at Georgia Tech. Over lunch, Harris laid out the emerging concept for EPRI and asked Starr if he knew anyone who might be a good choice to head it. "The way you've described it, I might be interested in it myself," was Starr's reply.

Later an executive search committee led by Jack Horton, then chairman and CEO of Southern California Edison Company, took Starr to lunch in Los Angeles to probe his interest further. They may not have expected that Starr would take the opportunity to instead probe their commitment, and that of their industry, to R&D. "I spent the next two hours lecturing the group on the unique opportunity EPRI presented for national leadership for shaping our society through electrification, improving environmental issues, and stimulating economic productivity," Starr recalls. Earlier Horton had asked for a résumé

Chauncey Starr: EPRI's Founding President
Already a nationally known expert on energy and nuclear power when he was tapped to build a world-class research organization for the electric utility industry, Starr drew on his management experience in the wartime Manhattan Project, as a top executive with Atomics International, and as the dean of the School of Engineering and Applied Science at the University of California, Los Angeles. Starr established scientific objectivity, thoroughness, and intellectual integrity as guiding principles of EPRI—principles that have earned it an international reputation for excellence. He also created a formal advisory structure that has kept EPRI closely attuned to the concerns of its utility sponsors and society at large. Utility interest at that time was focused mainly on improvements to conventional coal and nuclear technologies, although the Institute also pursued early R&D on advanced coal options.

Starr testifying at Senate hearing

Starr receiving the National Medal of Technology

The First Step Toward an R&D Plan

At about the same time that the Magnuson-Hollings legislation was proposed, the Electric Research Council set up a task force that would produce perhaps the most important contribution of the council's seven-year existence. The ERC's 17-member R&D Goals Task Force was charged with identifying the priorities and estimating the costs and timetables for all significant research projects that might be of interest or use to electric utilities through the year 2000. By June of 1971, the group had assembled a comprehensive report on R&D goals that came to be known as the Green Book for the color of its cover.

The Green Book was a broad-ranging compendium of research needs for both current and future methods of producing, transmitting, and distributing electricity. Projects and technologies to lessen the environmental impacts of producing electricity figured significantly in the overall program balance, and the plan even spoke of finding new and more-efficient customer uses of electricity.

As was intended, the Green Book became the benchmark for an expanded electric utility R&D effort. It foresaw the development of coal gasification and other advanced fossil fuel power generation technologies, such as fuel cells, long before they were called clean coal technologies. It set a high priority on the development of superconducting underground transmission to make the greatest use of existing rights-of-way. In releasing the Green Book, the ERC "concurred with the sense of urgency expressed in the report concerning the need for a much larger research effort to aid the industry in continuing to provide economical, reliable electric service in future years with minimal environmental effects."

The ERC also made note of the largest collaborative effort that had yet been undertaken by the utility industry—an effort that, like the release of the Green Book, signaled a new spirit of cooperation. Utilities were raising some $300 million among themselves for their share of a joint government-industry project to build and demonstrate a commercial fast breeder reactor. This advanced reactor, which produces more fissionable fuel than it consumes, was believed at the time to be a relatively near term technological necessity for stretching what were expected to be limited supplies of expensive uranium fuel.

Bringing the fast breeder to the point of commercial availability by the mid-1980s was in fact identified in the Green Book as the number one R&D priority in the area of energy conversion. Extensive discussion was devoted to its importance as a future nuclear generating option. And involvement in the funding and technical management of the breeder demonstration project would become an issue for EPRI in its early days.

Looking at some of the other critical R&D priorities identified by the industry task force in 1971 helps round out a sense of what seemed most important then. Besides the breeder and coal gasification, fusion was the other principal priority in energy conversion. An artist's conceptual drawing of an "urban fusion power plant" alongside skyscrapers graced the Green Book's cover. The task force figured fusion could be commercially available by the end of the century if scientific feasibility were demonstrated within five to eight years.

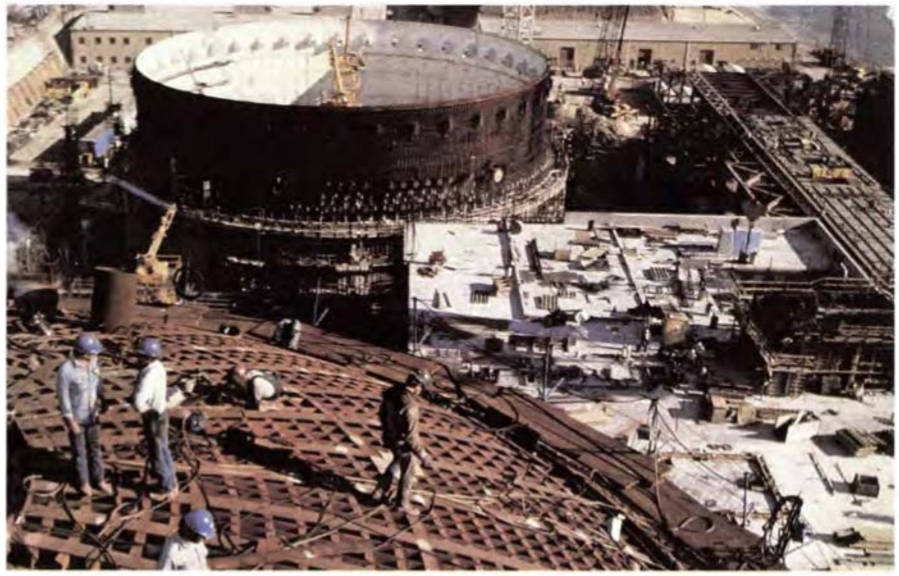
For transmission, the priority was to develop higher-voltage, higher-capacity versions of all types of transmission systems—versions that could carry 4 to 10 times more power through existing corridors. There was also a need for better facilities for testing high-voltage equipment and studying how various components interact in power system applications.

The top environmental priorities were to rapidly improve technologies for controlling sulfur

and nitrogen oxides and particulates from coal-fired plants (scrubbers and electrostatic precipitators were just beginning to be used); find ways to reduce the radioactive effluents associated with the nuclear fuel cycle (particularly gaseous and liquid waste streams from power plants); and develop better methods of dissipating or using waste heat from power plants, which was often discharged into water bodies.

Improved electrochemical batteries and other components for electric transportation were seen as a critical priority in an area, then called energy utilization, that held major possibilities for improving the environment. A broader priority was to "explore ways for the user to more efficiently utilize electric energy." The R&D Goals Task Force also thought a top priority for utility research should be to develop a national fuels model that would continually track and project out to 30 years the price and availability of all U.S. energy resources that could be converted to electricity.

At the same time that it identified the broad range of research that would be needed if the electric utility industry were to truly take control of its technological destiny, the Green Book also made clear that the cost of doing this would far exceed the $7 million to $10 million then being spent on research through the ERC. The task force estimated that it would cost more than $32 billion, including any government cofunding, over a 19-year period to complete all the work its report envisioned. But the group wasn't asked to raise the money, only to outline a set of R&D goals for the future of the electric utility industry. □



Nuclear plant construction

Coal liquefaction pilot plant

Fluidized-bed combustion development facility

of Starr's thoughts about EPRI, and Starr provided a three-page letter touching all the bases of what would uniquely define EPRI; it stands as a valid description of the Institute today.

Objectivity, thoroughness, and intellectual integrity, Starr insisted, must be at the heart of EPRI's values. He emphasized that aspects and problems of energy use that were not strictly technological in nature must also be part of the research agenda, and even that the views of people from outside conventional industry ranks must be considered.

"I believe it would be important to involve in EPRI's studies not only technical specialists but also those deeply concerned with environmental and social impacts," Starr told the committee. "EPRI could thus provide a device for making such opinion leaders a party to national problem solving. If such a program were successful, the resulting support of a broad intellectual community could be an important element in the influence of EPRI nationally, and it would become a symbol of the utility industry's sense of national responsibility."

Starr later recalled that after he sent his letter, he thought he probably would not hear from the utility industry again "because I knew that a program as broad as I described, and that incorporated the concept of a social purpose, was not going to be accepted. It was so divergent from what the industry people thought they needed, which was a group to mainly test hardware." Instead Starr had bluntly challenged the industry to accept as a social responsibility the need "to take a broad-gauge look at where the industry was going in terms of the technical options, the lines of development, and the magnitude of the research that needed to be carried out to improve the quality of electrical service in the country."

But by the end of the year, the committee offered Starr the job on his terms, "including an agreement that I would have five years of a free hand." Starr canceled a planned sabbatical leave to instead make plans to resign from UCLA. For a while in early 1973, EPRI was officially located at EEI's Park Avenue address in New York City while, from an anonymous campus office in Los Angeles, Starr began planning and directing the work of the Institute he now headed and served virtually alone. The initial financial commitment from utilities stood at $60 million.

Looking back, Horton, now retired, believes "there is no question we made a wise choice" for the man to launch EPRI. "We were delighted with the way he took charge and are proud of the success EPRI has achieved since then."

In February 1973, Starr appeared with utility executives before the Senate Commerce Committee, where he was introduced as the first president of the new Institute and asked to describe the research program he had in mind. The appearance immediately followed a news conference at which the formation of EPRI and Starr's appointment were publicly announced, and both events preceded the first meeting of EPRI's Board of Directors later that day. But even as he waited in the Senate hearing room for the committee to convene, even before he officially met the Board of Directors of the Institute he now headed, Starr was having to defend the sincerity and seriousness of its purpose.

"Before the hearing began, Ralph Nader came into the room followed by news photographers and spoke for quite a while about how the whole thing was a sham—a charade on the part of the industry to hold off the federal agency proposal. He thought that EPRI was doomed to fail because utilities would never support it," recalls Starr. "I had shared platforms with Nader before. As he left, I asked, 'Aren't you going to wait to hear what I have to say?' He said, 'I'll read about it in the newspapers.' "

Those who follow science and technology developments in the electric power field have been reading about EPRI in the newspapers and elsewhere ever since.

THE FORMATIVE YEARS

1973–1978

EPRI's character takes shape through key people and programs, as links with member utilities are forged.

The first five years of EPRI's existence—Chauncey Starr's tenure as president—saw rapid growth in budget, staff, and programs. Starr quickly assembled a cadre of technical managers and administrative aides who could help him build and manage the burgeoning Institute.

To develop and oversee the Institute's administrative function, Starr called on his longtime friend and former associate David Saxe, who was then at Rockwell International. Saxe became vice president for administration and played the major role in defining the Institute's business standards and style. Dealing with an expanding roster of R&D contractors raised many new issues. "The formation of EPRI was a new experience for everybody involved because of the unique relationships its creation brought about. It was the first large industrywide R&D consortium anywhere in the world, and there just weren't any patterns to follow," says Saxe, now retired.

"Very early on we had to develop a set of principles that all our contractors had to follow, and there were some lengthy and difficult negotiations over those," recalls Saxe. "The principal problems were over who would own the patents that resulted from EPRI-sponsored work and whether EPRI would have the right to audit the costs of the work. These were things we insisted on and in nearly all cases succeeded in getting."

Another of the early EPRI employees was Richard Rudman, who had been a graduate assistant of Starr's at UCLA. Signing on as an assistant to the president, Rudman helped with the major initial tasks of finding a home for EPRI and getting the Institute up and running. Dick Balzhiser, nearing the end of his White House stint, was soon hired as the first technical division manager. He was to head up all of the nonnuclear (fossil-fuel-fired) generation and advanced systems work, which was expected to about equal the nuclear research in magnitude. "I told Chauncey we had to call it something besides nonnuclear," he remembers. Thus was born the Fossil Fuel and Advanced Systems Division. Besides it and the Nuclear Power Division, there were the Electrical Systems Division and the Energy Systems, Environment, and Conservation Division.

Milton Levenson, associate director for

energy and the environment at Argonne National Laboratory, was brought on board to set up the nuclear program. Starr argued persuasively that management of the industry's role in the fast breeder demonstration project not be included in the Nuclear Power Division's research program, feeling that it would financially and administratively swamp other important issues. There were several other priorities right from the start, including risk assessment and reactor safety studies. There was also a pressing need for engineering work to address emerging utility maintenance and operating problems with steam generators in pressurized water reactors and with stress corrosion cracking in certain cooling pipes of boiling water reactors.

"Almost immediately we found ourselves managing work that was of international interest, with foreign governments sending us cosponsoring funds and leaving it to us to decide how to spend the money on tackling the problems," Levenson remembers. One of the early innovations for handling such special accounting situations was to establish—apart from EPRI's membership-funded base program—separately funded owners groups to tackle specific problems in nuclear plant operations. Later, special technology centers, such as the Nondestructive Evaluation Center, were established to provide hands-on training and technical capabilities to serve industry needs.

One of the first major tasks was selecting a location for EPRI. Because Starr's foremost objective was to hire the best people he could find to build EPRI's research programs as well as its reputation, the key criterion for a location was that it attract top-drawer scientists and engineers. McKinsey and Company was commissioned to do a study, which ranked the San Francisco Bay Area as the number one spot desired by professionals at that time.

Starr (who personally would have preferred Los Angeles) wanted a site close to a major research university and its faculty. Berkeley was briefly considered, but the then-much-lower cost of housing and office space on the San Francisco peninsula pointed strongly in the direction of Palo Alto and the part of Stanford University's property that was being developed as an industrial park. With a staff that numbered just 20, EPRI moved into the main (and then only) building at 3412 Hillview Avenue in September 1973; by the end of the year, the staff had grown to 100 and was managing over 150 R&D projects with a value of more than $164 million.

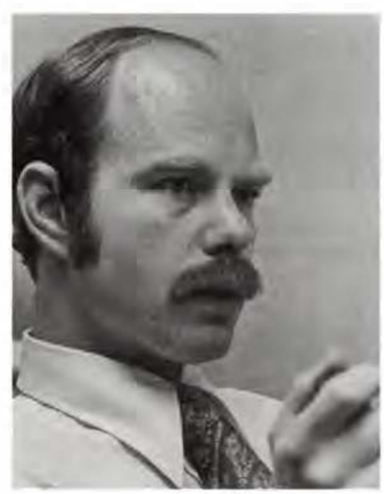
An office in Washington, D.C., opened in the same month as the Palo Alto headquarters. Although the capital had been briefly considered as the base for EPRI's operations, Starr decided early on that, in order to maintain the scientific credibility of its research results, the Institute must not become entangled, by virtue of proximity, in the politicized legislative and regulatory realms inside the Beltway. Still, having a presence there as a link with the agencies and organizations that EPRI would form cosponsoring and cooperative relationships with was seen as important.

In the winter of 1973–1974, the oil weapon was unleashed for the first time in an embargo imposed by exporting countries. The move sent the price of oil from $3 to $12 a barrel almost overnight,

Milton Levenson

David Saxe

Lou Elsaesser



Richard Rudman

triggering a decade of volatility in fuel prices that would have a profound and lasting impact on the cost of fossil fuels and electricity generated with them. Almost as soon as EPRI began, its work (and the government's) in advanced fossil systems was focused on technologies that would provide synthetic alternatives to oil, such as liquid and gaseous fuels from domestic coal.

As EPRI's staff and programs began to come together, another challenge soon became apparent: how to best and quickly put to work the money that was starting to pile up in the bank. "A significant flow of dollars began early on, and we needed an organization that could plan the work, manage it, and get it in place and under contract. Chauncey hired the best people he could find to run the technical divisions, but for a long time he resisted having an organization chart put down on paper," recalls Rudman, now EPRI's senior vice president for business operations. "He wanted to first find the right people and then design the organization around them."

Groundbreaking for EPRI Building 2

Board of Directors meeting, 1976

EPRI Building 1

- Chauncey Starr named first EPRI president
- Opening of Palo Alto headquarters

1973	1974
• Arab oil embargo • Alaskan oil pipeline approved	• International Energy Agency founded • U.S. Energy Research and Development Administration formed

One crucial issue that was resolved in the first year was whether EPRI would have its own laboratories for conducting research. Although the model that some people had in mind was Bell Laboratories, Starr felt that far greater sums of money than were necessary for electronics R&D would be required to do hands-on work in high-voltage equipment and power systems. Rather than investing in bricks and mortar, he favored a distributed contract approach to allocating EPRI's research dollars. "There was major argument about it, but the way it worked out is that EPRI keeps the intellectual activity under its control with its own staff, while the physical activity is subcontracted out on an international basis," says Starr.

Part of the work in the first year involved bringing into EPRI's research portfolio various EEI and ERC projects being managed by EEI. A key player in that transition was Lou Elsaesser, who had been EEI's director of research and who joined EPRI early on as an assistant to the president. "One of the rough spots in shifting projects from EEI's research division to a national institute was that most of the projects were managed by utilities, so I had to allay the concern of some utilities that they were giving up their authority and would no longer be doing hands-on research," Elsaesser recalls. "That's why it was very important that EPRI immediately established the utility advisory structure, which said to utilities that they were not out of the research business, but they were now the brains to tell EPRI what needed to be done."

Indeed, many observers credit EPRI's multitiered system of industry task forces, division committees, and the Research Advisory Committee (RAC) as a key organizational innovation that has kept the Institute close to its clients. An additional communication channel—between EPRI and the public—was opened with the establishment of the Advisory Council. This group, which includes experts in many fields outside the utility industry and members of the utility regulatory community, helps to create the Institute's intellectual climate and tenor and to determine its direction.

One of the first utility executives that Starr personally consulted on research planning and on translating a smorgasbord of research ideas and projects into a balanced program was Ludwig Lischer, who was vice president for engineering research at Commonwealth Edison Company. Lischer would serve four years as the first chairman of the RAC. The committee's initial charge was to take the ERC's Green Book as a starting point and advise EPRI on "what needs doing the most—to distinguish between the imperative and the important and the things that just would be nice to do," says Lischer. "The committee tried to forge a program that utilities could support, given the budget constraints."

Over the years, the Institute has nurtured its committee connections to its utility members as a two-way communications channel. "EPRI has been very successful in capitalizing on the assets of its advisory structure," observes Consolidated Edison's Bell, who is a past RAC chairman. "The nature and the priorities of the industry have shifted over the 20 years EPRI has been around, and in that time EPRI has worked with its advisors to make significant changes in direction and priorities that are part of what keeps it so relevant and critical to the industry today."

1975	1976	1977
	• Energy Utilization and Conservation Technology Program begun • First five-year EPRI R&D program plan • First issue of *EPRI Journal*	• Emissions Control and Test Facility opens in Colorado
• Oil price controls lifted	• Resource Conservation and Recovery Act	• Pacific Intertie HVDC transmission circuit enters full service • First National Energy Plan • Department of Energy established

RESPONDING TO THE INDUSTRY'S NEEDS

1979–1987

High costs, increased regulation, and industry crisis focus EPRI's R&D plans more sharply on near-term needs.

EPRI's focus both technologically and organizationally has adapted over the years in response to shifts in industry priorities and needs—shifts that, in turn, have reflected broader changes in the economy, national policy, and technology development. In the early years, the Institute had a relatively academic environment that reflected its original, intermediate to long-term R&D horizon. But as the organization matured and gained a reputation for the quality of its technical work, utilities increasingly called on EPRI for help with the many technical and analytical responsibilities they were shouldering as a result of new regulation, as well as with various operating problems that had developed in generating plants and systems.

Near the end of 1978, Chauncey Starr turned the helm of EPRI over to Floyd Culler, the former deputy and acting director at Oak Ridge National Laboratory (and a man whom Starr had known since Starr's early work for the AEC). EPRI was finding itself at the center of action in just about every major energy technology development effort going on anywhere in the country—and in quite a few outside the country. It was increasingly a joint sponsor of work with the federal Energy Research and Development Administration (which reincarnated the former AEC and would soon become the Department of Energy). Results and reports of completed EPRI studies and research projects already filled whole sections of technical library shelves. A major new challenge for EPRI was how to transfer its technology more effectively into utility use.

Culler, an ebullient chemical engineer turned career R&D administrator, guided EPRI through a decade of change and new responsibilities as the industry struggled in rough seas in a number of areas. Utilities were facing hostile ratepayers and shareholders in the late 1970s as they tried to absorb and recover the costs of many new nuclear plants. (In some cases, the additional capacity was not needed because higher energy prices had lowered the anticipated demand.)

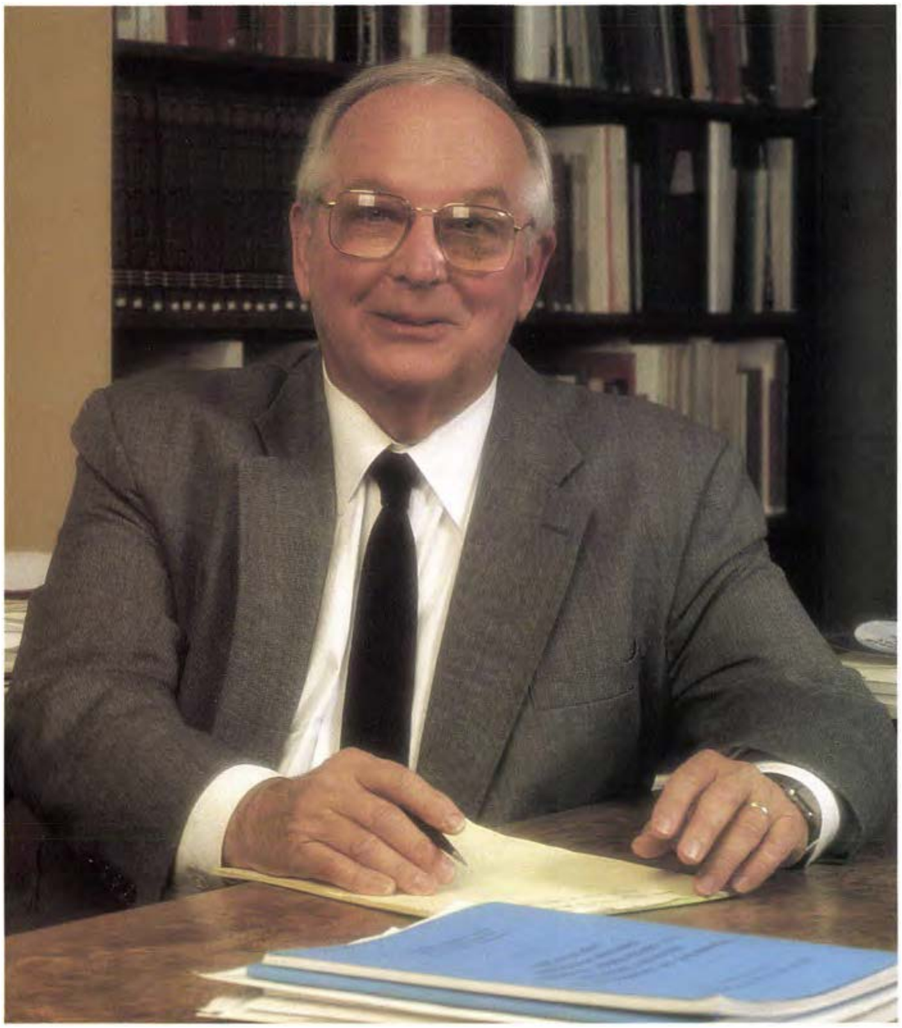
In addition, the 1979 loss-of-coolant accident at the Three Mile Island (TMI) Unit 2 reactor in Pennsylvania was a severe blow to technical and public confidence in nuclear power and in the utilities that operated nuclear plants. It triggered a wave of new regulatory requirements and design changes that would affect the cost and the R&D agenda for nuclear power generation up to the present day. EPRI's Nuclear Safety Analysis Center was created as a direct response to TMI, and Chauncey Starr and others at EPRI helped the industry organize the Institute of Nuclear Power Operations.

On another front, Floyd Culler led EPRI to add another D to its mission of R&D: research, development, and demonstration. Under his administration, EPRI came to realize that many of the new technologies nearing commercialization were languishing for the lack of some party to take the risk of demonstrating the initial unit in operation. This led EPRI to help organize and sponsor a number of major industry technology demonstration projects, from such well-known efforts as the Cool Water coal gasification project to utility fluidized-bed coal plants, new geothermal power cycles, and modular fuel cells.

Culler also oversaw the expansion of EPRI's research horizon to the other side of the utility meter into the world of end-use technologies and the nature of customers' demand for electricity. As *demand-side management* became an industry watchword in response to regulatory pressures for alternatives to building more power plants, utilities pushed EPRI to play a bigger role as their agent of science and technology in fostering the wider and wiser use of electricity for improved productivity and reduced environmental impact. What began as a small program in energy utilization coupled with environmental research was enlarged in a short period into a full research division. Before Culler retired, EPRI had opened the first 3 of what are now 14 electrotechnology application research centers around the country to help utilities' industrial and commercial customers reduce costs and improve quality through innovative applications of electricity.

At times stretching EPRI's financial and human resources to the limit, Culler pushed EPRI to make itself more available and accessible for responding to the industry's day-to-day needs for expert advice and consultation. Yet ever the research scientist at heart, Culler knew that such a new role for EPRI came at the expense of support for important longer-term research. "How can we say no? These are our clients, and they're in deep trouble. They need us," he would answer skeptics of the course.

"To a large extent, the problems of the here and now became so great in the 1970s that the industry was very lucky it had an organization such as EPRI that could focus on the problems, if you like, that were in the near- and midterm," observes Larry Papay, a former senior vice president at Southern California Edison and a member of the original



Floyd Culler: An Era of Technology Transfer and Demonstration The former deputy director of Oak Ridge National Laboratory presided over a decade of dynamic change and challenge for EPRI, as it responded to the needs of an industry stressed by many technical, financial, and political crises. Culler helped catalyze a broad and rapid response to the Three Mile Island nuclear accident and oversaw the refocusing of EPRI resources to more directly address the daily operational needs of utilities. As many of the major technologies that the Institute had pursued since its founding neared commercial readiness, Culler committed EPRI support for a host of pioneering collaborative demonstration projects, including the Cool Water integrated gasification–combined-cycle plant and TVA's atmospheric fluidized-bed combustion unit.

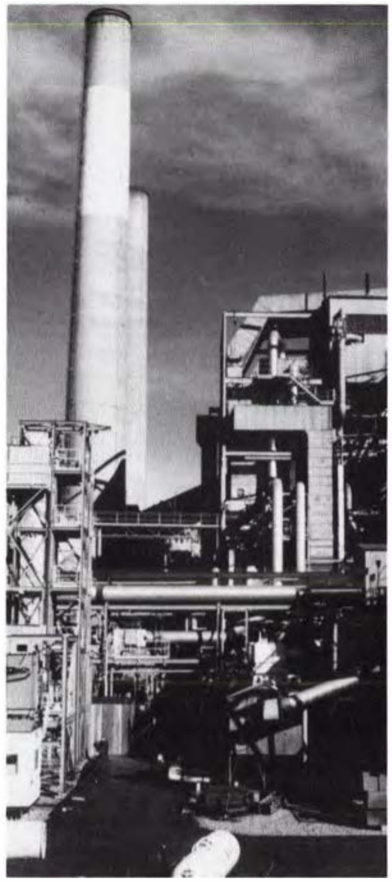
Culler at controls of prototype cable plow

EPRI RAC. "To an extent EPRI had to sacrifice some things that were for the long term, but it successfully demonstrated that it could respond to the needs of utilities," adds Papay, now vice president and manager of R&D for Bechtel Corporation. "But something had to suffer in the change of focus, and a conscious decision was made that it would be the longer-term research."

Despite a personal campaign to raise support among member utility chief executives for increasing the EPRI dues assessment formula and thereby the industry's overall fraction of revenue devoted to R&D, Culler was forced for part of his term to oversee a slight contraction of the Institute's budget in real terms. Declining member payments, based on revenue and electricity sales, reflected the dampened demand for

AFBC unit (left) at TVA's Shawnee plant

Arapahoe Emissions Control and Test Facility

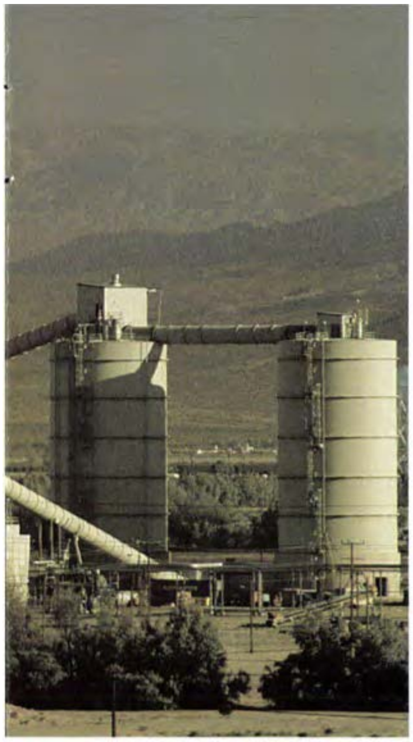


Cool Water IGCC demonstration

1978	1979	1980	1981	1982
• Floyd Culler succeeds Starr as EPRI president	• Nuclear Safety Analysis Center established	• Nondestructive Evaluation Center opens	• Battery Energy Storage Test Facility opens • Coal-Cleaning Test Facility opens • Utility Acid Precipitation Study begun	• Transmission Line Mechanical Research Facility opens
• National Energy Act, including – Powerplant and Industrial Fuel Use Act (PIFUA) – Public Utility Regulatory Policies Act (PURPA) • U.S. Synthetic Fuels Corporation established	• Iranian Islamic revolution • Three Mile Island nuclear accident • Oil price begins two-year rise from $13 to $34 a barrel	• Federal legislation creates Superfund for toxic waste site cleanup		

energy caused by higher prices in the late 1970s and early 1980s.

When he retired in 1988 to an office beyond the executive suite, Culler reaffirmed his lifelong interest in research and vowed to have a hand in helping to "replenish the barrel" with new science to sustain the industry for the long term. He seemed particularly intrigued by the potential opportunities for utilities in the biological sciences, including applications in environmental remediation. Such was the breadth of vision embodied in the Office of Exploratory Research, established by Culler's successor, Dick Balzhiser. Part of the intention in creating the office was to reaffirm the commitment to longer-range research, which the urgent needs of EPRI's sometimes turbulent first 15 years had often overshadowed.



Cool Water dedication

Three Mile Island Units 1 and 2, Pennsylvania

Battery Energy Storage Test Facility

1983	1984	1985	1986	1987
• First of 14 electrotechnology application centers opens	• Startup of Cool Water IGCC demonstration	• Advanced Light Water Reactor Program launched • Benefits assessments conducted with 25 member utilities • Startup of Heber binary-cycle geothermal demonstration	• EPRI–Stanford silicon solar cell reaches 28% efficiency	• Power Electronics Applications Center dedicated
		• Discovery of springtime ozone hole over Antarctica	• Oil prices collapse with failure of OPEC production quotas • Chernobyl nuclear accident in USSR • Discovery of high-temperature superconducting ceramic oxides	• PIFUA repealed, permitting expanded natural gas use

ADDING VALUE FOR A DYNAMIC INDUSTRY

1988 Onward

Stronger customer orientation and the development of transformative technologies will help members prosper in a more competitive future.

Now five years into his tenure at the top, having begun as the first technical director and later having served as vice president for all of EPRI's R&D, Dick Balzhiser can personally recall the details of the Institute's program development. As its senior and longest-employed research manager, he has a perspective that few others can claim on EPRI's evolution in response to a changing industry.

The major technical divisions and programs that were put in place during the administrations of Starr and Culler in the first three-quarters of EPRI's history continue to build momentum. They have continued to respond to the needs of a modern industry that is considerably more sophisticated technically and analytically than it was in 1973, when the Institute was formed. In doing so, they have passed program and technological milestones too numerous to catalog.

Project demonstration, which was taken on as a new role for EPRI in earlier years, is now an integral part of most development efforts. But in contrast to large generating-plant technologies that were demonstrated in cooperation with the operating utility and major equipment vendors, the Institute's broader, more diverse, and more customer-systems-oriented program today calls for many more demonstrations of typically smaller, less capital-intensive projects. The demonstrations also often involve more cosponsors than in the past.

While EPRI's organization chart has been redrawn more than a few times over the last 20 years, many of the major thrusts and areas of technical interest at the birth of the Institute remain important today. Others, meanwhile, have come and gone. Clean coal technologies and advanced nuclear reactors are among today's industry priorities, but the breeder reactor was put on indefinite hold over a decade ago; the emphasis now is on more safety, improved capital and operating costs, and better public acceptability with improved light water reactors. Fusion, which was believed at the time of EPRI's formation to be within 15 to 20 years of commercial demonstration, remains about as far from successful development today, although there is renewed interest in the wake of recent scientific developments in reassessing what a practical fusion reactor might someday look like.

Looking back over the menu of the past 20 years from which the utility industry has been charting its future, one finds that the list of technologies that were considered to be high priorities when EPRI was formed and are still considered priorities today is about the same length as the list of technologies that were once thought promising but are no more. "A lot of us in the industry had very high hopes that EPRI would be able to help us commercialize some of the new technologies we thought could have a major impact on the operations of our industry, such as coal gasification and fluidized-bed combustion," recalls A. G. Bullard, the longtime manager of research at Carolina Power & Light Company who served on the ERC Fossil Fuels Task Force as well as on EPRI's first RAC.

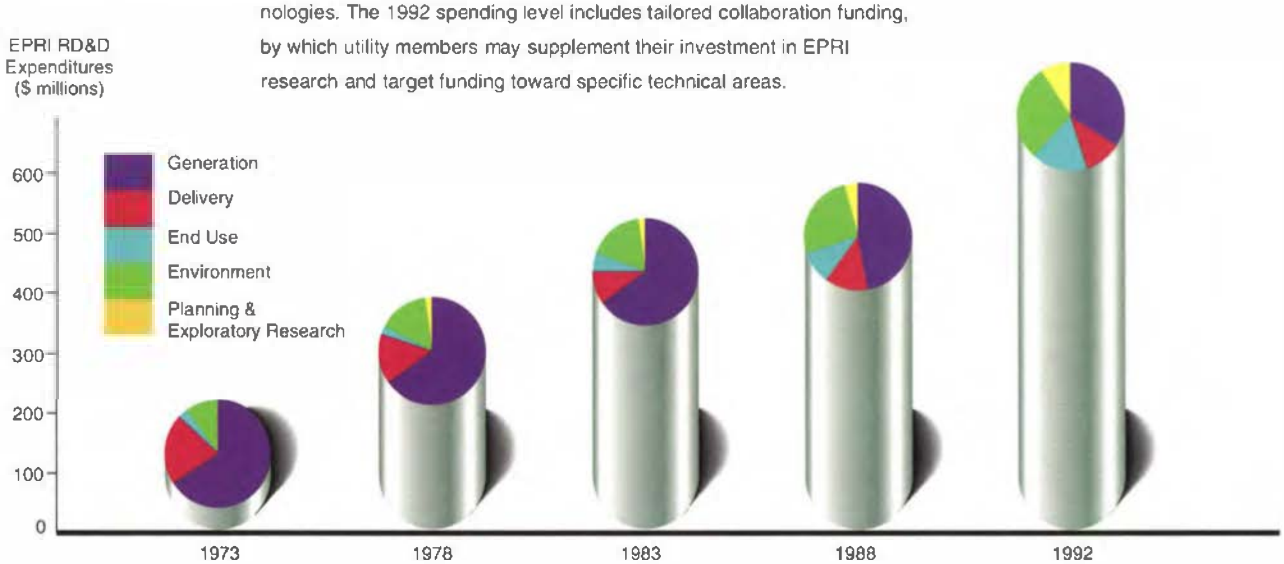
"But we expected things would happen a lot faster than has actually occurred," recalls Bullard. "Nevertheless, I think in many cases EPRI's involvement has brought commercialization sooner than it would have occurred otherwise. And while some of us in the industry had high expectations for early commercialization that were not realized, EPRI has played a major role in the development of technologies for our industry that are at the point of commercialization today."

Balzhiser takes special pride in recalling EPRI's role in incorporating modern chemical processing technology into an integrated power-generating system that gasifies coal, removes most of the pollutants, and burns the gas cleanly and with high efficiency in a gas-turbine-based combined cycle. He remembers the technical meeting at EPRI in which the system was conceived—"one of the most important afternoons any of us had ever spent"—and the way EPRI specialists then solicited the involvement of the oil companies who had the gasification technology but had never thought about applying it in a utility power-generating system.

He recalls how EPRI then helped a major turbine manufacturer develop a new methodology for high-reliability design that incorporated advanced technologies and materials developed for jet engines into the design of larger and more dependable utility-grade gas turbines. EPRI anticipated that such bigger and—most important—more reliable machines would be needed as prime movers of future integrated gasification–combined-cycle (IGCC) systems. Today such machines are available from a number of equipment vendors worldwide. And utilities have begun installing them—in simple-cycle mode for peak and intermediate generation and in combined-cycle configuration for

Richard Balzhiser: A Role for EPRI in the Global Village As a White House science and technology aide to President Nixon, Balzhiser voiced support for the idea of an independent utility R&D organization when it was proposed, and he soon joined the Institute as its first technical division director. Two decades at the heart of EPRI's senior management have shaped his vision of a global science and technology organization that delivers value for competitive advantage in an increasingly market-driven industry. Balzhiser has led the Institute in major initiatives to develop electric vehicles, advanced light water reactors, high-speed electronic transmission networks, and on-line technology transfer links to the utility research community. Also during his tenure, EPRI's horizons have expanded with the addition of international affiliates.

The Institute's RD&D Budget: Then and Now EPRI's member-funded budget for research, development, and demonstration has grown substantially over the last two decades, and the priorities for spending have evolved with changes in the utility industry's focus. A strong emphasis on power generation and delivery systems in EPRI's early years was followed by an expanding effort in environmental science and controls and, more recently, by a growing program in customer end-use technologies. The 1992 spending level includes tailored collaboration funding, by which utility members may supplement their investment in EPRI research and target funding toward specific technical areas.



baseload generation. They are in most cases fired with natural gas.

Balzhiser sees the new generation of high-efficiency gas turbines as the centerpiece of a new paradigm in power generation for the decades ahead. While the machines can be fueled with natural gas as long as prices of that fuel remain competitive, the turbines can, if properly planned and installed, also be fired with clean syngas made from coal in a gasifier built in future years. Eventually they could be integrated with fuel cells or other advanced generating systems. "The beauty of gasification will play out over decades," he notes.

IGCC is a transformative, enabling technology that ensures that the nation's (and the world's) vast coal resources can be used cleanly and efficiently to produce electricity in the next century. And Balzhiser sees an analog in FACTS (flexible ac transmission systems), the electronically switched, high-voltage power transmission systems and components conceived at EPRI a few years ago. Already FACTS has become a globally accepted technological concept for future transmission systems.

"In the case of both IGCC and FACTS, EPRI has adapted and brought into the mainstream technology that was outside conventional practice for the utilities and for the companies who supply equipment to utilities," explains Balzhiser. "And in both cases, EPRI has spurred

Solar photovoltaic cells

- Richard Balzhiser succeeds Culler as EPRI president
- Office of Corporate & Business Development established
- Office of Exploratory Research established
- Startup of AFBC demonstration at TVA

1988

- Montreal Protocol on Substances That Deplete the Ozone Layer
- NASA's James Hansen says global greenhouse warming has arrived

- Spinoff of CQ Inc. subsidiary

1989

- Exxon Valdez oil tanker spill, Alaska
- Pons and Fleischmann announce cold fusion results

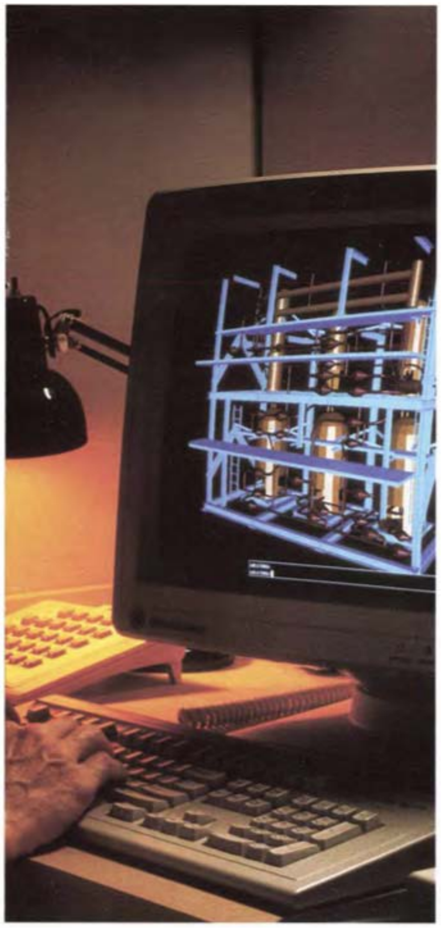
- First commercial production of Electric G-Van
- EPRINET begins full-scale operation
- Limited implementation of tailored collaboration begins

1990

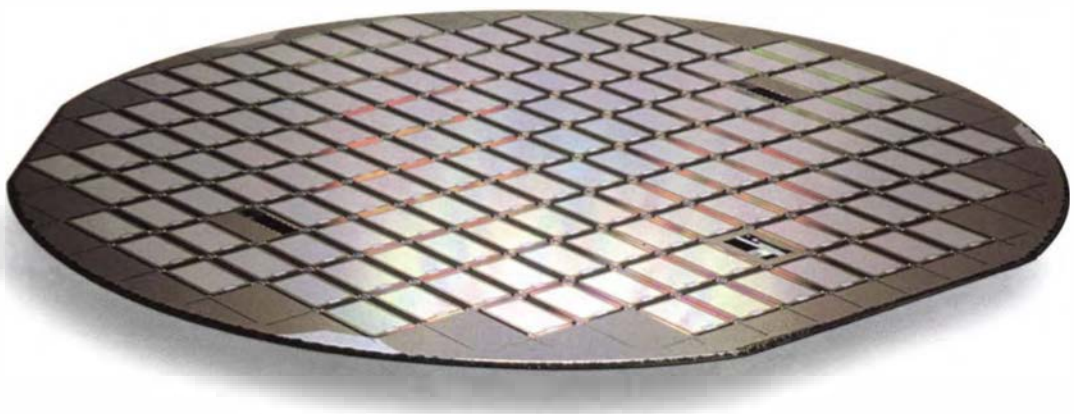
- Clean Air Act Amendments impose SO_2 cuts, allow emissions trading

Chrysler Epic electric van

Advanced light water reactor



Thyristors for advanced transmission system controllers



- Startup of Alabama Electric Cooperative CAES plant

1991

- Offices opened in Europe and Australia

1992

- National Energy Policy Act amends Public Utility Holding Company Act

International affiliates

collaboration and leveraging of funds by various groups with differing cultures and technical interests to create something new that nobody had thought of before and that may not have otherwise come about."

The new challenges for EPRI, as Balzhiser describes them, are less technological than they are institutional. For some years, the fundamental structure of the utility industry has been changing as competition has found its way into what had traditionally been a regulated monopoly. The trend toward competition and deregulation began in the wholesale power generation business, and it is spreading. With the recent passage of energy legislation (including revision of the Public Utility Holding Company Act), the pace of this change will accelerate. "Competition is here, and utilities must adapt to remain viable in the decade ahead. Keeping EPRI relevant and providing value to all of the industry as it changes is more important than ever," says Balzhiser.

"When I took over in 1988, the industry was beginning to see change on the horizon, and my challenge during these years has been to broaden our support base," says Balzhiser. "To survive in a more competitive industry, EPRI has to create value and deliver the value of our science and technology to every one of our members, who each year have to make a decision about whether to send some fraction of their revenues to us. The kinds of changes that are now well under way in the industry are going to cause many utilities, regardless of how the regulators look at us, to see R&D and EPRI as simply another cost that gets added to the cost of the product. So we need to be appreciated for delivering value that is commensurate with that cost."

Balzhiser has responded with initiatives to improve the efficiency and timeliness of delivery of EPRI products and research results in forms that are most useful to members. A major example has been the rollout and successful implementation of EPRINET, a new electronic gateway into EPRI. EPRINET links utility professionals, EPRI managers, researchers, and consultants in a global, real-time communications and information network. Now, every weekday, before the sun rises over the East Coast and long before anyone has arrived for work in Palo Alto, dozens of utility and research professionals have already logged on to EPRINET and accessed the latest news and research results.

Becoming more relevant and accessible to its geographically dispersed membership through electronic communications systems such as EPRINET and continuing to pursue those enabling, transformative technologies for the future that open new possibilities and ways of doing things are the kinds of challenges that Balzhiser knows from experience the Institute is capable of meeting.

"I think that with its collaborative nature, its ability to maintain a critical mass across many areas of technology simultaneously, and its superb intellectual resources—including staff, contractors, and utility advisors—EPRI has a fantastic opportunity to provide global leadership in ensuring that scientific and technological innovations contribute to continued electrification and its unlimited potential for improving our global well-being," says Balzhiser. "We've gone from finding better ways to produce and deliver electricity to a leadership role in finding better ways to use it. That poses just endless opportunity." ■

EPRI AT 20

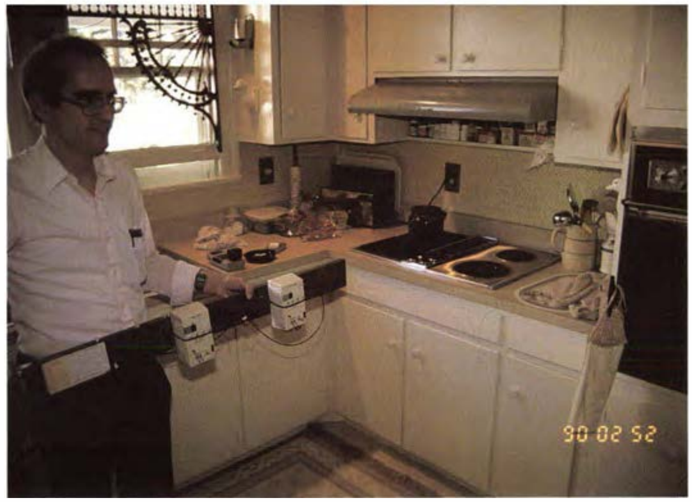
A DAY IN THE LIFE

Today the Institute is involved in a tremendous range of activities to serve the diverse needs of electric utilities and their customers. From its headquarters in Palo Alto to laboratories, research facilities, and utilities across the country, EPRI's people and research efforts are making a difference.

Monroeville, Pa. Westinghouse engineers, working under contract to EPRI, plan out large-scale testing of a heat exchanger for the safety system of an advanced, passive LWR.

Los Angeles, Calif. Several members of EPRI's Advisory Council sit on key committees of the National Association of Regulatory Utility Commissioners and keep the Institute apprised of regulatory perspectives on a wide range of issues.

Flagler Beach, Fla. EMF researchers record magnetic field levels in an actual residence as part of a groundbreaking survey of 1000 homes across the United States.

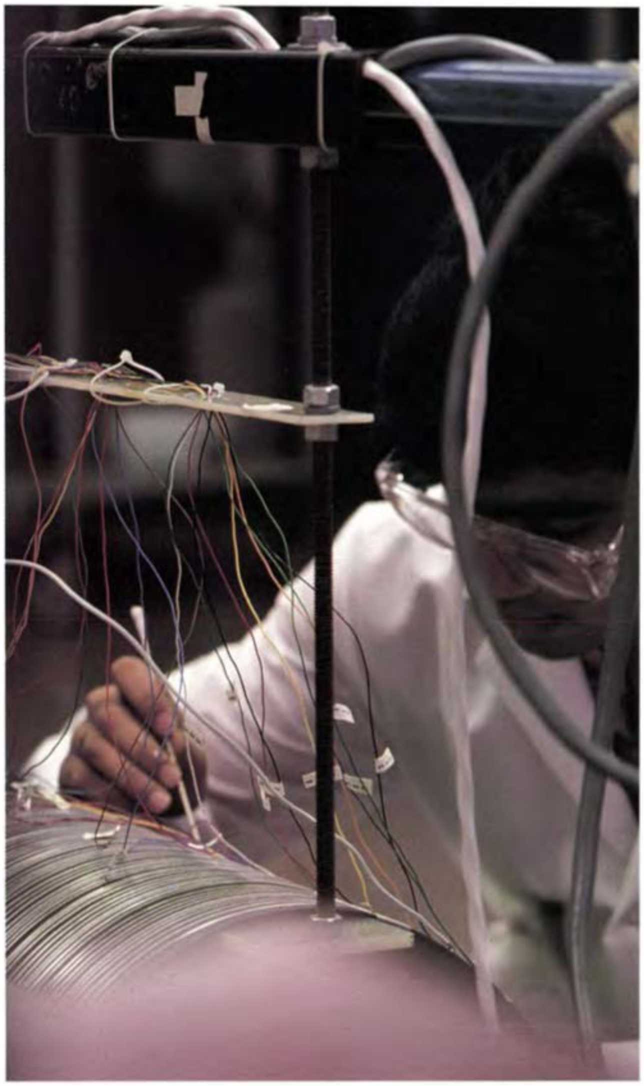


San Francisco, Calif. Experts share information on the latest advances in compressed-air energy storage at an EPRI-sponsored international CAES conference.

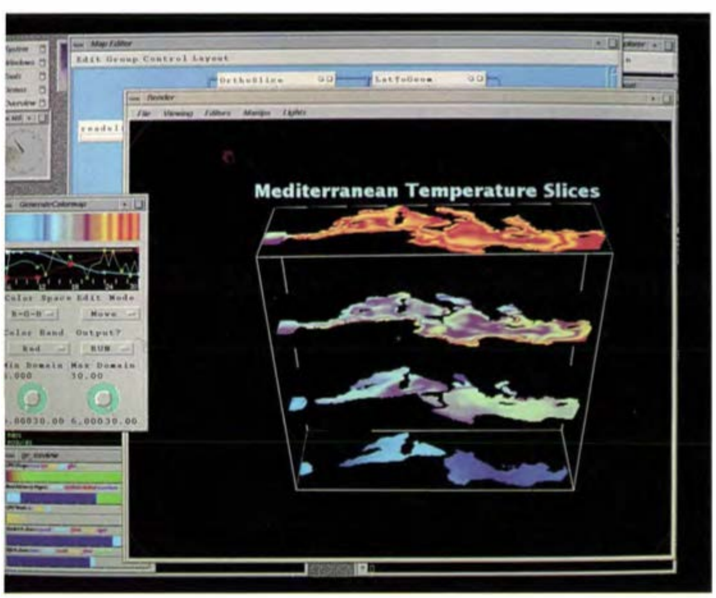
Little Rock Lake, Wis. Field researchers using superclean collection techniques sample lake water as part of a project to model mercury contamination in northern lakes.

Charlotte, N.C. EPRI's Nondestructive Evaluation Center offers utility personnel hands-on training in the latest NDE procedures, as well as experience in applying them to full-scale equipment mock-ups.

Chicago, Ill. Dr. Raphael Lee and his staff are developing diagnostic tools and therapeutic treatment for severe electric shock injuries at the University of Chicago's Electrical Trauma Center, recently established with EPRI support.



Boston, Mass. A researcher at American Superconductor prepares to test field-winding wire for a 25-W high-temperature superconducting demonstration motor developed by EPRI and Reliance Electric.



Boulder, Colo. EPRI provides major technical, financial, and management support for MECCA, an international effort being carried out at the National Center for Atmospheric Research to assess the reliability of global climate models.

Seattle, Wash. At the Lighting Design Lab, operated by Seattle City Light, Randal Smith uses EPRI's LightCAD™ software to help designer Denise Bruya Fong develop an efficient lighting scheme for a new office complex.

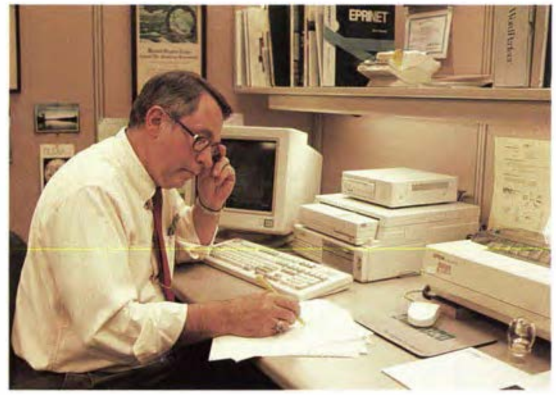
Lenox, Mass. EPRI's High-Voltage Transmission Research Center hosts a wide range of activities, from accelerated aging tests of insulators to training of utility personnel in the use of magnetic field mapping equipment.

Homer City, Pa. Mike McKelvy "cones and quarters" coal to prepare a uniform sample at EPRI's coal quality evaluation subsidiary, CQ Inc.

Birmingham, England Managers at PowerGen, one of EPRI's international affiliates, catch up on what's happening at the Institute's Palo Alto headquarters via a regular Tuesday morning videoconference call to loaned employee Rick Squires.

Barker, N.Y. Limestone and a wide variety of coals are brought to EPRI's High-Sulfur Test Center, which carries out research on sulfur dioxide emissions reduction in a utility-scale, real-world environment.

Hickory, N.C. A General Electric technician performs a final quality check during assembly of a low-loss, amorphous core distribution transformer, developed under EPRI sponsorship.



St. Louis, Mo. Gordon Prickett of Union Electric connects with the Institute every day via the EPRINET on-line information service to stay current on technical developments and EPRI offerings.

Wilsonville, Ala. Representatives from Energy & Environmental Research Corporation, DOE, and CQ Inc. discuss instrumentation installed at Alabama Power's Gaston station as part of the continuing development of EPRI's Coal Quality Expert computer program.

EPRI's

GREATEST ACHIEVEMENTS

Twenty years of R&D have produced hundreds of major scientific and technological advances related to every area of utility concern. Some were timely solutions to urgent utility problems; many others represent the culmination of long-term technology development efforts. The following pages present a selection of some of the Institute's best work: 20 achievements that demonstrate the breadth, quality, and value of EPRI's efforts.

World's Cleanest Coal Plant

Integrated Gasification–Combined-Cycle Technology EPRI's chemical engineering experts devised, initiated, and oversaw a new coal-based power generation project that in 1984 culminated in the first commercial-scale demonstration of IGCC technology. The Cool Water project, located at a Southern California Edison facility, produced the cleanest coal-fired plant in the world. The 100-MW unit reduced emissions of both sulfur dioxide and nitrogen oxides to about one-tenth of the limits set by the federal New Source Performance Standards. Even today, the only coal-fired power plants that match this level of emissions control are those that also employ IGCC technology. Moreover, IGCC increases the efficiency of coal-based power production. The successful EPRI-led demonstration has provided the impetus for further commercial use of IGCC, both in the United States and overseas. Cool Water project participants included Southern California Edison, General Electric, Bechtel, Texaco, and other domestic and international groups.

Pioneering Nuclear Safety Analysis

Nuclear Safety In the wake of the Three Mile Island accident, EPRI swiftly established the Nuclear Safety Analysis Center (NSAC) to address safety issues that were critical to the industry's future. Representing the industry's concerted response to the accident, the center conducted the first thorough analysis of it, offering unprecedented insight into the events at TMI. NSAC developed a system called SEE-IN to deduce the generic safety implications of operational incidents and electronically disseminate this information to all nuclear utilities; this was the forerunner of the operational safety information systems used today both nationally and internationally. Taking advantage of EPRI's pioneering work in probabilistic risk assessment, NSAC demonstrated the safety value of PRA analyses to nuclear utilities. Among the dozens of widely used products that have emerged from EPRI's nuclear safety R&D, one of the most important is the CHEC family of computer codes, which help utilities monitor and manage erosion-corrosion in piping systems.

First Utility-Scale FBC Demonstrations

Fluidized-Bed Combustion EPRI initiated and cosponsored the first utility-scale demonstrations of fluidized-bed combustion technology at three member utility plants. This effort provided the foundation for the commercialization of FBC and accelerated, by about 10 years, its adoption by a variety of electricity producers. Before the demonstrations, virtually no electricity-generating FBC units existed in the United States. Today there are 155 FBC units—with a combined capacity of 5400 MW—either operating or under construction in this country. Maximum unit size, now 165 MW, is increasing rapidly, with units of 250 MW already planned. The advantages of FBC technology include a documented 6–10% reduction in the cost of electricity, sulfur dioxide reductions comparable to those achieved with scrubbers, about one-fourth the nitrogen oxide emissions produced by a pulverized-coal boiler with combustion NO_x controls, and the ability to burn a wide range of fuels, such as coal waste products and petroleum coke.

Award-Winning Radiation Reduction Technologies

Occupational Radiation Exposure Reduction A world leader in the effort to reduce worker exposure to radiation in nuclear power plants, EPRI developed several radiation field control technologies that are responsible for at least one-sixth of the 300% exposure reduction achieved over the past decade. EPRI received an R&D 100 Award for each of four radiation reduction technologies. These four are LOMI, a chemical process that cleans nuclear plant piping without corroding it; GEZIP, a zinc additive for reactor coolant that reduces radiation buildup; NOREM, a new cobalt-free, wear-resistant alloy; and ELOMIX, a waste-processing technique for decontamination. In addition to substantially reducing radiation levels, LOMI and GEZIP are saving the industry more than $50 million a year in operation and maintenance costs. NOREM and ELOMIX, more recently developed EPRI products, are expected to further reduce radiation exposure once they are adopted widely in the utility industry.

Industry's First Predictive Maintenance System

Monitoring and Diagnostic Center With the cooperation of host utility Philadelphia Electric Company (PECO), EPRI created the industry's first integrated predictive maintenance system. This system, perhaps the most advanced utility diagnostic and monitoring system in the world, is designed to improve plant availability by 3%. Located at PECO's Eddystone plant, it links individual state-of-the-art, microprocessor-based diagnostic systems for individual plant components. To help transfer this technology to other utilities, EPRI established the Monitoring and Diagnostic Center, now called the Maintenance and Diagnostic Center. A separate facility at Eddystone that is electronically linked to the plant, the center hosts Institute-sponsored workshops attended by an average of 1000 member utility personnel annually. The center, which has also drawn the attention of utilities abroad, has effectively launched a new movement in the industry toward the use of comprehensive, integrated diagnostic systems. Last year the center received the Instrument Society of America's first-ever technology medal for its work in boosting the efficiency and reliability of power plants.

Nation's First CAES Plant

Compressed-Air Energy Storage EPRI engineers developed the small-capacity compressed-air energy storage concept that led to the design and installation of a 110-MW CAES plant at Alabama Electric Cooperative (AEC), the first commercial CAES plant in the United States. The facility, which represents the first new energy storage technology to be installed on a utility system in over 50 years, is the second commercial CAES plant in the world and the first ever to feature a recuperator, which reduces fuel consumption by 25%. Geologic formations in 75% of the United States have the potential to provide the reliable underground air storage required for a CAES plant. Since the AEC plant came on-line in May 1991, it has generated more than 55 million kWh of electricity during peak demand periods. Storage technologies like CAES provide an economically attractive method for utilities to better manage the balance between electricity supply and demand.

Critical Environmental Research

Managing Risks From Solid Wastes Breakthrough EPRI research has provided significant advances in understanding the chemical and physical processes that control the leaching of trace elements present in fossil fuel combustion wastes. These efforts have also clarified the complex processes that affect the movement of chemicals in soils and groundwater. The resulting information is being employed by experts around the world who evaluate these issues. For example, scientists at the U.S. Environmental Protection Agency have used EPRI knowledge as the basis for regulatory decisions required by the Resource Conservation and Recovery Act. Related EPRI work on the characterization of combustion wastes and certain noncombustion wastes (including chemically treated wood poles) led to a sound basis for regulatory decision making on the risks posed by these materials. The resulting classification of these wastes as nonhazardous is calculated to have saved the industry more than $13 billion over a 10-year period.

Wind Power at 5¢/kWh

Variable-Speed Wind Turbine EPRI established a utility/supplier alliance that led to the development of a variable-speed wind turbine that offers electricity for 5¢/kWh. This technological breakthrough is making wind power competitive with utility fossil-fired generation for the first time. The turbine, produced by U.S. Windpower with support from members of the Variable-Speed Wind Turbine Development Alliance (EPRI, Niagara Mohawk Power Corporation, and Pacific Gas and Electric Company), can operate at varying wind speeds. By contrast, conventional wind turbines that produce utility-grade power operate at constant speed. The variable-speed capability increases energy capture and prolongs the life of the turbine drivetrain, which in constant-speed turbines must withstand the extra torque created by gusts of wind. This advance effectively opens up the potential for developing previously unexploitable high-wind regions.

World's Only Dedicated NDE Facility

Nondestructive Evaluation Center Since it was established 12 years ago as a vehicle for moving new, nondestructive evaluation technology into nuclear power plants, the NDE Center has saved electric utilities more than $2 billion while helping nuclear plants maintain reliable, economical, and safe operation. Located in Charlotte, North Carolina, the center remains the only facility in the world devoted specifically to the development, field testing, and transfer of nondestructive evaluation techniques. To date, the facility's staff has trained over 6400 engineers and technicians in performing NDE techniques. The center also offers rapid on-site assistance to EPRI members and brings together experts from utilities, manufacturing organizations, and engineering firms to resolve problems that can be addressed through NDE. Among other accomplishments, the NDE Center has developed methods for detecting cracks in power plant piping, techniques for eddy-current testing and for ultrasonic examination, and an array of sophisticated software programs that assist utilities with NDE.

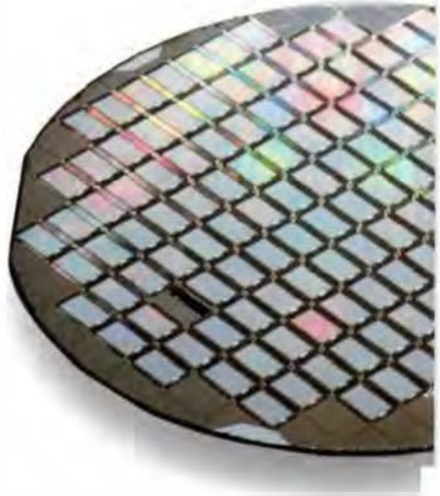
World's Largest EMF Research Program

Electric and Magnetic Fields Research EPRI was among the first organizations in the world to recognize electric and magnetic field exposure as a potentially important environmental issue: it established an EMF research program shortly after being founded in 1973. Today this program—funded at over $15 million a year—is the largest of its kind in the world, investigating potential EMF health effects while developing practical options to help electric utilities manage exposures, if necessary. The Institute has sponsored a number of significant studies exploring the potential link between EMF and cancer—including the largest childhood leukemia study to date, studies of basic biological response mechanisms, and several ongoing experiments examining cancer development in animals. EPRI has also developed a number of state-of-the-art instruments that measure and analyze magnetic field exposure, including the pocket-sized EMDEX device, which is being used by researchers all over the world. As part of its work in exposure management, the Institute conducts training courses at its research facility in Lenox, Massachusetts, and is developing management guidelines.

Efficiency Record for Space Conditioning

Advanced Heat Pumps The EPRI-developed HydroTech 2000 heat pump, manufactured by Carrier Corporation, is the most efficient space-conditioning and water-heating system available today, with the lowest operating costs. Introduced in 1989, it is 30% more efficient than conventional electric heat pump models and surpasses gas furnaces in overall system efficiency. The HydroTech 2000 is one in a family of high-efficiency heat pumps that EPRI has developed by working closely with manufacturers. Efficiency gains achieved by these benchmark units have catalyzed other manufacturers to push for the same energy-saving goals. Other members of the high-efficiency family include a line of dual-fuel units for commercial and residential use—the first single-package dual-fuel machines ever to be produced—and an advanced water-loop heat pump that is 25% more efficient than previous water-loop models. The most efficient water-source heat pump on the market today, this unit's energy use is comparable to that of many high-efficiency chillers.

Leading Edge of FACTS Revolution



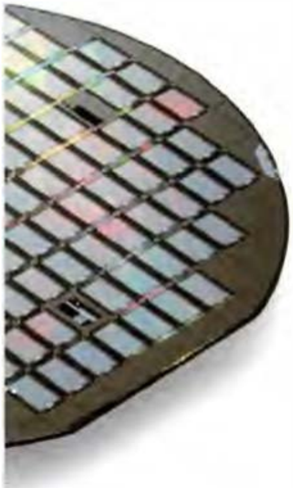
Advanced Transmission Controllers EPRI is developing technology that will make utility networks operate like giant, high-tech integrated circuits—with increased productivity, automation, and reliability. This technology, called FACTS (flexible ac transmission systems), was conceived by EPRI engineers and includes a family of advanced controllers. The new generation of high-speed electronic controllers is expected to revolutionize utility transmission systems by significantly increasing the utilization of installed capacity while reducing susceptibility to power disturbances and enhancing the control of power flow. In 1978 EPRI sponsored the development of the first solid-state, thyristor-based transmission line control device, a static VAR compensator, which helps keep voltage within acceptable limits on long, heavily loaded lines. This project led to the first application of solid-state switching for ac transmission lines. While FACTS technology may not be practical for all lines, using it to increase transmission capacity nationwide by 50% above the present average loading limit could save utilities more than $30 billion in avoided construction costs.

Revitalized Commercial Interest in EVs

Electric Vehicles In cooperation with Magna International and General Motors, EPRI spearheaded a project that resulted in the Electric G-Van, the first electric vehicle to pass federal motor vehicle safety tests and the first production EV in North America. The success of this project helped revitalize interest in EV technology, particularly among electric utilities. EPRI also collaborated with Chrysler to design and develop the TEVan, which will soon be that company's first commercial entry into the EV market. EPRI's work, which has included significant contributions to battery development, has concentrated on overcoming obstacles to commercialization and has helped raise confidence in EV technology as a possible solution to air quality problems. Given the country's current power generation mix, an efficient electric minivan generates less than half the carbon dioxide generated by a gasoline-powered minivan, one-hundredth the volatile organic compounds, 33% less nitrogen oxides, and 99.5% less carbon monoxide.

Largest Availability Problem Cut by 50%

Boiler Maintenance Workstation An EPRI-produced interactive expert system, configured in a user-friendly workstation, has allowed utilities to reduce boiler-tube-related availability problems by 50%. Boiler tube failures are the single largest contributor to availability loss in coal-fired plants, costing the utility industry an estimated $1.5 billion annually. The workstation provides access to five integrated software modules that incorporate knowledge gained through R&D on 22 major tube failure mechanisms. Utilities across the country have relied on this tool to identify the root causes of boiler tube failures and to design effective preventive maintenance programs that reduce forced outages. Initial applications at 16 utilities have already led to estimated savings of $202 million over a 10-year period. Before this system was developed, the root causes of tube failures at power plants were often misidentified, leading to recurring failures and repair problems. Commercially available since June 1991, the software has been used by virtually all the large U.S. utilities.



Lowest-Cost NO_x Control Option

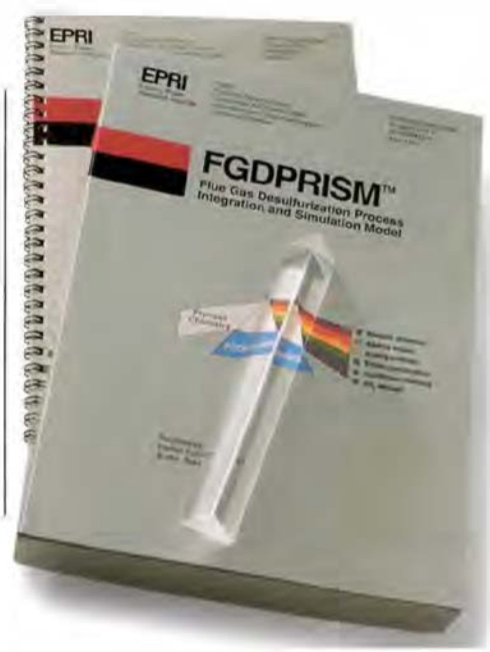
Low-NO_x Combustion Technologies Five years before federal regulations required the reduction of nitrogen oxide (NO_x) emissions from existing utility plants, EPRI sponsored about a dozen utility demonstrations that established the environmental performance, cost-effectiveness, and reliability of combustion-based NO_x reduction technologies. Data from these demonstrations provided a technical foundation that was pivotal in Congress's decision to allow utilities to use low-NO_x burners to comply with acid-rain-related requirements of the 1990 Clean Air Act Amendments. Not having to install the much more expensive and complex alternative technology (selective catalytic reduction), which is still unproven on U.S. coals, will save utilities an estimated $11 billion between 2000 and 2019. EPRI has also helped make commercially available such advanced NO_x reduction technologies as low-NO_x cell burners and the reburning process. These developments offer—for the first time—low-NO_x retrofit options for 50,000 MW of cell burner and cyclone utility boilers in the United States.

Controlled Major Nuclear O&M Problem

Remedies for BWR Pipe Cracking Pipe cracking—the biggest operation and maintenance problem for BWR plants in the 1980s—was at one point responsible for annual capacity losses of 16%, raising safety concerns and causing outages for piping replacement that lasted up to a year. EPRI R&D characterized the process responsible for the problem and developed a comprehensive set of procedures and technologies that brought it under control. The results of EPRI's effort, undertaken at the request of U.S. nuclear utilities, include a more stress-corrosion-resistant steel, innovative repair procedures, and techniques to improve nondestructive evaluation. By the mid-1980s, when EPRI-developed remedies were being widely used in the industry, related capacity losses were reduced by more than a factor of 10, and projected component lifetimes had more than doubled. The estimated savings to the utility industry: about $2 billion over the life of existing BWR plants.

State-of-the-Art Tool for Clean Air Compliance

Sulfur Dioxide Science and Control As part of a broad series of fundamental scientific studies on the release, movement, and effects of airborne emissions, EPRI conducted the pioneering Sulfate Regional Experiment, which explained for the first time how sulfur dioxide (SO_2) emissions behave and migrate in the atmosphere. The Institute followed through with the creation of the Flue Gas Desulfurization Process Integration and Simulation Model (FGDPRISM), a software program that synthesizes into a practical, problem-solving format the expertise gained from more than a decade of EPRI research in FGD system chemistry. The first and only program of its kind in the industry, this tool has been critical in helping utilities modify existing FGD systems and evaluate new FGD systems to comply with the SO_2 emissions reductions mandated by the 1990 Clean Air Act Amendments. Users include dozens of utilities and three of the world's leading FGD system suppliers. Industrywide use of FGDPRISM could save utilities about $2 billion in capital costs in complying with the Clean Air Act Amendments, as well as $10 million a year in operating costs.



70% Reduction in Distribution Losses

Amorphous Metal Transformers Conventional transformers account for the largest portion of the $7.5 billion in annual power losses on utility distribution systems nationwide. EPRI-contracted research led to the development of a new material called amorphous steel—a metallic glass offering extremely low electrical losses—for application in transformer cores. EPRI-sponsored research also incorporated this material into a product, the amorphous steel core for transformers. Power losses from distribution system transformers with these cores are 70% lower than losses from conventional, iron-core transformers. Commercially available since 1987, the amorphous metal transformers are now offered by all major industry vendors worldwide and represent about 5% of the annual domestic market for distribution transformers. This technology was cited by the U.S. delegation at the 1992 Earth Summit as one of the key technologies being adopted to improve this country's energy efficiency and reduce carbon emissions.

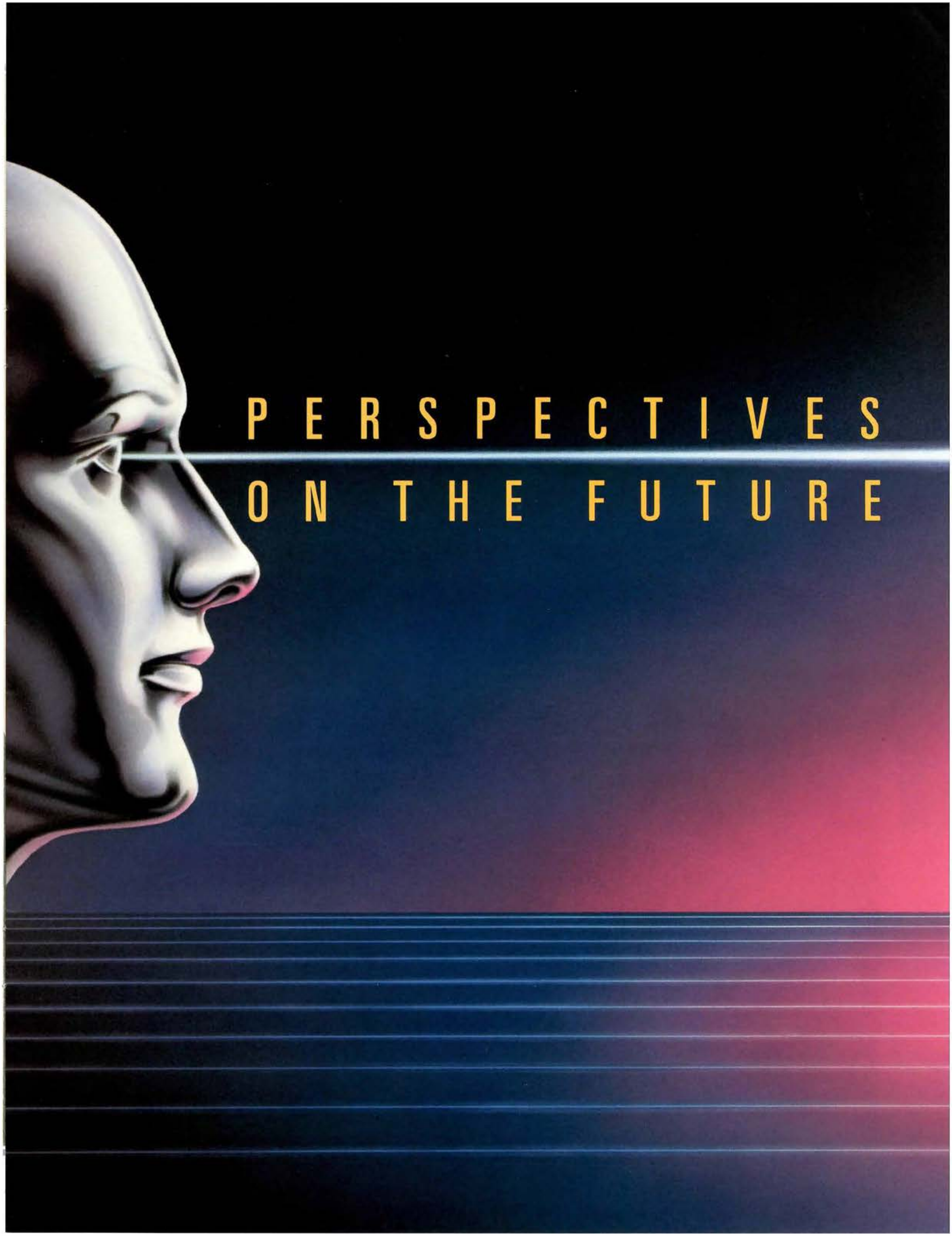
World Leader in PCB Management

PCB Management Tools A world leader in polychlorinated biphenyl research, EPRI has developed products for PCB detection that are saving the utility industry billions of dollars. EPRI's patented CLOR-N-OIL™ test kit measures PCB contamination in transformer oil. This tool (which costs about $4) enabled utility workers to conduct chemical analyses in the field for the first time, reducing routine testing time from hours to about 5 minutes. It is now widely used in the industry. A companion test kit, CLOR-N-SOIL™, measures PCB contamination in soil. EPRI has also compiled extensive information that has allowed for the simplified reclassification—with approval from the U.S. Environmental Protection Agency—of PCB-contaminated utility equipment. And a recently released EPRI product called Terrasight enables utilities to determine quickly the extent of invisible PCB and mineral oil spills. The winner of an R&D 100 Award, Terrasight could save the industry about $50 million annually in comparison with conventional procedures, which involve extensive random digging.

World Record for Silicon Cell Efficiency

Photovoltaic Cells EPRI-sponsored work at Stanford University led to the development of a high-concentration photovoltaic cell that holds the world record for sunlight-to-electricity conversion efficiency in silicon (28%). This efficiency level comes within a few percentage points of the theoretical limit for a silicon-only device. Unlike conventional large-area, flat-plate solar modules, which typically operate at a fixed tilt facing south, concentrator systems actively track and focus sunlight onto smaller modules that generate up to 500 times more current per unit of cell area. EPRI's R&D efforts in high-concentration photovoltaics have overcome manufacturing as well as scientific hurdles. Today two startup firms are planning to become commercial manufacturers of suntracking systems based on the technology. These environmentally benign systems have the potential to provide utility-grade electricity for 6–8¢/kWh (in 1992 dollars) within 10 years. The modular nature of these units and their short construction lead times will reduce technical and financial risks for utilities.

PERSPECTIVES ON THE FUTURE



How is the electric utility industry changing, and

With environmental and regulatory issues coming increasingly to a head, the electric utility industry appears to be at the threshold of fundamental change. A number of experts from inside and outside the industry share their perspectives on what the future will hold for EPRI, its members, and R&D itself. While the comments clearly predict difficult challenges ahead, they also stress the critical role that technology will play in meeting the broadest needs of industry and society.

I think we've got a slow period in which the face of the electric utility industry will be changed to look much like that in England: generation altogether separate from distribution, with many players competing with each other for customers. This will clearly change the way utilities do business, and it will change EPRI too. We will need research that helps us maintain the economic advantages of central-station generation. But because it's the devil we *don't* know, we need to be interested in technologies for distributed generation too. I happen to think that fuel cells will turn out to be very important and that we will eventually see 200-kW, 500-kW, 1-MW stacks right on customer premises. The decoupling of traditional utility activities will pose difficulties for EPRI, which was set up to serve the industry as an aggregated whole. It will have to be able to respond more directly to individual members and sell them just what they need. It will need to become less consensus-driven. In essence, EPRI will have to pay more attention to particular member segments and less to the industry as a whole in its planning, its research, and its marketing.

John Rowe
President and CEO
New England Electric System

what will this mean for technology and research?

Much of the utility industry is in a state of gridlock today, caught between recent environmental and regulatory actions and an economic recession that has substantially reduced the electricity demand growth rate. These constraints have created a tremendous strain on the ability of utilities to raise capital, leaving them with reduced financial flexibility for long-term investment. As a result, their focus has been pulled strongly to the near term. But the present becomes the future all too quickly. While demand growth has been slow, it is continuing, and electricity surpluses will eventually be used up. Five or 10 years down the road, utilities are going to need new capacity and improved operating equipment that cost-effectively conform to environmental and regulatory requirements: clean coal plants, advanced nuclear reactors, highly efficient gas-fired installations, more flexible delivery systems, and so on. In addition, today's uncertainties about the structure of the industry—about independent power producers, international alliances, and new rules on wheeling—will be playing out as harsh competitive realities. Advanced technologies can provide options for resolving all these problems, but the utility industry will have to break the gridlock on future strategies and be willing to invest in them.

Chauncey Starr

President Emeritus

EPRI

I think technology is going to become more of a differentiating factor in the utility industry. It's almost a truism that companies who capitalize on innovation and successfully use new technology become the most successful members of an industry. This will be a particularly potent concept for utilities. For one thing, the technology will be there, set before us. It seems to me that we're at the dawn of a new age of technology for all phases of the business—power plant performance, unconventional generation options, transmission and distribution, highly efficient end-use technologies. At the same time, regulatory and competitive factors are changing the shape of the utility industry. I see in the future an industry far less homogeneous than it is today, less vertically integrated. Many utilities will concentrate on smaller pieces of the business. They will need the technology that will help them excel in those particular areas, and they will have to think harder than ever before about how to assimilate and use technology in their operations. Their success in making these choices work will largely determine who the winners and losers will be.

John Sawhill

President and CEO

The Nature Conservancy

What areas of technology will be most import

As America continues to use more electricity in our industries, businesses, homes, and transportation, we are entering a future in which our reliance on advanced technology will intensify. That future was clearly defined when the Energy Policy Act of 1992 was signed into law last October. The act promotes increased energy efficiency and wider use of renewable resources to meet growing electricity demand. It places greater reliance on competition to ensure use of the lowest-cost generating resources. And it delineates a significant role for clean-air vehicles, such as those powered by electricity. Overall, the intent of the energy act is to enable consumers to obtain electricity at the least possible cost and, at the same time, to protect the environment.

Meeting these objectives will stretch all the capabilities of our industry, and most especially our technological innovation. In the coming years, we'll need advances to improve our competitive performance in generation, transmission, and distribution, to cut costs, and to improve quality of service. We'll need just as much progress in technologies that will enable our customers to use power more efficiently. And we will need improved battery technology to make electric vehicles a major transportation option in the 1990s.

Richard A. Clarke
Chairman and CEO
Pacific Gas and Electric Company

Once in a great while, the confluence of technical change and external factors causes something extraordinary—a revolution of sorts, a technologically driven discontinuity. People usually are not aware of being in such a transition, but when it's over, *everything* is changed. The technological ingredients for this phenomenon are now approaching a critical mass: computers, information science, biotechnology, materials advances, extreme miniaturization, environmental science, new power cycles, and many more. Advances in technology now (or soon to be) available will allow us to change for the first time in over a century the basic ways we generate, store, transmit, and use electricity, promoting higher efficiencies, expanded capabilities, and lower costs. Fuel cell technology is a prime example. For the first time, we can efficiently replace mechanical gear for converting heat into electricity—thus avoiding the Carnot trap in efficiency—and perhaps provide electricity at a selection of frequencies. Equally important advances are coming for other parts of the utility system. We're at the point of demonstrating and deploying most of the things that were well understood scientifically before 1960. As we make these technologies part of standard industrial practice, we must develop and demonstrate new concepts—use our imaginations to replenish the barrel with new goals and new science.

Floyd L. Culler
President Emeritus
EPRI

ant to pursue in light of these changes?

Certainly there will be great changes and technical challenges in the industry's future, especially regarding environmental issues. But there is an equally formidable challenge that is sociological rather than technical—the problem of public acceptance of technology. Nuclear power, for example, is a good technical solution to a need for electricity, but for it to continue, we have to gain public understanding. As an industry, we have been used to making our own decisions, serving the public good but relying on our own expert knowledge and good intentions. We cannot do that anymore because the public expects more control. This is a reality of our times. We must think differently about the sociological impacts of how we run our operations and how we develop and introduce new technologies. If we are to gain agreement with people on the best ways to conduct our business—and hopefully convince them of our wisdom in these matters—we need to forge better links with the public. We need to provide people with better information, include them in the decision-making process, and talk about issues in terms they relate to. We have to adapt ourselves, and we are not used to that.

Rémy Carle
Deputy General Manager
Electricité de France

I think we're just beginning to recognize how profoundly the industry's generation and delivery systems will be transformed in the coming years. I see this playing out in much the same way the computer industry has evolved. Large mainframe computers have given way to small, geographically dispersed desktop and laptop machines that are interconnected into fully integrated, extremely flexible networks. In our industry, central-station plants will continue to play an important role, of course. But we're increasingly going to need smaller, cleaner, widely distributed generators—combustion turbines, fuel cells, wind turbines, photovoltaic installations—all supported by energy storage technologies. A basic requirement for such a system will be advanced electronic controls: these will be absolutely essential for handling the tremendous traffic of information and power that such complicated interconnection will bring. EPRI is leading the pack in this area with its work on flexible ac transmission systems (FACTS) and custom power. The state-of-the-art solid-state switching devices being developed in these programs will dramatically enhance the capabilities of the nation's power delivery system, allowing us to increase overall system efficiency, preserve high levels of reliability, and provide the customer with a broader choice of service options and power quality.

Richard E. Balzhiser
President
EPRI

I believe that EPRI can contribute to the global need for more efficient energy production by becoming more active in international research. This is important for two reasons. First, all nations and industries now operate in a globally integrated economy, and knowledge is a primary currency. To prosper in this economy, it is vital to know what the Japanese, Germans, and others around the world are doing. How the utility industry fares is particularly crucial, because energy availability is at the root of our standard of living—efficient energy makes much in this world possible.

Second, we need to recognize that energy production and use also contribute to some forms of pollution on local, regional, and global scales. We have an obligation to find ways in which clean, energy-efficient technology can be diffused into the economy, not only domestically but worldwide. For EPRI this will mean research on conservation and efficiency practices, the development of publicly acceptable nuclear options, and movement toward nonfossil, renewable energy sources that can be used by all countries.

Robert M. White
President
National Academy of Engineering

Should EPRI become more involved in global issues

When you consider any projection of energy demand over the next 50 or 100 years, two things occur to you immediately. One is that most of the growth will take place in the developing world, and the other is that coal will fuel most of that growth. The result will be a substantial draw on both energy and environmental resources, because coal is a relatively dirty fuel with the habit of releasing lots of carbon dioxide. Such pressure on the environment cries out for technological approaches. In fact, if we are really going to get serious about the global environment, the industrialized world ought to be smart enough to approach it in the most efficient way—by developing and exporting clean technology to developing countries, where energy production and use are disastrously dirty and inefficient. My guess is that EPRI will become more global in the future, partially because of its central role in such technology but also because more and more of its members will follow the few who are already expanding their businesses internationally.

Robert Fri
President
Resources for the Future

The question of global stewardship is going to be an increasingly important factor at all levels of the energy industry. It's with us now, and it's going to grow. Certainly environmental protection is a big part of this, but we have to see the larger context and consider the entire cycle of energy use and the dominant role energy plays in both local and world affairs. Energy is the ultimate resource, the key to increasing the global quality of life. If you have adequate energy, you can pump water, you can fix nitrogen from the atmosphere, you can develop an agricultural economy to feed millions more people. You can also recycle any element found in the earth's crust if you're prepared to spend the necessary energy. It's getting to the point now where the primary virgin ores are not that much richer in the elements we want than are the local junk heaps. Our profligate, one-pass exploitation of resources is coming back to haunt us; we need to start developing closed cycles for using and reusing resources indefinitely.

D. Allan Bromley

Former Assistant to the President
for Science and Technology and Director,
Office of Science and Technology Policy

and international research?

Whether we like it or not, for at least the next two decades coal and nuclear will remain the most important primary energy resources for electricity generation worldwide. One of our highest priorities, then, must be to push the development of technologies that will address their environmental impact. Coal use will increase with population growth and global industrialization; generation efficiencies and the development of clean coal technologies must increase at an even faster pace if we are not to lose ground environmentally. I feel these challenges are very much within EPRI's focus. With regard to nuclear power, the problem will be primarily one of waste disposal, and again I think EPRI can play a leading role. Nuclear waste disposal is largely a matter of political and technical systems analysis. Governments will certainly be involved, but there is increasing awareness—in the United States, my country Germany, and elsewhere—that governments are not necessarily the organizations most capable of handling these kinds of complex issues. EPRI is in a unique position to interact with the government on the one hand and utilities on the other to find workable solutions that will truly serve the interests of both the industry and the public.

Wolf Häfele

Director
Research Center Rossendorf
Dresden, Germany

Can collaborative research survive in an increasingl

I don't think increased competitiveness between utilities undermines the principle of research collaboration at all. Each utility will need access to a broad range of R&D just to stay in the race. Whether they come out ahead in the competition will depend on how well they *harvest* results, how well they make R&D pay off in application. If you don't have the science and technology base with which to compete to begin with, then someone from the outside who has harvested that base is sure to come in and take your business. Maintaining that knowledge base, I think, is the survival issue, where scope increasingly requires the kind of collaborative team approach created by EPRI's founding fathers. Also, to thrive in a global economy, we can no longer afford the luxury of operating as small, discrete entities. Collaboration is the key to focusing strength. It will ensure that U.S. utilities have access to the very best science and technology—we can't risk keeping the United States locked at one technological level while the rest of the world moves on to another. Some utilities will inevitably harvest innovation better than others, but if there isn't a fertile field to begin with—research collaboratively sown and cultivated—then there will be no crop and we will all starve.

Kurt Yeager
Senior Vice President, Technical Operations
EPRI

My sense is that there will continue to be collaborative R&D because there is a culture that accepts it and realizes that it has a great deal to gain from such approval. In fact, competition may actually drive us more strongly in this direction. Even now, trying to squeeze 1–2% out of a budget to dedicate to research is a very difficult task, and if you do find the money, it's only enough for a very narrow program. Competition will worsen this situation by constraining available capital even further. If we pool our resources in a collaborative effort and share the results, we may realize less of a unilateral competitive advantage, but the alternative might be that the research isn't undertaken at all. The collaborative approach is the most efficient way to do research, and I think we will proceed in this vein because the economics will compel us to. We also have to remember that with more deregulation, much of our competition will come from outside the traditional utility industry; we as a group will need an R&D advantage over these new players if we are to prevail.

Randall Hardy
Administrator
Bonneville Power Administration

Even in this increasingly competitive society, we can't overlook our responsibility to the public and our ratepayers. It's just not farsighted to suggest that research be dropped unless it's justified for current competitive reasons. When R&D is aimed at cutting costs, improving safety, or reducing the potential risks of such things as EMF and hazardous waste, it's difficult to draw the line between competitive obligation and public responsibility. I think we have a duty to undertake collaborative R&D. And tailoring some portion of that effort to individual participants' needs, as EPRI is now doing, is a good idea too. That's the appropriate way to recognize the competitive aspects of our business. My only concern is the difficulty of striking an appropriate balance between individually chosen R&D and EPRI's broadly directed research, which may not be applicable today but which may be required as we move out in time—for example, EMF or superconductivity research. Unless a significant portion of EPRI's funding is devoted to that sort of effort, we'll find that such fundamental research just doesn't get done, because there's really no one else to do it.

John Ellis
Chairman of the Board
Puget Sound Power & Light Company

y competitive and deregulated environment?

EPRI faces a lot of pressure as the electric power business becomes more competitive. Some members may be less willing to ante up, simply because they're hard-pressed. Others may be reluctant to trade ideas on technology—or anything else, for that matter. These responses are similarly motivated: both of them reflect short-term, bottom-line thinking. As a regulator, I'm concerned that turning away from the significant kind of R&D that EPRI sponsors isn't necessarily in the public interest. It may save money for a utility in the short term but wind up costing ratepayers more.

I must admit that shared research among competitors is difficult to accomplish. But the past 20 years prove that ongoing, credible, and successful collaborative ventures produce ratepayer benefits that couldn't happen otherwise. Now, as the power industry changes, ensuring that such benefits continue may require intervention from outside the industry itself. Over time, I think, regulators are going to play an even stronger role than they have in the past in making sure this kind of work gets funded. After all, regulators have no particular interest in the outcome of utility competition, but they *are* interested in how it benefits electricity consumers.

Ashley C. Brown
Commissioner
Public Utilities Commission of Ohio

What are EPRI's greatest strengths and its gre

The broad-based funding built into EPRI's collaborative framework allows the Institute to be active in a full agenda of technologies and environmental concerns that most of its individual members would find difficult to even *monitor* comprehensively. I see a continuing need for this kind of breadth, although changes in the industry will probably increase members' demands on EPRI for research that will keep them lean and competitive. I personally believe that it's important for us to invest in an R&D resource we feel is objective and farseeing as opposed to purely market-driven. To continue in this mode, EPRI will have to maintain a solid agenda that is robust but doesn't try to do everything. It will also have to work on staying efficient as an organization, avoiding a lot of the baggage that loads down government and universities—bureaucracy and consensus concerns that tie them in knots. It occurred to me in a recent frustrating experience with a university: you can readily find good people and a million kinds of expertise on campus; it's harder to find a decision.

Walter Canney
Administrator
Lincoln Electric System

I tend to see EPRI's strengths in terms of the benefits it offers my organization, and I'd say those center around value and expanded opportunity. The greatest value is simply in having access to research that would otherwise be beyond our capability. This is especially important for a relatively small utility such as ours, but given the massive coordinated efforts needed for environmental research or the development of leading-edge technologies, the collaborative approach opens a lot of doors for big utilities too. It just makes sense to take advantage of leverage like this—we're getting a return of somewhere between two and a half and three-plus dollars for every dollar invested in EPRI, and have for some time. I also see great value in the opportunity for our employees to be involved in EPRI committees, task forces, and seminars. It allows them to become a more important part of the industry, to exchange thoughts with others and bring back new ideas. Our people are very talented, very smart. But this kind of cross-fertilization broadens them and broadens our opportunities as a utility.

Donald R. Norris
President and General Manager
East Kentucky Power Cooperative, Inc.

The quality of EPRI's technical staff is its key strength. Our people have become extremely adept at synthesizing information into knowledge and applying it to industry and societal concerns. This ability will become even more important in the future, as complicated issues—especially those driven by environmental imperatives—require the bridging of various scientific and technological disciplines. Because of its wealth of expertise, EPRI is in a unique position to integrate these complex issues and develop holistic solutions.

In terms of challenges, some of the toughest ones are likely to be institutional rather than technical. Because our industry is changing, we will need to introduce new degrees of flexibility for our members. Utilities are following dozens of different business strategies, and we've got

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to find ways of letting them focus on the research areas that are most relevant to what they're trying to do. Our tailored collaboration program, which allows utilities to target a portion of their regular dues to areas of particular interest if they are willing to match it with a like amount of additional money, is one way of providing such flexibility. We will be actively working with our members to determine what additional steps are necessary.

Richard L. Rudman

Senior Vice President, Business Operations
EPRI

EPRI's value is often expressed in terms of the technological advances it has delivered to the utility industry, and certainly it has been successful in this. But if we think of EPRI just in terms of equipment, we're selling it short. Its involvement in broad societal issues is largely why I see EPRI as the best instrument for handling the industry's collaborative research needs. These issues—questions about the environment, national productivity, public safety, and overall quality of life—are hard for a single utility to get its arms around. Sure, it's important to have advanced technologies on the system, but if you look further forward—or backward, for that matter—you recognize that the issues that lie beyond system operation and traditional industry practice are often even more important. Some see these as motherhood issues—a matter of being a good citizen. What's interesting is that, sooner or later, responding to societal issues turns out to be absolutely in a utility's self-interest. There's always a mix of near-term and long-term needs; the challenge is to be broad and imaginative in dealing with them, and these qualities are among EPRI's greatest strengths.

Erle Nye

Chairman of the Board and Chief Executive
TU Electric

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EPRI JOURNAL

January/February 1993

EJ-102128