Environmental Management

EPRI JOURNAL

MARCH/APRIL 1998

Advanced Metering

Distributed Resources

About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 700 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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EPRI Journal Staff and Contributors

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LESLIE LAMARRE, *Senior Feature Writer*
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JEAN SMITH, *Editorial Assistant/Circulation*
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JANET L. RUNYAN, *Director, Communications*
CLARK W. GELLINGS, *Vice President, Client Relations*

Address correspondence to:
Editor-in-Chief
EPRI Journal
P.O. Box 10412
Palo Alto, CA 94303

The EPRI Journal is published six times each year. For information on subscriptions and permissions, call (650) 855-2300. Please include the code number from your mailing label with inquiries about your subscription.

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COVER: On-site microturbines, fuel cells, and other small generation units will soon allow customers to cover their energy needs independently of the power grid and in some cases even feed electricity onto the grid for sale. (Illustration by Ron Magnes)

EPRI JOURNAL

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Editorial

A Need for Public-Private Cooperation

The U.S. electric power industry is going through its most fundamental restructuring in a century, a restructuring marked by increasing competition at all levels of the electricity enterprise. Over the next decade, changes in the industry are likely to be driven by three competitive-market demands: electricity cost reduction, which will enable U.S. industries to compete more effectively in global markets; enhanced electric reliability, which will help meet the power quality needs of an increasingly digital society; and the customization of utility services, including both the diversification of pricing structures and the convergence of traditionally distinct consumer services.

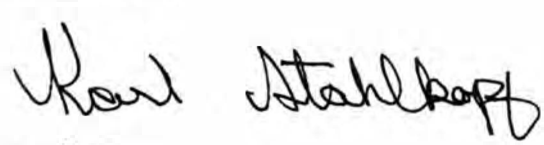
Meeting the challenges of a competitive market will require both institutional and technological responses. One example of efforts to coordinate these responses is the work of the Secretary of Energy Advisory Board's Electricity System Reliability Task Force, of which I am a member. The task force has already prepared a position paper dealing with institutional issues related to restructuring, and another paper—devoted to technical issues—is currently being drafted. Together, these position papers will provide a broad overview of how industry and government can work together to bring about a smooth transition to more-competitive electricity markets.

One of the major institutional questions addressed by the task force has been how to maintain power system reliability at a time when the need to reduce costs is driving up the volume of bulk power transactions. In several parts of the country, independent system operators (ISOs) are taking over control of transmission networks under agreements with the grid owners. In other regions, utilities have separated their transmission operations from their generation and retail business. There is considerable uncertainty, however, about whether the North American Electric Reliability Council (NERC) has the power to require ISOs and other transmission owner-operators to comply with its standards.

To resolve this issue, the task force has recommended that Congress adopt legislation that would enable the Federal Energy Regulatory Commission to invest a self-regulating organization—presumably NERC—with the authority to regulate the operations of its members. If such authority were granted, NERC could make its rules and procedures mandatory and could tie system reliability to measurable performance standards.

Successful restructuring of the industry in response to market forces will also require the use of advanced technology. Innovative approaches are particularly needed to resolve the sometimes conflicting demands for lower costs and higher reliability and to supply the customized services demanded by electricity consumers, who are being offered greater choice among retail service providers. Already, for example, some providers are experimenting with the real-time pricing of electricity and are seeking ways to integrate electric power service with such other services as gas, cable, and telecommunications.

Although the task force position paper addressing such technical issues has not yet been completed, support is building for private-sector leadership of electric power R&D, with the U.S. Department of Energy monitoring this effort and identifying potential research gaps. I would like to go a step further by urging increased coordination of public and private research efforts in this area. EPRI is already working with DOE and other stakeholders on an Electricity Technology Roadmap initiative that is designed to extend our technical horizon and encourage a broader collaborative research effort. Given the scope and complexity of the R&D required, I believe such public-private research cooperation will be vital to ensure that technologies are available to help meet the challenges of more-competitive electricity markets over the next decade.



Karl Stahlkopf
Vice President, Energy Delivery and Utilization

Contributors

Emerging Markets for Distributed Resources (page 8) was written by Taylor Moore, *Journal* senior feature writer, with principal assistance from two members of EPRI's Energy Conversion Division.

DAN RASTLER, manager for strategic options, came to EPRI in 1981 as a project manager for fuel cell systems. Previously he spent five years with General Electric Company's Nuclear Energy Division, four years in the U.S. Air Force, and one year with Toscopetro Corporation. Rastler received a BS degree in chemical engineering from the University of California at Davis and an MS in mechanical engineering from UC Berkeley.

DOUG HERMAN, manager for fuel cell evaluation, joined EPRI in 1993. Previously he spent 10 years with Pacific Gas and Electric Company in San Francisco, where he managed various engineering projects. Herman received a BS in mechanical engineering from the University of Santa Clara and an MS in energy and resources from the University of California at Berkeley.

The Future of Metering (page 18) was written by science writer John Douglas with assistance from two members of EPRI's Energy Delivery and Utilization Division.

DAVE RICHARDSON is currently target manager for advanced metering activities. Before joining EPRI in 1993, he was director of electrical engineering at U.S. Windpower; during his seven-year tenure there, he was involved in electrical system design and development for over 4000 wind turbines. Earlier he was employed by Wulfsburg Electronics and Black & Veatch. Richardson received BS degrees in both physics and electrical engineering from the University of Kansas, an MS in electrical engineering from the University of Missouri, and a PhD in electrical engineering from Kansas State University.

LARRY CARMICHAEL, manager for distribution system communications and controls, came to EPRI after two years as a project manager at Science Applications International Corporation. Earlier he was a project manager at Systems Control and worked as a principal engineer at General Electric Company's nuclear utility operation in San Jose, California. Carmichael holds a BS in chemical engineering from the University of California at Berkeley and an MS in mechanical engineering from Stanford University.

Environmental Management With ISO 14000 (page 24) was written by science writer Steven Voien with technical information from two of EPRI's environmental experts.

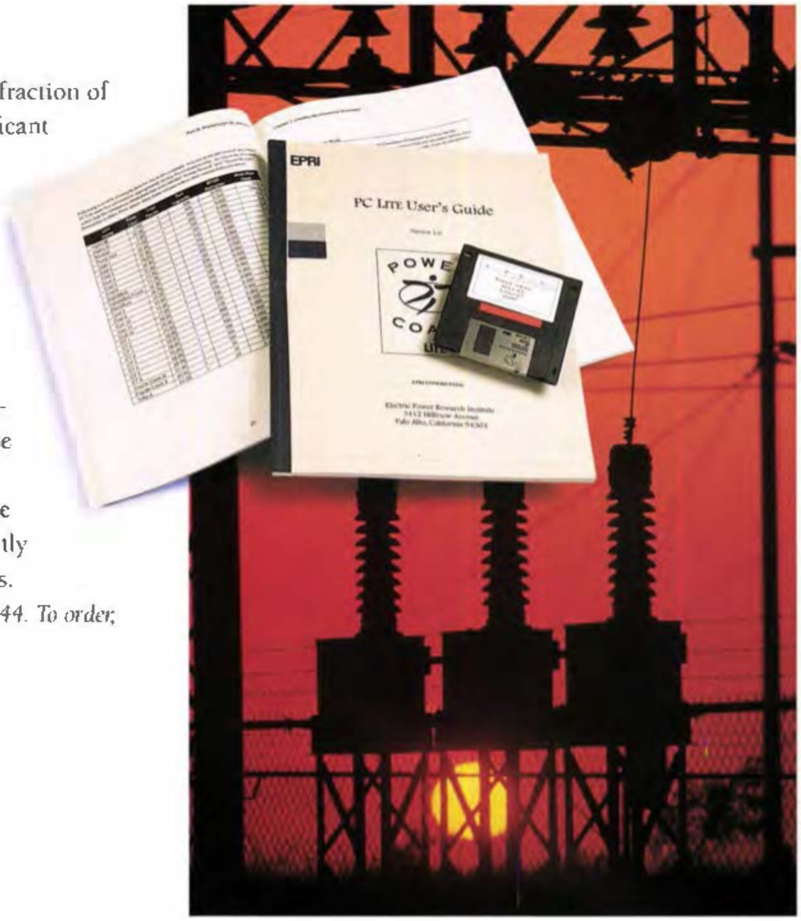
PAUL RADCLIFFE, manager of environmental support services, has been with EPRI since 1987, working as a project manager in the areas of industrial site redevelopment, air pollution control technology and economics, and pollution prevention. Earlier he was with Bechtel Corporation for 18 years, working on a variety of fossil power plant projects, and with Babcock & Wilcox Company for 2 years as a field service engineer. Radcliffe received a BS in mechanical engineering from the Illinois Institute of Technology and an MBA from Golden Gate University.

WINSTON CHOW, leader of the land and water product line, joined EPRI in 1979. Before that, he spent seven years as a power plant design engineering supervisor at Bechtel Corporation. Still earlier, he worked for Raychem Corporation on polymer research and development. Chow holds two degrees in chemical engineering—a BS from the University of California at Berkeley and an MS from San Jose State University—and an MBA from San Francisco State University.

Products

Deliverables now available to EPRI members and customers

POWERCOACH Lite



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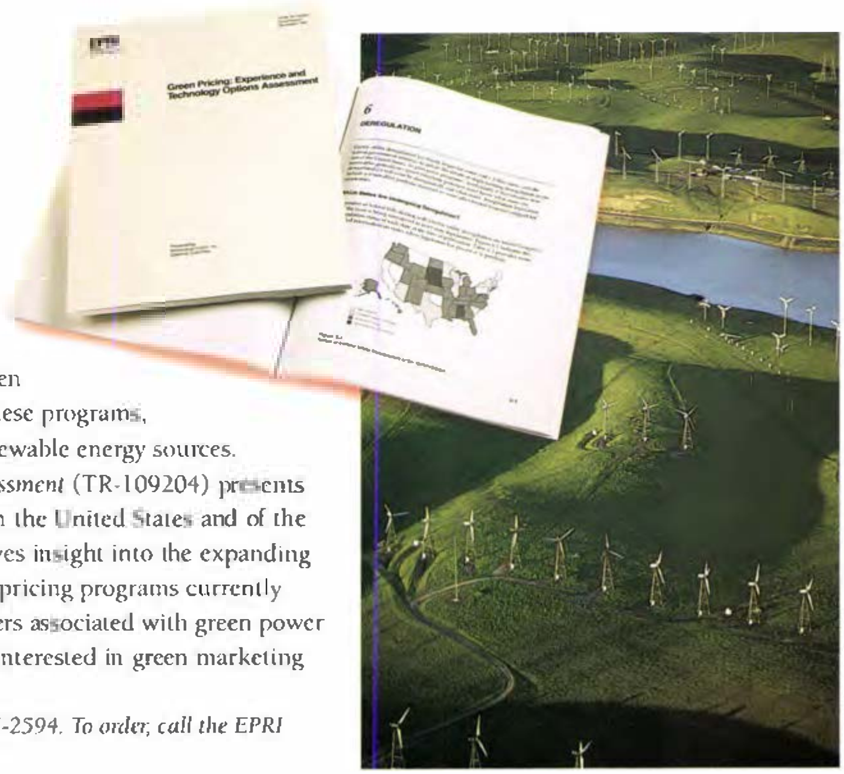
Although bulk power transactions are typically a small fraction of total revenues for utilities, they can represent a significant fraction of net earnings, adding tens of millions of dollars to the bottom line. Given the growth and accelerating pace of today's trading activity, however, power companies face a difficult challenge in balancing profit opportunities against risks. Based on EPRI's POWERCOACH® software, which has significantly influenced the way many utilities think about and analyze power marketing opportunities, POWERCOACH Lite is a spreadsheet program that is faster, more flexible, and easier to use and customize than its predecessor. This state-of-the-art decision support system helps trading analysts evaluate the benefits and risks of prospective deals quickly and efficiently and increases their ability to market their generating assets.

■ *For more information, contact Victor Niemeyer, (650) 855-2744. To order, call the Electric Power Software Center, (800) 763-3772.*

Insider Heat Pump

Developed by Consolidated Technology Corporation of Olive Hill, Kentucky, in collaboration with EPRI and the National Rural Electric Cooperative Association, this highly efficient, self-contained heat pump was originally designed to provide heating and cooling for manufactured homes. With the introduction of a new series of upflow models, use of the Insider is also becoming popular in apartments, condominiums, hotels, and schools. Unlike conventional heat pumps, which include outdoor units, the compact Insider system fits entirely within a utility closet. Affordable and quiet, it is efficient enough to be appropriate for many utility incentive programs. Developers of multifamily housing complexes point to another of the Insider's advantages: it allows the energy used in individual apartments and condominiums to be metered separately.

■ *For more information, contact Carl Hiller, (650) 855-8950. To order, call Consolidated Technology Corporation, (606) 286-5366.*



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Green Pricing Report

Spurred by customer demand, an increasing number of utilities have begun implementing green pricing programs over the past two years. Through these programs, customers pay a premium to support power from renewable energy sources. *Green Pricing: Experience and Technology Options Assessment* (TR-109204) presents an overview of the status of green pricing programs in the United States and of the renewable technologies used in those programs. It gives insight into the expanding market for green energy, examines the types of green pricing programs currently offered around the country, discusses issues and barriers associated with green power marketing, and presents recommendations for those interested in green marketing or in creating a green pricing program.

■ *For more information, contact Terry Peterson, (650) 855-2594. To order, call the EPRI Distribution Center, (510) 934-4212.*

Office Complexes Guidebook

In the United States, office buildings form the largest component of the commercial energy-use sector, which spends about $65 billion annually on utility bills. The *Office Complexes Guidebook* (TR-109450) provides utility marketing staff with 28 electricity solutions to typical problems encountered in office buildings. Each strategy is illustrated with an example drawn from actual experience. The solutions are based on innovative electrotechnologies that can improve the quality of energy service, reduce energy costs, enhance comfort, boost productivity, and increase electrification in existing and new buildings.

■ *For more information, contact Karl Johnson, (650) 855-2183. To order, call the EPRI Distribution Center, (510) 934-4212.*

Product Life-Cycle Management

Providers of energy services are rapidly introducing a wide variety of new products and services that are radically different from their traditional offerings. As a result, these providers now manage an increasingly diverse set of offerings in various life-cycle stages. This report, *Product Life-Cycle Management* (TR-108984), provides an understanding of the marketing and management techniques that are appropriate for each stage, allowing energy service providers to extend the life of successful product lines and optimize the profitability of their portfolio of offerings. The report draws heavily on examples from other competitive industries.

■ *For more information, contact Burk Kalweit, (650) 855-2329. To order, call the EPRI Distribution Center, (510) 934-4212.*

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Project Startups

New ventures of importance to power and service providers

EPRI Center Aims for More Efficient Semiconductor Manufacturing

Reducing energy costs for semiconductor manufacturing is a key goal of one of the first projects of the EPRI Center for Electronics Manufacturing. Established last fall with SEMATECH—the nonprofit semiconductor research consortium—the new center is addressing productivity, environmental, and energy issues in the electronics industry. The initial projects of the center, which is located at SEMATECH's headquarters in Austin, Texas, will focus primarily on the semiconductor industry.

More than 15 semiconductor plants worldwide (including facilities in the United States, Taiwan, South Korea, France, the Netherlands, and Singapore) are participating in the project to reduce energy costs. Each plant's energy use, electrically powered equipment, and facility designs have been evaluated to identify opportunities for savings. To ensure accurate comparisons between plants, pilot surveys were conducted at two of the facilities, an energy measurement template was compiled, and a weather normalization model was developed.

By January of this year, all the sites had submitted raw data for compilation. A report covering these results and identifying the best practices at the facilities is scheduled to be released this summer. Also planned is the formation of a users group for semiconductor manufacturers and their equipment suppliers. Participants in the group will share information and discuss how to redesign manufacturing equipment for better energy efficiency.

A final report that identifies and prioritizes ways to improve efficiency is expected to be released in the fall. The report will include recommendations on equipment installation techniques that can reduce the cost of wiring, breakers, and other electrical equipment.

According to Bill Smith, EPRI's manager for the new center, the goals of this project are to present strategies for reducing energy consumption at the plants by 15% and to help ensure that the next generation of manufacturing equipment will be designed for increased energy efficiency. This partnership between the electric power and semiconductor industries provides benefits for both: semiconductor manufacturers will save energy dollars, and the power industry will gain important knowledge about the energy consumption patterns and requirements of an important market segment.

Results from the project will also be useful to other industries that employ clean rooms, says Smith. These include pharmaceutical manufacturers, biotechnology companies, chemical laboratories, aerospace firms, and other electronics manufacturers.

Among the other projects now under way at the center is one on the use of advanced electrotechnologies—for example, photocatalytic ultraviolet filtration and electrolytic deionization—to help reduce the amount of water required for semiconductor manufacturing.

■ *For more information, contact Bill Smith, (650) 855-2415.*

EPRI Responds to TRI Reporting Requirement

EPRI is developing a comprehensive technical resource guide to help electric power companies accurately estimate and report their discharges of toxic chemicals. This project is part of a major EPRI effort to help the industry respond to new emissions reporting requirements.

Starting this year, power producers with coal- and oil-fired generating plants are required to estimate their releases of specific chemicals (including arsenic, chromium, and zinc) into the air, land, and water. This information is submitted to the U.S. Environmental Protection Agency on its Form R and goes into a multi-industry database known as the Toxics Release Inventory (TRI). The EPA maintains this database and makes the information publicly available. The intent is to enable local emergency response teams to react quickly and decisively during accidental releases and to encourage industries to reduce their emissions voluntarily.

A facility is required to submit estimates even if the estimates are zero. Form R submissions containing 1998 data are due to the EPA by July 1, 1999. Facilities that fail to file the form can be fined as much as $25,000 per day.

EPRI's TRI coordinator, Barbara Toole-O'Neil, points out that the inventory documents only the quantities of chemicals discharged and does not address associated health risks. The health risk issue is important to communicate, she continues, since some substances that utilities generate in large quantities, such as gas-phase acids, are believed to pose minimal risks.

Effective communication about health risks is just one of the many issues that will be addressed in the TRI technical resource guide EPRI is now developing. Data quality, data sources, and estimation methods will also be covered. The aim is to help make TRI reporting easier, more accurate, and less costly. Specific sections of the guide will be made available on-line via EPRIweb as they are completed later this year.

EPRI and other power industry organizations responded swiftly when the EPA released a draft of the new industry reporting requirements last July. EPRI's comments on the draft were carefully considered by the EPA in revising the document. Since then, EPRI has continued its efforts to ensure that sound technical information is available.

A number of EPRI products are helping member companies fulfill the reporting requirements. For instance, EPRI has developed a TRI software spreadsheet and an accompanying report to help utilities review commercially available TRI reporting software. Other useful products include the PISCES database and model, which utilities can use to simulate power plant releases; the *Emissions Factors Handbook* (TR-105611), which provides guidance on estimating stack releases of trace substances; and the COFERS software for predicting the chemical composition of solid-waste streams.

■ *For more information, contact Barbara Toole-O'Neil, (650) 855-1005.*

Robot Under Development for Removing Manhole Covers

Smoke, fires, and explosions in manholes are problems that utilities with extensive underground electrical systems periodically face. In order for fire-extinguishing or other measures to be implemented in such a situation, the manhole cover must be removed. When it is removed, however, the flow of oxygen into the underground structure can trigger an explosion.

According to EPRI's Ralph Bernstein, electric utilities experience about one major event (typically an explosion) for every 10,000 manholes per year. Minor events, including smoke and small fires, are more frequent, occurring 10–50 times more often. Current industry practice is for workers to use metal hooks to remove manhole covers, but researchers are working on a better alternative for performing this task: a remotely controlled robot that would keep all workers at least 20 feet away from a potential explosion.

Together with Consolidated Edison Company of New York, EPRI is funding the development of a prototype robot for removing manhole covers. Early in March, researchers tested a remotely controlled robot that Foster-Miller has developed to help the police diffuse bombs. Called the ferret, this robot is equipped with a beltlike traction system similar to that of a snowmobile—a feature that enables it to climb stairs and crawl over obstacles.

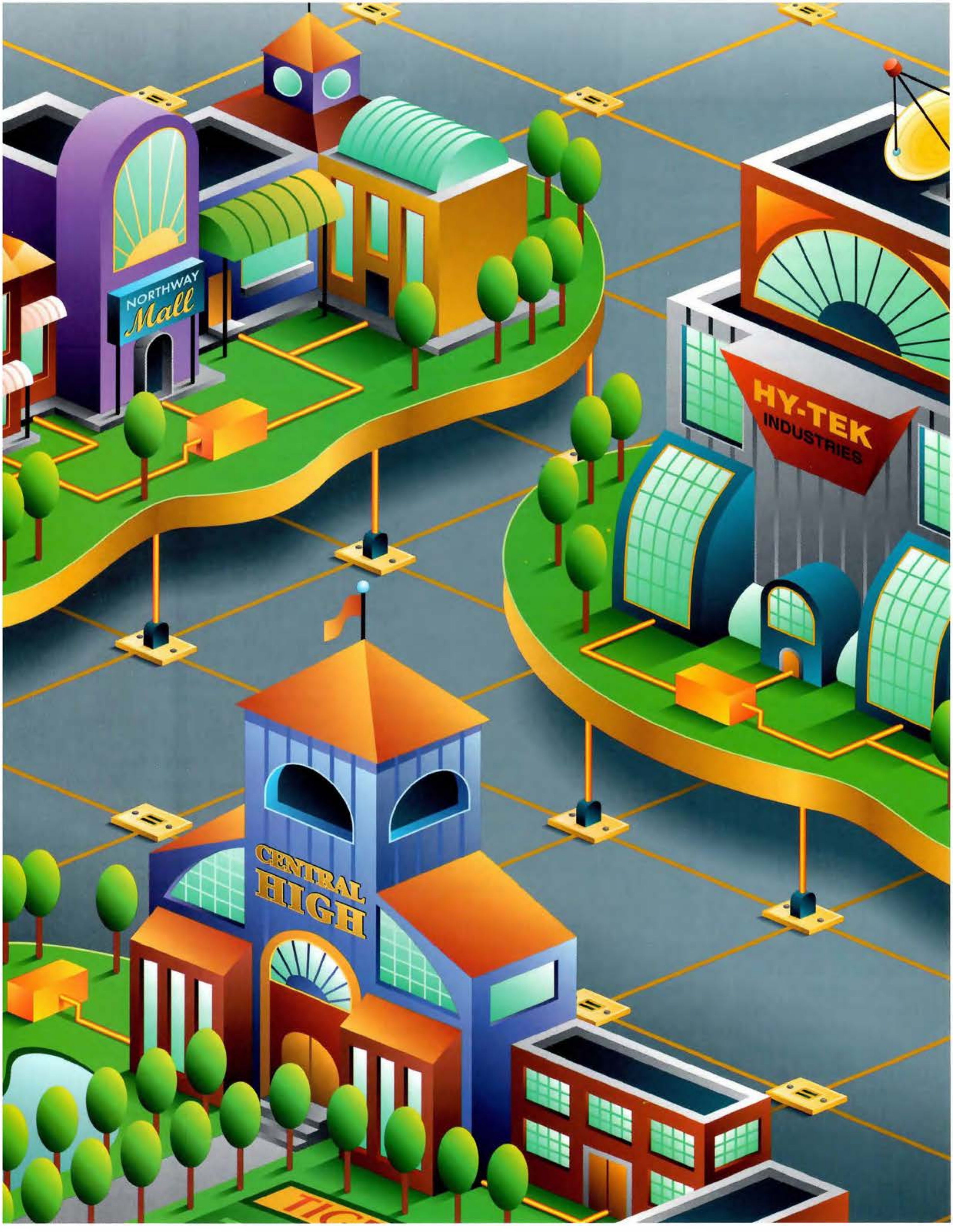
Says Bernstein, who is managing the robot project for EPRI, utilities would like to modify the ferret to make it more rugged, cheaper, and directly applicable to manhole work. Specifically, the new robot would incorporate an impact device to free covers and an electromagnet capable of lifting 9000 pounds. Also, says Leonard Burshtein, Consolidated Edison's manager for the project, the device would most likely include wheels so that it could move more swiftly. "During a single event, you might have several manholes smoking," explains Burshtein, noting that most of his utility's 225,000 manholes lie 300–600 feet apart.

The idea is for the robot to be hauled like a trailer and parked about 20 feet from the manhole of concern. A utility worker could then operate the device remotely. Because radio interference is common in the densely populated urban areas where this technology would most likely be used, a communications cable would provide the remote control capability.

Burshtein believes utilities might also be interested in using the technology on a routine basis—even for nonemergency manhole cover removal. As he points out, a single manhole cover weighs about 300 pounds, and the dirt and other debris that get caked in and around a cover can add to the difficulty of removing it.

Researchers are using the results of the field tests early this year to plan the prototype system, which they expect will be ready for its own field testing this fall.

■ *For more information, contact Ralph Bernstein, (650) 855-2023.*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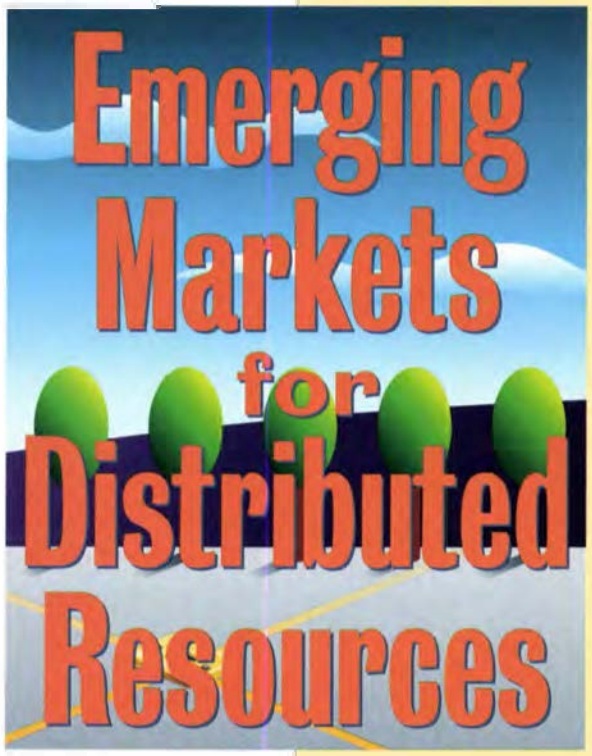
THE STORY IN BRIEF Producing electricity economically, efficiently, and reliably in small, geographically dispersed units, new technologies like fuel cells and microturbines promise to transform the landscape of power generation in a deregulated, competitive future energy services market. Such distributed generators, coupled with advanced energy storage devices, represent critical enabling technology for a utility industry in the process of restructuring. Some energy companies are already laying strategic plans to use distributed resources to create customized service offerings that can meet a variety of customer needs, including premium power, peak power, and cogeneration requirements. EPRI offers a giant portfolio of information and analytical tools that can sharpen the competitive edge of utilities pursuing the new business opportunities posed by the advent of pint-size power plants and other distributed resources.



by Taylor Moore

The topography of the U.S. electricity supply system could be about to change in a big way. Much as computer technology has evolved from centralized, mainframe systems to distributed networks of various computing platforms, the traditional paradigm of central-station utility generating plants is making room—in anticipation of a deregulated, competitive retail market for energy services—for a strategic vision of smaller, distributed resources.

Today, central-station fossil and nuclear plants supply 87% of the electricity used in the United States; most of this electricity is generated by coal-, oil-, and gas-fired plants that, on average, are 30 years old. Despite increasing environmental constraints, these aging fossil generating plants continue to provide efficient and reliable service. It is uncertain what form of generation will replace these plants as they are retired, although most new capacity in the near term is expected to be high-efficiency, gas-fired combined-cycle units producing low-cost, commodity-priced electricity.

Beyond that, beginning around the year 2000, "it appears increasingly likely that small, distributed generating units will emerge, initially in niche markets," says Tony Armor, director of generation technology development at EPRI. "At the same time, new manufacturing firms will begin to appear that are focused not on large boilers and turbines but on the assembly-line production of microturbines, fuel cells, photovoltaics, and other, yet to be developed, generating options. This development will signal a change in the power business as revolutionary as the microprocessor was to the computer industry."

No one is predicting the imminent demise of central-station generating plants, which—owing to engineering economies of scale—have long produced some of the lowest-cost electricity available anywhere in the world. But new technologies for smaller-scale, distributed generation promise to produce electricity as efficiently as larger plants and, in certain applications, at a cost competitive with centralized generation. Moreover, many analysts believe that the utility industry's restructuring (into regulated distribution companies, independent transmission system operators, unregulated generating companies, and integrated energy service providers) and the unbundling of prices for various components of service (in contrast to today's simpler, regulated rates) could create many new opportunities for distributed resources. Such resources could be applied at or near customer sites to manage multiple energy needs and to meet increasingly rigorous requirements for power quality and reliability. Distributed generators could also be deployed at utility sites—for example, at substations for transmission and distribution (T&D) grid support. Some experts predict that 20% or more of all new generating capacity built in the United States over the next 10 to 12 years could be for distributed applications, representing a potential market of several tens of gigawatts.

Fueling such optimism about distributed generation is the current or imminent commercial availability of small, low-cost, low-emissions generating technologies, both conventional and advanced. In numerous niche applications, mainly in commercial and industrial customer markets, such technologies could offer direct competition to today's regulated retail electric rates and to tomorrow's unbundled rate structures.

Conventional technologies for distributed generation range in capacity from several tens of kilowatts to tens or hundreds of megawatts and include reciprocating gas and diesel engines as well as larger gas turbines. Emerging technologies include microturbines of 25–75 kW, fuel cells of a few kilowatts to a megawatt or more, and even renewables-based distributed generation sources—for example, photovoltaics, which may be increasingly deployed on individual rooftops at the scale of a few kilowatts as costs continue to fall.

Distributed resources (or DR) include more than just small generators, however. They also include the backup batteries and other storage technologies that, in many cases, will be coupled with distributed generators to provide ride-through capability during momentary power disturbances and to maintain critical loads during the few seconds it takes to switch from grid power to on-site sources or vice versa. Advanced energy storage systems based on flywheels and ultracapacitors are entering commercial use and could play a significant role. In addition, distributed resources are broadly defined to include customer demand and peak-load management technologies that can minimize or defer the need for additional electricity from the grid.

In theory, high market penetration by distributed resources could lead to far-flung networks of small, interconnected generators and other devices, enabling utility systems to serve growing customer energy needs while minimizing investment in and construction of new central generating and grid capacity. But before that vision becomes a reality, improved interconnection technologies are needed to link multiple small generators together into larger networks that incorporate real-time communication of market prices and centralized, or perhaps local, automated dispatch.

"Utility interest in the potential of distributed resources as a basis for new retail product and service offerings continues to grow, fueled by technical developments and by the need to find new ways of delivering value to customers," explains Dan Rastler of EPRI's Energy Conversion Division, who manages two related DR target areas. "Recent breakthroughs in microturbine and fuel cell technologies for transportation and stationary applications, coupled with the restructuring of the electric power industry, are focusing attention on distributed resources as a potential new retail-access option and a new business opportunity for electric and gas utilities."

Says Christopher Maloney, vice president and general manager of Unicom Resources, a subsidiary of the Chicago-based corporation Unicom (also Commonwealth Edison's parent company), and head of Unicom's corporate development group: "We believe that, over time, distributed generation will play a critical role in shaping our industry."

Unicom formed an exclusive alliance last year with AlliedSignal's power systems unit to market—in a 12-state region and in the Canadian province of Ontario—AlliedSignal's TurboGenerator line of microturbines for distributed applications. The alliance is one of several AlliedSignal has recently formed with energy companies to market and distribute its microturbines. These pacts also include one with Public Service Enterprise Group, which covers the northeastern states, and one with New Energy Ventures of Los Angeles, which is targeting West Coast businesses as customers that could use microturbines to reduce their utility bills. Other ventures between utilities and major vendors of distributed generating equipment include Ballard Generation Systems (formed by New Jersey–based GPU and Canadian fuel cell developer Ballard Power Systems) and Plug Power (formed by Detroit Edison and fuel cell developer Mechanical Technology Inc.).

"Distributed generation has really become a focus for the competitive forces that are converging to create what many

Power Generation Value Chain

	Centralized Bulk Power	Local Logistical Power	Customer-Based Retail Power
Market	Wholesale market at pool/interpool level	Network/hub market	Decentralized end-use market
Customers	Bulk resellers, wholesale traders	Local distribution companies, independent system operators, energy retailers, municipals, cooperatives	On-site owners, nearby end users
Customer load	Baseload and intermediate-load demand	Intermittent and peak demand	On-site load following, plus specific customer needs
Pricing and returns	Commodity pricing and returns (percentages in the low teens)	Arbitrage and risk reduction pricing and returns (percentages in the midteens)	Customer solution/bundle pricing and returns (percentages in the high teens)

A new power generation value chain is expected to evolve as utility industry restructuring creates niche opportunities for distributed resources. In contrast to commodity-priced bulk power sold on the wholesale market, logistical power will involve local transactions between retail intermediaries and specialized generation companies that may own some local as well as bulk generating capacity. At the end-user level are sales of retail power, some of it generated on-site at customer premises. Eventually, logistical generation companies may offer T&D bypass and gas-electricity arbitrage services directly to customers, using networks of distributed resources to compete with on-site generation.

Because they offer high efficiency and low emissions, fuel cells are well suited for distributed generation applications. Already commercially available are 200-kW phosphoric acid fuel cells (PAFCs), and molten carbonate fuel cells have been demonstrated at the 2-MW scale. Solid oxide fuel cells ranging from 15 kW to 3 MW could serve as small cogenerators in commercial and multifamily residential buildings. Meanwhile, polymer electrolyte membrane (PEM) cells are under development for use in transportation vehicles and as stationary power plants at various sites. Cinergy Corporation recently placed the first commercial order for Ballard Generation Systems' 250-kW PEM fuel cell; a prototype is already operating on the BC Hydro grid.

PHOTOS COURTESY ONSI CORP.

California installation of ONSI's 200-kW PAFC

COURTESY BALLARD POWER SYSTEMS

Ballard's 250-kW prototype PEM fuel cell

American Power's 3-kW prototype residential PEM fuel cell and storage system

COURTESY AMERICAN POWER CORP.

believe will be the next revolution in our industry," says Maloney. He acknowledges that his bullish outlook surprises some in the industry. Commonwealth Edison was a pioneer of large central-station generation at the beginning of this century under its legendary founder, Samuel Insull. "Unicom's interest in distributed generation today is a reflection that the industry paradigms are not only shifting, they're being shattered," Maloney adds.

Structural changes drive interest in DR

The potential and roles of distributed resources in a competitive energy market will depend heavily on the pace, extent, and geographic pattern of regulatory reform across the country. Alternative paths to industry restructuring have been identified in EPRI research and have been used to frame various market outcomes and future scenarios for the deployment of distributed resources.

This work has yielded several insights. For example, regions and states where electricity prices are above average (such as California, New York, the mid-Atlantic states, and New England) have the greatest potential for DR penetration. Competition and the freedom of retail customers to choose among energy providers may evolve more rapidly in those regions, and retail service companies and other players will enter those DR markets more aggressively.

The most promising customer markets are businesses, factories, and various other sites needing steam or hot water from cogeneration; distributed generation technologies like fuel cells and small gas turbines are well suited for such sites. These and other distributed resources can also provide economical peak shaving, high power quality, and standby and uninterruptible power.

Distribution companies are expected to represent only 10–15% of the future DR market, since they will probably be prohibited from mixing unregulated generating assets with regulated T&D assets in the same corporate entity. But distribution companies are likely to form strategic alliances with unregulated retail affiliates, energy service companies, equipment vendors, or other third parties that may own or control DR assets.

EPRI analyses have identified three structural shifts in the electric power industry that are driving interest in distributed resources. First, the shift away from command-and-control market regulation will result in the deregulation of about 70% of the utility sector's total economic value. The generation, trading, and retailing segments of the industry will become much less regulated, while T&D functions will be more regulated.

Second, an enormous transfer of generation assets from the regulated rate base to unregulated enterprises is under way. At least 15 utilities have already announced plans to divest themselves of more than 25 GW of generating capacity. By 2001, fossil fuel plants totaling 100 GW could change hands; by 2006, some 400–450 GW of capacity could be spun off from the rate base of investor-owned utilities, most of it sold through auctions.

These shifts will, in turn, lead to a third major shift: the opening of a $500 billion, competitive wholesale and retail market that includes not only electricity and gas but also utilities that can be bundled with energy services (e.g., water and cable communications) and such ancillary services as facility management and performance contracting.

As a result of these major changes, "a new value chain will form, and new business models will evolve to seize market opportunities created by technology innovation and by ideas imported from industries that are already largely deregulated, such as telecommunications, natural gas, and financial services," notes Howard Mueller, EPRI manager for corporate strategy. "This value chain will be much larger than the power industry alone and will aim to serve a $1 trillion customer base for all the services—energy, telecommunications, and infrastructure—needed by people and organizations to operate in buildings." Mueller says there are plenty of signs that customers want to buy bundled energy and infrastructure services, noting the popularity of "total customer solution" marketing in many other service industries.

Compact combustion turbines based on jet aircraft engine designs and heavy-frame industrial turbines are commercially available in unit sizes of 1–100 MW. Simple-cycle units can provide peak power or T&D grid support. Advanced high-efficiency designs incorporating waste heat recuperation are ideal for industrial cogeneration (combined heat and power) applications.

COURTESY ALLIEDSIGNAL CORP.

AlliedSignal's 10-MW ASE120 aeroderivative gas turbine

The new value chain is likely to have five principal segments. Generating companies will focus on producing power under market conditions. Transmission companies or network operators will run the high-voltage systems for long-distance power transfers. Trading companies will buy power from generating companies and serve as intermediaries to sell power to downstream customers. Local distribution companies for electricity, gas, telecommunications, cable service, and the like will be the platforms for delivering electrons, Btus, and other services. Meanwhile, retail merchant companies will sell the services to customers, buying wholesale energy from traders and getting it to customers through the distribution companies.

Microturbines of 25 to 100 kW that can be mass produced at low cost are entering commercial markets for distributed generation. They are designed to combine the reliability of auxiliary power systems used on board commercial aircraft with the design and manufacturing economies of automotive turbochargers. The reliability and durability of microturbines for distributed applications remain to be demonstrated. Shown here are AlliedSignal's 75-kW TurboGenerator (below) and a 50-kW microturbine core originally developed for use in hybrid-electric vehicles.

PHOTOS COURTESY ALLIEDSIGNAL CORP.

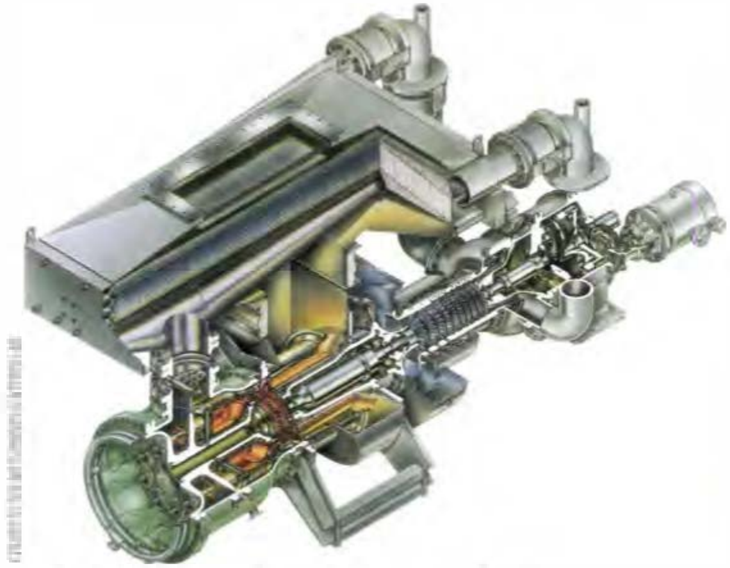
New opportunities in the value chain

EPRI experts believe the emergence of such a value chain will coincide with three other major trends. First, there will be both consolidation and fragmentation in the power industry. The ownership of large, centralized generating plants will be consolidated in order to cut production costs. At the same time, new opportunities will appear for localized and distributed generation in medium unit sizes to complement this bulk supply system and to serve as a hedging asset to balance supply and demand portfolios.

Second, there will be an outpouring of new service offerings to meet the needs of new wholesale and retail customers. Wholesale market offerings will tend to be structured; in the retail market, some customers will want customized solutions while most may prefer standardized, one-rate service plans.

Third, new technologies, both for generation and for trading and transaction processing, will be used to help serve these new customers. "Technology will profoundly affect the way electricity is generated and brought to the competitive market," notes Rastler. On the generating side, there will be plant upgrades and the reengineering of operation and maintenance activities; enhanced real-time diagnosis and control; advanced gas turbines and more-flexible operating cycles; and improvements in distributed generation, including more types of prime movers, better controls, lower costs, and increased reliability. On the trading and transaction side, faster trading systems and bargain-hunting expert systems will play a role, as will advanced customer knowledge systems and the growing sophistication of service offerings.

The new value chain envisioned will involve three forms of power. Commodity-priced bulk power for wholesale transactions at the power pool or interpool level will be generated by large baseload and intermediate-size plants. (The price of such baseload-generated electricity could fall in a competitive market because most U.S.



Solar Turbines' 4.2-MW Mercury 50 recuperated turbine

COURTESY GE MARINE & INDUSTRIAL ENGINES

General Electric's 45-MW LM6000 aeroderivative turbine

regions currently have a capacity surplus.)

The second type of power—for local (generally intrapool) purchase by distribution and retail merchant companies—is called logistical power and will be generated in smaller amounts and for shorter periods to help balance wholesale supply and retail demand. It will be produced by specialized generation companies operating within regional electricity networks. In each region, half a dozen such specialized logistical producers may emerge, each supplying 40–50 energy companies. These producers will offer backup reliability services, peak-management contracts, and price risk containment insurance.

The third type of power, retail power, will be sold at the end-user level as part of a broader offering (bundled with other commodities and combined with facility services). Some of that power will be generated at customer sites. Eventually, the regional logistical companies mentioned above could offer T&D bypass and arbitrage services, using networked and other interconnected forms of distributed generation to compete with on-site distributed generation.

"Industry restructuring and the emergence of a new value-added chain in the production and delivery of electricity is likely to lead to an explosion in electricity product innovation," says Rastler. "Distributed generation will offer the means for providing more-profitable, value-added custom service offerings in the intermediate wholesale and retail markets."

Focus on customers

One upshot of industry restructuring along a new value-added chain is the emergence of an entirely new set of potential DR customers. Merchant retail companies may develop local networks of distributed generation to support their service business. Distribution companies could become customers for distributed generators in the 1–2-MW range for operations support. Energy demand aggregators may want to own interests in similar-size units to help firm up loads for better prices. Logistical companies may own some cogeneration or small, dispersed power units to balance asset portfolios and provide flexibility to power contract transactions.

Given the anticipated involvement of these types of players, end users are expected to account for no more than 15–25% of the total amount of distributed generation that is installed. But even that percentage range could translate into very large numbers of installations in various types of buildings. EPRI has analyzed a significant number of key customer market segments in detail and has identified a potential market totaling 1.6 million existing establishments—representing an aggregate load of 288 GW and annual revenues of some $66 billion—where distributed resources conceivably could be economical.

DR penetration of these customer markets is likely to occur gradually. But by the time that retail electricity markets are fully deregulated (around 2002–2003), the equivalent of 25–30 GW of load may be accessible to distributed generating units in the 200-kW to 1-MW capacity range. During the transition to full retail competition, some dozen or more utilities may invest in on-site generating facilities in applications of 1–2 MW as part of a strategy to retain larger customers, creating a near-term market for distributed generation of as much as 2 GW. Regulators may limit such investments, however, to pilot programs or franchises to unregulated subsidiaries, which are expected to take the lead in developing distributed resources.

Throughout the transition to competitive energy markets, the pace of DR deployment will be strongly affected by regulatory treatment of utilities' stranded costs. These include not only costs for noncompetitive central-station power plants built in a regulated environment—plants based on demand projections that turned out to be too high—but also wires charges for maintaining and operating newly independent transmission networks.

"Whether energy service companies and customers can avoid or bypass these wires charges and capture the full benefit of distributed generation is an issue," says Rastler. "A vertically integrated utility can identify economic benefits all the way through its system, from lower generating costs to reduced T&D requirements. But for a restructured, disaggregated utility, how those benefits can be captured through market mechanisms is still an open question."

Energy storage devices, including batteries and advanced technologies like flywheels and ultracapacitors, can be integrated with distributed generators to provide peak power or ride-through power during transitions between grid supply and local generation. For example, Trinity Flywheel Power's 700-kW system, which features twin flywheel motor-generators, can deliver electricity on demand for 5 seconds. And Maxwell Energy Products' PowerCache ultracapacitor cells can be configured in series or parallel arrays to meet a range of storage requirements. A 28-cell module can provide up to 12.5 kW of power for a few seconds, and several modules together can provide ride-through capability for a 75-kW microturbine.

COURTESY TRINITY FLYWHEEL POWER

Trinity Flywheel's 700-kW system

COURTESY BEACON POWER CORP.

Beacon Power's 1-kW/2-kWh flywheel system for use in cable TV and standby power applications

Maxwell's PowerCache ultracapacitor cells and modules

Pollutant emissions with a potential impact on local air quality could be another wild card for certain distributed generating technologies. Most states are expected to follow the example of such states as California and Massachusetts, which offer legal waivers to potentially lengthy permitting requirements for fuel cell generators because of their intrinsically low pollution and quiet operation. State agencies, however, may continue to strictly apply low-emissions standards for reciprocating engines and gas turbines.

Uncertainties versus potential

Not every utility is readying business plans to pursue distributed generation. Some with low generating and T&D costs and ample capacity reserves may feel there is plenty of time to wait until the full impact of deregulation on electricity prices and industry structure—as well as customer responses to those changes—can be reasonably gauged. Many are frankly skeptical that the customer markets for distributed resources are as large as some analysts estimate. These utilities believe that distributed resources will face tough competition, given the 2–3¢/kWh busbar cost of available commodity-priced electricity. And they note the numerous and significant cultural and institutional barriers that can easily dampen customers' interest in undertaking or contracting for on-site generation. Still, many utilities acknowledge the large potential for distributed resources, even as they express doubt about how quickly it will materialize.

"We looked at our marginal costs for the T&D system several years ago to see what opportunities might exist for deferring some costs by installing distributed resource options," says John Nesbitt, a distribution planning engineer with Wisconsin Electric Power in Milwaukee, "but we didn't find any obvious situations where we could save a lot of money. We can still build distribution capacity pretty cheaply, in the range of $100–$150/kW, and average generation costs in the Midwest are pretty low as well. None of the distributed options available today can beat that."

But, continues Nesbitt, who chairs the client advisory group for EPRI's DR target for energy services and delivery enhancement, "there are viable applications for distributed resources even without restructuring and deregulation. If a customer needs a high-power-quality, high-reliability energy source, has a heating load that can maximize the potential efficiency, and is willing to pay a premium price, fuel cells and conventional generating technologies are available that can do the job.

"The difficulty is that we don't really know which way prices will go in future competitive markets. If it turns out there is a wide difference in cost between peak and off-peak times of day, some customers may feel sufficient incentive to own their own generation for peak shaving. But there are a lot of others, including most small customers, that won't want to deal with market price fluctuations and will want to lock in a flat rate. The real opportunities for distributed resources may be where they have always been—with large customers."

Nesbitt acknowledges that distributed generation gives electricity companies a way to enter competitive markets beyond their traditional service areas and can serve as a market entry vehicle to new players with no service area. "I think that, for a number of reasons, there will be more distributed generation," he says. "The rate at which it expands will largely depend on what happens with pricing. But while it seems that we're closer than ever, it also seems that distributed generation has been just around the corner for a long time. Technology breakthroughs that bring costs down considerably could cause it to really take off. Something that can be mass produced inexpensively and bought off the shelf has the best chance of becoming a real option for a majority of customers."

Optioning customers' generators

Some utilities already see on their systems a significant installed base of customer-owned distributed generation that may be ripe for very low cost conversion to dispatchable, firm peaking capacity. Utilities see this potential when they look at customer sites that have emergency backup generators, most of which are rarely called into service or even started.

PacifiCorp of Portland, Oregon, is pursuing the development of customer-owned backup generators as distributed peaking capacity. Following pilot tests last year, the company is recruiting customers and negotiating commercial arrangements to pay to take over the operation and maintenance of backup generators at customer sites. PacifiCorp will retrofit the machines with closed-transition switchgear and a software-based control system to make them remotely dispatchable and aggregate them as a significant block of peaking capacity. Customers will collect a fee for the conversion and will be paid for electricity their generator supplies to the grid.

David Engberg, technology business development director at PacifiCorp Energy Ventures, says the company is pursuing this form of distributed generation not only because it promises to be low in cost but also because PacifiCorp has a business interest in the dispatch and control technology being used. This technology, called the Virtual Power Plant, is a computer-based system developed by Encorp of Fort Collins, Colorado, for the remote monitoring, control, and grid paralleling of dispersed generators.

Converting installed backup generators to dispatchable, firm peaking capacity "can be a very low cost alternative for adding capacity, on the order of $100/kW," notes Brian Beck, vice president of PacifiCorp Energy Services. He says that correctly determining the value of such a call option on distributed generating capacity so that it can be properly compared with alternative options is perhaps the biggest hurdle to using the approach.

"This type of distributed generation tends to get overlooked, but it can be valuable to a utility and to generator owners because it gives them some return on investment for what is otherwise a dead asset," Beck says. "We will use it in the future as one of the resources to help manage peak demand." Still, he adds, "it's not going to change the landscape." He notes that closed-transition switchgear is neither standardized nor commodity priced. Its cost—higher than that of the simpler switchgear commonly used for backup generators—can make conversion uneconomical for units of less than a few hundred kilowatts.

Integration with the grid

The need for less-expensive, standardized switchgear is only one of several issues to be addressed regarding the interface between distributed generation and utility distribution systems—issues that are likely to become more prominent as DR penetration increases. Another is the need for broadly accepted interconnection standards that ensure personnel safety and the protection of customer-owned equipment from distribution system operations or anomalies. Although some IEEE standards and guidelines for connecting distributed resources with the grid have been developed, particularly for photovoltaics, compliance is voluntary and often inconsistent. Few utilities have established generic procedures for communicating interconnection requirements for on-site generation by customers.

In addition, to enable higher levels of grid-connected distributed generation in the future, it will be necessary to improve power conversion and inversion technology through the use of thyristors or other power electronic devices. Some distributed power sources~~, including fuel cells,~~ need inverters to convert dc output to grid-quality ac, while other technologies—such as various turbogenerators—require ac-dc-ac converters.

New, lower-cost, programmable power electronic packages are needed that can flexibly serve the conversion and inversion requirements for most or all distributed power technologies, according to Frank Goodman, a project manager in EPRI's Energy Delivery and Utilization Division who is directing a startup effort to pursue such development. "The next gen-

Distributed Generation Options

Type	Size	Efficiency (%)*	Market
Diesel engines	50 kW–6 MW	33–36	Standby power for commercial and small industrial customers; T&D support
Internal combustion engines	5 kW–2 MW	33–35	Primary power; commercial cogeneration
Combustion turbines	1–100 MW	33–45	Industrial cogeneration; T&D support
Microturbines	25–100 kW	26–30	Standby power; remote power; commercial cogeneration
Phosphoric acid fuel cells	200 kW–1 MW	40	Commercial cogeneration; premium power
Solid oxide fuel cells	25 kW–3 MW	45–65	Commercial cogeneration; primary power
Molten carbonate fuel cells	3–5 MW	55	Primary power
PEM fuel cells	<1–250 kW	40	Residential customers; premium power; remote power
Battery storage	500–5000 kWh	70–75	Power quality; voltage regulation; premium power
Photovoltaic arrays	<1–1000 kW	10–20	Remote power; peak shaving; power quality; green pricing
Flywheels	2–20 kWh	70–80	Telecommunications, cable TV; premium power
Stirling engines	1–25 kW	20	Residential customers; remote power

*Generating efficiency only (excludes recoverable thermal energy); for PV arrays, sunlight to ac power.

Several recently improved and new technologies will play important roles in competitive strategies involving distributed generation.

EPRI Tools for DR Analysis

EPRI's two distributed resource targets provide funders with a comprehensive portfolio of information, technologies, and analytical tools for developing and executing new DR business strategies. Drawing on expertise in three areas—customer systems, energy conversion, and power delivery—this balanced program is creating and delivering products to help clients understand and implement cost-effective distributed resources.

The targets cover the spectrum of R&D from strategic business assessments, information resources, and distribution system investment planning tools to the definition and development of new DR technology products for retail customer markets. DR applications are being developed that can migrate from niche markets to mass markets. The EPRI targets offer numerous tailored collaboration opportunities for direct client participation in pilot tests and customer demonstrations of emerging distributed technologies that promise significant benefits in critical competitive applications.

One key EPRI information resource is a CD-ROM-based DR equipment and product database that presents detailed, vendor-specific performance and cost information on emerging and commercially available distributed technologies. This extensive database contains crucial information for retail service analysts and distribution planners interested in evaluating DR options for customer service applications or in managing DR assets. The database can be tapped with two EPRI-developed analytical software products for personal computers: the DR Technical Assessment Guide (TAG-DR) and the Distributed Resources Workstation. These Windows-based products enable clients to perform customer- and utility-specific calculations to determine the cost and performance of various DR applications.

The TAG-DR software provides generic cost and performance information on distributed generation and storage technologies, end-use technologies, and distribution system upgrade equipment. Scheduled for general release this spring, TAG-DR is designed to serve as a one-stop information source and analytical tool for preliminary planning for DR-related implementation. It is intended primarily for use by utility planners and marketing and finance analysts for evaluating various DR options, for both the regulated and the unregulated sectors of the electricity industry.

To successfully implement distributed resources as a business line, energy service providers must be able to offer customers packaged, turnkey solutions. The Distributed Resources Workstation enables users to identify custom solution packages that are best suited for individual customer applications. It can evaluate DR options for such key energy services as cogeneration, standby power, peak shaving, premium power, and uninterruptible power. Recent enhancements to the software have added capabilities for modeling complex load shapes as well as rate structures for purchased energy.

"The DR Workstation enables customer-specific analysis that can quickly identify the optimum solution for combining services and equipment to meet individual customer needs," says EPRI's Doug Herman, a project manager in the DR area. "It provides an analytical platform that can help energy companies evaluate all of a customer's options, from buying power to installing on-site generation, installing load-control devices, and improving energy efficiency."

On the basis of load and rate modeling and the evaluation of various technology and service scenarios, the DR Workstation can generate a report that details the economics of an optimum customer solution. Because the information is so highly customized in terms of both local utility rates and customer needs, such reports can have great strategic value for marketing distributed resources. "Correct analysis of which DR options make the most sense for each customer can spell the difference between a successful project and an unsuccessful one," notes Herman. "Companies that want to pursue DR business opportunities have no choice but to conduct this kind of detailed, customer-specific analysis. The DR Workstation greatly simplifies and streamlines the process." □

EPRI's considerable work in the area of distributed resources includes the strategic business and technology assessments documented in these reports, which are available to funders of the distributed resources targets.

Selected EPRI DR Reports

Distributed Resources Strategic Review: Market Drivers Impacting Future Business Prospects (TR-110245; forthcoming)

Understanding Customer Needs and Markets for Distributed Resources (TR-109234-V1)

Markets for Distributed Resources: Business Cases for DR Applications (TR-109234-V2)

Assessment of Micro-Generation Technologies for Distributed Generation Applications (TR-107634)

State of the Art of Fuel Cell Technologies for Distributed Power: Technical and Strategic Assessment of Products, Markets, and Retail Competitiveness (TR-106620-R1)

State-of-the-Art Assessment of Advanced Combustion Turbines for Distributed Generation (TR-108862)

State-of-the-Art Assessment of Polymer Electrolyte Membrane Fuel Cells for Distributed Power Applications (TR-107064)

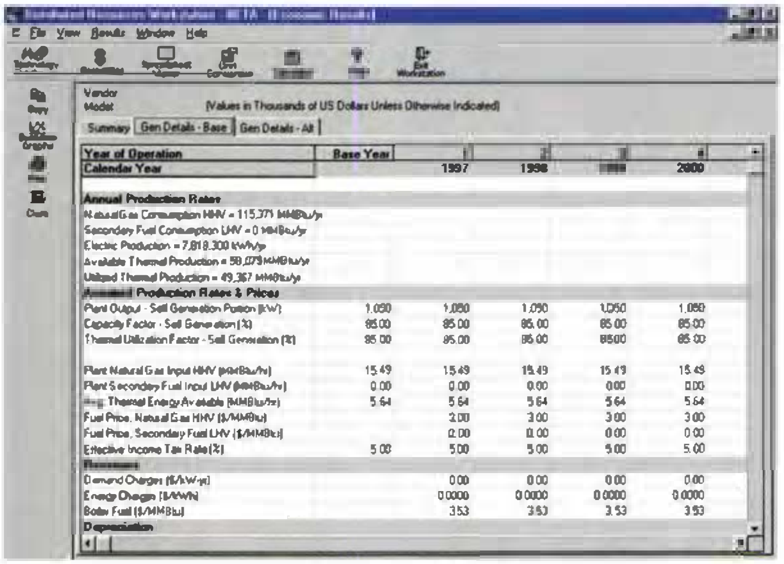
Commercial-Sector Solid Oxide Fuel Cell Business Assessment (TR-106645)

Santa Clara 2-MW Fuel Cell Demonstration: Power Plant Test Report (TR-108252)

Internal Combustion Engine Advances for Distributed Generation Markets (TR-108861)

eration of inverter or programmable operating device for interconnection could have many functions besides dc-ac conversion, such as protective functions and the capability for communications with central control systems. It will be able to serve as an adaptable interface for integrating distributed resources at high penetration levels,” says Goodman.

“If we build modularity and programmable logic into these devices, eliminate inductive components, and make the devices compatible with many applications (to increase manufacturing volumes), we should be able to drive costs down and improve reliability. We hope to eventually develop inverters and other electronics that are smarter and significantly cheaper and that can be applied with nearly all types of distributed resources.”



EPRI's Distributed Resources Workstation, which draws on detailed vendor- and model-specific data on the performance and economics of various DR technologies, can be used to analyze and compare alternative options for individual customer applications.

A flexible energy option

Although opinions vary widely about how rapidly and how extensively distributed resources will be developed and deployed in the United States during this period of power industry transition, there is little disagreement about their virtually infinite potential in developing countries that have little or no existing power delivery infrastructure. Moreover, in Europe, rapidly growing customer markets for cogeneration (combined heat and power) are providing opportunities for distributed generation. The deployment of distributed resources abroad is expected to help reduce costs, which in turn will make the technologies more competitive in U.S. markets.

PacifiCorp and Unicom are among the utility companies actively pursuing DR projects overseas. “Many of the manufacturers of distributed generating equipment are getting a lot of interest from governments and agencies around the world that don't have the billions of dollars needed to build central-station power plants and transmission infrastructure,” says Christopher Maloney of Unicom Resources. “Global market forces are creating a need for these technologies.”

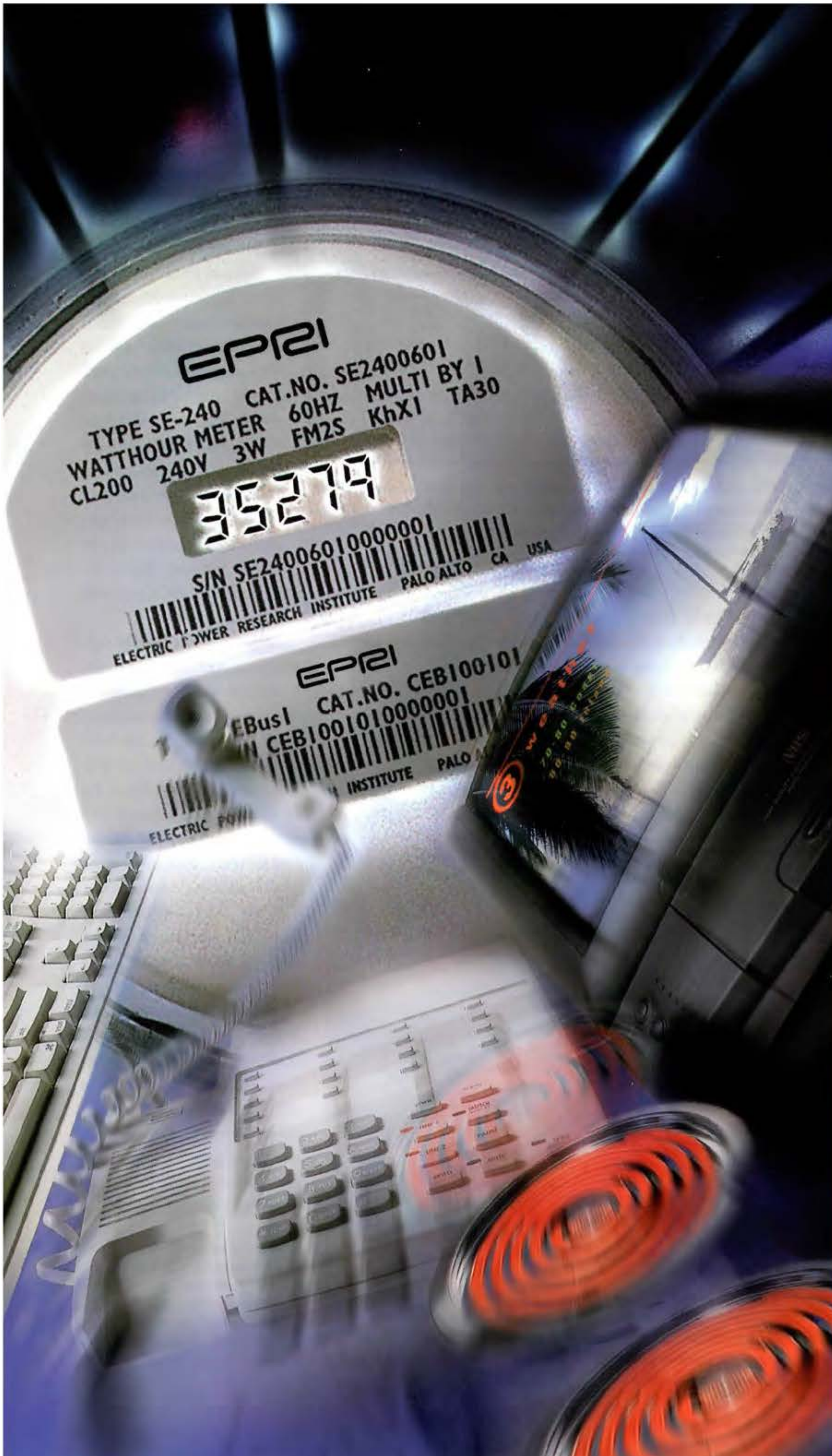
Indeed, worldwide, the convergence of market competition, customer choice, and the undeniable benefits of electrification are making future prospects for distributed generation brighter than ever. “There is a significant cultural change under way today at many U.S. utilities as they rapidly transform their businesses from century-old electric utilities into competitive energy companies and service providers,” notes Maloney. “We're beginning to see energy solutions and performance contracts being wrapped around the electron and the Btu, and for the first time, we're seeing customers and all the energy services they're demanding being considered on a par with the asset side of the business.

“Utilities clearly see a potentially substantial competitive threat. Those of us engaged in the energy services business, however, now see a product or series of products on the horizon that we can bundle with natural gas, O&M, and such financial services as leasing. In addition, for the tens of thousands of customers that have cogeneration requirements, we believe distributed generation is going to be a very attractive solution.

Encorp's Virtual Power Plant software is designed to let users monitor and control multiple remote standby (emergency) generators at various locations via phone lines or other means of communication. PacifiCorp Energy Ventures plans to use the Virtual Power Plant network to dispatch small generators at customer sites as peaking capacity.

“Only time will tell how successful distributed generation products and services will be in penetrating the energy market,” concludes Maloney. “There are still many challenges ahead, but we believe distributed generation will give Unicom and other energy companies a flexible energy solution for customers that can complement electricity straight from the grid.” ■

Background information for this article was provided by Dan Rastler, Doug Herman, and Tony Armor, Energy Conversion Division; Howard Mueller, Corporate Development; and Frank Goodman and Gopalachary Ramachandran, Energy Delivery and Utilization Division.



The Story in Brief

As industry restructuring introduces competition into the retail electricity market, utilities are seeking ways to retain their present customers and expand their market share. An important element in this effort is the customization of service—providing new choices and new benefits to individual clients. Some customers may be attracted by new ways to lower their electric bills, for example, while others are more interested in premium power quality. And beyond the differentiation in electricity service, new opportunities are arising for single providers to offer multiple utility services, including gas, telephone, home security, and Internet access. Whatever the service option, more-sophisticated customer interface technology—especially advanced meters—will be needed to meet the data collection and communications requirements of the utility service revolution.

The Future of Metering

by JOHN DOUGLAS

It is the nature of revolutions to make the familiar strange, and few customer interfaces are as familiar as the electric meter. Virtually unchanged for decades, the conventional watthour meter is a common sight in both rural and urban settings, in mansions and tenements. More than 110 million residential meters are currently deployed in the United States, and 3.5 million new ones are manufactured each year—two-thirds of which are used as replacements. At an average cost of only $20–$25 apiece, these simple electromechanical devices pose a formidable challenge to those who want to replace them with more-powerful alternatives that will better serve utilities' and customers' future needs.

EPRI has accepted this challenge on behalf of its members and is pursuing the development of flexible, low-cost meters that will allow greater service customization in both residential and commercial/industrial applications. Related EPRI efforts involve market surveys to determine customer preferences for new types of service, standard communications protocols to help integrate advanced meters into the utility infrastructure, a nonintrusive load-monitoring system to improve end-use data collection, new tools for load profiling, and pioneering research on sensor technologies that could substantially lower metering costs and enhance power quality monitoring.

"I believe that the customization of utility services will be *the* driving force in deregulated retail markets," declares Karl Stahlkopf, EPRI's vice president for energy delivery and utilization. "And advanced metering provides the key to offering such customized services."

Meter as cash register

Traditionally, an electric meter has performed one basic function—keeping track of cumulative electricity consumption at a customer site—and has been read manually by the same utility providing the power and sending out the monthly bill. As customized retail services are added, however, the meter will necessarily become more of a cash register—a sophisticated point-of-sale terminal that differentiates between types of service, acts as a gateway for multiple service providers, and enables real-time communication between utilities and their customers. In some cases, information from the meter may be obtained by one company, processed by another, and sent to still another for billing—none of the three being the company responsible for actually sending electrons through the distribution wires to the customer.

As retail customers are given greater choice among utility services and providers, electric meters will have to monitor each type of service and make the resulting information available more readily and efficiently. Real-time pricing, for example, is expected to become increasingly popular as a way to reduce customers' electric bills while improving utility load profiles. This pricing option is based on the fact that the cost of providing electric power may be several times higher during peak hours than during off-peak hours. A meter that could either record time-of-use electricity consumption or communicate real-time consumption levels to the provider would enable customers to take advantage of lower off-peak rates. Other capabilities might include appliance monitoring for customer convenience and some form of automated meter reading to reduce a utility's dependence on the inefficient manual reading process.

All these advanced functions, however, require fundamental changes in meter design. In particular, the traditional electromechanical meter is not capable of tracking time-of-use consumption and does not lend itself to real-time communication. And electronic meters that do have these capabilities—so-called smart meters—have been too expensive ($110–$125) for routine use with small or midsize customers. For such applications to be cost-effective, the price would have to be reduced to the $40–$80 range, according to a majority of utilities that plan to implement advanced metering functions. One of EPRI's first priorities in advanced metering research, therefore, has been

PHOTOGRAPHY: JACK CHRISTIANSON, LIGHT DESIGN/MATTHEWS DESIGN GROUP to develop a new low-cost, all-electronic residential meter.

Metering the home

In the development of new meters for residential and commercial/industrial applications, two design features have been given top priority—modularity and open architecture. Modularity allows the new meters to be customized easily to meet the needs of various service providers and customers. Open architecture ensures that modules from different manufacturers are compatible with one another.

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COURTESY WM. NESBIT & ASSOCIATES

Providing customized retail electricity service to residential customers will require more-sophisticated electronic meters. To make these meters inexpensive enough to compete with conventional electromechanical meters, EPRI has focused on a design featuring modularity and standardization. The result is the SE-240 meter, whose platform has a built-in electronic display and a standard interface and can accommodate a variety of plug-in modules for such functions as communications, time-of-use metering, and load monitoring.

The EPRI SE-240 residential meter is the first result of this effort. It consists of a standardized platform, which would ordinarily be owned by the utility distribution company, and plug-in modules, which could be owned by another service provider or even by the customer. The platform has a built-in electronic display for conventional energy-use reading and is based on a set of open-systems protocols for data transmission so that any vendor could manufacture compatible plug-in modules. The modules themselves enable such customized features as time-of-use billing, communications, prepayment, automated meter reading, and appliance monitoring.

"Our ultimate goal is to facilitate retail service restructuring by offering end-to-end open standards for the whole metering process, from pin connections to data management," says EPRI's Dave Richardson, target manager for advanced metering. "The SE-240 is a key element in this standardization initiative because it offers an open-architecture meter platform instead of the usual proprietary platforms. In the future, meters will become the point of competition for deregulated retail markets, and the best way to keep costs down as meters become more complex is through open architecture that enables easy upgrades."

Technically, the SE-240 is a residential form 2S meter, designed for 240-V, two-phase, three-wire service. Once the meter is in full-scale production, its cost is expected to be comparable to that of conventional meters. Pilot lots of the SE-240 are being made available exclusively to EPRI members through the tailored collaboration program. Host utilities will be able to choose plug-in modules that meet their particular needs. Communications capabilities are likely to be the most popular option, with multiple manufacturers already committed to producing the required modules.

Several communications options are currently being considered—including radio frequency, telephone modem, cellular phone, power line carrier, and optical signal. Utilities are expected to choose the communications media best suited to customer characteristics. For example, radio-frequency modules for drive-by meter reading would probably be chosen for urban areas, while telephone modems would be used with more-dispersed customers in suburban or rural areas. For utilities that continue to read meters manually, the process could be speeded up by what is called an Opto-Port module, which could be used with existing handheld reading devices. For offering more-sophisticated energy management services, two-way communication between customer and utility could be provided by a power line carrier module.

Two other capabilities being pursued are metering of multiple utility services and load monitoring. For combined metering, researchers envision a configuration of the SE-240—tentatively called the unified service meter—designed to record water and gas use as well as electricity use. So far, development work in this area has concentrated on gas and water flow sensors and on interfaces for existing gas and water meters. EPRI is cooperating with the American Water Works Association on the unified service meter.

A load-monitoring module could be added to the SE-240 to enable a service provider to obtain end-use data for planning, pricing, and program development. Such a capability would also allow individual customers to better control their electricity consumption patterns and reduce their costs and could potentially detect faulty equipment. The new module would use EPRI's Non-Intrusive Appliance Load-Monitoring System (NIALMS). Traditionally, load monitoring has required either individual appliance meters or multichannel meters with remote sensors on appliances—both very expensive options. NIALMS determines the energy consumption of individual appliances in a household by analyzing small changes in the voltage and in real and reactive power at the meter.

Commercial and industrial metering

In preparation for developing the next generation of open-architecture, modular meters for commercial and industrial (C&I) applications, EPRI has conducted three surveys to determine what features utilities and their customers require. The first of these surveys focused on the needs of 61 member utilities, selected to provide a wide range of company sizes and locations. The survey revealed a variety of specific plans for retail competition, including innovative rates, energy information and management services, and power quality services. The results of this survey were complemented by two surveys of C&I customers—seeking, respectively, the viewpoint from corporate headquarters and that from the field—to determine which of the value-added services would be of interest to them and what that might imply for meter requirements.

A survey of 21 national account customers focused on the advanced metering needs of major retail, supermarket, restaurant, health care, lodging, and convenience store chains, as well as industrial customers and government agencies. Typically, national account managers purchase energy services for major corporations with facilities throughout the country. According to the survey, power brokers have already offered most of these firms alternatives to their traditional electricity providers—alternatives expected to yield cost savings of 5–30% within five years. In connection with these developments, the national account managers showed a strong interest in automated meter reading, customized billing, and outsourcing of energy analysis and management services. Interestingly, few of the managers reported problems with power quality, although many thought that service reliability might become a concern in the future.

A somewhat different picture emerged from a survey of 757 customer facilities managers, who are typically responsible for handling site-specific services. Some 40% of these local managers reported power quality problems, and about one-third of them expressed willingness to pay for premium power. Such responses are being considered as a strong indication that power quality monitoring might be an important modular feature for the new C&I meter. In addition, 41% of the facilities managers were interested in learning more about real-time pricing options, and 33% said they would consider using a utility's communications network to obtain various information services, including energy data, security, end-use monitoring, and Internet access services. These responses suggest the need for various types of communications modules.

On the basis of these findings, EPRI prepared a preliminary requirements document for the development of an advanced C&I meter and sent the document to 20 manufacturers in North America and Europe. Initial emphasis has been placed on the development of modules for power quality monitoring, nonintrusive equipment diagnostic monitoring, energy management, and communications. More than a dozen favorable responses have been received, and a demonstration project involving prototypes of the new meters is scheduled for late this year. A host utility is now being sought for the demonstration under EPRI's tailored collaboration program.

The ability to tell what appliances in a home are in use at any given time—without having to resort to expensive individual monitors or sensors—would allow customers to better control their electric bills and would give service providers valuable data for use in planning and rate design. EPRI's patented Non-Intrusive Appliance Load-Monitoring System (NIALMS) algorithms determine the energy consumption of individual appliances by recognizing patterns of change at special meters, like the one shown here.

"Much of the basic hardware has already been developed for an advanced C&I meter, which represents a major improvement over so-called time-of-use meters that differentiate only between consumption off-peak and on-peak," says project manager Larry Carmichael. "Our efforts are concentrated on developing the applications software needed to support new energy services. We are also concerned about lowering the cost so that the new meter can be used in smaller customer facilities. In addition, we're developing a commercial-sector version of NIALMS, which we call C-NILMS, to provide more-accurate monitoring of such complicated equipment as large refrigeration and air conditioning systems."

Load profiling

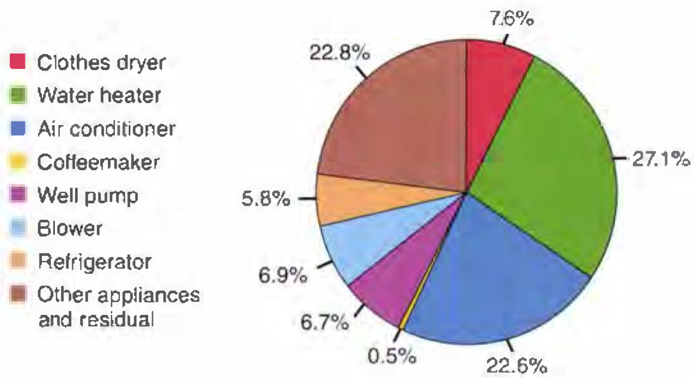
Until low-cost advanced meters are widely available, however, other strategies will be needed to enable small and medium-size customers to take advantage of retail market restructuring. One alternative to collecting real-time data for time-of-use pricing is to develop load profiles of different customer segments. Given a particular customer's metered total energy use and a load profile showing the pattern of daily energy use for that customer class, a utility could estimate what the customer's hourly consumption would have been.

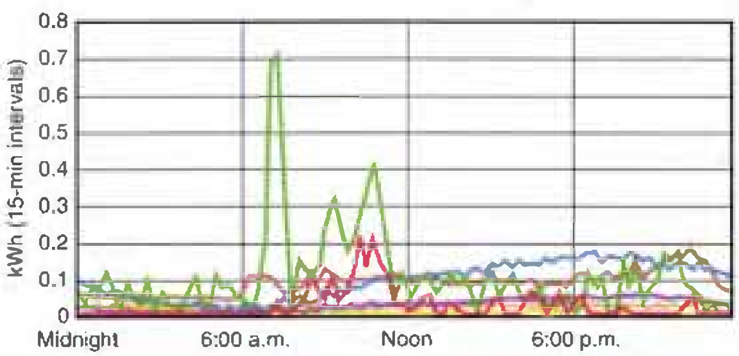
A small convenience store open all night, for example, might have a fairly level daily load profile, except for sharp peaks during summer afternoons, when its air conditioning load is highest. Very different load profiles would be shown by a welding shop or a law firm. Even residential loads show great variability: consider, for example, the differences in load profiles for a home where children are present all day and a home that is usually unoccupied between breakfast and supper.

As retail deregulation proceeds state by state, an increasing number of customers will be eligible for rates based on load profiling. In New Hampshire, for example, customers with maximum demands less than 100 kW can choose electricity suppliers that offer them load profiling rather than time-of-use metering. In California, customers with demands less than 50 kW are initially eligible for load profiling, although most of those in the 20–50-kW range will eventually have to install meters that record load data for selected time intervals.

Reliance on load estimates rather than on direct metering offers both advantages and risks. The main benefit is that load profiling enables more customers to participate in retail direct access while allowing utilities to defer major investments in new meters. On the other hand, by relying on approximate load data, utilities may experience more energy imbalances in system operations and may even lose customers. For example, if an alternative service provider could determine which of its competitors' customers have usage patterns that differ in substantial and beneficial ways from their assigned load profile, the alternative provider could offer them a more attractive rate.

"Clearly, load profiling is an increasingly important and complex issue for many utilities," points out EPRI's Jeremy Bloom, manager for retail market tools and services. "We can help them in three ways: by providing load research data, simplifying the use of these data for market selection, and reducing the amount of sample metering required to create load profiles."





By applying NIALMS, customers and utilities can keep track of appliance use and total energy consumption. This profile of household energy consumption for an average weekday, for example, shows an early morning peak for a water heater, a later peak for a clothes dryer, and a gradual rise in air conditioner use throughout the afternoon. Aggregating such daily data into a monthly cumulative report reveals that together the water heater and the air conditioner account for about half of all the energy consumed in this household. (Graphs courtesy Enetics, Inc.)

To help provide utilities with better information on customer loads, EPRI has established the Center for End-Use Energy Data, or CEED—the only national clearinghouse for the collection, assembly, and distribution of high-quality load research results. CEED has created an extensive database on hourly electricity consumption for all major residential and commercial market segments. The center can also provide individual utilities with customized, weather-adjusted load profiles for every hour of the year. In addition, CEED offers a variety of consulting services on the use of its data for modeling the consumption of specific customer groups.

Utilities can use load shapes from CEED directly in EPRI's ProfitManager software to select, and then prepare to serve, particular market segments. Specifically, on the basis of load profiles of various market segments, ProfitManager can determine the sectors' marginal profitability in light of proposed service offerings. In addition to telling a utility the likely effect of losing or gaining a customer in a specific market segment, ProfitManager can help determine what type of rate structure would provide a suitable balance between the cost of serving a customer and the revenue received.

Eventually, most utilities will have to supplement the data obtained from CEED by conducting some time-recorded metering of electricity end use at their own customers' sites. This process can be expensive and time-consuming, but EPRI offers ReShape, a set of software tools to leverage existing data and minimize the need for detailed metering. ReShape enables a utility to construct load shapes from easily obtainable sources of information, such as billing records, customer surveys, and small-scale metering projects. More-costly end-use metering may then be required only for model calibration.

The need for standards

The most important unresolved issue related to metering as the utility industry prepares for greater retail competition is the need for standards on how meter data are to be formatted and communicated. As the first state to give electricity service providers direct access to all retail customers, California has been at the forefront of the sometimes contentious process of adopting metering standards. In May 1997, the California Public Utilities Commission (CPUC) ordered the state's three major utility distribution companies to hold a workshop with other interested parties to develop the necessary standards for metering equipment and functions.

Endorsing the use of open-architecture standards, the report from this workshop recommended that specifications for interfaces, services, protocols, and data formats be "vendor neutral, published, freely available" and be agreed on "in an open process, under the auspices of a recognized national or international standards body." The report also identified three key metering systems for whose interfaces the use of open-architecture standards should be considered: the meter itself, the meter data communications system, and the meter data management server (computer system).

Responding to this workshop report in a separate "joint comments" submittal to the CPUC, other interested parties, including EPRI, recommended two interfaces in particular for the application of open-architecture standards to facilitate retail competition: the interface between the meter and the meter reading and communications system and that between the meter data management server and the application software used by service providers. The group noted that standards already exist for the physical interface between the meter and the meter socket on the customer premises and said that no standards are currently needed between the meter data communications and data management systems, since specifications for this link could easily be negotiated by the companies involved.

Acting on these and other recommendations, the CPUC in November 1997 issued a decision covering meters and metering services. The decision endorsed the concept of open architecture, established a set of interim minimum standards to be used during the transition period to retail direct access, and created a working group to recommend what permanent standards the CPUC should adopt. The working group was also asked to indicate whether other standards are expected in the future and to recommend a process for reviewing possible future changes to the permanent standards.

EPRI's William Blair, manager for information and automation technology, explains the importance of the CPUC decision for EPRI members: "At least a dozen states are following closely the metering standards of California, so what we're seeing here is probably the birth of de facto national standards. It now appears that EPRI's Utility Communications Architecture should play a key role in providing the technical basis for these standards, since UCA includes detailed protocols for meter data formatting and data communications. Such open-architecture standards would facilitate the interoperability of equipment produced by different vendors and used by energy service providers, meter data management agents, and meter agents. UCA would also enable the addition of new services without massive system upgrades and provide greater security for customer data."

Ongoing research

Even as discussions about metering strategies and standards continue, a technological wild card has appeared that may change some basic assumptions. New current and voltage sensors now emerging from the laboratory could help reduce the cost of all-electronic meters enough to make them competitive with electromechanical watthour meters. The sensors are created by a silicon-etching process and thus can be built into the integrated circuitry of an electronic meter, replacing the current transformers now used. Researchers believe these semiconductor-based sensors may also make power quality monitoring cost-effective in many more situations.

Meanwhile, EPRI is conducting surveys of households to determine the likely response of residential customers to new types of services made possible by advanced meters. In particular, customers will be asked to indicate their interest in automatic billing to a credit card, itemized billing showing energy consumption by major appliances, time-of-use rates, and a single billing for multiple utility services. The results of this survey, like those of the C&I surveys already conducted, will help utilities evaluate customer desire and willingness to pay for new meters and the services they facilitate.

To help members prepare for the metering changes ahead, EPRI's Advanced Metering Target has launched three new Internet Web sites. One site (www.epri.com/pdg/dist/jtargets/am) provides general information and is open to the public. Another (www.epriweb.com/pdg/dist/jtargets/am), open only to EPRI members, provides in-depth, market-sensitive information on the metering industry. Both sites include a database of domestic and foreign meter products and vendors, news about advanced meters and automated meter reading technologies, and guides to metering publications. The third Web site (www.se240.com) is primarily for potential providers of modules for the SE-240 meter. Detailed technical specifications for interfacing modules with the SE-240 are included at this site.

"EPRI's accomplishments in the advanced metering area illustrate the importance of collaborative research in an era of retail competition," concludes Karl Stahlkopf. "Not only are our efforts producing low-cost meters that will help facilitate competition at the retail level, but we are also making sure they encourage the use of open architecture—rather than proprietary protocols that could lock a utility into using the products of a single vendor. In addition, our basic research has led to the development of new sensors that could further revolutionize metering in the near future. And through cooperation with individual utility members and their state regulators, we are providing technical support for the development of nationwide standards for formatting and communicating meter data." ■

Background information for this article was provided by Dave Richardson and Larry Carmichael, Energy Delivery and Utilization Division.

Environmental

The Story in Brief ISO 14000 is a series of voluntary international standards for implementing an effective environmental management system. Since the first standards were issued in 1996, hundreds of companies abroad and dozens in the United States have chosen to adopt them and become registered. Two U.S. utilities who moved swiftly to do so say that they have realized significant efficiencies and cost savings and that their environmental stewardship has been enhanced. Questions remain about market acceptance of the standards and about the response of regulators and environmental groups. But many companies see ISO 14000 as a way to gain a competitive edge and are acting accordingly. EPRI has a range of field-tested products that can help utilities implement their environmental management goals—whether or not those goals are driven by ISO 14000. **by Steven Voien**

Management with ISO 14000

As GENERATING FACILITIES GO, the Michigan City station—owned by Northern Indiana Public Service Company—is not unique: it consists of a 500-MW coal-fired plant and three small gas boilers. What makes it interesting is its location—or, more specifically, its neighbors. On one side is an outlet mall bustling with customers; on another side is a marina, with an adjoining national park and the blue water of Lake Michigan stretching beyond. Across a dogleg of the creek that supplies the station's intake water is a Coast Guard facility; not far beyond that is an office of the state Fish and Wildlife Division, which falls under the authority of the Indiana Department of Natural Resources. "You could say we have interested neighbors," says John Flegel, environmental and chemical compliance specialist at NIPSCO.

Because of the Michigan City plant's location, NIPSCO has always exercised heightened vigilance with regard to environmental issues—for example, paying special attention to stack opacity and taking a range of measures to control dust from the Powder River Basin coal that is the plant's main fuel. Despite these measures and despite an excellent record of environmental stewardship, NIPSCO chose in September 1996 to go further, launching an initiative to attain ISO 14000 registration, which it achieved in March of last year.

Moving to ISO 14000 wasn't a difficult decision, according to NIPSCO's Arthur Smith, principal executive and counsel, Environmental Affairs. "Adopting these standards was very consistent with where we were going anyway. Upper management was always supportive."

PHOTO ILLUSTRATION BY ROBERT BAUSCH

Smith admits that achieving ISO 14000 registration was "a bit of work." But he says NIPSCO has reaped significant benefits in terms of cost savings, reduced environmental impact, and better-managed operations—so much so that it has now gone on to register all four of its coal-fired power plants and seven service facilities.

Smith and other NIPSCO managers believe ISO 14000 has been a net plus for the company. Management at Niagara Mohawk Power Corporation, the other U.S. utility to adopt ISO 14000, is equally positive. But are these two utilities the rule or the exception? Should utilities that already have an effective environmental management system (EMS) in place make the extra effort to adopt ISO 14000? Before attempting to answer these questions, it's worth taking a closer look at what ISO 14000 is—and what it isn't.

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In the United States, large companies in the chemical, automotive, and electronics industries are leading the way to ISO14000 registration. Most of these—including IBM, 3M, Du Pont, and the Big Three automakers—have significant international operations.

Companies can choose

ISO 14000 is a series of voluntary international standards for implementing an effective EMS. The standards are designed to help manufacturing and service companies of any size—across all industries—develop a uniform set of EMS elements that will help them achieve their own environmental goals. Companies that choose to adopt the standards make a clear management commitment to an environmental policy, formulate a plan to carry out that policy, identify activities that significantly impact the environment, and train personnel in environmental practices. Finally, they create an audit and senior management review system to ensure that the program is implemented and maintained.

A registration audit may then be carried out by a third-party registrar that has been accredited by a joint program of the American National Standards Institute and the Registrar Accreditation Board (ANSI/RAB). Subsequent surveillance audits, conducted once or twice a year, confirm continued progress toward environmental goals and are a condition of maintaining registration. As an alternative to registration, a company may choose to simply declare itself to be in conformance with ISO 14000 standards.

Compared with many international regulatory standards, ISO 14000 is a flexible set of criteria, one that is aimed at improving the process of environmental management rather than measuring pollution output. Companies or organizations, even those within the same industry, may have widely differing EMSs and performance and still comply with ISO 14000.

"What's striking about these standards," says Winston Chow, EPRI's product line leader for land and water, "is what they're not. They aren't thick, complicated documents that lay out specific measures of performance. They aren't regulatory measures with the force of law or a set of limits on pollutants or emissions. They don't address occupational health and safety requirements. Instead, they're short, relatively simple principles that encourage a company, first, to identify clear goals with respect to the environment and, second, to find ways to measure progress toward achieving those goals. The idea essentially is that if everyone adopted roughly similar environmental management practices, we would all be better off."

EPRI's Mary McLearn, manager for environmental asset management, notes that EPRI has been working for nearly a decade to develop a family of tools, guidelines, and methodologies to allow utilities to achieve their own objectives with regard to environmental excellence. These EPRI products anticipated the emergence of ISO 14000 by several years, she says, and can be used—either individually or in combination—in implementing the new standards.

ISO 14000 includes 20 standards, the first 5 of which were released in September 1996. The foundation document in the series, ISO 14001, presents core specifications for developing an EMS and is the only standard open to audit for the pur-

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poses of registration (also called certification, especially outside the United States). All other standards either support ISO 14001 or tell how to analyze product characteristics. The 14004 standard complements 14001, providing descriptions, examples, and practical advice for implementing an EMS. ISO 14010, 14011, and 14012 contain guidelines for audit procedures and lay out qualifications for auditors. The sixth standard—14040, which came out in June 1997—presents a framework for the application of life-cycle assessment principles. Future standards will cover environmental labeling, site review, and performance evaluation.

Where do the standards come from? ISO, the International Organization for Standardization, was founded in 1946 as an independent, nongovernmental organization with a mandate to develop voluntary consensus standards for goods and services. ISO's goal is to achieve greater functionality of goods and services between countries and to develop standards for emerging technologies. The organization's standards cover everything from credit card thickness to the safety of wire ropes to photographic film speed. ISO is made up of representatives from more than a hundred countries, including the United States, which is represented by ANSI. Technical work, highly decentralized, is carried out by some 2700 committees, subcommittees, and working groups. It took four years to develop and gain approval of the ISO 14000 standards released to date; a U.S. technical advisory group participates in the development and review process.

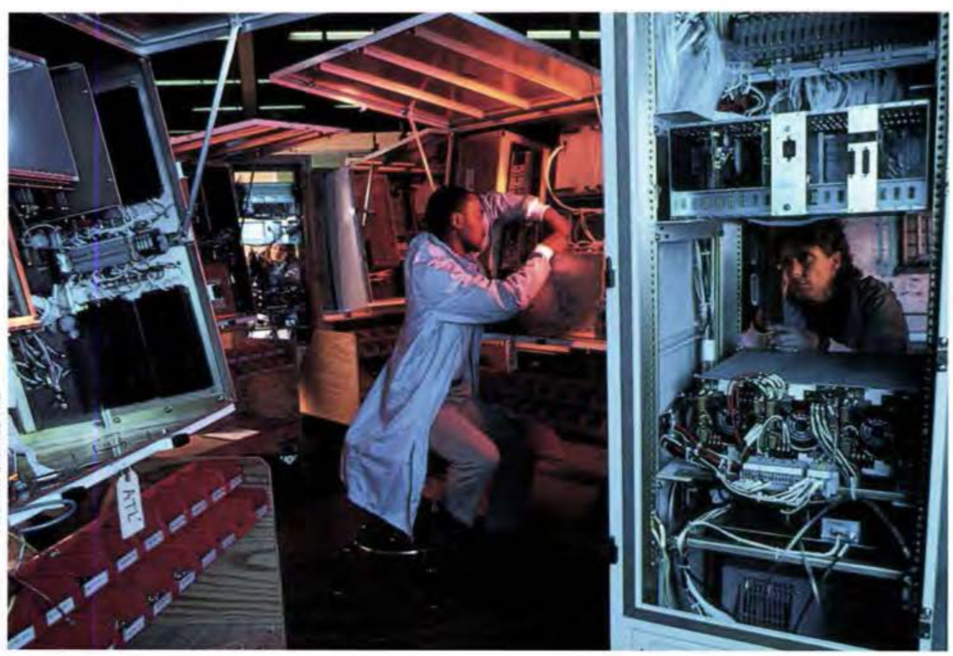
The 14000 series of standards grew out of an increasing global interest in sustainable business practices—and out of a concern that proliferating individual-country environmental standards might lead to more-restrictive trade barriers. In the late 1980s, ISO released a series of quality management system standards (ISO 9000) that have gained widespread international acceptance. Adoption of the ISO 9000 standards is now generally viewed as a beneficial business practice; in some industries and regions, it is a prerequisite for competing in the marketplace. The ISO 9000 series is not a model for or a precursor of ISO 14000, however; the two sets of standards are very different, and the general acceptance of one doesn't mean the other will be similarly received. Thus it's worth taking a look at how the market has responded to ISO 14000 after the first full year of the initial standards' availability.

The market begins to move

Acceptance of ISO 14000 has been most rapid in Europe and Asia, where registration has been driven by proactive government support. More than 450 companies in Asia have facilities registered. Some 300 of these are in Japan, whose Ministry of International Trade and Industry is actively promoting the standards; Canon, Toyota, Sony, and Mitsubishi, for example, are all moving rapidly toward registration. A number of other Asian countries have also adopted ISO 14000.

In Europe, more than a thousand companies have registered, with the majority of these in the United Kingdom, Germany, and the Netherlands. The European Commission is currently considering whether ISO 14000 standards may satisfy the implementation requirements of regulations now being used in member countries—the Eco-Management and Audit Scheme, or EMAS, and the British environmental standards BS 7750. Canada has also moved swiftly toward the new standards, specifically for the electric power industry. The Canadian Electricity Association has called for all its members to have an EMS in place that is either ISO 14000 certified or is consistent with ISO 14000 standards. The association will verify conformance through random audits, using ISO 14001 as its benchmark specification.

The numbers are smaller in the United States—something over 75 companies to date have registered—but the names stand out: IBM is looking at corporate-wide registration; Rockwell and Lucent Technolo-



Implementing ISO 14001

ISO 14001 specifies 17 elements for developing a certifiable environmental management system (EMS). These elements are designed to create continuous improvement, but they do not specify how this improvement should take place or mandate specific technologies or emissions levels.

1. Create a planning and action framework by defining your firm's commitment to pollution prevention and the environment.
2. Identify the significant environmental consequences of your products, activities, and services.
3. Identify relevant laws and regulations.
4. Establish environmental objectives and targets for your firm that are consistent with company policy.
5. Create an environmental management program—an action plan for achieving objectives and targets.
6. Establish management responsibility and authority as well as financial resources for implementing your EMS.
7. Provide skills and awareness training to employees so that they can carry out their environmental responsibilities.
8. Set up procedures for internal and external communication about environmental management issues.
9. Establish documentation describing the interaction of EMS elements.
10. Ensure effective procedures for controlling and accessing system documents.
11. Achieve operational control by planning and managing operations and activities in line with company policy and objectives.
12. Identify potential emergencies and establish preparedness and response procedures.
13. Monitor key activities and track performance.
14. Investigate and correct "nonconformances" to prevent recurrence.
15. Keep adequate records of ongoing EMS performance, documenting compliance, training, audits, and corrective actions.
16. Perform periodic audits of your EMS to be sure it is operating as intended and providing feedback to management.
17. Review the EMS periodically to effect continual improvement.

gies are registering selected facilities; Honda and Ford expect to be registered within two years; Du Pont, 3M, General Motors, and Chrysler are also moving toward registration. According to Paul Radcliffe, a senior project manager at EPRI, it's no accident that these companies have moved so aggressively: "Most either have operations overseas or compete in those markets. If Europe and Asia are going to ISO 14000, U.S. companies that operate there will have to do the same to avoid being placed at a competitive disadvantage."

Radcliffe points out that this will have ripple effects in the domestic economy, even for companies that don't operate overseas. The Big Three automakers, he says, are already looking seriously at requiring their suppliers—including their energy suppliers—to be in compliance with ISO 14000. To help put ISO 14000 developments in perspective, EPRI has recently prepared a white paper on the impact of the standards on the utility industry.

Brian Borofka, senior strategist at Wisconsin Electric Power Company, observes that there seems to be steady progress toward market acceptance of ISO 14000, particularly in the auto and high-tech industries. "There's a growing perception that if we need to measure EMSs, ISO 14000 might be the best standard to use."

Divided regulators, mixed greens

ISO 14000 puts regulatory agencies in something of a quandary. On one hand, they recognize that a flexible, market-driven approach to pollution prevention may ultimately prove more effective than traditional command-and-control environmental regulations; as the economy grows in size and complexity, regulators have begun to realize they simply don't have the resources to micromanage compliance. A set of standards like ISO 14000—which, rather than simply focusing on what comes out of a stack or effluent pipe, encourages source reduction practices and decision making that takes into account effective life-cycle costs—makes sense.

On the other hand, regulators worry that if they give special recognition or preference to registered companies, those companies may expect some form of regulatory relief. This conflict is evident at the U.S. Environmental Protection Agency, which has endorsed the overall goals of ISO 14000 but has been wary of suggestions that it grant registered companies some form of special treatment. A visible fault line has emerged at the agency between those who see promise in ISO 14000—as a means of reinventing government and harnessing market forces toward the goal of pollution reduction—and those who advocate a more traditional compliance approach.

Late last year, however, the EPA took a step toward adopting a single agencywide position, and the step clearly favored the reinventors. In an internal memo, Deputy Administrator Fred Hansen declared: "Environmental management systems hold great promise for improving environmental conditions in the United States and internationally." Hansen gave Chuck Fox, associate administrator for reinvention, lead responsibility for EMS pilots, programs, and communications and directed his team to encourage EMS partnerships with states and private-sector groups.

A number of states haven't waited for the EPA but have already begun to explore the benefits of ISO 14000. More than 12 are participating in a multistate working group established last summer. The states will each run 5–10 pilot programs and will collaborate to assess the economic and environmental benefits. States see in ISO 14000 the potential for doing a more efficient job of protecting the environment while at the same time helping the economy. According to one Wisconsin regulator, "accountable devolution" of regulatory authority is more effective than a centralized command-and-control approach—an approach, he says, that addresses barely 10% of "the opportunities and problems associated with the environment."

Michigan, although not a participant in the multistate working group, has moved forward with its own EMS-based experiment. Companies that have a good compliance record, have a formal pollution prevention program, and are either ISO 14000 registered or have a similar EMS are invited to join the Clean Corporate Citizen, or C3, program. C3 firms receive permit waivers for site construction or modification, get fast-track permits for air quality modifications, and are allowed to operate under a plantwide applicability limit. Ford, Chrysler, and General Motors have entered the program; a number of other companies are applying.

Over the coming years, these ongoing demonstrations will provide hard evidence of whether ISO 14000 does in fact make good sense for both the environment and the economy. If the answer is positive, regulators seem prepared to get on board. They may not, however, be joined by environmental organizations. According to Michael McCloskey, chairman of the Sierra Club, EMS standards that focus on improving process rather than on measuring specific pollution outputs are based on an assumption that firms will be led toward doing the right thing. But, he says, such standards "stop short of inquiring about whether the right thing in any given case actually gets done."

McCloskey acknowledges that a properly implemented ISO 14000 program should improve a company's overall level of environmental performance, increase

Key ISO 14000 Standards and EPRI Products

Environmental Management System (ISO14001)

- Pollution Prevention Planning Guide (TR-104377)
- ASAPP2: Accounting Software for Pollution Prevention (AP-106564)
- Information Strategies for Environmental Excellence (TR-107694)

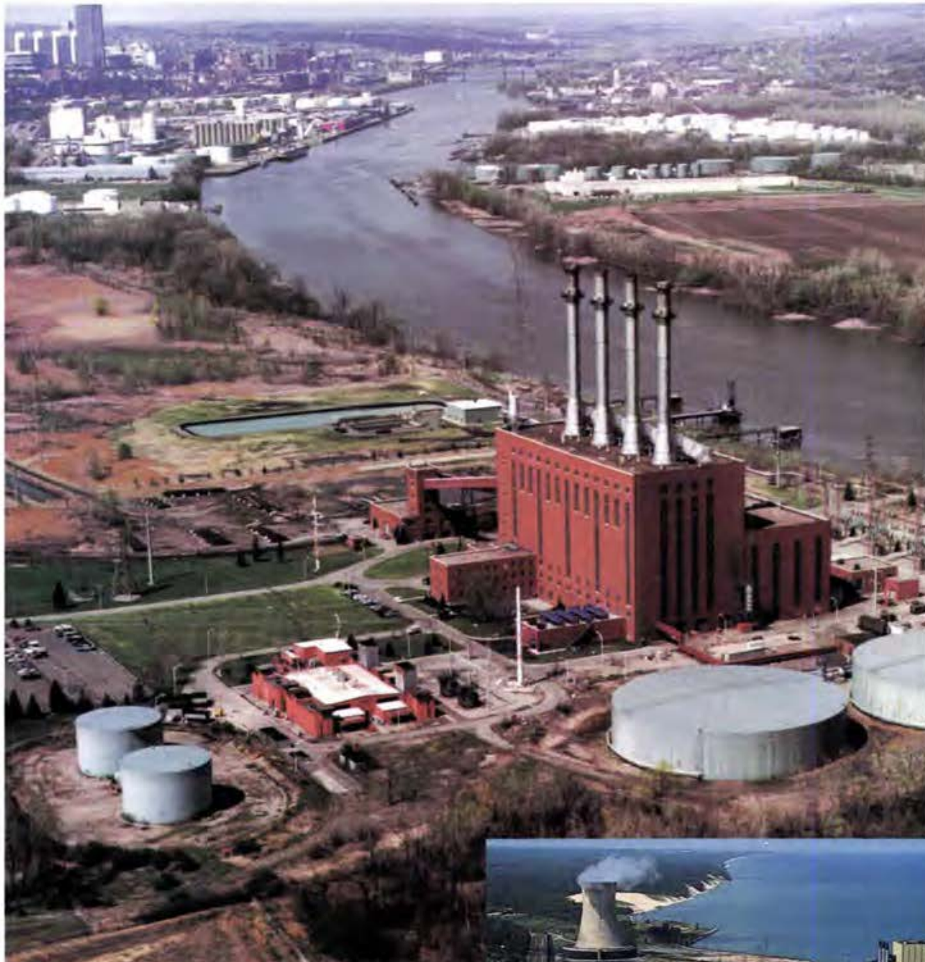
Environmental Performance Evaluation (ISO14031)

- Environmental Performance Measurement Framework (TR-106078); being revised in 1998

Life-Cycle Assessment (ISO14040)

- Life-Cycle Cost Management System (TR-105443, Vols. 1–3), software and manual; being revised in 1998
- Life-Cycle Decision-Making System (TR-105443, Vols. 4–5), software and manual; being revised in 1998

EPRI has developed and field-tested a variety of products to help utilities implement their environmental management goals. Many of these products correspond directly to the individual elements involved in ISO14000 registration.



The Albany steam station of Niagara Mohawk Power Corporation was the first U.S. oil/gas-fired electric generating station to adopt ISO 14001. After achieving fast-track registration for the station in approximately one month, the company went on to register three other fossil fuel plants and two nuclear plants.

The Michigan City generating station—a 500-MW coal-fired plant bordered by a mall, a marina, and a national park—was selected by Northern Indiana Public Service Company as the first of its facilities to adopt ISO 14001. It became the first U.S. coal-fired plant to be registered to the new standards.

business buy-in (since it was developed under the guidance of the business community itself), and give market legitimacy to environmental goals. He also lauds the fact that ISO 14000 would set a floor for acceptable business operations, something that may be of particular value in the developing world. At the same time, he worries that ISO 14000 registration might mislead the public, implying that a given firm is minimizing its impact on the environment when in fact "it's unclear how much bad performance can slip through the process-oriented net of ISO 14000." McCloskey also complains that U.S. firms are not required to make the results of their audits public and that there is inadequate provision in the ISO 14000 process for public participation.

Some environmental organizations in Europe have already come out publicly against ISO 14000, asserting that firms are using it as a means of getting around emissions standards. U.S. environmental groups are still trying to sort out what ISO 14000 may mean for the environment, but they are watching the EPA and state regulators closely for signs that existing legislation may be relaxed. As McCloskey puts it, the government "should steer clear of getting entangled in ISO 14000."

Yes, yes, and "not now, thanks"

Two U.S. utilities, Niagara Mohawk Power Corporation and NIPSCO, have moved quickly and comprehensively to embrace ISO 14000. What did these companies see in the standards—but other utilities have not yet seen—that made them take the plunge?

Christopher Kolarz, director of Niagara Mohawk Environmental, says, "We were already good practitioners of corporate environmental management, but we felt this would drive our compliance program to a much higher level. And we were pretty sure we would realize a host of improved operational efficiencies and other attendant benefits—which, in fact, we have."

Niagara Mohawk's managers were also motivated by market considerations. The company is divesting itself of all its nonnuclear generation capacity—fossil and hydroelectric assets amounting to 4217 MW—and sees ISO 14000 registration as a way to add value to the plants it will place on the market. More broadly, Niagara Mohawk believes that it won't be long before companies selling in international markets will be required to be registered—and that this will rapidly work upstream to energy suppliers.

Niagara Mohawk registered its first fossil fuel plant in April 1997. Kolarz describes the process as something of a sprint, carried out in about 30 days and requiring several hundred hours of preparation; all the work was done in-house, but an ANSI/RAB-accredited registrar was called in for the registration process. By the end of November 1997, the company had repeated the process at three other fossil plants and two nuclear plants. This year, it is pursuing registration for its hydroelectric generating capacity. It is also using its expertise to help other companies, including some of its customers, implement the standards.

Kolarz says that many utilities, especially those with a relatively robust EMS in place, should be able to do most if not all of the preparatory work for ISO 14000 in-house. He feels strongly, however, that an accredited auditor should be called in for the registration phase. "Someone from the outside has to take a look. I don't think those companies that wholly self-certify are engaging in a process that will create optimum value for them."

Kolarz cites regulatory relations as one of the positive benefits of ISO 14000. "State regulators have applauded our efforts and affirmed our environmental leadership in vigorously pursuing voluntary international registration," he says. "This doesn't diminish their regulatory responsibilities, but it may provide them with the opportunity to improve turnaround times for applications and permits."

Drawing on Niagara Mohawk's experience, Kolarz has suggestions for utilities considering ISO 14000. First, he says, the program will go nowhere without a strong commitment from top management. Second, companies should not use ISO 9000 as a model, since its documentation requirements are relatively onerous and rigid; the 14000 standards are more flexible. Third, companies should make maximum use of performance management activities already integral to their efforts, such as business planning processes, measurement metrics, and external relations and outreach. Says Kolarz, "You can cost-down this effort by doing most of it yourself and by keeping it lean and focused." Finally, Kolarz suggests that utilities take a hard look at the outside registrar they bring in, choosing one that has utility industry and environmental experience—not just someone with ISO 9000 expertise.

"ISO 14000 is not for the faint of heart," he concludes. "It takes commitment and some hard work. But we're convinced it's been a good thing for us."

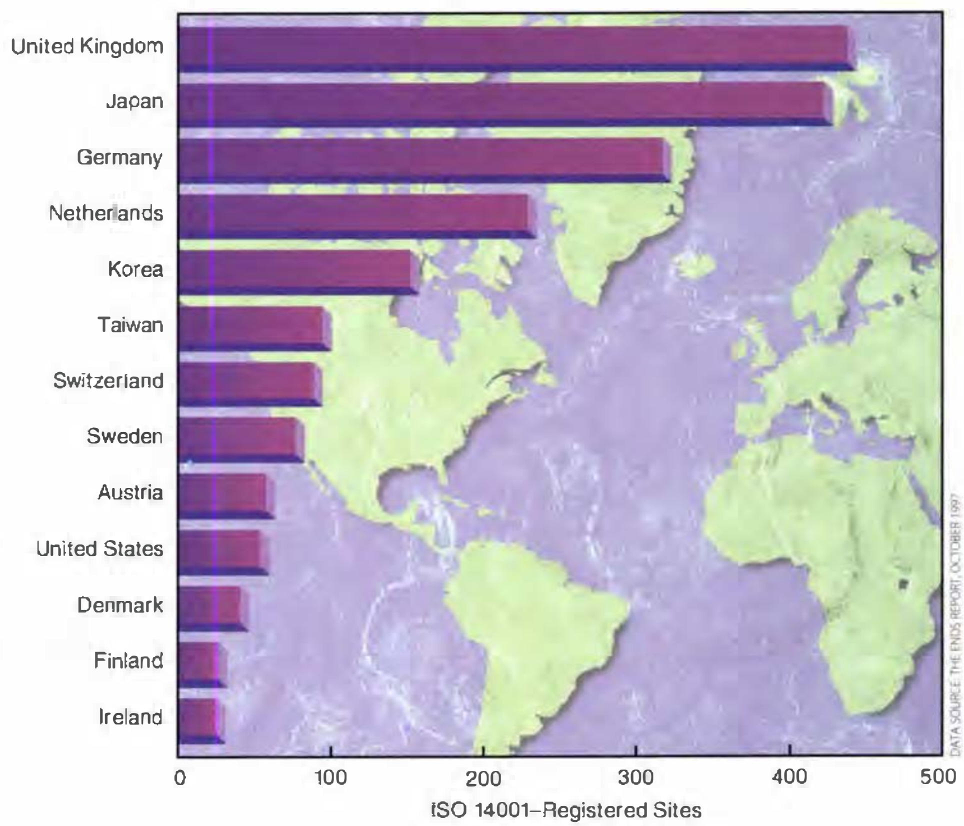
Like Niagara Mohawk, NIPSCO moved quickly on ISO 14000, registering more than a dozen facilities in 1997; these include a large multiunit generating plant, a sizable liquefied natural gas plant, and two hydroelectric plants. The company used a consultant for the initial analysis, in contrast to Niagara Mohawk, but it then did the rest of the preparatory work in-house. Joe Baker, program leader for environmental auditing at NIPSCO, says that out-of-pocket costs—including the costs of registration audits—were relatively small. "There's a significant cost in personnel hours, though. We had eight people who spent about a quarter of their time on this for more than a year."

NIPSCO's John Flegel, who worked at the plant level to help implement the standards, says that the ISO 14000 process integrates a host of different programs and procedures that once operated separately. The environmental and compliance sides of the house, he says, are now working much more closely with operations. Because of a firm management commitment, acceptance has been good, right down to the shop floor, where people have goals and work assignments directly related to the environment. "It's moved responsibility for environmental issues from implied to defined. People now feel more like this is part of running the business, not a separate issue."

Flegel adds that ISO 14000 has helped move NIPSCO plants and facilities out of a reactive mode, reducing the chances that he has to be a firefighter. "It's so much easier if someone calls and says, 'Something doesn't look right on the precipitator; better get up here,' than if someone calls the next day and says, 'You won't believe what happened.'"

From a corporate standpoint, NIPSCO's Arthur Smith considers ISO 14000 a useful management tool in an area that "has not been as effectively managed as some other areas," and he points to concrete operational efficiencies and cost savings. "We thought our system was pretty good already, but as we walked through the process, we were surprised at the opportunities that arose for better performance." Smith says that because NIPSCO is doing a better job at getting rid of waste, the company has been able to eliminate long-term storage facilities, a significant expense. And more clearly defined environmental goals have resulted in more-focused training programs.

Like Niagara Mohawk's Kolarz, Smith believes ISO 14000 will help his company stay ahead of the regulatory and market demand curves. He also points out that it will help in terms of coordination with



The United States lags behind European and Asian countries in the number of sites registered to ISO14001, as these data from last fall show. Registration by U.S. companies is growing, however, and some industry analysts estimate that for every registered company in this country, there are 20 to 25 more that are implementing environmental management systems based on the ISO14001 standard.

possible acquisitions as NIPSCO grows, and that it demonstrates to interested stakeholders that the company is firmly committed to environmental improvement. When asked if ISO 14000 had given NIPSCO a competitive advantage, he says yes and then adds, "How much of a competitive advantage, of course, will depend on customer demand."

During the ISO14001 process, various operating scenarios must be examined in terms of the environmental impacts associated with turbines and all other power equipment.

California's Pacific Gas and Electric Company also saw ISO 14000 registration as a possible competitive advantage, particularly with its energy market moving toward deregulation. Three years ago, PG&E undertook an EPA-funded demonstration project to benchmark its existing EMS against developing ISO 14000 standards.

After a companywide self-assessment, senior managers—citing two major challenges—decided not to implement ISO 14000. First, they objected to what they saw as a strong emphasis on documentation, which ran counter to the company's "ingrained corporate bias to minimize paperwork." Second, they felt ISO 14000's plant-by-plant approach to registration would be meaningless, because, given the large number and diversity of PG&E's energy sources, the company would not be able to tell customers "the exact source of the electrons or gas molecules we provide." And registering all 1500 facilities, they decided, would create administrative costs and burdens that would be unacceptable.

PG&E noted that its participation in the demonstration project allowed it to improve its existing EMS and helped position it for eventual ISO 14000 registration if that becomes a "valid business need." For the moment, however, PG&E has chosen to wait and see.

An ISO 14000 checklist

So where does this leave a utility trying to decide whether to take the ISO 14000 plunge? Here are some of the costs, benefits, and downsides a company may wish to consider.

A typical electric generating facility may require 9–12 auditing days for registration, with fees running approximately $1200–$1500 per day. Costs for most service facilities should be significantly less. Internal costs to prepare for an audit are both more significant and more difficult to quantify, since they consist mainly of employee hours and depend on a utility's existing EMS and on the approach taken. A typical generating facility should take three to six months to achieve registration, although, as Niagara Mohawk has demonstrated, the process can be carried out in as short a time as one month.

Potential internal benefits include improved operating efficiencies, reduced storage and disposal costs, less downtime resulting from regulatory actions, fewer emergency responses, and fewer employee claims. In addition, a company will benefit from more-effective management control of part of its working capital—what can be described as environmental assets. External benefits may include better relations with regulators, improved public and community relations, and increased sales due to green marketing.

In the control room of Niagara Mohawk's ISO 14001–registered C. R. Huntley steam station, operators work from procedures that have been mapped to significant environmental aspects identified in the plant's environmental management plan. The personnel know the environmental impacts of facility operation and may, for example, modify operating profiles at a given time to keep emissions under the levels defined by the plant's operating permits.

To the extent ISO 14000 is perceived as reducing the risk of adverse environmental, health, and safety impacts, registration may reduce insurance rates. One major insurance carrier is reportedly preparing a lower-premium package for registered companies. The commercial banking community is examining ISO 14000 for possible use as a factor in loan qualification; registration may result in better and more-flexible financing terms. Investment bankers are looking at ISO 14000 as it relates to merger and acquisition activities. Finally, ISO 14000 may become an important standard of due diligence in legal actions, since it establishes a track record of consistent, good faith efforts to manage environmental performance.

What about the downsides of ISO 14000?

At Niagara Mohawk's Dunkirk steam station, on-site water treatment is performed to meet the requirements of the plant's discharge permits. For ISO 14001 registration, a facility must meet all relevant regulatory and legal requirements; periodic assessments ensure conformance. Whether a plant chooses to minimize environmental impacts even further is a decision made by management during the targets and objectives phase of the ISO 14001 process.

Certainly, implementing the standards requires a significant commitment of personnel resources. After registration, regular audits require ongoing—albeit much smaller—efforts. The standards also require significant documentation. And this documentation, although advantageous from information management and operations points of view, could be misinterpreted. As NIPSCO's Flegel points out, an ISO 14000–driven EMS will do a good job of documenting any operational nonconformances. A nonconformance is not necessarily a regulatory noncompliance, but that distinction might not be clear to some outside the field. In addition, some observers have suggested that ISO audit documents might be used out of context by an adversarial party in litigation.

Focusing on the best possible EMS

ISO 14000, in the end, is a tool. Uncertainties remain as to whether it will eventually be embraced as the best possible tool for evaluating and improving a utility's EMS and whether it will confer competitive advantage. These uncertainties should not obscure the fact that—ISO 14000 aside—an effective, comprehensive, and well-integrated EMS will without question improve a utility's bottom line, its environmental performance, its market position, and its relations with important stakeholders.

EPRI has a range of products to help members plan and develop the best possible EMS. These include waste-accounting tools, guidelines for managing chemicals and minimizing waste, and methods for benchmarking and tracking environmental performance. The Life-Cycle Cost Management System helps strike an optimal balance between environmental concerns and economic realities, enabling utilities to become both cleaner and more competitive.

For 1998, EPRI's Pollution Prevention and Environmental Excellence Target has evolved into an Environmental Asset Management program—a development reflecting a shift in focus from simple pollution prevention toward helping members manage their environmental assets as corporate business assets. In addition to providing tools and methodologies, EPRI will continue to track the development of ISO 14000 standards, as well as evolving market and regulatory responses.

In three to five years, many of the remaining uncertainties about ISO 14000 will probably be ironed out. For some utilities, especially those that already have robust environmental programs in place, the benefits of implementing ISO 14000 may already outweigh the costs, and it may not make sense to wait until all the answers are in. For utilities that do choose to wait, taking a hard look now at their existing EMSs and benchmarking them against ISO 14000 standards may prove to be a highly valuable exercise. This process will allow them to identify and implement improvements in their EMSs and also to position themselves to make the move to ISO 14000 if it eventually does, as Wisconsin Electric Power's Brian Borofka says, "become the gold standard for the industry." ■

Further reading

ISO 14000 Environmental Management Standards: Impact on the U.S. Utility Industry. EPRI White Paper. March 1998.

ISO 14000 Standards for Environmental Management. EPRI Issue Brief PS-109185.

Begley, Ronald. "Value of ISO 14000 Management Systems Put to the Test." *Environmental Science & Technology,* Vol. 31, No. 8 (August 1997), pp. 364A–366A.

"Digging Into Pollution Prevention." *EPRI Journal,* Vol. 18, No. 6 (September 1993), pp. 6–13.

On-line resources

ISO 14000 InfoCenter: www.iso14000.com

Articles and case studies on ISO 14000 and EMSs: www.trst.com

ISO Web site: www.iso.ch

Forum for environmental groups interested in ISO 14000: www.ecologia.org

Subscription-based service maintained by the nonprofit Global Environment and Technology Foundation: www.iso14000.net

Background information for this article was provided by Winston Chow, Product Line Management Division, and Paul Radcliffe and Mary McLearn, Environment Division.

In the Field

Demonstration and application of EPRI science and technology

Aerosol Duct Sealing Goes Commercial After Successful Field Tests

Leaks in residential air ducts cost U.S. homeowners some $5 billion a year and can result in the loss of nearly a quarter of the energy used to heat and cool homes. Time-consuming conventional

leak repair—which requires testing the ductwork, patching with mastic and duct tape, and then retesting to make sure leaks are sealed—is only about 60% effective.

An innovative, cost-effective technology that promises to greatly reduce leakage from heating and cooling ducts in residential buildings is entering the commercial market after successful field tests in about two dozen homes by EPRI and several member utilities. The technology, aerosol duct sealing, was conceived and patented by Lawrence Berkeley National Laboratory scientist Mark Modera. It was developed and tested with support from EPRI, the California Institute for Energy Efficiency, the U.S. Environmental Protection Agency, and the U.S. Department of Energy.

Aeroseal, Inc.—an Austin, Texas, startup company in which Modera is a principal—is now marketing the technology to utilities and other potential users. Meanwhile, EPRI is looking for some half-dozen member companies that are interested in participating in a tailored collaboration project to apply the technology. "Aerosol sealing could save homeowners up to $300 annually on utility bills and could increase comfort as a result of more-even heating and cooling throughout a home," says John Kesselring, EPRI's manager for customer heating and cooling systems.

In the aerosol sealing process, fine adhesive particles are sprayed into heating and cooling ducts. A fan suspends the particles in the airstream so that they don't stick to duct walls. As the airstream turns sharply through holes in the duct walls, the sticky particles adhere to the edges of the holes and build up seals. Leaks as large as 1 inch in diameter can be sealed in this way. The adhesive sealant used is commercially available and environmentally friendly. The technology has been judged safe by Underwriters Laboratories and by Lawrence Berkeley's indoor environment program.

In the field tests, 23 homeowners in six states gave researchers free rein to determine how well the duct sealing technology performed in their homes, which represented various construction and basement types. Logistical support for the tests was provided by Cinergy Corporation's PSI Energy; GPU subsidiaries Pennsylvania Electric and Metropolitan Edison; OG+E Electric Services; and Western Massachusetts Electric, a subsidiary of Northeast Utilities. In the tests, more than 80% of supply duct leaks and 70% of return duct leaks were sealed within two hours, compared with the several hours that would be required with conventional methods. A brochure (BR-107894) on the technology is available from the EPRI Distribution Center, (510) 934-4212.

■ *For more information, contact John Kesselring, (650) 855-2902.*

Seismic Testing Program Shakes Out Savings

In the past three years, 14 utilities that operate nuclear plants have shared more than $2.4 million in savings on the seismic qualification of over 500 equipment items, thanks to a program managed by EPRI Plant Support Engineering (PSE) in Charlotte, North Carolina. Known by its acronym—SQURTS, for seismic qualification reporting and testing standardization—the program was created to increase data sharing, standardize test procedures, reduce costs, and shorten schedules for seismic qualification testing. The program now has 22 utility participants.

"Our costs for seismically qualifying electrical items dropped dramatically as a result of using the SQURTS program,"

says David Lindley, a seismic engineer at Carolina Power & Light.

Utilities must seismically qualify new equipment items that are not identical to the obsolescent parts being replaced. Before SQURTS was established, many different technical requirements and response spectrums were used in performing qualification tests, and test results were reported in various customized formats. There was only limited sharing of results between utilities. The high cost of seismic testing and the time required often made such testing a last resort among available qualification methods.

SQURTS has already achieved its initial goals. Over the past three years, it has established a 15-g testing response spectrum, 33 standard functional and seismic testing procedures, and a uniform reporting format. These standards have driven down the cost of testing and increased the usefulness of the results. They have also reduced the utility effort required to generate test plans and accept reports.

Test items from member utilities are assembled and tested on a six-week cycle. Each test sequence is witnessed by a SQURTS utility test representative, who gains substantial experience and insight on equipment seismic response. For emergency work, utilities may use the SQURTS process to accelerate the qualification of schedule-critical items.

One SQURTS member utility that has tracked the program's impact on equipment dedication costs for electrical items requiring seismic qualification reported net savings of $375,000 over a two-year period.

The SQURTS library at the PSE center in Charlotte currently has qualification reports on over 500 items. SQURTS members can reduce future testing by procuring items covered by the reports.

■ *For more information, contact Leonard Loflin, (704) 547-6010.*

Medium-Voltage Transfer Switch Keeps Ford Parts Plant Humming

For more than a year, a Ford Motor Company parts plant that is a critical link in the automaker's just-in-time inventory system has avoided the voltage sags and momentary power disturbances that previously caused costly and crippling production shutdowns. The reason for the change is a new solid-state, medium-voltage subcycle load transfer switch developed for EPRI and now available from PowerDigm Systems of Baltimore. Detroit Edison installed the thyristor-based switch under a tailored collaboration project with EPRI and has also upgraded feeder lines to the industrial substation at Ford's million-square-foot Sheldon Road plant.

In response to voltage sags or other disturbances, the solid-state switch can transfer the plant's electrical load from one feeder line to another in 4 milliseconds, or as little as one-quarter of one cycle of 60-Hz alternating current. Conventional motor-operated switches, in contrast, require several cycles to complete such a transfer.

As a result of the switch's high-speed load transfer capability, disturbances that previously could lead to a plant-wide shutdown, with ripple effects throughout Ford's production system, no longer disrupt production. The installation's success is saving Detroit Edison approximately $430,000 a year in service guarantee payments and is helping the utility retain the Ford plant as a valued customer.

With the Sheldon Road plant installation, Detroit Edison became one of the first utilities in the country to implement this Custom Power product for improving customer service reliability and power quality. EPRI is developing a variety of Custom Power tools that provide utilities with new ways to isolate faults and mitigate electrical disturbances on distribution systems.

■ *For more information, contact Dave Richardson at EPRI, (650) 855-2331. For information specifically on ordering, contact Todd Eudy at PowerDigm Systems, (410) 265-4800.*

New Technical Reports

Requests for copies of reports should be directed to the EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, California 94523; (510) 934-4212.

ENERGY CONVERSION

Condensate Polishing Guidelines for PWR and BWR Plants: 1997 Revision
TR-101942-R1, Final Report
EPRI Project Manager: P. Frattini

Soil-Structure Interaction Analysis Incorporating Spatial Incoherence of Ground Motions
TR-102631, Final Report
EPRI Project Manager: H. Tang

Predictive Maintenance Guidelines, Vol. 2
TR-103374-V2, Final Report
EPRI Project Manager: R. Pflasterer

Qualified Life of Main Steam Isolation Valves
TR-105416, Final Report
EPRI Project Manager: J. Carey

Evaluation of Stress Intensification Factors for Circumferential Fillet-Welded or Socket-Welded Joints
TR-106415, Final Report
EPRI Project Manager: S. Gosselin

Stress Intensification Factors and Flexibility Modeling for Concentric and Eccentric Reducers
TR-106416, Final Report
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EPRI Project Manager: A. McIlree

State of the Art of Fuel Cell Technologies for Distributed Power: Technical and Strategic Assessment of Products, Markets, and Retail Competitiveness
TR-106620-R1, Annual Update
EPRI Project Manager: D. Rastler

Evaluation of a Hydrogen Sensor for Nuclear Reactor Containment Monitoring
TR-106818, Topical Report
EPRI Project Managers: J. Hosler, R. James

Calvert Cliffs Nuclear Power Plant License Renewal Application Technical Basis
TR-106843, Interim Report
EPRI Project Manager: J. Carey

Preventive Maintenance Basis: Project Overview Report
TR-106857, Final Report
EPRI Project Managers: R. James, J. Gisclon

ORAM-SENTINEL User's Manual, Version 3.0: All Modes Maintenance and Safety Function Advisor
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TR-108068, Final Report
EPRI Project Managers: P. Lyons, H. Ng, D. Von Dollen, P. Vujovic

Reliability-Centered Maintenance (RCM) Technical Reference for Power Delivery: Software User Manual
TR-108076, Final Report
EPRI Project Manager: P. Lyons

Laterally Loaded Rock-Socketed Foundation Research
TR-108254, Final Report
EPRI Project Manager: A. Hirany

Non-Intrusive Appliance Load Monitoring System (NIALMS): Beta Test Results
TR-108419, Final Report
EPRI Project Manager: L. Carmichael

Application of FACTS Devices to Increase the New York State Central-East/Total-East Interface Transfer Limits
TR-108505, Final Report
EPRI Project Manager: R. Adapa

Effect of Grout Thermal Conductivity on Vertical Geothermal Heat Exchanger Design and Performance
TR-108529, Final Report
EPRI Project Manager: C. Hiller

Application of EPRI's Transmission Reliability Evaluation for Large-Scale Systems (TRELSS) Program to BPA System
TR-108815, Final Report
EPRI Project Manager: R. Adapa

Nonlinear Analysis Methods for Sustained Interarea Oscillations
TR-108821, Final Report
EPRI Project Manager: D. Sobajic

Geothermal Heat Pump Potassium Antifreeze Corrosion and Thread Sealants Study
TR-108860, Final Report
EPRI Project Manager: C. Hiller

Guide for Application of Transmission Line Surge Arresters: 42–230 kV
TR-108913, Final Report
EPRI Project Manager: B. Clairmont

Soil Thermal Properties Manual for Underground Power Transmission: Thermal Property Measurements, Thermal Stability, and the Use of Corrective Thermal Backfills
TR-108919, Final Report
EPRI Project Manager: T. Rodenbaugh

Fiber-Optic Cables in Overhead Transmission Corridors: A State-of-the-Art Review
TR-108959, Final Report
EPRI Project Manager: A. Hirany

Disaster Planning and Mitigation Technology: Interim Technology Inventory Report 1
TR-108972, Interim Report
EPRI Project Managers: R. Bernstein, J. Oggerino

Using Activity-Based Costing to Manage Profitability in the Energy Services Industry
TR-108983, Final Report
EPRI Project Manager: P. Meagher

Proceedings: Manhole Event Workshop (August 1997; Lenox, Massachusetts)
TR-109109, Proceedings
EPRI Project Manager: R. Bernstein

Residential Microwave Clothes Dryer: Market Potential and Positioning
TR-109116, Final Report
EPRI Project Manager: T. Henneberger

Deep Cable Ampacities: Guidelines for Calculating Ampacities of Cables Installed by Guided Boring
TR-109205, Final Report
EPRI Project Manager: T. Rodenbaugh

Transients on Transmission Systems: 500-kV Line Monitoring and Staged Switching Tests
TR-109231, Final Report
EPRI Project Manager: M. Wilhelm

Evaluation of ASD Systems for Electric Arc Furnace and Argon Oxygen Decarburization Refiner Baghouse Fans
TR-109254, Final Report
EPRI Project Manager: B. Banerjee

Gas Pipeline ASD Application Study
TR-109255, Final Report
EPRI Project Manager: B. Banerjee

Charging Circuit Interrupting Device Test and Evaluation: Field Test of Level 2 Connecting Equipment
TR-109366, Final Report
EPRI Project Manager: L. Sandell

Data Mining: An Introduction
TR-109453, Final Report
EPRI Project Manager: S. Kondepudi

Substation Integrated Protection, Control, and Data Acquisition: Utility Communications Architecture—Interoperability Test Plan
TR-109474, Interim Report
EPRI Project Manager: J. Melcher

Enhancements to ANNFTLF, EPRI's Short-Term Load Forecaster
TR-109482, Final Report
EPRI Project Manager: D. Maratukulam

ENVIRONMENT

Life-Cycle Cost Management, Vols. 4 and 5
TR-105443-V4–V5, Final Report
EPRI Project Manager: M. McLearn

Field Evaluation of Comanagement of Utility Low-Volume Wastes With High-Volume Coal Combustion By-Products: CL Site
TR-108242, Final Report
EPRI Project Manager: I. Murarka

Use of a Spreadsheet Program for Modeling the Interaction of Low-Frequency Electric and Magnetic Fields With Biological Objects
TR-108473, Final Report
EPRI Project Manager: C. Rafferty

Developmental Toxicology Study in Rats Exposed to 60-Hz Horizontal Magnetic Fields
TR-108946, Final Report
EPRI Project Managers: C. Rafferty, R. Black

Source Reduction Demonstrations for Utility Wastes, Vols. 1–2
TR-109009-V1–V2, Final Report
EPRI Project Manager: P. Radcliffe

STRATEGIC SCIENCE AND TECHNOLOGY

Corrosion Fatigue of Water-Touched Pressure Retaining Components in Power Plants
TR-106696, Final Report
EPRI Project Managers: B. Dooley, R. Pathania

CHAT Plant High-Temperature High-Pressure Expander
TR-108518, Final Report
EPRI Project Manager: A. Cohn

Testing Methods for Prediction of Onset of Interarea Split in a Full-Scale Real-World Context
TR-108533, Final Report
EPRI Project Manager: D. Sobajic

Water Recovery From Humidified Power Cycles
TR-108545, Final Report
EPRI Project Manager: A. Cohn

Energy Storage in a Restructured Electric Utility Industry
TR-108894, Final Report
EPRI Project Manager: S. Eckroad

Moisture Nucleation in Steam Turbines
TR-108942, Proceedings
EPRI Project Managers: B. Dooley, T. McCloskey

Studies on the Mechanism of EMF Interactions With Cells: Cellular Stress Response in Magnetic Fields, and Electric and Magnetic Signal Transduction in a Membrane Protein
TR-108947, Final Report
EPRI Project Manager: C. Rafferty

Review of Type IV Cracking in Piping Welds
TR-108971, Final Report
EPRI Project Manager: R. Viswanathan

Proceedings: Steam Turbine Stress Corrosion Workshop
TR-108982, Proceedings
EPRI Project Manager: R. Viswanathan

Proceedings: Year 2000 Embedded Systems Workshop
TR-109135, Proceedings
EPRI Project Manager: J. Weiss

New Computer Software

Orders for EPRI-developed software should be directed to the Electric Power Software Center, 11025 North Torrey Pines Road, La Jolla, California 92037; (800) 763-3772.

CORETRAN-01
Version 1.41 (HP-UX)
Division: Energy Conversion
EPRI Project Manager: Lance Agee

CPM-3: Core Physics Module
Version 1.00 (Windows)
Division: Energy Conversion
EPRI Project Manager: Jason Chao

Electricity Book
Version 0.7 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Art Altman

EOOS: Risk and Reliability Workstation Module
Version 2.6a (Windows)
Division: Energy Conversion
EPRI Project Manager: Frank Rahn

ESPRE: EPRI Simplified Program for Residential Energy Analysis
Version 3.0 (PC-DOS)
Division: Energy Delivery and Utilization
EPRI Project Manager: Karl Johnson

GTOP™ (Gas Turbine Overhaul Plan) W501SC
Version 0 (Windows)
Division: Energy Conversion
EPRI Project Manager: Robert Frischmuth

NO_x LOI Predictor
Version 1.1 (Windows)
Division: Energy Conversion
EPRI Project Manager: Jeff Stallings

ORAM-SENTINEL
Version 3.0 (Windows)
Division: Energy Conversion
EPRI Project Managers: S. Pal Kalra, Jeff Mitman

PISCES: Power Plant Chemical Assessment Model
Version 2.0 (PC-Windows)
Division: Energy Conversion
EPRI Project Manager: Barbara Toole O'Neil

PQDB: Power Quality Database
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Sid Bhatt

PQDS (Power Quality Diagnostic System): Event Modification Module
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Sid Bhatt

PQDS: Measurement Module
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Sid Bhatt

PQTB (Power Quality Toolbox): Voltage Sag Analysis Module
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Sid Bhatt

PQTB: Wiring and Grounding Analysis Module
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Sid Bhatt

RBR: Regulatory and Administrative Burden Reduction
Version 1.1 (Windows)
Division: Energy Conversion
EPRI Project Manager: Frank Rahn

RCM Technical Reference for Power Delivery
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Paul Lyons

RCM Workstation for Power Delivery
Version 1.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Paul Lyons

SCAAD: Strategic Capacity and Analysis Database
Version 2.0 (Windows)
Division: Energy Conversion
EPRI Project Manager: Robert Frischmuth

SDWorkstation: Substation Design Workstation
Version 1.1 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Ben Damsky

TIM (Transmission Inspection and Maintenance) System
Version 1.0 (Windows NT; Windows 95)
Division: Energy Delivery and Utilization
EPRI Project Manager: Paul Lyons

TLWorkstation™: Transmission Line Workstation
Version 3.0 (PC-Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Anwar Hirany

TRUE: Total Risk of Utility Emissions
Version 1.2 (Windows)
Division: Environment
EPRI Project Manager: Leonard Levin

UTWorkstation™ (Underground Transmission Workstation): ACE (Alternate Cable Evaluation)
Version 3.0 (Windows)
Division: Energy Delivery and Utilization
EPRI Project Manager: Tom Rodenbaugh

EPRI Events

MAY

4–8
Cyclone Boiler Unit Operations
Kansas City, Missouri
Contact: Melanie Moore, (800) 745-9982

5–6
Secondary-Cable Workshop
Charlotte, North Carolina
Contact: Kathleen Lyons, (650) 855-2656

5–7
Vibration Analysis
San Antonio, Texas
Contact: Melanie Moore, (800) 745-9982

6–8
Generator Operation, Troubleshooting, and Maintenance Course
San Antonio, Texas
Contact: Melita Guellert, (650) 855-2010

6–8
Internet for Plant Automation
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

11–12
Continuous Emissions Monitoring Program (Part 75) Audit Training Course
New Orleans, Louisiana
Contact: Michele Samoulides, (650) 855-2127

11–12
Power Quality Opportunities in a Changing End-Use Market
Knoxville, Tennessee
Contact: Martha Powers, (423) 974-8288

12–13
Plant Support Engineering Issues Meeting
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6017

12–13
Power Plant Optimization Workshop
St. Louis, Missouri
Contact: Megan Boyd, (650) 855-7919

12–14
Agricultural Technology Alliance and Food Technology Alliance Joint Meeting
Memphis, Tennessee
Contact: Chuck Sopher, (703) 737-0401

12–15
Feedwater Heaters Short Course
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

12–15
Hydrogenerator Maintenance Course
Atlanta, Georgia
Contact: Karen Goodeve, (416) 620-5600

12–15
Turbine Lube Oil/Electrohydraulic Controls Working Group
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6017

13–15
MIDAS Training/Users Group
Phoenix, Arizona
Contact: Susan Marsland, (650) 855-2946

13–15
1998 CEM Users Group Meeting
New Orleans, Louisiana
Contact: Michele Samoulides, (650) 855-2127

14–15
Seminar on the Prediction and Mitigation of Severe Weather Loads
Baltimore, Maryland
Contact: Kathleen Lyons, (650) 855-2656

17–20
International Ground-Source Heat Pump Technical Conference
Stillwater, Oklahoma
Contact: Shelly Fitzpatrick, (800) 626-4747

18–19
Chemical Decontamination Conference
Greenville, South Carolina
Contact: Linda Nelson, (408) 255-8079

18–19
OASIS Workshop
Danvers, Massachusetts
Contact: Cindy Layman, (650) 855-8763

18–20
Advanced Power Quality Workshop
Knoxville, Tennessee
Contact: Martha Powers, (423) 974-8288

18–20
Joint DOE/EPRI/GRI Fuel Cell Technology Workshop
San Francisco, California
Contact: Melita Guellert, (650) 855-2010

19–21
Simulator Acceptance Test Procedure Workshop
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

19–21
Vision at Low Light Levels
Orlando, Florida
Contact: Larry Ayers, (800) 525-8555

27–29
Light Fair
Las Vegas, Nevada
Contact: Mark Gabriel, (650) 855-2660

JUNE

1–2
Symposium on Improving Building Systems
Fort Worth, Texas
Contact: Mukesh Khattar, (650) 855-2699

2–5
Heat Exchanger Performance Prediction
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

3
1998 Wires Conference and Technology Expo
New Orleans, Louisiana
Contact: Melita Guellert, (650) 855-2010

8–11
PQA '98 North America
Phoenix, Arizona
Contact: Megan Boyd, (650) 855-7919

8–12
Structured On-the-Job Simulator Training Program
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

9–11
Predictive Maintenance Program: Development and Implementation
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

9–11
Steam Generator Strategic Management Workshop
Jackson Hole, Wyoming
Contact: Ulla Gustafsson, (650) 941-8552

9–12
Steam Turbine–Generator Maintenance and Inspection Seminar
San Antonio, Texas
Contact: Paul Sabourin, (704) 547-6155

9–12
3d International Workshop on Welding and Repair Technology for Power Plants
Scottsdale, Arizona
Contact: Brent Lancaster, (704) 547-6017

10
Water and Energy Conference
St. Louis, Missouri
Contact: Kim Shilling, (314) 935-8590

11–12
Plant Support Engineering SQURTS Meeting
Richmond, Virginia
Contact: Brent Lancaster, (704) 547-6017

15–17
8th International Joint ISA POWID/EPRI Controls Conference
Scottsdale, Arizona
Contact: Melita Guellert, (650) 855-2010

15–17
Symposium on Balance-of-Plant Heat Exchanger Nondestructive Evaluation
Lake Tahoe, Nevada
Contact: Debbie Pascone, (704) 547-6124

15–19
CHEC Users Group Meeting
Bellevue, Washington
Contact: Peggy Amann, (650) 855-2259

16
Pricing Strategy and Tactics Workshop
Washington, D.C.
Contact: Michele Samoulides, (650) 855-2127

16
Value-at-Risk Workshop
Washington, D.C.
Contact: Michele Samoulides, (650) 855-2127

16–18
Infrared Thermography: Level 3
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

17–18
ProfitManager Training Workshop
Dallas, Texas
Contact: Lynn Stone, (972) 556-6529

17–19
Healthcare Initiative Conference
Memphis, Tennessee
Contact: Kelly Ciprian, (614) 855-1390

17–19
Innovative Approaches to Electricity Pricing
Washington, D.C.
Contact: Michele Samoulides, (650) 855-2127

18–19
ProfitManager Users Meeting
Dallas, Texas
Contact: Lynn Stone, (972) 556-6529

20–28
International Food Technology Exposition
Atlanta, Georgia
Contact: Myron Jones, (650) 855-2993

21–23
Motor Rewind Seminar
Cleveland, Ohio
Contact: Melita Guellert, (650) 855-2010

22–24
Reactor Pressure Vessel Conference
Santa Fe, New Mexico
Contact: Susan Otto, (704) 547-6072

22–26
Combined-Cycle Operations for Utility Engineers
Castine, Maine
Contact: Sarah Vanberg, (816) 235-5623

23–25
Machinery Balancing Course
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

23–25
Valve Packing: Application, Configuration, Engineering
San Antonio, Texas
Contact: Melanie Moore, (800) 745-9982

25–26
EPRI Partnership for Industrial Competitiveness
Milwaukee, Wisconsin
Contact: Bill Smith, (650) 855-2415

25–26
3d National Green Power Conference
Sacramento, California
Contact: Cindy Layman, (650) 855-8763

29–30
Ground-Penetrating Imaging Radar Workshop
Ridgefield, Connecticut
Contact: Andrea Duerr, (650) 855-2719

30–July 2
6th Annual EPRI Terry Turbine Users Group Meeting
Jackson Hole, Wyoming
Contact: Linda Suddreth, (704) 547-6061

JULY

6–7
Service Water Assistance Program Coordinators Meeting
Williamsburg, Virginia
Contact: Brent Lancaster, (704) 547-6017

8–9
Improving Service Water System Reliability
Williamsburg, Virginia
Contact: Brent Lancaster, (704) 547-6017

13–14
3d International Conference on Arsenic Exposure
San Diego, California
Contact: Janice Yager, (650) 855-2724

13–15
EPRI/ASME Radwaste Workshop
Orlando, Florida
Contact: Michele Samoulides, (650) 855-2127

13–17
Boiler Operating Theory Fundamentals
Castine, Maine
Contact: Sarah Vanberg, (816) 235-5623

14–17
Machinery Alignment
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

15–17
1998 International Low-Level-Waste Conference and Exhibit
Orlando, Florida
Contact: Michele Samoulides, (650) 855-2127

20–22
Steam Turbine Performance Monitoring and Diagnostics Course
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

20–22
Technology Delivery Workshop
Denver, Colorado
Contact: Megan Boyd, (650) 855-7919

20–24
Drum Boiler Unit Operations
Castine, Maine
Contact: Sarah Vanberg, (816) 235-5623

21
Extending Time Between Generator Inspections
Philadelphia, Pennsylvania
Contact: Jan Stein, (650) 855-2390

22–24
Power Plant Pumps Short Course
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

27–31
Supercritical Boiler Unit Operations
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

28–30
Fluid-Film Bearing Diagnostics
Eddystone, Pennsylvania
Contact: Melanie Moore, (800) 745-9982

EPRI JOURNAL

March/April 1998

EPRI
Post Office Box 10412
Palo Alto, California 94303

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U.S. POSTAGE
PAID
PERMIT NUMBER 181
LIBERTY, MO 64068

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in the United States of America

EJ-110264