Perceptions of EPRI

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Cover: Tunnel vision—the limited
focus of individual perception—
suggests the need for a collective
viewpoint.

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About This Issue

January 1 marked both an anniversary and a point of transition for EPRI. Five years ago to the day, Chauncey Starr accepted the job of transforming an ambitious concept into a workable organization, was deemed its first employee, and was inaugurated as the founding president. His five-year term has now expired, and Floyd Culler, former deputy director at Oak Ridge National Laboratory, will become the next chief executive officer this May. And Chauncey Starr will assume the position of permanent vice chairman of the Board.

The character of an organization very often strongly reflects the character, style, and vision of its leadership. In times of changing leadership, it is useful, therefore, for people to take stock—to see where they have been, to assess their achievements, their successes and failures, and to reexamine the fundamental issues that gave the organization its reasons for being. What has been done? What remains to be done? What new missions and problems have emerged?

We have taken this occasion of transition in leadership to explore EPRI in such a manner, to reassess where EPRI has been, how it has been structured, and how it operates, in order to look with some clarity to the future. Five years is not a long time in the research business, and only now are solid, concrete achievements beginning to emerge. This suggests a threshold has been reached; one that portends a new phase in the Institute's development. Clearly the next five years will be different.

Organization assessment is tricky business. No single viewpoint is complete; no two perceptions exactly coincide. With this in mind, we invited a large number of informed people to share their particular insights into EPRI, hoping that objectivity would emerge more readily from the collective view.

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In preparation for this month's lead article, Nilo Lindgren moved about, gathering the memories, opinions, and perceptions of a dozen or more individuals central to the creation of EPRI. Integrating their viewpoints with fact, he provides a fresh look at the Institute's origins, a retrospective that carefully traces "The First Five Years: Chauncey Starr and the Building of EPRI" (p. 4).

Lindgren brings to bear his own perspective gathered in 25 years of writing about high-technology organizations. Currently, he is a multimedia communications consultant, editor of the *EPRI Executive Report*, and a contributing editor to *IEEE Spectrum*. An electrical engineering graduate of MIT, Lindgren has been affiliated with the research arms of Xerox Corp., Philco Corp., Grumman Aircraft, and Hughes Aircraft, and was one of the founding members of *Innovation* magazine.

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A little over a year ago, at the request of Chauncey Starr, the EPRI Board began an independent and sweeping review of the Institute's operations and management. The audit committee, chaired by William Gould, executive vice president of Southern California Edison, solicited the opinions of virtually every group affiliated with or affected by EPRI's work. The result was a 70-page report of distilled conclusions and recommendations. These are highlighted, along with Gould's personal observations of the information collection system he set in motion, in "After the Facts" (p. 17). The piece was written by John Kenton, EPRI communications specialist in nuclear technology.

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The highly active industry advisory structure of EPRI provides a formal link to its sponsors, one that ensures direct access and strict accountability. In "Gauging the Return" (p. 21),

Ludwig Lischer, long-standing chairman of EPRI's Research Advisory Committee, evaluates what the industry is getting for its money and shares his perception of the Institute's technical and organizational progress.

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Turning things about, Robert Loftness, director of EPRI's Washington liaison office, casts his view toward the federal establishment and the energetic developments of the past year. "Energy in Washington" (p. 25) provides a capsule summary of the National Energy Plan, the formation of DOE, and recent changes in congressional committees, nuclear power policies, and environmental initiatives. With an R&D budget that is orders of magnitude greater than EPRI's, the federal energy programs carry enormous weight. Loftness, former deputy director for technology, Office of Atomic Energy Affairs, U.S. State Department, discusses the implications to the industry's own R&D programs.

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In this month's final piece, a roundtable format was used to elicit the viewpoints of EPRI's four technical division directors and the director of planning. Asking the questions, which ranged from technical highlights to national concerns, were Donald Christiansen, editor and publisher of *IEEE Spectrum* and Llewellyn King, publisher of *Energy Daily*. Supplying the answers during the four-hour, freewheeling "Round of Response" (p. 28) were directors Richard Balzhiser, Fossil Fuel and Advanced Systems; John Dougherty, Electrical Systems; Milton Levenson, Nuclear Power; René Malès, Energy Analysis and Environment; and Ric Rudman, Planning. President Chauncey Starr joined the group intermittently.

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THE FIRST FIVE YEARS

Chauncey Starr and the Building of EPRI

by Nilo Lindgren

"Discount the first year," everyone says. "It's really only been four years." What they mean is that the achievement has been breathtaking, given the starting point. There were barely a dozen people in EPRI for the first half year. And for the first part of that, there was only Chauncey Starr with plans for a vast research and development program tucked in his vest pocket. At Senate hearings in early 1973, when Dr. Chauncey Starr was being introduced as the president of the new R&D arm of the electric utilities and "the only employee at that time," there was not even stationery with a letterhead. Some people took the whole thing to be a sham; they publicly disparaged the ability of the industry to get this new endeavor off the ground. But Chauncey Starr was characteristically so sure of where he was going, and why, that he reports he felt both amused and annoyed. "Amused at the criticism and annoyed that it would be given any kind of credence by the Senate committee."

Yet the utility industry leadership had been brought to a perception that time was running out, that a massive technological R&D enterprise was required, and that if the industry did not do it, the federal government would, and rightly should in case of such a default. As Shearon Harris, then president of Edison Electric Institute and later chairman of the EPRI Board of Directors, relates, "The time had arrived for this undertaking to be born, and truly it needed to be done. While it was a mammoth undertaking and required a tremendous amount of time and effort, it was so obviously needed that there was no escape from it."

The sense of inevitability, however, did not diminish the odds against success. Starr reflects, "Just making a lot of motions and having a lot of projects does not ensure that you are going to come out with anything worthwhile. R&D is a gambling operation, one that is highly speculative . . . only a fraction of what you do ever gets into use. But," he adds, putting out his hands as if to take hold of one of his basic principles, "the odds of success go up if you have the very best people guiding the way, making the choices, and creating new approaches and new ideas." For the new institute to have any value, it "would have to have the very best minds that could be brought to bear on the problems of the industry." Attracting those first-rate people from good positions, from tenure, to come to work for a fledgling institute whose chances for survival (at least externally) were not clear, to work in the context of an industry with which they had little previous connection, and to work for an organization in which attractive offerings, such as stock options, were not to be had was a task for which Starr had no qualms. He simply knew he could do it.

And now, in a bare four or five years, the staff has grown to nearly 420, half again the size that was initially estimated, and the budget to $220-odd million, supporting more than 900 different projects, large and small. One gets the sense around EPRI that it all still feels rather new. Even at that, probably not many people know the details of the "early" history, just a few short years ago. Nor, perhaps, do many people recognize Chauncey Starr's vision of what the new Electric Power Research Institute should be. It went beyond the obvious concept of a purely technological mission.

The following seven sections provide a perspective on the formation and evolution of EPRI—and on the role, management style, and influence of its first president—based on interviews and discussions with many of the early participants.

THE SHAPING FORCES

The formation of something like EPRI had become inevitable

Although EPRI was really incubating for years under the wings of Edison Electric Institute (EEI), and taking some initial shape in the work of the Electric Research Council (ERC), it took some careful planning and maneuvering by farsighted electric utility executives to launch it on its way. It was something of a forceps delivery at that.

The backlog of technological problems facing the industry had been accumulating, and they were of a character that could not be expected to be handled by the traditional vendors alone. The utility industry began to perceive that it had reached a plateau in new technology for the generation of electricity. On the one hand, in the 1950s and 1960s, it was getting more kilowatthours out of the same amount of fuel, but was hitting temperature and pressure limitations. There was, consequently, a flattening of expectations for fossil fuel generation. There was also the recognition that much more was to be done with nuclear energy, and exotic concepts, such as fusion, were looming as tremendously large undertakings of a long-range, high-risk nature. Of that period, Harris reflects, "There was within our industry a perception that greater technological efforts were needed than even the vendors could be expected to make." The payout time was simply becoming too long for manufacturers. If the manufacturers had to make great investments and could not expect a return in less than 30 years, this really evolved into a larger societal responsibility. But there was no existing mechanism that could address such technological needs.

Another perception of the same basic problem, says Starr, is that the electric systems were simply getting larger and more important than their individual components. As the utilities grew, the vendors continued to supply the hardware and give counsel on system interconnections, but the performance of the systems—their overall reliability—became more and more the responsibility of the utility in-house engineers. "Then because of the complexity of the problems," says Starr, "a whole series of incidents pointed to the need for the utility industry to have its own independent technical center."

The very first efforts to get the industry interested in setting up a new R&D organization go all the way back to 1954, when Williams Lewis, a consulting electrical engineer in Palo Alto, California, and Dr. Jesse Hobson, then director of the Stanford Research Institute, presented the first of a series of papers at an AIEE Winter Meeting in New York. But Lewis concedes that his and Hobson's efforts were those of a gadfly, and they recognized the need for someone close to the industry to "quarterback" their concept. That effectively came from Joseph Swidler, then chairman of the Federal Power Commission, who in 1963 addressed EEI on the serious need for an organized research program. Swidler evidently drew on Lewis and Hobson's earlier ideas. Under his thoughtful prodding, ERC was formed and sponsored some research studies on a modest basis through the late 1960s.

A more massive prod to the industry resulted from the famous 1965 Northeast blackout; that, says Starr could be seen as the real genesis of EPRI. It triggered public and government criticism and

"Traditionally, the electric utility industry depended upon the manufacturers to do research and product development," reflects Frank Warren, current chairman of EPRI's Board of Directors, "but our conditions and problems were obviously changing; there was a great deal of pressure to move into a research program, which the industry took to heart."

led to proposed legislation in the early 1970s (by senators Magnuson and Hollings) for a federal agency to be set up to do research and development for the industry. The work of this agency was to be supported by a tax on utilities.

About the same time, ERC was completing what Harris saw as its most significant contribution, namely a report on the R&D needs for the electric utility industry for the remainder of this century. Called the green book, that study pointed to the need for $30 billion of R&D to be sponsored over the next three decades. In contrast to the $7–$10 million being expended annually in support of ERC's studies, which already looked pretty large to the cost-conscious utilities, this $30 billion was an absolutely staggering figure, even though it included projections of possible government financing. It was also clear that the part-time counseling and task-force committees of ERC were not the kinds of institutional mechanisms that could grapple with the levels of R&D management that would be required. The question was whether or not the utilities generally would be prepared to undertake the support of such a gigantic, long-term mission.

As Harris notes, "We had chief executives from everywhere with all kinds of different ideas about what was best for their companies in the short range. Very few utility executives were prepared to see the value of a coordinated effort that would address the total of technological needs over a long period of time. 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?'"

There was considerable skepticism too at the federal level—as expressed by Senator Magnuson, Chairman of the Senate Commerce Committee, and Senator Hollings, one of the ranking majority members of that committee—that the electric utility industry would ever do what it should about R&D, and they were pushing hard for their proposed kilowatthour tax to set up a trust fund for a government agency to handle electric R&D.

Navigating between these forces—the threatening whirlpool of federal involvement and the rock of utility reluctance—Harris took on as the principal thrust of his leadership at EEI the private sector's acceptance of its R&D responsibilities. Armed with the preliminary findings of the ERC green book study, he went to George Bloom, then president of the National Association of Regulatory Utility Commissioners, and laid out a "crude vision of what the electric utility industry could do with all this." Bloom's support was enlisted, and subsequently, at NARUC's 1971 fall convention, they managed to win a resolution that gave NARUC's blessing to the endeavor. It called on the industry to implement the grand program with the proper institutional arrangements and laid the way for allowing the utilities the appropriate rates that would help cover it. The plan was to expand the ERC into a more formal, professionally staffed institution.

By March 1972 Harris, along with Charles Luce, chairman and chief executive of Consolidated Edison, a lawyer from the state of Washington (Magnuson's home state), and formerly Assistant Secretary of the Interior, presented joint testimony at the first hearing of the Magnuson committee, detailing the intensive efforts to establish an industry R&D organization. Though Magnuson and Hollings remained highly skeptical, believing the task was far bigger than the industry could take hold of, Harris and Luce were able to win from them a year's stay in order to establish a new electric power research institute. Harris, moreover, promised that if it could not be gotten under way by the industry, he would come back to Washington and personally support Magnuson's legislation. As Harris says, "It was essential to the national welfare. If we as an industry couldn't pull ourselves together and do it, then it ought to be done by government."

Included in his arguments was the concept that the traditional R&D role of the manufacturers and vendors should be vigorously perpetuated and that their work not be supplanted by the utilities' own R&D institute. On the one hand, there was a danger the new institute would be competing (perhaps unfairly) with commercial vendors, and on the other, it would diminish their incentive to continue making R&D investments. What this pointed to was the longer-range, higher-risk character of EPRI's mission, which thus became a piece of its early goal definition. Inherent in this definition was the sense that some technologies would be so long-range, so massive and risky, that the government, the utilities, and the manufacturers would need to undertake them together.

In any event, Shearon Harris remembers that with the year's respite granted by the Magnuson committee, he knew the mission "had to be a success." What was needed was the support of the chief executives of the utilities. "It meant nothing," says Harris, "to have a checklist of all the R&D that had to be performed if we didn't have the will and the resolve of the leadership of the industry to tackle the job." This would take some "missionary work," even though the legislation proposed by Magnuson had become a powerful catalyst. "All we had to do," says Harris, "was to go out to the chief executives and say we have a year. If we put it together in a year, it can be an industry-managed undertaking. If we don't . . ."

Given the strong support of investor-owned, public, and cooperative utilities (EEI, APPA, TVA, NRECA), as well as the utility regulators, the next vital task was the selection of the chief executive. That person "would really be the organizer." Reports Harris, "I was aware that the real success of this enterprise was going to depend more on this one man *than any other single factor.*" Shearon Harris then wrote out his prescription for the man they were seeking: "He would have to be an internationally respected scientist with uncommon administrative ability." That person had to administer a large and diversified program and would

need to be a unique and strong research scientist who could pull "all the shooting stars together and have them pull in the same direction." That certainly would require uncommon administrative capabilities. With that special person selected, Harris says, he knew that "it would be a lot easier going out to the 183 EEI companies, the 900 cooperatives, and the 3000 American Public Power Association members and getting them to commit to EPRI in a major way."

FINDING THE PRESIDENT

One who could make the difference between success and failure

People credit Shearon Harris with being Chauncey Starr's special sponsor but he says not, although he was an admirer of Starr's before they met. Starr had written what became an influential article, "Energy and Power," for *Scientific American* in September 1971. Among others, Harris had read it and had been struck by its "clarity, persuasion, and logical thrust," and he began to quote from it in his own speeches on energy. About the time that work had begun on converting ERC into EPRI (the spring of 1972), Harris met Starr at a seminar at Georgia Tech, where they were both participants. Over a lunch, Harris laid out the emerging concept of EPRI and asked Starr, then the dean of the UCLA School of Applied Engineering and with a wide acquaintance of professional people both nationally and internationally, to suggest some people who might be suitable for heading the new organization. "The way you've described it," said Starr, "I might be interested in it myself."

In fact, a selection committee had been set up by ERC, chaired by Jack Horton, chairman of the board, Southern California Edison Co., and Starr's name had already appeared on the initial list of candidates. But apparently, says Harris, Starr was very careful in his consideration of the possibility. At a later dinner in New York with Harris, he probed into the matter of just how far the utility industry would go in support of R&D and whether or not there really was a promise of EPRI's being something of "genuine significance."

It is worth remembering that during the early 1970s, perhaps even more than today, there was widespread and deep mistrust of business organizations generally; and even after EPRI was well on its way, there were still many imputations that EPRI was but the docile showpiece for an industry that was reluctant to shoulder seriously its technological responsibilities.

Once Starr became convinced of the genuineness of the industry's resolve, he became more excited with the magnitude of the opportunity. If there were any disjunctions at that point, it was perhaps only between Chauncey's "personal style" and the style of the utility executives and between the scopes of their respective visions as to what the institute might conceivably be. As described to Starr, the new institute's activities were focused too exclusively on technology and on aiding the development of new hardware for the industry. But that kind of motivation—the development of technology simply to buttress the electric systems against coming apart—did not strike Starr as a sufficiently worthy and vitalizing goal for a serious R&D community. As he pondered it, he came to feel it had to be much more than that.

"I have always felt," he states, "that the role of technology in *social* development is a very key one and that the electric utility industry played an essential function in the structure and prosperity of our society. For some decades, I had believed that one cannot separate hardware from its use and its impact on society as a whole. One of my values is that a scientist, an engineer, a toolmaker mustn't simply develop a piece of hardware, drop it into the middle of a social situation or structure, and walk away. He has to have a continuity of concern, responsibility, and feedback into the technology. The point is that here was the electric utility industry starting a new institution from scratch—it was an entirely new line of endeavor—which opened up an opportunity for that industry to take a substantial step in our total national social development through

Shearon Harris, past chairman of the EPRI Board of Directors, spelled out a simple prescription of the first president: "He would need to be an internationally respected scientist with uncommon administrative ability."

During a number of meetings, Chauncey Starr, one of the candidates, probed the utility industry's intentions and seriousness in supporting R&D, and whether the new Institute would be a truly significant entity in the American industrial scene.

electric technology."

Asked by Jack Horton of the ERC Selection Committee for a résumé of his thoughts on the new Electric Power Research Institute, Starr wrote a succinct three-page letter about its public status, its purposes and potentials, its role in technology and national planning, and its organization, which could stand as a valid description of EPRI today. In that letter, he emphasized the need for its complete objectivity, thoroughness, and intellectual integrity.

"I believe," wrote Starr, "that it would be important to involve in EPRI's studies not only technical specialists but also those deeply concerned with environmental and social impacts. 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 social responsibility."

The upshot was that Starr was selected from a long list of competent candidates. It was very clear, both Shearon Harris and Frank Warren testify, that "Chauncey Starr was the strongest, the ablest, and the best man for the job." More important, the leaders of the electric utility industry "bought" Starr's broad concept of what EPRI should be and gave him wide latitude in building the institute on the terms he had outlined. It is difficult to imagine, and perhaps easy to underestimate, how different the character of EPRI might have been and what its role might be today on the national and international scene if the industry leaders and Chauncey Starr had not agreed at that juncture in late 1972.

GETTING THINGS GOING

A vest-pocket start, but built on solid principles

For Starr personally, the opportunity to take on the job of developing an electric power research institute presented a challenge that was "very hard to turn down." EPRI represented for him a culmination in his career in which he could bring all his skills together—in engineering, in science, in the management of large programs, in the recruitment of superior people—to create an entirely new and "major productive element in the American scene." No less was it an opportunity for him to "learn new things as well," and thus satisfy a need that is deep in most professional people.

In accepting the challenge, Starr had no hesitation and no uncertainty about his own ability for achieving his objectives. "I had no doubt," he says, "no quivering at the knees about being able to work at this task. It was something that professionally I knew how to do." This confidence is difficult to describe, he adds, "because it has an ego-ring that people misunderstand." But he had been engaged in R&D on an organized, large-scale basis since 1946. Even during World War II, as a young research scientist, he was already managing groups and multi-million dollar programs on the Manhattan Project at Oak Ridge. And in his career at Atomics International, from 1946 to 1966, he built an organization from a half-dozen people to one that eventually employed over 3500 people. So building R&D organizations had become, in a sense, simply his profession, comparable, say, to being a skilled surgeon or a professional mountain climber, two images that Starr resorts to when he describes how he feels about his particular mission. "I had no uncertainty that I could conduct the operation. I had no uncertainty that I could get the team of the best people together—I knew where they were; I knew how to get started." Equally important, he was not unaware of the problems. "I knew the difficulties; I knew the probability of success or failure."

What added to the attractiveness of the challenge, what made it "literally a massive opportunity," was the fact that the utility industry, through the ERC Board (and later the EPRI Board after the institute was incorporated), made it clear that he would operate with unusual freedom—there were to be "no strings" attached to the power and the five-year contract of his presidency. In fact, without further discussion of the scope of the work other than with the ERC Selection Committee and a few utility executives, Starr took on the post on January 1, 1973. He continued to clear up his work as dean of engineering at UCLA; recruited his first lieutenants, Ric Rudman to serve as his assistant and David Saxe to become his director of administration; got a program for EPRI started; "even got a piece of stationery with a letterhead"; had a press conference in early February to describe EPRI's objectives and program; and only then went into his first meeting with the EPRI Board of Directors to describe the technical program that had been planned.

As mentioned before, his first priority was to go after the "best minds." For EPRI to be of any real value to the industry, Starr carefully argued to the Board, "it could not be a second-grade engineering assembly." And to the present day, when he is asked what he feels is his greatest contribution to EPRI, he asserts that it was the quality of staff he brought in during the first couple of years.

This was so important that the new institute did not create an organization chart for four months. Starr's idea was

that you build the organization chart around the people. That is why, says Ric Rudman, explaining a perhaps not-well-known fact, the Institute has a Fossil Fuel and Advanced Systems Division under Dick Balzhiser, for those were *his* interests. Had someone other than Balzhiser come in, EPRI today would probably have five technical divisions rather than four.

Balzhiser, who was the fourth person hired, and the first of the technical directors, accepted the position while he was in Ann Arbor, without even knowing where the new institute would be located. He, like the other technical directors, reports that he was excited and stimulated by the almost complete freedom that Starr gave him to organize and to staff what was then called, for lack of a better name, the "nonnuclear" work. For that, too, was part of Starr's continuous operating style—to bring in good people and then with minimal "coaching," let them get things going with maximum freedom.

From his background, Starr "had a pretty good idea of what the industry's needs were," and he had, as well, a program partly inherited from the work of ERC. But very quickly, says Starr, "the industry began to feed me ideas . . . why not do this, or that . . . and we pieced together a kind of smorgasbord initial program in which the total balance was not analyzed." These were then gradually phased into a planned set of activities in which allocations were carefully balanced.

From the beginning, Starr and his colleagues worked to set general guidelines for EPRI's R&D programs. For instance, he proposed that the Institute ought to be spending as much on coal as it was on nuclear, and from that day to this, EPRI has devoted about a quarter of its operating budget to each.

In choosing a site for EPRI, Chauncey Starr's touchstone, as with other important decisions, was what area would most likely attract top-caliber scientists and engineers. A survey by McKinsey and Co. pointed to the San Francisco Bay Area as the No. 1 spot desired by professionals. An available location in Palo Alto crystallized the decision (Berkeley was the other strong Bay Area contender). Chauncey Starr might have preferred Los Angeles, but he adjusted to the basic requirement.

Some consideration had been given to Washington, D.C., but it was concluded that this would be a mistake because the Institute should be clear of the politicization that inevitably touches everything in that city. The basic sense was that EPRI was going to be a nationwide organization, so wherever it was located, it would be near some of its utility constituents and a long way from many of them.

Nonetheless, EPRI did establish a Washington liaison office, which has served important communications functions during the evolution of the Institute. To head the Washington office, Starr called on Dr. Robert Loftness, a scientist and personal colleague of long standing, who had considerable experience in government, scientific, and technical affairs.

To get the new institute running smoothly as an organization—apart from the technological issues that interested him most—Chauncey Starr depended heavily on David Saxe, as he still does today. Starr and Saxe have known each other for nearly 30 years, from the time when Saxe worked as a contract representative of the Atomic Energy Commission in the late 1940s and Starr was setting up an organization for North American Aviation (later to become Atomics International). In 1961, Saxe joined Starr at AI to become the director of the Administration Division, a position similar to that he holds in EPRI. In fact, the day after the announcement of his becoming president of EPRI, Starr telephoned Saxe to join him at EPRI. In David Saxe, Chauncey Starr was well acquainted with a man who is known to be compassionate, intelligent, and rational and who, through his wide experience in the administration of large-scale R&D programs in both government and private sectors, could relieve him of much of the day-by-day management of the Institute. Rudman, who had returned from industry to complete his doctoral studies at UCLA and work as Starr's assistant, was asked to join Starr at EPRI in March 1973. His interests straddle administrative and technical planning matters, so he also participates in various management questions. By the time EPRI moved into its new headquarters in Palo Alto in September 1973, these three in the nucleus had grown to 20 people, and by the end of that first year, the staff had grown to nearly 100.

How large was the new organization to become? That was a subject of argument among the members of the early nucleus of EPRI, but Starr's sense was that it should not go beyond several hundred. From experience, he judged, to run an organization "that is creative all the way to the bottom, there is a communications limit, from management's point of view, beyond which people lose sight of the objective, the theme, and the spirit of what the organization is trying to do." In effect, the control of top management over the quality and direction of R&D tasks "disappears."

David Saxe reports that he and Starr discussed the potential size very often in the first year or two, and he thought Starr's estimate of 300 seemed on the high side. Considering today's staff of 420 and next year's projected 500, David Saxe says with amusement, "I was terribly wrong, Chauncey was pretty far wrong."

What made the difference in size, in fact, reflects a fundamental shift in the character of EPRI from what Chauncey Starr and David Saxe originally visualized. They had assumed that the Institute would work on a relatively small number of large, long-range projects, which could be handled by a relatively small staff with responsibilities towards a limited number of contractors. As things evolved, and as the utility industry representatives began to discover the capabilities of EPRI, they brought in more and more of their technical problems and requested EPRI to take them on.

There were many technical problems

Selected to build and manage an R&D program that, in sheer magnitude, is second only to the U.S. Department of Energy was a man whose career spanned many aspects of science and engineering. Starr received both his BS and his PhD (1935) degrees in electrical engineering from Rensselaer Polytechnic Institute. He was a research fellow in physics at Harvard University from 1935 to 1937, and a research associate at the Massachusetts Institute of Technology from 1938 to 1941. From 1942 to 1946, he was engaged in atomic energy work for the Manhattan Project at the Radiation Laboratory of the University of California and at Oak Ridge National Laboratory. Thereafter, at North American Aviation, Inc., he served successively as chief, Special Research; director, Atomic Energy Research Department; general manager, Atomics International Division; and from 1960 to 1966, president, Atomics International Division. From 1966 through 1972, he was dean, School of Engineering, UCLA. On January 1, 1973, he became the first president of EPRI.

As a research associate at MIT in the late 1930s, Chauncey Starr designed and built a cryogenic tank and adiabatic demagnetization apparatus and ran experiments in the Magnet Laboratory.

During his years at Atomics International, Starr led efforts to develop methods of generating electricity from atomic energy sources. Under his direction, simple and inexpensive research reactors were developed as educational devices around the world; and a miniature, satellite-mounted liquid-metal-cooled nuclear generating station, SNAP 4, was developed to operate in space orbit in 1964. During this period, Atomics International became a world leader in the engineering of large sodium-cooling systems.

At UCLA, Starr worked at strengthening the teaching, research, and business management staffs. He reorganized the College of Engineering, was instrumental in creating an Institute of Medical Engineering, and started a multidisciplinary environmental science and engineering program. One of his papers, "Social Benefits Versus Technological Risk" (*Science*, 1969), helped crystallize risk-benefit analysis as a tool of policymaking.

During Starr's five-year tenure as president, EPRI has become a world center for assessment, planning, and management of research and development needed for the production and delivery of electric energy by the utility industry.

that Starr, Saxe, and others had simply thought the utilities had well in hand. But this turned out not to be so. For instance, the utility industry had already spent $400 million on stack gas scrubbers, but ran into so many problems, it began to importune EPRI to get involved. Then the owners of the Mark I boiling water reactors came with their problems.

EPRI got involved only in what were considered generic research questions on these, on the argument that technical fixes on specific designs were up to the individual companies, the vendors, the architects and engineers to solve. Nonetheless, the list kept growing, and the scope of projects expanded.

To do a responsible job on such a spectrum of projects required a different kind of staff, a larger staff. Says Starr, "We began to see and analyze what was happening. The biggest single reason for our large staff is that the scope of our activities doubled."

EVOLVING DIVISION MANAGEMENT

"Good people," minimal coaching, and lots of freedom

An interesting consequence of Chauncey Starr's executive style of giving great freedom to his technical directors is that the management of each division has evolved along rather different lines, according to their different objectives.

As Milt Levenson, director of the Nuclear Division, notes, his division is strongly organized along technical discipline lines. For instance, "Basically, all of the materials people are in one department, even though they work on projects that affect all departments. Administrative support is centralized."

By contrast, the organization of the Fossil Fuel and Advanced Systems Division under Richard Balzhiser is structured along major project and program lines, one group being responsible for coal gasification, another for coal liquefaction, and so on. Administrative support in this case is decentralized, with each department manager having an administrative assistant.

Despite the decentralization and freedom of management across the four technical divisions, the focal point for the direction of all the programs has remained in Chauncey Starr's office. Though it is not Starr's style to hold frequent staff meetings, division directors do meet informally with him whenever they feel the need or when he senses an imminent problem. Also, although the content of the various programs is up to the division directors and their staffs, Starr still examines every individual project at some stage.

"Sometimes he only looks at a new project for a minute," says Balzhiser, alluding to a characteristic of Chauncey Starr that is well known by all his associates, namely his mental quickness and sometimes his impatience, "but in that minute he can focus on the key issues and important concerns." Though everyone, necessarily, gets limited time with the chief executive, it is clear that he maintains a hold and a sense of the direction of the programs.

In addition to such interactions, Chauncey Starr is known to have a tremendous appetite for written material, and probably reads all EPRI's technical reports, as well as ranging afield. Comments Balzhiser on this reading, "He never forgets a thing."

The impact of Chauncey Starr's style of operation can be measured from the inside and from the outside, and John Dougherty, director of the Electrical Systems Division, who came to EPRI in 1975 from Philadelphia Electric, has seen it from both sides. As a utility engineer, he was deeply involved in the EPRI advisory structure, chaired working groups on the task forces, and even had a hand in the ERC green book R&D study that laid out some early ligaments of EPRI. Despite his close connections, Dougherty says that he perceived EPRI from the outside as "a very tightly knit one-man operation," and that Chauncey Starr was "calling all the shots inside the Institute." Thus, he was greatly surprised by the freedom and control the directors have in running their divisions. "There is no doubt in anyone's mind who the boss is," says Dougherty, "but he gives us our head, unless or until we get into trouble. From my personal point of view, coming from a highly structured utility, it was a pleasant surprise."

Milt Levenson suggests that it may even be a misnomer to describe Chauncey Starr's role in terms of management style. "To build something like EPRI from scratch," he says, "with no precedent in the industry, and to recruit senior people from outside the immediate family of that industry is really beyond the normal requirements of management." The attraction of EPRI, says Levenson (whose background, like Starr's, is nuclear engineering), was that there was a lot of concern about our national electric energy problems and "some new kind of institutional arrangement was needed to get things moving, and it looked like Chauncey might be capable of putting together a good group to do just that."

Another view of Chauncey Starr's role, from someone who has seen it outside and inside, is that of René Malès, director of the Energy Analysis and Environment Division, who came on loan a year and a half ago from Commonwealth Edison. He stresses the constancy and consistency of Starr's character and role as a knowledgeable, scientific spokesman

for the industry on technological matters, "a role he has established in an incredibly short time." It is a role that Chauncey Starr clearly prefers over day-by-day management issues. His role as a credible, objective spokesman on future technological needs is only dimmed, Malès suggests, insofar as Chauncey Starr is perceived by some as an "unreformed nuclear enthusiast and unabashed technologist." For the antitechnologists, even Chauncey Starr's verve and enthusiasm, his belief in technology as our only unlimited resource, and his ability to communicate, do not always carry the day.

BUILDING RELATIONSHIPS

The Institute had to build bridges to many constituencies

Getting an organization started is one thing; building it to last is another. To do that, traditional management wisdom says that the chief executive must forge dynamic relationships between himself, his Board, and his staff. In addition, relationships must be developed between the organization and its various constituencies and with other agencies and businesses. The actual productive work must go forward, while the constituencies are kept informed of the progress, and they, in turn, infuse their insights into the organization. Information must flow within and without, for an organization is at its core a collective intelligence, and long-range planning must depend on internal cohesion. Similarly, an organization must also get to know itself, through clear cognition of its goals, either through formation of policies, strategies, and decisions, or through the acceptance of rules and procedures, or from an evolution of "style" (which is, perhaps, only a more graceful acquisition of implicit rules). Its identity and, hopefully, its productivity grows. All along, problems must be solved and daily fires extinguished. The job and the shared excitement for the participants in a new organization is making it all happen and seeing it succeed. Curiously enough, organizational lore seems to point to five years as a kind of "half-life" for new organizations, when they have begun to solidify and need to be refreshed.

Though EPRI was formed as a unique organization to meet extraordinary needs, it has not been exempt from the laws of growth, though by all accounts it has grown with an unusual élan.

Although Chauncey Starr was granted a broad scope, he in fact has worked closely with the Board, which has always been a very strong one, and they have had much "good argument about the policy, direction, and scope" of EPRI. Every major issue has been thrashed out with the Board, and the arguments, says Starr, "were well-founded, not trivial, and very constructive."

Frank Warren, present chairman of the Board, agrees. In Chauncey Starr, he found a "man of broad knowledge, broad interest, and always a constructive approach . . . which many matters have borne out." And because the Board was strong, composed of chief executive officers of major electric utilities, and all, by and large, "strong, independent types," it was crucial that the president of EPRI be a real match. I think, says Warren, "a large portion of the policy and the direction—the objectives concerning EPRI's relationships with the industry and government—has to come from the Board. But if you look from the other end, of starting from ground zero in assembling a group with the background and ability to decide what must be done in various fields, how much must be spent, how many people are needed, that is an unusual task, requiring an unusual person to do it. I feel that Chauncey was unusually well suited to do just that!"

As one talks with both men, it is clear that there is a deep mutual respect. Chauncey Starr, reflecting on his "personal style," says, "I don't think EPRI necessarily has all the problems I have as an individual"—referring to the differences he experiences in coming from "industrial, technological, scientific, and academic spheres" when working closely with men who have come from legal and financial backgrounds, though nonetheless with broad interests as individuals. "What has happened over a period of time," Starr explains, "is that I have gotten used to their ways and they have gotten used to me. They haven't changed, and there is no reason why they should. I haven't changed, and there is no reason why I should, either. What has happened is that I have developed a tremendous respect for the chief executive officers—a deep, sincere respect. Those on my Board have been great." And Starr adds later, "I have never felt that the Board of Directors has said 'No' to me on a matter of vital importance to the success or health of the Institute. Nor has it ever asked me to compromise on any of our findings or to hold back technical results."

One of the early significant decisions that Starr and the Board had to make was whether or not EPRI should get involved in regulatory proceedings. The Institute was approached on supplying expert witnesses in various kinds of licensing and regulatory activities. The Institute decided, however, to adopt a policy of not appearing for either side in adversary proceedings, a policy that was sometimes difficult to explain to EPRI's supporters. (The matter of furnishing expert testimony to government regulatory commissions is being reexamined currently with the dual aim of making the Institute's

expertise available for public purposes while not aligning the Institute on one side or the other.) But Starr, Saxe, the Advisory Council, and the Board were in full agreement that EPRI should not become classed as an advocate and that the long-run value of EPRI to the industry was in its becoming an objective research base whose technical results would come to be trusted and relied upon by a much wider constituency.

As a practical matter, it is interesting that about the time EPRI was being formed, Frank Warren, as vice chairman of EEI and chairman of the Atomic Policy Committee in EEI, was involved in pushing the development of the breeder reactor and in the early stages of the Clinch River project (then managed primarily by Commonwealth Edison and TVA). The collection of funds for that project became somewhat merged with the collection of funds for EPRI, and there was some thought that EPRI might become involved in backing Clinch River. But when Chauncey Starr was appointed president of EPRI, he argued forcefully against becoming involved, regarding such a huge development project as a potentially disastrous financial drain on the vitality of the young institute. In effect, this became one of the defining guidelines of EPRI.

A more general ground rule, set as the first item in the Institute's bylaws, specifically excludes EPRI's involvement in utility business, financial, and operating activities, that is, in nontechnical matters. Starr had worried that these could get the Institute into the quicksand of emotional and political issues. Interestingly, the recent agreement of the Institute to undertake the Electric Utility Rate Design Study, in fact, runs counter to this ground rule. EPRI accepted the study "very reluctantly," says Starr, at the specific request of the National Association of Regulatory Utility Commissioners.

Of the organizational achievements that Chauncey Starr points to with greatest pride is the industry advisory structure that, he says, "came with a lot of pain but which has turned out to be extraordinarily successful." The architecture of EPRI's relationship with industry, probably unique in any research organization, and probably also the single feature that most distinguished EPRI from ERDA (DOE) and other energy R&D entities, derives from another of Starr's basic principles. The key to EPRI's success now and in the future, says Starr, lies in its maintaining a continuous set of relationships between the results of its R&D activities and their end use by industry. No matter how good the results, they are useless unless they flow into the operations of the utility industry. "We are an institution funded for knowledge put to work," Chauncey asserts, echoing a research principle that Thomas Edison advocated a hundred years ago. This meant that the scientific and engineering staff in the Institute had to develop a clear perception of real industry needs, and industry engineers had to gain an appreciation of the kinds of "future solutions" that might be flowing down the pipeline.

Problems abounded in bringing people with very different motivations and outlooks, within EPRI and within industry, to communicate and understand one another and to work together. The problems were somewhat compounded by the industry committee management arrangements EPRI inherited from ERC. Although the process of evolving the new industry advisory structure cannot be detailed here, what happened in effect was that there was a transition period in which industry people were moved from a management role into an advisory role, with EPRI staff assuming full-time management of projects and then making the advisory role one of intimacy with EPRI's full-time staff. In building the advisory structure, headed by the Research Advisory Council, Starr worked closely with L. F. Lischer, who has chaired the Council since the beginning; their capacity for mutual trust and cooperation facilitated the process. Without the industry advisory structure, says Starr, we would have made some R&D progress, but it would be only a fraction of what we have now. "I think this is one of the really great achievements."

Looking in other directions, it was important for EPRI to build clear relationships with equipment vendors in the private sector, on the one hand, and with agencies and laboratories of the federal government, on the other. The objectives were to minimize duplication of efforts and to build a synergism among the elements of our society that are practically concerned with the development of electric technologies. In both these directions, the growth of relationships has been interesting, and not always easy.

One of the questions that always comes up at Board meetings, reports Ric Rudman, is why EPRI is doing something rather than the vendors. Chauncey Starr's stance has been aggressive, trying whenever possible to keep vendors involved as active participants in problem solving and cost sharing *and* in not expecting vendors to make profits on R&D work that EPRI is supporting.

From the beginning, EPRI set out to make cooperative arrangements with the federal agencies that were doing related research—Atomic Energy Commission, National Science Foundation, the Department of the Interior, the research branch of EPA, and, when ERDA was formed, the two drew up a Memorandum of Understanding. This led to an increasing number of jointly planned, jointly funded, and jointly managed projects. Now efforts are under way to translate these into the substance of joint work with the new U.S. Department of Energy.

There is one aspect of EPRI that perhaps was not originally planned but which has been gradually moving from the periphery of its interests towards the center of its attention, namely, the importance of communications in its work.

As its staff has grown, as its interrelations with other people in other organizations have expanded, as the substance of its work has spread out over a spectrum of technological options and possibilities, so has its need to inform and be informed, for it has become rather like a central nervous system of previously separated activities and needs. In this

Starr

"One of the great psychic rewards of the field of work we are in," states Chauncey Starr, partially explaining his own motivations, "is the feeling of having made a contribution that is not going to be washed out with the sands of time. If one looks at science, research, accumulation of knowledge, learning in general, the only value to society as a whole comes over the long term. An individual, or a generation, involved in creative activity may get immediate pleasure from it, but the real benefits flow to the succeeding generations. The only justification for society's supporting R&D is not to keep society happy at that time, but in fact to make the world better for the future. Few of us ever question this. I think it's the right way . . . for us to create an intellectual or technological endowment for our children and their children—an endowment that will materially affect the welfare of the future world."

Robert Loftness

"When he is in Washington, he is always working. Normally we start with a breakfast appointment, go till 10 at night, and start all over again the next day. Every meeting, every dinner, is designed to accomplish some sort of business. He is, in effect, an entrepreneur, and he drives hard, sometimes pushing other organizations to do things they start out thinking they can't do."

Milton Levenson

"To put together something like EPRI from scratch, to recruit senior people from outside the immediate family of the industry, to convince them that they ought to join a new undertaking without some of the motivations that usually attract people to new jobs—when it doesn't look like a sure thing—takes a very unusual talent."

Ric Rudman

"He doesn't usually show a lot of emotion, but when he gets on something that is intellectually gripping, like energy-GNP relationships, he really gets excited, bounces around the room, writes on the blackboard, gets into it 150 percent!"

Richard Balzhiser

"He has an exceptionally quick mind and is an effective debater on any issue. He's better with half the facts than most people are with all the facts. He homes in on the essence of an issue and quickly brings to bear a very broad perspective and all of the relevant arguments."

David Saxe

"His distinct, informal style is one key to his success as a research leader. He doesn't like structure, he doesn't like rules, and anytime a rule or formal procedure gets in the way of something sensible being accomplished, he is completely impatient with it and completely impatient with anyone who cites the rule rather than the objective."

sense, it does fill a new place in the American industrial scene.

But its communications problem, which some regard today as its most important problem, is symbolized by its flood of scientific and technical reports at one level, and by the inclination of Chauncey Starr at another level to "speak out more and more" on issues of technical policymaking in the national and international arena. Key to communications is that when a message is sent, it is also grasped; otherwise there is no meaning, only paper or some other medium (with due apologies to Marshall McLuhan).

There seems at times today a mounting frustration within EPRI to have the messages heard, not only within but also by the leadership and staffs of the utility industry, by their constituents and customers everywhere, by all citizens concerned with energy and its influence on society, and by decision makers in the wider world. Frustration is an interesting symptom, whether exhibited in an individual or in an organization, for it suggests trapped riches. For a giver there must be a taker.

When the director of the Communications Division, Robert Sandberg, met with Chauncey Starr a few years ago to consider with some dubiousness whether he might want to work "in a research institute job that did not sound very creative," he was entranced to find a man who did not talk only about "stiff and starch technical matters." Chauncey Starr talked to him about the values of research, about its implications for society, about population and the problems of government, and how the supply of electricity and/or energy was going to influence the kind of nation we are and could become. "That," says Bob Sandberg, "was the key right there. Without that kind of vision, the life and meaning of this Institute might be very different than it is."

CHAUNCEY STARR'S EXECUTIVE STYLE

A confidence not always understood but always respected

It is a rare challenge to try to describe the executive style of a man to whom the following descriptives have been applied: brilliant, agile mind, effective debater on any issue, quick study, technological hard-liner, egotistical, workaholic, arrogant intellectual, pixielike vigor, elder statesman, impatient, a private person, strong personality, professorial, a hard man to trip up. A common denominator of them all is respect, perhaps affection, a certain distance.

One needs to focus on how Chauncey Starr works. Then those various descriptions match Starr's own description of himself and underline the source of his certitude and his strength.

His colleague of long standing, David Saxe, says of the distinctive style that has made Chauncey Starr a successful research leader: "He has a very informal style; he doesn't like structure: he doesn't like rules. Anytime a rule gets in the way of accomplishing something that he thinks is sensible or important, he is completely impatient with the rule—and completely impatient with anybody who cites the rule rather than the objective. He just goes to the heart of the matter. He is the goal-oriented leader par excellence."

All the technical directors who have worked closely with Starr concur in saying they have experienced his ability to go unerringly and with amazing speed to the heart of any problem. "When he is presented with a new problem," explains Rudman, "he likes to think in terms of analogies to other things. With technical presentations, one of his favorite questions is 'O.K., assume everything you tell me is correct, and you can build X. When it is built, what am I going to use it for?' It is a characteristic of looking at the total problem, the solution, balancing that against the pragmatic realities of the situation, and seeing if everything makes sense."

Chauncey Starr himself describes it this way: "I believe that individuals should be willing to face the truth, which is a vague quantity sometimes; but one should not close his eyes to realities. I think the worst thing one can do is kid himself. It is important for individuals and societies to have ways of filtering out wishful thinking, fantasies, social myths. The way I do this is not to operate intuitively; I don't close my eyes and commune and wait for the right answer. With any new question, I tend to try to follow a series of analyses and evaluations of options prior to making a decision. With either technical matters or management affairs, I try to go back to fundamental principles and derive the answer, almost as a matter of routine. Whether it has to do with personnel policies for EPRI or systems problems for the industry, I don't accept other people's values per se. I want to know *why* the values are there! I want to know their origin and what they mean, and I accept those that make sense to me. This means that when I come to a conclusion, I know *why* I have reached it. It is not whimsical. Now that carries with it an image of self-confidence or arrogance."

Starr's demeanor is therefore one of assurance, a certitude built on hard work and analysis rather than on presumption. He has built his confidence over the years by the gradual establishment of "verifiable realities," the things that determine how the future really should go. "The confidence I exhibit," he explains, "comes from having plowed thoroughly, verify-

ing information and perceptions that are closer to reality. These act essentially as guidestones for me in deciding what ought to be done."

This approach, this whole system of thinking, stems from his years as a student of science and engineering. It is the scientific method, in effect, put into practice moment by moment on problems. Though it has its special limitations, as for instance in certain forms of human relationship, it has its own powerful and special rewards.

In terms of the Electric Power Research Institute, his approach and style have played a crucial role. The Institute emerged under conditions crying for an objective, reliable basis for making decisions about electric energy—all forms of energy. Hard, rational decisions have had to be made that will affect all levels of our society, decisions ranging from technical options to the development of a rational energy policy for the nation.

So for many reasons, the needs and the style coincided. As Dr. Robert Seamans, former administrator of ERDA and from time-to-time colleague of Chauncey Starr, said, "We thought they had picked the right man for it, but it was a pretty novel thing to do, and not a sure thing, so we were going to watch with great interest to see if even he could pull it off.

"Certainly by the time ERDA was formed," Seamans continues, "I had no doubts that he had built a very effective instrument and attracted a very able team. Matter of fact," Seamans admits with amusement, "I looked with some envy on the manpower Chauncey had and wished I could get some of it into ERDA."

What stands out perhaps most of all is not the internal management of EPRI —for Chauncey Starr initiated and built EPRI from a set of fundamental principles, and then let it run in consonance with those principles. What stands out is Starr's growing role in the larger world of national and international technical policymaking, a role that interests him most of all. There he has succeeded in establishing himself as an important spokesman, representing a constituency based on the rationalities of science and engineering.

In describing Chauncey's style and his career, it is pointless to look for the personal anecdotes that often typify other leaders. Never mind that social gatherings are painful for him, that he does not laugh with the boys, bend an elbow, play golf, or engage in such professional leisure pleasures, or that he prefers to hike with his family. His joys and his pleasures, he asserts, have stemmed from his achievements. When he makes something happen, turns an important person around, gets a new policy established, he experiences the exhilaration of the player who has made an important touchdown and is dancing in the end zone. "I understand that player's feelings," Chauncey says. Nonetheless, he most frequently talks about himself as he does about EPRI, with the same dispassionate sense of objectivity. His excitement rises when he is faced with a good problem, and then he will dance to the blackboard in his office.

The real point about Chauncey Starr emerges slowly, but then with great clarity, as one distills the evidence. For these first five years, in an important way Chauncey Starr has been EPRI and EPRI has been Chauncey Starr. It stands today as his unique achievement.

UNFINISHED BUSINESS

When Chauncey Starr was asked by Llewellyn King, publisher of *Energy Daily*, for which King was writing a profile of Starr, whether he considered that EPRI had failed in any sense, Starr's answer was consistent with his expressed social concerns. "Yes, I think we must do more to develop a clearer perception on the part of the industry generally as to its role in the total socioeconomic growth of the country. That perception we are only beginning to develop because it is such a basic question that involves technological options as well as economic factors. The role of the electric utility industry in the social welfare . . . was taken for granted, without much introspection, until various groups began to question the impact of energy growth and whether or not the expansion of the industry was desirable. The industry really needs a clearer understanding of its own relation to the total life of our society, and that relation has to be more thoroughly explored. This is an area in which we have just begun to work, and where our research and analysis is beginning to give us new insights. This is the area in which I would have hoped that we could have accomplished more sooner."

AFTER THE FACTS

Gathering information and opinion far beyond Institute sources, the Board reaffirms the purpose, promise, and present course of EPRI.

During its short existence, EPRI has solidly established itself as the technical focus for innovative thinking in the electric power industry today." This assessment by William R. Gould, executive vice president of Southern California Edison Co., is a striking statement of the position EPRI has attained in four years of operation. His own organization is a leader in electric power research.

At its November 1976 meeting, EPRI's Board of Directors decided it would be desirable to evaluate the Institute's progress. It established an ad hoc committee on effectiveness composed of three of its members and gave it a mandate "to assess the effectiveness of procedures established thus far in light of experience to date, and to review and to specify more definite goals for the future and the most effective and economical approaches to meeting these goals." Composing the top-level review committee were Gould as chairman, T. Louis Austin, Jr., board chairman and chief executive officer of Texas Utilities Co., and Donald P. Hodel, administrator of the Bonneville Power Administration.

This yearlong review was completed on November 7, 1977, when a 70-page report of distilled opinions, perceptions, and recommendations was issued. It contained 14 major conclusions, 38 "additional conclusions," and a series of detailed appendixes.

How the committee worked

When it called for the effectiveness review, the EPRI Board of Directors made clear that although it wanted the EPRI review conducted in-house, it wanted the broadest possible perspectives that could be given by others deeply involved with its operations. The Board wanted inputs collected as widely as possible in order to obtain a balanced report. It did not want the evaluations of an outside consultant who would have to be educated in the nuances of EPRI history, goals, and relationships, nor did it want an in-depth management audit to be carried out.

The hub of the effectiveness review effort was a three-man group of aides to

the three committee members, working with the support of the EPRI staff and the EPRI utility advisory structure. The committee set in motion an information-collecting endeavor that extended far beyond EPRI sources. "The further we got into defining the assignment, the more we realized that we had a very, very large task," Gould recalled recently in an interview. The entire EPRI advisory structure, including the Research Advisory Committee (RAC), the Advisory Council, the division committees, and the task forces, was asked to contribute. RAC established four supportive ad hoc subcommittees to pursue various aspects of the review. As a result, a detailed series of papers on individual and collective views of EPRI began to pour in. Similarly, opinion beyond the formal structure of the organization was sought. Questionnaires and interviews were used to obtain views from ERDA (now DOE), trade associations, universities, large private and government laboratories, public utility commissions, and the few utilities that had dropped their membership in EPRI.

The outcome of this fine-tooth combing and of the inclusion of some individual and minority views among the 38 additional conclusions is, Gould believes, an objective, candid, and unbiased assessment—one that is difficult to fault on grounds of being self-laudatory or in any sense a rubber stamp. It was directly aimed at uncovering any major areas where efficiency of the Institute may be lower than desired, he says.

Overall finding

The approach proved very important and the most crucial result of the entire exercise, Gould asserts, is the reaffirmation that EPRI is on the right course. The report's first conclusion, called the overall finding, states:

"The entire EPRI organization, both the staff and the utility advisory structure, merits the Board's commendation for the significant accomplishments which have been achieved in the relatively short time during which EPRI has existed. All constituents should be encouraged to continue the rate of progress which has already been achieved. . . . "

One can readily conclude from internal and circumstantial evidence, Gould observed, that an organization is doing well. But it is not until "the votes are in," until a poll is taken or feedback is obtained, that such a conclusion is confirmed. "In a sales-oriented enterprise, performance is directly linked to the public and thus directly measurable," he says, "but in a membership R&D organization, there is no such direct linkage."

Therefore the overall finding of the review—which Gould speaks of not so much as an author but as an objective reviewer who watched the results come in—is an affirmation of EPRI's progress and gratifying to its management.

Substantive conclusions

The effectiveness review report is organized in six major categories:

- Mission and goals of EPRI
- General Institute policies
- Advisory relationships
- Relationships with other organizations
- Contracting policies
- Technical program results: evaluation and communication

All the raw data obtained from the review are compiled in a series of six reports, or topic summaries. This information was further distilled and presented in several action-oriented major conclusions. Some of the six major subject areas are quite broad. For instance, under "contracting policies" there is not only a conclusion pertaining to the relative desirability of funding solicited and unsolicited proposals but also one dealing with the nation's industrial base.

Industrial base

Among the major specific conclusions in the report, one of the most significant is that dealing with the problem of ensuring an adequate industrial base for newly developed technology. The report recommends that the Board direct EPRI management to "require that the adequacy of an industrial base be made an integral part of the approval process for any new project which would result in a technically and economically feasible product." The report adds that the advisory structure should also make this a critical consideration when judging the relative merits of proposed projects.

The report goes on to explain that as various EPRI programs advance from the research to the development stage, great care will have to be exercised to ensure that adequate manufacturing potential exists to support commercialization of the final product, so that the products of the R&D program can reach the marketplace once the technology is proved. Without this, EPRI's efforts cannot be utilized to their maximum potential.

"Too often," Gould noted, "we start to develop technology for which there is no broad-based manufacturing capability.

"Why, in the early years of civilian nuclear power, for example, did the world go in the direction of light water reactors?" he asked. "One simple reason: the development was being grafted onto naval propulsion systems. Let's say that we are back at Fermi's first pile under the Stagg Field stands in 1942, with the future of civilian nuclear power development before us and all choices open. It may be that without the naval reactors program we would have gone in the direction of water technology anyway—there was and is, after all, a preponderance of steam plants around the country. But on the other hand, there is just a chance that we might have gone in the direction of gas technology. However, there was then no industrial base under the gas. There was an industrial base under naval propulsion systems—the *Nautilus* project antedated the Shippingport project by six years—and there was an industrial base under utility boilers and utility steam vapor turbines.

"When we consider a new technology, I think we have to consider not only the cost of demonstrating feasibility but also

the cost of bringing about commercialization. We must ask if it is indeed possible to make it commercial. The gas-cooled reactor almost became commercial prior to the oil crunch, and quite possibly the orders that had accrued up to that time might have carried the program through to commercialization. The gas-cooled reactor has much in its favor, but its greatest hurdle is its lack of an industrial base.

"So when we are looking at as many new technologies as EPRI is—fusion, solar, geothermal, fuel cells, liquefied or gasified coal, superconducting transmission, utility storage batteries, and all the rest—we must pay close attention to this question of the industrial base."

Setting priorities

Setting the right priorities among the several goals of EPRI is in itself a high-priority matter, the effectiveness review concludes. It recommends that RAC take "deliberate actions on an annual basis" to review the Institute's general goals and the priorities attached to them, so that EPRI may "effectively fulfill the needs of the utility industry in full recognition that EPRI cannot solve every industrial problem."

Both RAC and the EPRI staff have an obligation to give some evidence to the Board that this has been done, Gould declared.

Another problem that received close attention was the matter of funding large projects, such as demonstrations of new technology. The review committee came to the conclusion that EPRI should seek a general agreement with DOE for use of its much larger funding capability as a basis to assume financial responsibility for "agreed-upon EPRI projects once they have reached the appropriate stage of development." Alternatively or in parallel, the report adds, EPRI might consider investigating various other funding procedures. One such alternative might be special utility assessments from time to time, in addition to the regular annual subscription contribution. Both this method and the concept of a "two-tier budget" (i.e., base program plus facility funding) should be investigated by the EPRI Finance Committee, the report urges. It adds, "Every effort should be made to explore new ways involving 'creative financing' techniques to satisfy the potentially large funding requirements of future EPRI programs."

Internal procedures

Several recommendations have to do with improving internal procedures and organizational matters. Two notable conclusions in this area have to do with strengthening the utility advisory structure and the staff's planning, budgeting, and review procedures.

The review committee pointed out a need for establishing minimum standards for the degree of utility advisory committee involvement and influence across all divisions of EPRI "in keeping with the formal charter of each committee, including direct and active involvement in formulating program plans, proposing projects, reviewing work to be funded, and monitoring project performance after it is funded." The report goes on, "A further strengthening of the advisory structure would result if a larger proportion of advisory committee members were able to devote more attention to their EPRI responsibilities."

"We have found in the last four years," Gould comments, "that utility membership on Institute committees requires dedicated attention and conscientious work from the individuals who serve on our committees. For a great variety of reasons, an appointed individual may not be able to perform at the level required to maintain the quality of input expected from utility advisers.

"We believe," he adds, "that there should be some mechanism whereby, without prejudicing a man's career, a replacement may be obtained for someone who doesn't contribute or who, on the other hand, has a tendency to try to dominate a committee.

"This is touchy and tricky business, obviously, because you don't tamper lightly with a man's pride or position with his employer. But the stake for the utilities is too great in terms of the manpower they make available to EPRI—let alone the cash—not to have some kind of adjusting mechanism available to bring about the greatest possible advisory effectiveness. It will require great tact and human understanding to devise such a mechanism, but it needs to be done."

Another report recommendation calls on the staff and the utility advisory structure to act jointly to develop "in-depth program planning, budgeting, and review techniques that ensure that the needs of the industry are met in a timely manner with proper attention to future business conditions. Particular attention should be focused on developing clear and concise procedures to evaluate objectively the progress and the benefit-cost aspects of all Institute programs, on a continuing basis."

Delegation of funding authority

To remove from the Board much of the burden of routine review and approval of each proposed research project, the effectiveness report concludes that the Board "should look forward to the time when it may be able to delegate its funding authority as definable milestones are reached in building the necessary confidence levels and in developing monitoring and assessment techniques."

Because this has such far-reaching implications, Gould was asked when his committee contemplated that the time might be ripe to implement this recommendation.

"The very simple answer would be, 'When the Board felt that it was secure in relinquishing the authority'—but maybe that's not a completely facetious answer. The approval process is ponderous. The Board may have more than 100 project applications on its agenda at one meeting, and the directors just don't have the time to get into that much detail. I think an excellent job is being done with the present process, as I observe it working. Most of the directors come to the meeting having done their homework.

"However, if the Board is going to give more policy guidance and approach the subject more from a 'Whither goes EPRI?' orientation, I think it is going to have to be released from part of the burden of detailed review. There has to be a means whereby only items of crucial importance come to the Board for approval. It may be that the Board, in time, will want to devise a monetary cutoff point. Or it might be that some other criterion will be developed."

Updating the review

With the completion and submission of its report, the EPRI Board Ad Hoc Committee on Effectiveness considers itself discharged, Gould says. This is notwithstanding a general conclusion of the committee that such a review should be carried out regularly.

"If an effectiveness review committee becomes a standing committee of the Institute, it's our judgment that effectiveness reviews will become routine and stale. I believe the Board has an obligation to convene similar ad hoc committees at frequent intervals, no longer apart than five years. I personally believe that it shouldn't be more frequent than two years, because otherwise we would be walking around in the same tracks, plowing the same ground. This would produce the staleness we must avoid.

"If one of the members of the previous review committee is still on the Board, and if he could serve as a continuing member, such a bridge would be useful. But I think it's extremely important that the majority of the committee be new members who come in with a new view and take a new look."

Nonelectric research

An intriguing statement appears in one of the appendixes, to the effect that the Board should adopt a single policy statement detailing the current scope of EPRI's responsibility in a number of areas, including "R&D on the transportation, recovery, and storage of alternative energy resources and the required funding to carry them through to full-scale demonstration." Gould was asked if a literal interpretation of this would not put EPRI right into the tanker and shipbuilding business, the pipeline business, oil prospecting, coal mining and unit trains, and the like. Gould responded, "It could—if it were interpreted as meaning that EPRI should move into these areas completely. But what we're saying is that the Board should say, 'Look, you have no responsibility in these areas,' or, 'You have full responsibility,' or, 'You have a piece of it, and this is the piece.' In other words, we're saying there is a need for guidance here, and these things should not float around in limbo."

Another passage in the report having equally broad or even broader implications states, "It has become clear that demonstration must be considered along with the more familiar rubric of research and development in the commercialization of new technologies." It was suggested to Gould that this could lead to an extension of R&D to RD&D, and if carried out, could have far-reaching effects on other industries.

"Rather than that," explains Gould, "its effect could be that the R&D agent would take a role in defining where the last "D" is going to be done. We really believe that EPRI should not be doing RD&D—it should be doing the R&D. But the question it needs to answer is: Is there someone, a group of utilities, maybe, who should be stimulated to proceed with the demonstration? Let's say we have an MHD research program that is almost at the point of success, and we need a demonstration plant. Somebody in that R&D group should start thinking about who is going to be the external group that will be host to the technology and take over the second 'D' when EPRI completes the first.

"EPRI's role is not to sponsor such demonstrations, but it should try to be a catalyst in seeing that completed R&D doesn't lie 'on the shelf' for want of a demonstration plant sponsor."

Universality of EPRI

The report speaks of the need for stable funding and warns against "any tendency for member utilities to support EPRI at less than the prescribed formula or to drop out of EPRI altogether."

Gould sees no serious danger of this: "Oh, I think the hazard is always there. I have been involved in the formation and operation of other industry groups, and you do have a certain amount of coming and going in the membership.

"I don't think there are going to be wholesale defections from EPRI, however, and I don't think there is going to be any major continuance in the dropout syndrome.

"There are some that are precluded from being part of EPRI by their charters or by action of their governing bodies, the regulators in the state, or the commissions that created them.

"But I think that the idea of EPRI—the concept of EPRI—is so fundamental to the operation of the utility industry that a utility of any significance cannot long stay away from the EPRI operation."

Of the effectiveness review as a whole, Gould says: "I think this has been a landmark effort in large-scale research management.

"We can see how some of the things that have already been learned can be applied in other group-participation and group-support organizations. It has pulled the Institute closer together. We have learned how a large variety of people feel about EPRI. Routine, everyday continuing observations have been brought into focus by the formal review process."

Although another major accomplishment has been entered into the continuing EPRI progress log, Gould emphasizes that we are only over the first hurdle in this particular effort. "Accordingly, I encourage everyone who has been involved with this review to continue the same level of enthusiasm and diligence in carrying through the implementation of the several recommendations developed by this initial effort. It is only with such action that our overall EPRI goals can be reached in the most efficient possible way."

Ludwig F. Lischer's perceptions come from his 4 years as chairman of EPRI's Research Advisory Committee and, inevitably, from his 40 years on the engineering staff of Commonwealth Edison Co. in Chicago.

In November of last year, Lischer resigned his RAC chairmanship and was succeeded by Ellis Cox, executive vice president and chief operating officer of Potomac Electric Power Co. But Lischer remains a member of EPRI's senior technical advisory group, and he continues as Commonwealth's vice president for engineering, research, and technical activities.

Asked about the origin of his RAC participation, Lischer recalls being on an Electric Research Council committee 10 years ago, with the assignment to assess electric utility industry research needs between then and the year 2000. "As part of our report, we not only laid out research areas, time frames, and priorities, but we also suggested a research structure very similar to what EPRI has since become." Along with several other members of the ERC committee, Lischer was later named to RAC and appointed as its first chairman.

GAUGING THE RETURN

The first chairman of EPRI's Research Advisory Committee offers personal commentary on the industry's growing investment.

What substantive results have been achieved by EPRI that are of immediate or near-term value to the electric utility industry? Our committee asked that question a year ago, and 44 specific responses were compiled from three years of Institute operation. Thirty examples were summarized in the JOURNAL recently: "30 R&D Solutions: An Application Agenda," August, pp. 20–27.

The criteria for that compilation were severe. At the very least, a project had to have produced results that were being used in utility system analysis and design. More likely, it would apply to construction on an individual system or generating unit or to a utility's current operations.

In any event, a project was judged applicable if in some manner it could show economic benefit to the user before 1979. My point is that EPRI has worked to get projects under way, move them through to conclusion, and see that the results be used quickly.

Progress in research

As an example, the high-intensity ionizer for stack-gas cleanup is a marvelous development in terms of cost and efficiency; it is useful for retrofit as well as for new plants. Then there's the work on foamed-glass distribution poles, which are made from one of our industry's by-products (fly ash) and are less costly than wood. And the BWR torus problem: EPRI was called upon to study the generic aspects and within a few months produced the answers that were needed

to resolve questions posed by the NRC. So we were able to keep reactors in operation that might otherwise have had to be shut down. This ability to respond rapidly to a truly critical problem has been one of EPRI's major accomplishments.

We also recognized that some distinctly valid accomplishments are not widely applicable. Compact transmission lines, for example. Whether a utility can use a tight conductor configuration depends heavily on geography. Wind, icing, and related conditions preclude close spacing if conductors can oscillate and touch one another. This is a regional matter. Just as geothermal plants can't be sited where there are no steam or hydrothermal resources, a transmission line design can't be used where it won't meet basic reliability criteria.

Timing was another criterion—a problem hits some utilities sooner than others. Underground transmission is a case in point. New York obviously had the first need; Chicago, Philadelphia, and similar large metropolitan areas were next. Other cities will surely face the need in years to come.

Progress in relationships

Technical accomplishment, in my opinion, is only one mark of success for EPRI at this early date. There is the nontechnical side as well, notably the dialogue between the advisory committee structure and the EPRI staff. Even within this one year, we have made improvements in our working relationships on this two-way street.

It wasn't consistently that way at the very beginning, something that's to be expected when a new organization is formed and new groups of people are working together. We all grope, and some of us make progress faster than others. But I'm very gratified today. Our industry people feel they are being listened to, in fact, that their inputs are sought. I hope we hold this high level of openness of exchange, recognizing that our common purpose is to get the best results for the money spent, doing the urgent things first.

Effectiveness review

In this connection it's important to comment on a review of EPRI's effectiveness that was conducted during 1977. This was triggered by discussion within the Research Advisory Committee, and at the same time, the Board of Directors recognized the need for some assessment of EPRI performance.

EPRI enjoys a very high degree of credibility and acceptance. But just because things are going well, we can't sit back and relax; we have to make sure they continue to go well. The way to do that is to "take pulse and temperature" periodically—look at aspects of the operation to head off potential difficulties before they develop.

Bill Gould of Southern California Edison chaired the Board's ad hoc committee for the effectiveness review, and our committee supplied many of the people who worked on its subgroups, particularly those assessing technical performance. Their work was completed and submitted to the Board in November. The ad hoc committee report contains a number of recommendations that need to be considered for adoption, which are being reviewed by EPRI staff, by our committee, and by the Advisory Council. The consensus will go to the Board for consideration at its February meeting.

Meantime, what impresses me is the way the review was done—in an excellent, open, and cooperative spirit. That's not to say every facet of the EPRI operation was deemed to be perfect; we expected to find areas where improvement can be made. But overall, the effectiveness review has been a very successful undertaking, revealing a record that both EPRI and the utility industry can be proud of.

As individual utilities, we are spending our customers' money through EPRI, and our regulatory commissions allow us to include this in our rate structures. As responsible stewards—both as advisers and as directors—we want to be sure that we're doing the job in the best possible way, that the results are really useful, and that we're earning a return on our investment.

It's also important to demonstrate to those few utilities who aren't now supporting EPRI that we're running a tight ship—a good research operation in an efficient and businesslike manner. We want those companies to become EPRI members.

Program evaluation

In contrast to periodic overall reviews of EPRI (principally a cognizance of the Board of Directors), there is the continuous process of program evaluation for which the Research Advisory Committee is responsible. Our concern extends down through the advisory structure of division committees and task forces.

How do we evaluate the worth of pursuing a specific project? We tend to think in terms of cost-benefit analyses, and they certainly have their place. We can readily quantify the cost and, which is more difficult, sometimes the benefit to be derived. But some EPRI projects, by their nature, are such that it's very difficult to say flatly what they will be worth over the next five years. For example, work in the health effects field is hard to quantify. It certainly is important to be able to comply with regulations and limits that are established. But the limits themselves, whether a regulation is indeed wise, and the scientific basis of the numbers must be looked at—to quantify benefits is very difficult, but we know they are there.

Nevertheless, as in any business organization, I believe we must determine whether or not proposed work is worthwhile or is in a doubtful category. Our committee has a subgroup that has been wrestling with this question for several months. It has been working with EPRI staff on techniques for program evaluation, seeking a methodology with consistent criteria.

Our committee is receiving progress reports on the development of this methodology. But we realize that not all decisions can be made on the basis of numbers alone. Engineering experience and judgment have their place. When

exercised by people whose personal experience lends authenticity and who also have thorough grounding in the rationale for a particular area of electric power research, then that judgment is the best available. We're not going to be 100% right, I'm sure, but we want a high batting average to justify the work that EPRI undertakes.

Employee exchange

There is one more matter that belongs in any comment about 1977, if only because it is very important in my view of R&D that truly serves the entire utility industry. This is the employee exchange program, and it was acknowledged briefly in the Board's review of EPRI effectiveness.

EPRI has utility people on loan, working temporarily as part of the EPRI organization. In a limited way so far, the program also works in the other direction. The individuals who participate bring background, experience, and input that otherwise would not be available.

The word *exchange* implies that the program is a two-way street. I would like to encourage both EPRI and the industry in the opportunity to have staff members of one organization spend some time with the other. The people will be enriched, bringing back insights that will be useful in their further careers with either EPRI or the utilities.

EPRI research scope

Turning to a longer view of my advisory connection with EPRI, I would like to remark on the inherent difference between EPRI's research structure and that of an individual utility. It is that EPRI's total program should have no gaps. It must be complete, coherent, and coordinated. As separate program areas are established and projects undertaken within them, they must fit together and present a complete picture when the work is done, with no missing pieces. In the environmental field, for example, if EPRI is to study power plant stack emissions and air quality, there must be tools of measurement, and there must be studies on the formation of pollutants, their transport, their conversion, and their fate. There must also be investigations of health effects.

A utility's own R&D, in contrast, cannot take on such a large universe. So it is likely to concentrate on more specific needs and, I should add, usually more urgent ones. Because high-voltage lines in the Chicago area must generally be underground, in my company we have worked on forced cooling to reduce the high cost of underground transmission. Our lines can now carry 50% more power with only 25% higher cost, and we're close to getting a 100% increase in transmission capability with a 50% cost increment. This is the kind of thing a utility can do, particularly in distribution, where research project costs are not apt to be as high as in the generation field.

There is also a middle ground, the situations where a group of utilities (perhaps with a manufacturer as well) band together for a certain project.

Utility research responsibility

EPRI's existence doesn't rule out or diminish the need for individual companies to conduct their own research. There are still needs peculiar to a given utility or urgent enough to warrant independent research, perhaps even in parallel with EPRI. A utility shouldn't ignore EPRI's contribution; neither should it ignore its own interests simply because EPRI exists. I think the emphasis may have changed a bit in the research that utilities do on their own, but this fact doesn't diminish its value.

For the very small utilities, those that don't generate their own power, research at any level is at least indirectly beneficial. They pay a price for the power they purchase and then distribute, and that price depends on the availability, the reliability, and the efficiency with which the power is produced and transmitted by a larger utility.

Research in distribution directly serves the smaller utilities because it addresses the principal technical content of their operations. This point has come up in the Research Advisory Committee. It bears on the establishment of EPRI research priorities so as to serve the entire spectrum of member utilities.

Putting research results to work

Determining and conducting a "perfectly balanced" R&D program, with all priorities correctly reckoned, can fall far short of its potential value if the results aren't put to use at every opportunity.

What has come out of the work of EPRI? What is the industry doing with it? This concerns me because there have been a number of fine results directly useful to utilities, and there are many volumes of reports on completed projects, as well as progress reports of ongoing work, that contain useful data. I'm a little fearful that some of it may get lost along the way, so it's important to emphasize some of the ways that utilities can get firsthand knowledge of EPRI's work.

First, of course, is to scrutinize research reports very carefully, to look for project results that can be implemented and savings that can be realized. I realize the sheer volume can be discouraging, which suggests the need for setting up a systematic way to review the reports as they are published. At Commonwealth, for example, all the reports come to my office and I read a number of the abstracts—projects I'm particularly interested in or have some knowledge of the work or of which I tend to be critical. In a few cases I read a considerable portion of the report itself.

Then I pass the reports to a research coordinator on our staff, and he distributes them to the departments that may have direct use for the data. To make sure that our people take the next step, I occasionally make a phone call or write a note: "What are we doing on this?" or "How is that coming?" or even "What do you think is the value of the report?"

From my own experience, I know that it is difficult to see the applicability of research when my first exposure is the final report. Issues are much more real, and opportunities much more apparent, to the person who has participated in the work in some way. This is where EPRI's

many avenues for utility—and vendor—involvement become important.

Avenues of involvement

I've mentioned the advisory committee structure. It is the main avenue, I think. Direct work for EPRI on a specific project is another. And the employee exchange program is a third avenue. Also, workshops and seminars are widely and freely available for insight into and contributions to EPRI's programs. EPRI conducts these in many subjects, and people come from all over the country to participate. If something good is seen, it's going to be used.

Vendors become involved in this way, as well as in the contract work they perform. Utilities seldom make hardware; they buy it. And a vendor that has taken part in R&D becomes another avenue for implementation of results; its marketing effort involves and updates utilities. This is especially apparent in the electrical systems end of the business—current-limiting devices, for instance. It will also be demonstrated in larger-scale, longer-range technologies—electrostatic precipitation, gasification, liquefaction, and other types of conversion processes. Vendor participation is thus important, but we must be careful not to relieve manufacturers of the responsibility they should properly bear to carry on their own R&D.

There is still another avenue, that of the utility as host organization for a prototype or pilot installation. I'm thinking, for example, of the high-intensity ionizer, the gasification–combined-cycle facility, the fuel cell, solvent-refined coal—and of compressed-air storage, where a number of utilities are grouped together. In these cases engineers have very direct involvement, and they talk to each other. (In our business, we can talk to our "competitors!")

In all these ways we share knowledge that is coming out of a project, so there is a natural infusion of progress and results into the nationwide utility arena. It's a little more difficult if the R&D must take place apart from utilities—say, in a university. But even here there is guidance and interest by an EPRI task force or program committee of utility people.

Ultimately, of course, research implementation is up to each utility. I can't and shouldn't judge how a utility goes about it. We each do it in a different way. And I don't think there is much that EPRI itself can or should do beyond working with utility information coordinators and helping them disseminate results systematically among members.

Perhaps the EPRI Research and Development Information System (RDIS) is an exception. That came out of discussions in the Research Advisory Committee because we saw the need for a mechanism to let one another know what we are doing. In the pre-EPRI days, there was only an annual reporting. Now there is the RDIS; information on utility projects and on all EPRI projects are fed into this data base. It's frequently updated, so there is no one- or two-year lag. Some utilities have their own terminals with which to interrogate the system. Others rent the service, or they write or phone for a data search.

RDIS tallies what is being done in an area or on specific apparatus; who is doing it; what its status is, and where the full information can be obtained. It's like putting a book into a man's hands. We provide the information, but we can't read it for him. I think our responsibility has been fulfilled in giving him the book.

Trends becoming apparent

Having mentioned the role of utilities as hosts for prototype and pilot plant demonstration of research results, I'm reminded of an important trend in our industry. That is the matter of increasing size or, really, cost. There is hardly a demonstration or pilot plant that doesn't cost at least $200 million today. This is an intolerably large amount for EPRI's budget alone to accommodate. In most cases it's also too much for a single utility. Clearly there is room for groups of utilities to work together when they have a common interest.

Even apart from the money involved, we don't have a mechanism in EPRI for financing such projects. It might be easier if we did (but it might not). There is some virtue in not having a well-defined policy because we then have the flexibility to use whatever mechanism is best suited to a particular project at a particular time.

Another trend—and this pertains to the original research itself—is the increasing proportion of solicited proposals in EPRI's total program. It reflects the Institute's improved definition of industry needs and of the best approaches to take in dealing with them.

Nevertheless, I don't think the proportion of unsolicited proposals should ever fall to zero. No matter how well we structure our program, there will always be good ideas generated outside—in a utility, by a manufacturer, or at a university.

Particularly in the university area, we must not shut the door to the possibility of proposals that may fill a real need. For example, Ohio State has tremendous expertise in metallurgy and welding, as good as any to be found in the country. All things being equal, I favor the involvement of universities because this is another mechanism for building two-way streets between utilities and the principal institutions from which their technical personnel originate.

Specifying and demonstrating results

There are some research tasks that are less well suited for university assignment—say, where an answer is needed in very short order or where the scale and cost of facilities is proportionately great. To an increasing extent, EPRI's proposal requests are able to specify not only the obvious limits of budget and time but also the results that are to be produced. This underlines the fact that EPRI isn't only a research institute. It is a development institute as well.

This is as it should be. And to the extent that EPRI is able to encourage and take part in large-scale pilot and prototype projects, it will properly influence the complete evolution of new electric utility technology: research, development, and demonstration.

ENERGY IN WASHINGTON

The energy initiatives that dominated the capital in 1977 will have far-reaching implications for electric power R&D.

Congress, the president, and federal units gave energy top billing on agenda crowded with other urgent domestic and foreign issues in 1977. This emphasis and flurry of activity resulted in major changes in the structure, policy, and direction of the nation's efforts to deal with its energy problems.

The year began with a new president and a new administration committed to attacking the energy problem with legislative and executive action. Legislation in the form of the National Energy Plan was proposed by the president in the spring and debated by Congress for the remainder of the year. The nation also watched formation of the new Department of Energy (DOE) to consolidate existing energy agencies and to provide a framework for carrying out national energy policy. Then came a series of legislative initiatives and policy directives in the areas of power generation, energy conservation, and environmental protection.

EPRI has been following these major developments closely, as they will have a significant effect on electric power research and development for years to come. Although it is premature to predict what the influence will be, it is useful to review recent events in the context of their relationship to energy R&D.

Department of Energy

Reorganization of energy activities was a key initiative of the Carter administration and the major structural change was establishing DOE, a process that required seven months from proposed legislation to the new department officially opening its doors for business on October 1.

The reorganization consolidated energy activities that were scattered throughout several agencies of the federal government. The new department took in all of the Federal Energy Administration (FEA), the Federal Power Commission, and the Energy Research and Development Administration (ERDA). It also incorporated parts of the Department of the Interior (including authority over the Bonneville Power Administration), the Department of Defense, the Interstate Commerce Commission, the Department of Commerce, and the Department of Housing and Urban Development. As a result, federal energy activities were elevated to cabinet level, with a first-year budget of $10.4 billion and a staff of nearly 20,000.

The structure of DOE is of particular interest to the electric utility industry because of the way energy R&D programs are grouped and the concept underlying that grouping. The structure reflects the philosophy that new or emerging technologies should be organized by their stage of evolution in the research, development, and application process, rather than by fuel type (e.g., solar, fossil, or nuclear). Basic research, defined by DOE as that which is "potentially applicable to a variety of energy systems," is to be conducted by the Office of Energy Research. At the present time, it does not appear that this office will be the main focal point for the R&D of primary interest to the utility industry, although the overview functions of the office will be of significance.

The utility industry focus will be the responsibility of the units administered by the assistant secretaries for Energy Technology; Resource Applications; Conservation and Solar Applications; and Environment. Assignment of projects to these units will follow new guidelines. When a technology is at a stage where demonstration of technical feasibility is the primary objective, it will come under the jurisdiction of the Assistant Secretary for Energy Technology. This unit will have authority for all primary R&D areas—solar, geothermal, fossil, and nuclear—including projects involving energy storage, electric energy

systems, and improved energy efficiency. Formerly, most of the research projects in this area were administered by ERDA.

Once a specific project has been developed to commercial demonstration, it will be transferred to the Assistant Secretary for Resource Applications or to the Assistant Secretary for Conservation and Solar Applications. Resource Applications will also have jurisdiction over power marketing (including Bonneville) and over enriched uranium production. Input from the Assistant Secretary for Environment will be solicited at all levels of R&D.

Although not directly related to R&D, there are several other units within DOE that are of interest to the utility industry. The five-member Federal Energy Regulatory Commission (FERC) is an independent organization within DOE that is not subject to the supervision or direction of any department officials. FERC has many of the functions of the old Federal Power Commission, including issuing and enforcing licenses for hydroelectric power projects and governing rates for the interstate sale and transmission of electricity. The Economic Regulatory Administration (ERA) will administer many of the regulatory programs formerly under the jurisdiction of the Federal Energy Administration. The Energy Information Administration is a data-gathering and -analysis group, and the unit administered by the Assistant Secretary for Intergovernmental and Institutional Relations will provide the data to the public.

Changes on the Hill

Significant structural changes also occurred during 1977 in the way that the two chambers of Congress deal with energy matters. The Joint Committee on Atomic Energy, once the focal point for all nuclear energy matters, was abolished and its authority dispersed among a number of existing and newly formed House and Senate committees.

In the House, authority over nuclear energy regulation, safety issues, and land management was given to the Subcommittee on Energy and the Environment of the Interior and Insular Affairs Committee. Broad authority over electric power matters was given to the Subcommittee on Energy and Power of the Interstate and Foreign Commerce Committee, whereas concerns over nonproliferation and nuclear exports were assigned to the International Relations Committee. Nuclear energy R&D was given to the Science and Technology Committee, which now has jurisdiction over all energy R&D matters for the House. Energy tax matters remain with the Committee on Ways and Means and an Ad Hoc Energy Committee was formed to shepherd the administration's energy legislation through the legislative process.

The Senate created a new committee, the Energy and Natural Resources Committee, with jurisdiction over all matters relating to energy policy, regulation, conservation, and R&D—including nuclear. Tax matters remain with the Senate Finance Committee, and environmental matters were given to the new Committee on Environment and Public Works.

The proliferation of committees dealing with energy matters on Capitol Hill tends to make the review process for R&D programs more diffuse and cumbersome. It also increases the burden for the R&D community in responding to multiple requests for testimony and technical information on pertinent issues.

In addition, four congressional organizations have become increasingly involved in assessments of R&D programs. The Office of Technology Assessment, the General Accounting Office, the Congressional Research Service, and the Congressional Budget Office conduct studies for Congress, including critiques of the National Energy Plan. In the future, the assessments of these four organizations may exert considerable influence on the pace at which energy programs are implemented.

National Energy Plan

In the same sense that 1977 saw significant structural changes in the nation's efforts to deal with energy matters, the year also recorded important policy initiatives.

Paramount among these initiatives was the administration's National Energy Plan, introduced in April as "the moral equivalent of war" and embodied in legislation that dominated congressional attention for the rest of the year. Consisting basically of a series of measures to reduce U.S. dependence on imports of foreign oil in particular and to cut down on energy demand in general, the administration's plan is complex, controversial, and far-reaching in its implications for future energy R&D.

The cornerstone of the plan is emphasis on energy conservation, labeled as the "cleanest and cheapest source of new energy supply." This emphasis indicates a direction for energy R&D toward end-use technologies: for example, time-of-day metering and the use of cogeneration and district heating for waste heat utilization. Traditionally, EPRI's focus has been R&D in the generation, transmission, and distribution of electric energy. Only recently has the Institute broadened its scope to include end-use technology development. The increasing emphasis on conservation in the National Energy Plan may channel electric power R&D more and more in that direction.

Expanded use of coal is another key provision of the energy plan. Claiming that coal will "meet the greatest portion of increased U.S. energy needs," the plan predicts a doubling of present coal production by 1985. However, it cautions that environmental considerations must be taken into account, and it calls for a comprehensive effort to make sure that coal use meets environmental requirements effectively and economically. Since electric power plants offer the only practical means for a greatly expanded coal use in the United States, this emphasis implies a greater role for electricity in meeting national energy demand and indicates increased significance for research efforts to develop effective emissions control technology.

Finally, the National Energy Plan stresses the importance of the newer, advanced energy sources, the so-called soft, or decentralized, technologies. Public enthusiasm for the soft technologies has created the necessity for the R&D com-

munity to conduct thorough economic and technical feasibility studies of alternative energy strategies. The increased emphasis on alternative technologies in the National Energy Plan, as well as growing public interest, implies that the R&D community will be spending more time investigating these technologies in the future.

Nuclear power initiatives

Even before the president released the National Energy Plan, he addressed the issue of nuclear power policy. "There is no dilemma today more difficult to resolve than that connected with the use of nuclear power," was the White House statement on April 7. "The benefits of nuclear power are very real and practical. But a serious risk accompanies worldwide use of nuclear power—the risk that components of the nuclear power process will be turned to providing atomic weapons."

The statement announced a major change in the direction of U.S. nuclear energy policy and established two themes that seemed to pervade discussions of nuclear power development during 1977: concern with nonproliferation and emphasis on alternative fuel cycles.

Specifically, the administration announced that the United States would indefinitely defer commercial reprocessing and recycling of nuclear fuels; that it would restructure the breeder program to give greater priority to alternative strategies; and that it would redirect funding of U.S. nuclear R&D to accelerate research into nuclear fuel cycles that do not involve direct access to materials usable in nuclear weapons.

The effect of this redirection of nuclear policy was immediately seen in the R&D community. For example, ERDA (now DOE) withdrew its funding from a joint project with EPRI to design the prototype large breeder reactor, the next step in the breeder program beyond the Clinch River Demonstration Plant in Oak Ridge, Tennessee. (EPRI is continuing the program at a reduced level of funding.)

For the Clinch River breeder reactor itself, the administration requested a level of FY78 funding that most experts agreed would have effectively terminated the project. This action, and the opposition to it on Capitol Hill, turned the CRBR into a symbol of the struggle over nuclear power development and the fate of the breeder program in this country. On the one side was Congress, which voted $80 million in funding to keep the CRBR project alive, and on the other, the president, who used the first veto of his administration to kill the bill authorizing the project.

What are the implications of these actions for future R&D in the nuclear power area? On the positive side, there seems to be an indication on the part of the administration of a renewed commitment toward resolving some of the major issues associated with this technology: licensing delays, uranium availability, enrichment, and spent-fuel storage. Indeed, in October the administration announced a long-awaited policy for the storage of spent fuel from nuclear reactors, under which the government would take title to spent fuel from utilities for a one-time storage fee. If this commitment applies to other issues as well, it could mean increased cooperation with the utility industry (and EPRI in particular) in its programs of LWR safety and reliability. This in turn could mean a general strengthening of the combined government-industry effort to resolve some of these problems.

The direction of government policy for breeder technology is uncertain, although there is evidence of increasing emphasis on alternative proliferation-resistant fuel cycles. This indicates a major increase in R&D in these areas. An international fuel cycle evaluation study, involving 40 countries and 8 working groups is now examining the technical aspects of these issues. In the United States, the next step toward the demonstration of breeder reactor technology has been deferred until this study has been concluded. At the same time, other countries are continuing to develop demonstration breeder reactors, as well as the infrastructure for independent nuclear economies.

Environmental initiatives

Initiatives in the area of environmental protection were also forthcoming during 1977. One issue that received increased attention was the possible effect of carbon dioxide (CO_2) on the earth's atmosphere. The National Academy of Sciences published a report expressing concern that increasing levels of CO_2 from fossil-fuel-burning power plants and other sources might cause permanent global climatic change. The report warned that this so-called greenhouse effect should be watched closely. If further study indicates that this climatic change is a likely possibility, it could have a dramatic long-term effect on the future use of coal and other fossil fuels for energy production and might indicate increasing use of nuclear power or other alternative sources. Environmental research in this area will undoubtedly increase.

Another major initiative with implications for environmental R&D was the enactment of amendments to the Clean Air Act. One particular section of this legislation (Section 165) is of particular concern to the electric utility industry because it mandates that new power plants employ the "best available control technology." As designated by the Environmental Protection Agency, this is presently defined as stack gas scrubbers. The legislation also requires EPA to establish standards for regulation of nitrous oxides, hydrocarbons, carbon monoxide, and other emissions.

The last word on these environmental regulations has not been spoken, however. A federal judge in Indiana ruled, for example, that a utility need not install scrubbers because the EPA has not designated an acceptable method for the disposal of the sludge from the scrubbers.

In any event, the legislation passed this year will increase the importance of R&D in emissions control to the electric utility industry. It is critical that the industry have the benefit of thorough and extensive research in various technologies so that it can meet these regulations in the most economically acceptable manner.

The exchange was so lively and the participants so engrossed, it took several tries to interrupt for a lunch break. The occasion was a four-hour, freewheeling discussion among EPRI's technical division directors, planning director, and president that illuminated some of the most pressing technical issues facing our energy future and showed how EPRI is working on them. Moderating the forum were Llewellyn King, publisher of The Energy Daily, *and Donald Christiansen, editor and publisher of* IEEE Spectrum. *Nine major topics emerged from the 153-page transcript. They include highlights of EPRI's accomplishments in 1977, EPRI's mission and program, commercialization of technology, the breeder, conservation, and major concerns.*

EPRI participants were division directors Richard Balzhiser, Fossil Fuel and Advanced Systems; John Dougherty, Electrical Systems; Milton Levenson, Nuclear Power; René Malès, Energy Analysis and Environment; and planning director Ric Rudman. EPRI President Chauncey Starr joined the discussion from time to time.

A ROUND OF RESPONSE

Highlights of 1977

Christiansen: Perhaps each of you would highlight what you consider the major accomplishments of the year.

King: Yes, if you would. From the outside, where I sit, it seems rather amorphous. You might also mention whatever frustrations you may have.

Levenson: Well, I'm not sure the big highlights are necessarily the most important, at least in nuclear. Some recog-

"What is the role of EPRI with the public? I know you don't have an advocacy role, but the mere fact that you have the facts puts you into the public debate."

nition of utility needs and our ability to aid is something that has been developing quite a bit in the last year. You have to recognize that while EPRI is chronologically four years old, there were only ten of us in this building in September of 1973. So statistically we are more like two years old. And a significant amount of our work is resulting in feedback at a highly diffuse level, like people running plants, changing the way they operate them, revising operating procedures.

We run a large number of workshops now, which were originally conceived as a mechanism for getting input on problems we had not heard of. It turns out that many of them are more valuable as a means of communication between utilities and vendors and within the utility industry. There has been a lack of this kind of communication. Within the last year or so we have begun to recognize workshops as important and very useful.

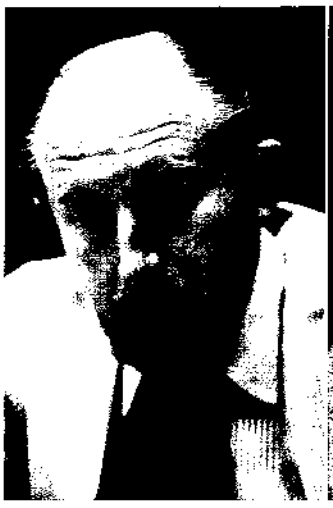
In specific areas it is hard to know exactly when the results of research become important. For instance, it was a little over a year ago, I think, that our tornado missile program indicated pretty clearly that utility poles don't have the same damage potential as armor-piercing shells, which was the previous guideline. That has now been pretty well accepted.

Christiansen: What do you see as major developments in analysis and testing?

Levenson: Within the last year a number of our major analytic tools have been put into use. One of our big analytic tools that is useful in fuel management is now being tested by some 16 or 17 utilities. Now these don't necessarily sound as if they are worth very much in money, but a fact you have to remember is that the calculations on refueling a reactor in many cases take a number of months and can cost a quarter of a million dollars.

A number of developments in nondestructive testing have been put into

"How does EPRI select, integrate, and manage 1000 projects? Is it really a haphazard process or simply a jury of executive opinion . . . done from the top down or the bottom up?"



Llewellyn King, publisher of *The Energy Daily*

Donald Christiansen, editor and publisher of *IEEE Spectrum*

Richard Balzhiser, director of the Fossil Fuel and Advanced Systems Division, formerly with the White House Office of Science and Technology

John Dougherty, director of the Electrical Systems Division, formerly with Philadelphia Electric Company

use. We have a very interesting phenomenon today: In anything you inspect that is ten years old you will find defects that were unknown originally. It does not mean the apparatus is deteriorating or falling apart or that there are new cracks. It just means that we have so advanced the state of nondestructive testing that you find new defects.

So a number of our programs characterize and differentiate benign defects from critical defects. The results of these efforts have been put into use as people begin to find strange signals on inspection devices.

In the nuclear area I can sum it up by saying that in the big programs we're working on, like the breeder program and new options, nothing has come into being in an organization that is statistically only two years old. But there have been a fair number of advances in three areas. One is the information exchange that I mentioned previously.

A second is problem solving for the people running the plants. There really isn't anywhere else to turn because—one fact that is not common knowledge—there really isn't any one vendor for a power plant. People talk about a boiling water reactor being a GE power plant. But the part of that power plant that General Electric sold under its contract is probably no more than 10%. The total system came from 1100 vendors.

In the area of safety, a lot of our work is aimed at reducing uncertainty. In the original licensing process, when something was unknown, our closest estimate was no better than plus or minus 20%, and the licensing restrictions took advantage of that and said, "You can't go beyond here." Each one or two percent in reducing that uncertainty can be worth millions of dollars a year in the operation of the plants. You have not reduced the safety margin at all. You have just reduced the uncertainty and thus can operate in a better mode.

Dougherty: Well, I think there isn't a single answer to the question as to what was the one big accomplishment for the year, particularly in a program like mine that is so diffuse. Nor is there a single frustration. There are many of both.

There are products of finished contracts coming out of all the programs in the electrical systems area that we look upon as worthwhile to the industry. Some of them appear mundane, such as chemicals for controlling the regrowth of trees to reduce the tree-trimming problem for utilities. But spread over the country, the method has a tremendous financial impact—you can double or triple the time between tree trimming around power lines.

Christiansen: Are there other projects with a high potential for cutting utilities' costs?

Dougherty: The fly ash pole is going to be a real winner, we believe, particularly in areas where utilities are having problems with wood poles. There are six Kansas utilities waiting with open arms for the first fly ash poles to come out of the kiln so they can take them back to Kansas and prove that the woodpeckers won't chew them up. That is a serious problem for them.

King: And frustrations?

Dougherty: In the frustration area, there are two problems that have beset EPRI's research program in this division since its inception. One of them is the so-called treeing problem in synthetic or plastic insulations. The other is the fact that despite continuing effort in several ongoing projects, we have not yet produced a viable, economical fault current limiter. Both of these are so important to the industry that the fact we don't have all the answers to them is what makes them

Milton Levenson, director of the Nuclear Power Division, formerly with Argonne National Laboratory

René Malès, director of the Energy Analysis and Environment Division, on loan from Commonwealth Edison Company of Chicago

Ric Rudman, planning director, formerly associated with IBM as a consultant

Chauncey Starr, EPRI president

such a frustration.

Christiansen: You're working on distribution automation, too, aren't you?

Dougherty: That, I think, is a real winner, too, and very important for the industry, although I am not sure that full implementation is going to be as short-term as some people think.

But we do have, jointly with DOE, five test beds that will be put in place on five different systems in the country for a total of 700 installation points. Seven hundred homes will have encoded meters installed—or existing meters retrofitted for encoding—and some type of a two-way communication system. I say "some type" because three of these projects are power line carrier systems, one is a telephone system, and the new one being negotiated is radio.

The primary objective is meter reading, and the remote meter reading concept makes available a mechanism for many of the new rate structures that are being discussed. These test beds, incidentally, would be ideal places to evaluate different rate structures to find out what the public's reaction would be to time-of-day billing or anything of that nature. The two-way communication system also makes possible load management in a true sense—managing the customer's load, for example, turning water heaters on and off or any other appliance that the customer might be willing to put on an interruptible basis.

And finally, if we do have a two-way communication system, we've got a great potential for monitoring and controlling switches, transformers, any component on the system. That should greatly improve reliability and facilitate restoration after storms.

Malès: You know from your background, Don, the technology to do this has been here for a long time. What we really need to do is to test the actual systems with two front-end mechanisms in mind, proving both the lowest cost possibility of construction and sufficient reliability for the utility operation. And the other side of it is that we have to find sufficient functions to share the cost.

Dougherty: And it looks as if they are coming together.

Malès: I'm not sure we have winners, but like John, I have such a diverse group of projects and program areas that I really have to mention more than one.

We got the SURE [sulfate regional experiment] network in operation. The SURE program is an attempt to correlate the emissions inventory in the eastern third of the United States with the ambient conditions, and it looks as if we have a fairly high probability of reasonable success. We won't be able to predict exactly what it will look like, based on emissions, but we will better understand where the ambient air came from and some of the major controlling factors on ambient inversion problems.

Humidity and temperature seem to be two of the major variables, both of which people don't have a lot to do with but have to live with. Perhaps there can be some better coordination between nature and people's activities, thereby bringing about more cost-effective control of ambient conditions.

The other area of environmental studies in which we have made significant progress has been the evaluation of what we know and don't know about SO_2. We took a look at the state of the art—what has been done, how well, and whether it is reliable enough to be used.

We have started laboratory studies, and we will be going to human clinical studies fairly soon, which I think will help us at least identify whether or not we are seeing real effects on human beings at the levels of the current standards.

King: You are analyzing the CHESS studies, are you not?

Malès: Yes, we have been reviewing the CHESS documents, the Community Health Evaluation Surveillance System studies, which were done between 1968 and 1972 by EPA [Environmental Protection Agency] on large populations. There are over 50 of these studies, and we have reviewed four of them. The CHESS studies suggested there was a link between the incidence of asthma and SO_2 levels in New York City, based on data collected by EPA in 1970 and 1971. An EPRI report of this review was published last May and showed, I think to everybody's satisfaction, that the data in the CHESS documents do not support the conclusions made by EPA. In fact, there were many errors in the data. In addition, careful analysis indicates that there is no correlation between SO_2 and the health effects they were looking at.

There will be more reports coming out in the spring on another half-dozen of these CHESS studies, which, as far as we can tell now, corroborate that initial finding. One of the interesting findings for Dick Balzhiser to deal with is that we are starting to see some correlation between particulates and health effects. This is one of the reasons that Dick's program has been turning more toward the control of particulates. It may be that this is the area where, in terms of health effects, we want to invest more money.

The frustration in that area is the one we talked about earlier: How do you get across this idea of cost-benefit analysis? How do you make the trade-off between the values of the system and the cost of the system?

Christiansen: What about energy demand and supply forecasts?

Malès: We have published what are essentially staff summaries of the assessments of where energy demand is going, based on all the research we put together, and where resources stand.

On both sides, supply and demand, we are coming out with results not surprising for someone in the electric utility industry. But for some of the stronger advocates of rate changes in the future, we are showing demand considerably higher than the standard of the more ardent conservationists.

We foresee resources a little more plentiful than the industry has predicted, and I think we have a valid basis for saying that. There is good evidence, even on uranium. There are telltale signs that give us reason to be more optimistic. But as we point out, for a planning base, we must also consider the possibility of a pessimistic outcome.

King: I understand you are engaged in some new approach in energy modeling.

Malès: Yes. That would be our Energy Modeling Forum, where we bring together the modelers and the model users—the decision makers—and analyze what is going on inside the models in an attempt to achieve a better understanding between those who develop models and those who use them. I compare it to a truth-in-lending law. It is a mechanism by which you are forced to bare your soul as a modeler. There has to be an understanding of the uncertainties and a communication bridge between modelers and policymakers.

The current Forum project is dealing with coal. We batched together about nine preeminent models that deal with coal, and we are finding revealing things. Given the same input, the output was completely opposite. The modelers are going to reduce that 180 degrees to maybe 95 degrees. But at least the project identifies that there are all kinds of assumptions that the modelers—as informed as they might be—or the policymakers or the experts on coal—as informed as they may be—have to make on how the economy is going to work in the future, and those assumptions are guesses. We have got to recognize that.

Christiansen: What about frustrations?

Malès: In terms of frustration, I think it comes with trying to turn theory into practice. It is very hard to get the academic economist to apply his trade and his knowledge to the good old electric utility in terms that the electrical engineer can use. I think we are making great strides, but we are far from having reached the optimum.

Finally, I want to mention that the Rate Design Study is also in this division. The study brought together both the theoretical and the practical experts, and they started finding some common ground, although they will forever have differences of opinion. But there is a tremendous bridging of that gap between the two camps on the basic questions of load control, marginalism, and time-of-day pricing. The summary report on the study, *Rate Design and Load Control,* was published in November.

Balzhiser: One of the things that many people don't seem to realize—and I'm going to talk primarily about coal—is that we are not going to have advanced coal-fired generation options available before 1985. It is just not in the cards—fluidized combustion, gasification—as much as we know about gasification, we know very little about how to integrate it into a power-producing system.

Fluidized combustion is grossly oversold at this point. There are a lot of potential problems, and the latest environmental standards may obsolete the atmospheric fluidized-bed combustion [FBC] before it really gets off the ground, so I don't want to dwell on it.

"EPRI's program in particulate control is in a position to yield benefits that will more than offset industry contributions to us so far."

We are in the middle of those programs. We have key projects in Powerton; it is the cutting edge of gasification development. While not a funder of the Rivesville FBC pilot plant, we follow its progress. However, while Rivesville is an important project, we will be unbelievably lucky if, at that scale, it oper-

ates well with the relatively inadequate data base it had to be built on. Our more modest scale facility at Babcock & Wilcox, we think, is going to be a key part of providing essential data for FBC design, including the data necessary to correct problems at Rivesville.

So, recognizing that we are not going to have advanced coal-fired options before 1985, we're going to be building a lot of conventional coal-fired plants, and they're going to be increasingly encumbered with environmental control apparatus. Had we started 10 years earlier, we could have had a real impact on scrubbers and sulfur removal. For the last four or five years it has been a rather chaotic scene. We got organized almost too late to do other than a lot of firefighting in terms of trying to work with the utilities and the vendors to unscramble the chemistry, the operating difficulties inherent in the limestone technology. We have tried to get ahead and look at advanced options to avoid these problems, but it is a tough battle to keep pace with constantly changing standards. We are deeply involved now in regenerable systems to avoid the serious sludge and solids disposal problems of lime/limestone scrubbing, not to mention the sizable limestone mining and transportation requirements.

King: Could you elaborate on other aspects of your environmental control work—particulates, NO_x, water quality?

Balzhiser: What I really want to talk about is our work in particulate control because I think that EPRI's program is in a position to save the industry more money, more grief, and to yield benefits in this one area that will more than offset industry contributions to EPRI so far.

I think René's evidence, pointing to particulates as the harmful agent, is beginning to confirm some of our intuition. We got started in it early. Particulate control is an art, not a science, and the vendors are the first to admit they've got real problems with today's precipitators. They don't understand the chemistry well at all; they have an inadequate basis for sizing precipitators at the time the plant is designed. We have expanded significantly, but still not completely, the kind of data base needed to design the precipitator in the first place and to understand the contributions that things like rapping make to particle loss. We are looking at advanced technology that can be incorporated with a precipitator to prevent it's becoming obsolete if tighter particulate standards are ordered. The vendors are very eager to work with us.

We now have precipitators, and we have bag filters, and it is very clear that if you are going to be forced to the kind of standards that the State of New Mexico has established for fine particulates, probably the only way you can meet it with the available hardware today is with a baghouse filter, a fabric filter. It does very well in that submicron region where the precipitator seems to have some kind of window. That technology also is an art. It has been used in cement plants, plants that have heavy particulate loadings, but not really in plants that treat the amount of gas volumes that utilities do. But we have documented performance of the fabric filters on utility plants as well as precipitators, and we have a basis for comparing their relative collection efficiencies over the spectrum of particulate emissions.

We are trying to get ahead of the game in studying trace elements, another potential problem rumbling down the track. At the same time that we are characterizing particulate matter in terms of size, we are also determining chemical composition so that we get some idea of the extent to which the trace elements are concentrated in certain size ranges of the particulates.

Christiansen: The ionizer appears promising in improving particulate control.

Balzhiser: The ionizer can be awfully important. It helps the precipitators, which is by far the more attractive of the two approaches for particulate control. We are testing it now under actual operating conditions at our particulate control test facility at the Arapahoe Station of the Public Service Company in Colorado.

The high-intensity ionizer was developed by Air Pollution Systems, a Seattle firm, under contract to EPRI. We expect that it will be commercially available in 1978 and could save utilities up to 70% in capital costs on retrofit installations and as much as 30% on new units.

But more important, because even the ionizer does not solve the fine-particulate problem, is a technology that now looks very attractive in the laboratory for agglomerating particulates so you can begin to shift them from the hard-to-collect range into a range where the conventional precipitator can do a better job. That is encouraging and we are about to move this development to the facility at Arapahoe.

A lot of our frustrations come in having to deal with the people who impose the regulations. We hope that with the data base we have in terms of our control options, which are so close to commercialization, we can forestall the kind of mandates that are being made in Colorado—and I'm sure will follow elsewhere—the demand to abandon an online precipitator, solutions that are certainly going to cost a lot and that may or may not solve the problem, yet are being pushed. We think we are in a position to provide improved options that will lead to savings for utilities and consumers and likely improve the environment as well.

The other frustration is that we are limited in terms of the number of staff we have, so it is awfully difficult to maintain the pace of the R&D program and at the same time have people who understand it well enough to go out and present the information to the regulators, utilities, and others who should be aware of these developments.

I think in this one area—particulates—because of its emerging importance and our increasing understanding of the science as well as the hardware, we will probably have by far the largest impact over the next two or three years in something that is of real importance, rather

than in many of the other areas, which may be important but are ten or fifteen years off.

Anatomy of EPRI

Christiansen: Would one or more of you give a brief review of EPRI's charter?

Rudman: To develop new and improved technology for the electric utility industry in transmission, distribution, generation, and utilization, with the idea of developing systems that are environmentally acceptable and cost-effective.

King: What is your level of funding?

Rudman: For 1977 the R&D budget was around $180 million, and our Board of Directors has approved $190 million for 1978. I might add that about 88% actually goes into projects.

King: And how is this split up?

Rudman: Roughly 25% to Nuclear, 25% to Fossil, 20% to Electrical Systems, 15 to 20% to Advanced Systems, and about 10% to Energy Analysis and Environment.

Levenson: There might be one thing added, Ric. There was some implication in what you said that our charter limited us to developing new technology, but a fair part of our program in some areas involves improvements in existing technologies, as well as bringing new technologies into existence.

Rudman: If I did not use the adjective *improved,* then I should have, because that is one of the major changes in EPRI's program emphasis in the last five years as a result of the input we've received from our industry committees.

Christiansen: Can you comment on the membership organizations that make up EPRI?

Balzhiser: All segments of the utility industry are participating. There is also representation from the American Public Power Association and NRECA [National Rural Electric Cooperative Association] and participation from the major federal utilities—TVA, Bonneville, Bureau of Reclamation, and so forth.

King: Would someone explain why it was that we had this change in the source of electric R&D and producing it in the private sector?

Malès: And by the utilities as well, although that was not as large. I think there are several pressures. On the one hand, the technical changes necessary to meet the new requirements; the technical changes to adapt and work with new technologies that are appearing on the horizon—nuclear, some higher-voltage lines—all of these made more pressing the need for R&D within the utility industry.

Simultaneously, for a whole host of reasons the vendors were reducing their proportionate share of R&D, and there was at the same time a drive to get the federal government into the picture. The industry felt quite strongly that it was important to play a role in order to control their future.

The genesis traces from a committee within the utilities' structure, and out of that committee came EPRI as an answer on all three fronts: the need to do more electric utility R&D, the need to complement the manufacturers' R&D efforts, and the need to be sure to stay on top and complement federal government R&D work. These needs are being fulfilled with the present operation.

Balzhiser: Let me fill that out a bit. I simply want to mention the report of the R&D Goals Task Force that came out in 1971.

Dougherty: Put together by the Electric Research Council.

Balzhiser: They laid out programs that they felt represented the utilities' needs, and that served as the basis. Then, with that report completed, the question, How do we implement it as an industry? was dealt with.

That began the discussions, and the concept of EPRI emerged. It sort of coincided—or collided, depending on how you put it—with the Magnuson-Hollings attempt in Washington to create an energy trust fund to finance energy R&D by taxing electric energy. I think it was pretty clear to the utilities that they were more capable of identifying their needs and directing a program that would be responsive. And that really gave the impetus to the creation of EPRI.

King: Some of you are rather distinguished and have been in the industry. How were you attracted to EPRI, besides the weather outside? And how many of you are there?

Rudman: Let me take the easy part of the question. Right now there are about 430 on the staff. Our plans are to increase next year to about 550, of which some 300 will be technical professionals.

"This is where the action is . . . the leading edge of research."

Malès: I think your question is very interesting. The principal attraction that I find with people I'm dealing with—and I think it is true with the other directors—is that this is where the action is. This is really the leading edge of research. These people will probably stay with EPRI for three to ten years, develop their skills and their programs, and then go back into a university setting, to a federal agency, or to a utility or manufacturer. They see it as an opportunity to develop very quickly, to develop these program areas, and to get that real-world experience.

Shaping the Program

Christiansen: I have trouble coming to grips with the method by which EPRI

selects, integrates, and manages 1000 projects that range from developing new utility poles to very sophisticated technology. Is it really a haphazard process? Is this simply a jury of executive opinion, or of expert technical opinion that decides through iterative processes what is going to be funded and to what extent? Is it gap-driven? Is it personality-driven? Is this whole process of selecting and prioritizing done from the top down or from the bottom up?

Levenson: Maybe we ought to go through the role of the industry advisory structure in developing EPRI's program, because it is both top-down and bottom-up. At the bottom we have advisory task forces, which are basically advocacy groups. They are utility specialists who identify problems in their areas and need answers because they are the guys on the firing line. Each division director has a corresponding advisory committee he interacts with. Part of the division committee role is to set priorities within an area of competing problems. In my case, in the nuclear area, I have competing needs coming in now in connection with improving fuel, as opposed to developing new options, versus developing analytic tools. The Nuclear Division Committee and I attempt to normalize what we think are priorities within nuclear. Then, in turn, there is the Research Advisory Committee, and its role is to say, "Well, that may be great in nuclear, but its priority relative to solar or environmental issues or fossil is quite different." So you have an advocacy relation at the bottom and normalizing at the top.

Rudman: The strategic planning that goes on at the level of the division directors and the Research Advisory Committee really sets the overall program plan of the Institute. In going through and looking at projects that we will take to our Board of Directors for approval, one of the first questions always asked is, "Is this project consistent with the objectives of the program plan?" This results in what we think is a very integrated approach to the Institute's R&D program. One of our difficulties is that the breadth of the program makes it very difficult to describe this integration.

Malès: Each of us has a general objective of what to do in the future. This is further detailed in a series of program areas with specific objectives, and in my area we have actually outlined the projects that we're going to undertake in the next five years. These are tentative, obviously. But they are continually reviewed, internally, as well as externally with the Advisory Committee, to give us our basic thrust. At the time the project is ready to be implemented we have to ask if it is still as important as we thought it was when we originally conceived it and the staff started working on it. Has something else more important come up? Should we change? All of us have changed our line of objectives and programming.

Rudman: There are two other aspects of external review that should be mentioned. We work very closely with the key government agencies. We always send them copies of our program plan, and our program managers work with them on a weekly basis. So we are aware of what is going on there and they are aware of what is going on within EPRI.

There is also a complementary relationship with the research that is being sponsored by the electric utility industry. We have a computerized R&D information system that lists all the projects that are being sponsored by local utilities, and it is checked prior to initiating EPRI projects.

Levenson: When you really get down to the fine structure, the selection of specific projects includes a subjective assessment of the probability of success. There is a big difference between defining a problem and knowing how to solve it. In many cases everybody agrees there is a problem, but no one really knows what to do about it, and so there are no projects in that area. Similarly, there are many areas where the combination of competent people and physical facilities is limited. We look around and say, "Well, the people that are capable of getting more data in this area are fully occupied and fully funded," and so we pick another project.

Malès: I do think that in terms of understanding the program, going through our five-year plan gives you the broad umbrella first. Then the detailed planning document shows how the program is to be implemented. And below that level are the project diagrams that we use to try to lay out a plan of action—subject, of course, to new information.

Rudman: That is another important point. We go through this cycle every year, so we can update the plan and can incorporate new information and new shifts in policy to make the plan as responsive to the current situation as we can.

Dougherty: A thousand individual projects are difficult to grasp as an entity. Yet it is probable that less than fifty of that thousand don't fit well into a defined subprogram, which fits into a program, which fits into a division's responsibility. So that twenty projects on a specific type of cable are all focused into one subprogram for that type of cable and its accessories.

"We do more perfecting than innovating, but I think that would be true of anybody in this field."

Christiansen: Is each program then tied strictly to a single division?

Rudman: In 99% of the cases.

Balzhiser: However, there is a lot of overlap in interest.

Levenson: There is interchange between division and government agencies.

Malès: In terms of actual program activity, there is a lot of mutual interest. Our environmental people work very closely on the coal combustion problems. We're also working with the Nuclear Power Division, and we're involved with the high-voltage problems that are close

to the Electrical Systems Division.

King: Let's open this up. What is wrong with EPRI? What are its areas of weakness?

Malès: Clearly one of the major problems is that of communications, the problem of getting the results out. How do you, in fact, implement the results from R&D?

Also, the time for planning is limited in a program that is growing on the order of 30 to 40% per year and has grown from ground zero five years ago to $180 million today. It's a tremendous effort just to mount that. Once we get to a stable and perhaps a more slowly growing program, the time for planning will be a little greater. Associated with that is the syndrome of "How can we get out today what is needed yesterday?" Some of our programs, I think, fail or fall short because we try to get the quick, dirty answer, because it is absolutely mandatory that the answer be out.

Rudman: Are you talking about analytic work or hardware development?

Malès: I'm talking about the kind of things Milt has to do on a daily basis to try to respond to operating light water reactors. We really ought to have the time to stand back and look at the whole system from ground zero, but we don't have that option.

King: I have heard it said that EPRI is more of a perfecter than an innovator. Is that true?

Dougherty: I think it is true. We do more perfecting than we do innovating, but I think that would be true of anybody in this field. There are just so many innovations that are going to occur.

Balzhiser: I think we have a mix of people. We have some who are very innovative, some who are always submitting and who accept discovery awards for their own ideas within the Institute. Others work very closely with somebody who comes up with an idea; they work to refine it. The ionizer, developed to improve the performance of electrostatic precipitators, was just that sort of thing. The idea originated with the people at Air Pollution Systems. Our task was to further refine it, to bring it through. There was clearly a little bit of innovation and a lot of perfection involved in that.

Malès: I think the question of totally new ideas that are brought about by the real genius—one who starts a whole new line of research, a whole new line of development, whether it be in the arts or technology—is overplayed. There are very few of those people. For the most part we're working with ideas that have been around. The basic physics laws don't really change. We only have one Einstein per century.

Rudman: Instead of an innovator or a perfecter, I like the idea of a catalyst, because I think that combines the talents of both.

Balzhiser: Let me give you one example in the area of coal liquefaction. We've developed a group of people that are technically very capable. By virtue of our orientation outside the petroleum industry—an industry that because of antitrust and other things has virtually no interaction—we find this industry coming to us with their ideas. Our group has become a focal point for interaction among the scientists. We have some very interesting projects that have produced important fundamental information in understanding coal chemistry, and we can diffuse it through the industry as well as the university community. As such, we find ourselves in a position we had never anticipated.

Malès: In our division there are a number of areas where innovative work is going on. We are funding, for example, a joint idea of our staff and George Dantzig, one of the prime operations research investigators at Stanford University. It will get input-output from totally different flow systems. Instead of dollars, he is building his system in terms of physical goods. It is a whole new area of modeling. We also have a fellow at MIT who is looking at the application of control theory to evaluating resources—a totally new idea.

However, the large part of the budget is obviously devoted to an understanding of known technology, to get it working, and working in good fashion.

King: How do you deal with the problem of competing approaches? Taking your area, Dick—fluidized bed, gasification, scrubbers, and so forth—do you do a little bit everywhere or . . . ?

Balzhiser: Yes. We are involved with substantial expenditures in all of those areas, and we recognize that at some point we ought to develop the kind of fact base that permits us to say, "This is the preferred approach." But we don't yet have that fact base in hand. It is a dynamic operation. What we're doing is trying to assess the facts in a consistent way, so that we have criteria in terms of how they're going to be evaluated by the industry. We have to make assumptions on all the economic parameters, inflation, and so on, and get a particular contractor to look at a number of design configurations that would be considered by a utility. With that kind of input, we can develop a methodology that takes those capital cost estimates and operating goals and parameters and puts them into a system, using a generation expansion consistent with the way utilities go about making decisions. We can then ask the question, "At what point in time will a technology penetrate? And how much?"

We also have the ability to look in terms of sensitivity. We don't just look at what comes out on the top. If we can see that there are some technologies that come within a few percent of making it, we can examine more closely less quantifiable factors that would influence acceptance. Some clearly ought to be eliminated, and we can adjust our program accordingly. We do this on a regional basis, because you can't just generalize for a single system. We also test our procedure with actual utility systems.

So that gives us some basis to begin to lay priorities in the future. We can't build a demonstration plant in gasification, combined cycles, fluidized combustion, and advanced scrubbers, and all of these things. But if we begin to narrow them down and aggregate, I can think of

significant contributions to those that are justified.

Rudman: Three or four years ago there was a long list of potential liquefaction processes that we were looking at, as well as a whole series of questions associated with each one. As a result of the research that we supported, that has now been narrowed down to several.

Balzhiser: The same thing with gasification. And storage, too. It's a sifting process. We eliminated one or two options in the course of establishing our program, and later, after a short investigation, we threw out flywheels.

King: How do you deal with technology that you shun? There are those who feel that EPRI is not taking gas-cooled reactors seriously enough.

Malès: An assessment was made that indicated it had a fairly low probability of playing an important role. There have been some utility people who feel that the gas reactor could play an important role, and EPRI ought to play a larger role in its development. We are willing to reflect that, if a system can be supported.

Rudman: We have been conducting studies on the gas-cooled reactor for the last three or four years. The point René makes is not whether it is a good machine—because the consensus is, yes, it is a good machine and it works—but a question of what is the probability of its getting into the marketplace. And unless there is a massive initiative by the federal government, that probability is very low.

Fact Generator

King: What is the role of EPRI with the public? I know you don't have an advocacy role, but if you're dealing in an area that is in dispute, the mere fact that you have the facts puts you into that debate.

Starr: I think you have described a basic point, namely that we have a gradually increasing status as a fact base in many areas of national concern and public debate. And we have, as a matter of principle, made these facts available to anybody who wants them.

There is an activist role in carrying the fact message to people who need it, and that role we have entered into only in a moderate degree. There are three levels of constituencies that have to be faced. One is the professional level of engineers and scientists engaged in the technical fields we encompass. In spite of the fact that we have thousands of people who get our technical publications, that is still only a very small fraction of the technical audience. That job is perhaps the easiest one for us to do, but we're just embarking on it.

There is another constituency, the policymakers, both in industry and in government. They usually don't have enough technical insight of their own to enter into technical judgments and yet they are faced with making decisions where the basis is a technological one. We have prime examples of this in air pollution, nuclear power, and many other such issues. There our problem is how to translate our objective findings into terms they can use. We often make the mistake, as professionals, of trying to talk quantitatively to people who do not think quantitatively but comparatively. So we have to translate what we're doing into comparative terms for the decision makers, because they always have a problem of choosing among optional approaches, and they want to know the comparative merits. And we have only crudely done this.

Finally, the third constituency is the public at large. It is probably the one that we are least effective in reaching, because there we have to get into a discussion not only of the comparative values of optional choices but also of their value systems. It is an area in which I don't think we will ever be able to make a very profound contribution. I think there are going to have to be intermediate organizations that translate what we provide for the public at large.

King: One of the phenomena of our times is that the politicians are beginning to fall in love with technology. Time was when technology was left to technologists—not so any more. The obvious example is many politically motivated people have considerable enthusiasm for solar power, but they rarely have experience with it. What is the role of EPRI in dealing with political choices in technology?

Starr: We have issued studies on what it would take to make solar sources convert into usable forms; what it means in terms of economics and step-by-step procedures; what it means to the end user; what it means in terms of resource requirements, and so on. I think what we have come out with in that particular case is an overview that the professionals in the business agree with in general, even though there may be differences of opinion on minor points.

Nevertheless, we have not been very successful in communicating these findings. And the reason, I think, is we have assumed that people who we want to talk to, want to hear. And I think we're finding out there are many people who don't want to hear, because they don't want to find out that this miracle around the corner, in fact, does not exist. They have to have faith to support the position they have taken. They have to have faith that there is a miracle alternative—and solar is that one.

Malès: I think Chauncey is a bit too self-deprecating in terms of our effectiveness in communicating results. I think there have been important inroads. Dick's program has provided a good deal of factual material that utilities can use. They have absorbed this and are now starting to transmit it.

I also think that Dick's work has forced solar advocates in the scientific community to examine more carefully and with greater discipline what they have been saying. We find their positions changing as they are reexamined in a more critical environment.

Balzhiser: I would like to follow that up briefly. The confusion surrounding

solar stems from the fact that technically you can do it. It is hard to dispute that you can heat water or generate electricity or do all the other things that the advocates claim. The problem is how one takes a diffuse energy source available only at certain times and integrates it with an electrical system. That is a much tougher question to address, whether you're talking about the impact of solar-heated homes or whether you're talking about solar electricity. If you're going to use solar when it is available, you're going to have to make certain investments to cover your needs when it is not available.

King: There is a powerful philosophical idea abroad at the moment that suggests that centralized electricity is a bad way to go; it is on a collision course with EPRI. It reached a point of institutionalization two days ago, when the Council on Environmental Quality [CEQ] sent a memorandom to President Carter that assumed as fact that centralized electricity generation was not in the national interest and, of course, that nuclear power wasn't.

It said without quotes, without explanation, as though it were now an established part of the lexicon, that the nation should pursue soft power without qualification. I found it interesting that they were dealing at that level with that lexicon. How is EPRI going to deal with that?

Starr: The Lovins thesis is basically unsound because it presumes that the soft technologies are not being pursued and that, in fact, there is a conflict between the soft and hard technologies. That is not only factually incorrect, but it artificially creates positions of opposition.

Operationally, in fact, we have some soft technologies right now. Your private automobile is a soft technology. It is not a high technology device in the sense that Lovins talks about. We have solar energy use going on; we have solar heating in homes now.

Rudman: I would like to make the point that we're working on decentralized technologies. We have fuel cells, solar-heated homes, battery storage. But there is a difference in what these can do and in what time frame.

Starr: But you are again talking about the technical side of this, and I am getting back to the CEQ position, which is really not a technical position.

King: But it is one you have to deal with.

Starr: It is one the industry certainly has to deal with. But the CEQ position is based on an assumption that there is something philosophically wrong with what we're doing and the fact that what we're doing is philosophically exclusive: having central station power automatically means that we cannot have decentralized power. And I am saying that

"We have to distinguish between what we as individuals might want to do out of a broad social consciousness and what EPRI as an institute has as its mission."

thesis is not only wrong in theory, it is even wrong in practice.

Now, the question of EPRI's role is a peculiar one on this, because we are, in general, neither structured nor oriented as a mission to argue on philosophic terms, to dissuade the philosophers of their philosophy. That is not really our mission. Our mission has been to develop the technical options for the industry and to solve the technical problems for making those options feasible. We are working just as hard to get solar electricity at a low cost as we are to get nuclear power stations on-line. We do not distinguish between them in terms of our mission. Now that the philosophers are playing games with reality, it puts us in an odd position.

King: That is my essential question. How do you deal with these games?

Starr: We have to distinguish between what we, as individuals, might want to do out of a broad social consciousness and what EPRI, as an institute, has as its mission.

Malès: We do have some role that allows us to participate in the debate on this question, and Chauncey is bringing it out. It is first the technical evaluation, in terms of hardware and cost and economic development, and second, trying to go through the philosophic distinction between hard and soft, or centralized and decentralized.

As Chauncey was suggesting, one of the things we can demonstrate fairly well in terms of analyzing the technologies involved is that the centralized technologies are not necessarily centralized —but this is only an arbitrary definition. And the decentralized technologies have a higher centralization implicit in them. For example, the centralized production of solar collectors to get their cost down is part of the system, so there is an inconsistency in definition.

But in the area of the value system, the social philosophy, there we really do not have expertise and we really can't argue. We can provide arguments as individuals, we can provide the background for the technical arguments, but there is an entire level of this thesis of centralization versus decentralization that concerns values on which technology can't speak, and where we can only speak as individuals.

Levenson: I think that is a very important point. One of the questions at the beginning was, What is EPRI's role? Basically, it is a factual, technical role. Regarding the question of how one comes to grips with things that don't have much technical content, let me say that cartoonists can have much more impact on that than six volumes of technical data. In fact, in yesterday's paper there was a little cartoon that I think has some application to solar energy. In it two cats are talking, and one of them says, "My father was right. The best things in life are free," and the other cat says, "You're absolutely right. The only trouble is, they are not available."

Balzhiser: Let me speak to the point briefly. First, our job is to put together the technical fact base; that is the mis-

sion; that is what we get paid for. As we have built the Institute essentially from scratch, it has not left us a hell of a lot of time to go out and speak in an interpretive sense. Second, we take a great deal of pride in the independence with which we can operate. The fact that we do put together an objective technical fact base, regardless of what it may ultimately mean to an investor-owned utility's business position, should give us maximum credibility. I think as people become more familiar with the output, as they become more familiar with the staff, they will go away convinced that indeed the organization is working in the public's interest and not just in the industry's interest.

But there is that question of the time it takes for us to translate, because when Chauncey talks about our tendency as technical people to talk in technical terms, he is right. It takes a good deal of effort to translate into terms that are really meaningful to the general public.

Commercialization

King: I would like to hear a little more about the whole crisis of commercialization. If we have, as it seems to me, a problem in getting from here to there in energy technologically, much of that revolves around commercialization. We don't seem to have any mechanism for getting large new developments into the marketplace.

Malès: Lew, I think that your statement is a fair one, except in localizing it to energy. I think that is true in whatever field. It is not enough to just build a better mousetrap; you have got to have some way of translating that product into a marketable entity.

Rudman: I think we're making big strides. Our programs have been set up to promote transfer from the R&D phase to the end user. The APS high-intensity ionizer and the Battery Energy Storage Test Facility, which is located on the PSE&G grid, are good examples. And the FCG-1 fuel cell is a perfect example of how the utility industry, the federal government, the manufacturer, and EPRI are all working in a cooperative sense to get this thing out on the line.

Balzhiser: Let me make a point and try to speak to the heart of the question. One of the real problems with commercialization today, particularly with major energy systems, whether it is gasification, fluidized-bed combustion, the breeder, coal liquids, or whatever, is that we are talking about enormous investments. Given this need for capital, the major problem today is uncertainty. We're trying to hit a moving target. We're not sure what government policy is going to be with regard to oil and gas. We're even less certain as to what kind of reserves or resource base we have to work with. We are also very uncertain as to what kinds of environmental requirements are going to be imposed in the future.

"One of the real problems with commercialization today is that we are trying to hit a moving target."

Let me give you a good example: solvent-refined coal has been a very successful development. We're now moving into the final development stages with a process that could be commercialized from a technical point of view. The emerging question is, Can it meet the kind of standards that EPA is now talking about? Here we have a moving target: new criteria for pollutants being added and levels being tightened. We're trying to anticipate where it is going politically and at the same time trying to work closely with the environmental effects people.

In moving toward commercialization we have, I think, played an important role and are playing an increasingly important role. But the dollars for development, given these large uncertainties, are awfully hard to come by, even out of the Exxons or General Electrics. We are in a position to share development costs on behalf of an important user, and that has been a key factor in a number of these projects going forward.

Christiansen: Are you now talking only about funds for development or for demonstration projects too?

Balzhiser: Development. When you go to the demonstration—that first commercial plant—it is awfully expensive. We don't foresee having the kind of budget over the next five-year period that will allow us to aggregate enough on behalf of the utility industry to make that happen without substantial federal and other private sector participation.

With regard to limited funds, let me follow with one final point. We have to discriminate, with as good and as solid a technical fact basis as possible, among all the options now being promoted—some by individual vendors, and often with the cooperation of a senator or some influential member of the Washington community. A lot of them originate from what I call medicine men. They are out there promoting an instant solution, and although they have a very weak technical base, they make a good political case for it. There are only so many things you can do at the demonstration scale. It is a real problem to keep a lot of second-rate projects off the agenda until we get the fact base sufficiently developed for the more promising ones.

Rudman: One of EPRI's real problems is that a mechanism does not exist for pooling private sector money into the large demonstration projects, and by large I'm talking about the $500 million to $1 billion level.

We are in a couple of major projects right now: at Exxon we have $40 million, at Powerton we have $30 million. But that is about the limit of what we can put into any one project.

King: Why is that the limit?

Dougherty: Because of the size of our total funding.

King: To what extent does EPRI worry about money? If the capital markets are not going to be able to sustain these big systems, there is not much point in working toward them.

Starr: We do worry about it, and we worry about it jointly with the rest of the utility industry. Our function is to analyze what it is going to take in order to get from whatever development programs we have to the end use. That end use may involve hundreds of millions of dollars of capital investment by somebody, even to get the first option developed, and we do not have that kind of cold cash at EPRI.

We have taken the position with our Board of Directors that when things go beyond the development stages, the utility industry must develop special mechanisms for either individually or jointly pooling funds to take the next big step. We now have various projects that have done that—they involve utility contributions, manufacturing contributions, and government contributions to raise the total amount of funds.

Malès: Specifically in the capital area we are very interested, because the utilities are very interested. They are the most capital-intensive industry, and one of the constraints on growth, one of the constraints on technological change, might be their inability to attract sufficient capital resources during a transition period in nuclear technology or in the implementation of a new kind of technology.

There are mechanisms that are available for attracting more capital from the other uses society might have for funds, for having higher savings rates. As you probably recognize, our society is one of those that has the lowest savings rate in the world. We can change that, but it does mean postponing current consumption.

Our job here is to try to identify the shortages that might take place, or the dislocations, or the short-term aberrations in a normal supply pattern of those resources having to do with full deliverability in the long run. Implementing a higher rate of return for all electric utilities is a possible means of forming sufficient capital for the industry, but it is not our job to advocate. We can merely point out the option.

Balzhiser: We recognize potential capital limitations as an important constraint. When we look at advanced systems, particularly in the fusion and the solar areas—the inexhaustible areas that some people feel we will get to in twenty-five, fifty, or a hundred years—we must look at the capital requirements. Part of the input to the federal program focuses on that criterion. And it is a very important point, because there are lots of ways one can configure, lots of options in solar or fusion, some of which are far more capital-intensive than others. So we look at that and take that into consideration in our own planning prioritization.

The Breeder

King: To what extent does EPRI's work follow the directions taken by the federal government? And how does that apply, say, to the breeder? EPRI has been a very aggressive proponent of the LMFBR, and the national policy is to not proceed with the LMFBR.

"The excess plutonium the breeder makes is less than that produced by any of the existing nuclear systems."

Levenson: We follow only those things we perceive to be correct, and that is much broader than nuclear. It is not at all my perception that it is the government's policy not to proceed with the breeder. There is a question, however, whether they want to proceed with Clinch River as a way into the breeder program, but President Carter has not removed $300–$500 million per year from the budget. He is advocating it be there. So I think there is a lot of confusion over the administration's action on Clinch River.

King: But there is a certain amount of gamesmanship there, because the fact of the matter is that Clinch River is not being suspended because it is not cost-effective. It is being suspended because President Carter perceives that it will contribute to proliferation. In order to justify this, Schlesinger has found it was not cost-effective. The national policy is one of extreme hesitance about plutonium.

Levenson: Well, the money in the budget that I am referring to, several hundred million dollars, is basically to continue to develop a breeder option. You have to recognize that while there is a lot of conversation about commercialization, the breeder option is at best decades away. Our program is aimed at trying to define what the option should be if it turns out that the super-optimists about uranium reserves are incorrect and the country decides that it does, after all, need the breeder. If that decision should be made tomorrow, there is nothing we can do to implement it. We don't have the breeder option yet, and our programs in the breeder area have nothing to do with deployment or commercialization.

Starr: There is no way this nation can meet its energy needs in the next twenty-five years without expanding nuclear, and there is no way to expand nuclear without having the fast breeder come through. So I think all the President can do is delay. I don't think he can prevent the eventual denouement of the breeder. And every study we make indicates that the time required to develop that option is so lengthy that we are already way behind and are playing catch-up.

Levenson: I just want to add that one of the glossed-over misconceptions is that the breeder is capable of making more plutonium than it uses, which is technically correct. But the second half of

that usually is left out: that the excess plutonium the breeder makes is less than that produced by any of the existing types of nuclear systems. Both the heavy water reactor and the light water reactor make more excess plutonium than the breeder, because they don't burn any of it.

Starr: If you look at the stuff out of pile in a breeder system, it is a fraction of what it is out of pile in the light water reactor.

Conservation

King: What is EPRI doing in conservation? Conservation seems to be an amorphous subject.

Starr: Let me talk about the general philosophy. There are three aspects to conservation. One is to use technological improvement to give us more electricity—more usable energy for less input of primary fuels—and that means raising the conversion efficiency of power stations and all the other things that go into fuel conversion efficiency.

The second aspect is to employ technology better at the user end, to take electricity, or whatever energy form the

"Conserving scarce resources, such as oil and gas, by substituting more plentiful ones, such as coal and uranium, is rarely discussed."

user gets, and convert that into what he needs—like heating a home—more effectively. It is an applied technical step when the manufacturer uses the rejected heat from a boiler or some other kind of chemical process, and that is a major field of our work.

The third aspect of conservation is to decrease what the consumer is asking for. This we have nothing to do with, but it is what many people mean when they talk about conservation—reducing the materialistic demands of your lifestyle and thereby reducing the total demand for goods and services that energy is required for. We don't get into that one at all, other than to recognize it analytically, to determine how conservation is going to affect the energy system.

Rudman: There is another aspect of conservation—conserving scarce resources, such as oil and gas, by substituting more plentiful ones, such as coal and uranium. This aspect is rarely discussed.

Starr: That is what I call political and global conservation in a resource sense.

Balzhiser: The real objective is to meet a certain end-use function by using less—or less scarce—primary resources.

King: It seems to me that most of your projects are directed towards the supply of electricity. Where does your solar work fit in? Is it part of conservation, or is solar part of something else?

Balzhiser: Half of our solar program is devoted to actual energy applications, either residential, commercial, or industrial. And a good bit of that has been aimed at understanding how the use of solar in various configurations and for various applications relates back to capacity requirements that will affect the utility industry. About half of our program is oriented to the kind of applications we see coming the earliest, namely, solar heating, and so on. And the balance of our program is looking toward generation options and solar central power stations. It is not a substitute for coal or nuclear. If solar makes it, for power generation in this century, it is going to be in the Southwest.

Starr: We don't have a responsibility to promote solar heating. We do have a responsibility to thoroughly analyze what the development of solar heating and cooling would mean to the electric utility systems and their customers in the United States and to the total energy picture.

Levenson: I think there is a point here about EPRI as a whole: There is a better overview of systems interactions and systems problems here than almost anywhere else, because one of the five of us is responsible for some piece of it, and the overlap just forces you to recognize that yes, you can save some gas over here, but somebody has got to build a new electric generating plant as a result.

High-Voltage Effects

Christiansen: Let's turn to the topic of high-voltage effects.

Malès: That's in my bailiwick.

Dougherty: We share that responsibility in Electrical Systems. We worry about the size of the fields the systems are going to produce, and René determines for us what effects those fields will have on flora, fauna, and biota.

Malès: A normal field under a 765-kilovolt line is about 10 to 12 kilovolts per meter. The problem is to determine if there are effects. Concern about effects dates back about six years when some substation workers were reported to experience such symptoms as nausea, sleepiness, and lack of sex drive. You can recognize that such symptoms would be exceedingly difficult to discern in test animals.

However, there have been some effects noted under certain kinds of experiments. The question is, are these effects real or are they the results of the form of the experiment? We have been designing a program to address this and are trying to replicate some of the existing experiments under carefully controlled conditions.

Dougherty: There have been proposals for limiting the field level to values that are not compatible with the use of electricity at all. There was a recent suggestion that the maximum permissible field strength at the edge of a right-of-way should be 0.4 kilovolts per meter. You've

got three times that much field strength on the surface of your skin when you sleep under an electric blanket.

Malès: There is little understanding of the question of trade-offs in our society, and there are no mechanisms for arriving at rational trade-offs. There is no way in which we can live in a society where there are zero effects. We've got to communicate this idea of getting some benefits for very little risk. Are we willing to accept that? How do we measure it? How do we come to some conclusion?

Major Concerns

Christiansen: What are some of your major long-range concerns?

Starr: I am deeply concerned about the gross mismanagement of our national resources—technology, industry, infrastructure—everything that we call our national wealth and resources. The gross mismanagement of these resources in the energy field, arising from simple-minded interventions by well-meaning government and minority groups, especially disturbs me.

The measure I use is a comparative one. Take countries such as France and Japan—you find management centralized with very little public explanation required as to how the nation is optimizing its use of resources. What you see there are well thought-out programs, technically moving very rapidly. All the options are being developed, both hard and soft. You see professional differences of opinion, but the objective is not in dispute. And even in the large systems that compare in complexity and size with those in the United States, progress in meeting all the issues can be made at a pace much greater than ours.

Malès: To build on that, I'm concerned over the inability to take action on the one hand, and the tremendous leverage that the charlatan and the medicine man have had—the quick and easy fix, which is neither quick nor easy—that has been sold. Someone like Amory Lovins can get 45 minutes of the president's time and make him believe.

King: That is what I referred to earlier as a negative dynamic of society. We have changed the nature of American society, so instead of the old dynamics of action and of progress and the values that were once associated with that ethic, we now have more ways to disrupt than we do to construct. There is an increasing number of levers of power in the society that are negative. We must stop this trend because in the end the negative sector is going to be larger than the positive sector, and the whole society is going to unravel.

Rudman: When you talk privately with Europeans, they look at the United States with a combination of amusement and bewilderment and fear: amusement and bewilderment because they see a nation that is incredibly rich in technology and capital but is just dead in the water; and fear, because they know that unless we start using our resources of coal and uranium we're going to be competing directly with them for a dwindling supply of oil.

King: Absolutely. That is a lot to be scared about.

Starr: The common bond that kept this country moving, certainly until the last several decades, was a conviction on everybody's part that increasing the material welfare of the population was intrinsically a good direction. The underprivileged, the blacks, and all the minorities agreed that as the total output of the country went up—goods and services—even if their share was small, it would still be an increase for them, too. This has now been attacked as materialistic by people who have enshrined what really amounts to a Buddhist philosophy that it is glorious to be poor and simple and that, in fact, the goals of the nation have been so materialistic that the spiritual values, the psychic values, have been overlooked.

"I am deeply concerned about the gross mismanagement of our national resources."

This attitude has not been sold to the public but to a group in society who are sufficiently affluent and who have always participated in the political process. And so what we have is a highly organized minority of the population that, having made it, now says the country does not have to work any more to improve its material status.

Levenson: "Poor is beautiful" does not have many advocates among the poor.

Starr: No. But the point is: what has happened is that the taproot on which the whole society was built has been partially destroyed.

Malès: Let me just add one thing in a different line. I thought Lew's negative levers point was very instructive. I would like to suggest that the same thing is true for the press and for the public communications area. It is much easier to write a negative story and get something out of it than to write a positive story. It is one area we worry about. It is one of the principal problems we have in getting our story across.

King: This is an old one. People are always unhappy with the press. It is a highly imperfect institution, and it is imperfect because it is both a reflector of its own ills and a reflector of its employees and its times, and it is based on certain prevailing assumptions. Those assumptions today include a suspicion of technology, a suspicion of large institutions, and they are reflected in the press. What you are actually aiming at is not the press; you are trying to kill the messenger. The messenger is telling you what the people think. The message is going to irritate you because there are specific examples where it is going to be distorted. But it is, in fact—albeit inexact—a mirror of society.

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