Managing Risk

Also in this issue • Retaining Residential Customers • Asian Energy Markets

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Cover: After a long history of monopoly status with very limited downside risk, electric utilities need financial vessels and navigational strategies that are more effective for maneuvering through the turbulent waters of competition. (Illustration by Rob Barber)

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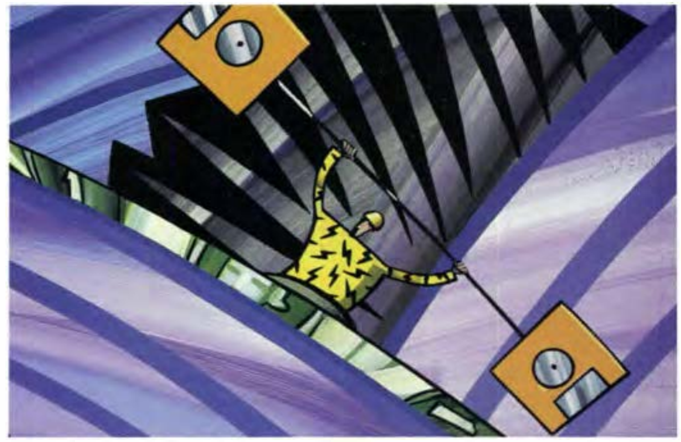

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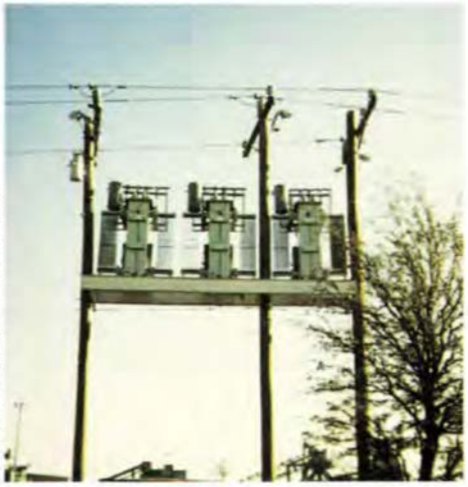


COURTESY POWER QUALITY SYSTEMS, INC.

IntelliVAr

An advanced static volt-ampere-reactive compensator (SVC) for the distribution system, IntelliVAr is designed to mitigate frequent, nonoutage power line disturbances, such as voltage flicker. Developed by Power Quality Systems, Inc., under the sponsorship of EPRI and the National Rural Electric Cooperative Association, IntelliVAr uses power electronics–based technology to control voltage fluctuation and improve power factor. The device is small enough to be mounted on a platform or a pole. Another advantage is that it can be connected directly to the distribution line rather than requiring the pad-mounted coupling transformers typically used with SVCs at distribution voltages. IntelliVAr is adaptable to three-phase or single-phase power and can easily be relocated to other sites when loads change.

For more information, contact Ashok Sundaram, (650) 855-2304. To order, call Power Quality Systems, (412) 464-1295.

Hydropower Guidebook

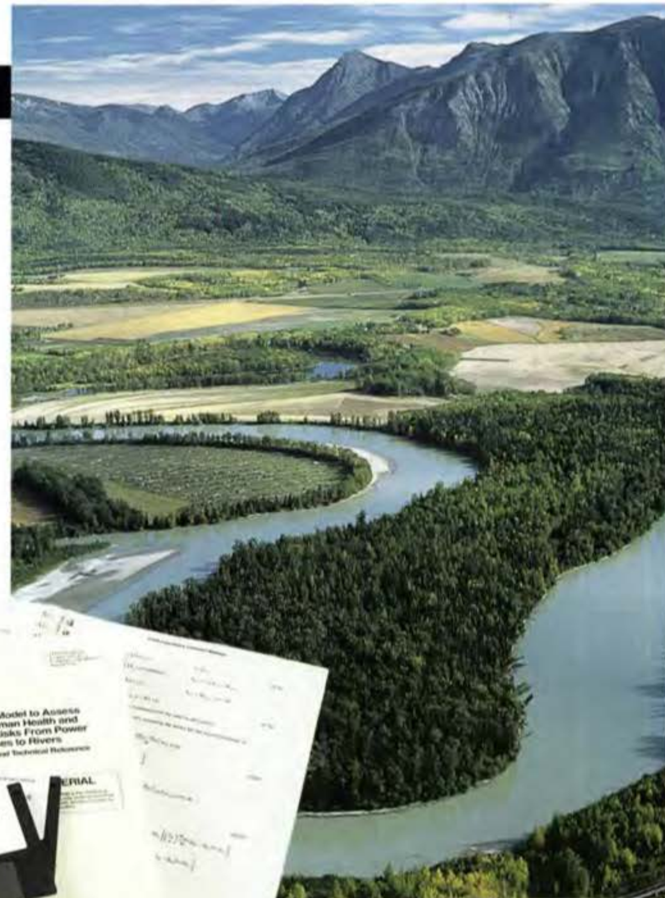
Power customers, boaters, anglers, environmental groups, and Native American tribes are among the diverse stakeholders whose needs must be considered in relicensing hydroelectric plants. EPRI research suggests that improved communication and early and frequent interaction with these stakeholders can help reduce the controversy and delays associated with traditional relicensing approaches. This report, *Water Resource Management and Hydropower: Guidebook for Collaboration and Public Involvement* (TR-104858), helps power companies establish a robust and effective public outreach program. Using this reference, a company can proactively involve a cross section of stakeholders representing all water resource interests (rather than just agencies and intervenors) and can develop a water management plan that reflects the interests of the community it serves.

For more information, contact Chuck McGowin, (650) 855-2445. To order, call the EPRI Distribution Center, (510) 934-4212.

Nuclear Waste Guidelines

Properly characterizing all low-level radioactive waste streams is an essential element of an effective waste management program. This report, *Low Level Waste Characterization Guidelines* (TR-107201), is designed to lead utilities through the waste characterization and documentation processes. It presents an overview of waste characterization, emphasizing representative sampling, the use of laboratory data to develop scaling factors, the determination of radionuclide content and waste classification, and future radwaste manifest requirements. With the help of these guidelines, utilities can reduce total characterization program costs, avoid overreporting key nuclide activities, and make informed decisions that take into account ultimate waste management.

For more information, contact Carol Hornibrook, (650) 855-2022. To order, call the EPRI Distribution Center, (510) 934-4212.



HARALD SUND/IMAGE BANK

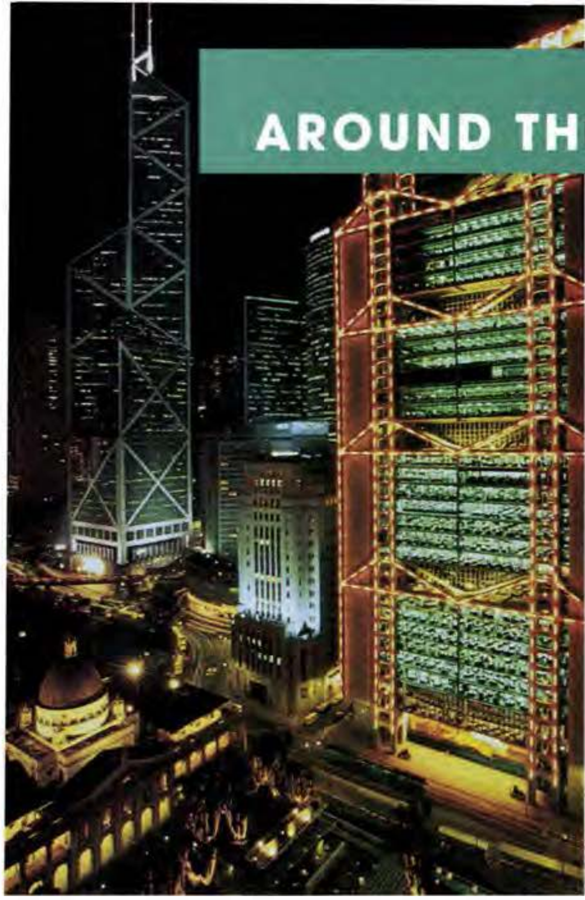
RIVRISK

This interactive Windows-based model for personal computers simulates the flow of power plant releases into rivers so that power companies can better manage such releases. With RIVRISK, users can predict the concentrations of chemical releases, the changes in water temperature resulting from thermal releases, and the potential human health and ecological risks of releases. The program contains an environmental chemistry module to help users determine the effects of various environmental processes on chemicals released into rivers. The speciation of metals in a river can also be investigated by using RIVRISK's metal speciation database.
For more information, contact Robert Goldstein, (650) 855-2593. To order, call the Electric Power Software Center, (800) 763-3772.

BARROS & BARROS/IMAGE BANK

Market Reports

Telecommunications companies, airlines, banks, and many other businesses have undergone deregulation in recent years, and electric utilities can learn a lot from their experiences. EPRI's *Best Practices in Strategic Market Management* (TR-106043) offers detailed case studies of companies from various industries that have successfully completed the transition to retail competition. A companion report, *Five Essential Tests of Market Strategy* (TR-106389), details five strategic market management principles that power companies can use to keep their marketing plans on the right track.
For more information, contact Thom Henneberger, (650) 855-2885. To order, call the EPRI Distribution Center, (510) 934-4212.



STELE/IMAGE BANK

New Center Tests EPRI Software for Asian Markets

A new Center of Excellence (COE) has been established at the University of Hong Kong's Department of Electrical and Electronic Engineering to demonstrate and modify EPRI power delivery software for use in Asian markets. Asian power systems are the fastest growing in the world, and there is an increasing need to analyze them with the most sophisticated computerized techniques. However, these power systems differ significantly from the North American systems for which the EPRI software was originally designed. Work at the Hong Kong COE, led by Professor Felix Wu and Associate Professor Elsie Ni, will focus on identifying and resolving potential problems in applying the software to Asian power systems.

Asian and American power systems have major differences in planning and operating standards and in data collection practices and formats. Also, Asian utilities use a mix of locally manufactured and imported equipment with widely varying characteristics. At the same time, some advanced technologies—such as Flexible AC Transmission System (FACTS) controllers—are being deployed in Asia. Modifications to the EPRI software are therefore likely to include provisions for data format conversion, different operating considerations, and the modeling of FACTS devices and other equipment in the Asian context.

Initially the Hong Kong researchers will concentrate on using EPRI software to analyze two major representative Asian power systems. One is the East China Power System, which typifies a large-scale, fast growing, heavily loaded network with extensive interconnections to other large systems. The other test system is the Hong Kong Island Power System, which represents a geographically confined network with very high load density and security demands. Eventually other Asian power systems will also be analyzed, both to provide information useful in creating software enhancements and to help the utilities involved address some of their most pressing system needs. In addition, the COE will hold short courses for academics and utility personnel from throughout Asia on how to use the EPRI software.

According to David Becker, EPRI's manager for the COE, the computer programs to be tested include PSAPAC, for static and dynamic analysis of bulk power systems; DEWorkstation, for designing distribution systems; the Operator Training Simulator, for training both system operations and planning personnel; TLWorkstation, for analyzing and upgrading overhead transmission lines; UTWorkstation, for analyzing and upgrading underground transmission systems; and EMTP, for simulating high-speed transient effects in power systems. The center's first workshop, covering PSAPAC, is slated for mid-February of next year.

"Asian utilities face some daunting challenges as they try to keep up with demand growth while maintaining power system security," says EPRI's Mark Lauby, director for international development in the Power Delivery Group. "As a result, many of them are anxious to use EPRI's software, which is widely considered to be the industry standard. Work at the Hong Kong Center of Excellence will help make these computer programs more available and applicable to Asian power systems."

■ *For more information, contact Mark Lauby, (650) 855-2282.*

EPRI Tool Helps With Transmission Pricing in Poland

Like many electric utility industries around the world these days, Poland's is in the process of privatizing. As part of this process, the Polish Power Grid Company (PPGC), the country's sole transmission provider, wants to restructure its system of charging for transmission services. In a recent project, EPRI researchers used an EPRI-developed software tool to support the Polish company as it does just that.

Currently PPGC charges all purchasers of transmission services a flat fee per use—a fee that does not vary with the distance the power travels. In an effort to aid PPGC in its goal to make this transmission pricing more efficient, EPRI researchers implemented a software code called MCTN (Marginal Costing Within Transmission Networks). Developed recently for use in the United States, the code was specially designed to analyze transmission economics.

The researchers used MCTN to conduct an economic assessment of the Polish power grid and to analyze alternative tariffs for the system. The study included an analysis of a two-part transmission tariff that incorporates both efficient, location-based usage pricing and an access fee. The access fee provides enough revenue to pay for the significant investment that has been made in the transmission network, while the usage fee increases the efficiency of the network during periods of peak demand. The two-part approach is based on EPRI's research on real-time pricing tariffs for retail service employed by a large number of U.S. utilities today. EPRI also conducted a two-day seminar at PPGC to help experts there learn how to use the software.

Charles Clark, EPRI's manager for the project, reports that PPGC's response to the study has been very favorable. Actual implementation of any new pricing system, however, would have to be approved by the country's energy ministry. Clark notes that the analysis of the two-part tariff that EPRI designed in this project will be of interest to utilities in many other countries.

■ *For more information, contact Charles Clark, (650) 855-2994.*

Braced for the Big One

There has never been a major earthquake in the vicinity of a nuclear power plant. Nevertheless, U.S. plants—and most plants worldwide—have been specifically designed for that possibility. EPRI has closely studied seismic activity over the past 10 years and has collected data to help ensure the continued integrity of nuclear power plant components.

Through an ongoing project in a seismically active region of Mexico, EPRI is focusing on the seismic performance of mechanical and electrical equipment commonly used in nuclear power plants, such as pumps, valves, electrical switching gear, and battery chargers. In collaboration with the Centro de Instrumentación y Registro Sísmico—a nonprofit Mexican research organization that installed a seismic early-warning system for the Mexican government after the earthquake that devastated Mexico City in 1985—EPRI has installed sophisticated monitoring instrumentation at three industrial sites in Mexico. Data culled from these sites are being used to determine how the facilities' equipment performs in a strong earthquake.

Installed in 1992, the monitoring instrumentation has already collected data from several small earthquakes and one large one. So far, the news—as expected—is quite good, says Robert Kassawara, EPRI's manager for the project. "This effort has verified the industry's work over the last 20 years, which has shown that mechanical and electrical equipment in nuclear plants is very seismically robust."

Data from the large earthquake that occurred in Manzanillo on October 9, 1995, are included in a detailed EPRI report (TR-108478) to be published this fall. These data were recorded by instrumentation installed at the Manzanillo power plant, a large oil- and gas-burning plant owned by Mexico's national utility, Comisión Federal de Electricidad. Similar instrumentation is also in place at a steel mill in Lázaro Cárdenas and at a cement plant in Oaxaca. As Kassawara explains, these sites were chosen both for their location in seismic gaps (places where major earthquakes are anticipated) and for the similarity of their equipment to that used in nuclear plants.

The 12-story Costa Real Hotel, located just north of Manzanillo, collapsed during the earthquake on October 9, 1995, killing 40 people.

PHOTOS COURTESY EQE INTERNATIONAL

Kassawara notes that the firsthand experience gained through this project is a critical contribution to the industry's understanding of earthquake effects. In fact, EPRI's work in this project is part of its ongoing validation of a new method for verifying that safety-related nuclear power plant equipment is adequately designed to withstand a major earthquake. Approved by the Nuclear Regulatory Commission in 1992 for application in older U.S. plants, this method uses data from actual earthquakes rather than relying on expensive tests and analyses. Ultimately, this method will greatly reduce the cost of seismic qualification of nuclear plant equipment and will actually improve safety margins, says Kassawara.

The 1995 Manzanillo earthquake measured 7.6 on the Richter scale, but as Kassawara points out, that scale is not always a good predictor of damage to structures and equipment, since it does not provide any measure of ground acceleration at a specific location—the major cause of earthquake damage. The instrumentation installed for the Mexico project is specially configured to record the acceleration of the ground and the resulting movement of the building and its installed equipment. Monitoring at the three sites will continue. Results will be assessed and reported annually.

■ *For more information, contact Robert Kassawara, (650) 855-2775.*

Fighting Frost in Heat Pumps

Utilities recognize that heat pumps play an important role in retaining and increasing electricity's share of the commercial and residential heating, ventilating, and cooling market. While each season can cause special problems for heat pumps, winter poses the biggest concern, since the pumps often exhibit reduced airflow and limited heat exchange owing to the extreme weather conditions. As frost forms on the surface of a heat pump evaporator, airflow passages between the evaporator's fins become blocked, and the pump must be switched to the defrost mode. At the end of the defrost period, the pump switches back to the heating mode and the process begins again. Studies have shown that the defrost cycle can degrade performance by as much as 20–30%. Although it is known that ice does not form as quickly or adhere as strongly on a hydrophobic surface as on an uncoated one, no studies have been done specifically on hydrophobic coatings for heat pump applications.

To assess the performance of such coatings on heat exchanger surfaces, EPRI commissioned a research team at Texas A&M University to study the effects of a silicone-based coating and an acrylic coating through bench tests and tests on actual heat pump evaporators. The researchers gathered extensive qualitative and quantitative information on drop size distributions, measured heat and mass transfer coefficients, and performed digital microscopy on the condensed droplets.

The coatings were sprayed on an already assembled heat exchanger, and their performance was compared with that of an untreated aluminum surface. The silicone-based polymer coating provided a superb hydrophobic surface, and both the polymer and acrylic coatings were found to reduce the adhesion of water droplets.

In one test, a small section was cut from a single-row split-fin-and-tube heat exchanger. The section was submerged in a pan of water, withdrawn, and then allowed to drip-dry for 1 minute before being weighed. Compared with the uncoated heat exchanger section, the silicone-coated section showed a 38% reduction in the amount of water retained. With one exception, all tests showed the two types of coating to result in longer frost buildup times, faster defrosts, and higher integrated coefficients of performance. Additional research into the endurance of the coatings is needed to ensure that they will adhere to heat exchanger surfaces for an extended period of time.

The Texas A&M researchers also studied whether acrylic or silicone-based coatings would make heat exchanger surfaces resistant to corrosion and whether the coatings could enhance the removal of moisture from the coils of air conditioning units. Initial tests have documented that the coatings result in a 10–15% increase in the rate of condensate shedding. In one possible application, the coatings could be used on the heat exchangers of air conditioning units aboard commercial and U.S. Navy ships. They also have great potential for units in large apartment buildings, corporate office buildings, and even residences—especially those in extremely humid climates. And the defrost cycle of commercial freezers could be shortened by retrofitting their heat exchange units with the coatings.

There is a great deal of support for the use of hydrophobic coatings to increase system efficiency. In fact, new second- and third-generation coatings, now being manufactured by leading U.S. and Asian companies, may be even more effective for heat pump and air conditioning units than those tested. ■ *For more information, contact Sekhar Kondepudi, (650) 855-2131.*

COURTESY TEXAS A&M UNIVERSITY

Laboratory tests show that hydrophobic coatings applied to a heat pump's evaporator coil can significantly reduce the kind of frost buildup shown here.

Inorganic Membranes for Gas Separation

Purified gases, such as oxygen, are found everywhere—on board planes, in hospitals, and in doctors' offices. However, many who use oxygen, nitrogen, helium, and other purified gases are not aware of the energy-intensive nature of the gas separation process required to produce them. A study conducted in 1991 found that of the total energy consumed by the chemical and petrochemical industry (5.8 quads a year), nearly half was devoted to the separation of gases. Consequently, the industry is extremely interested in finding faster, less expensive means of separation. Doing so would translate into lower overall costs for the industry and might also result in cost savings for the end user.

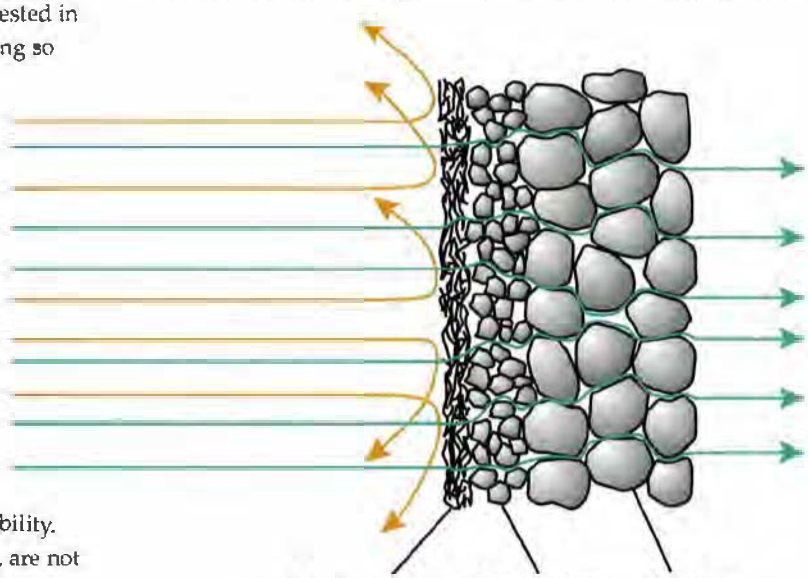
The gas separation industry now relies primarily on distillation and cryogenic separation processes, both of which are energy-intensive. To improve efficiency, the industry would prefer to use membranes for purification. A membrane works basically like a sieve, allowing some molecules to pass through its surface while blocking the passage of other, larger molecules. For membranes to be an efficient means of separation, they must have high mechanical strength, a wide operating-temperature range, good selectivity, and good permeability.

Organic membranes, while effective in some uses, are not universally applicable, since they have low mechanical strength and are limited in terms of operating temperature. Although existing inorganic membranes show good stability and strength, their pore size—in the 5-nm range—is too large to allow good selectivity. In order for inorganic membranes to be competitive, their selectivity must be improved by significantly reducing their pore size—without sacrificing permeability (i.e., without reducing the amount of gas that can flow through the membrane).

EPRI, the Gas Research Institute, and the National Science Foundation's Division of Chemical and Transport Systems jointly funded a study at the University of New Mexico to develop more-effective inorganic membranes. The objective of this effort was to develop rugged inorganic membranes combining good selectivity and permeability with thermal, chemical, and mechanical stability. The results proved so promising that EPRI and the University of New Mexico have jointly submitted a patent application for consideration.

On the basis of laboratory work, the New Mexico researchers have proved that a silica-based sol-gel process can produce very thin inorganic, polymeric membranes that, upon drying, can develop the required fine pore size distribution and can withstand high temperatures. These fabricated membranes have operated consistently at temperatures up to 200°C, which is ideal, and they can also withstand harsh chemical environments and aggressive cleanup after fouling.

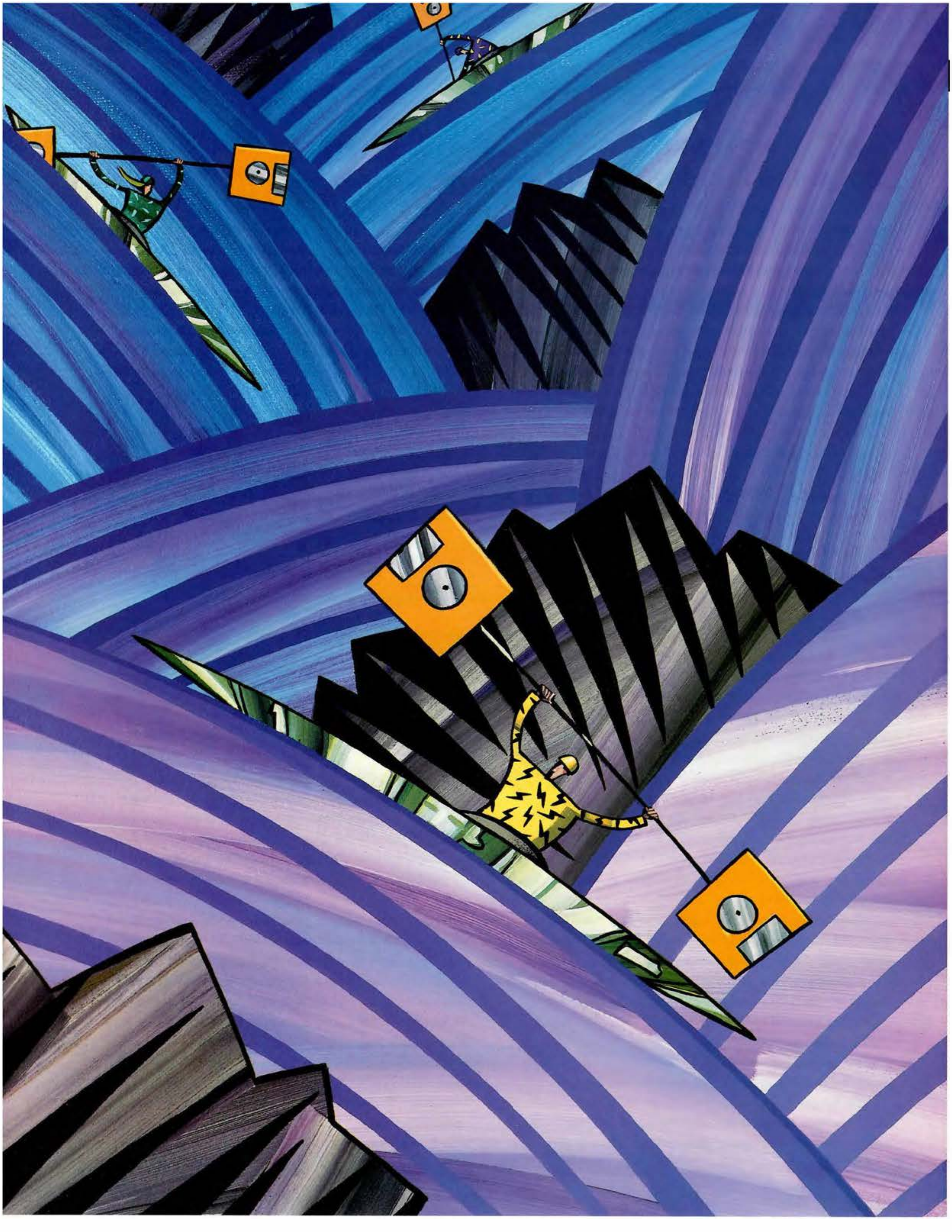
Using carbon dioxide and methane as the model gas mixture, the researchers found that at each level of permeability, the selectivity of the inorganic membranes was at least one



order of magnitude greater than that of organic membranes. Titanium-modified films also showed very high nitrogen-methane separation factors (above 20) at temperatures between 120° and 220°C; organic membranes have a separation factor of only 3. Finally, the inorganic membranes were deemed stable in hot, humid air for at least two and a half months.

There are a variety of potential applications for rugged inorganic membranes. In the chemical and petrochemical industries, they could separate impurities from natural gas. In hospitals, small on-site oxygen generators would be far easier to transport and use than large metal tanks of oxygen. As for utilities, lower-cost air separation would be beneficial in coal gasification–combined-cycle plants. The membranes might also be used to separate nitrogen oxides from the flue gas of conventional power plants, providing a low-cost way to decrease NO_x emissions to a much lower level than is currently possible.

■ *For more information, contact Wate Bakker, (650) 855-2462.*



Navigating the Currents of Risk

THE STORY IN BRIEF Deregulation means rough waters for utilities, as aggressive new players enter the energy market and substantial downside risk becomes part of the financial equation. Now a variety of new risk management software tools are becoming available that can help utilities navigate the dangerous currents of an increasingly commodity-based business environment. EPRI's Electricity Book, for example, enables managers to calculate the risk exposure of an existing portfolio of wholesale power resources and contracts and to determine appropriate ways of hedging this exposure. Other products help utilities design risk-based retail pricing structures and create strategies for corporate-level risk management.

by John Douglas

With annual sales of almost $300 billion, electricity represents the country's

After decades of enjoying regulated monopoly markets and relatively stable financial returns, electric utilities suddenly face rising competition, unprecedented market uncertainties, and substantial financial risks. How well they handle these risks will largely determine which utilities survive and prosper in the new era of deregulation.

For a regulated business, the range of probable returns on investment is usually quite narrow and almost never negative: as long as regulators deem an investment prudent, there is very little chance of losing money. Risk is essentially passed along to consumers through rate adjustments, which compensate for market uncertainties like fuel price fluctuations. For a business in a highly competitive market, however, the range of possible returns is much broader—with more opportunities to increase profits but also a significant potential for suffering financial loss. Ultimately, the burden of risk is passed on to investors, not customers, and risk management becomes a daily business concern.

Risk is especially high in volatile commodity markets, where prices may fluctuate widely and quickly. And as deregulation makes electricity more of a commodity, the growing spot market for wholesale power promises to be considerably more volatile than other energy markets. Because electricity is not readily storable and must be generated in virtually instantaneous response to changing demand, it can experience larger swings in price during a single day than oil or gas may encounter in a whole year. Other factors contributing to high volatility include constraints on the power delivery network (surplus power in Washington state cannot be used to alleviate a surge in demand on hot days in Georgia, for example) and the need for almost limitless availability (as one industry wag puts it, "We can't give a busy signal").

With annual sales of almost $300 billion, electricity represents the country's largest commodity market—bigger than the markets for natural gas and crude oil combined. It's no wonder, then, that deregulation of the U.S. transmission grid has already attracted a large number of independent power marketers and produced stunningly rapid growth in wholesale transactions—from less than 10 million MWh in 1994 to nearly 140 million MWh two years later. Utilities thus find themselves exposed not only to the inherently greater risks of a deregulated market but also to competition from a new breed of sophisticated, aggressive market players. Enron Corporation, for example, the nation's largest independent power marketer, recently increased its transaction volume more than sixfold in a single year—to some 20% of the wholesale market.

How can electric utilities manage such unaccustomed levels of financial risk? A variety of analytical tools for assessing and limiting risk have been developed over the past two decades for use in commodity markets. As electric power becomes more of a commodity, these risk management techniques need to be adapted for use by utility power marketers. The Power Markets & Resource Management (PM&RM) Target in EPRI's Power Delivery Group has become a leader in this product development area.

Betting the ranch

Everyone engages in some form of risk management. One of the most common risk management strategies, for example, is purchasing home insurance—that is, paying someone else to accept the financial risk of your house's burning down or being burglarized. Because the cost of replacing a house is relatively large, most people are unwilling to "bet the ranch" by relying solely on their own resources, although the probability of fire or theft is small. Even if a person can afford to rebuild the house and replace its contents, self-insurance has a hidden cost: keeping enough funds on hand to cover such an emergency would mean forgoing investment opportunities.

Electric utilities facing deregulated markets will have to adopt new strategies of risk management, often using unfamiliar financial instruments originally developed in other markets. In the past, utilities used overcapacity as a form of insurance, passing the cost on to customers, and also kept enough capital available to handle routine financial obligations. Using such traditional risk management methods to cope with a volatile, competitive market for electric power, however, is the business equivalent of betting the ranch. Companies that can't manage the new risks successfully may lose money and eventually be taken over by stronger market players. In a deregulated environment, capital that formerly might have been set aside for self-insurance or new facilities can be invested in nonelectric enterprises. For example, there is already a trend among some of the financially strongest power companies to make investments enabling them to offer customers innovative service packages that combine electricity, gas, telecommunications, and Internet access.

Among the new risks that could threaten a company's existence, one of the most pressing involves stranded investments. The book value of elec-

What Makes Electricity Prices So Volatile?

Factor	Consequence
Lack of large-scale storability	No major reserves are available to smooth out the peaks and valleys of demand.
Instantaneous availability	Generation in response to continuously changing demand leads to wide intraday price swings.
Geographic variability	Because of transmission system constraints, low-cost power from one region may not be available to meet demand in another region.
Weather	Electricity supply and demand both change substantially from season to season.
Absence of market history	Prices for electricity, both for immediate sale and for sale in the future, are hard to establish, in part because electricity's history as a market-traded commodity is so short.

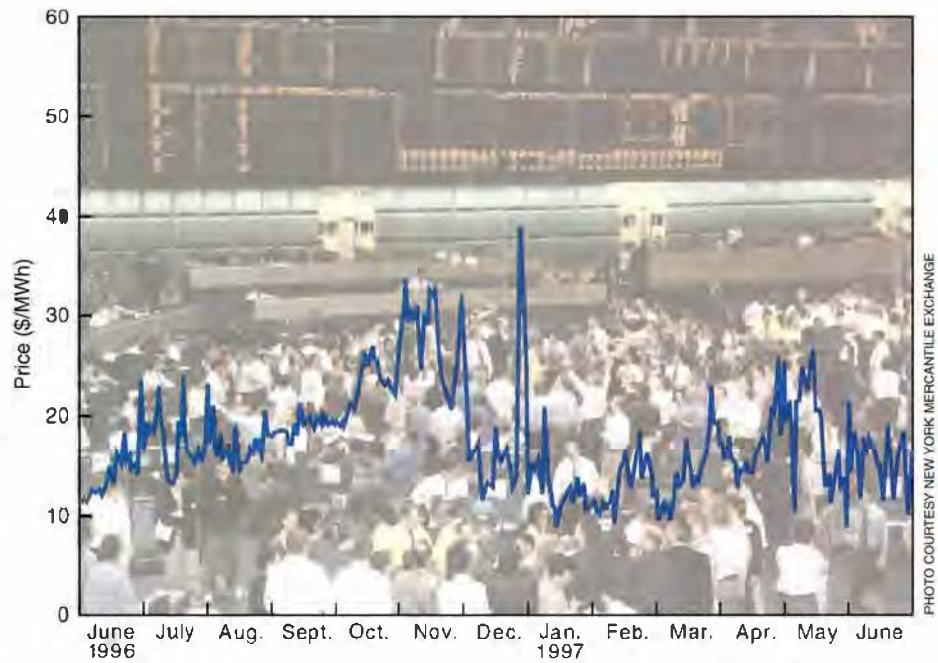
ILLUSTRATION P[illegible] BY ROB BARBER

largest commodity market—bigger than the markets for natural gas and crude oil combined.

tric power industry assets, which is based on construction costs and expected return under regulated rates, is close to $1 trillion. However, the assets' *market* value, based on the expected return from future electricity sales in competitive markets, may be very different and is often significantly less. A nuclear power plant with rates based on amortized construction costs and high interest payments, for example, would have to be devalued in order to reduce its rates to currently competitive levels. Such devaluation could mean that some utilities would be unable to recoup their investments.

Although federal and state regulators are examining ways to allow recovery of stranded investments, utilities will still be faced with strategic questions about what to do with the facilities involved: early retirement, life extension, repowering, refurbishment, or mothballing. In such cases, risk management requires carefully assessing the market value of existing assets and considering various ways to enhance their overall value. Risk-based valuation methods that explicitly incorporate the value of uncertainty represent a significant advance over traditional approaches. EPRI has published a set of reports summarizing these techniques: *Valuing Generation Assets in Uncertain Markets* (AP-107748). Ongoing work, described later, will also be applicable.

Other major risks are more directly associated with trading in deregulated wholesale power markets. Pricing risk, for example, occurs because utilities are exposed to price swings in the substantially independent spot markets for electricity and fuel. A similar risk, called basis risk, involves exposure to two related markets that differ in a significant attribute, such as geography. Quantity risk results from an imbalance between power supplies and sales at a given time. To manage such market-based risks, utilities can choose among a growing variety of financial instruments.



A VOLATILE COMMODITY The Dow-Jones weighted average prices for on-peak power delivered at the California-Oregon border show wide swings, both daily and seasonally. On any given day, prices that individual utilities face may peak at an amount several times the average.

Hedging your bet

Technically, risk management means deciding how much financial risk to accept and how to limit (hedge) the rest. For risks that arise because of market price exposure, hedging involves undertaking a related exposure with offsetting risk. Usually the second kind of exposure entails a contract whose value depends on the price of the underlying commodity; hence the contract is called a derivative.

There are two basic kinds of derivatives: forward contracts and options contracts. In the case of electricity, a forward contract is an obligation to sell (or buy) a specified amount of power at a predetermined price on a particular date. By selling a forward contract, a power supplier hedges against the risk that prices on the spot market may fall to unacceptably low levels on the day in question. Conversely, the contract buyer hedges against the risk that prices may rise unacceptably. The agreed-on price reflects what both parties consider an acceptable level of risk—a compromise that symmetrically limits upside potential and downside losses for both parties.

Such forward contracts have, of course, long been used by individual utilities and their customers. What's new is the rise of a futures market, in which instruments very similar to forward contracts can be traded as independent entities by third parties. These exchange-traded instruments are called futures contracts. The New York Mercantile Exchange (NYMEX) now provides a futures market for electricity contracts written for delivery at two locations: the California-Oregon border and the Palo Verde generating complex in Arizona. The ever-changing value of these contracts is quoted daily in the *Wall Street Journal*, along with quotations from other commodity markets. Because of the constraints facing power delivery systems, NYMEX is expected to soon establish markets in futures contracts for delivery in other regions of the country.

In contrast, options contracts provide a *right* to buy or sell rather than the *obligation* carried by forward or futures contracts. A call option confers the right to buy a given amount of power at a specified price—the strike price. A put option confers the right to sell at a specified price. (If a put or a call can be exercised only on a designated future date, it's called a European option. If it

Electricity has a young futures market and lacks the history of market-based

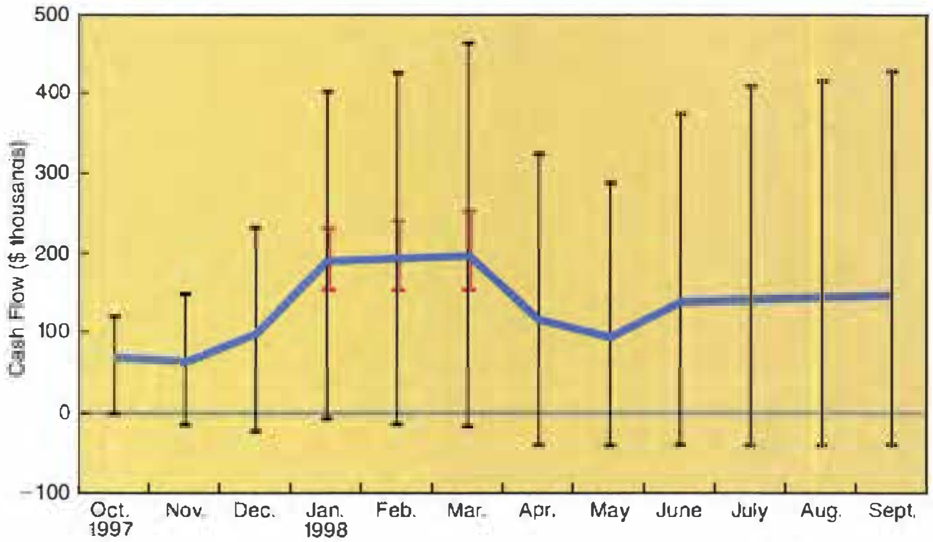
can be exercised anytime before that date, it's called an American option.)

Unlike forward and futures contracts, individual options create asymmetrical limits on risk. Since a call option cannot be exercised profitably unless the spot price for electricity rises above the strike price, it is used to establish a price cap. Such a risk management strategy would be attractive for a major consumer to use to insure against the risk of high prices—without losing the ability to take advantage of lower prices. Similarly, a put option establishes a price floor. Used together, puts and calls can establish both upper and lower limits on risk.

The trick, of course, is determining how much to charge for an option itself. The option seller is essentially offering insurance to the buyer and expects to receive a premium in return. If the option isn't exercised, the seller makes a profit by keeping the premium. Setting a fair option premium requires in-depth knowledge of market volatility for both spot prices and futures contracts. The task is particularly difficult in the case of electricity, which has a young futures market and lacks the history of market-based pricing that traders need to discover patterns of change and thus forecast future prices.

Derivatives that are even more sophisticated can be created by combining multiple basic contracts. A trader concerned about diverging gas and electricity prices, for example, can buy a so-called spark spread, which essentially equates a future quantity of natural gas with its Btu equivalent of electricity. Most electricity options and combination derivatives are now traded between individual parties, but a more comprehensive secondary market is expected to grow rapidly. Shannon Burchett, senior vice president of Duke/Louis Dreyfus (one of the top three power-marketing firms), predicts that "electricity derivatives will become one of the largest commodity markets, rivaling or exceeding volumes of other energy products."

Obviously, trading in derivatives can also create new risks. These instruments are highly leveraged; that is, their value can change greatly with modest swings in the underlying commodity price. As well as being used by commodity buyers and sellers to hedge existing market exposure, derivatives can be traded by third-party investors to take advantage of what they perceive as market imperfections. Because third-party investors generally do not have access to an independent supply of the actual commodity in question, however, they have no fallback position and thus can lose everything. One of Britain's oldest banks, for example, recently collapsed because of speculation by a single trader in an overseas branch office. To use electricity derivatives wisely, both utilities and other investors need a risk assessment and management tool specifically designed to handle the volatility and uncertainty in today's electric power market. EPRI has recently developed a software product that can meet these requirements and more.



NARROWING UNCERTAINTY The value of hedging to reduce risk can be indicated by confidence intervals that represent uncertainties in cash flow over time. An unhedged market exposure, with 80% confidence intervals shown in black, has a wide range of uncertainty and thus considerable risk. The use of forward contracts can significantly reduce the risk, as shown by the confidence intervals in red for the hedged position in January through March.

The Electricity Book

In the parlance of financial markets, a book is an account of assets and obligations. These may include tangible assets, such as a power plant; commitments to buy and sell; and hedging instruments, such as options. EPRI's Electricity Book is a computer program that provides a database for such information and combines it with market descriptions to calculate the market value of current assets, project future cash flow, and reveal exposure to various financial risks. The Electricity Book can be used by utility financial officers, power marketers, and resource planners to develop investment and risk management strategies in a competitive market.

Specifically, the Electricity Book enables managers to answer questions like these: What is the overall risk exposure of my existing portfolio of resources and contracts? Which of these risks do I need to hedge? What's the most effective financial instrument to provide the hedge? How large a hedging position should I take? How frequently might I need to change it? And are the available hedging instruments fairly priced? The Electricity Book addresses such issues more directly than traditional tools in that it deals more explicitly with uncertainty and uses option valuation theory and simulation techniques derived from Wall Street commodity-trading experience.

pricing that traders need to discover patterns of change and thus forecast future prices.

Providing answers that are appropriate to a particular company requires not only computational capacity but also judgment. Electric utilities vary widely in their risk management preferences, and an attractive feature of the Electricity Book is that it provides graphics that clearly illustrate the risk exposure inherent in current and projected portfolios.

One of the most convenient ways to view risk is a graph that presents a cumulative probability distribution of the net present value (NPV) of future cash flow. The lower tail of this S-shaped curve shows instantly how much chance there is of losing money. Traditionally, utility cash flow curves rose steeply at the expected value, indicating little probability of going much higher or lower. With deregulation, however, the curves have broadened considerably, with tails that cross the zero-NPV level—indicating the probability that the current portfolio will produce negative cash flow. As a manager tries out various hedging scenarios, the Electricity Book indicates how each of these would affect the shape of the NPV curve. For example, a utility might buy a put option to eliminate the risk of having to sell power below a critical price—thus shifting the NPV curve to the right so that its tail no longer extends into negative territory.

Another important way to demonstrate the effects of various risk management strategies is to plot expected cash flow through time and indicate uncertainties with vertical bars showing a likely range of fluctuation. A manager could use this type of graph to see how hedging instruments could reduce uncertainty for specific periods by locking in higher profits or reducing potential losses.

The Electricity Book supplies a utility manager with two key parameters for judging the adequacy of a hedging strat-

Hedging With the Electricity Book

A simple example illustrates how the Electricity Book can be used by utilities to hedge financial risk.

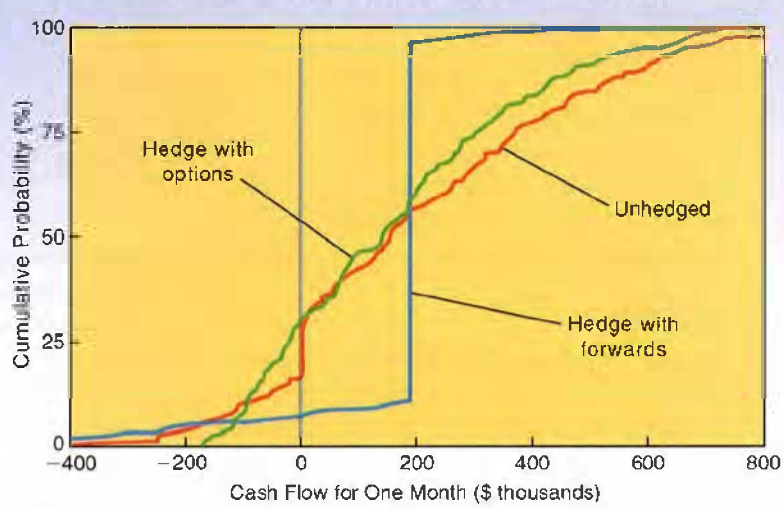
Consider the case of a generation facility with one 110-MW gas-fired baseload unit. Such a unit is fully exposed to the uncertainties of spot markets; that is, profits at any moment depend on the difference between the spot prices for electricity and fuel. Assuming a monthly fixed cost of $40,000, a forced-outage rate averaging 10%, and a heat rate of 7000 Btu/kWh, the Electricity Book calculates a median monthly cash flow for the unit of slightly less than $200,000. Average market prices are assumed to be $25 per on-peak MWh and $12.50 per off-peak MWh for electricity and $2.50 per million Btu for gas. The market forward price term structure, the volatility term structure, and market correlations have also been estimated and input to the database.

With unhedged exposure to a single power market and a single gas market (red line), such a plant exhibits a broad range of possible outcomes. Profits are expected to exceed $400,000 over 20% of the time, but they will be less than $50,000 about 35% of the time; losses exceeding $200,000 have about a 5% likelihood. The plant generates a zero cash flow during forced outages because of its lack of prearranged commitments to buy fuel or sell power. The Electricity Book can be used to evaluate ways to hedge market risks (i.e., modify the financial risk profile) for this generating unit without significantly changing the median cash flow.

One hedging strategy (blue line) would be to use forward contracts on both power sales and gas purchases in order to lock in the median expected cash flow. Such contracts would reduce the risk of negative cash flow to under 10% but would also mean that the plant would make more than $400,000 less than 1% of the time. This form of hedging trades upside potential for downside protection. The source of profit uncertainty in this case is the 10% outage rate, which results in some modest exposure to spot markets.

Alternatively, the plant owner can remain exposed to spot markets but purchase options as insurance against disappointing price swings. A call option on fuel will limit the price the utility might have to pay, and a put option on electricity will ensure that a minimum price is received for its product. Put and call options can be used to reduce or nearly eliminate the possibility of loss while preserving the upside potential for profit, but they can be expensive. In this case (green line), in which the options cost is figured into the evaluation, the essential effect of the options package is to cap the potential loss at around $180,000 while preserving most of the profit potential.

Further experimentation with the Electricity Book in combining forwards, options, and exposure to the spot markets will enable this utility to find a set of hedges that creates a risk strategy consistent with its corporate objectives. In fact, utilities can use the software in developing corporate risk profile objectives.



In a commodity market, forward curves serve as the critical benchmark of value...

egy. The first of these—called delta, following the standard terminology of financial markets—indicates a portfolio's exposure to market volatility. Sometimes known as the hedge ratio, delta is defined as the change in portfolio value resulting from a change in the price of the underlying commodity. Generally speaking, a larger delta suggests a greater need to hedge a portfolio against risk from market exposure. The second parameter, called gamma, indicates the stability of a hedging strategy itself. Gamma is defined as the change in delta for a given change in the underlying commodity. A large gamma suggests that adjustments should be made in the hedging strategy to make it more stable.

"Given the complexity of bulk power markets, utilities need a tool like the Electricity Book to assess their current risk exposure and evaluate alternative hedging strategies," says Art Altman, manager of wholesale risk management research. "But I want to emphasize that the Electricity Book represents only one part of EPRI's risk management package. Our customers need to develop an integrated set of market capabilities in order to maximize profits while accepting an appropriate level of risk. For this reason, we are sponsoring a series of seminars on market participation, decision analysis, and risk management. These seminars have been running at full capacity, and we're scheduling more as quickly as we can."

Utility case studies using the Electricity Book are now under way, and there are opportunities for additional studies. These case studies give the participating utilities a chance to benefit from working with EPRI experts to customize the new techniques to meet their individual needs. In addition, the Electricity Book will be updated in 1998 to include generation valuation.

Forward curves

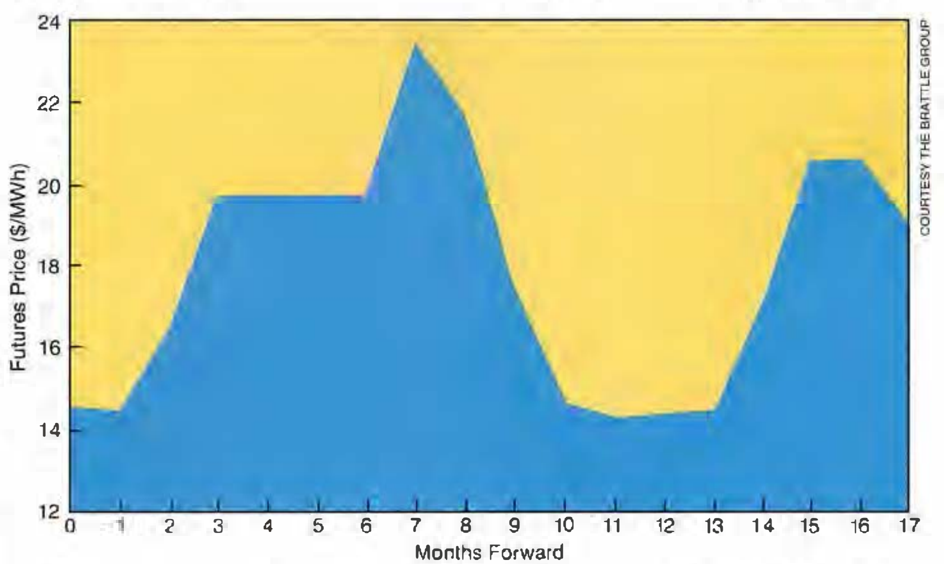
In order to apply the Electricity Book, a user must supply not only detailed information about a particular utility portfolio but also a so-called forward curve of prices for both electricity and relevant fuel markets. A forward curve presents a set of forward prices for a commodity—that is, the set of *current* market prices for the sale of the commodity at specified times in the future.

For established commodity markets, forward curves are readily constructed. In the case of electricity, however, deregulation has come so recently that much of the pertinent market information is not yet available. EPRI has thus undertaken a project to help utilities construct and use forward curves based on limited available data. In addition to supplying critical input to the Electricity Book, these curves are useful in calculating the market value of current assets and in creating a profitable mix of retail products.

In a commodity market, forward curves serve as the critical benchmark of value. Projections of higher future prices increase the current value of production facilities and purchase agreements. Conversely, a declining forward curve increases the value of existing sales agreements and a utility's customer base.

A forward curve, however, is not the same as a price forecast. As Vic Niemeyer, PM&RM's manager for power markets, explains, "Price forecasting, as such, is not that useful for risk management. A forward curve is like a price forecast with the cost of risk management factored in. Lots of vendors are currently engaged in price forecasting. Our work with constructing forward curves differs in three ways: we take risk into account explicitly; we incorporate estimates of market uncertainty in ways that will be most useful for decision making; and we work directly with utility members to help them integrate forward curves into their own analytical models."

How one constructs a forward curve—that is, how one determines the present value of electricity to be delivered in the future—depends most heavily on the time frame involved. In the short term (up to a few months), the price of electricity varies greatly with changes in the weather, generation unit outages, and interregional power flows. For such a case, some guidance is offered by historical spot price data, to-



FORWARD CURVE **On a given day, the cost of contracting to purchase a month's worth of electricity sometime in the future is based on the forward curve of prices for delivery at a major transmission system reference point. This forward curve shows prices quoted on May 1, 1997, by the New York Mercantile Exchange for power delivery at the California-Oregon border. Seasonal variability results from the need to use more-expensive generating units during periods of peak demand. Because electricity prices differ substantially among particular markets and regions, EPRI is helping utilities develop customized forward curves for their own use.**

A forward curve is like a price forecast with the cost of risk management factored in.

gether with deterministic system modeling. Medium-term price fluctuations (up to a few years) are determined primarily by load growth, shifts in fuel price, and customer response to retail price changes. Building a forward curve in this case involves studying futures and options prices and using probabilistic system modeling. Long-term electricity price changes (over several years) are also influenced by load growth and fuel price shifts, but they are significantly affected as well by performance improvements made possible through the use of new generation technology. In this case, market data provide little direction, and forward curve construction is based largely on probabilistic system modeling and asset investment and retirement analysis.

The current focus of EPRI's research in this area is to develop protocols for constructing forward curves for a variety of circumstances. Rather than issuing a new computer program, EPRI will work directly with its members on regional case studies, using the utilities' own analytical tools. In a recently held workshop, the first in a projected series, EPRI staff and contractors showed utility representatives how to build forward curves and use them for pricing electricity for various kinds of retail load shapes.

Retail risks

As deregulation reaches the retail level—giving customers a choice among electricity providers—utilities will face a whole new set of market risks. "Retail electricity may prove to be the riskiest commodity market of all," says Rich Goldberg, who manages PM&RM's pricing and risk management work. "It's virtually a different commodity every hour, and hedging is inherently difficult because consumption represents a nonliquid risk. You don't know when a customer is going to turn on the lights, yet you've got to be ready for it even if that means generating more power at a higher cost. There's no true secondary market to compensate for that sort of uncertainty. Rather you have to design a package of retail prices that take both your customers' preferences and your own risks into account."

For purposes of risk management, various retail pricing structures can be analyzed in terms of financial market equivalents. Traditional flip-the-switch service, for example, is particularly risky from the provider's point of view, since it sets a fixed price for an indefinite quantity of power, available on demand. Even in a regulated environment, this kind of service can have a perverse market impact by effectively encouraging consumption at times when the cost of generating power is highest—for example, in the middle of a hot afternoon. In comparison, a two-part real-time-pricing (RTP) program (with a variable price above a basic demand level) is equivalent to combining a forward contract with access to the spot market. Adding a price cap to the RTP rate is like selling the retail customer a call option.

To enable utilities to assess and manage the risk of their retail portfolios, EPRI is creating an enhanced version of the Electricity Book that can analyze the potential losses and returns associated with various rate structures. This version will also show users how to manage specific retail risks by hedging in the wholesale market. For example, in anticipation of having to meet increased demand on hot August days, a utility might purchase forward contracts on either the bulk power market or the natural gas market.

Risk management, however, represents only one aspect of retail rate design. Customer preferences must also be considered. A new software product that will offer this capability—called Product Mix—is scheduled for prototype testing later this year. Product Mix calculates probable customer response to various rate options on the basis of known customer preferences. In addition, it predicts the market share for each option, models the resulting customer loads, and projects utility revenues. An important feature of Product Mix is that it calculates customer profitability and risk exposure in a retail market for use as input to the Electricity Book. The two software products have been designed to use consistent descriptions of market data, such as forward curves.

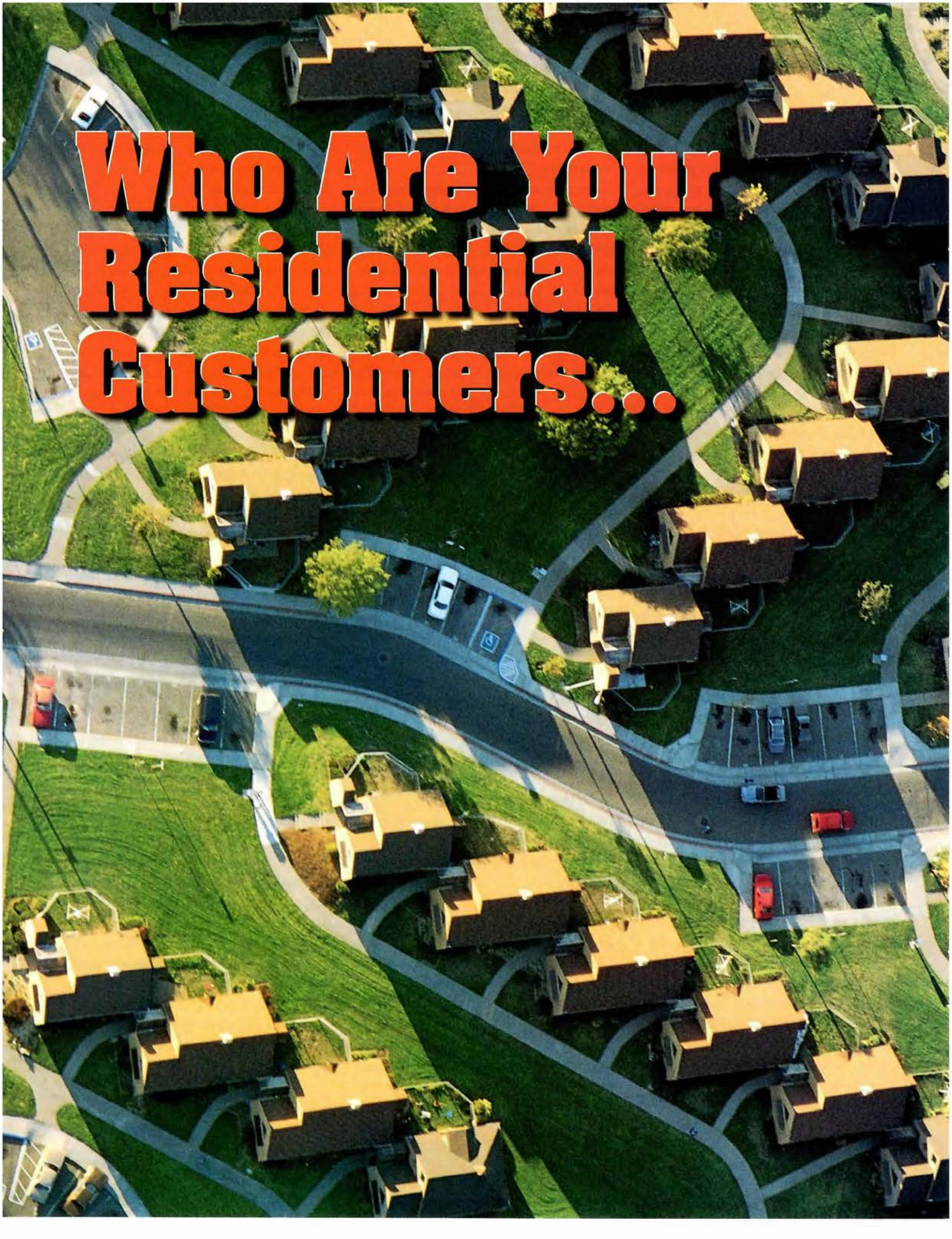
Corporate risk management

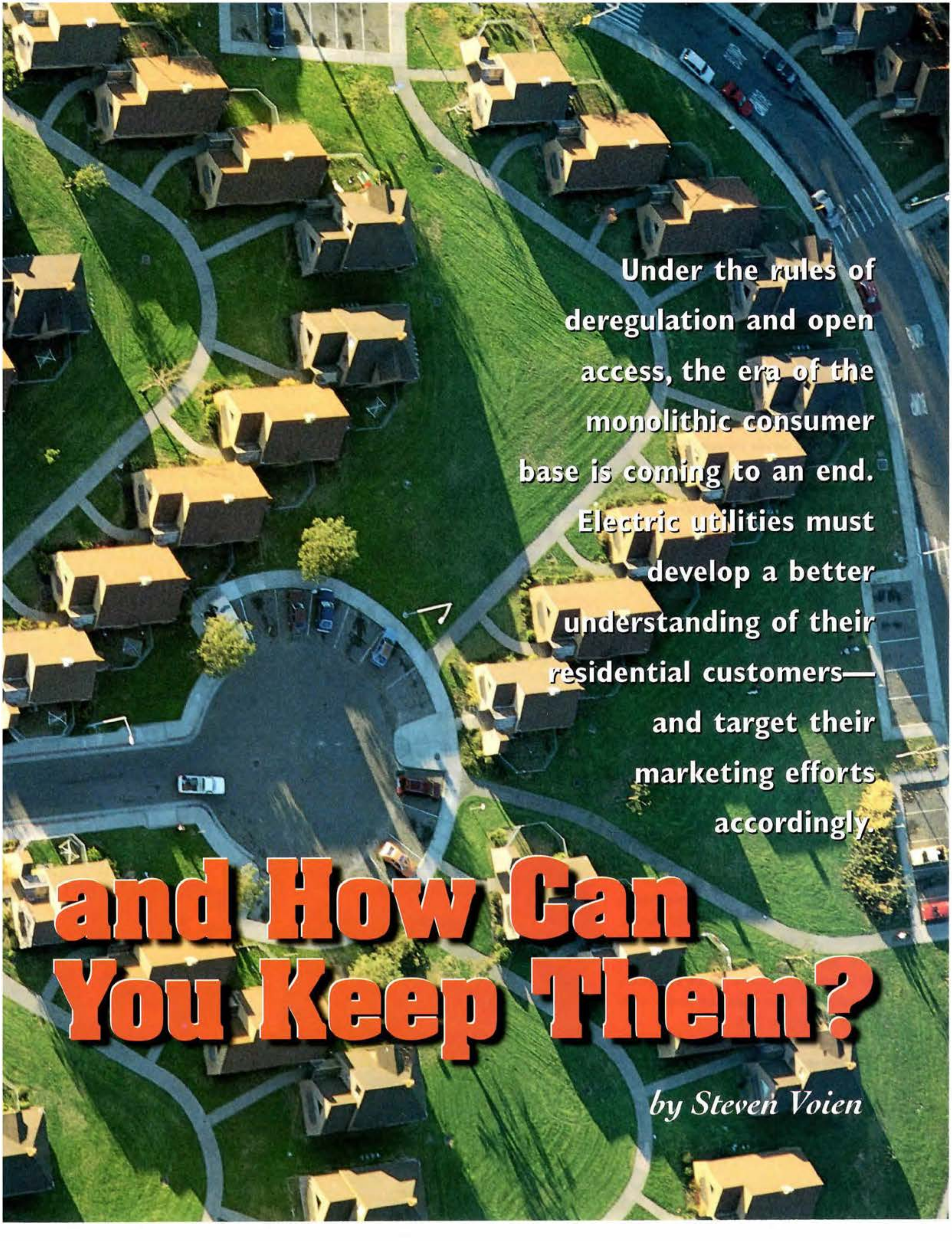
Ultimately, the responsibility for utility risk management rests at the corporate level. Part of the reason lies in the new fiduciary responsibilities that will affect electric utilities as a result of deregulation. In addition, however, synergies exist among the risk management strategies of different business lines. For example, when electricity prices on the spot market are high, retail profits may be adversely affected. This exposure can be offset by more-aggressive participation in the wholesale market and by trading in electric power derivatives. Such balancing of risk requires explicit identification of a utility's corporate posture regarding risk, however, and must be guided by senior management. To help its members develop corporate-level risk management strategies, EPRI is developing new methods and protocols, which will be delivered next year.

"Our goal is to help utilities manage risk at all levels," concludes PM&RM Target Manager Charles Clark. "In particular, our products are designed to be used together so that our members can identify potentially profitable deals at both the wholesale and retail levels and then manage the risks associated with each. Powercoach Lite, for example, can be used to pick out attractive wholesale transactions; then the Electricity Book will show how to hedge the resulting market exposure. Similarly, at the retail level, Product Mix will help identify rate packages that will please customers; then the Electricity Book can be applied to manage the accompanying risk. Meanwhile, our work on forward curves provides the glue that holds all these tools together by providing risk-based estimates of prices and present values." ■

Background information for this article was provided by Art Altman, Vic Niemeyer, Rich Goldberg, and Charles Clark of the Power Markets & Resource Management Business Area/Target.

Who Are Your Residential Customers...





Under the rules of deregulation and open access, the era of the monolithic consumer base is coming to an end. Electric utilities must develop a better understanding of their residential customers—and target their marketing efforts accordingly.

and How Can You Keep Them?

by Steven Voien

Next time you fly into an airport set in a residential area, close your newspaper and take a look at the houses below the airplane—at the cookie-cutter roofs and neatly laid-out yards, with only the occasional swimming pool to break things up. If you spot a few tiny human figures, they won't be recognizable as individuals.

This, essentially, is the perspective electric utilities have had for decades. With a mandate to deliver a commodity product to a captive market, they were free to focus their efforts on generation, delivery, and quality of service. Customer retention and acquisition simply weren't part of the equation.

To say this will all change, and soon, would be the wildest understatement. New England is already in rapid motion, California is set to experience a deregulatory "big bang" of enormous proportions on January 1, and most of the rest of the country will have signed on to this revolution by the year 2000.

Existing utilities will suddenly find themselves just individual players in a crowded retail market. A multitude of competitors, some with vastly greater experience in a deregulated environment, will be muscling in. Customers, for their part, will find themselves confronted with—and somewhat bewildered by—a wide range of choices.

To thrive in this new era, utilities will have to shift quickly from the airplane view down to the street level, where the houses look as individualized as the people inside them. They will have to find out more about the needs, desires, and preferences of their newly freed-up customer base. And they will have to begin marketing themselves not to a monolithic consumer but to a range of individuals—individuals who sometimes make choices on the basis of impulse and less-than-perfect information.

First and foremost, this means developing information-gathering systems of formidable proportions. But sheer volumes of data won't be enough. Utilities will find that the information they gather—as recent EPRI research shows—sometimes yields more paradoxes than definitive answers. A stated intention to switch service providers, for example, may differ dramatically from actual switching behavior; customer satisfaction may turn out to have little relation to loyalty; loyalty itself will prove to be an elusive measure of customer behavior; and price discounting, while an important tool, will not necessarily be the most important one.

Richard Gillman, who manages EPRI's research on understanding energy markets, says, "The most crucial ability for a successful utility in the new era will be the capacity to determine which customers it should keep, which it can ignore, and which it must go after. This requires an understanding both of how customers make choices and of the economics of engaging them. Ultimately, the value of a customer is the return a retail provider can earn over

ONE INTO SIX **Developed from data obtained through the ReQuest III™ survey, these customer groupings are a useful way to break down the residential population. The questions asked in the survey yielded a range of insights into customer demographics, intentions to switch service providers, interest in advanced services, and attitudes toward deregulated utilities, such as long-distance phone companies.**

10¢ a Dance

The most restless of the groups, these individuals feel their electric bill is too high.

- 29% of population
- General age ranges
- Lower income
- Widowed, separated, divorced
- Renters, three-person households
- Eager to switch

Distance Runners

Well educated and in the nest-building phase of life, these are the informed decision makers.

- 21% of population
- 25–44 in age
- Well educated, higher income
- Married, four-person households
- Willing to adopt new technologies
- High willingness to switch

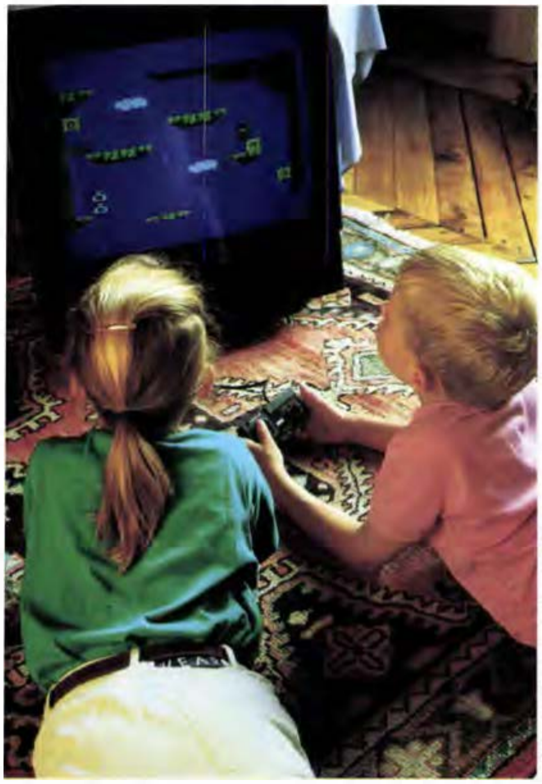
Got My MTV

In general, this group hasn't nested yet; most own a home computer and an entertainment center.

- 12% of population
- Under 35 years old
- Average education and income levels
- Never married, rent their homes
- Moderate users of utility services
- Above-average willingness to switch

PHOTO PAGES 16–17 BY BARRIE ROKEACH/IMAGE BANK

STEWART COHEN/TONY STONE IMAGES



PASCAL CRAPET/TONY STONE IMAGES

the costs of acquiring and retaining that customer."

How does one determine value, exactly? We'll get to that, but we must first take a hard look at information.

Breaking "the customer" into six

It's now widely understood that utilities must change from simple providers of electricity to database-driven marketing firms—firms that, in some cases, will offer electricity as only one of a bundle of services. Understanding a new imperative is not the same as implementing it, however; most utilities don't yet have the information they need to understand the dynamics of customer choice.

EPRI has led the way for electric utilities in this area through, among other research, its participation in a continuing, broad-based study of more than 30,000 households across the country. The most recent results are detailed in *ReQuest III™: Assessing Changes in the Residential Telecommunications and Electric Marketplace* (EPRI TR-107631). On the basis of responses to a range of survey questions, this report presents one possible way to break down the monolithic residential electricity population—by attitudes toward switching electricity providers, responses to price discounting, and attitudes toward other utility services, such as long-distance phone service and cable television.

The ReQuest III research identifies six clusters that, on the basis of switching intention, can be thought of in two rough groups: switchers and loyalists. Three of the six clusters have a distinctly higher-than-average intention to change electricity providers once retail competition is introduced; the remaining three are relatively disinclined to do so. Since the faithful types make up only about a third of the survey population, two-thirds of the market looks to be at significant risk.

Useful information, already. A utility attempting to retain its customers should clearly devote its marketing efforts to the at-risk groups above the switching midline and worry less about the groups below it. And since other ReQuest III data show some correlation between switching intention and satisfaction level—the three clusters with the highest willingness to switch have the lowest satisfaction levels—the goal of these marketing efforts, one assumes, should be to raise satisfaction and thereby improve retention.

A closer look at the data reveals several problems with such a strategy. First, targeting the three likely-to-switch groups may not be as simple as it sounds, because the demographics of the six clusters don't always break down along traditional lines of age and income. Compare two groups, one that might be described as well informed about their decision making (Distance Runners) and another that could be described as self-employed and skeptical (Home Grown). The two groups' demographics—age 25–44, four-person households, medium-to-high incomes—appear nearly identical, and yet their stated intentions to switch are very different. Thus next-door neighbors, with similar incomes and homes and with children in the same school, might have totally different switching intentions.

Second, stated intention to switch has to be factored down in order to be a reliable indicator of actual switching behavior. When the stated intentions of AT&T customers were compared with their behavior, for example, it was found that while roughly one in four customers said they planned to switch during a given year, only about one in ten actually did so.

Finally, it turns out that higher levels of customer satisfaction—counterintuitively—do not necessarily result in customer retention. Volumes of market research, including work done by Xerox in the early nineties, have demonstrated that, as business writer Thomas Stewart wrote in *Fortune* magazine, "Satisfied customers often don't come back." Satisfaction, it seems, creates loyalty in only a small percentage of consumers, those who are not merely satisfied but are wildly happy about their

Home Grown

Self-employed skeptics, these individuals are homeowners with a moderate willingness to adopt new technologies.

- 17% of population
- 25–44 in age
- Medium education and income levels
- Divorced or never married
- Four-person households
- Moderate willingness to switch

Give Me My MTV

Many in this group are empty nesters, still in their peak earning and discretionary income years.

- 14% of population
- 45–64 in age
- Higher education and income levels
- Married homeowners, two-person households
- Open to new technologies
- Moderate willingness to switch

Status Quo

This group has the lower incomes associated with retirement and has low electric bills.

- 7% of population
- 55 and older
- Lower education and income levels
- Married or widowed, one- or two-person households
- Little interest in new technologies
- Reluctant to switch

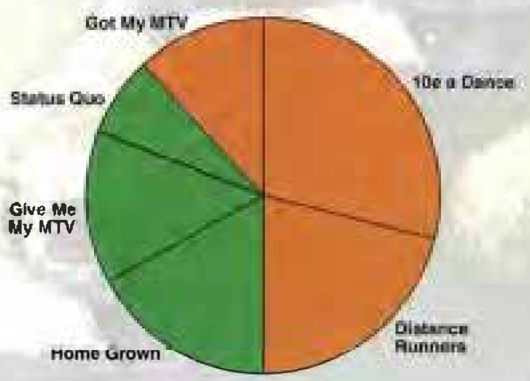
experience with a given company. Satisfaction may be a useful standard for measuring the state of the customer relationship, but it cannot be used as a key driver when designing a strategy to attract and retain customers.

Paul Rappoport of PNR and Associates, which conducted the ReQuest studies used by EPRI, says, "Does all this mean that market segmentation, switching intention, and satisfaction levels are unimportant metrics for a utility? Not at all. What it means is that these metrics, in and of themselves, won't be enough to get the job done. Utilities will have to master these and move on."

true not only for stated intention to switch but also for actual switching behavior. Sprint, MCI, and AT&T have competed brutally on a cost basis, both with one another and with an army of smaller competitors. Cost has the cardinal virtue of simplicity, which makes it an attractive standard both for utilities trying to develop a coherent marketing plan and for customers faced with a confusing array of choices.

Does this mean utilities can throw their other marketing metrics out the window and compete on cost alone? For most, the answer is no. To begin with, strictly in terms of the bottom line, such a strategy would be difficult to implement. Existing providers are likely to face at least one aggressive competitor willing to slash prices down to or below profitability levels. This sort of competitor will have the advantage of entering the market "clean"—that is, without stranded costs and without having to overcome a perception that it is expensive and bureaucratic, a perception some consumers have of their current utility.

SWITCHERS OUTNUMBER LOYALISTS **Three of the six ReQuest III customer groups show relatively high levels of inclination to switch electricity providers, even without incentives. Thus in a competitive environment nearly two-thirds of the customer base may be at immediate risk.**



Customers Willing to Switch

	Price Discount		
Group	0%	10%	20%
10¢ a Dance	64.5%	97.4%	98.7%
Distance Runners	35.6%	96.5%	98.3%
Got My MTV	32.3%	90.5%	95.0%
Home Grown	4.1%	51.1%	71.2%
Give Me My MTV	8.3%	43.9%	67.9%
Status Quo	2.0%	14.5%	23.0%

The largest utility bill

Cost, without question, will be a major consideration for most consumers in choosing their electricity provider. When customer willingness to switch at price breaks of 0%, 10%, and 20% was looked at, the effect across all six segments was dramatic. For every group, a 10% price discount created a spectacular increase in willingness to switch, with a further leap at 20%. The self-employed skeptics (Home Grown), for example, express only a 4% willingness to switch at no discount but vault to a 51% willingness at a 10% discount. Other ReQuest III data show that for most residential customers, their monthly electric bill—often the largest utility bill they receive—is such a major factor they would be willing to make trade-offs in other attributes (quality of product and service, for example) in order to receive a discount.

Long-distance providers, already well into the deregulated era, have found—tellingly—that the effect of discounting holds

Even a utility that does choose to distinguish itself by offering rock-bottom prices may find that its customers don't get the message. More than one pilot project has shown that ordinary consumers, allowed to choose among several electricity retailers, most often point to cost as their prime decision-making factor—and then promptly scatter their choices among several of the available providers. Further investigation has shown that few of these customers did the necessary homework to make an effective cost comparison. Thus it won't be enough for a provider to *be* the cheapest; it will have to be *perceived* as the cheapest. And in a market filled with a welter of competing claims, that will be difficult to pull off.

Most analysts agree that utilities will have to compete on cost but that cost alone won't make them competitive. "The most recent work we're doing takes a look at whether price, in and of itself, is an adequate indicator of whether customers are likely to change electricity providers," says EPRI's Gillman. "What we're finding is that people want more than just low cost. They want value, good service, and a quality product, and many are willing to pay a premium for these."

The two faces of customer loyalty

If cost by itself is not the answer, should existing utilities focus instead on loyalty? After all, when the big bang goes off, they'll be standing at ground zero, already in possession of the entire residential market. A utility that succeeds in cultivating high loyalty levels among its customers should, it would seem, succeed at retaining most of its customers, even in the face of competition.

The difficulty with choosing loyalty as a marketing goal becomes clear the moment we try to define it. Instinctively, we might say loyalty is the tendency of customers to stay with their current provider, even when the market offers alternatives. This is in fact a good description of loyalty behavior, but it fails utterly to get a grip on loyalty motivation. A recent EPRI conference paper points out that customers are usually loyal either to offers or to brands. Residential electricity customers who appear to be loyal to their existing provider may not actually be motivated by brand loyalty; they may simply feel that their utility is currently offering them the best deal. Such loyalty to an offer may disappear the moment some telemarketer offers them $50 to switch.

What about loyalists to a brand, those who—driven by a temperamental disinclination to switch—consistently stay with their long-distance phone company, financial services provider, dry cleaner, and grocer? As it happens, these customers make up only a small percentage of the market. And in spite of their immobility and brand loyalty, new competitors will be gunning for their business. In the words of one observer, these customers are "hard to get hold of but good to have."

This in no way means that loyalty can be dismissed or that brand names are unimportant. Even customers driven by offer loyalty often use brand names as a shortcut to identify preferred product packages. Thus a utility that consistently provides attractive product packages may find that long-term brand loyalty does begin to emerge. At this point, a further question arises: Is a loyal customer necessarily a *good* customer?

Value: the sum of all information

According to Gillman, the answer is "Not necessarily. From a business point of view, credit ratings, solid incomes, and regular card usage. As competition in the bank card business grew more cutthroat, someone noticed that many of these customers—who paid their bills every month and thus incurred no interest charges—weren't actually generating much return. Acquisition efforts began shifting toward customers who were likely to pay their bills eventually but who, in the meantime, often carried monthly balances and thus generated greater return.

"Rather than trying to attract loyal customers," says Gillman, "companies should focus on attracting customers with the greatest life-cycle value—in other words,

SHOW ME THE SAVINGS
For all the ReQuest III groups, the willingness to switch electricity providers goes up dramatically with a 10% price discount. A further leap occurs at a discount of 20%.

Switching Intention Versus Behavior

	"I Will Change Providers"	"I Changed Providers"	Actual/ Expressed*
AT&T customers	27.5%	10.0%	36%
MCI customers	46.6%	28.9%	62%
Sprint customers	37.2%	21.6%	60%
Others	38.6%	24.9%	64%

*Actual switchers as a percentage of those expressing an intention to switch.

WILL THEY OR WON'T THEY?
Stated intention to switch a utility provider may differ markedly from actual switching behavior, as shown by the experience of long-distance providers in the deregulated telephone market. These time-series data show intended versus actual behavior over a one-year period.

MARK HARMEL/TONY STONE IMAGES

value, not loyalty, should be what is emphasized."

Value, as a concept, is most often used to describe what a customer might receive from a business; yet businesses must begin making the same determination with regard to their customers. To make this point, Gillman returns to the ReQuest III results and the breakdown of customers into loyalists and switchers. A utility might assume a loyalist to be a good customer and a switcher to be a bad one. If the loyalist has such low usage rates that the account fails to generate even a minimal return on investment, however, and the switcher—while admittedly expensive to attract and retain—uses significant amounts of electricity during peak months, then loyalty, as a metric, doesn't tell the whole story of these customers' real worth.

Yet another example comes from the financial services industry. Five years ago, bank card companies focused their acquisition efforts on consumers with good those who contribute most to the bottom line." Value, it turns out, is a multidimensional concept that pulls together customer responses to price, to competing offers, and to various ancillary features, then measures these against the cost of customer acquisition and retention over time. As a benchmark, value is both the most useful and the most difficult to calculate; essentially it moves a utility into a brand-new realm.

EPRI is implementing a number of studies that will allow utilities to make increasingly accurate determinations of customer value. One of these, an intensive round of small focus groups, is digging deep into the underlying determinants of customer loyalty. A second round of focus groups, in combination with a follow-on survey of 20,000 households, is looking at how customers define green power. The results will help predict how many might be interested in green power and will provide rough estimates of the premium they

Look, Then Leap: Two Providers Take the

For existing utilities, one of the most unsettling aspects of deregulation is that they will have to make decisions about how to position themselves, company-transforming decisions, *before* they know where the market is going. This may be business as usual for a company like Boeing—which, given massive and long-term development costs, virtually bets its survival on each new model of aircraft—but it's something new in the electricity business.

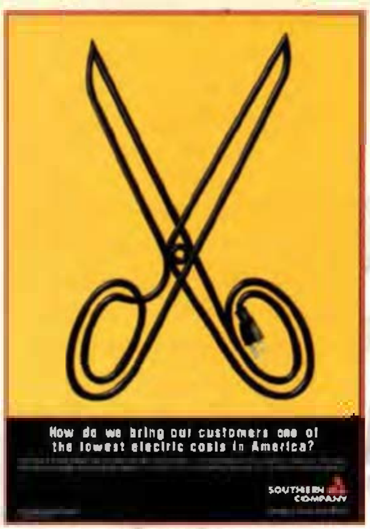
Two existing utilities have accepted that they cannot be all things to all customers and have begun to differentiate themselves by becoming—well, different. Each is going flat out to create a viable niche for itself by building on existing corporate strengths. In effect, each has chosen to create loyalty, be it the offer variety or the brand variety, in a particular part of the market by becoming exactly what that part of the market wants.

UtiliCorp United, based in Kansas City, has chosen to compete on the concept of simplification through bundling. The company has joined with PECO Energy to create EnergyOne, a freestanding enterprise that brings together a portfolio of services, including electricity, gas, long-distance telephone (AT&T), and home security (ADT) services. EnergyOne will sell this portfolio not to residential customers but rather to the utilities that serve those customers.

UtiliCorp spokesman Jerry Cosley says participation in EnergyOne will allow a utility to jump-start the process of becoming a broad-spectrum provider. "The utility won't have to start from scratch building relationships and negotiating contracts with other providers like AT&T. That's expensive and laborious. Even if utilities had the money to do this on their own, they don't have the time." By the end of the year, says Cosley, EnergyOne hopes to combine all these services on a single bill. "That won't be easy, but it's the goal. It's what the customer wants—simplicity."

Green Mountain Energy Partners, instead of offering a broad spectrum of services, has focused on a single color band—green. Beginning with a pilot project in New Hampshire, the company has fashioned a proenvironmental image through such tactics as sending out spruce saplings (Green Mountain is now widely referred to as "the people who give the seedlings away") and offering EcoCredit in-

MARKETING AN IDENTITY Existing utilities, as well as new providers, are already marketing themselves aggressively to many different niches within the overall market. In the process, they are transforming their corporate identities.



COURTESY SOUTHERN COMPANY

COURTESY ENERGYONE

COURTESY SOUTHERN CALIFORNIA EDISON

would be willing to pay for it.

These projects, in combination with the homework utilities should already be doing to understand their own markets, will allow for better customer predictability and the development of ever-more-sophisticated marketing tools. Gillman notes, however, that these tools will have to be kept sharp through constant use. "The 'customer' is a moving target," he says. "By the time we've run our data through the computers and reached conclusions, the customers we're studying have already begun morphing into something new."

One customer trait emerging from comparative data on long-distance phone service may work to the advantage of existing utilities. A settling-out factor appears to be at work among some customers. After years of playing the long-distance market, customers feel they've "been there and done that" and are ready to stick with one provider. This willingness is related to a broader sentiment, expressed increasingly in focus groups, that people are simply tired of making choices. Alert utilities will watch this sort of trend and factor it into an evolving determination of a customer's value.

Adding up the future

AT&T may be the standard by which electric utilities should measure themselves ducements. The strategy has been a winning one, placing the company at the forefront of retailers offering environmentally friendly power.

Green Mountain is dead serious about capturing a sizable chunk of California's $20 billion residential electricity market, says Julie Blunden, regional director for the company's California affiliate, Green Mountain Energy Resources. "We expect to have broad-based appeal," she says, "by making it clear to our customers that the money they send through us goes directly to suppliers of renewable energy. In effect, we'll let customers vote with their dollars for a change in the way energy is produced in this country."

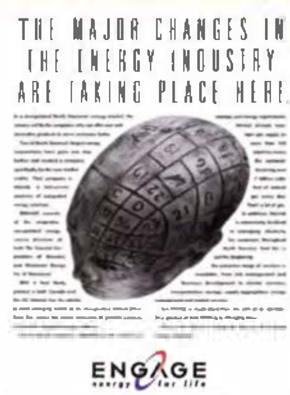
Industry analyst Bill Huss, who is conducting a broad study of pilot energy programs, notes that while each of the marketing approaches described above will get results, each entails risk. "No one has studied bundling and single billing yet in any pilot program," he points out. "And we're seeing some resistance to the idea. People like the idea of a single bill, but they worry about getting 'captured' and paying too much for one or more of the services on that bill."

With regard to Green Mountain, Huss says that while the company has crafted a successful approach, it won't be alone in that approach. A number of solid competitors—Working Assets, for example—will be attempting to squeeze into the same niche. And even if that niche proves large enough to hold more than one provider, it may be self-limiting in terms of growth. "In a flat market for residential electricity," Huss says, "that could prove costly over the long term."

Are companies like UtiliCorp and Green Mountain leaping too soon, taking on unnecessary risk? Some skeptics point out that electricity is a conservative and complex business and that change may come more slowly than anticipated. But the evidence from California suggests otherwise. In July of this year, when new electricity retailers began registering with the California Public Utilities Commission, more than 30 company names were on the books almost immediately. These included Green Mountain, PG&E Energy Services (Pacific Gas and Electric's affiliate), and Enron, as well as companies such as Friendly Power Company, Affluent Target Marketing, Thrifty Power, and The People's Power Company. Some of the names on the list are tiny players that won't last long or make much of an impact on the market. Others, however, are real competitors who believe the big bang is for real—and aren't shy about telling you they think the initial period of deregulation will offer the greatest opportunity to acquire new customers. Existing utilities who avoid risk by taking a wait-and-watch approach may find themselves watching their customers walk out the door. □

COURTESY GREEN MOUNTAIN ENERGY RESOURCES

COURTESY ENABLE



COURTESY ENGAGE


COURTESY ENRON

as they enter retail competition. Once a monopoly, AT&T successfully developed broad information-gathering capacities and a range of effective marketing approaches. Despite years of ferocious competition, AT&T continues to be the dominant player in its industry and has become adept at recapturing customers who, after switching to another provider at some point, have become disillusioned and are willing to return.

The successful utilities, in the end, will be the companies that are able to build on the positive aspects of their current brand images, collect huge amounts of information and assemble it into a portrait of customer value, and make bold positioning and marketing decisions on the basis of that determination of value. The rewards for this kind of corporate transformation—as AT&T has demonstrated—will be substantial. ■

Further reading

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Background information for this article was provided by Richard Gillman of the Retail Market Tools & Services Business Area.

China *and the* New Asian Electricity Markets

THE STORY IN BRIEF *Electrification, a prime force for global development throughout the last century, will be especially important for fast-developing Asian economies over the next 20 years. Such economic development is the key to greatly improving the quality of life for many of the world's poor. The challenges and opportunities involved in extending electricity's reach were the focus of "Global Electrification: The Next Decades," an international forum hosted by EPRI in March of this year. The forum was organized and chaired by Jack M. Hollander, a professor emeritus of energy and resources at the University of California at Berkeley. This article, which examines the prospects for electricity growth in China and India, was adapted from a paper by Hollander that captures the discussions and conclusions of the forum's participants, including EPRI staff and invited guests.*

by Jack M. Hollander

Revolutionary combinations of electric, information, and communications technologies are rapidly transforming the world into a very small place. But despite the economic expansion that is occurring in many of the world's less-developed countries, some 2 billion people—40% of the global population—still do not have electric lights or other basic energy services in their homes. In developing countries, electrification is increasingly recognized as essential for raising health and living standards and as a fundamental tool for achieving sustainable development through enhanced productivity, efficiency, and environmental quality.

Finding the pathways to global electrification—technical, financial, institutional, and political—poses formidable challenges yet offers immense opportunities to the electricity industry in the coming decades. A shared international vision is needed of electricity's strategic role in the future world of globalized markets and environmental concerns (key among which is the potential for carbon dioxide emissions from fossil fuel combustion to cause global climate change). To help foster such a vision, EPRI held a forum on global electrification earlier this year that brought together international energy scholars and scientists from several countries to consider, in the context of the historical record, the world's future use of resources and energy. The forum's primary focus was on the fast-growing economies of Asia, which provide an important and fascinating window on the future of global electrification.

Asia on the ascent

With continuing strong economic performance and growing world importance, Asia is attracting increasing international interest in its electricity markets. By 2010, Asia may produce 27% of the world gross domestic product (GDP), up from 20% today, and its share of world electricity output may grow from 15% to 23%, according to David Jhirad, U.S. deputy assistant secretary of energy for international energy policy. The region includes the world's most populous countries: China, with 1.2 billion people, and India, with 970 million.

China is experiencing especially rapid growth. Its GDP has grown at an annual rate of 9.2% over the past 15 years—four times the growth rate of the large industrial economies—and over the next decade, annual growth of 7% is expected. By 2030, China's economy will be the world's largest, surpassing that of the United States, according to a forecast by the Chinese Academy of Social Sciences. China's energy use may grow only half as fast as its GDP because of efficiency improvements, but the figures still imply a doubling of energy consumption in two decades.

Today China's per capita electricity consumption is only 8% of that of the United States. Over the next two decades, China is planning to add 15–18 GW of power-generating capacity per year, about three-quarters of which will be coal fired. Even if China succeeds in a maximum-innovation scenario that pushes every alternative—including clean coal technology, Western levels of industrial efficiency, aggressive indigenous gas resource development, extensive hydroelectric development (equivalent to several dams like the Three Gorges complex now being built), and advanced nuclear technology (as much as 30 GW)—its per capita electricity use would still be only 15% of the current U.S. level.

China's planned growth in power-generating capacity will require $200 billion of investment capital to 2010, at least a third of which must come from foreign sources. With the number of independent power producers growing rapidly, 20% of China's electricity in 2010 may be generated by privately owned installations.

China's large coal reserves suggest that most generating-capacity additions will be coal fired. This new capacity can be made both technically efficient and environmentally tolerable if China is willing and able to invest in advanced generating technologies that are now reaching the stage of commercial viability in Western countries.

For China to pursue a development strategy aimed at decarbonizing its energy use, however, extensive substitution for coal would be necessary, along with large amounts of hydro, gas, and nuclear power. In particular, installed nuclear generating capacity would have to grow from 2 GW today to at least 30 GW in 2020. Achieving such a level in 2020 would require high levels of commitment to projects and financing in the next few years. A complicating factor is that some proponents of

decarbonization are opposed to nuclear power as an alternative. And even if a decarbonization path were followed, the best that China could do over the next two decades would be to reduce the expected growth in total carbon emissions from three times the current level to double the current level.

Contrasting models of development

What kinds of models can best guide the development of the global electricity industry? Two very different visions of the future are apparent. A Western model that can be characterized as a "customer power" model pictures an industry with little regulation, open competition, and wide customer choice. An Asian model sometimes referred to as *da huo* ("big flame") describes an enterprise driven by a sense and tradition of social equity. In this vision, the electricity industry is not left to market forces alone: governments assume responsibility for stable supplies of electricity. This model is strongly embraced in most of the rapidly developing economies of Asia. A critical issue is whether dependable and affordable energy supplies can be based on Western market models in the developing world.

Meeting the requirements of Asian electricity development in the context of these two kinds of models is a challenge calling for unprecedented innovation. The capital requirements are daunting, changes in policy and institutional structure are essential, and innovative technology is fundamental to achieving efficient and environmentally sound electrification.

Approximately $150 billion annually—10% of total global investment—is needed for electricity development in China, India, Korea, and Southeast Asia. Multilateral institutions like the

China's determined push to become an economic giant in the Far East is highly dependent on increased electrification; much of its new power capacity will come from coal-fired generation.

World Bank and the Asian Development Bank could supply, at most, about $7 billion per year (although they can play other useful roles, such as guaranteeing private investments, disseminating credible information, and evaluating the results of competition in terms of cost, reliability and service, and protection of the environment).

ALAIN LE GARSMEUR/TONY STONE IMAGES

A business-as-usual strategy will not work. Private capital must fill the gap, implying a profound change in the relationships between governments, energy industries, and the private sector. Lighting the way are the several large, privately financed power projects that have been successful in Asia. Innovative financing must be found, however, for smaller projects (under 50 MW) involving cogeneration, coal gasification–combined-cycle, industrial heat recovery, and wind turbine technologies. The needed capital will be forthcoming only if investors perceive that the opportunities, risks, and pricing structures are all favorable.

Although in Asia energy has been considered a social good provided by government-owned, -operated, -regulated, and -financed monopolies, today a new paradigm is emerging. People are looking less to government and more to the market system and the private sector as the main instruments of energy supply. The structure of policy and the organization of the energy industry worldwide must adjust accordingly. In Asia, as elsewhere, profound institutional innovation is needed.

In China, where the electricity system has been highly centralized and government controlled, with a strong sense of social equity (the *da huo* paradigm), the trend toward decentralization, deregulation, and competition ("customer power") is in the early stages. The trend is also just beginning in the Philippines but is further along in Indonesia, Singapore, and Malaysia.

Electricity price structures are also changing in Asia. Historically, the price of electricity has been low, with government subsidies keeping it below production cost (e.g., 4.7¢/kWh in India and 1.9¢/kWh in China, compared with 19¢/kWh in Japan and 9¢/kWh in the United States). Pressures for full-cost electricity pricing are coming from the increasing number of foreign investors in the Asian power sector. However, the financial institutions needed to bring about these pricing changes are not yet well established.

Electrification on a broad front

As outlined in forum discussions led by Felix Wu of the University of Hong Kong and by David Jhirad, critical system changes—such as the construction of new transmission interconnections—are also occurring in Southeast Asia. Since 1982, members of the Association of Southeast Asian Nations have cooperated in building transmission interconnections, with major lines already completed from Malaysia to Singapore and from Malaysia to Thailand.

China is building a large transmission and distribution system that will reduce system losses and better use domestic coal resources and hydro facilities, including the 18,200-MW, $24 billion Three Gorges hydro complex under construction on the Yangtze River, planned to begin operation in 2009. Since 1992, China has also been considering interconnections going beyond its national borders.

Electrified transportation systems will play a key role in the Asian electrification programs as new infrastructures are developed. China, Singapore, and Indonesia are planning electric trolley systems, while Taiwan is developing electric scooters.

Information technologies are also being incorporated in Asia's developing electricity systems. Moving rapidly in this area, China is employing state-of-the-art computer systems for the control of power plants, real-time power dispatch, and optimization of distribution systems.

Funding the new electrification projects raises some challenging sociopolitical questions. Because of the paradigm of social equity that has historically governed electrification in Asia, there is resistance to the idea of corporatization, which in Asia basically means moving state assets into private hands. This is in contrast to the Western concept of market liberalization, which means rationalizing cost and pricing structures.

It is an open question whether the political will exists in Asia to develop pricing structures that will produce the huge amount of capital needed to accomplish the ambitious electrification plans being proposed. Most of the pressure for changing pricing structures is coming from outside investors. Politicians in Asian countries balance these pressures with internal political pressures to keep the price of electricity low.

Outside investors also face the longstanding social traditions guiding personal and business interactions in Asian societies, which are foreign to most Western business people. Whether new ways of working can be developed that will satisfy external investors is an open question. Members of the U.S. business community who understand English and Asian languages as well as the social traditions of both cultures enjoy a great advantage in developing business relationships in Asia.

Nuclear power does not figure strongly in the current electrification schemes of most Asian countries. Although China is building some nuclear plants and includes nuclear power in its decarbonization scenarios, coal appears to be the fuel of choice. Most other Asian countries are taking a wait-and-see attitude toward nuclear power. Taiwan, which had a strong nuclear program, has backed off in the nuclear area.

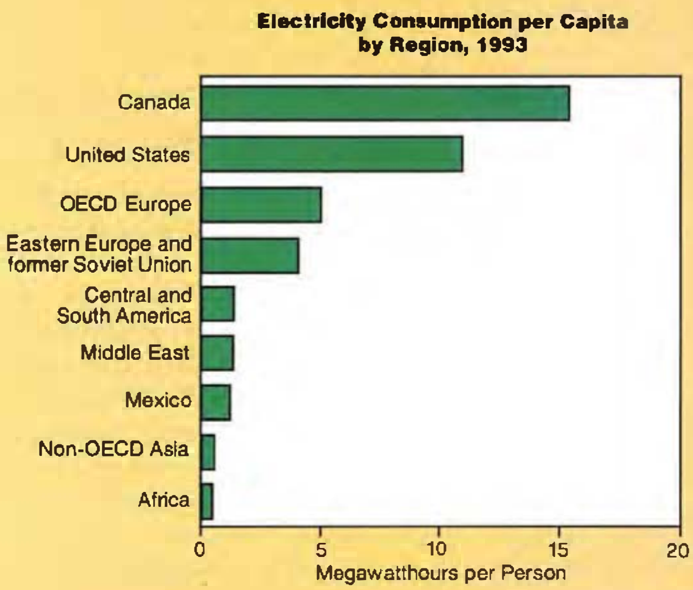
Education and training are critically needed in the Asian countries to prepare people for work in the rapidly expanding electricity industries. Many companies investing in electricity in Asia also build educational centers stressing management training as well as technical education. Mitsubishi Heavy Industries, for example, recently established a technical training center in Beijing.

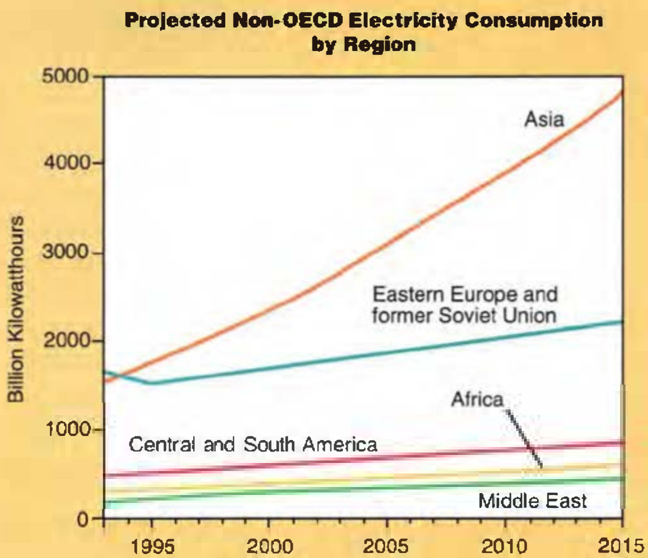
China's leaders face difficult strategic and financial issues as they plan their country's energy future. Coal use, today about equal to that of the United States, is projected to climb to twice the U.S. level in 15 years. Natural gas use is expected to increase fourfold. Financing must be found for the heavy investments that will be required for clean coal generation.

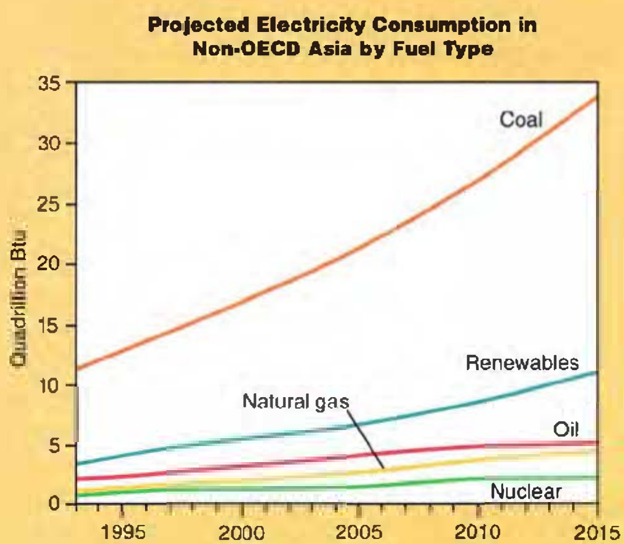
Especially vexing will be China's projected oil imports, which could grow to 8 million barrels per day by 2015 (equal to today's U.S. oil imports), even with aggressive domestic oil and gas exploration. The massive hard currency requirements for these imports will be met from exports, many to the United States, which may create serious tensions in the U.S.-China trade relationship.

U.S. trade policy on energy technologies may be seriously challenged. Capacity additions in China will be huge—some 15–18 GW per year, more than the likely capacity additions in the United States, Canada, and Mexico combined. An enormous market for efficient and environmentally superior energy technologies will be created. The U.S. energy industry has an obvious stake in this market.

But significant political impediments hinder the U.S. energy equipment trade. The U.S. government allows fewer concessions in financing (e.g., export credits and loans) than the Japanese and European governments. American companies are prohibited from selling nuclear technologies to China, which has purchased two plants from Canada and five from France







ELECTRICITY USE IN ASIA'S DEVELOPING ECONOMIES
The advanced industrial economies of Canada, the United States, and western Europe are the largest per capita consumers of electricity today. But China, India, and the rest of Asia other than Japan are expected to experience the largest growth in electricity consumption over the next 15 years of any region worldwide, with more than half of the growth projected to occur in China alone. Coal is expected to remain the fuel of choice to meet the region's rising demand for electricity. (Source: U.S. Department of Energy, Energy Information Administration, *International Energy Outlook 1996*, Washington, D.C., May 1996; DOE/EIA-0484[96].)

Improvements in efficiency and integration across the entire power infrastructure are key to making electricity available to more of India's population. Foreign investment in new power plants, such as the one shown here—the 2450-MW Dabhol plant, being built by Enron near Bombay—will also help.

COURTESY ENRON

and is considering Russian plants. And government restrictions on such agencies as the U.S. Agency for International Development prevent them from undertaking projects in China.

At a minimum, the United States should establish a coherent and consistent trade relationship with China and remove barriers that inhibit energy investments by U.S. firms in China. The continuing viability of the U.S. energy industry depends in no small measure on its ability to compete in the huge and growing Asian energy market.

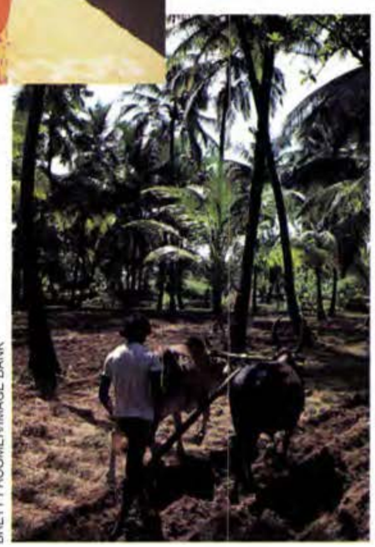
CARLOS NAVAJAS/IMAGE BANK

STEPHEN WILKES/IMAGE BANK

The subcontinent of India

Forum discussions led by energy analyst Karl Knapp and by Jayant Sathaye of Lawrence Berkeley National Laboratory outlined the even more difficult set of challenges confronting the advancement of electrification on the Asian subcontinent. The Indian electricity system is plagued by inefficient operation and an unrealistic price structure. Residential electricity is sold below production cost; many homes are illegally connected to the system and pay nothing. Farmers pay almost nothing, and information on the total amount of electricity they use is poor. In contrast, industrial customers pay high tariffs for service that is often of poor quality; as a result, they generate much of their electricity themselves, often inefficiently. Transmission and distribution losses, although not precisely known, are usually greater than 20%. Performance of individual generating plants is typically poor, with load factors lower than 55% in most areas.

But the inefficiencies of the present imply sizable returns on investments that can improve power quality. The potential is far higher than that for power system investments in the United States.



BRETT FROOMER/IMAGE BANK

Current Indian government plans call for an increase by 2006 of at least 84 GW of installed capacity beyond the present 92 GW. The estimated cost of the additional capacity is $86 billion ($130 billion if transmission and distribution costs are included). Great savings could potentially result from technical and institutional changes that would improve load factors in the existing capacity, thereby reducing the need for new capacity. Similar savings could be obtained by integrating the grid system.

Although the official plan calls for 65% of the new capacity to be generated through the private sector, recent experience in India indicates this expectation to be unrealistic. The problem is not one of technical adequacy. Rather the poor investment prognosis is tied to the cumbersome Indian administrative infrastructure. The need to overcome current infrastructure barriers results in a high level of risk aversion among potential investors and extraordinary demands on rates of return.

For planned technical advances to become reality, India's entire electricity system needs to be restructured. The system must be privatized, generation separated from distribution, and illegal connections eliminated. Successful privatization requires that a stronger shareholder culture be developed in which equity markets can function properly. This will require many current business norms and practices to be replaced by a regulatory apparatus that ensures greater financial disclosure.

Implications for energy security

The globalization of energy markets creates new risks. Relying on market mechanisms and the international market system to deal adequately with energy security in the twenty-first century is fraught with uncertainty, especially in view of the increasing foreign ownership of energy facilities. Different countries will probably impose different limits on foreign ownership, and some may even consider renationalization in times of conflict.

Energy supply systems with pipelines and transmission lines that cross national boundaries will play an important role in global electrification, especially in the developing countries of Southeast Asia. But they also pose significant risks, because the regions with the most promising possibilities for cooperation—for example, long-distance electricity transmission grids in China and Southeast Asia and long-distance natural gas pipelines in Russia and the Middle East—are also the regions where the potential for future political and military conflict is greatest.

The major shifts in political and economic power toward Asia over the next 50 years will have significant security and risk implications for the global energy system and international energy trade. The question is what levels of trust and cooperation will develop between the key countries in the energy arena to avoid major international conflicts over this power shift.

A key to sustainable development

Population, as always, is the key multiplier for resource use and energy demand, noted forum participant Jesse Ausubel of New York City's Rockefeller University. "In the developing countries, the momentum for population growth remains enormous," he said. "Electrification could be a major factor in reducing population growth. With electrification and associated technologies, people become controllers of production rather than simple laborers. With increasing mechanical capacities in production, children cease to be essential to the labor pool of families, and the pressure for large families is reduced." Ausubel added, "Because we simply do not know whether the world's future population will be 8 billion, 12 billion, or 50 billion, we should prepare for a large population and seek superproductivity and efficiency in resource use."

Gail McCarthy, director of Strategic R&D at EPRI, puts the forum in perspective: "Global electrification is a strategy that contributes to global stability by substantially raising the quality of life at the lower end of the economic spectrum. Access to electricity can reduce infant mortality, improve sanitation, extend life expectancy, and foster educational opportunities. Significant benefits can be realized within a single generation. While electrification tends to increase per capita energy use among the poor, its path is nonetheless inextricably linked to the path of global sustainability.

"How can a greater number of people have a lesser impact on resource reserves and the environment? Successive waves of electrification in developed economies have typically peaked at lower energy intensities and declined with time thereafter. But will the increase in energy efficiency outpace the increase in the population using electricity, and will the population using electricity increase faster than the population without access to electricity? Both are important for sustainability, and both present considerable challenges." ■

Visiting Forum Participants

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Jenny Hou
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Alexander Kalinin
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Peter Meisen
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ALTMAN

NIEMEYER

GOLDBERG

CLARK

GILLMAN

HOLLANDER

Navigating the Currents of Risk (page 8) was written by science writer John Douglas with background information from four members of EPRI's Power Markets & Resource Management (PM&RM) Target.

Art Altman, who currently heads PM&RM's wholesale risk management research, has also worked on advanced information technology in Strategic R&D, where he developed EPRI's research target in field force automation. Before coming to the Institute in 1990, he spent four years at Metropolitan Life Insurance. He was also previously employed by Wells Fargo Bank and Rockwell International's Science Center. Altman holds a bachelor's degree in mathematics from the State University of New York at Buffalo, a master's in computer science from the University of Rochester, and an MBA from the University of California at Berkeley.

Victor Niemeyer, manager for power markets, previously worked on environmental risk management issues in the Institute's Environment Group. Before joining EPRI in 1978, he was a senior associate at Charles River Associates and an associate with the Center for Energy Studies at the University of Texas. Niemeyer holds an AB in economics from the University of California at Berkeley and a PhD from the University of Texas, also in economics.

Rich Goldberg is currently manager for pricing and risk management, having previously headed PM&RM's risk and asset management work. Before coming to EPRI, he was a senior associate at Decision Focus Incorporated, specializing in electric and gas utility issues, and he has also held research positions at Stanford University, Lawrence Livermore National Laboratory, Princeton University, the National Center for Atmospheric Research, and the Harvard-Smithsonian Center for Astrophysics. Goldberg received an AB in astrophysical science from Princeton and MS and PhD degrees in physics from Stanford.

Charles Clark, manager of the Institute's PM&RM Target, has been at EPRI since 1991. He was previously a vice president at Decision Focus Incorporated and was earlier employed by ARCO, Northrop Corporation, Rockwell International, and SRI International. Clark holds a BS from the University of California at Los Angeles, an MBA in production management from the University of Pennsylvania's Wharton School of Business, and an MS in operations research from Stanford University. ■

Who Are Your Residential Customers . . . and How Can You Keep Them? (page 16) was written by science writer Steven Voien. Background information was provided by **Richard Gillman,** manager of market and load research in the Retail Market Tools & Services Business Area. Soon after coming to EPRI in 1991, Gillman established the Center for Electric End-Use Data, which has become the focal point for addressing the utility industry's load research requirements. Earlier, from 1981 to 1991, Gillman worked at the Bonneville Power Administration. He holds bachelor's and master's degrees in economics from Colorado State University. ■

China and the New Asian Electricity Markets (page 24) was adapted by *Journal* senior feature writer Taylor Moore from a paper by **Jack M. Hollander.** Hollander is professor emeritus of energy and resources at the University of California at Berkeley, having taught there from 1980 to 1983. From 1973 to 1976, he was the first director of the Energy and Environment Division at Lawrence Berkeley National Laboratory. He also directed the National Academy of Sciences Committee on Nuclear and Alternative Energy Systems study, cofounded the American Council for an Energy-Efficient Economy, was the first director of the California Energy Institute, and was chairman of the Beijer Institute of Energy and Human Ecology in Stockholm. Hollander was editor of the international book series *Annual Reviews of Energy* from 1975 to 1992. From 1983 to 1989, he was vice president for research and graduate studies at Ohio State University. He received a BS in chemistry from Ohio State and a PhD in nuclear chemistry from UC Berkeley. ■

Pestering the Power Industry

Woodpeckers, squirrels, and owls may give some of us a warm, fuzzy feeling inside. But to owners and operators of electrical transmission and distribution systems, they can be a real nuisance. Woodpeckers hack away at utility poles and have caused more than $1 million in damage annually at a number of individual power companies. Squirrels, meanwhile, slip into substations and interfere with electrical equipment. Owls, which are attracted to the convenient perches provided by utility poles and wires, have also caused their share of system outages.

About 30 people, including power company representatives and consultants, attended an EPRI workshop last May to vent their frustrations about woodpecker damage and to share advice on deterring the birds. Feedback from a number of EPRI members has since revealed problems with lots of other creatures, including rats, mice, and snakes.

Woodpeckers cost some power companies more than $1 million in damages each year.

In response, EPRI is planning a program to address all kinds of pest control. The goal is to identify and develop effective, animal-friendly methods of deterrence. Some of the methods already employed in the power industry include using fox urine to keep squirrels at bay and covering electrical equipment with loose plastic tarps to prevent all types of birds from nesting. High-pressure sodium lights have also been effective against nesters. As for woodpeckers, some power companies have discouraged them by treating utility poles with slick or sticky materials or by covering them with a specially designed cloth.

These and other techniques will be studied more closely in EPRI's pest control program, which is expected to be established by early next year.

■ *For more information, contact Bruce Bernstein, (202) 293-7511, or Ben Damsky, (650) 855-2385.*

EPRI Explores E-Beam Disinfection for Beef, Water

Aware that recent *E. coli* outbreaks are making some U.S. consumers hesitant about eating meat, EPRI researchers are pushing ahead with a technology that may help them rest easy. Called electron-beam (E-beam) disinfection, the technology involves using electricity—in the form of electron beams—to kill potentially life-threatening bacteria in food and water supplies. Already proven as an effective disinfectant for food and water, the technology is not yet cost-effective. EPRI intends to change that.

In a project that got under way last January, EPRI-funded researchers at the University of Missouri at Columbia are investigating whether the use of certain chemical compounds can help reduce the significant electricity costs currently associated with E-beam disinfection. Preliminary research conducted in the 1960s and 1970s indicates that these compounds, called sensitizers, may reduce the dose of E-beam irradiation required to destroy microorganisms in various media. Focusing specifically on the destruction of *E. coli* in ground beef and the inactivation of *Cryptosporidium* (another harmful pathogen) in drinking water, the researchers aim to identify which chemical compounds are most effective and to quantify the efficiency improvements possible with each. Their preliminary calculations indicate that the use of sensitizers in combination with new accelerator technologies, such as the nested high-voltage generator, may make the technology practical for widespread use.

Given the problems with *E. coli* in the food supply in recent years, including the outbreak that led Hudson Foods of Rogers, Arkansas, to recall 25 million pounds of ground beef in August, public interest in disinfection technology is on the rise. "E-beam technology looks promising for both *E. coli* and *Cryptosporidium*," says Keith

Carns, EPRI's manager for the project. "While the technology is well understood, there are no full-scale systems currently in use in either the water treatment or the food processing industry."

So far, eleven sensitizers have been identified that modify radiation resistivity. Of these, three have been approved for use in food. If the appropriate sensitizers are identified, Carns estimates, the technology could be widely applied in the food processing industry within three years and in the water treatment industry within five years. EPRI's project is expected to be completed by next June.

■ *For more information, contact Myron Jones, (650) 855-2993, or Keith Carns, (314) 935-8598.*

Fuel Cell Runs on Wastewater Treatment Plant Gas

EPRI helped fund the recent installation of a phosphoric acid fuel cell powered by anaerobic digester gas—the first demonstration of its type in the world. The 200-kW power plant, located at the wastewater treatment plant in Yonkers, New York, began operating in April of this year.

The aim of the project—also funded by the U.S. Department of Energy, the New York State Energy Research and Development Authority, and the New York Power Authority (NYPA)—is to assess the viability of anaerobic digester gas as a fuel, to improve air quality, and to gain experience with a distributed generation technology. Distributed generation, which entails the deployment of relatively small power generation units close to or at customer sites, is expected to become more common in a deregulated power market.

Like all wastewater treatment plants, the Yonkers plant generates anaerobic digester gas—a by-product of the bacterial and biological processes occurring during wastewater treatment. High in methane and carbon dioxide, the gas is typically burned and exhausted into the atmosphere. NYPA realized the potential for the efficient use of the gas as a fuel and for the reduced emissions associated with this use; discussions with Westchester County, the owner and operator of the wastewater treatment plant, resulted in the fuel cell project. Aside from the benefit of power production and nearly free fuel, the project is also helping Westchester County meet the requirements of the federal Clean Air Act.

The 200-kW power plant has two main components—the fuel cell and the gas processing unit. The anaerobic gas from the wastewater treatment plant flows to the processing unit, which removes sulfur-containing compounds, moisture, and halides. The result is a mixture of 60% methane and 40% carbon dioxide, which powers the fuel cell. At the Yonkers site, the fuel cell is connected to the plant's electrical distribution system so that any power produced is used directly by the wastewater treatment plant.

COURTESY NEW YORK POWER AUTHORITY

This gas processing unit is unique to the fuel cell installation at Yonkers, New York.

The fuel cell uses only some of the gas produced by the treatment plant. Additional gas is used to fire the plant's boilers. Any excess gas is combusted. According to NYPA and Westchester County, the wastewater treatment plant produces sufficient gas to power one or two more fuel cells, opening up the potential for the expansion of the power plant.

Through this project, NYPA is hoping to gain good experience in the niche market for environmentally friendly distributed power generation. The utility provides electricity to some 30 wastewater treatment plants in the state, and most of these are well suited to employ the technology.

It took less than three months to install and start up the power plant at Yonkers. EPRI is monitoring the plant during its first year of operation and will publish an interim report on its findings before the end of the year. The fuel cell stack is expected to last about six years before it needs to be replaced.

Although the fuel cell technology installed at Yonkers is commercially available and its performance well proven, the gas processing technology is under development. Currently more than 80 fuel cells in the world are operating on natural gas—mostly in the United States and Japan. However, none has ever before used anaerobic digester gas.

■ *For more information, contact John O'Sullivan, (650) 855-2292.*

Visibility Study Helps TU Electric Manage Emissions

As part of an effort to reduce haze in the Dallas–Fort Worth area, Texas regulators issued a rule that would require two of TU Electric's lignite-fired power plants to reduce sulfur dioxide emissions to 1.2 pounds per million Btu if it could be demonstrated that the reductions would improve visual air quality in the area. To learn how the proposed SO_2 reductions would influence the area's winter haze, researchers needed extensive information on the size and chemical characteristics of haze-forming particles in plant emissions; the climatological and meteorological factors associated with the occurrence of winter haze; and the atmospheric chemical reactions and transformations that determine how changes in the plants' emissions relate to haze formation. Another goal was to approximately attribute the haze to all major emissions sources.

The Texas Natural Resource Conservation Commission established a steering committee in 1993 to direct this research effort, called the Dallas-Fort Worth Winter Haze Project. EPRI was selected as the study coordinator on the recommendation of TU Electric. The project presented an opportunity to build on previous and ongoing visibility research by EPRI's Environment Group and to apply science and technology developed in that research to solve a specific air quality management problem.

A broad field measurement effort characterized the meteorological and climatological factors associated with winter haze formation when the direction of airflow was from the TU Electric plants toward Dallas and Fort Worth. Observations yielded information on the concentration gradients of haze-forming aerosols and provided a haze formation predictive capability. On the basis of these results, it was possible to rule out one of the plants—Monticello—as a significant contributor to the haze.

Next the researchers conducted intensive field measurements with air- and ground-based monitoring tools. They used tracer techniques to establish actual dispersion parameters for TU's Big Brown plant on clean-air days. They used aircraft-based measurements to determine reactivity in the vicinity of the plant plume.

The measurements and other data from the field work were analyzed with existing EPRI aerosol and optics models to assess how the proposed SO_2 reductions would alter the frequency and intensity of haze episodes. The study found that any change in visibility resulting from the proposed SO_2 reductions at the Monticello and Big Brown plants would be practically imperceptible. These findings, endorsed by the project steering committee, suggest that achieving significant improvements in Dallas–Fort Worth's winter haze will require further in-depth study of air quality, regional atmospheric dynamics, and all emissions sources.

As a result of the project's scientific assessment, Texas regulators decided that the proposed emissions reductions would not improve the haze situation—a decision that saved TU Electric and its customers approximately \$793 million in SO_2 scrubber retrofits. A three-volume technical report on the project (TR-106775) is available from the EPRI Distribution Center, (510) 934-4212.

■ *For more information, contact Peter Mueller, (650) 855-2586.*

Aerosol measurement and meteorological monitoring equipment

Power Quality Brochure Helps Educate Textile Customers

Power quality is critical to modern, highly automated textile plants that aim for world-class manufacturing excellence. New technologies for spinning, weaving, knitting, and other operations make unprecedented demands on the electric power distribution system. Recognizing the importance of power quality to its customers, Duke Power Company designated a special staff section to help customers resolve productivity problems related to power quality issues. Taking a proactive approach, Duke wanted to provide information to fiber and textile producers—its largest industrial customer base—so that procedures for avoiding power quality problems can be implemented before the installation of equipment sensitive to voltage waveform distortion.

Diagnosing and avoiding power quality problems are key concerns at today's highly automated textile plants.

To hold down the cost of developing customer educational resource materials, Duke turned to EPRI for assistance. The result was a brochure—*Power Quality Considerations for the Textile Industry*—which Duke initially presented at two one-day conferences for textile customers that drew 200 participants. In a coordinated effort, the EPRI Adjustable-Speed Drive Demonstration Office and the EPRI Textile Office worked with Duke to produce the brochure, which was based on information from six power quality case studies at fiber and textile plants served by Duke, Carolina Power & Light Company, Georgia Power Company, and Northeast Utilities.

In one case study involving a major fiber manufacturer, frequent failures of adjustable-speed drive (ASD) capacitors that forced costly shutdowns of a polymer extrusion process were found to be the result of using equipment designed for a 380-V, 50-Hz power system. The installation of higher-rated ASD dc-bus capacitors accommodated the higher operating voltage in the plant and eliminated the shutdowns, which had cost the customer several thousand dollars for each scrapped beam of synthetic yarn.

In another case study, utility capacitor switching near a spun-yarn thread plant customer was causing overvoltage on a dc bus, which in turn led to production shutdowns. Low-cost line reactors proved effective in protecting the spinning frames from electrical transients; new machines now come equipped with such reactors. The solution is broadly applicable to fiber and textile manufacturing facilities.

"The power quality brochure is a tremendous asset for any electric utility with textile customers," says Barry Batson, Duke's market segment manager for textiles. Applying techniques detailed in the brochure can help utility textile customers reduce downtime, increase production and productivity, and improve product quality. The brochure (BR-105425) is available through the EPRI Distribution Center, (510) 934-4212.

■ *For more information, contact Marek Samotyj, (650) 855-2980.*

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

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EPRI Project Manager G Heffner

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Contractor. Resource Dynamics Corp.
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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

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EPRI Project Manager Frank Rahn

C-VALU
Version 2 50 (PC-Windows)
Contractor Christensen Associates
Business Area Power Markets & Resource Management
EPRI Project Manager. Richard Goldberg

DESK BOOK™: Residential End-Use Technologies
Version 2.0 (Macintosh)
Contractor. Energy International, Inc
Business Area: Residential Technologies & Services
EPRI Project Manager John Kesselring

EMTP '96
Version 3 0 (Windows 3 1, Windows '95, Sun-OS, Sun-Solaris)
Contractor. Ontario Hydro
Business Area Grid Operations & Planning
EPRI Project Manager Ram Adapa

ESCORE
Version 1B-MOD03 (PC-DOS, UNIX)
Contractor Anatech Corp
Business Area Nuclear Power
EPRI Project Manager Suresh Yagnik

GasPlan: A Gas Procurement and Operations Planning Tool
Version 1 51 (PC-Windows)
Contractor Applied Decision Analysis
Business Area Power Markets & Resource Management
EPRI Project Manager Richard Goldberg

GOTHIC: Generation of Thermal Hydraulic Information in Containments
Version 5 0e (PC-DOS, UNIX)
Contractor. Numerical Applications, Inc
Business Area Nuclear Power
EPRI Project Manager Avtar Singh

PowerDOE™
Version 1 0 (PC-DOS)
Contractor J. J Hirsch & Associates
Business Area Commercial Technologies & Services
EPRI Project Manager. Karl Johnson

WASTECOST-Wet
Version 1 09 (PC-DOS)
Contractor Nosh Productions
Business Area Nuclear Power
EPRI Project Manager. Carol Hornibrook

EPRI Events

OCTOBER

7–8
Motor Rewind Course
Wharton, New Jersey
Contact: Peggy Amann, (650) 855-2259

7–8
REEPS Software Training
San Diego, California
Contact: Paige Schaefer, (800) 398-0081

7–9
Infrared Thermography: Level 3
Long Beach, California
Contact: Esther Blanco, (562) 493-7741

7–9
PCI Power Coatings
Charlotte, North Carolina
Contact: Eileen Mauro, (614) 421-3440

7–9
Workshop on Simulator Acceptance Test Procedures
Kittanning, Pennsylvania
Contact: Sarah Vanberg, (816) 235-5623

7–10
Hydrogenerator Maintenance Course
Boise, Idaho
Contact: Karen Goodeve, (416) 620-5600

8–10
Live Working 2000 Workshop
Lenox, Massachusetts
Contact: Kathleen Lyons, (650) 855-2656

8–10
Substation and Switchyard Predictive Maintenance
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

9–10
COMMEND Software Training
San Diego, California
Contact: Paige Schaefer, (800) 398-0081

13–14
INFORM Software Training
San Diego, California
Contact: Paige Schaefer, (800) 398-0081

13–17
Combined-Cycle Unit Operations Course
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

14
Applications of Motors and Drives
Kansas City, Missouri
Contact: Carrie Koeturius, (510) 525-1205

14–17
Circuit Breaker Inspection and Overhaul
Long Beach, California
Contact: Esther Blanco, (562) 493-7741

14–17
Safety and Relief Valve Workshop
Huntsville, Alabama
Contact: Linda Suddreth, (704) 547-6141

15
Power Quality Mitigation
Baltimore, Maryland
Contact: Carol Holt, (650) 855-2808

15–17
Maintenance Proficiency Evaluation
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6041

16–17
EPRI-DOE Wind Turbine Verification Program Workshop
Green Bay, Wisconsin
Contact: Julie Fennell, (650) 855-1009

16–17
EPRI Partnership for Industrial Competitiveness
Allentown, Pennsylvania
Contact: Bill Smith, (650) 855-2415

18–22
Managing the Marketing Research Process in a Deregulated Environment
Dallas, Texas
Contact: Heidi Beck, (888) 334-3774

20–21
Municipal Water and Wastewater Competitiveness Symposium
San Francisco, California
Contact: Myron Jones, (650) 855-2993

20–21
Power Quality for the Polymer Processing Industry
Charlotte, North Carolina
Contact: Karen Forsten, (423) 570-2418

20–24
Infrared Thermography: Level 2
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

20–24
Steam Plant Operations for Utility Engineers
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

20–24
3d Annual Distributed Resources Conference
Baltimore, Maryland
Contact: Lori Adams, (650) 855-8763

21–23
Transmission Inspection and Maintenance System Training
Atlanta, Georgia
Contact: Kathleen Lyons, (650) 855-2656

22–23
MANAGES and MOSES-MP Software Training
Charlotte, North Carolina
Contact: Adda Quinn, (650) 855-2478

22–24
Healthcare Initiative Workshop and Conference
Philadelphia, Pennsylvania
Contact: Kelly Ciprian, (800) 432-0267

23–24
HELM Software Training
Dallas, Texas
Contact: Paige Schaefer, (800) 398-0081

23–24
Successful Selling in Materials Fabrication
Columbus, Ohio
Contact: Eileen Mauro, (614) 421-3440

24
Heat Rate Improvement Course
Long Beach, California
Contact: Esther Blanco, (562) 493-7741

26–30
1997 EPRI Performance Measurement Workshop
Denver, Colorado
Contact: Lynn Stone, (972) 556-6529

27–28
OASIS Conference
Danvers, Massachusetts
Contact: Peggy Amann, (650) 855-2259

27–28
Power Quality Marketing Workshop
Knoxville, Tennessee
Contact: Lisa Nederhoff, (423) 570-8014

27–29
NMAC Workshop on Stationary Battery Maintenance
Atlanta, Georgia
Contact: Linda Suddreth, (704) 547-6141

27–31
Boiler Operating Theory Fundamentals
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

28–30
Achieving Success in Evolving Electricity Markets
Houston, Texas
Contact: Michele Samoulides, (650) 855-2127

29
Screening Industrial Power Generation Options
Pittsburgh, Pennsylvania
Contact: Margo Norman, (713) 963-9306

29–31
Fossil Plant Welding Workshop
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6041

29–31
Power Quality Advanced Training
Knoxville, Tennessee
Contact: Lisa Nederhoff, (423) 570-8014

30
Specialty Chemicals and Pharmaceutical Initiative
Philadelphia, Pennsylvania
Contact: Margo Norman, (713) 963-9306

NOVEMBER

3–5
Power Quality Interest Group
San Diego, California
Contact: Carrie Koeturius, (510) 525-1205

4–5
Applications of Motors and Drives
Omaha, Nebraska
Contact: Carrie Koeturius, (510) 525-1205

4–6
Fossil Plant Personnel Proficiency Evaluation Training
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6041

4–6
Transmission Inspection and Maintenance System Training
Dallas, Texas
Contact: Kathleen Lyons, (650) 855-2656

5
PQ-DeBUG Meeting
San Diego, California
Contact: Carrie Koeturius, (510) 525-1205

5–7
Fuel Supply Seminar
Chattanooga, Tennessee
Contact: Megan Boyd, (650) 855-7919

6
Electrosynthesis Symposium
Clearwater, Florida
Contact: Jigar Shah, (412) 826-3068

9–12
Electric Furnace Conference
Chicago, Illinois
Contact: Joe Goodwill, (412) 268-3435

10
Integrated Cycle Chemistry Improvement and Boiler Tube Failure Reduction Training
Nashville, Tennessee
Contact: Michele Samoulides, (650) 855-2127

10–11
Application and Development of Superconducting Cables
Columbia, South Carolina
Contact: Kathleen Lyons, (650) 855-2656

10–12
Workshop on Decision Analysis for Utility Planning and Management
San Diego, California
Contact: Peggy Prater, (650) 855-2951

10–14
Simulator Instructor Operations Course
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

11
Applications of Motors and Drives
Washington, D.C.
Contact: Carrie Koeturius, (510) 525-1205

11–12
Forecasting in a Competitive Electricity Market
Arlington, Virginia
Contact: Lynn Stone, (972) 556-6529

11–13
Boiler Tube Failure
Nashville, Tennessee
Contact: Michele Samoulides, (650) 855-2127

11–13
Lubrication Oil Analysis
Long Beach, California
Contact: Esther Blanco, (562) 493-7741

12–14
Managing Hazardous Air Pollutants
Washington, D.C.
Contact: Lori Adams, (650) 855-8763

12–14
Root-Cause Analysis
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

14
Integrated Cycle Chemistry Improvement and Boiler Tube Failure Reduction Training
Nashville, Tennessee
Contact: Michele Samoulides, (650) 855-2127

16–20
NARSTO (North American Research Strategy for Tropospheric Ozone) Science Symposium
West Palm Beach, Florida
Contact: Meredith Smith, (650) 855-2464

18–20
The Future of Power Delivery in the 21st Century
La Jolla, California
Contact: Melita Guellert, (650) 855-2010

19
Workshop on Environmental Issues of Dielectric Fluids
Long Island, New York
Contact: Steve Lindenberg, (202) 293-6184

DECEMBER

1–3
Power Quality Technical Training
Knoxville, Tennessee
Contact: Lisa Nederhoff, (423) 570-8014

2–4
Transmission Inspection and Maintenance Training
Las Vegas, Nevada
Contact: Kathleen Lyons, (650) 855-2656

8–9
Generator Retaining Ring Workshop
Miami, Florida
Contact: Michele Samoulides, (650) 855-2127

8–11
CHEC-T Users Group
Reno, Nevada
Contact: Megan Boyd, (650) 855-7919

8–11
EPRI/NMAC Pump Maintenance Workshop
Charlotte, North Carolina
Contact: Linda Suddreth, (704) 547-6141

8–12
Drum-Type Coal-Fired Steam Plant Operations
Kansas City, Missouri
Contact: Sarah Vanberg, (816) 235-5623

9–10
Insulator-Aging Workshop
Palo Alto, California
Contact: Bruce Bernstein, (202) 293-7511

9–12
Nuclear Utility Procurement Training Course
Charlotte, North Carolina
Contact: Brent Lancaster, (704) 547-6041

10–11
Ancillary Services Workshop
Miami, Florida
Contact: Michele Samoulides, (650) 855-2127

10–12
International Conference on Instrumentation and Control Issues in Nuclear Power Plants
St. Petersburg, Florida
Contact: Melita Guellert, (650) 855-2010

15–17
14th International Electric Vehicle Symposium
Orlando, Florida
Contact: Pam Turner, (650) 548-0311

JANUARY 1998

4–7
Industrial Electrotechnologies for Competitive Advantage
Lake Buena Vista, Florida
Contact: Eileen Mauro, (614) 421-3440

14–16
NMAC Safety and Relief Valve Users Group
Orlando, Florida
Contact: Linda Suddreth, (704) 547-6141

27
4th CMP Symposium on Electric Arc Furnace Dust Treatment
Pittsburgh, Pennsylvania
Contact: Joe Goodwill, (412) 268-3435

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