Transmission Costing

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ELECTRIC POWER RESEARCH INSTITUTE

EPRI JOURNAL

JULY/AUGUST
1995

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

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

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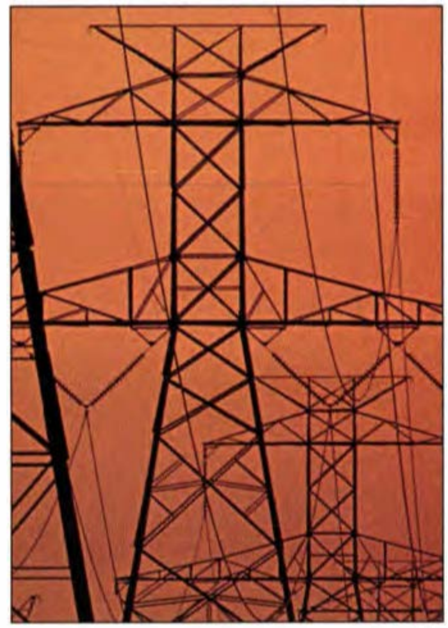
Cover: Proposed rules on open access will require utilities across the country to post tariffs for transmission services, separating out costs that have traditionally been embedded in overall electricity prices

EPRI JOURNAL

Volume 20, Number 4 July/August 1995



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UCA/DAIS Video

This 9-minute video (VT-104190) provides an overview of two powerful new information management tools developed by EPRI, the Utility Communications Architecture (UCA) and Database Access Integration Services (DAIS). UCA is an internationally recognized protocol that allows for communication between the separate and often incompatible computer systems within a utility, such as those pertaining to transmission and distribution, control centers, and corporate headquarters. DAIS facilitates the management of data between dissimilar databases; it can help a utility access information in its databases to answer pressing questions on operating costs, efficiency, economics, and competitiveness. The video details how UCA and DAIS can work together for a utility in today's increasingly information-intensive environment.

For more information, contact Bill Blair, (415) 855-2173. To order, call the EPRI Distribution Center, (510) 934-4212.

SOAPP Workstation and Technology Modules

Recent years have seen major advances in fossil power plant technology. To help deliver information on these advances to utilities, EPRI teamed up with Sargent & Lundy to produce the State-of-the-Art Power Plant (SOAPP) Workstation and a comprehensive set of technology modules. This award-winning multimedia software package gives users the ability to quickly screen, analyze, and visualize alternative plant configurations. Each technology module is a stand-alone software program that offers an overview of a power plant process or component, along with detailed information on technology alternatives. The workstation helps users integrate selected technologies into a conceptual plant design and interactively evaluate the impacts of key sensitivities and technology selections. Currently the workstation and modules address simple-cycle and combined-cycle combustion turbine power plants. Plans call for future versions to address additional technologies, including integrated gasification–combined-cycle systems, fluidized-bed combustion, pulverized-coal plants, and distributed generation.

For more information, contact Stanley Pace, (415) 855-2693. To order, call the Electric Power Software Center, (800) 763-3772.

Wind Power Primer

Planning Your First Wind Power Project (TR-104398) is a user-friendly primer that offers utilities everything they need to know to bring their first wind power plant on-line—from project conception through equipment selection, construction, and successful operation. Users will become familiar with the technology and with the evaluation and development process, and they will learn how to identify areas in which additional expertise is needed. Specific topics covered include assessing the magnitude of wind resources, determining the economic feasibility of a proposed project, conducting resource planning and evaluation, complying with permitting and tax requirements, and specifying and selecting equipment. The primer includes a glossary of wind energy terms and a list of organizations that archive valuable wind resource data.

For more information, contact Earl Davis, (415) 855-2256. To order, call the EPRI Distribution Center, (510) 934-4212.

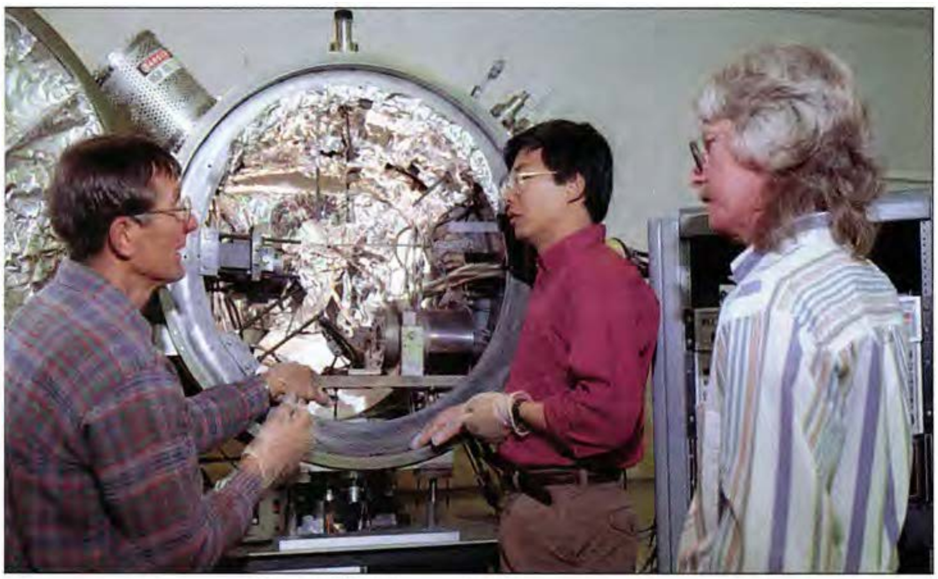
High-Efficiency Heat Pumps

EPRI and Lennox Industries recently introduced a new line—the L Series—of commercial heat pumps that hold the industry record for efficiency. These single-package units for both new and retrofit applications come in seven cooling capacities, ranging from 3 to 20 tons, and are designed for low life-cycle costs. Each unit in the series contains a state-of-the-art integrated modular controller with advanced diagnostic capabilities. The controller can also communicate with an energy management system to ensure maximum efficiency. The competitively priced units are designed with ready access to electrical, plumbing, and blower components for easy maintenance. Each heat pump is built to customer specifications and can be delivered within weeks.

For more information, contact Wayne Krill, (415) 855-1033. To order, call Lennox, (800) 453-6669.

New Record Set for Superconducting Wire

The newest member of EPRI's Advanced Superconductor Wire Initiative has set a record for current-carrying capacity in a high-temperature superconducting material. Researchers at the Department of Energy's Los Alamos National Laboratory announced that they have exceeded a current density of 1 million amperes per square centimeter, more than 100 times the current-carrying capacity of competing high-temperature superconductors. (In comparison, the copper wires used to conduct electricity today carry less than 800 amperes per square centimeter.) The new development is considered a significant step toward the commercialization of low-loss power lines, high-efficiency electric generators and motors, and superconducting magnets for energy storage and power quality applications.



The record was set with a ribbonlike tape measuring 5 centimeters long, 1 centimeter wide, and a few tenths of a millimeter thick. The tape is made of a three-layer material based on a high-temperature ceramic superconductor called yttrium-barium-copper oxide (YBCO). Normally, YBCO cannot be bent without breaking because it is so brittle. And since, like other superconductors, YBCO has a crystalline structure, it can lose superconductivity when fabricated into strands of wire; the crystal grains of the YBCO material must be well aligned in order to transmit electricity without resistance. Moreover, unless the crystal grains are nearly parallel, YBCO loses superconductivity in the presence of the high magnetic fields generated by large motors and other applications that superconductivity is expected to serve.

The Los Alamos researchers say the new three-layer material solves all of these problems. The researchers used a process called ion-beam-assisted deposition first to lay a film of zirconia crystal grains, almost perfectly aligned, onto a thin ribbon of nickel alloy and then to deposit the YBCO layer. The YBCO film took on the alignment of the zirconia, which resulted in superior superconducting properties. The three-layer arrangement allows the superconductor to bend with the metal—even at sharp angles—without cracking. Laboratory tests at Los Alamos showed that the film retains half its current-carrying capacity in magnetic fields about three times the strength of those generated by a large industrial motor. Los Alamos has applied for a patent on the technology.

Like other high-temperature superconductors, YBCO (which loses its resistance to electricity at −292°F) has the advantage of being able to use liquid nitrogen (which boils at −320°F) for cooling. Liquid nitrogen is relatively inexpensive and easy to handle, compared with the liquid helium required for more-conventional superconductors, which lose their resistance at about −423°F. (Liquid helium boils at −452°F.)

Before the development at Los Alamos, the current-carrying capacity of superconductors was not significant enough for many electromagnet applications. "I knew that the researchers at Los Alamos had been making steady progress in critical current levels since late last summer," says EPRI's Paul Grant, who oversees the Advanced Superconductor Wire Initiative. Grant, who had been negotiating with Los Alamos to join the initiative since last summer, says that the Institute's contract with Los Alamos was finalized in March of this year, about six weeks before the breakthrough was announced. The contract with EPRI supports half of the group's research budget.

Other participants in EPRI's Advanced Superconductor Wire Initiative are Stanford University, Lawrence Berkeley Laboratory, and the University of Wisconsin at Madison. EPRI's current budget for this initiative is $600,000, representing the country's largest single program in this area. Funding for 1996 is expected to exceed $1 million, says Grant.

■ *For more information, contact Paul Grant, (415) 855-2234.*

Study Shows No Link Between EMF and Fetal Growth

An EPRI-sponsored study conducted by the Yale University School of Medicine provides "reassurance that exposure to residential electromagnetic fields and electrically heated beds during pregnancy are unrelated to fetal growth."

The study, directed by epidemiologist Michael Bracken, followed 2967 pregnant women receiving prenatal care in the New Haven, Connecticut, area. Participants were all interviewed prior to 16 weeks of gestation. The women who reported using either an electric blanket or a water bed were randomly assigned to one of three monitoring groups, and their EMF exposure was tracked over a seven-day period (either the 20th, 28th, or 36th week of pregnancy). The women who did not use electrically heated beds were also intensively monitored for comparison. The researchers looked for intrauterine growth retardation (IUGR) and low birthweight. Their analysis accounted for smoking and a number of other factors known or thought to be associated with IUGR.

The study concluded that electric bed EMF exposure, whether it occurred at conception, prior to or at 16 weeks of gestation, or in the third trimester, was unrelated to IUGR. This conclusion was consistent for a variety of exposure measures, including 24-hour bedroom measurements, personal exposure measurements, the length of time per day in electric bedding, and the electric bed setting (i.e., off, low, or high).

■ *For more information, contact Leeka Kheifets, (415) 855-8976.*

EPRI, Penn State Team Up on Superhighway Project

EPRI's Monitoring & Diagnostic Center in Eddystone, Pennsylvania, and Pennsylvania State University's Applied Research Laboratory (ARL) are collaborating on an information superhighway project that will allow researchers in both groups to access each other's information electronically.

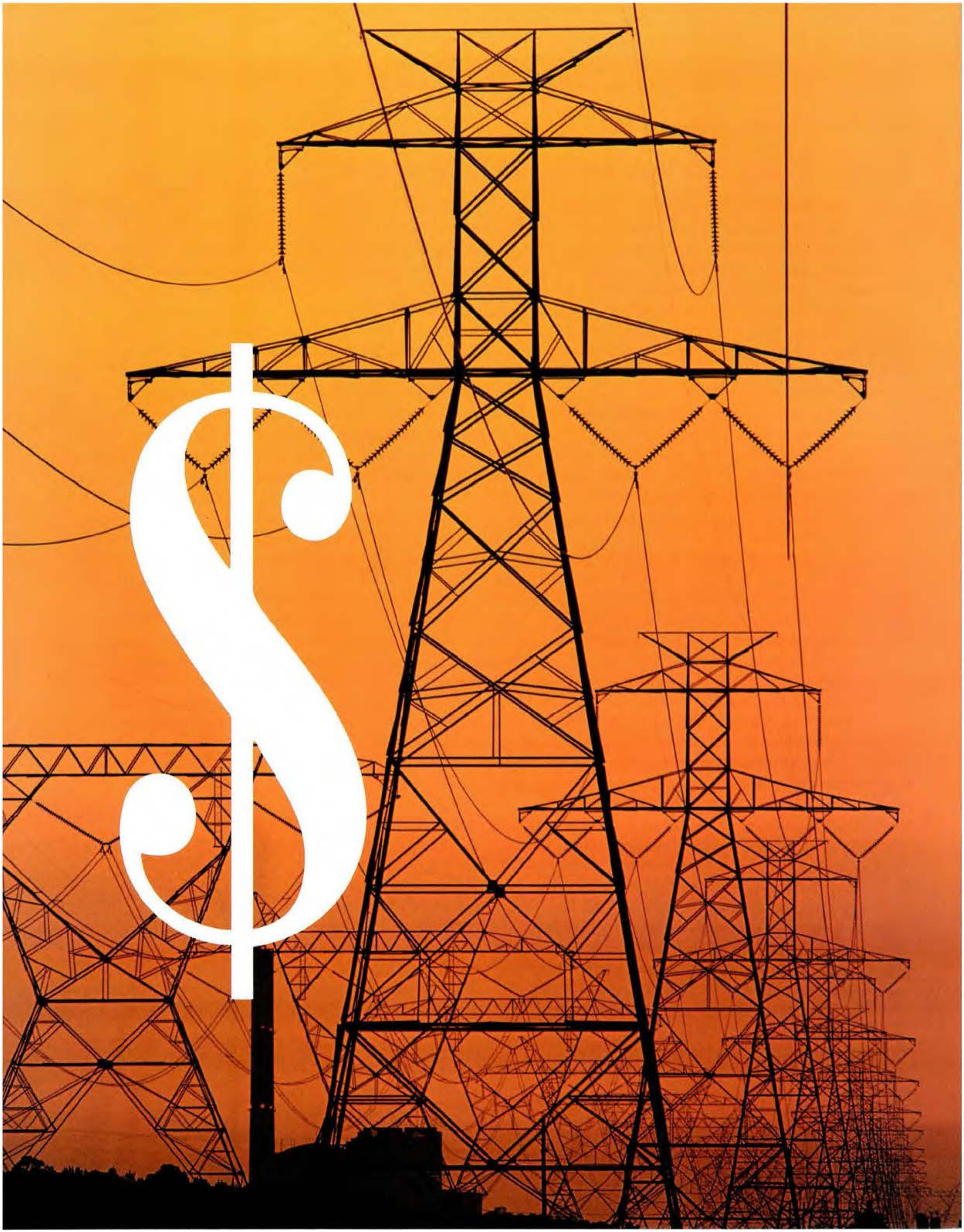
The EPRI–Penn State team was among 5 groups (out of more than 250) that were awarded superhighway contracts by the Department of Defense's Advanced Research Projects Agency last fall. Each of the selected groups is developing a communications network to allow for the sharing and retrieval of data.

The EPRI–Penn State project, administered by the Department of Energy, received $4.3 million from the Department of Defense; EPRI is providing technology worth an additional $6.7 million, and Penn State is contributing $120,000. The project will support three years of research and will result in a communications link between the two sites. At this time, researchers do not know the exact medium this link will use—fiber optics, coaxial cable, telephone line, or a combination of mediums. To complete the link, the research team intends to use two EPRI-developed information management tools—the Utility Communications Architecture, which offers a standard communications protocol, and Database Access Integration Services.

To test the link, researchers at the two sites will share valuable tools and information that they have developed independently. For instance, EPRI has developed sophisticated software programs for monitoring and diagnosing power plants that can also be used to monitor and diagnose aircraft engines for ARL, a Navy-sponsored research facility. At the same time, ARL has developed sophisticated programs for prognostics of Navy aircraft engines that can also be used for power plants. Once the communications link is established between ARL and the M&D Center, ARL researchers will use their computer programs to perform prognostics on utility boilers, and the M&D Center will use EPRI's computer programs to monitor and diagnose Navy aircraft engines.

"The idea is to demonstrate that we can exchange this kind of technology over a standard network," says EPRI's Rich Colsher, a regional manager with the M&D Center. "Once the network is established, other companies will be able to join it. Right now, the project is focused on sharing monitoring, diagnostic, and prognostic information. But this is just the test bed. If successful, the network could be used for sharing all kinds of information—the sky's the limit."

■ *For more information, contact Rich Colsher, (610) 595-8870.*



Measuring the Cost of Transmission Services

THE STORY IN BRIEF Recently proposed federal rules would require public utilities to provide open access to their transmission systems for wholesale power transactions by third parties and to post tariffs for transmission services that would apply to both their own transactions and those of others. To help utilities cope with this type of change, EPRI has developed the comprehensive Transmission Services Costing Framework, which can be used to facilitate utility cost management and to provide a foundation for establishing appropriate prices for transmission services. The framework defines basic types of transmission services in terms of their attributes, identifies specific costs for each type of service, and enables the user to choose an appropriate cost calculation method to meet particular objectives.

by John Douglas

The forces of deregulation sweeping the American electric power industry have come to focus on the nation's transmission system. Declaring that "monopoly control of transmission is the single greatest impediment to wholesale competition," the Federal Energy Regulatory Commission recently proposed rules that would require utilities under its jurisdiction to provide transmission services to eligible customers "comparable to the service they provide themselves." The big question is, at what cost?

Traditionally, transmission charges have been bundled with the other internal costs of a vertically integrated utility and passed on to wholesale or retail customers as part of a single, regulated price. The wheeling of power across a utility's lines for the benefit of a third party was provided primarily on a voluntary basis and had relatively little impact on the revenue of the transmission system owner. The most common form of pricing for such unbundled wheeling transactions was a simple "postage stamp rate," so called because it represents a per-unit charge based on aggregate, rather than specific, costs. Indeed, the disaggregated costs of providing specific services, such as supplying adequate reactive power and voltage control to facilitate a transaction, were closely held proprietary information.

All that is about to change. Under the proposed FERC rules, transmission system owners must file open-access tariffs, which will be provided to all wholesale buyers and sellers of electricity. Furthermore, system owners must apply those tariffs in their own wholesale transactions and must use the same electronic information network that is available to their potential competitors.

At the same time, several technical hurdles must be faced. These include operating transmission networks within their physical constraints while the number and complexity of wholesale transactions increase, and finding new ways to communicate information among all the parties concerned in the transactions. In addition, there are such thorny issues as determining the recoverable cost of having certain existing utility investments "stranded" by increased wheeling—that is, rendered uneconomical because customers may seek new options for obtaining power.

"EPRI is ideally positioned to help the electric power industry address many of the most pressing technical problems associated with open access," says Ali Vojdani, manager for power systems analysis in EPRI's Power Delivery Group. "We have just released the comprehensive Transmission Services Costing Framework, which will help utilities prepare their open-access tariffs. In addition, we are working on a communications protocol that will facilitate the development of the real-time information network proposed by FERC. In the broader picture of transmission access, EPRI can also provide the advanced power flow controllers and analytical tools needed to plan and operate transmission systems more efficiently under increasingly complex conditions."

The road to deregulation

Pressure to deregulate the electric power industry has been building for many years, largely in response to customers' concerns over energy prices. As electricity rates began to rise during the 1970s, many firms in energy-intensive industries began turning to cogeneration and demanded access to the wholesale power market to sell their surplus power. The result was passage of the Public Utility Regulatory Policies Act of 1978, which required utilities to purchase electricity from cogenerators and independent power producers at rates that reflected the utilities' avoided costs.

In 1992, the Energy Policy Act required utilities to provide transmission access to third-party producers and authorized FERC to establish rules that would encourage competition in the wholesale power market. On March 29, 1995, the commission responded by issuing a notice of proposed rulemaking (NOPR), which essentially mandates open access to transmission networks and sets out minimum terms and conditions of service that utilities must offer. Meanwhile, competition is also heating up on the retail side, driven largely by the push toward deregulation at the state level.

Underlying these trends is what the well-known regulatory economist Alfred Kahn refers to as "my economic version of the physical law that nature abhors a vacuum: society abhors big gaps between prices and marginal costs." Today in many areas of the country, customers are paying electricity prices that are several times higher than what would be the cost of power from new generating facilities. The spread between the highest and lowest residential rates charged by various utilities nationwide is more than 10¢/kWh. Even within some states, the rates currently charged by neighboring utilities may differ by a factor of 2. Under such circumstances, there is a strong economic incentive to make less-expensive electricity more widely available by opening up the wholesale power market to greater competition.

"Clearly this commission is not 'introducing' competition to the electricity industry," declares FERC Chair Elizabeth Moler. "Competition has introduced itself. Marketplace economics have changed. Customers are simply demanding access to lower-cost supplies in other regions and access to newer, lower-cost generation resources."

Terms of the NOPR

Recognizing that its proposed rule would create fundamental changes in the electric power industry, FERC issued a particularly wide-ranging, voluminous notice in March. Frequently referred to in the industry as the mega-NOPR, the 500-page document not only covers the basic requirements for providing open transmission access but also addresses several issues arising from increased competition. These include the functional unbundling of transmission services, stranded costs, the implementation process, jurisdictional questions, and the need for real-time information access. Utilities have 120 days to comment on the NOPR before the final rule is reviewed. It is expected to go into effect sometime in 1996.

Much to the relief of most utilities involved, the NOPR does not require them to sell assets to a nonaffiliate or to establish a separate affiliate to manage transmission, as had previously been speculated. The proposal does, however, require the functional unbundling of transmission services in three senses: the tariffs for each service must be the same for the utility and its competitors; the tariffs must include clearly stated rates for each service component; and a utility must rely on the same electronic information network that is available to its customers for marketing power.

If the available transmission capacity is not sufficient to provide a service, a utility may be required to add facilities. At a minimum, the owner of a transmission grid must provide both point-to-point and network services, including at least six ancillary services—loss compensation, scheduling and dispatching, load following, provision of energy imbalance, reactive power support, and system protection. EPRI's Transmission Services Costing Framework provides a further breakdown and expansion of such ancillary services.

One of the most important principles established by FERC is that "utilities are entitled to full recovery of legitimate and verifiable stranded costs at both the state and federal levels." Much uncertainty remains, however, about the extent to which utility commitments made under previous regulations can now be considered recoverable stranded costs. Some utilities argue that—in addition to capital assets (mostly expensive generating plants) that would no longer be economically viable if cheap power were wheeled in from other regions—certain demand-side management programs and existing obligations to independent power producers should be considered for cost recovery. By such accounting, the stranded commitments of some utilities might actually exceed shareholder equity. The NOPR proposes a "reasonable expectation" standard to determine what stranded-cost recovery related to interstate commerce will be permitted and stresses the need for utilities to attempt to mitigate these costs and negotiate their settlement. The assignment of many specific stranded costs, however, will probably have to be determined by future FERC activities and rulemaking by state regulatory bodies; EPRI's framework does not try to resolve this issue.

FERC proposes a two-stage implementation process for open access. In the first stage, each utility would have 60 days after the final rule goes into effect to apply pro forma tariffs established by the commission. These tariffs consist essentially of fixed rates for specific services covered in the NOPR. In the second stage, which starts after the initial 60 days, either utilities or customers could propose new tariffs. The EPRI framework provides a theoretical basis for calculating costs that could be used in establishing the new rate structures.

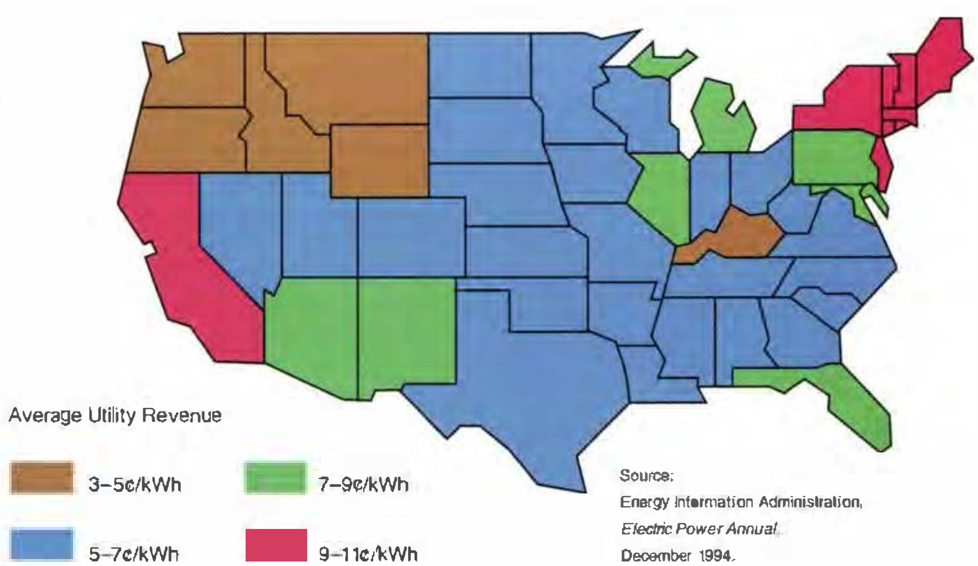
Although FERC authority is generally restricted to interstate commerce, the distinction between inter- and intrastate commerce may sometimes be difficult to apply in specific cases. The NOPR thus sets out some guidelines that reflect FERC's views of its own jurisdiction for implementing open access. For example, the commission asserts exclusive jurisdiction over the delivery of power across state lines from a third-party supplier to a purchaser that then sells the electricity to end users. If a utility uses its own transmission lines for the interstate delivery of power and then delivers the electricity to end users through its own facilities, however, state authority is recognized over portions of the local distribution.

Accompanying the NOPR was a notice by FERC that it will hold a technical conference to help establish a uniform format for real-time information networks (RINs), which would be used by both utilities and their wholesale customers to share information on open-access tariffs. The conference goal is to fix the requirements for such networks and the type of information that should be made available on them. FERC's stated intention is that the RINs should be in place by the time the final rule goes into effect. EPRI is cooperating with the North American Electric Reliability Council (NERC), individual utilities, and others involved in working through the technical issues associated with the RINs.

Framework overview

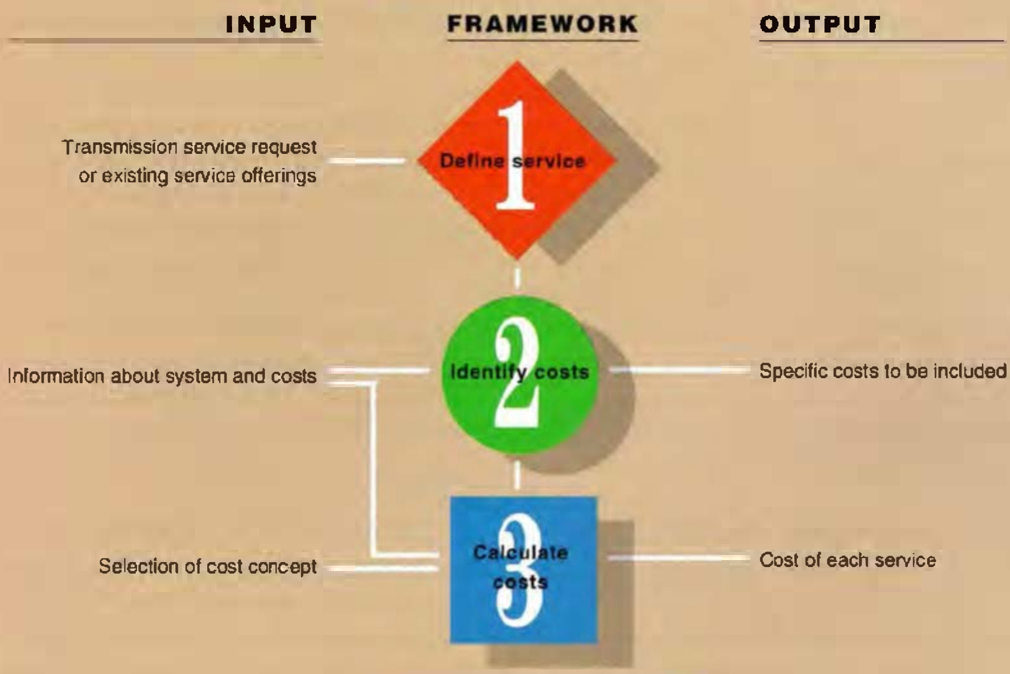
The EPRI framework—fully delineated in a two-volume EPRI report (TR-105121)—can be used both to facilitate the management and control of transmission costs and to provide a foundation for establishing appropriate prices for transmission services. The framework does not, however, address the issue of prices directly, since setting tariffs involves several explicitly political and social considerations in addition to cost. Such considerations include, for example, determining which stranded commitments qualify for cost recovery and which public service programs should be retained in the rate base. The framework was developed in cooperation with an advisory board representing 21 utilities.

The framework is applied in three steps. First, various transmission services are de-



ELECTRICITY PRICES The large differences in electricity prices from state to state have created a strong incentive to make less-expensive electricity more widely available through open access to transmission networks.

FRAMEWORK OVERVIEW **Under proposed FERC rules, public utilities owning transmission systems will have to file open-access tariffs that reflect the costs of unbundled transmission services. EPRI's new Transmission Services Costing Framework provides a step-by-step procedure for preparing such a practical and justifiable transmission costing structure, from the definition of services by their attributes to the identification of costs for each type of service to the actual figuring of costs by an appropriate calculation method.**



fined in terms of their attributes. Next, specific service costs are identified. Finally, the costs themselves are calculated, using one of several methods selected to meet particular objectives.

In the first step, transmission services are defined by various combinations of seven service attributes. Two of the most important of these attributes are the amount and firmness of a service, which together largely determine its impact on capacity requirements and possible system expansion needs. Amount can refer either to a reserved-capacity (megawatts) level or to the total energy (megawatthours) to be transferred. The former implies firm (noninterruptible) service. The latter is usually called a block sale and gives a utility considerable flexibility in how and when to transmit the electricity, implying nonfirm service that may range from "as available" to interruptible for specified reasons.

Two timing attributes—duration and time profile—describe the initial date and length of service and the expected loading pattern (such as off-peak or on-peak). The remaining three attributes identify receipt and delivery points, responsibility for energy losses incurred as the service is provided, and a miscellaneous "other" category (which includes specifically negotiated arrangements for provision of ancillary services).

Using these attributes, the framework defines six common types of transmission service, broadly divided into point-to-point services and network services. In both categories, service can be firm or nonfirm. For point-to-point services, firm service is broken down by duration of the capacity reservation—either long-term (more than a year) or short-term (less than a year). Nonfirm point-to-point service is usually on an as-available basis or with specified interruption conditions. Although utilities can expect customers to request these six basic services initially, other services are likely to become more common in the future.

Service components

After a transmission service has been defined in terms of its attributes, it must be analyzed to determine what requirements it will impose on the provider. The second step in applying the framework describes the eight service components (SCs) required to provide a transmission service and identifies the actions and costs associated with each. "You can think of the service components for moving bulk power as being roughly analogous to those encountered in moving household goods across the country," says Ali Vojdani. "A mover starts by analyzing the service required, dispatching the right-sized truck, defining the best route, servicing the equipment, and obtaining insurance. Then he finishes by monitoring delivery and presenting a bill. Each of these steps has an associated cost and is paralleled by a service component in the delivery of bulk power on a transmission network."

Two of the SCs represent administrative

functions, which may sometimes be provided by a third party: analyzing and arranging the requested service, and billing for services and collecting revenue. A particular focus of the initial analysis is the determination of what effect a service will have on the existing transmission system. If the amount of transfer is substantial and firm delivery is requested, for example, detailed load flow analyses and contingency planning may be required. Consideration must also be given to the effect that providing a service may have on neighboring transmission systems.

The next two SCs involve making sure that sufficient transmission resources are available for a transaction: reserving transmission capability from available facilities, and building additional facilities if necessary. Although the responsibility for providing physical facilities—transmission lines and substation equipment, for example—currently resides with the utility owner, constructing additional facilities could involve the participation of several parties. Firmness and duration are key service attributes affecting capacity reservation and determining whether new facilities will be needed. In general, nonfirm service should not result in modifications in an existing transmission system, but it may require redispatch of the system.

The final group of SCs is associated with the actual delivery of power. These four SCs, described below, are generally provided by the transmission system operator, which may or may not be the owner of the facilities.

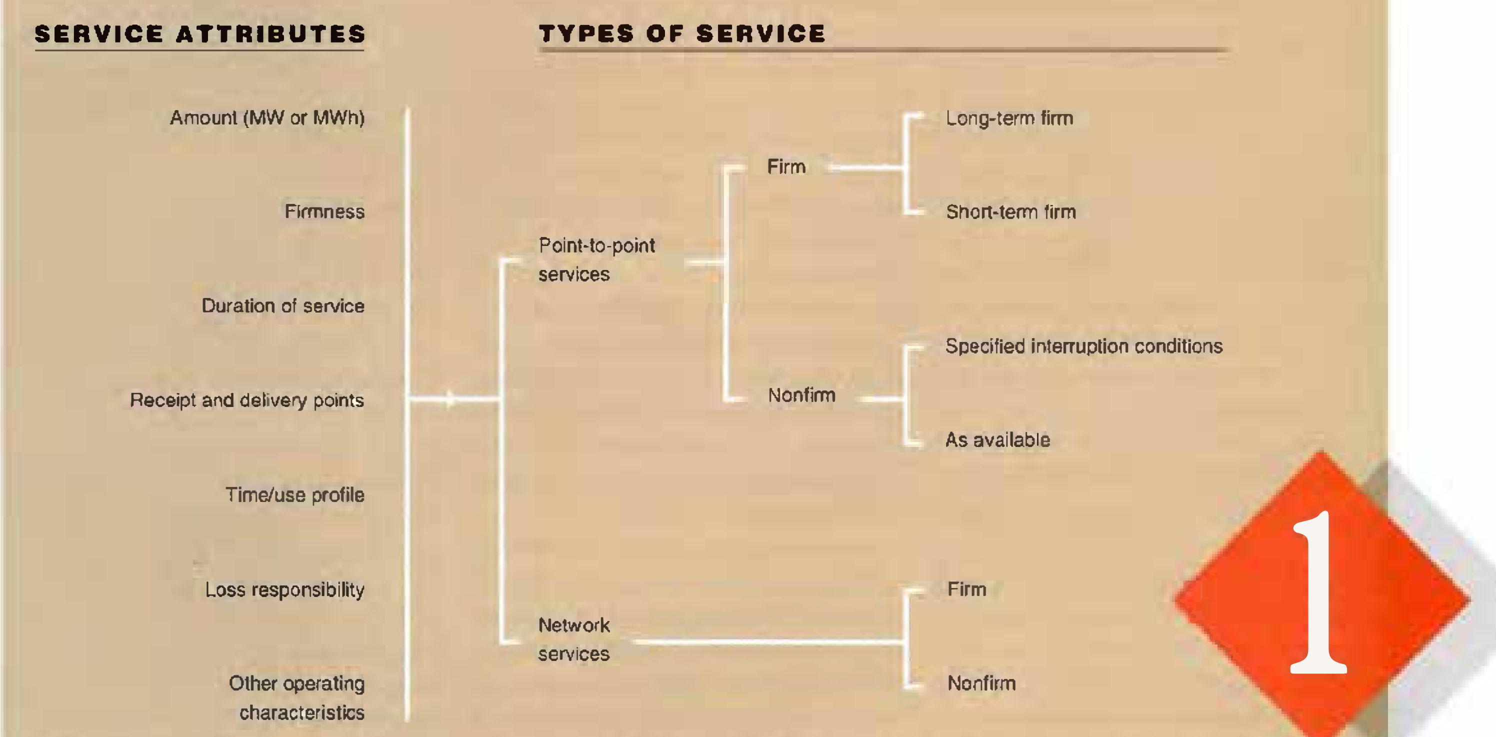
□ Controlling power flow and frequency is required for all transmission activities, and providing a requested service may cause significant changes in a utility's commitment of generation units. For this reason, substantial exchange of information is needed among the parties involved in a transaction, potentially including utilities in different control areas.

□ Supplying adequate reactive power is required to keep bus voltages within acceptable limits. The service attributes that particularly affect the need for reactive power are the amount of energy to be transferred and the location of receipt and delivery points.

□ Maintaining system security and availability involves the need to keep adequate generation and transmission reserves ready and to coordinate activities between control areas. In real-time operation, considerable monitoring of line status, voltages, and power flows may be required at key interconnections.

□ Monitoring of service delivery is essential to verify that a service has been provided as requested. In some instances, new monitoring and metering equipment may be needed to ensure accurate measurement at the delivery point.

By showing how each of these SCs is supported by the various functional areas of utility operation—that is, generation, transmission, distribution, system opera-



DEFINING SERVICE: Different values of seven basic attributes can be used to define types of transmission service. Although the six service categories shown here are the most common now, open access is expected to give rise to several new types of service.

tions, and administration—the framework identifies more than two dozen categories of activities or responsibilities whose associated costs may need to be considered. The SC for controlling power flow and frequency, for example, may require adding facilities to the transmission network, modifying generation dispatch, changing transaction schedules at control centers, or conducting new administrative studies of the power system.

This breakdown of SCs gives utilities a more-detailed way of unbundling services and costs than is provided by the six broad categories of ancillary services suggested by FERC. Also, many of the identified activities could potentially be provided separately, as part of a new service market. Following power system deregulation in England, for example, a separate market for VAR support has arisen, with new generators being built by independent power producers specifically for that purpose.

Cost calculation

Once all potential cost components have been identified, the actual calculation of costs—the third step in applying the framework—depends on two critical decisions: defining the relevant economic cost concept for a particular application and choosing a calculation method appropriate for use with that concept. The cost concept is defined by four key economic aspects, which vary according to the kind of transaction involved. These aspects are type of cost, whether the cost is being calculated before or after it is incurred, the duration of time involved, and whether there is time-period differentiation.

The choice of type of cost depends on a utility's immediate objectives. Knowing total costs, for example, can help determine the total amount of revenue to be collected. Average costs provide a simple, easily verifiable basis for developing tariffs to submit for FERC approval. However, to achieve economic efficiency, marginal and incremental costs are likely to be more useful.

Either historical or projected cost data can be used, but there is an important trade-off involved. Historical costs are more accurate, but they may not adequately reflect future conditions. Projected costs are inherently less accurate, but they may help provide a better price signal to customers.

Choosing the duration of service has important implications for both the service provider and the customer. Prices based on cost calculations for a single year, for example, tend to be more accurate than those based on projections for several years. From the provider's point of view, this means that meeting cost management objectives for less than a year will probably involve a focus on operating details, while lowering costs for a longer duration will more deeply involve planning functions. From the customer's perspective, a year's commitment at a fixed price simplifies the decision process, while a long-term contract with year-to-year resetting of price may ultimately be less expensive but entails higher risk.

Time-period differentiation allows a utility to take into account seasonal or even daily changes in the cost of producing and delivering electricity. Such differentiation can help match cost and price more efficiently, but the difficulty of calculation rises sharply with progressively shorter time periods.

Once the relevant cost concept has been defined, an appropriate cost calculation method must be chosen. The framework describes 12 generic classes of methods for analyzing transmission costs—3 traditional methods and 9 emerging methods. Generally speaking, the traditional calculation methods are well established in the electric power industry and have a significant history of applications. The emerging methods have largely been developed over the last decade and focus on new ways to allocate costs or measure marginal costs for unbundled services.

The most common traditional method—cost accounting and related analysis—starts with accounting records of costs for all relevant items. These costs are then allocated throughout a utility organization in proportion to their relationship to various operational functions. For example, part of the cost of a new capacitor bank at a substation might be allocated to the transmission system and part to the distribution system, since it helps provide voltage support for both. Unfortunately, determining the proportion of costs that should be allocated to each supported service is often difficult. Furthermore, although relying on historical accounting costs may be useful for providing insights into the relationship between a service already provided and the cost incurred, this method gives little information on how alternative arrangements could enhance economic activity.

To address such questions, particularly as they involve investments in system expansion, some utilities have proposed using one of the emerging calculation methods that involve economic optimization modeling based on marginal costs. A long-range marginal-cost method, for example, would use a model that explicitly considers trade-offs between expansion of the transmission network and dispatch of more-expensive generators closer to a load in order to avoid bottlenecks in the present transmission network. A short-range marginal-cost method, on the other hand, would use full ac network modeling combined with an economic dispatch model for generation to optimize current operations and send appropriate price signals to customers.

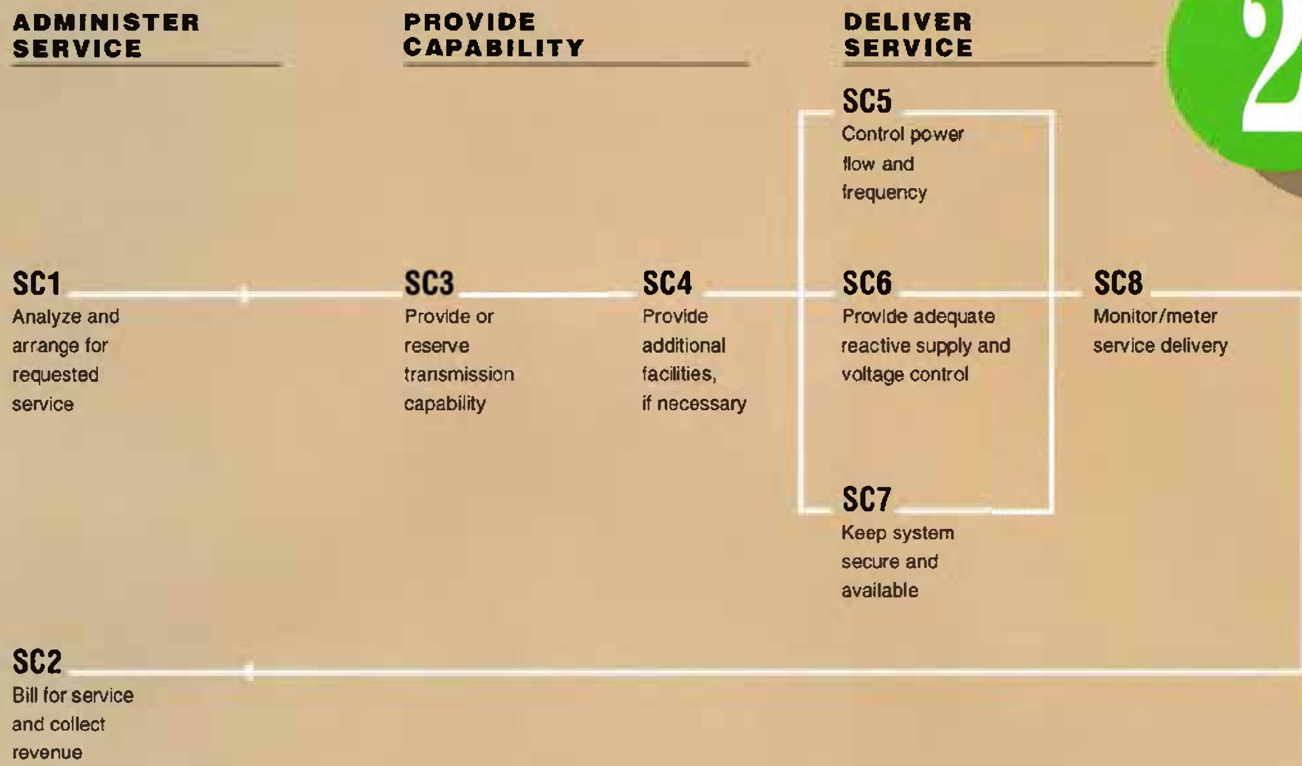
The detailed modeling required in marginal-cost methods is far more complex and expensive to perform than cost accounting and related traditional methods. Most of the other methods lie between these extremes, and the framework assesses each according to its usefulness in achieving cost management and pricing objectives and its ability to address difficult issues, such as economies of scale and "lumpiness" of costs associated with transmission system expansion.

"The Transmission Services Costing Framework has laid out an excellent basis for conducting the debate over technical and economic issues related to open access for years to come," concludes Vojdani. "Volume 1 of the framework report gives the technical and economic fundamentals of transmission costing, and Volume 2 presents a description of the framework, together with sample applications."

Competitive future

Opening access to transmission networks is only the latest—and surely not the last—

SERVICE COMPONENTS **Once a transmission service has been defined, it can be broken down into eight components that will be used to identify specific costs. These service components broadly describe the activities needed to administer a service, provide adequate facilities, and ensure delivery.**



ACTIONS AND COSTS FOR SERVICE COMPONENTS **Each transmission service component requires that certain activities be carried out by various functional areas of a utility, with corresponding costs. For example, some generation resources may be required to provide dynamic reactive power in support of a wholesale transaction. Committing such resources involves both capital costs and O&M costs.**

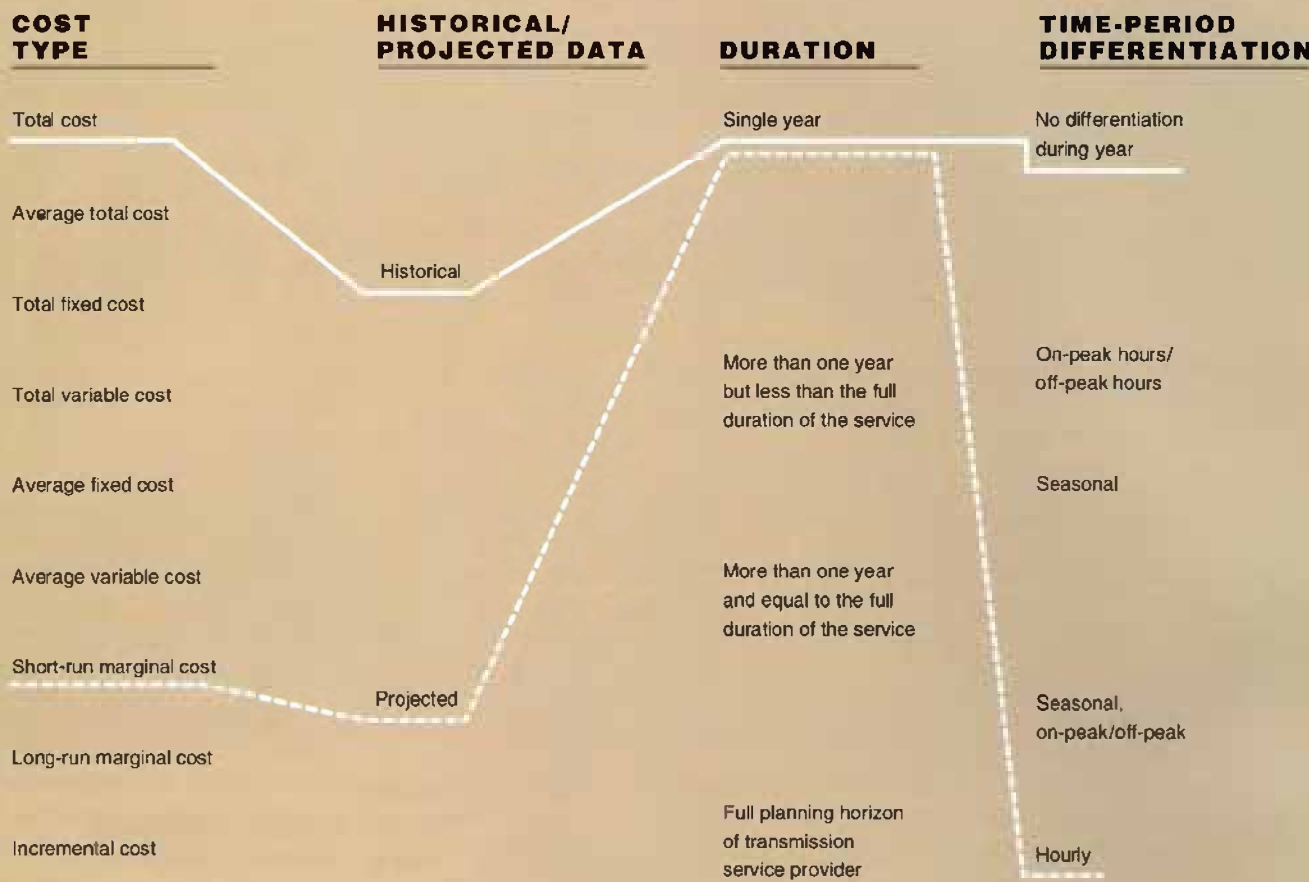
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8
Transmission system								
Generation system								
Distribution system								
System control								
Administration								

Actions:
Provide dynamic reactive power from generation facilities for loads and reactive losses

Capital Costs:
- **Generators**
- **Exciters**
- **Balance of generation plant**

Operation and Maintenance Costs:
- **Labor and materials for equipment O&M**
- **Fuel used to produce reactive power**

DEFINING A COST CONCEPT **The relevant cost concept for a particular transmission service depends on four economic parameters, chosen according to a utility's immediate objective. For example, in cost management applications (solid line), it might be appropriate to use historical data to calculate, for a single year, total costs with no time-period differentiation. On the other hand, for spot pricing (broken line), a utility might choose to use projected data to calculate, for a single year, short-run marginal costs with real-time price differentiation.**



COST CALCULATION METHODS **Once the cost concept has been defined, an appropriate cost calculation method must be chosen. The framework describes 12 generic classes of calculation methods—3 well-established, traditional methods and 9 emerging methods that may help allocate costs for unbundled transmission services.**

TRADITIONAL METHODS

- Cost accounting and analysis
- Simple incremental and average cost
- Contract path

EMERGING METHODS

- Megawatt-mile
- Rated system path
- Transmission cost actual path
- Impacted megawatt-mile
- General agreement on parallel paths
- Allocated contract path
- Investment cost related
- Nodal long-run marginal cost with expansion
- Nodal short-run marginal cost

3

stage of increasing competition in the American electric power industry. As utilities adapt to changing regulations at both the federal and state levels, new business structures are being developed to provide competitive advantage. The use of advanced communications and power control technologies is also being explored in an effort to increase both the operational and economic efficiency of power delivery systems for the future.

Although FERC did not order corporate restructuring explicitly, the commission has repeatedly emphasized its desire for an industry structure in which utilities cannot exercise monopoly power. One way to speed the development of competitive wholesale markets, FERC believes, is through regional transmission groups (RTGs), which would coordinate bulk power transactions. In FERC's view, RTGs would also increase transmission system operating efficiency, provide a framework for coordinating regional transmission planning, and reduce administrative burdens for both the commission and the utilities involved. To encourage the formation of RTGs, the commission exempted them from the tariff provisions of the recent NOPR and has announced its intention to allow them substantial latitude for innovative pricing.

Some RTGs are already being set up. The Mid-Continent Area Power Pool (MAPP), for example, recently formed an RTG for its members to make voluntary sales or exchanges of electricity at market-based prices. Subject to approval by FERC and by MAPP's 29 voting members, the RTG will establish rates and terms for coordinated transmission service and will also integrate transmission planning for facilities of 115 kV or higher. Eventually, MAPP intends to broaden access to the RTG to include other entities that wish to participate.

Further restructuring is likely if state regulatory bodies move to allow retail wheeling—access to a utility's distribution system by a competitor wishing to sell power directly to end users. The Energy Policy Act of 1992 specifically excludes FERC from mandating such retail wheeling, but several states have moved toward permitting some form of direct access at the distribution level. The California Public Utilities Commission, for example, has proposed establishing a statewide power pool by 1997 that would buy electricity from generators and sell it at a spot market price to all pool customers. In Illinois, the legislature is considering allowing customers to choose their electricity supplier beginning in the year 2000. Recognizing that about 90% of utility assets are regulated at the state level, one FERC commissioner commented that the recent NOPR is only the commission's "10% solution" to industry restructuring.

Utilities are currently divided over what type of restructuring might best meet their future needs, given increased competition at the wholesale and retail levels. Some might sell their transmission assets to a separate transmission company (TRANSCO), while others have suggested setting up an independent grid operation (IGO) company that would control network operations. The main difference between these two scenarios is that a TRANSCO would own the transmission facilities it operates, while an IGO company would effectively lease the grid. In addition, some of today's vertically integrated utilities may further unbundle operations by spinning off generation companies (GENCOs) and distribution companies (DISCOs).

Although changes in the regulatory climate have led to the current focus on increased competition and the unbundling of services, technology has also played an important role from the beginning. As early as the 1960s, the development of efficient gas turbines for power generation fundamentally challenged the economies of scale in large central facilities and enhanced the potential role of independent power producers. More recently, the rapid development of information technologies has made possible the level of coordination needed to handle more-complex transactions on the transmission network and to offer more-sophisticated distribution services—such as real-time pricing—to end-use customers.

In the future, the importance of technology as a driving force for change in the industry is likely to grow even more. As an immediate example, FERC's notice that utilities will have to establish RINs accessible to all transmission system users has led to concern about what communications standards will be used. EPRI has already developed the Inter-Control Center Communications Protocol (ICCP) for real-time data exchange between control centers, power pools, and utility business centers. Designed largely to facilitate communication between control center equipment from different vendors, ICCP could also provide the foundation for establishing the RINs required by FERC. For RIN applications that do not need the full functionality of ICCP, however, EPRI is working with NERC and others to develop a simplified communications protocol, which would be based on the same internationally recognized standard (the so-called Manufacturing Messaging System, or MMS).

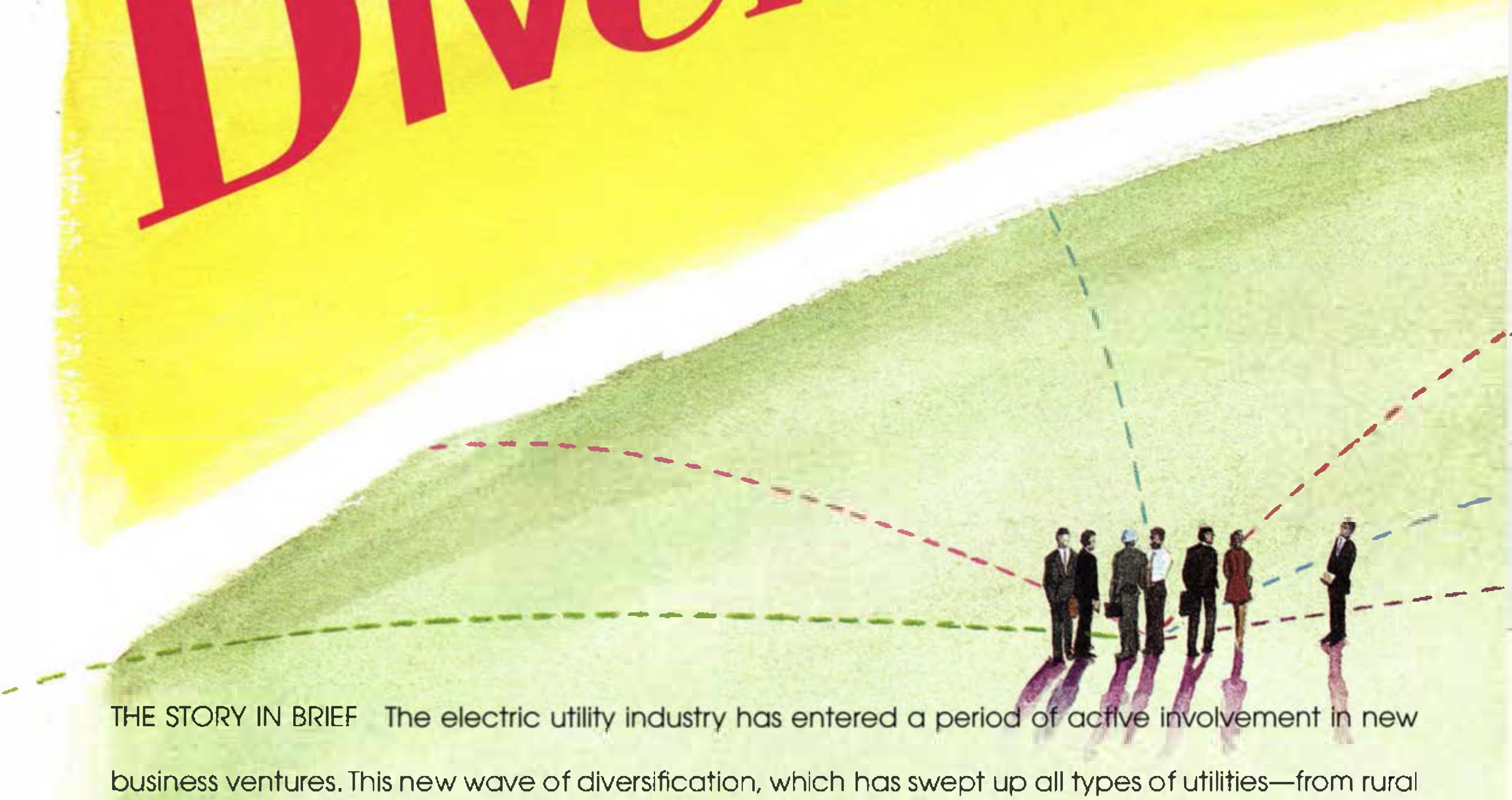
Other sorts of technology that are likely to find wider use as a result of increased competition in power delivery include the hardware and software needed to control network operations. EPRI's FACTS (flexible ac transmission system) technology, for example, offers power electronic controllers that can help overcome bottlenecks on current transmission grids and increase the capacity of specific lines, as needed. On-line computer programs that perform system stability and security assessment for power systems, using real-time data, are also being developed.

"As we have seen from the experience of other industries, deregulation coupled with technological innovation will dramatically expand markets and the opportunities for competition," says Karl Stahlkopf, EPRI's vice president for power delivery. "The key to a smooth transition to an open transmission system is achieving agreement on tariffs that can be charged for wholesale wheeling. EPRI's framework represents a major achievement in this area by providing the intellectual foundation for calculating costs that can be used to develop appropriate tariffs while helping utilities reduce their transmission expenses." ■

Background information for this article was provided by Ali Vojdani of the Power Delivery Group's Substations, System Operations & Storage Business Unit.

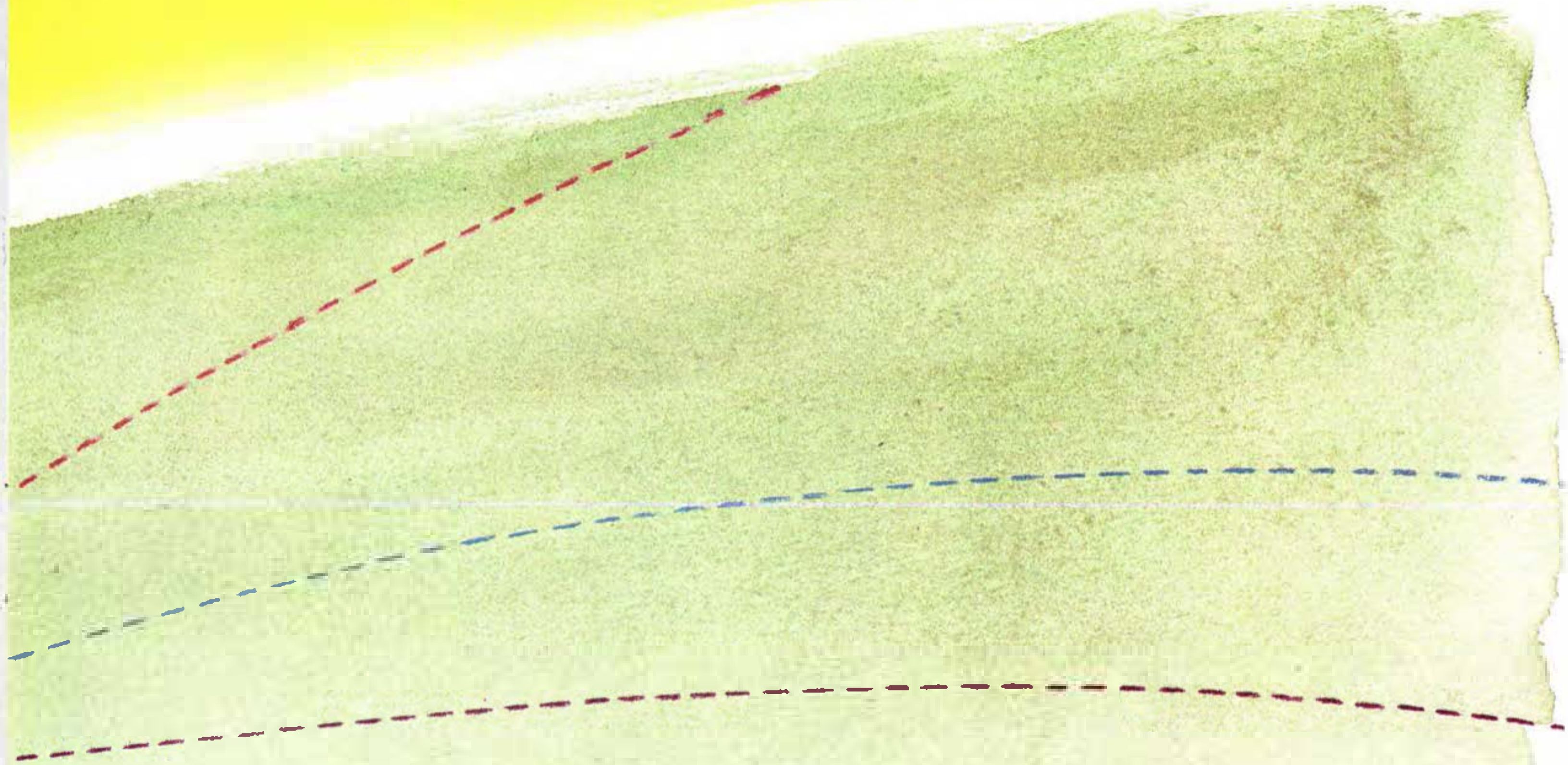
by Leslie Lamarre

Diversifica



THE STORY IN BRIEF The electric utility industry has entered a period of active involvement in new business ventures. This new wave of diversification, which has swept up all types of utilities—from rural electric cooperatives to investor-owned utilities—generally involves activities that are closely related to the core utility business of generating and delivering electricity. Increasing competition, the limited growth of traditional utility business areas, stable cash flow, and the globalization of the electric power business are just some of the factors encouraging utilities to diversify. Industry analysts advise utilities against straying too far from their traditional areas of business. A recent EPRI study concurs, offering additional insight and advice based on the experiences of electric utilities involved in a variety of new businesses.

tion IN THE '90s



When Murphy Warehouse Company upgraded the electrical system for its 1-million-square-foot storage complex in Minneapolis last December, Richard Murphy Jr., president of the company, saw a perfect opportunity to get rid of three 40-year-old transformers that supplied power to 60% of the space. "The switchgear for this system belonged in a Frankenstein movie," recalls Murphy, adding that the 10-foot-tall, 3-ton steel transformers were bulky by modern standards.

The major problem was not so much the appearance or size of the transformers but that they contained polychlorinated biphenyl, a toxic substance now heavily regulated by the Environmental Protection Agency. Because of the PCB, Murphy Warehouse Company wanted someone it could trust to dispose of the transformers. Officials for the company chose its electric utility, Northern States Power. "We had the option of going with private hazardous waste firms, but we just felt very comfortable that NSP was going to do it correctly," says Murphy.

Murphy Warehouse Company isn't the only customer calling on its electric utility to carry out nontraditional tasks. Heightened competition, the limited growth potential of traditional utility business areas, stable cash flow, and other factors are driving electric utilities to venture into a tantalizing array of new business opportunities. As a result, customers across the country are relying on their electric utilities for an increasing variety of services, ranging from cable television to financing packages.

"It certainly makes sense," says EPRI's Ingrid Bran, a manager for R&D planning and analysis who oversaw a recent study of diversification. "These diversified services provide new revenue sources and help retain existing load. And in addition to these obvious advantages, many diversification activities offer utilities the opportunity to get closer to their customers and enhance their relationships at a critical time." She notes that the customer base for diversified services may include other utilities and their customers, state and federal agencies, and international groups.

Unlike the diversification efforts of the 1980s, in which a number of utilities strayed far afield from their core business of generating and delivering electricity, this new wave of electric utility diversification is generally more closely related to the core business. "There were a lot of disasters during the diversification movement of the 1980s, and utilities learned their lesson," says Dan Rudakas, an electric utility analyst with Capmarc Securities. "Like so many other businesses that have gotten into new areas over the years, utilities have learned it's wise to stay close to home." Rudakas notes that utilities often played a passive role in the less successful ventures, simply investing money in a new business and taking little if any part in its direct management.

Several recent studies concur with Rudakas's assertion. EPRI's study, the results of which were released in a July 1994 report, *New Service Opportunities for Electric Utilities* (TR-104345), states that utility diversification has tended to be most successful in areas closely related to the core business. Similarly, a report published last year by the Edison Electric Institute (EEI), *Nonutility Business Activities of Investor-Owned Electric Utilities*, notes that a common characteristic of successful nonutility business strategies is that they involve a "series of smaller core-related businesses."

Precisely which activities are considered close to the core business may vary, depending on whom you ask. For instance, some utilities view telecommunications and other opportunities opened up through the information superhighway as a natural extension of their core business, especially if the core business already includes things like load control—a service that utilizes communications technologies that are part of the superhighway infrastructure. Other utilities, however, may perceive telecommunications as a separate business entirely.

EPRI's study identifies four general categories of core-related diversification for utilities: financial services, information services, communications services, and products. "Of course, these aren't the only areas where we found activity by utilities. But they tended to be the most illustrative in terms of potential returns and lessons learned," says Bran. She notes that some diversification activities do not fit neatly into one category. Often, she says, activities cut across two or more of the groups.

Changing times

As is the case in other industries, the motivation for electric utility diversification has changed over time. Some 20 years ago, diversification among utilities grew largely out of a desire for more control over the cost and availability of power plant fuel. Areas of investment included coal mining and oil and gas exploration and development. A more aggressive period emerged in the 1980s, characterized by a robust industry with lots of money available for investment. During this period, acquisitions outside the core business, including areas

FOUR AREAS OF DIVERSIFICATION A recent EPRI study identifies four categories of diversification that are closely related to the traditional utility business of generating and delivering electricity. Listed below are some examples of the kinds of services in each of the four categories.

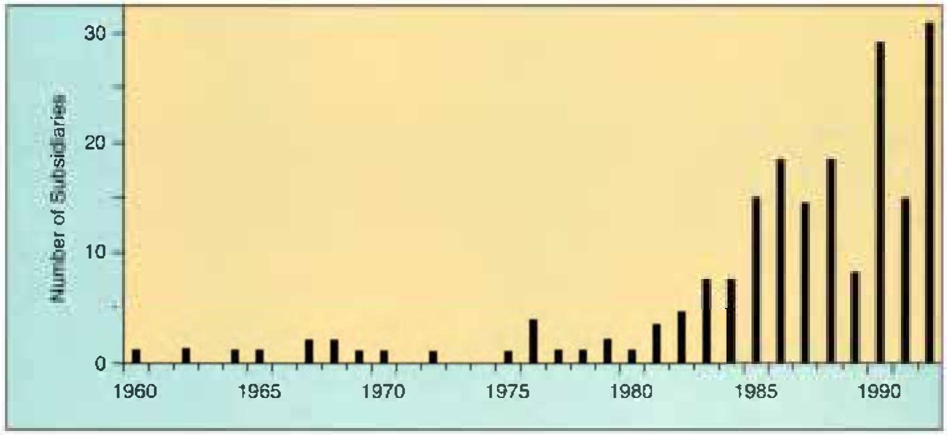
FINANCIAL SERVICES Equipment financing Equipment leasing Equipment service contracts Equipment warranties Rebates			**INFORMATION SERVICES** Demand-side management Energy audits Power quality consulting Engineering design Environmental consulting Waste management
COMMUNICATIONS SERVICES Cable television Telecommunications Home automation Time-of-use rates Direct load control Energy management services Data services			**PRODUCTS** Appliance sales Equipment brokering and testing Equipment O&M services Design of computer software R&D on end-use technologies

like insurance and real estate, were not unusual. Some highly visible failures in this era led to a retrenching phase in the late 1980s, during which utilities generally moved away from diversification.

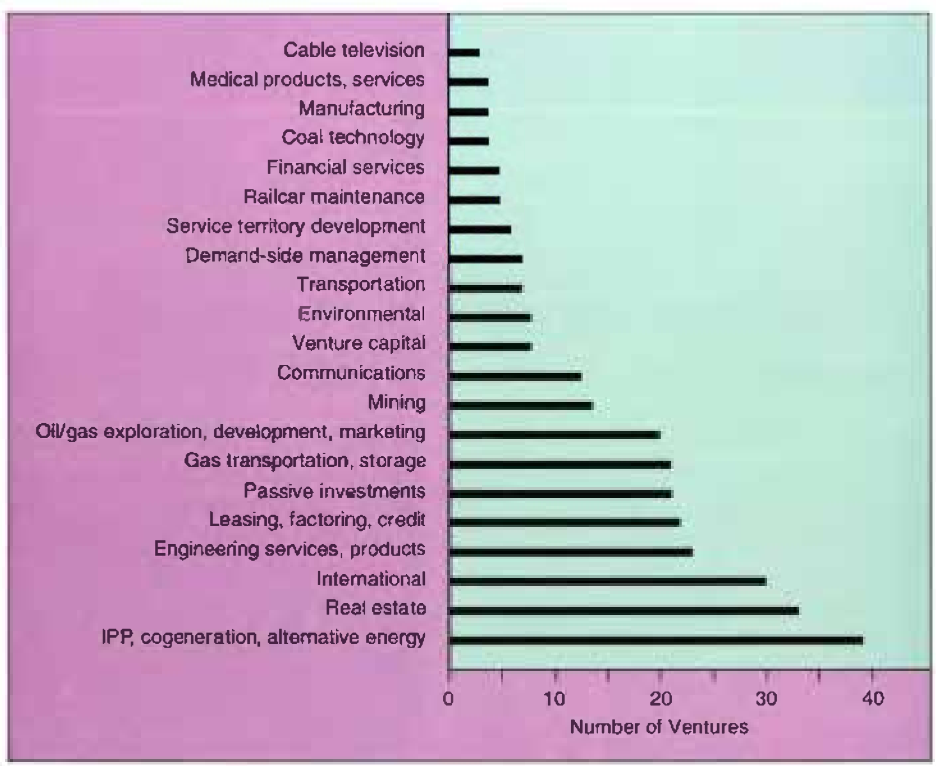
Today a large number of utilities are cautiously but steadily wading back into the diversification waters. According to EEI, the number of diversification ventures of investor-owned utilities—specifically ventures involving subsidiaries—hit a record high in 1992, the last full year for which figures are available. Among the 99 utilities studied by EEI, there were 32 new subsidiaries in 1992, compared with only 5 a decade earlier. This current phase of active diversification has a number of motivators behind it. It appears that the overriding factor is increased competition, which is forcing utilities to search for new areas of growth outside their traditional business. The globalization of the electric utility industry is also playing a role, opening up opportunities for international ventures that utilities are finding hard to resist. In fact, EEI's study found that international ventures are the third most popular of 21 diversification activities today.

Moreover, industry analysts say, many utilities are experiencing a significant positive cash flow. This might sound odd, given the widely publicized industry downsizing under way. But as David Pickles of Synergic Resources Corporation explains, the downsizing is being undertaken largely to gear up for increased competition, which has only just begun to materialize. Pickles and Alan F. Destribats were the principal investigators for EPRI's diversification study. "A lot of power plants that were built 30 years ago or more are now paid for," says Pickles. "For the many utilities with slow sales growth and excess capacity, there's no reason to invest in new generation." In the case of investor-owned utilities, which are the focus of both the EPRI and EEI reports, this predicament offers a great incentive for utilities to invest in other areas that may earn a decent return for stockholders.

Changing customer needs are also encouraging utilities to diversify. Industrial and commercial customers in a wide range of businesses are facing, both domestically and internationally, competition more fierce than ever before. As a result, they are paying more attention to the bottom line—specifically, in some cases, to the cost of electricity. At the same time, the equipment and technologies these customers rely on are becoming more sophisticated. Since electronic equipment like adjustable-speed drives is often sensitive to power disturbances that can be generated on- or off-site, customers are considering more carefully the quality as well as the cost of their electricity service. The declining influence of trade unions has simultaneously created an environment of more-flexible working

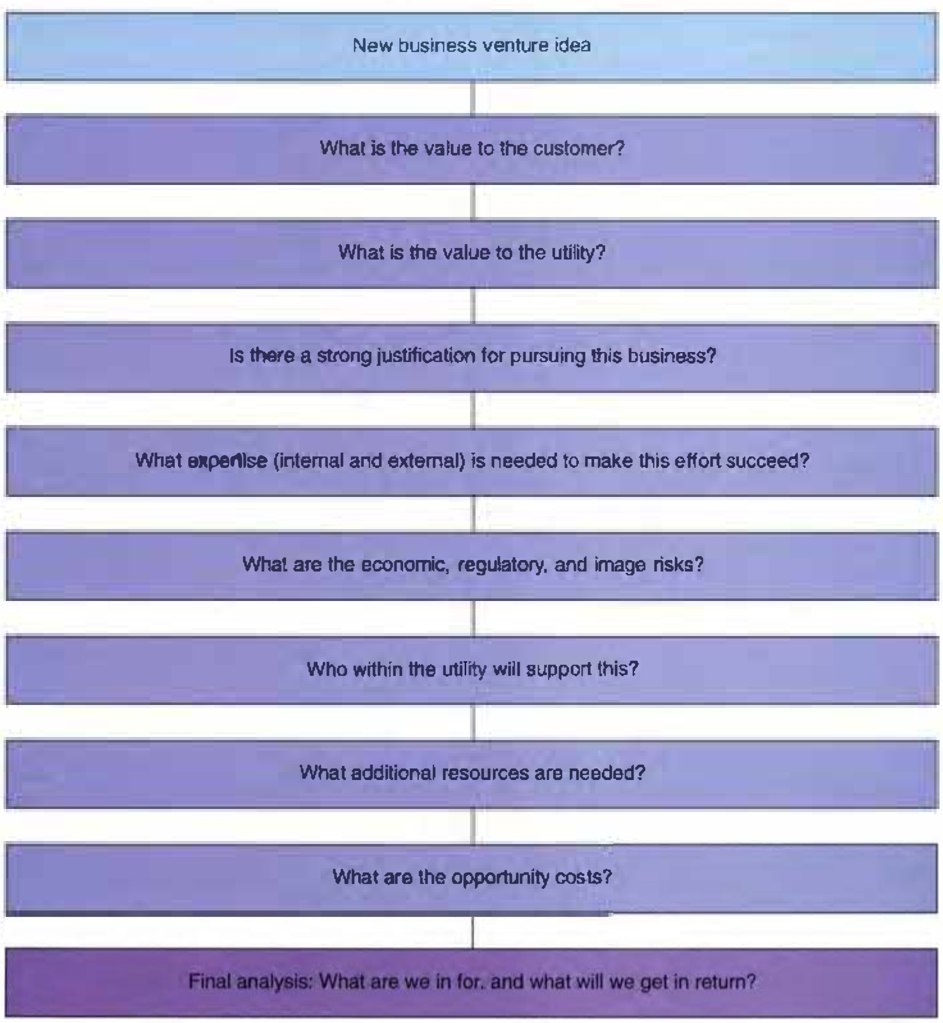


DIVERSIFICATION ON THE RISE A recent Edison Electric Institute study of 99 investor-owned electric utilities indicates that diversification is on the rise. As the graph above shows, diversification activities, measured by the number of new electric utility subsidiaries (either established or acquired), reached a record high in 1992, the last full year for which figures are available. The graph below indicates the types of diversification activities most common among the utilities surveyed. (Graphs courtesy of the Edison Electric Institute)



hours and plant schedules. The result is that many companies can now take advantage of innovative rate practices, such as time-of-use rates, that could help lower their electric bills.

EPRI's study explains that while large customers have in the past considered handling some of their generation needs themselves, companies now appear to be more interested in devoting whatever available cash they have to their own core businesses. In other words, rather than spending money on a cogeneration plant and dealing with its operation and maintenance, a manufacturer might prefer to invest that money into upgrading its production line. "Customers have learned that the energy business is a time- and expertise-intensive business," the report states. "Increasingly, utilities are maintaining (and even owning or leasing) customer equipment." Such equipment may include cogeneration plants as well as distribution networks and standby power generators. In addition, customers are finding that it's too expensive to maintain in-house expertise in certain areas. Given the complexity of the electric power business, utilities have had to cultivate staff experts in topics ranging from environmental regulations to power quality; now they are beginning to fulfill customer needs for such expertise on a consulting basis.



EPRI'S DIVERSIFICATION FRAMEWORK A recent EPRI study of diversification among electric utilities shows that successful ventures typically result from a logical planning framework that identifies opportunities, carefully evaluates them, and develops a management plan to implement and monitor the business activities. On the basis of information obtained from successful utility diversification ventures, EPRI has developed the framework shown here as a guide for other utilities.

Four areas of diversification

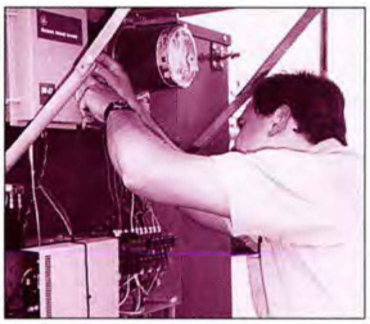
EPRI's study showed that financial services represent one of the most profitable and aggressively pursued areas of utility diversification. EPRI's definition of financial services is broad, incorporating such activities as owning customer equipment, leasing equipment to customers, providing equipment warranties, and offering rebates and other financial incentives (e.g., loans with or without subsidized interest rates) that encourage equipment acquisition.

In offering such services, some utilities have opted to establish their own energy service companies (ESCOs)—firms that typically provide energy savings by installing, operating, and/or maintaining energy-efficient technologies for customers. Other utilities have chosen to partner with an established energy service company or have brokered loans to a third-party lending institution.

ESCOs and other utility-based sources for financing energy-related equipment have proliferated over the past five years, as have financing sources outside the industry. These outside sources include special energy-financing loan services, which have become part of traditional banking practices at companies like Citicorp, and residential energy efficiency financing packages, which are expected to be offered through the Federal National Mortgage Association. Although a large customer may be able to attract capital at rates equivalent or superior to those offered by a utility financing service, the utility service can still be more attractive, especially if its package includes administrative services and expertise in the form of feasibility studies, performance guarantees, and project management.

A second category of utility diversification, communications services, is perhaps best known for projects related to the information superhighway—projects that have

Northern States Power runs a hazardous waste business, which handled the disposal of the three 40-year-old transformers shown on the trailer.



Glasgow Electric Plant Board in Kentucky is a pioneer on the information superhighway. Among other services, it offers a geographic information system center (top) and remote meter reading (the photo on the bottom shows a technician completing one such installation).

Wahlco Environmental Systems, a subsidiary of San Diego Gas & Electric, offers pollution control services and devices, such as these flue gas conditioning systems.

One subsidiary operated by Otter Tail Power provides medical imaging services through a mobile unit serving hospitals that cannot afford to purchase imaging equipment; another subsidiary supplies agricultural equipment, such as this beet piler, which stacks sugar beets for storage after harvesting.

gotten a lot of publicity in recent years. These ventures often involve the provision of detailed and timely energy-related information to customers. Some utilities are even opening up communications links between their customers and third parties for such services as banking, shopping, entertainment, and education.

In many cases, the establishment of an infrastructure—for example, fiber-optic or coaxial cable networks—can fulfill multiple needs, benefiting both the utility and the customer. For instance, facilities installed for automatic meter reading may also be used to provide real-time pricing, distribution system automation, and possibly even home automation. Utilities may also opt to lease space on their communications networks to other companies.

A number of utilities have reaped extra benefits from systems established for their own purposes. For instance, Alabama Power Company installed a telephone-based alarm-monitoring system as part of a security system for its facilities. The utility currently monitors about 55 of its own locations. As an experiment, Alabama Power conducted a pilot program through which it extended the monitoring service to its employees. The program's success has encouraged the utility to request regulatory approval to offer the service to the general public.

Utilities involved in a third category of diversification, information services, have found that another in-house resource, staff expertise, can be funneled into a variety of valuable customer services. Only very large businesses like utilities can afford to keep abreast of such issues as emerging electrotechnologies, environmental compliance, and regulation. And since energy-related projects are generally not a priority for today's cash-pressed utility customers, many welcome utility consultation on these topics.

Take the example of Duquesne Light Company. Like other utilities, Duquesne Light keeps up with current industry regulations as part of its everyday business. While investigating the potential impacts of upcoming regulations resulting from the 1990 Clean Air Act Amendments, the utility learned that 300 dry cleaners in its ser-

This chiller plant in downtown Indianapolis is part of a district cooling system run by Mid-America Energy Resources, a subsidiary of IPALCO Enterprises, the holding company of Indianapolis Power & Light.

Minnesota Power's holding company has subsidiaries involved in such activities as waste-water treatment and coal mining.

vice territory would be affected by new regulations governing exposure to a dry-cleaning solvent. Before going to these customers with the news, the utility researched the availability of technologies that would enable compliance with the regulations. It also discovered that at the time the state of Pennsylvania offered grants to partially offset the cost of such equipment. Having informed the dry cleaners of this news, the utility installed more than 20 new combination washer-dryer machines that recycle the regulated solvent. New electricity sales resulted.

The fourth category of diversification covered in EPRI's study, products, can be among the most challenging of all diversification activities. This category includes a wide variety of product-related activities, including the direct retail sale of appliances, R&D work on electrotechnologies, the operation and maintenance of customers'—including other utilities'—facilities and equipment, the provision of standby generators and related equipment, the sale of transmission and distribution equipment, and the sale and/or leasing of power quality equipment.

One of the factors making product-related endeavors difficult is that—unlike some other areas of diversification, in which the utility's expertise and access to information give it a clear advantage over potential competition—products are often available from multiple suppliers who may be equally attractive to the customer. For this reason, the success of a utility product will be based not so much on its intrinsic value but on whatever competitive edge the utility has, be it an existing relationship with a customer, unique facilities or expertise, or an existing low-cost infrastructure.

One area of significant competitive advantage that CINergy Corp. (the parent company of PSI Energy) has exploited successfully is the sale of utility equipment. The business got started about 10 years ago when PSI was forced to cancel a nuclear plant. The utility formed a company called Power Equipment Supply Company (PESCO) to market the significant stockpile of unused equipment that had been acquired for the canceled project. As this mission progressed, PESCO decided to stay in business to serve the many other utilities that have excess inventories to sell. Today PESCO continues to purchase (or consign), warehouse, maintain, and resell unused power supply equipment. PESCO has also acquired a related company, North American Machinery, which is involved in the refurbishment of utility switchgear.

Regulation

Clearly, there are many potential areas of diversification a utility can get into. But precisely what types of businesses it winds up pursuing may depend as much on regulation as on the utility's own interests. Different types of utilities face different regulatory restrictions. For instance, investor-owned utility holding companies are regulated by the Securities and Exchange Commission, which must approve any diversification the companies intend to pursue. Typically, the SEC rejects a proposed area of diversification when the utility cannot show that the new business venture has a "functional relationship" to the company's core business. Holding companies eager to pursue diversification more aggressively have become frustrated with SEC oversight and are among the groups pushing for reform of the Public Utility Holding Company Act.

But holding companies aren't the only utilities being restrained. Investor-owned utilities that aren't holding companies may also have to gain approval—from their public utility commissions or equivalent state regulatory bodies. As David Pickles of Synergic Resources Corporation explains, any diversified activities funded with ratepayer money must be reviewed and approved by such regulatory bodies. However, activities funded by shareholder money are not regulated and can often yield higher rates of return. Typically, such activities are carried out through an affiliate or subsidiary of the utility.

Just what kind of activities commissioners deem appropriate for utilities to pursue can vary drastically from state to state. In the state of Virginia, for instance, Virginia Power sought to lease excess communications capacity on its fiber-optic network to a nearby financial institution. Chesapeake and Potomac Telephone Company challenged the arrangement before the Virginia State Corporation Commission, which ruled that the proposed new service was beyond the scope of the utility's authority. Utilities in other states, meanwhile, have received regulatory approval for similar services. Beginning in the late 1980s, for instance, the Iowa Utilities Board allowed a subsidiary of Midwest Resources called MWR Telecom to install fiber-optic cable along utility rights-of-way and to lease capacity from this system, essentially allowing MWR Telecom to compete against local telecommunications services. (On May 1 of this year, MWR Telecom was sold to a local telecommunications firm.)

Municipal and rural electric cooperative utilities can face restrictions similar to those faced by investor-owned utilities. Municipals and co-ops are generally regulated by their own local governing boards, and some are subject to state regulation as well. Co-ops are also limited by federal legislation, which specifies the level of diversification they are allowed to pursue. The legislation currently specifies that a co-op can invest an amount equal to 15% of its total capital investment—a total investment averaging about $1 million per co-op—in diversification activities. (Up until the Reconciliation Act of 1987, the limit was 3%.) However, a new rule issued by the Office of Rural Economic and Community Development would allow co-ops in good financial standing to invest in diversification at any level they desire. Also under the proposed rule, all co-ops, regardless of their financial standing, would be unlimited in their investment in certain projects—namely those involving water, wastewater, propane, and telecommunications. A three-month comment period for the new rule is under way, during which the National Rural Electric Cooperative Association, co-ops, municipals, and other utilities are allowed to comment. According to Dan Kamerman, NRECA's manager of economic development, no serious objections are expected.

The local regulation of rural electric cooperatives can be fairly strict. Typically, diversification activities must come before a board of directors for review. "The boards of directors of co-ops take their fiduciary responsibility extremely seriously," says Kamerman. "They like to make certain a co-op is diversifying into a business that is likely to succeed." Neither cooperatives nor municipal utilities are allowed to profit directly from their diversification activities. Generally, co-ops establish profit-making subsidiary corporations to handle diversified ventures while municipals do not. Any profits that municipal utilities accrue through diversification can be used to cover the utility's debt, to subsidize the cost of electricity service, or even to support other municipal budgets. Like cooperative utilities, municipals have gotten heavily involved in telecommunications—most commonly fiber optics and coaxial cable. Many own and operate their own cable television stations.

Federal utilities are a different story entirely. In the words of one U.S. Department of Energy official, "Most utilities can do anything they want unless specifically barred by law. Federal utilities can only do things that are specifically authorized in the law." The most restricted of the federal utilities are the Western Area Power Administration, the Southeastern Power Administration, the Southwestern Power Administration, and the Alaska Power Administration, which are authorized by federal statute to operate only as wholesale power suppliers. The statutes that established the remaining federal utilities, the Bonneville Power Administration (BPA) and the Tennessee Valley Authority, are less restrictive, offering these utilities a number of opportunities to pursue diversification. Like the municipal and cooperative utilities, federal utilities are not allowed to profit from diversification. However, any money brought in may subsidize the cost of providing electricity service.

CINergy Corp.—the parent company of PSI Energy—has a number of nonutility subsidiaries, including PSI Recycling, which recycles paper and other materials from a variety of sources, and Power Equipment Supply Company, which sells unused power equipment acquired from other utilities.

Motivating factors

Although providing stockholders a decent return on their investment may be a significant motivating factor nudging investor-owned utilities toward diversification, this incentive does not exist for municipal, cooperative, and federal utilities. Nevertheless, other factors can be just as persuasive. For instance, any services that contribute to the economic growth of a region will in turn benefit the utility serving that region through increased electricity sales.

Many co-ops and municipals are motivated to pursue new ventures in order to fill voids in the market. "There are communities with no cable television service; the region's cable company has turned them down, reasoning that such a small market isn't worth the expense of running the new lines, especially if the area is remote," says Kamerman of NRECA. "Knowing this, a local co-op might decide to get into the business of selling satellite dishes." Co-ops have even gotten involved in providing telephone and water service. "If they don't pick up on such opportunities, the void will simply weaken the community, which will have a profound impact on the rural electric system," says Kamerman. On the other hand, providing such services certainly makes a community more attractive and could even help draw a housing development or a new business.

The connection between co-op diversification and economic development is widely recognized and is viewed as part of the motivation behind the proposed rule issued by the Office of Rural Economic and Community Development that encourages increased diversification among co-ops. "It's pretty obvious that the government is encouraging co-ops to get involved in economic development projects," says Kamerman. "The RECD rule is an attempt to get more private investment in areas where federal programs are becoming more limited." Already in some cases there is a three-year wait for communities in need of water and wastewater systems, he says, noting that the involvement of co-ops in such projects would not only speed up the introduction of the systems but also provide a solid infrastructure for future development.

At this time, the major motivation for federal utilities is competition. According to Paul Majkut, assistant general counsel for BPA, the utility is already feeling the impact of increased competition. Its second largest public customer, Clark Public Utilities, which historically has purchased virtually all its power from BPA, has signed a contract to buy power from an independent power producer with a 240-MW combustion turbine. "Our mandate is to recover our costs," says Majkut. "So if someone pays us revenues for something such as unused fiber-optic capacity, this could help defray the cost of the transmission system."

"Like other utilities, we're under pressure to cut our costs and maximize equipment utilization and expertise," notes John Pyrch, manager of BPA's energy service business, which is less than a year old. "If there's a need out there and we have the equipment already in place to meet this need, then it makes sense to try to fill it." Pyrch says that BPA is exploring a number of potential areas of diversification, including demand-side management services, water quality and air quality information services, fiber optics, and load management. The goal is to test at least three new services within the next year.

WPL Holdings, the parent company of Wisconsin Power & Light, has a number of nonutility subsidiaries. One is RMT, an environmental consulting firm; shown here are ductwork on an air pollution control system designed by RMT, a chemical manufacturing process designed by RMT, and an industrial waste landfill designed by RMT, which also managed its construction. Another WPL subsidiary, Heartland Properties, develops and manages affordable housing.

Taking the plunge

Pierce-Pepin Electric Cooperative of Ellsworth, Wisconsin, sells appliances to customers in the region.

Aside from monetary advantages, diversification activities offer utilities a number of other benefits, such as stronger relationships with customers, an increased likelihood of long-term energy sales, and opportunities for professional growth among utility staff members. Fortunately, utilities are in an advantageous position to venture into diversification activities. "Utilities have a competitive advantage in that customers tend to view them as the appropriate entity for energy solutions," says Ingrid Bran of EPRI. "When a problem or need arises, customers currently tend to call on utilities first."

Also working in the industry's favor is that utilities for the most part have good reputations. According to a report published in June 1994 by Venture Associates, a unit of Arthur Andersen, "In spite of some inefficiencies, utilities generally enjoy a benign public image. Indeed, given the expectations of federal and state regulators, the U.S. electric industry has performed exceptionally well. It is a world leader in service reliability; it has met the rapid growth in kWh demands at acceptable cost; and it has provided consistent profitable returns to shareholders."

Fortunately, too, much has been learned about diversification through past activities—enough for industry analysts to have compiled some common elements of successful ventures. EPRI's study cites competitive market experience and the ability to identify customer needs as fundamental to the success of diversification ventures. "Almost without exception," the report states, "successful utility ventures are staffed by experts with an aggressive, customer-driven attitude who thrive in an entrepreneurial environment of uncertainty and flexibility."

Unfortunately, however, the traditional utility environment of a highly centralized, hierarchical organization is not conducive to such characteristics. Typical problems of such organizations involved in diversification include a lack of timely decision making, an unwillingness to "bend over backward" for the customer, and an inability to take independent action. Experts say it is critical that utilities become more flexible and timely in their diversification pursuits.

Common elements of successful diversification ventures, according to EEI, include a strong management team, good financial health before diversification, involvement in a number of small, core-related businesses related to strengths of the utility, and early entrance into such markets. Successful activities have included joint ventures with companies experienced in the new business area and typically have involved in-depth appraisals of the potential strengths and weaknesses of the new venture. Unsuccessful diversification ventures have tended to be large in relation to the size of the parent utility and highly unrelated to the utility's core business.

EPRI's experts stress that the way in which a utility chooses to identify and implement a new business opportunity may be more important than the specific activity chosen. Indeed, a well-designed planning process should steer a utility away from activities in which performance will be poor. As part of the planning process, a utility should identify any competitive advantages it already has and try to pinpoint the business areas that will offer the highest probability of success. A competitive advantage may be a skill or resource, a special relationship with a customer, ownership of or access to needed facilities, or capital availability.

The expertise of utility staff is crucial to the success of diversification, EPRI's study found. And commitment from senior management is indispensable. "If senior management is known to be unwilling to commit to the new venture, staff will be hesitant to become associated with the project, will fail to commit themselves fully to the venture, will spend too much time 'preserving their bridges,' and will constantly be checking with management to see if 'things are okay,'" the study asserts. The study encourages utilities to offer compensation incentives to motivate and retain employees at a time when changes brought about by diversification may significantly increase workload.

Other important aspects of the diversification planning process include a thorough analysis of regulatory impacts as well as extensive market research. As part of this research, utilities should strive to understand customer needs and how to address them, carefully estimate the cost of delivering the services, become familiar with who their allies and competitors will be, and analyze the mistakes and successes of competitors. This kind of research can prevent disastrous blunders—for example, the case of a utility that failed to research ally relationships and wound up offering power quality consulting services without supplying the power quality equipment. The utility learned too late that it was not able to control the quality of the installations.

Naturally, even if a utility does the proper planning up front, there is plenty of opportunity for things to go awry. "You're dealing with a competitive marketplace, and anything can happen," says Dan Rudakas of Capmarc Securities. "There's always going to be a certain amount of risk involved in making these investments, but the risks of traditional business areas are increasing too. The bottom line in this age of change is that if you don't consider expanding into new areas of business, you're putting your future at risk." ■

Background information for this article was provided by Ingrid Bran of the Customer Systems Group.

Developing Countries

Between now and the year 2020, according to some estimates, as much new power generating capacity will be installed around the world as was built in the entire past century. But in a historic shift that reflects a changing global pattern of energy consumption, a majority of that new capacity will be built not in the United States or in western Europe or even in the evolving market economies of eastern Europe; it instead will serve the surging economies of developing countries in Asia, Latin America, and Africa.

China and India, home to 40% of the world's population, together are expected to account for fully one-quarter of the projected growth in electric generating capacity over the next 25 years. Each of these countries is planning to build as much or more new capacity in the next decade as was commissioned in the United States during its last major era of economic growth and generation expansion: the 1960s. In China, where at least 10% of the 1.2 billion people have no access to electricity, the government wants to double the present installed capacity by the year 2000, adding an average 21,000 MW a year, or the equivalent of a medium-sized fossil fuel power plant every week or so. And these projections assume that China's economic growth, which boomed an average 10% a year over the past decade, will moderate to 8–8.5% a year over the next decade as the country becomes one of the world's largest economies.

The subcontinent of India, meanwhile, pulsates with the heartbeats of some 950 million people—a population that is growing at a rate twice that in the United States. By 2025, India will likely be the world's most populous nation in the world's fastest-growing region. Its urban middle class (middle, by local standards), which exceeds 250 million, is nearly as large as the entire U.S. population. India's central government reckons that the country needs to nearly triple the present installed generating capacity of 76,000 MW by adding some 142,000 MW in the next 15 years, requiring investment of some $170 billion. To accomplish this, the government has opened the power generation sector to private (includ-

THE STORY IN BRIEF Electricity supply infrastructures in many developing countries are being rapidly expanded as policymakers and investors around the world increasingly recognize electricity's pivotal role in improving living standards and sustaining economic growth. But in the face of enormous capital requirements, utility systems that were once strictly government run are giving way to a growing interest in privatization and foreign investment. The tremendous need for expanded electricity supply and availability is creating major market opportunities in developing countries for advanced generation technologies as well as for efficient electrotechnologies for end-use application. EPRI is pursuing several energy initiatives with government, industry, and electric power organizations in India and with others in the developing world—initiatives that could lead to substantial involvement by member utilities.

on a Power Drive

by Taylor Moore

ing foreign) investment, as it desperately tries to reduce critical capacity shortages and rotating blackouts that sharply limit its success in a more pressing objective: achieving the economic growth that will raise living standards and help alleviate the crushing poverty in which several hundred million of its people live.

But China and India are only the largest and most obvious developing countries whose leaders and industries are scrambling to expand essential infrastructure for communications, energy, and transportation, either to catch up with recent economic growth or to provide energy and services to fuel future growth. Similar stories of economic growth and electric generating capacity expansion are unfolding in Indonesia, Malaysia, Pakistan, the Philippines, South Korea, Taiwan, Thailand, and elsewhere in the developing world. Everywhere, development of the electricity supply infrastructure is considered pivotal to virtually all other economic development and to efforts to raise living standards by extending even the most basic electricity service, and the benefits it makes possible, to areas and people without them.

Problems with infrastructure

National governments and leaders are increasingly recognizing the unique combination of economic stimulus and social transformer that electrification represents. More than ever, developing countries view increased electrification as the critical lever for improving economic productivity and efficiency as well as for addressing environmental concerns.

"It's hard to imagine economic growth in much of the developing world without the use and availability of far more electricity than the countries now have," says Dennis Anderson, energy and industry advisor to the International Bank for Reconstruction and Development—better known as the World Bank. "The world still has approximately 2 billion people across huge regions without electricity. The populations and the economies in these regions are growing rapidly. If developing countries are deprived of modern energy supplies or their growth is stopped, it would be not only an economic calamity but an environmental one: billions of people, literally, would be driven to gathering and consuming even more fuel wood than is used now."

But serious economic, political, and social barriers to energy supply expansion persist in many developing countries. The capital-intensiveness of energy infrastructure projects is one key barrier. In addition, many countries have a long tradition of state ownership of heavy industry, and in those countries, utilities and energy projects must often take a backseat to competing demands for public health, poverty alleviation, and education spending.

The present situation in most developing countries is marked by a general and often acute shortage of generating capacity in areas where electricity service is actually available, primarily large cities and their environs. The challenge is even greater in rural areas, where many towns and villages, if they have any electricity, rely on scattered, stand-alone diesel generators to serve small, isolated loads.

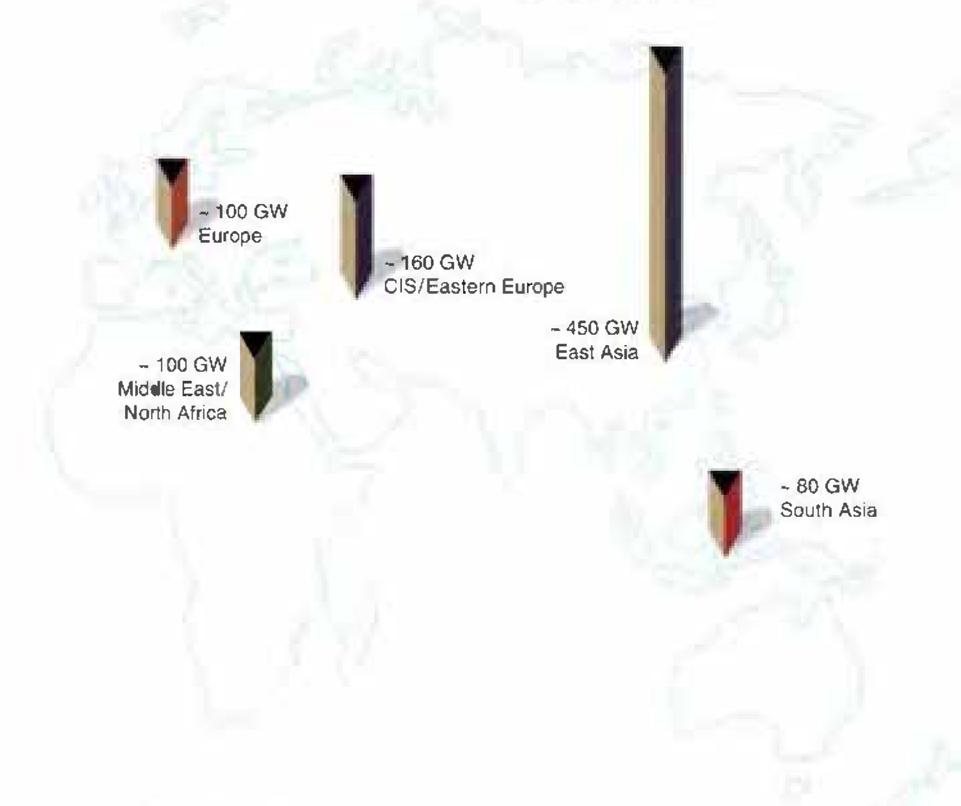
Most fossil fuel steam power plants operate with very low levels of availability, in part owing to a near total lack, by western standards, of systematic maintenance. The poor performance often results in long rotating outages or in brownouts—voltage and frequency fluctuations that can damage industrial equipment. Many commercial customers pay a premium for reliability in the form of backup generators. On average, 40% of the generating capacity in developing countries is unavailable for service at any given time, according to a 1994 World Bank report on infrastructure.

Despite the shortage of supply, there is little incentive to conserve at the point of use because much of the electricity that is produced is distributed free to farmers or is priced very low. This situation suggests a two-pronged course of action for developing countries: tapping the considerable potential for improving the output and reliability of existing electricity supply systems and at the same time substituting efficient electrotechnologies at the point of end use. These two elements are increasingly recognized as key to a strategy that could most quickly make available, and could ultimately make more affordable, the electricity services that are vital to global development. Some analysts put the potential gains from the more efficient use of energy overall as enough to raise—with only modest increases in per capita energy consumption—the average standard of living in developing countries to that enjoyed by western Europe in the 1970s.

Increased electrification is the centerpiece of most developing countries' energy and economic strategies. "Over the next century, electricity will become something of a global equalizer, diminishing the impact of geographic variation in the distribution of natural energy resources and the tension that this disparity produces," notes Kurt Yeager, EPRI's executive vice president and chief operating officer. "Because of its versatility, efficiency, and broad applicability, electricity has the potential to expand in the next half century to satisfy more than half the world's energy demand while providing the means for the most effective conservation of the world's natural resources. Electricity will be an essential component of the realization of sustainable development in a twenty-first-century world of 10 billion humans."

Experts in energy efficiency, including EPRI's, have noted that the potential efficiency gains for rapidly growing emerging economies with limited or poor electricity supply infrastructures are likely to be much larger than for developed economies, such as the United States, that have high levels of embedded capital investment and that are growing much more slowly. Moreover, efficiency in electric power could help break the traditional catch-22 of global development. Power generation reportedly consumes one-fourth of global development capital, the demand for which over the next few decades is expected to be eight times larger than the available supply. The application of efficiency techniques and technologies in the power systems of developing countries could be key to saving the capital needed for other purposes.

GLOBAL ELECTRIC POWER GROWTH, 1995–2005 Projections by different organizations of worldwide growth in the use of electric power vary in time frame and exact numbers, but all estimates suggest that most of the increase in generating capacity in the coming decades will take place in developing countries in Asia, Latin America, and Africa.



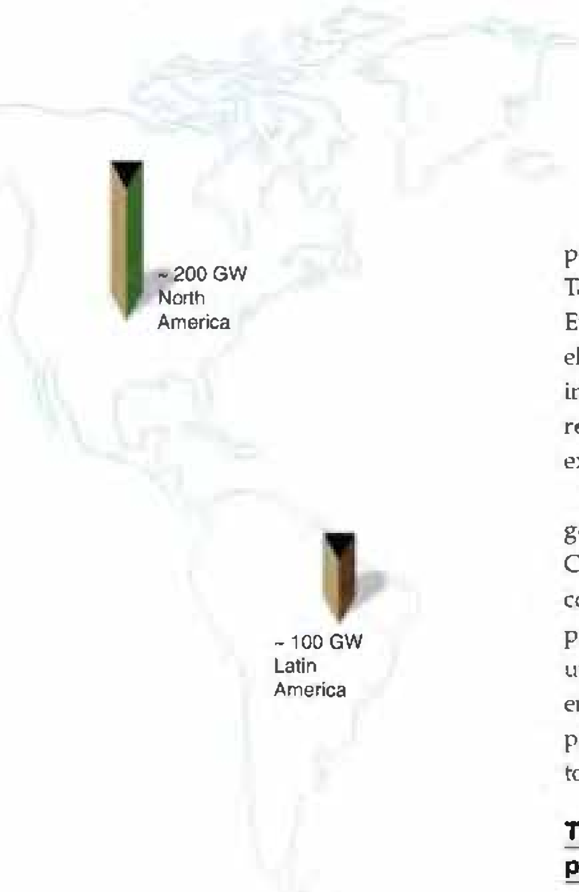
Source: U.S. Department of Energy.

Yet even as they begin to embrace efficiency improvements and renewable energy resources, most developing countries are simultaneously pursuing the expansion and upgrading of power plants and transmission and distribution systems as well as extensions of the grid or of nongrid electricity services to villages and remote areas. For China and India, the needs are so great that even with stunning success on all fronts, major areas and parts of the population will likely remain unreached by electricity service a decade hence.

Traditionally, the development of an emerging economy's energy infrastructure hinges on technologies that are affordable, are rapidly deployable, and make use of locally available fuel or other energy resources (whether they be oil, gas, coal, or hydroelectric potential). China, India, and Indonesia, for example, have large coal reserves, and India has extensive, still mostly untapped, hydroelectric resources.

Increasingly, developing countries are recognizing opportunities to deploy advanced technologies, including clean coal combustion, high-efficiency gas-fired combined cycles, and renewables-based generating systems. Such technologies can provide the means for rapidly deployable distributed generation off the grid as well as for industrial cogeneration and central station plants. And at the same time they can address environmental concerns and the need for a broader fuel or resource base.

In some developing countries, nuclear power will play a significant role in expanded electric generating capacity, helping to offset some of the growth in carbon dioxide emissions that would otherwise result from expanded fossil power generating capacity. China has announced plans to increase by 2010 its nuclear capacity from the current two or three plants producing 3300 MW to over a dozen units with a combined capacity of some 20,000 MW. Leaders there cite the pollution and transportation costs of additional coal use that such a nuclear expansion would avoid. After purchasing two pressurized water reactors of French manufacture, China appears to be pursuing the development of an indigenous nuclear power generation industry and says that it plans to build two PWRs for Iran. (The U.S. government at present bans American manufacturers from selling nuclear generating systems to China.) China has also announced intentions to develop a capability for recycling plutonium from light water reactor fuel for use in breeder reactors.



India currently has slightly over 2000 MW of installed nuclear generating capacity in several natural-uranium-fueled, CANDU-type reactors purchased from Canada, and it had plans for another 5000–6000 MW by 2000. But that planned expansion is believed to have slowed considerably in the face of higher projected costs. South Korea has 7 additional nuclear units slated among the 30 new power plants it is planning by 2000, and Taiwan is planning its fourth nuclear unit. Even Vietnam, which now gets most of its electricity from hydro dams, says that it is interested in nuclear plants of South Korean manufacture in order to significantly expand generating capacity.

Yet wherever the need for additional generating capacity is the most urgent—China and India, for example—gas-fired combustion turbines and combined-cycle projects offer the most rapidly deployable units. Even in Vietnam, two American energy companies (Mobil and Raytheon) are partners with the government in a project to build a 600-MW gas-fired power plant.

Tidal wave of private power development

In many countries, a shortage of capital and the implicit (and often explicit) acknowledgment of the failure of state-run enterprises are triggering a tidal wave of privatization of power generation projects and, in many cases, government-owned utilities themselves. The trend is being encouraged by multilateral lending agencies, including the African, Asian, and Latin American development banks and the World Bank, which estimates that the capital requirements of power systems in developing countries in the 1990s alone could top $1 trillion. Clearly, the amounts required are many times greater than the governments of such countries can afford, and multilateral lenders will be able to provide only small stakes for limited protection from political risks to individual projects.

As a result, much of the needed capital is being sought from the private investment community. In every part of the developing world, private power consortiums that include many U.S. equipment manufacturers, independent power producers, and subsidiaries of a significant number of U.S. utilities are actively developing and negotiating new projects. The Overseas Private Investment Corporation and the U.S. Export-Import Bank are expected to play a growing role in helping to finance such projects. But private investment follows the greatest potential for profit and is thus unevenly allocated. The Organization for Economic Cooperation and Development, or OECD—the coordinating agency for the world's biggest industrial economies—estimates that 80% of all private investment flows to just 20 developing countries.

Not surprisingly, in view of the rapidly growing economies in the region, Asia and the Pacific Rim are of paramount interest currently. Projections of the required investment for power projects in that part of the world, despite varying assumptions and time frames, bear a common bottom line of enormous numbers. Morgan Stanley, the investment banking firm, expects that private companies will account for about $100 billion in new power projects in the Asia-Pacific region by 2002—one-fourth of the 436,000 MW of new capacity that is expected to be built in that time. General Electric says it expects that more than 510,000 MW of new capacity will be ordered in Asia (including Japan) over the next 10 years. Another study estimates that the capital required just to meet China's projected energy demands by 2015 will amount to $1 trillion, with a bit over half going for electric power generation.

Compounding the political, currency, and other risks inherent in investing in emerging markets, a particular concern related to electric power projects in developing countries is that all of the electricity they generate over their lifetimes actually be paid for and that the price charged fairly reflect the cost. The first round of private power projects with major overseas investment stakes


A Honduran mother and daughter shop with the help of a fluorescent light powered by photovoltaics.

Enersol Associates


Rooftop photovoltaics at a medical center in Western Samoa.

Solarex Corp.

GROWTH MARKETS FOR RENEWABLES **Generating systems based on locally available hydroelectric, solar, or biomass resources can be used for rapidly deployable distributed generation off the grid as well as for industrial cogeneration and central station plants. Major market opportunities are emerging for renewables in countries that are rapidly expanding their electricity supply infrastructures. Directly competitive in many cases with available alternatives in developing countries, renewable energy resources can provide environmentally sustainable solutions for meeting energy needs.**


Photovoltaics powers a rural community water system in the Dominican Republic.

Enersol Associates


Bagasse pile at a cogenerating sugar mill in Costa Rica.

USAID; Winrock International

in India has required counterguarantees from the central government as insurance to back the power purchase agreements that must be made with India's state electricity boards in order to arrange financing. The counterguarantees add another layer of political controversy, yet are considered essential to jump-start private power in India because the state electricity boards are generally insolvent and have poor credit ratings, in part because they provide much electricity free or below cost.

In Latin America, Mexico's recent financial crisis has reinforced perceptions that investments in developing countries are risky, and it has affected the ability of developers in other emerging markets to finance power projects. Nevertheless, more than 41,000 MW of new generating capacity, mostly hydroelectric, requiring some $19 billion of investment capital, is expected to be installed in Latin America by 2000, with most of the capacity additions concentrated in Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela. Most electric power projects in Mexico are expected to proceed as planned.

The crisis in Mexico has even had a positive ripple effect on Brazil, Latin America's largest economy, where foreign investment—much of it fleeing Mexico—has more than doubled in the past year. Brazil is reviving efforts to attract private capital to its electricity sector with plans to privatize two power companies and a number of hydroelectric dam concessions. General Electric has a contract to examine prospects for building $9 billion worth of coal-fired generating capacity in southern Brazil.

Compared with Asia and Latin America, Africa is a more embryonic center of investment in electric power expansion. An initial market of more than 13,000 MW in private power project offerings has recently materialized in 7 of Africa's 53 independent countries, most of which are expected to eventually turn to the private sector for expansion in generating capacity. (The U.S. Trade and Development Agency cites a potential for $126 billion in energy projects in Africa by the year 2000.)

Electric utility privatization initiatives in the Ivory Coast, Morocco, and Uganda have already spurred the active planning or development of new power projects. Promising markets are seen in Ghana, Mozambique, Nigeria, and Senegal as the governments of these countries begin to encourage private investment to improve their electric power infrastructure. In South Africa, the end of apartheid marked the start of a seven-year campaign by the state-owned utility Eskom to electrify one and three-quarters million black households by 2000. The campaign is now ahead of schedule, with the utility making nearly 1000 new service connections every day.

Asia's stirring tigers

For several years, the practical operating headquarters for many of the world's investment banking and power plant finance, construction, and equipment companies has been Asia, where the magnitude of national markets and even individual projects is often expressed in enormous terms. Perhaps nowhere is this more true than in China, where planned projects include dozens of large coal-fired generating plants, industrial coal gasification plants, a 500-mile-long coal slurry pipeline, the world's largest pumped-storage hydroelec-

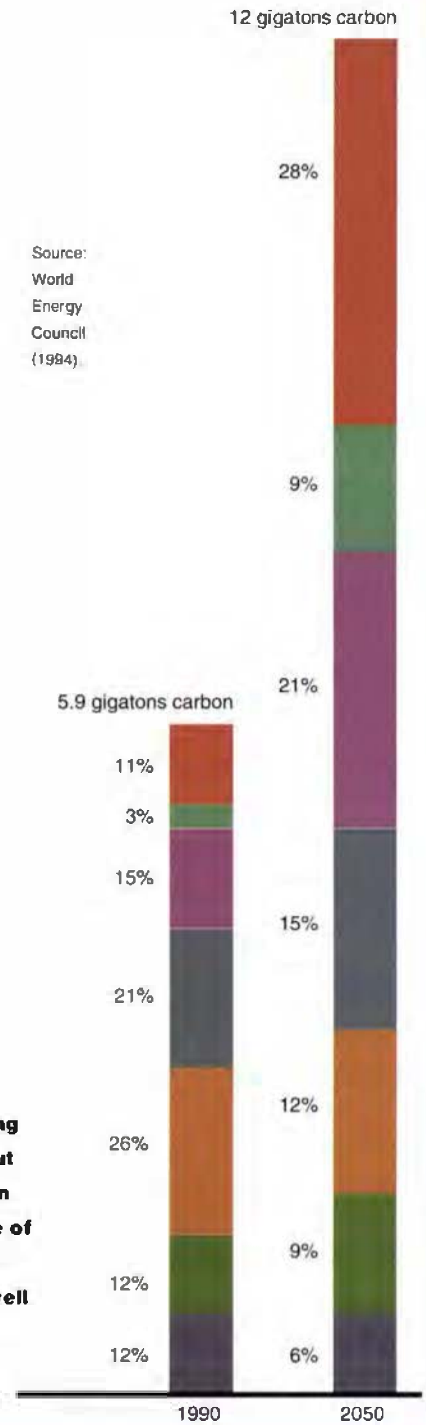
The Greenhouse Connection

Against the backdrop of booming power generation markets in many developing countries is the ongoing worldwide debate about the changing global pattern of emissions of carbon dioxide from fossil fuel combustion and about the control of future emissions. (CO_2 emissions are thought to trap heat in the earth's atmosphere, possibly contributing to global warming.) Developing countries today account for a little more than a quarter of the world's energy consumption but are expected to account for as much as 60% of the total by 2020. As a result, their share of global carbon emissions—now below 30%—is projected to surpass that of the developed countries early in the next century, rising to as much as 70% of worldwide carbon emissions by 2025 under the most pessimistic assumptions. Much of the projected increase in carbon emissions in developing countries is expected to come from the fossil power plants that dominate the current and planned growth in generating capacity in Asian-Pacific markets.

Because China and India are expected to continue to rely in large measure on vast domestic coal reserves as generating fuel, together they may account for as much as a quarter of global carbon emissions by 2010. Indonesia is also rich in coal and will continue to rely heavily on it for power generation as well as to export it around the Pacific Rim. Indonesia and Malaysia are both planning to fuel much of their future generation expansion from large reserves of natural gas, which also produces CO_2 emissions, albeit about a quarter as much as coal does per kilowatthour.

Disagreements among industrialized countries, which account for the majority of current carbon emissions, and between developed and developing countries over the urgency, timing, and allocation of responsibility for limiting future emissions of CO_2 are paradoxically creating major opportunities for the early adoption of advanced energy technologies in the less-developed countries. These technologies include—in addition to modern and efficient central station power plants with environmental controls—clean coal technologies, renewables-based and other distributed generating technologies like wind turbines and solar photovoltaics, advanced power delivery systems and components, and high-efficiency end-use technologies for industrial and commercial application.

Even as their resistance increases to making commitments to curtail future growth in carbon emissions, developing countries are beginning to embrace efficiency and advanced technology for the potential to leapfrog their national economic development along a more environmentally sustainable, less energy-intensive path than was followed by today's industrial economies. This is creating new markets for renewable and advanced energy technologies that resonate with international plans for trials of so-called joint implementation approaches to greenhouse gas emissions reductions. Under the joint implementation concept, developed countries could gain credit for emissions reductions by implementing various energy efficiency measures—including sponsorship of advanced generation technologies in a developing country. The developing country, in turn, would benefit from access to cleaner, more-efficient technologies than it could otherwise afford. □



GLOBAL CO_2 EMISSIONS: A SHIFTING SCENE **According to the World Energy Council, China, India, and other developing countries collectively accounted for about 29% of global carbon dioxide emissions in 1990. But their planned growth in the use of coal and other fossil fuels is projected to raise their share of global emissions to well over half of the total in 2050, a total expected to be double that of today.**

A Role for EPRI?

Beyond the over half a dozen memorandums of understanding EPRI has signed with Indian government and industrial organizations to establish relationships and pursue specific projects, a broader strategy is in the works. "There is much that could be done in India—for example, introducing off-the-shelf products like some of our plant optimization software, leveraging new markets for emerging technologies like renewables that are already cost-effective there (with the possible result of improving the technologies' prospects domestically), and creating new opportunities for collaborative investment with our members that could contribute to the expansion of the country's electric power infrastructure," comments Murthy Divakaruni, a leader in EPRI's initiatives in India. "So much of the technology that we have to offer matches the needs today in India. It would be a shame not to take advantage of the opportunities."

According to Richard Goldman, director of the U.S. Agency for International Development's office of environment, energy, and enterprise in New Delhi, "The entire gamut of EPRI's work could potentially be brought to bear in India to help improve the country's electric power infrastructure." Goldman says that he would like to see EPRI become involved in an emerging U.S.-India utility partnership program for personnel exchange, technical training, and technology transfer. (Under USAID sponsorship, more than 20 U.S. utilities have adopted sister utilities in developing countries.) And in recent visits to India by EPRI executives, the country's Rural Electrification Corporation has expressed strong interest in working with the Institute.

Goldman is aware of evolving plans at EPRI for a series of initiatives that could lead to a significant EPRI presence in India. "The opportunities for EPRI and for U.S. companies and for new technology in India are tremendous, and USAID can facilitate EPRI's entry into India and suggest ways to participate in the rapidly evolving electric power sector."

Also attuned to EPRI's growing interest in India is the World Bank's Dennis Anderson. "EPRI embodies a lot of expertise and has a lot of excellent contacts with utilities that have technical as well as immense financial and managerial expertise," says Anderson. "One would like to see more developing countries working a lot more with institutes like EPRI. The level of performance of electric utilities in developing countries is still very poor; they have a lot of planning to do and a lot of work to incorporate cleaner energy technologies. So there is tremendous market opportunity, not only for EPRI but for foreign as well as local investors."

The commercial developers of two solar-energy-based renewable generating technologies that EPRI helped to develop are actively pursuing near-term projects and long-term business opportunities in India. Kenetech Windpower (formerly U.S. Windpower)—which, with the support of EPRI and two member utilities, developed the first variable-speed wind turbine to generate cost-effective electricity—is planning to de-

Indian government agencies are promoting photovoltaic applications.

World Bank

INDIA: A TIGER STIRS **On its way to becoming the world's most populous country, India is opening its electric power market to private investment to fill a critical shortage of electric generating capacity. A suite of private power plant projects involving many U.S. companies is on a fast track for approval and construction. India has a tremendous need for environmentally sustainable clean coal technologies, since it will continue to rely heavily on large domestic reserves of high-ash coal. But the country also has substantial untapped hydroelectric potential and extensive other renewable energy resources, including solar, wind, and biomass (bagasse from sugarcane). In efforts led by the U.S. Agency for International Development and the Department of Energy, the United States is providing training and financial assistance to India's power sector.**

ploy some 700 machines representing over 200 MW of wind generating capacity in India by the end of next year. There is interest in developing a new turbine for India that would operate at even lower wind speeds and thus in wider areas than the current model. Meanwhile, Amonix, the commercializer of an integrated high-concentration photovoltaic (IHCPV) array that promises cost-competitive electricity in large-scale production, sees strong possibilities for deploying the arrays in massive numbers in India, both for grid support and for remote village application. Separately, EPRI and Amonix are pursuing an early 2-MW demonstration of the IHCPV array in India.

Low-loss amorphous-metal distribution transformers and the emerging power-electronics-based elements for the FACTS (flexible ac transmission system) technology could eliminate much of the financially draining technical losses in India's power delivery systems as they evolve toward a truly interconnected nationwide grid. On the demand side, the high-efficiency single-phase Written-Pole™ motors that EPRI developed with Precise Power Corporation hold major potential for application throughout India's agricultural, commercial, and manufacturing sectors.

EPRI is exploring—with Thermax, Ltd., of India—opportunities for collaboration on industrial electrotechnology applications for water purification, medical waste sterilization, and food processing (for example, freeze concentration). Other efforts are focusing on battery-powered electric transportation, which could make a major contribution in reducing the constantly visible air pollution that chokes and sickens people in all of the country's large cities. Although automobiles are still relatively rare in India, authorities are anxious to convert to electric power the thousands of two-stroke motorized rickshaws that clog the streets. The developer of the Horizon advanced lead-acid battery, which received R&D support from EPRI, has made an agreement with an Indian manufacturing group that is expected to lead to the technology's introduction to the Indian market. USAID, meanwhile, is funding a demonstration of electric power conversion with India's largest manufacturer of three-wheeled motor vehicles.

Jeff Seabright, director of USAID's office of energy, environment, and technology, says that his agency has cooperated with EPRI and its member utilities in the past in pursuit of a common agenda of making the U.S. electric utility industry strong in international markets. Two recent examples involved the USAID-funded sublicensing of EPRI software—DSManager to the Ukrainian utility Minenergo and IRP-Manager to the Andhra Pradesh State Electricity Board in India. In other examples, a subsidiary of New England Electric System provided technical assistance through USAID to the Polish Power Grid Company as it established a unit for integrated resource planning, and Central Maine Power Company has hosted a utility partnership for several years with NEK, the Bulgarian utility.

Seabright says that EPRI and its members could gain further access to international markets by participating in such efforts as future USAID projects aimed at developing private, independent power markets and at introducing integrated resource planning and demand-side management concepts in India and elsewhere. □

This two-unit, 500-MW coal-fired power plant at Dahanu, Maharashtra, began operating this year.

BSES Limited

Photovoltaic module manufacturing.

World Bank

Charging battery-powered village lanterns with solar photovoltaics.

USAID; Winrock International

Black & Veatch

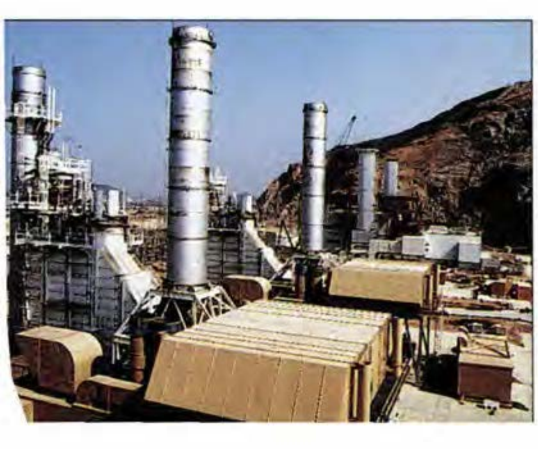
Philippines: 735-MW coal-fired Pagbilao plant.

tric project, and—overshadowing all—the $17 billion Three Gorges hydro complex, which is expected to take 17 years to build and to displace a million people when completed. Senior officials have said that China is looking to attract $20 billion in foreign investment for its power industry by the year 2000, nearly doubling the sector's share of total foreign investment, in order to achieve a goal of 300 GW of generating capacity.

But a ceiling imposed by the government in late 1993 on the rate of return permitted for planned projects nearing financial closure (initially set at 12% and later revised to around 15%) is discouraging some investment and clouding the intermediate term outlook in China. And a decision announced last year to bar foreign investors from holding majority stakes in future large power plants and other projects has reportedly stalled talks on several major deals.

Financiers generally expect higher returns to compensate for the increased risk of investment in developing countries. The government of Pakistan, for example, may allow an investment return as high as 25% to spur expansion of that country's hydroelectric generating capacity. A possible breakthrough for future power expansion in China recently emerged in a mandate from the Asian Development Bank for a consortium developing a planned 1800-MW coal-fired plant for Shanghai to employ so-called project finance methods. Under project financing, a portion of future revenues from the sale of electricity is used to repay the original project loans. Such arrangements are widely believed to be essential for funding many of the proposed private power projects in Asia.

China: Shenzhen Energy Corporation's 100-MW Yeuliangwan power plant uses two General Electric aeroderivative steam-injected gas turbines.



GE Marine & Industrial Engines

While China remains the focus of many of the worldwide power generation industry's major players and other global companies, another Asian tiger beginning to stir is India. Economic reforms and expanded privatization efforts that began there in 1991—plus a democratic society, an English-speaking business community, and an English-style legal system—present more-manageable prospects to western companies. India's markets seem more accessible in other ways as well: half of the 35 million television sets now in India receive satellite or cable channels, providing a new window on the outside world for more than 60 million people and creating a mass consumer market almost overnight. Along with a few lights, a community television set—powered by a diesel generator or, in a growing number of instances, batteries charged by solar photovoltaics (PV)—is often the first electric appliance that India's rural poor experience.

India has been a focus for expanding government and trade contacts by U.S. officials and companies since 1992. In May of that year, an Indian delegation led by officials from the ministries of power and nonconventional energy sources was hosted on a tour of American utilities and other organizations (including EPRI) by the U.S. Agency for International Development. USAID and the Department of Energy are leading the U.S. government's technical training and financial assistance efforts for India's power sector as part of a broader campaign to promote trade, investment, and sustainable development in India. Since 1992, Commerce Secretary Ron Brown has led a U.S. trade delegation to India and Energy Secretary Hazel O'Leary has twice visited the country to sign some two dozen memorandums of understanding for planned business relationships representing $10 billion worth of projects. The projects primarily involve renewable energy development and energy efficiency programs linking Indian and U.S. companies and organizations. EPRI is a lead signatory for several of these efforts. Secretary O'Leary's recent mission specifically created an opportunity for EPRI to establish high-level contacts and enter into substantive discussions in India much more quickly than might otherwise have been possible.

In addition to the many state electricity boards that generate some power and distribute electricity, India has several privately owned utilities that operate modest amounts of generating capacity. The independent, publicly owned Power Grid Corporation operates the high-voltage transmission lines and is seeking increased interconnections between the regional systems. The National Hydroelectric Power Corporation operates most large hydro generation sites, and the National Thermal Power Corporation operates many of the country's fossil power plants, which for the most part burn high-ash coal. Typically run at very low load factors, many of the units must burn imported oil through the night to remain operating because of the low turndown capability when firing coal. Electricity losses in various regions are said to range from 20% to 40%, with about half attributed to T&D losses and the rest to theft.

India's coal-fired plants need improved thermal efficiency and optimization technologies to raise performance and reliability. They also need particulate emissions controls and upgraded maintenance. And there is strong interest in coal beneficiation at the minemouth to reduce ash content and transportation costs. Several years ago, USAID and EPRI confirmed the feasibility of coal gasification technology as a promising option for increased use of Indian coal for power generation in the future. (Coal gasification almost completely removes ash before combustion, producing a by-product that can be used as a high-quality construction material, something that is also in short supply in some parts of India.)

Ready markets for renewable energy

Generating technologies based on renewable energy resources are of particular interest in India for several reasons. They are considered directly cost-competitive with conventional alternatives in far more applications in India than in countries with highly developed electricity supply infrastructures. India has ample renewable biomass resources, like bagasse from sugar production and other agricultural wastes, as well as solar insolation. The technologies could be rapidly deployed in small increments throughout the country to provide basic electricity services. Their use could also form a basis for indigenous technology manufacturing. And they have few or no fuel requirements that would cost the economy in foreign exchange.

"There are unique opportunities for innovative solutions like photovoltaics in India, as well as in most other developing countries," says David Jhirad, an American of Indian origin who was formerly with USAID and is now deputy assistant secretary for international energy policy at DOE. "PV can be deployed on a large scale with many small distributed units to provide basic electricity services for community lighting, public health purposes, and communications in the rural areas where most people live. Just a few watts to a few hundred watts of generating capability can be enough to transform people's sense of what is possible in their economic existence."

Jhirad describes an emotional moment for Energy Secretary O'Leary on her trip to India earlier this year, when she visited a village where a mother of modest means proudly explained how new lights powered by PV and batteries had made it possible for her two sons to study at night, improving their prospects for a life of dignity and economic self-sufficiency. "Electricity can open many windows to the world," notes Jhirad. "Electric light opens the way to a world of social, economic, and intellectual advancement. Television is, of course, a powerful window on the world. Refrigeration for vaccines is a window to a level of health care that many people have never known before."

Charles Feinstein, senior operations officer in the World Bank's global environment coordination division, says that "there are vast untapped markets for renewable energy technologies in countries like India, and the governments of such countries are starting to commit resources and put in place supportive policies to allow development of those markets. Countries like India and China are beginning to view renewable energy technologies not just as a potential solution to local environmental problems or as a means of being good citizens for the global environment (frankly, limiting greenhouse emissions is not very high on their agendas) but as something that's of strategic and practical importance to their long-term industrial development and economic growth."

The World Bank-administered Global Environment Facility is a multilateral trust funded by $2 billion in pledges from developed countries over the next three years as part of agreements under the Global Climate Change Convention. The GEF expects to make a significant portion of its funding available for renewable energy projects in the developing countries, Feinstein says. "The enormous energy demands in developing countries are not going to go away, and meeting them is absolutely essential to improving living standards in those countries. Yet we must be careful to do this in a way that is efficient and sustainable."

Building on experience gained through the GEF and other earlier, limited programs, the World Bank last year launched a solar initiative to accelerate technology commercialization and applications, particularly for power generation, in developing countries. It is expected to include efforts to encourage the deployment of solar-thermal technologies for applications such as water purification. There is also a great need in the developing world for low-cost solar-thermal technologies like improved solar cookers and water-heating systems as alternatives to the direct use of fuel wood.

An important, potentially large, and virtually untapped source of renewables-based electricity generation is the waste bagasse biomass from India's more than 400 sugar mills. The potential for 4000 to 5000 MW in industrial cogeneration of steam and electricity from bagasse with current-technology, low-pressure boilers is believed to exist in India. But until recently, sugar processors had no financial incentive to produce excess steam for power generation. Indian authorities are said to believe that in the longer term, a much larger potential exists for biomass cogeneration from bagasse and other agricultural wastes using compact, high-pressure boilers and—eventually—

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Egypt: Cairo South combined-cycle plant.

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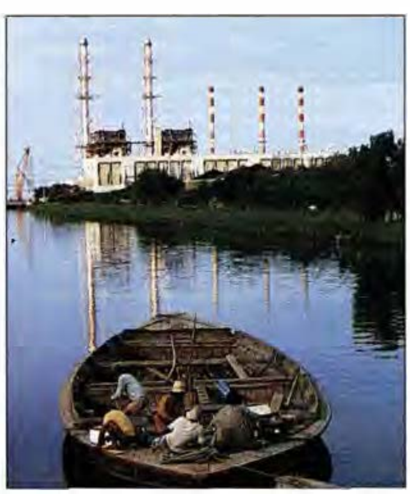


Indonesia: 500-MW Muara Karang combined-cycle plant.

packaged, high-efficiency combined-cycle units that feature aeroderivative gas turbines.

India's two richest, most-industrialized states, Maharashtra and Gujarat in the west, are the site of most private power investment in the country. The furthest along and most closely watched of the projects is the 2015-MW Dabhol plant planned near Bombay in Maharashtra by a consortium led by the U.S.-based Enron Corporation. The combined-cycle plant is to be fueled with liquefied natural gas shipped from a major new Enron development project in Qatar. GE Capital and Bechtel Enterprises each have 10% stakes, and Entergy Corporation, the U.S. utility holding company, says that it plans to buy a 20% stake. (Unlike most other developing countries, which have placed limits on foreign equity stakes, the Indian central government has decided that private investment may account for as much as 100% of project financing.)

Dabhol's 695-MW first phase is scheduled to begin operating by late 1997, selling electricity to the state electricity board under a long-term, government-counterguaranteed contract. Recently, however, members of a coalition of political opposition groups that gained control of the government in Maharashtra in state elections earlier this year have questioned the lack of competitive bidding for the project and have threatened to delay it.

Dabhol is the leader of a pack of eight private power plant projects for which revenue counterguarantees have been promised by the central government and that have been placed on a fast track for approval. As such, it is viewed by many observers as a test case for future foreign investment in India's infrastructure. Six of the eight projects are being developed by U.S. firms—firms that are involved in over half of the 41 pending projects opened to foreign investment and participation. The first two projects for which counterguarantees have been approved have been permitted rates of return on investment of 16–20% if the plants meet target levels of productivity.

Opportunities abound

A convergence of need and urgency at nearly every level of India's electric power sector presents opportunities for the application and deployment of a complete spectrum of technologies, conventional and advanced. Factors in this convergence include the country's large installed base of underperforming coal-fired generating capacity, which is lacking most emissions controls; the country's emerging private power market for new generating capacity, with its potential for very rapid and enormous growth; the virtual absence of industrial cogeneration or efficient end-use technologies; and a dire need to make basic electricity services available to more of the 80% of the population who live in half a million or more villages. The technologies needed range from clean coal and advanced environmental control systems to state-of-the-art power plant design tools, T&D equipment, and modular and distributed generating systems (including wind turbines, PV, and biomass) to such end-use technologies as electric vehicles, high-efficiency single-phase motors, and water purification systems.

"There is an extremely wide array of opportunities for innovative technology, policy, and financing solutions of every kind to address the challenges facing India's electricity sector today," says Jhirad of DOE. "As an organization with a successful track record in technology innovation and commercialization for the electric power sector, EPRI could bring tremendous value to the scene."

Jhirad explains, "EPRI embodies the U.S. technology system. Its ability to take technology through R&D, accelerate its flow into the marketplace, and work with a large web of equipment vendors, utilities, and universities to make it all happen embodies the very notion of innovation and dynamism that is what I believe the electric power industries in India and the rest of Asia need. Electric power projects in those countries have to serve as multifaceted solutions: they have to solve an energy problem, an environmental problem, and an economic problem, and they must contribute to improving the quality of life."

Noting the tremendous unmet demand in India for electricity and for technology to advance the electric power sector, Jhirad says that the convergence of opportunity for broad participation with Indian energy organizations and of strategic developments under way at EPRI to integrate its growing initiatives in India could not be more timely. "This is an exciting time for EPRI to be thinking about its role in global electrification," adds Jhirad. "India could serve as a prototype for how EPRI could collaborate with DOE, other federal agencies, and the private sector to enter the rapidly expanding electric power markets in developing countries. The benefits to both countries would be immense: investment in high-technology industries and jobs in the United States and a sustainable electric power development path for India."

Agreeing with Jhirad is Murthy Divakaruni, a leader in EPRI's initiatives in India. "EPRI represents 72% of the U.S. utility industry and can view these worldwide opportunities as a vehicle for enhancing value for its members. EPRI can be a catalyst for both its members and its contractors. Together with DOE, EPRI can work toward building opportunities for the U.S. electric power industry." ■

Siemens

Malaysia: The Paka plant, the country's first privately owned combined-cycle power plant, will have about 800 MW of capacity when fully operational in October.

CONTRIBUTORS

Technical sources for Journal feature articles

VOJDANI

BRAN

DIVAKARUNI

RABL

Measuring the Cost of Transmission Services (page 6) was written by science writer John Douglas with assistance from **Ali Vojdani** of EPRI's Power Delivery Group. Vojdani is manager for power systems analysis in the Substations, System Operations & Storage Business Unit. Before joining the Institute in 1993, he was supervisor of systems engineering at Pacific Gas and Electric Company, where he provided analytical and computer services to operations and planning departments for 11 years. Vojdani has a master's degree in engineering and a PhD in electrical engineering, both from McGill University in Montreal, Canada. ■

Diversification in the '90s (page 16) was written by Leslie Lamarre, *Journal* senior feature writer, with information from **Ingrid Bran** of the Customer Systems Group. Bran, a manager for R&D planning and analysis, came to EPRI in 1992 after two years as a senior analyst with Micronomics, Inc. Her earlier experience includes four years as a load research analyst for Southern California Edison Company and two years as a market planning and research analyst and international economist for Union Bank. She has a BA in economics from California State University at Fullerton and an MA in the same field from the University of California at Berkeley. ■

Developing Countries on a Power Drive (page 26) was written by Taylor Moore, *Journal* senior feature writer, from interviews and information from various sources, including several EPRI staff members who have visited India in recent months.

Murthy Divakaruni, who has led EPRI's initiatives in India, is manager of business development in the Generation Group's Fossil Power Plants Business Unit. He was previously a program manager for fossil plant operations and, before that, a project manager for fossil plant controls and diagnostics. Divakaruni joined EPRI in 1981 and worked for five years as a project manager in nuclear plant safety. Between 1976 and 1981, he was with General Electric Company. Divakaruni earned a BSME at the University of Madras, India; an MSME at the Indian Institute of Technology in Madras; an MS from the University of Cincinnati; and an MBA from Xavier University in Cincinnati.

Veronika Rabl is director of EPRI's Customer Systems Group. She joined the Institute in 1981 to manage work on load management technologies and later headed the Demand-Side Management Program. She has held her present position since 1991. Before coming to EPRI, Rabl was with the Energy and Environmental Systems Division of Argonne National Laboratory for five years and also managed the technical and economic analysis program for DOE's Office of Energy Systems Research. She has a master's degree in physics from the Weizmann Institute of Science in Israel and a PhD in physics from Ohio State University. ■

Executive Appointments Round Out EPRI Senior Management

Yeager

Jones

Peck

Courtright


A number of executive appointments were made at the spring meeting of the EPRI Board of Directors. Kurt Yeager, previously the Institute's senior vice president for strategic development, was named executive vice president and chief operating officer.

In announcing the Board's action, EPRI President and CEO Richard E. Balzhiser said the appointment "recognizes that Kurt has the vision, leadership, and vitality to help deliver the right technology for the electric utility industry, the nation, and the global economy. Kurt is a valuable partner in the mission to power the future."

In his previous position, Yeager was responsible for strategic development activities, including vital environmental issues, exploratory and applied research, advanced innovations, and external relations. Before May 1994, Yeager was EPRI's senior vice president for technical operations, responsible for the integrated management of five technical divisions and exploratory and applied research. Before joining the Institute in 1974, Yeager was director of energy R&D planning at the U.S. Environmental Protection Agency's Office of Research.

The Board of Directors also appointed Robin Jones vice president for the Nuclear Power Group (NPG). Jones succeeds John Taylor, who retired at the end of 1994. Balzhiser commented on the selection, "Robin's technical expertise and management skill will be invaluable assets in realizing NPG's and its domestic member utilities' goal of expanding worldwide nuclear R&D collaboration."

Jones has more than 30 years of experience in materials-related research and R&D management. During his 16 years with EPRI, his assignments have included leadership of industrywide programs on the reliability of BWR piping, reactor vessel internals, and PWR steam generators, as well as on improved technology for radioactive waste management. Before joining EPRI, Jones was manager of the metallurgy program at SRI International.

Stephen C. Peck, previously director of the Environmental & Health Sciences Business Unit, was appointed vice president for the Environment Group. "I appreciate the depth of Stephen's understanding of environmental and health sciences research and his calm, logical way of adding balance and wisdom to complex issues," stated Yeager. "I know he will be even more valuable in his new position."

Peck's responsibilities include R&D on global climate change, air and water quality, and electric and magnetic fields. Before joining EPRI in 1976, Peck was on the faculty of the University of California at Berkeley.

Henry "Hank" Courtright, formerly director of the Customer Systems Group (CSG), was appointed vice president for client and external relations. In his new position, Courtright has responsibility for client relations, international relations, regulatory relations, and the Institute's Washington, D.C., office. "Consolidating these important relationships under the leadership of Hank Courtright further strengthens EPRI's ability to meet the science and technology needs of all our clients and stakeholders," stated Yeager. "Hank has an outstanding ability to understand what's needed and make it happen."

Before joining EPRI in 1992 as CSG director, Courtright was vice president for marketing at Buckeye Pipe Line Company, one of the country's largest independent oil pipelines, where he was responsible for strategic planning and new business development. Courtright previously worked for 18 years in the electric utility industry and served as director of marketing and economic development for Pennsylvania Power & Light Company.

Ozone Consortium Gains Members

A public-private consortium aimed at bringing together the scientific resources of Canada, Mexico, and the United States in a major effort to study tropospheric ozone concentrations over North America—a consortium that EPRI helped found—now boasts a sizable number of U.S. electric utilities as members.

Representatives of about 50 members of the consortium—which includes U.S. federal and state government agencies, academic institutions, environmental organizations, and utilities, as well as the Canadian and Mexican governments—attended a White House ceremony in February to sign the charter of the North American Research Strategy for Tropospheric Ozone (NARSTO). This document pledges participants to coordinate their investigations of ozone formation and transport in the lower levels of the atmosphere, where it is a major component of urban smog. EPRI was represented at the ceremony by Executive Vice President Kurt Yeager.

The NARSTO effort will synthesize findings from several decades of research and will coordinate new work aimed at understanding more reliably how changes in emissions of key ozone precursors—nitrogen oxides and volatile organic compounds—influence the occurrence of ozone. The results will provide guidance in the selection of options for managing precursor emissions to achieve the National Ambient Air Quality Standard for ozone. (One such emissions management effort, for example, is being undertaken by 12 northeastern states and the District of Columbia, which make up the Ozone Transport Commission. The group's recently adopted plan calls for achieving major reductions of ozone precursors from both stationary and mobile sources.)

Among those signing the NARSTO charter were representatives of EPRI, the Edison Electric Institute, and these utilities: Allegheny Public Service, Atlantic Electric, Baltimore Gas and Electric, Duquesne Light, General Public Utilities, New York State Electric & Gas, Niagara Mohawk Power, Northeast Utilities, Northern Indiana Public Service, Northern States Power, Ohio Edison, PECO Energy, Pennsylvania Power & Light, Public Service Electric and Gas, Southern Company, and United Illuminating. NARSTO was conceived in 1993 by the U.S. Environmental Protection Agency, EPRI, and the National Oceanographic and Atmospheric Administration.

At the consortium's first meeting, the week after the signing of its charter, Peter Mueller of EPRI's Environmental & Health Sciences Business Unit and Jim Vickery of the EPA's Office of Research and Development were elected to serve as cochairs of the executive steering committee for the next two years.

Some of the utilities that signed the NARSTO charter are participating—along with major federal and state agencies and organizations in other industries—in NARSTO-Northeast, a regional study to obtain the atmospheric data necessary for understanding the factors that drive ozone events during summer. For example, some utilities will participate in a project with the EPA and various state environmental agencies to install modern technology to characterize the evolution of atmospheric layers and winds during periods of ozone accumulation. Such meteorological information about the ozone transport region is essential for simulating ozone occurrences resulting from projected changes in precursor emissions.

Sustainable Development With DOE

Senior officials of the Department of Energy and EPRI recently held their first executive conference to detail their Sustainable Electric Partnership plan. Secretary of Energy Hazel O'Leary and EPRI President and CEO Richard E. Balzhiser kicked off the partnership with a signing ceremony last October.

O'Leary said, "This conference and resulting joint plan represent a major initial milestone in this new expanded relationship with EPRI. This partnership is a gleaming example of how this department intends to do more with less through better leveraging of information and existing funds with the nation's electric power industry through EPRI."

Balzhiser noted, "Electricity is a prime mover underlying economic and social development. It is essential that EPRI and DOE, representing this country's electricity R&D infrastructure, work together."

Key features of the draft plan include the following:

- A $40 million program to stimulate the development of advanced air toxics and NO_x control technologies for coal-burning utilities
- A value assessment of photovoltaic and wind energy deployment, and commitments to bridge the gap between research and commercialization
- Milestones for joint research in such areas as power electronics, communications, sensor technology, and real-time controls
- Joint projects to reduce production lead time for metals casting, an important competitive issue for U.S. automakers, and to analyze cost reduction technologies for U.S. glass producers
- Cooperative agreement on technologies to ensure cost-effective construction and implementation of advanced light water reactor plants, and agreement to expand collaboration on R&D for existing nuclear plants in several areas—including life-cycle management, instrumentation and controls, reactor vessel internals and vessel annealing, plant fuel performance, and spent-fuel storage and transportation
- Development of an EMF exposure assessment database under the EMF clearinghouse being developed by the National Institute of Environmental Health Sciences as part of DOE's EMF RAPID Program
- Joint assessment of analytical frameworks to explore the costs and impacts of alternatives for dealing with potential global climate change issues

Test Results Available on District Heating Turbine at Lithuanian Power Plant

U.S. utility interest in the use of cogeneration plants to supply district heat, industrial steam, and power prompted EPRI to investigate advanced turbine designs developed in the former Soviet Union, where cogeneration is widely used. A recent EPRI report provides a detailed account of the field testing and performance of a Russian 180-MW advanced district heating turbine and describes the unique features that permit sufficient steam extraction with a very low cooling-steam flow rate. Field tests of the T-180/210-130 turbine installed at Vilnius Power Plant 3 in Lithuania were conducted for EPRI by Joseph Technology Corporation.

Several U.S. utilities have recently assessed the feasibility of extracting thermal energy from existing single-purpose condensing plants to supply steam for district heating and cooling along with electricity. But converting such units requires that high rates of exhaust, or cooling, steam enter the condenser, which reduces turbine efficiency. EPRI tests of the advanced Russian turbine have demonstrated that such features as two rotating grid-type diaphragms minimize the leakage of cooling steam for efficient extraction for district heating.

The EPRI project team visited the Vilnius plant and conducted various turbine tests through the closed grid diaphragms: a test for overspeed protection in the idling mode and two types of tests, express and precise, to determine the cooling-steam leakage rate. Overall, the tests demonstrated that the turbine can operate with a minimum leakage rate through the diaphragms of about 1.5% of the nominal live steam flow rate. Thus 98.5% of the steam flow entering the condenser is available for district heating. The researchers estimate that such a low leakage rate—compared with the 20% cooling-steam leakage rate that is typical in current U.S. practice—results in annual fuel savings equivalent to 200,000 million Btu.

Using cogeneration to supply district heating and cooling, industrial steam, and electricity for the residential, commercial, and industrial sectors can help U.S. utilities reduce their thermal generating capacity heat rates by as much as 20% while increasing compliance with the Clean Air Act Amendments of 1990. Although single-purpose condensing plants are not designed to extract the large amounts of steam required, the rotating grid-type diaphragms featured in the Russian 180-MW turbine can substantially increase the efficiency of steam extraction.

EPRI is evaluating the need for a detailed technical and economic assessment of the retrofitting of a typical U.S. single-purpose turbine with such diaphragms and is recommending further investigation of the advantages of using them in turbines operating with steam extraction. A report on the field testing of the Russian turbine (TR-104958) is available from the EPRI Distribution Center, (510) 934-4212.

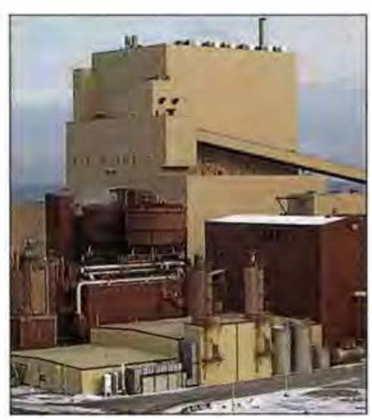
■ *For more information, contact Walter Piulle, (415) 855-2470.*

High-Sulfur Test Center Becomes Environmental Control Technology Center

EPRI's High-Sulfur Test Center has been a leading site for research in the area of wet and dry flue gas desulfurization technologies for nearly eight years. Recently, the facility shed its name in favor of a new one: the Environmental Control Technology Center (ECTC). The change reflects a widening of the center's research focus to include other, high-priority environmental issues even as it continues to serve as the largest and most comprehensive facility for flue gas emissions control R&D in the United States.

The ECTC has taken advantage of its flexibility and capabilities to encompass a broad range of environmental control R&D, including work on hazardous air pollutants, NO_x control, continuous emissions monitoring, and wastewater reuse and recycling. The center is well regarded for its equipment flexibility and extraordinarily high data quality and for providing the critical step between concept and commercialization. EPRI estimates that for each dollar funneled into ECTC research, the utility industry gains $154 in benefits.

■ *For more information, contact Gary Andes, (716) 795-3397.*



EPRI's Environmental Control Technology Center (foreground) at New York State Electric & Gas Corporation's Kintigh station

Food and Agriculture Office Expanding

EPRI's Food and Agriculture Office—now called the Food Processing Center (FPC)—is expanding in order to further advance electrotechnologies in collaboration with the food processing industry. The goals of this work are to increase productivity, improve product quality, and meet environmental challenges.

The FPC offers opportunities for EPRI member utilities and their food processing customers to become familiar with and apply beneficial electrotechnologies. The FPC will have two branches that will manage and direct R&D and technology transfer activities: one for technology development, located at the University of Minnesota's St. Paul campus under the sponsorship of Northern States Power Company and its partners, and one for technology implementation, located at the Edison Industrial Systems Center (EISC) in Toledo, Ohio, under the sponsorship of Centerior Energy Corporation.

"The Twin Cities area is the center for a number of food processing companies and the location of the University of Minnesota, which has a strong food science and agricultural engineering program," says Kevin Lawless, manager of electric marketing and product development at Northern States Power. "The FPC can leverage these resources."

Noting Centerior's close collaboration with EISC, Jim Thompson, the utility's technical support manager, says, "We recognize EISC's ability to transfer technologies. This is a natural fit to bring energy advances to the food processing industry."

According to Ammi Amarnath, an EPRI project manager, "Everyone benefits when EPRI joins with member utilities and their customers to implement energy-efficient and environmentally friendly processes for local industries." Partnerships managed by the FPC will have various collaborators, including electric utilities, research institutions, and universities, who will work together on technology development and implementation.

In the first partnership, Midwest Power in Des Moines and Iowa State University in Ames will use a state-of-the-art electron beam facility at the university to remove and destroy *E. coli* bacteria in meats. It is hoped that the results will lead to regulatory approval for widespread use of the technique.

Other areas in which the FPC is expected to advance ongoing efforts include the following:

□ Process water recovery—the use of membrane separation technology for water conservation and the treatment of liquid waste streams.

□ Freeze concentration of dairy foods—a process whereby some of the water in liquid food is converted into ice crystals, which can be recovered. A pilot facility in Fond du Lac, Wisconsin, produced freeze-concentrated dairy product samples for use in market development. Future efforts will focus on commercialization.

□ Maximizing process industry energy efficiency by using pinch technology to identify energy reduction and cost-saving opportunities. For example, properly sited industrial heat pumps result in additional energy efficiency, including the recovery of waste energy.

□ Optimizing energy use in the industrial freezing of food. Work at the University of California at Davis has generated data on magnetic resonance imaging (MRI) spectra and freezer calorimetry for use in developing a mathematical model of the freezing process. The model will help food processors use MRI technology for optimum energy efficiency and product quality during freezing.

EPRI is looking for other interested utilities and industries to collaborate on FPC projects and share in the results.

■ *For more information, contact Ammi Amarnath, (415) 855-2548.*

Power Quality

Solutions to Voltage Sag Problems

by Marek Samotyj, Power Quality Business Unit

ABSTRACT *EPRI has undertaken a number of case studies to evaluate solutions to the most important power quality concern of the 1990s—equipment sensitivity to voltage sags. Focusing on power-conditioning equipment, the studies have demonstrated the effective use of various technologies—constant-voltage transformers, magnetic synthesizers, motor-generator sets, and superconducting magnetic energy storage—to provide ride-through support for critical loads. In addition, researchers have looked at the role that equipment procurement specifications can play in helping to protect sensitive equipment against voltage sags.*

Equipment sensitivity to voltage sags has become the most important power quality concern of the 1990s. Voltage sags are defined as any reduction in ac voltage up to, but not including, the complete loss of ac power as in an interruption or outage. Power systems and the way they operate have changed very little in the past 10 years. However, today's advanced electronic end-use equipment—including microcomputers, microprocessor-based controls, adjustable-speed drives (ASDs), and robotic devices—has dramatically greater sensitivity to voltage sags than the equipment it has replaced. For example, some ASDs trip off-line for a voltage sag to 90% of nominal lasting only six cycles. The incidence of such equipment shutdowns depends on many factors that vary from situation to situation—factors like type of service, type of feeder, and geographic location—but the result is always disruptive to utility customers.

EPRI's Power Quality & Information Technology Business Unit, in conjunction with selected EPRI member utilities and Electrotek Concepts, has completed a number of case studies, and has several other studies in progress, to evaluate solutions to the voltage sag problem. Most of these studies have focused on power-conditioning equipment in end-user facilities. In the past, uninterruptible power supplies (UPSs) served as the primary protection device for sensitive equipment. UPSs typically use battery energy storage to protect loads from shutting down during voltage sags. An EPRI case study conducted at a semiconductor facility in New Mexico characterized the performance of UPSs. However, as the studies described below demonstrate, other technologies can also be used effectively to provide ride-through support for critical loads.

Constant-voltage transformers

A 1990–1992 case study with one utility involved a large semiconductor manufacturer who reported that water chillers were tripping off-line during voltage sag conditions. The problem was traced to a temperature process controller that shut down for voltage sags of 20% (i.e., to 80% of nominal). The chiller motor itself was unaffected by these voltage sags, but when the process controller tripped, the chiller was shut down. If enough chillers had gone off-line during an event, the entire manufacturing plant could have been affected.

After evaluation, it was decided to use a constant-voltage transformer (CVT), also known as a ferroresonant transformer, to improve the voltage sag ride-through capability of the process controller. CVTs are especially attractive for constant, low-power loads like process controllers. (Variable loads, especially those with high inrush currents, present more of a problem for CVTs because of the tuned circuit on the output.)

Figure 1 shows the voltage sag ride-through improvement for the temperature process controller when fed from a 120-VA CVT. Use of the CVT enables the controller to ride through voltage sags of almost 70% (i.e., down to about 30% of nominal). Also shown, for reference, is the undervoltage portion of the Computer and Business Equipment Manufacturers Association (CBEMA) curve. This curve is part of a standard developed by CBEMA—and included in IEEE Standard 446-1987—that outlines minimum over- and undervoltage specifications for computers.

A financial analysis of this CVT application shows potential net savings of $250,000 a year over the life of the equipment.

Magnetic synthesizers

At a hospital served by another utility, EPRI is evaluating a magnetic synthesizer for the protection of a CT (computerized tomography) scanner used in medical imaging. The scanner pulses an X-ray tube for longer periods than does a conventional X-ray machine, providing images the conventional machine cannot. But because the scanner is controlled by a microcomputer, it is much more susceptible to voltage variations than is conventional equipment.

Often used to protect large computers and other sensitive electronic equipment, magnetic synthesizers are electromagnetic devices that take incoming power and generate a clean three-phase ac output waveform, regardless of input power quality. They are generally used for relatively large three-phase loads; a load of at least several kilovolt-amperes is needed to make these units cost-effective.

Figure 2 compares a magnetic synthesizer's voltage sag ride-through capability, as specified by one manufacturer, with the CBEMA curve. The graph shows that a magnetic synthesizer will give sensitive equipment better ride-through capability than that specified in the CBEMA standard.

Power quality monitoring of both input and output is being conducted at the hospital in order to characterize the operation of the magnetic synthesizer. There was concern that the synthesizer would have problems with the pulsing nature of the CT scanner load, but at this writing no such problems have been reported.

Motor-generators

An industrial customer of a third utility was concerned about the sensitivity of process and clean-room equipment because of the high cost of downtime in the clean-room area. The equipment in question included manufacturing equipment for silicon wafers and support equipment for gas and fire detection. The sensitivity of this equipment closely mirrored the CBEMA curve. The sensitive loads were separated from the more conventional loads, and a motor-generator (M-G) set was used to provide ride-through support for the sensitive loads.

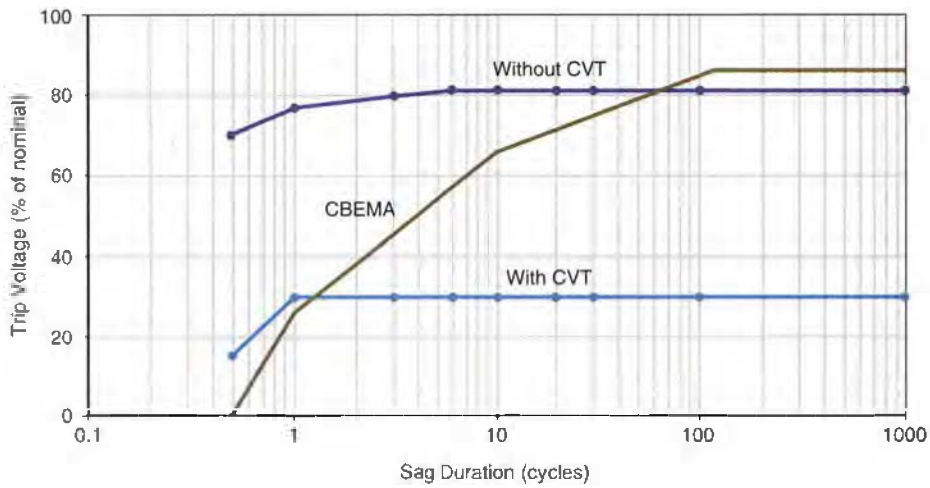
M-G sets come in a wide variety of sizes and configurations. The type used in the case study features an electric-motor-driven synchronous generator that can produce a constant 60-Hz frequency regardless of the speed of the machine. It is able to supply a constant output by continually changing the polarity of the rotor's field poles so that each revolution can have a different number of poles. Constant output is maintained as long as the rotor is spinning at a speed between 3150 and 3600 rpm. Flywheel inertia keeps the generator rotor rotating above 3150 rpm for 15 seconds after the power shuts off, which is fast enough to produce 60-Hz output under full load.

Figure 3 presents monitoring results, for a 24-hour period, of the input and output of the 35-kVA M-G set used in this 1993 case study. As shown in the figure, there was a voltage sag down to almost 86% in the input, but no voltage sags were recorded in the output and the voltage regulation remained constant.

Superconducting magnetic energy storage

Another technology being applied for power conditioning is small-scale superconducting magnetic energy storage, or micro-SMES, technology. A three-year research project with a fourth utility is examining the use of micro-SMES equipment to protect critical loads at three industrial customers—a manufacturer of plastic bags, a manufacturer of packaging material, and a third customer to be selected. The project began in late 1992.

Figure 1 Voltage sag ride-through capability of a process controller with and without a constant-voltage transformer. (The area below a curve represents conditions that can cause the equipment to trip off-line.) Without CVT protection, a sag to around 80% of nominal voltage can cause the controller to trip. With CVT protection, the controller can ride through sags down to almost 30% of nominal. The CBEMA curve showing undervoltage sensitivity specifications for computers is included for reference.



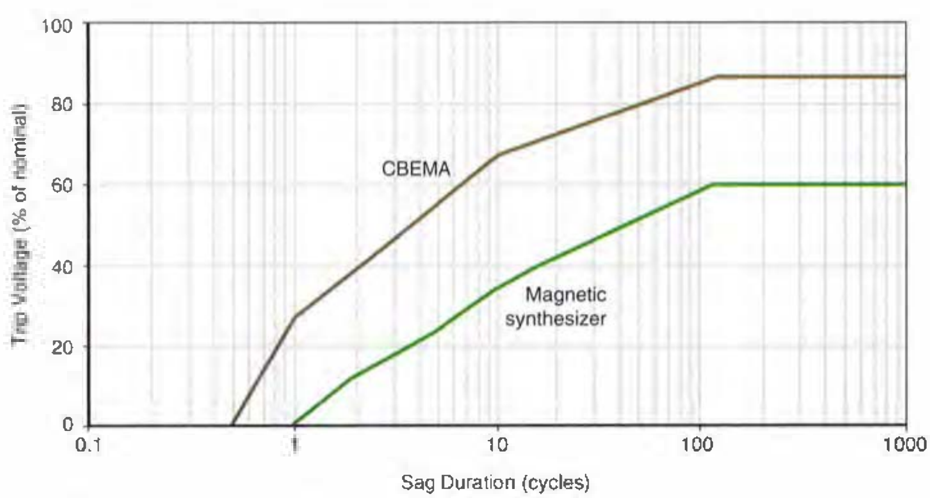
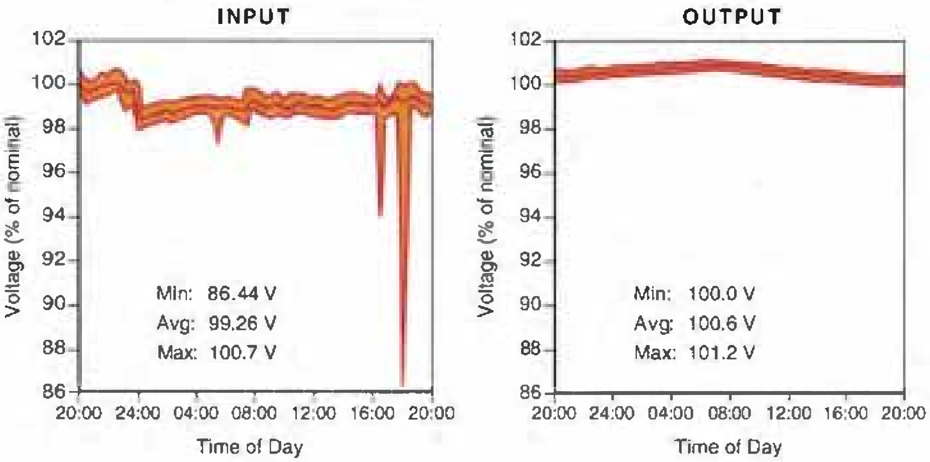


Figure 2 Voltage sag ride-through capability of a magnetic synthesizer, as specified by the manufacturer. Such a synthesizer can be used to protect sensitive equipment, resulting in ride-through performance better than that specified by the CBEMA curve.

Figure 3 Input and output voltage of a 35-kVA motor-generator set used to protect process and clean-room equipment against voltage sags. The measurements, recorded over 24 hours, show a sag down to almost 86% of nominal in the input voltage but no corresponding sag in the output.



Micro-SMES equipment uses a superconducting magnet to store energy in the same way that a UPS uses batteries to store energy. The main advantage of micro-SMES is that a much smaller space is needed for the magnet than is needed for batteries. A micro-SMES unit also requires fewer electrical connections than does a UPS, which should increase reliability and reduce maintenance. And superconducting technology allows very rapid charge-discharge cycling of the magnet.

At the first customer site, a micro-SMES system was installed to protect a group of extruders, winders, and controls used in making plastic grocery bags. The site is located on a long rural distribution feeder that experienced many voltage disturbances during the one-year test program. It was found that the overall process of converting plastic pellets into spools of plastic bag material was sensitive to even minor voltage variations. In the year of EPRI testing at this site, several improvements for the micro-SMES equipment were identified. These were implemented when the unit was installed at the second customer site in April 1994—a plant that produces reinforced container corners from recycled plastic and that has several extrusion-type loads. The result has been improved performance.

Figure 4 presents monitoring results from one of the events recorded at the second site. The left-hand graph shows a severe voltage sag in the input; the right-hand graph shows the output voltage supplied by the micro-SMES unit to the critical loads. The pickup setting for the unit in this application—i.e., the user-specified voltage level at which the unit turns on—was about 85% of nominal.

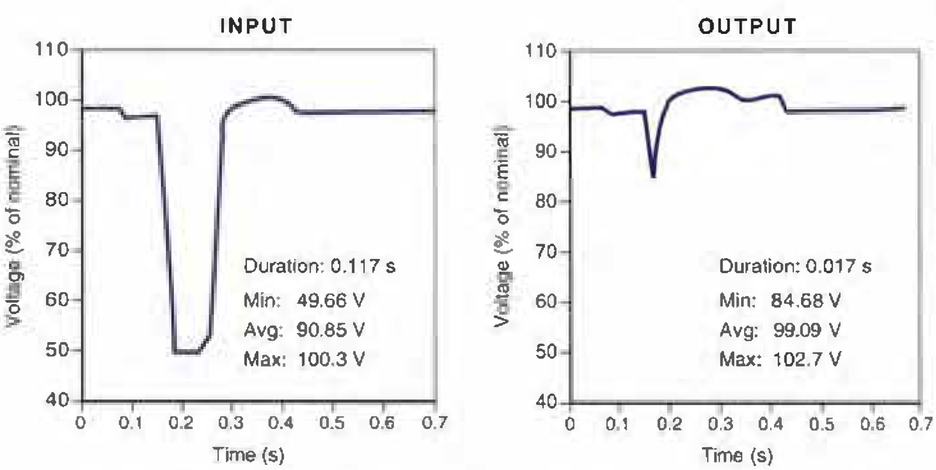


Figure 4 Input and output voltage of a superconducting magnetic energy storage unit installed at a manufacturing site to provide ride-through protection for critical loads. The input measurements show a severe sag, while measurements of the output provided by the unit to the sensitive equipment show a much smaller, shorter sag.

Equipment specifications

End users can combat voltage sag problems not only with the technologies described above but also through their equipment procurement practices. For example, they should begin to demand that equipment manufacturers provide voltage sag ride-through capability curves (similar to the CBEMA curve and the magnetic synthesizer curve shown in Figure 2) so that buyers can evaluate equipment properly.

Also, companies should establish a mechanism that rates the importance of equipment to be acquired. If the equipment is critical, adequate ride-through capability must be included at the time of purchase. If the equipment is not critical or if its malfunction will not cause major disruptions in manufacturing or jeopardize plant and personnel safety, voltage sag protection may not be justified.

Another factor to be considered is the appropriate extent of protection. The probability of experiencing a voltage sag to 70% or less of nominal is much lower than the probability of experiencing a sag to 90% of nominal. Therefore, it makes sense that the upper limit chosen for a ride-through capability specification curve should fall in the 70–75% range and no higher. The ideal value would be around 50%.

In the long run

Voltage sags are among the most important power quality problems affecting industrial and commercial customers today. Industrial processes can be particularly sensitive to relatively minor voltage sags. Utilities can improve system fault performance, but it is not possible to completely eliminate faults on a system. Therefore, customers will have to improve the ride-through capability of sensitive equipment in their facilities. That can be achieved through power conditioning or through modifications in the equipment itself.

EPRI-sponsored case studies have characterized and demonstrated several power-conditioning options. They have addressed equipment protection over a wide range—from the use of CVTs to protect small process controllers to the use of M-G sets and magnetic synthesizers to protect complete processes and the use of micro-SMES technology to protect entire facilities. More case studies will be conducted in the near future; one study now being organized will characterize the performance of an active power line conditioner for ride-through support.

Power conditioning to improve voltage sag ride-through capability can be very expensive, however. Solutions often require the protection of virtually an entire process, and when that is the case, very large energy storage devices must be used. In the long run, it will be more economical to improve the voltage sag ride-through capability of the actual process equipment itself. ASDs provide a good example: some manufacturers now have the capability to resynchronize ASD output into a spinning motor, allowing the motor's inertia to be used to ride through most voltage sag events. Ongoing EPRI power quality research is exploring both types of solutions—power conditioning and equipment enhancement (including design-level solutions).

New Contracts

Project	*Funding/ Duration*	*Contractor/EPRI Project Manager*
Customer Systems		
Activity-Based Costing (WO2343-20)	$50,000 9 months	Venture Associates/ *P. Sioshansi*
Biological Denitrification of Drinking Water for Rural Communities: Demonstration (WO2662-84)	$100,000 12 months	University of Colorado/ *M. Jones*
Municipal Water/Wastewater Project: Arsenic Treatability Options (WO2662-85)	$50,000 15 months	Fort Worth Water Department/ *K. Carnes*
Sonochemical Upgrading of Heavy Oils: Proof-of-Concept Tests (WO3245-24)	$70,000 11 months	M. W. Kellogg Co./ *A. Amarnath*
EMF Characterization of Electric Vehicles and Battery Chargers (WO3254-6)	$50,000 9 months	Power Quality & Electrical Systems/ *M. Samotyj*
Review of Demand-Side Management Evaluation Programs (WO3269-35)	$90,000 9 months	EDS Management Consulting Services/ *R. Gillman*
Local Area Expansion Screening (WO3337-22)	$160,300 10 months	Applied Decision Analysis/ *S. Chapel*
Local Area Expansion Screening (WO3337-23)	$110,000 10 months	Energy & Environmental Economics/ *S. Chapel*
Utility Resource Guide for Manufactured Homes (WO3512-18)	$59,400 6 months	Levy Partnership/ *S. Kondepudi*
Market Assessment for Duct-Sealing Technology (WO3512-22)	$50,000 5 months	Today Associates/ *S. Kondepudi*
Building Codes and Electric Vehicle Issues (WO3625-11)	$89,900 29 months	National Conference of States on Building Codes and Standards/ *G. Purcell*
Demand-Side Management Community Initiative: Ridgehaven "Green" Building (WO3737-5)	$110,000 10 months	Gottfried Technology/ *S. Baruch*
Photocatalytic Air-Cleaning System: Technical Feasibility Study (WO3742-7)	$300,000 16 months	E. Heller & Co./ *M. Jones*
Assessment of On-Site Electropyrolysis of Medical Waste (WO3742-8)	$350,000 12 months	Bio-Oxidation/ *M. Jones*
Market Penetration of Energy-Efficient Heat Pump (WO3799-3)	$112,500 5 months	American Electric Power Service Corp./ *S. Kondepudi*

Project	*Funding/ Duration*	*Contractor/EPRI Project Manager*
Environment		
Long-Term Monitoring at EBOS (Environmental Behavior of Organic Substances) Site (WO2879-38)	$1,420,800 83 months	Meta Environmental/ *A. Quinn*
EMF Exposure of Electric Utility Workers in Relation to Suggested Exposure Guidelines (WO2966-14)	$69,700 10 months	T. Dan Bracken/ *R. Kavet*
Public Perceptions of the Potential Ecological Effects of Climate Change (WO3041-16)	$250,000 14 months	Industrial Economics/ *T. Wilson*
Response of Trees to Aspects of Ozone Exposure (WO3315-2)	$102,700 9 months	Boyce Thompson Institute for Plant Research/ *L. Pitelka*
Low-Magnetic-Field Design for Transmission Lines (WO3798-4)	$129,900 11 months	J. A. Jones Power Delivery/ *R. Lordan*
Magnetic Field Management Research at the Power Delivery Center (WO3959-8)	$750,400 11 months	J. A. Jones Power Delivery/ *R. Lordan*
Utility and Industry Emission Cost Model (WO4082-1)	$198,600 12 months	ICF Resources/ *V. Niemeyer*
Area and Mobile Source Emission Cost Model (WO4082-2)	$199,800 12 months	National Economic Research Associates/ *V. Niemeyer*
Generation		
Advanced Displays and Human Factors (WO3152-27)	$110,000 10 months	Consolidated Edison Co. of New York/ *R. Fray*
Nickel Speciation Measurements at Oil-Fired Power Plants (WO3177-27)	$68,000 10 months	Carnot/ *P. Chu*
Compact Simulator With Emulated Siemens Man-Machine Interface (WO3384-19)	$140,000 17 months	PowerGen/ *R. Fray*
Demonstration of Compact Simulator Flexibility (WO3384-25)	$240,000 19 months	TRAX Corp./ *R. Fray*
Foxboro I/A Control System Emulation (WO3384-26)	$757,700 18 months	Foxboro Co./ *R. Fray*
Intelligent Tutoring System for Fossil Power Plants (WO3384-35)	$90,000 11 months	Babcock & Wilcox Co./ *R. Fray*
Compact Simulator for a Circulating Fluidized-Bed Boiler (WO3384-37)	$530,000 23 months	TRAX Corp./ *R. Fray*

Project	Funding/ Duration	Contractor/EPRI Project Manager
Sorbent Injection for Removal of Mercury From Utility Flue Gas (WO3453-7)	$74,900 9 months	Radian Corp. / *R. Chang*
Generic NO_x Control Intelligent System (WO3545-2)	$70,400 24 months	PowerGen / *J. Stallings*
Forestry Data Analysis for Wood Cofiring (WO3576-3)	$55,800 4 months	Tennessee Valley Authority / *E. Hughes*
Development of an Ash Deposition Predictive Tool (WO3667-2)	$260,000 23 months	Sandia National Laboratory / *A. Mehta*
Steam Turbine Thermal Performance Improvement (WO3849-1)	$421,000 50 months	Stress Technology / *T. McCloskey*
Design, Development, and Testing of Steam Turbine Performance Improvement Retrofits (WO3849-2)	$1,217,000 46 months	Carolina Power & Light Co. / *T. McCloskey*
Weld Repair Technology for Turbine Rotating Component (WO3963-1)	$289,900 12 months	J. A. Jones Applied Research Co. / *V. Viswanathan*
Nuclear Power		
Modeling the Ultrasonic Inspection of Reactor Components (WO2687-15)	$102,500 12 months	Iowa State University / *T. Taylor*
Design Review of RETRAN-3D (WO2853-38)	$100,000 9 months	Computer Simulation and Analysis / *L. Agee*
Evaluation of BWR Feedwater Iron Reduction Techniques (WO2977-16)	$166,400 23 months	Finetech / *P. Millett*
ASME Code Case Development for Cured-in-Place Pipe (WO3052-14)	$148,100 22 months	Proto-Power Corp. / *N. Hirota*
MAAP Code Maintenance (WO3068-10)	$263,400 12 months	Fauske & Associates / *J. Chao*
Cavitation Heat (WO3170-28)	$50,000 11 months	E-Quest Sciences / *T. Passell*
Development of Baseline Data for Equipment Qualification Condition Monitoring (WO3186-38)	$99,500 21 months	Sargent & Lundy / *F. Rosch*
Generic Seismic Technical Evaluations of Replacement Items, Phase 2 (WO3186-39)	$96,100 10 months	Vectra Technologies / *T. Mulford*
Moisture Separator/Reheater Sourcebook (WO3186-41)	$54,200 9 months	J. A. Jones Applied Research Co. / *M. Downs*
Service Water System Chemical Addition Guideline (WO3186-42)	$69,900 12 months	Puckorius & Associates / *M. Downs*
Biosphere Model Development for Spent-Fuel and High-Level Waste Disposal at Yucca Mountain (WO3294-18)	$61,300 10 months	Intera Information Technologies / *J. Kessler*
Shutdown Thermal Hydraulics Tool Kit (WO3333-16)	$59,800 9 months	Science Applications International Corp. / *P. Kalra*
Permanent Radiation Shielding Feasibility Study (WO3395-4)	$50,000 2 months	Sargent & Lundy / *H. Tang*
Development of Computerized Operability Evaluation Guidelines for Piping Systems (WO3395-5)	$50,300 7 months	Kaman Sciences Corp. / *H. Tang*
Investigation of Passive Films on Stainless Steel Using Surface-Enhanced Raman Spectroscopy (WO3468-9)	$75,100 21 months	University of California, Berkeley / *L. Nelson*
Root Cause Advisory Workstation (WO3562-1)	$150,000 15 months	FPI International / *A. Singh*
Instrument Performance Analysis Software System (WO3785-3)	$91,400 9 months	Edan Engineering Corporation / *R. James*
Enhancement of Code EDDY-2D (WO4048-1)	$137,400 13 months	Washington State University / *J. Spanner*
Development of a Service Water Corrosion Model (WO4115-2)	$50,000 9 months	Altran Corp. / *R. Mahini*
Power Delivery		
Foundation Analysis and Design Software (WO1493-14)	$63,000 12 months	J. A. Jones Power Delivery / *A. Hirany*
Revised Tutorial on Interconnected Power System Dynamics (WO1915-16)	$120,200 10 months	ECC / *D. Sobajic*
Generic Heuristic Scenario Builder for the EPRI Operator Training Simulator (WO1915-17)	$55,500 2 months	National Systems & Research Co. / *G. Cauley*

Project	Funding/ Duration	Contractor/EPRI Project Manager
Transient Behavior of Systems With FACTS Devices (WO2149-15)	$57,900 17 months	University of Waterloo / *R. Adapa*
Power System Analysis Package (PSAPAC): Advanced User Interface (WO2447-7)	$1,318,500 23 months	Powertech Labs / *P. Hirsch*
Advanced Power Transformer Prototype (WO3697-2)	$2,447,100 17 months	ABB Power T&D Co. / *S. Lindgren*
Capacity Determination of Transmission Line Structures (WO3748-8)	$149,100 9 months	J. A. Jones Power Delivery / *M. McCafferty*
Transmission Line Conductor Icing (WO3748-9)	$86,600 12 months	J. A. Jones Power Delivery / *M. McCafferty*
Damper Placement for Aeolian Vibrations (WO3748-10)	$73,000 6 months	J. A. Jones Power Delivery / *M. McCafferty*
Conductor Wind Loading Research, Phase 2 (WO3748-12)	$62,100 9 months	J. A. Jones Power Delivery / *P. Lyons*
Manhole and Service Box Full-Scale Demonstration (WO3927-7)	$84,900 3 months	General Electric Co. / *R. Bernstein*
Unified Power Flow Controller: Initial Tasks (WO4154-1)	$280,000 7 months	Westinghouse Electric Corp. / *A. Edris*
Unified Power Flow Controller: Transient Network Analyzer Scale Model (WO7006-1)	$165,000 10 months	Westinghouse Electric Corp. / *A. Edris*
Slow Release of Fungicides for Wood Pole Applications, Phase 2 (WO7017-1)	$400,800 62 months	Oregon State University / *B. Bernstein*
Strategic R&D		
New Approach to Power System Stability and Control: The Generalized Hills Method (WO8014-8)	$170,000 23 months	V&R Co., Energy Systems Research / *D. Sobajic*
Development of Diagnostic Tools for Fault Detection in Rotating Machinery; Study of Transient Heat Conduction in Laminated Thermal Coatings (WO8015-6)	$187,500 60 months	University of Illinois, Urbana / *M. Wildberger*
Coherency-Based Method for Power System Rescheduling (WO8016-8)	$108,800 21 months	Washington State University / *D. Sobajic*
Advanced Concepts in Energy Resource Scheduling and Generation Control: Constrained Dynamic Dispatch (WO8016-9)	$100,000 10 months	ESCA Corp. / *D. Sobajic*
Advanced Concepts in Energy Resource Scheduling and Generation Control: Load Frequency Control (WO8016-12)	$100,000 8 months	Network Management Technology / *D. Maratukulam*
Parallel Coordinates and Application to Analysis and Control (WO8017-8)	$70,000 11 months	Rutgers University / *M. Wildberger*
In-Service Durability of Geomembranes (WO8019-11)	$186,400 11 months	Southwest Research Institute / *D. Golden*
Assay for Dietary Exposure to Metals (WO8020-10)	$55,000 17 months	University of Wyoming / *J. Mattice*
Application of Phosphor Thermography to Waterwall Cold-Side Temperature Measurement (WO8031-2)	$89,700 18 months	Martin Marietta Energy Systems / *B. Dooley*
Application of Chaos Theory to Boiler Flame Diagnostics (WO8032-2)	$100,000 12 months	Martin Marietta Energy Systems / *J. Stallings*
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Creep/Corrosion Behavior of Alloys in Mixed Oxidants (WO8044-3)	$179,900 24 months	Commission of the European Communities / *W. Bakker*
Chemical Applications of Electrohydraulic Cavitation for Hazardous Waste Control (WO8060-10)	$72,300 12 months	California Institute of Technology / *M. Jones*
Microwave Effects on Liquid and Solid State Materials Processing (WO8060-12)	$50,000 12 months	University of Florida / *A. Amarnath*
Micellar Systems for Modulating Microwave Heating of Chemical Reaction Processes (WO8060-14)	$160,000 32 months	Massachusetts Institute of Technology / *A. Amarnath*
Welding Procedures and Evaluation of NOREM for Hydroturbine Applications (WO9000-30)	$117,900 11 months	EPRI NDE Center / *H. Ocken*
Effect of Coal Chlorine Content on Fire-Side Corrosion and Fate of Trace Elements (WO9999-1)	$693,100 31 months	PowerGen / *A. Mehta*

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CUSTOMER SYSTEMS

Transmission and Distribution Benefits of Direct Load Control: Seattle City Light and Snohomish Public Utility District Pilot Project Evaluations
TR-103993 Final Report (RP3817-1); $200
Contractor: Quantum Consulting, Inc.
Business Unit: Marketing Tools & DSM
EPRI Project Manager: G. Heffner

Characterization of Energy Storage for Transportation
TR-104559 Final Report (RP2415-31); $200
Contractor: Bechtel Group, Inc.
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EPRI Project Manager: E. Riddell

CLASSIFY-Profiles, Vol. 1: Residential Customer Needs and Energy Decision Making
TR-104567-V1 Final Report (RP4001-3); $200
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Quality Function Deployment: A Customer-Driven Process to Create and Deliver Value
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TR-104801 Final Report (RP2982-10); $200
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EPRI Project Manager: P. Sioshansi

Perceptions of Compact Fluorescent Lamps in the Residential Market: Update 1994
TR-104807 Final Report (RP3249-3); $200
Contractor: MCM Energy Research, Inc.
Business Unit: Marketing Tools & DSM
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TR-104832 Final Report (RP2034-46); $200
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Business Unit: Residential & Small Commercial
EPRI Project Manager: J. Kesselring

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TR-104890 Final Report (RP3512-4); $200
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Design Description and Performance Monitoring of the HydroTech 2000 Variable-Speed Heat Pump With Integrated Water Heating
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TR-104741 Final Report (RP2485-30); $200
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TR-104893 Final Report (RP2879-9, -12, -35; RP9024-2); $200
Contractors: META Environmental, Inc.; Atlantic Environmental Services, Inc.; Utah State University
Business Unit: Environmental & Health Sciences
EPRI Project Managers: I. Murarka, A. Quinn

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Business Unit: Environmental & Health Sciences
EPRI Project Manager: I. Murarka

GENERATION

Economic Evaluation of Particulate Control Technologies, Vol. 2: Retrofit Units
TR-100748 Final Report (RP3083-4); $10,000
Contractor: Sargent & Lundy
Business Unit: Environmental Control
EPRI Project Managers: R. Chang, R. Altman

Cycle Chemistry Guidelines for Fossil Plants: Oxygenated Treatment
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Business Unit: Fossil Power Plants
EPRI Project Manager: B. Dooley

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TR-103976 Final Report (RP3288); $10,000
Contractors: Decision Focus Inc.; Strategic Decisions Group
Business Unit: Fossil Power Plants
EPRI Project Managers: R. Fray, M. Blanco, R. Goldberg

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TR-104563-V1, TR-104563-V2 (RP9026-3); $10,000 for set
Contractor: Radian Corp.
Business Unit: Environmental Control
EPRI Project Managers: D. Owens, R. Moser

Cost Maps for Fossil Assets Management (Based on a Case Study With Minnesota Power Company)
TR-104566 Final Report (RP3288); $10,000
Contractors: Decision Focus Inc.; Strategic Decisions Group
Business Unit: Fossil Power Plants
EPRI Project Managers: M. Blanco, R. Fray, R. Goldberg

Gas Turbine and Combined-Cycle Capacity Enhancement: Second Interim Report
TR-104612 Interim Report (RP3401); $10,000
Contractor: Fern Engineering, Inc.
Business Unit: Fossil Power Plants
EPRI Project Manager: R. Frischmuth

Standard Equipment Coding for Reporting Gas Turbine Reliability
TR-104758 Final Report (RP2952-5); $10,000
Contractor: Strategic Power Systems, Inc.
Business Unit: Fossil Power Plants
EPRI Project Manager: R. Frischmuth

Creep Behavior of Modified 9% CrMo Cast Steel for Application in Coal-Fired Steam Power Plants
TR-104845 Final Report (RP1403-23); $5000
Contractor: MAN Energie GmbH
Business Unit: Fossil Power Plants
EPRI Project Manager: W. Bakker

Relaxation and Creep of NiCr Bolting Alloys for Application in Steam Turbines of Coal-Fired Power Plants
TR-104846 Final Report (RP1403-23); $5000
Contractor: MAN Energie GmbH
Business Unit: Fossil Power Plants
EPRI Project Manager: W. Bakker

Introduction to the Marginal Value Approach for Fossil Asset Management
TR-104852 Final Report (RP3288); $10,000
Contractor: Decision Focus Inc.
Business Unit: Fossil Power Plants
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EPRI Project Managers: R. Fray, M. Blanco, R. Goldberg

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Business Unit: Fossil Power Plants
EPRI Project Managers: R. Fray, M. Blanco, R. Goldberg

Field Testing of the T-180/210-130 District Heating Turbine at Vilnius Power Plant 3, Lithuania
TR-104958 Final Report (RP2819-30); $10,000
Contractor: Joseph Technology Corp., Inc.
Business Unit: Fossil Power Plants
EPRI Project Managers: W. Piulle, E. Petrill

NUCLEAR POWER

Recommended Practices: Cured-in-Place Pipe Liner for Rehabilitation of Service Water Piping
TR-103992 Final Report (RP3052-10); $50,000
Contractor: Northeast Utilities Service Co.
Business Unit: Nuclear Power
EPRI Project Manager: G. Adams

Radiographic Image Storage and Restoration
TR-104044 Final Report (RP3343-1, -11, -13); $5000
Contractors: The Better Image; High Energy Services Corp.; Polestar Applied Technology, Inc.; Grove Engineering, Inc.
Business Unit: Nuclear Power
EPRI Project Managers: J. Carey, M. Lapides

Experience With the Use of Programmable Logic Controllers in Nuclear Safety Applications
TR-104159 Final Report (RP3406-4); $1000
Contractor: ABB Combustion Engineering Nuclear Operations
Business Unit: Nuclear Power
EPRI Project Manager: J. Naser

Development of Macrocycle Purification Systems for PWR Secondary Water
TR-104207 Final Report (RP3500-21); $200
Contractor: IBC Advanced Technologies
Business Unit: Nuclear Power
EPRI Project Manager: P. Paine

ORAM™ Dial-CAFTA: User's Manual (Version 2.0 for Windows)
TR-104277 Final Report (RP3333-10, RP3896, RP3342, RP3531); license required
Contractors: ERIN Engineering and Research, Inc.; Safety Management Services, Inc.; Science Applications International Corp.
Business Unit: Nuclear Power
EPRI Project Manager: P. Kalra

Nuclear Plant Life Cycle Management Economics
TR-104326 Final Report (RP2643-35); $10,000
Contractors: Grove Engineering, Inc.; Polestar Applied Technology, Inc.
Business Unit: Nuclear Power
EPRI Project Managers: J. Carey, M. Lapides

Stress Corrosion Cracking of Alloys 182, 82, and 72 Weld Metals in BWRs: Literature Review
TR-104740 Interim Report (RP2293-1); $10,000
Contractor: ABB Atom AB
Business Unit: Nuclear Power
EPRI Project Manager: J. Nelson

Advanced Technology Training System (ATTS) Authoring Manual (Joint EPRI-CRIEPI Human Factors Studies)
TR-104743 Final Report (RP3111-78); license required
Contractor: Galaxy Scientific Corp.
Business Unit: Nuclear Power
EPRI Project Manager: L. Hanes

Development and Testing of an On-Line Iron Probe
TR-104816 Interim Report (RP3173-3, RP3388-7); $200
Contractor: Babcock & Wilcox Co.
Business Unit: Nuclear Power
EPRI Project Manager: P. Millett

Reactor Pressure Vessel Thermal Annealing Assessment for Two PWR Plant Designs
TR-104934 Final Report (RP3475-2); $5000
Contractor: Westinghouse Electric Corp.
Business Unit: Nuclear Power
EPRI Project Manager: R. Carter

Electrochemical Potential Monitoring in the PWR Secondary Cycle of St. Lucie 2
TR-104951 Final Report (RPS416-2); $200
Contractor: NWT Corp.
Business Unit: Nuclear Power
EPRI Project Manager: P. Millett

POWER DELIVERY

Static Electrification in the External Oil Circulation System of Power Transformers
TR-102112 Final Report (RP1499-16); $5000
Contractor: Cooper Industries, Inc.
Business Unit: Substations, System Operations & Storage
EPRI Project Manager: S. Lindgren

Nonlinear Control and Operation of FACTS: Methodologies and Basic Concepts
TR-103398 Final Report (RP4000-6); $200
Contractor: Oregon State University
Business Unit: Substations, System Operations & Storage
EPRI Project Manager: D. Maratukulam

POWERCOACH®: An Intelligent Decision System for Evaluating Bulk Power Transactions
TR-104394 (RP3581); $10,000
Contractor: Strategic Decisions Group
Business Unit: Utility Resource Planning & Management
EPRI Project Manager: L. Rubin

A Primer on Electric Power Flow for Economists and Utility Planners
TR-104604 Final Report (RP2123-19); $200
Contractor: Incentives Research, Inc.
Business Unit: Substations, System Operations & Storage
EPRI Project Manager: S. Chapel

Electrical Performance of Conductive Suits
TR-104640 Final Report (RP2472); $5000
Contractor: General Electric Co.
Business Unit: Transmission
EPRI Project Manager: P. Lyons

Error Reduction in State Estimator Measurements and Modeling Parameters
TR-104643 Final Report (RP2473-57); $200
Contractor: Industrial Research and Development Corp.
Business Unit: Substations, System Operations & Storage
EPRI Project Manager: D. Sobajic

State Estimation Issues: External System Modeling Enhancements, Vols. 1 and 2
TR-104644-V1, TR-104644-V2 Final Report (RP3355-1); $5000 for set
Contractor: Macro Corp.
Business Unit: Substations, System Operations & Storage
EPRI Project Managers: G. Cauley, D. Sobajic

Guidelines for the Life Extension of Substations
TR-105070 Final Report (RP2747-9); $5000
Contractors: Sargent & Lundy; Harold Moore and Associates; Doble Engineering Co.
Business Unit: Substations, System Operations & Storage
EPRI Project Managers: J. Porter, M. Hammam

Transmission Services Costing Framework, Vols. 1 and 2
TR-105121-V1, TR-105121-V2 Final Report (RP3216-1); $200 for set
Contractors: CSA Energy Consultants; Putnam, Hayes & Bartlett, Inc.
Business Unit: Substations, System Operations & Storage
EPRI Project Manager: A. Vojdani

STRATEGIC R&D

Mixed Oxidant Corrosion in Nonequilibrium Syngas at 540°C
TR-104228 (RP8041-1); $200
Contractor: Lockheed Missiles & Space Co., Inc.
Business Unit: Strategic R&D
EPRI Project Manager: W. Bakker

Pipelines to Power Lines: Gas Transportation for Electricity Generation
TR-104787 Proceedings (RP3201-6); $95
Contractor: Energy Ventures Analysis
Business Unit: Strategic R&D
EPRI Project Manager: J. Platt

Environmental Measurements With an FM Spectroscopic Fast Chemical Sensor, Vols. 1 and 2
TR-104805-V1, TR-104805-V2 Final Report (RP8004-8); $200 each volume
Contractor: SRI International
Business Unit: Strategic R&D
EPRI Project Manager: A. Hansen

EPRI Events

SEPTEMBER

19–21
International Conference on Remediation of Contaminated Sites
Prague, Czech Republic
Contact: Ishwar Murarka, (415) 855-2150

25–26
Feedwater Heater Technology Seminar
Kansas City, Missouri
Contact: Linda Nelson, (415) 855-2127

27–28
EPRI/DOE Wind Turbine Verification Program
Fort Davis, Texas
Contact: Earl Davis, (415) 855-2256

27–28
Feedwater Heater Technology Symposium
Kansas City, Missouri
Contact: Linda Nelson, (415) 855-2127

28
Risk Analysis of Surface Water Quality and Thermal Issues
Palo Alto, California
Contact: Bob Goldstein, (415) 855-2593

28–29
Strategic Asset Management for a Competitive Utility Environment
Denver, Colorado
Contact: Mikie Alves, (415) 854-9000

28–29
12th Annual Operational Reactor Safety Engineering and Review Groups Workshop
Baltimore, Maryland
Contact: Susan Bisetti, (415) 855-7919

OCTOBER

5–6
Decision Analysis for Environmental Risk Management
Palo Alto, California
Contact: Mimi Warfel, (415) 926-9227

10–12
Achieving Success in Restructuring Electricity Markets
Atlanta, Georgia
Contact: Susan Bisetti, (415) 855-7919

12–13
Live Working 2000 Workshop
Lenox, Massachusetts
Contact: Jeanne Heil, (413) 499-5701

12–13
Pollution Prevention Applications
Irving, Texas
Contact: Lynn Stone, (214) 556-6529

12–13
Seminar on UCA (Utility Communications Architecture) Version 2
St. Petersburg, Florida
Contact: Lori Adams, (415) 855-8763

18–20
Magnetic Field Management
Lenox, Massachusetts
Contact: Gary Johnson, (413) 499-5712

18–20
1995 Fuel Supply Seminar
New Orleans, Louisiana
Contact: Susan Bisetti, (415) 855-7919

18–20
Risk Management in Competitive Markets
Kansas City, Missouri
Contact: Susan Marsland, (415) 855-2946

25–27
EPRI Conference on New Power Generation Technology
San Francisco, California
Contact: Linda Nelson, (415) 855-2127

NOVEMBER

1–3
PWR Plant Chemists Meeting
Orlando, Florida
Contact: Barbara James, (707) 823-5237

6–8
Radiation Field Control Conference and Decontamination Seminar
Tampa, Florida
Contact: Lori Adams, (415) 855-8763

6–9
6th Conference on Decision Analysis for Utility Planning and Management
San Diego, California
Contact: Charlie Clark, (415) 855-2994

7–9
Distributed Control Systems Retrofit Workshop
Knoxville, Tennessee
Contact: Susan Bisetti, (415) 855-7919

8–9
Control Coordination Between Power Plants and Energy Control Centers
Knoxville, Tennessee
Contact: Susan Bisetti, (415) 855-7919

15–16
Opportunity Knocks: The Changing World of Energy Services
Palm Springs, California
Contact: June Appel, (610) 667-2160

28–30
1995 EPRI International Clean Water Conference
La Jolla, California
Contact: Lori Adams, (415) 855-8763

28–30
Utility Motor and Generator Predictive Maintenance and Refurbishment
Orlando, Florida
Contact: Susan Bisetti, (415) 855-7919

DECEMBER

4–7
Reliability-Centered Maintenance
Newport Beach, California
Contact: Denise Wesalainen, (415) 855-2259

5–6
Vitrification of Low-Level Waste: The Process and Potential
San Antonio, Texas
Contact: Denise Wesalainen, (415) 855-2259

6–8
Meeting Customer Needs With Heat Pumps—1995
St. Louis, Missouri
Contact: Linda Nelson, (415) 855-2127

6–8
Polymer Technology Workshop
Palo Alto, California
Contact: Bruce Bernstein, (202) 293-7511

6–8
Seminar on Resource Planning in a Competitive Environment
Phoenix, Arizona
Contact: Lynn Stone, (214) 556-6529

12–14
North American Electric Vehicle and Infrastructure Conference
Atlanta, Georgia
Contact: Lori Adams, (415) 855-8763

FEBRUARY 1996

5–7
Substation Equipment Diagnostics Conference IV
New Orleans, Louisiana
Contact: Denise Wesalainen, (415) 855-2259

MARCH

19–21
Managing for Biodiversity: Emerging Ideas for the Electric Utility Industry
Williamsburg, Virginia
Contact: Christy Lillie, (415) 855-2010

APRIL

9–11
The Future of Power Delivery
Washington, D.C.
Contact: Lori Adams, (415) 855-8763

MAY

8–10
CEM (Continuous Emissions Monitoring) Users Group Meeting
Kansas City, Missouri
Contact: Linda Nelson, (415) 855-2127

22–24
1996 Heat Rate Improvement Conference
Dallas, Texas
Contact: Susan Bisetti, (415) 855-7919

EPRI JOURNAL

July/August 1995

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PAID
PERMIT NUMBER 181
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in the United States of America

EJ-105338