Wired for Telecommunications

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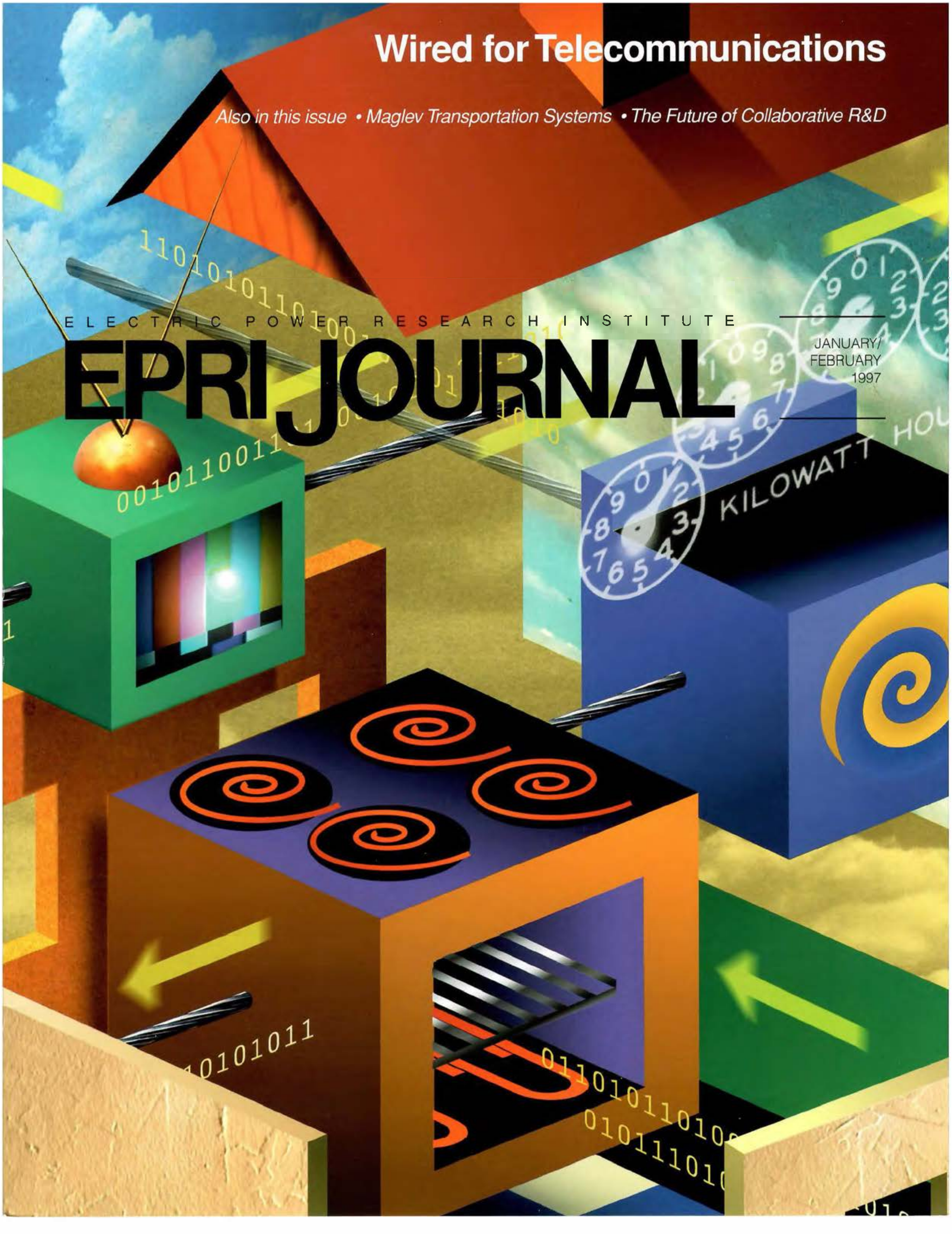
ELECTRIC POWER RESEARCH INSTITUTE

EPRI JOURNAL

JANUARY/
FEBRUARY
1997



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

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

EPRI JOURNAL Staff and Contributors
David Dietrich, Editor-in-Chief
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Debra Manegold, Typographer
Jean Smith, Editorial Assistant/Circulation

Art Direction: Kathy Marty

Janet L. Runyan, Director
Corporate Communications

Henry Courtright, Vice President
Marketing and External Relations

Address correspondence to:
Editor-in-Chief
EPRI JOURNAL
Electric Power Research Institute
P.O. Box 10412
Palo Alto, California 94303

Please include the code number on your mailing label with correspondence concerning subscriptions

Cover: The establishment of two-way communications channels between utilities and their customers will permit a great variety of new service options, including real-time electricity pricing, appliance diagnostics, interactive energy management, home security monitoring, and on-line bill payment. (Art by Glenn Mitsui)

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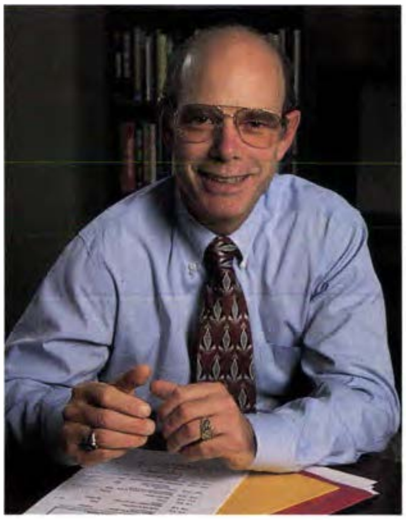

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PRODUCTS

EPRI-sponsored deliverables now available to utilities and their customers

Cable Removal Truck

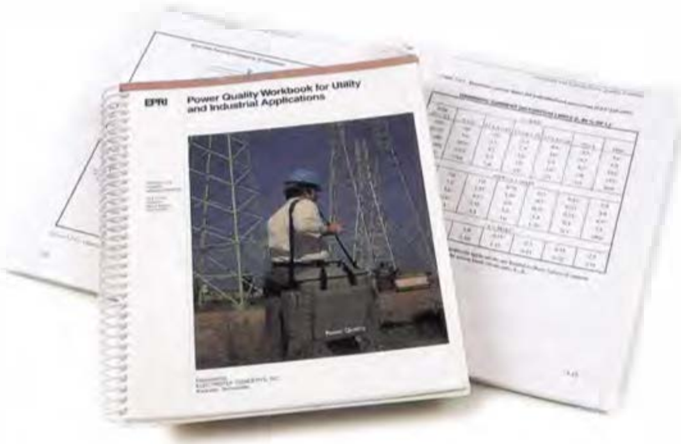
Electric utilities face a formidable challenge in laying new lines beneath congested urban streets. Underground conduit space is increasingly limited, and constructing new conduits is expensive and entails digging up and disrupting already crowded urban streets. Now there's a better alternative. With a cable removal truck jointly developed by EPRI and Consolidated Edison Company of New York, utilities can extract abandoned, jammed cables from their underground conduits and reuse the conduits. The efficient and effective cable removal system combines lubrication under pressure with vibration techniques and hydraulic pulling to succeed where old, brute-force methods failed. What's more, since all the required accessories are mounted on the truck itself, the system is easily maneuverable—even in cramped urban quarters.

For more information, contact Ralph Samm, (415) 855-2289.
To order, call Harvey Reed at OK Champion Corporation, (916) 587-7381.

Flow-Accelerated Corrosion Report

Flow-accelerated corrosion (FAC)—a phenomenon that results in metal loss from piping, vessels, and equipment made of carbon steel—is a major concern for power plant operators. It occurs under flow, chemistry, geometry, and materials conditions common in much of the high-energy piping in both nuclear and fossil power plants. If it goes undetected, FAC can cause leaks and ruptures. Although major failures are rare, accidents have occurred and even caused the death of utility workers. Through a collaborative research effort, EPRI and Electricité de France have made substantial progress in understanding FAC. Now these research partners have published a book (TR-106611) that gathers the best information available on FAC into a single volume. Written as a reference for utility engineers, the book draws on the experience of many nuclear and fossil plants around the world.

For more information or to order, contact Bindi Chexal, (415) 855-2997.



Power Quality Workbook

Whether it's harmonic distortion, voltage sag, transients, or some other type of power quality disturbance, this workbook (TR-105500) will help utilities and their customers diagnose the problem and select the appropriate fix from the wide array of power-conditioning equipment available. The workbook defines procedures and recommended practices for maintaining acceptable power quality on electric utility transmission and distribution systems as well as at industrial and commercial customer sites. It presents analytical methods, evaluation techniques, worksheets, and guidelines for resolving power quality issues at both system and equipment levels. *For more information, contact Marek Samotyj, (415) 855-2980. To order, call the EPRI Distribution Center, (510) 934-4212.*

SAFER-PC

The decision to run, repair, or retire power plant turbine and generator rotors is a perennial dilemma facing electric utility engineers. Extended operation of a critically flawed rotor can result in catastrophic failure, yet premature retirement of equipment burdens a utility financially. The EPRI Stress and Fracture Evaluation of Rotors program for personal computers (SAFER-PC) enables utility engineers to make tough decisions with confidence. Adapted from a mainframe program already used by over 50 utilities, SAFER-PC provides objective assessments of the remaining life of turbine and generator rotors. Estimating the probability of rotor failure over time, SAFER-PC allows utilities to adjust operating schedules to optimize remaining life and helps them plan turbine maintenance and schedule inspections and outages. Users can also make prepurchase comparative life predictions for various rotor designs. *For more information, contact Tom McCloskey, (415) 855-2655. To order, call the Electric Power Software Center, (800) 763-3772.*

Fast Fault Finder

An increasing number of underground distribution lines in residential areas are reaching the end of their useful life and are beginning to fail. Locating faults on these systems can be difficult and time-consuming. In fact, most of the techniques in use today require the expertise of highly trained operators. Moreover, some of the techniques involve repeated electrical impulses, which may further damage the cable being analyzed. In contrast, EPRI's Fast Fault Finder is easy on cables and enables utilities to pinpoint the location of failures quickly and easily—without the help of an expert operator. This device is also inexpensive enough to be installed as a permanent monitoring instrument, ensuring the fastest possible utility response to a fault. *For more information, contact Harry Ng, (415) 855-2973. To order, call Edison Control Corporation, (908) 819-8800.*

Taking a Cue From Nature

Natural structures and processes are fascinating enough in themselves, but EPRI-sponsored researchers are learning that they might also hold the keys to a variety of challenges the electric utility industry faces.

Take, for instance, the issue of carbon dioxide, which is emitted from a variety of sources, including power plants. Implicated as a potential contributor to global warming, CO_2 is not yet regulated, but international pressure to consider regulation is mounting. So far, there is no system for economically removing CO_2 emissions from the exhaust of power plant stacks, but at least one natural process offers a clue.

As researcher Gillian Bond of the New Mexico Institute of Mining and Technology discovered, mollusks in the process of developing their shell material (calcium carbonate, or $CaCO_3$) absorb CO_2 from their aquatic environment at a relatively high rate. What if researchers could mimic this process in a power plant to absorb CO_2 before it was released from the stack? That is exactly what Bond, with EPRI's support, is trying to do through the science of biomimesis—the mimicking of natural biological structures or processes.

Bond, who conducted a literature review for an EPRI scoping study on the potential applications of biomimesis in the electricity industry (TR-104128-V1), was engrossed in research aimed at mimicking the shell development process for use in depositing thin films in industrial applications when she stumbled onto the idea of using biomimesis for capturing CO_2. As Bond discovered, some mollusks secrete an enzyme, carbonic anhydrase, that catalyzes the hydration of dissolved CO_2. The resulting HCO_3 and/or H_2CO_3 then reacts with dissolved calcium and precipitates as $CaCO_3$.

To mimic the process in the laboratory, Bond and her research associates added carbonic anhydrase to an aqueous solution containing dissolved CO_2 and Ca. Almost immediately, $CaCO_3$ began to precipitate, whereas without the catalyst the precipitation required several minutes to initiate. The next step—more closely approximating the power plant environment—was to bubble CO_2 through an aqueous solution containing Ca and carbonic anhydrase. In these tests, however, the carbonic anhydrase clung to the CO_2 bubbles, creating a nonreactive froth. Bond's research team has recently stabilized the enzyme by attaching it to glass surfaces, thereby eliminating the froth formation. Other approaches to minimizing the froth effect are currently being studied.

EPRI is examining other potential utility applications of biomimesis and recently published a report (TR-104128-V2) that identifies research opportunities. These include copying natural designs to engineer durable, lightweight materials and

employing artificial photosynthetic processes to create high-efficiency photovoltaic technologies. "Basically, we're taking our cues from nature," says EPRI's John Stringer, who is overseeing the biomimesis research. "The solutions to many of the technical challenges we face may be right before our eyes."

■ *For more information, contact John Stringer, (415) 855-2472.*

Microwave Heating for Chemical Processing

Using microwaves to heat chemical process streams could potentially provide several advantages over conventional methods of heating. For example, the liquid streams could be heated more uniformly by microwaves than by contact with heated reactor walls, and the chance of overheating near the walls, which can degrade the product, would be reduced. Microwave heating also occurs more rapidly, providing opportunities to reduce capital and maintenance costs and equipment size.

Unfortunately, important reference data—particularly the dielectric properties of common organic solvents at microwave frequencies—have not been available. The lack of such data has inhibited the use of microwave heating in the chemical industry, where standard dielectric values would be required for both pure solvents and mixtures before they could be used with microwaves in process streams.

Now, with EPRI funding, Paul Laibinis of the Massachusetts Institute of Technology has found that the critical properties can be characterized by three frequency- and temperature-dependent parameters. The parameters are a high-frequency dielectric constant, a static dielectric constant, and a time constant that reflects the rotational lifetime of the molecular species.

Laibinis has measured these parameters for a variety of single solvents and solvent mixtures and has created "mixing rules" that will enable chemists to achieve the desired microwave heating characteristics by adjusting the mixture composition. He also has developed a method for measuring temperatures within a microwave cavity without the introduction of physical probes. The method is based on the temperature-dependent emission of light from molecules called fluorophores, which are introduced into the cavity.

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

Magnetic Fluids Could Cut Transformer Upgrade Costs

By the end of the century, electric utilities needing to upgrade their transformers may not have to invest millions of dollars in hardware retrofits to accomplish the task. EPRI researchers believe that magnetic fluids could be used as coolants in such equipment, enabling utilities to increase the capacity of their existing transformers.

Electromagnetic devices like transformers heat up during operation because of resistive losses in their electrical and magnetic components. The rejection of waste heat is critical, since excessive temperatures can damage insulation, precipitating failures; failed transformers cost millions of dollars to replace, require months to repair, and can leak toxic fluids. Cooling capability ultimately determines the amount of power that can be reliably handled by a transformer. As a result, most such equipment is designed to maximize heat rejection, and this often means bulky and expensive designs.

Enter magnetic fluids. Developed in 1960s research on low-friction seals for rotating shafts, MFs are now used as sealants in computer hard drives. In preliminary EPRI-funded experiments, these fluids have demonstrated significant heat transfer capabilities when exposed to electromagnetic fields. If further research proves that MFs are truly effective coolants for electromagnetic equipment, it is possible that they could be used as direct substitutes for conventional coolants, with minimal hardware modifications required.

A typical MF is a colloidal mixture of tiny spherical magnetite particles coated with oleic acid and suspended in a thick carrier liquid, such as transformer oil. The suspension is stable, with the balance of forces acting on the particles to prevent them from settling or sticking. When exposed to electromagnetic fields, such as those generated by transformers and other electrical equipment, MFs can be highly magnetized while retaining the liquid properties of the carrier oil. The higher the temperature, the lower the level of magnetization an MF can achieve, until this capability is lost between 70°C and 250°C.

Already, researchers have determined that MFs exhibit greater heat rejection than conventional coolants used with electromagnetic components. However, the exact way in which cooling occurs is still under debate. One theory is that the magnetic fields generated by a device effectively spin the MF particles, increasing turbulence and improving heat transfer. According to another theory, the highly magnetized portions of an MF are attracted to a device's magnetic fields. As these portions near the electromagnetic components, they are rapidly heated above the temperatures at which they lose their magnetism, and they are then displaced by cooler portions with higher magnetization. This circulation enhances cooling.

EPRI-sponsored scientists at Energy International of Bellevue, Washington, have investigated these and other hypotheses in their explorations of MF-based cooling. To simulate electromagnetic devices, the researchers submerged conductors in dielectrically suitable MFs. In each experiment, the fluid was subjected to time-varying magnetic fields, and the amount of heat removed from the system (benefit) was compared with the power dissipated by the applied field (cost).

The results indicate that MFs represent a viable heat rejection technology. Benefit-to-cost ratios of 2.5 to 3.8 have been attained with readily available fluids. Now that proof of the concept has been established, EPRI and Energy International are planning detailed technical and economic analyses. Comprehensive tests of MF-based cooling will be conducted in bench-scale models of common utility equipment. If the testing is successful, prototype systems will be developed and demonstrated in the next couple of years.

■ *For more information, contact John Maulbetsch, (415) 855-2438.*


KILOWATT HOURS

At Home With Telecommunications

THE STORY IN BRIEF Forget the cable company, the phone company, and other big hitters in telecommunications. Electric utilities want to be the ones to deliver new and tantalizing information services to consumers. Faced with impending competition and armed with an investment in telecommunications technologies that already rivals that of the communications industry, electric utilities across the country are exploiting the impressive capabilities of these technologies to provide advanced services to their customers. And many are targeting the residential market. Time-of-use pricing and appliance control are already saving consumers money on their electric bills while shaving utility costs and securing a more intimate customer link that is critical in a competitive environment. Home security, on-line bill payment, and remote diagnostics are just some of the other capabilities in the works. Whether they are expanding their existing communications infrastructures, leasing space on these networks to other telecommunications providers, or teaming up with partners to deliver the goods, these utilities are serious about bringing telecommunications home.

by Leslie Lamarre

The mercury hovers around 110°F in the dusty border town of Laredo, Texas, as Rene Rodriguez makes his way home after a long day of work one September evening. But he knows his home will be cooled to 77°F when he steps through the front door. And he knows he isn't paying extra money for this comfort. In fact, Rodriguez—who can program his air conditioner and other big appliances to coincide with his electric utility's high, medium, and low rates for the day—estimates he is saving about $40 a month on his electric bill. If he decides to change the programmed settings, he simply plugs a slick-looking console into the wall and punches a few keys.

Across the country in Walnut Creek, California, the Grimes family is absorbed in the evening news when a report on the current heat wave reminds them of their electricity use. With the touch of a button on a special remote control device, a status bar appears at the bottom of their television screen showing Steve and Stella Grimes how much electricity major appliances like the air conditioner and refrigerator are using. They can also program their porch lights to come on and go off at desired times of the day—all without missing a beat of Dan Rather.

These are just two examples of the many ways in which electric utilities are using advanced telecommunications technologies to offer more conveniences to their customers. Gearing up for full-fledged competition among power companies, the utilities involved in these efforts believe the new services that telecommunications enable might help them retain existing customers and maybe even snag new ones. Whether the utility-customer connection uses telephone wires, fiber-optic lines, coaxial cables, radio waves, utility distribution lines, or some combination of these channels, the capability for two-way communications is becoming increasingly important. And the time-of-use pricing and appliance control options that are saving Rene Rodriguez money on his electric bill are just the start. Remote appliance diagnostics, home security service, and on-line bill payment are among the vast array of other advanced capabilities utilities are exploring.

These services are not intended to benefit only the customer; they have built-in benefits for the utility as well. For instance, time-of-use pricing—through which rates vary during the day to more accurately reflect the actual cost of generating and delivering power at a given time—encourages customers to shift energy use away from periods of peak demand. The result is lower power bills for the customer, which can give the utility a competitive edge. Remote meter reading, meter-tampering detection (which accounts for as much as 1% of utility revenues), instant information on the time and location of power outages, remote connection and disconnection of customers, and information about electricity consumption patterns are just some of the business advantages. In addition, such services enable utilities to get closer to their customers at a time when building customer loyalty is critical.

"Just as the telecommunications field is undergoing a virtual explosion in innovation and information transfer capabilities, electric power companies are reaching a competitive phase in which they are finding that these technologies might very well help them distinguish themselves from all the other power providers out there," says Steve Drenker, manager of EPRI's Information Systems & Telecommunications Business Unit. "Telecommunications is an exciting tool that utilities can use to get an edge in the market."

There are other reasons for electric utility involvement in telecommunications. Over the years, power companies have built up extensive infrastructures of telephone wire, fiber-optic cable, radio links, and other communications channels—mainly to meet their own internal communications needs. In fact, the electric utility industry ranks second only to the communications industry itself in its use of telecommunications media. What's more, utilities typically use only about 3% of the capacity of these elaborate communications webs for their own purposes. As one utility executive puts it, "We're sitting on a gold mine."

The fact that power companies already have access to virtually every home and business in the country offers added incentive for utilities to pursue the telecommunications market. And that's exactly what many are doing—in a variety of ways. Some are opting to expand their communications infrastructures to offer advanced energy management and other capabilities directly to their customers. Others are leasing available space on their networks and letting other companies deliver the goods. Still others are teaming up with telephone and cable television firms that are vying for the same customers. Some power companies are even investing directly in the development of related hardware and software technologies for both wired and wireless applications.

The telecommunications reform bill that President Clinton signed last February makes it easier for electric utilities to compete with phone companies, cable firms, and other service providers vying for a piece of the market. Among other changes, the bill removes state and local prohibitions against utility involvement in telecommunications, protects utilities' internal communications systems, and allows utility holding companies to diversify into telecommunications.

Taking control

One holding company that wasted no time on this front is Central and South West Corporation, which filed to become a telecommunications provider within hours of Clinton's signing of the bill. As a result, its subsidiary CSW Communications became the country's first so-called exempt telecommunications company. (There are now 12 such companies, according to the trade group called UTC: The Telecommunications Association.) Among CSW Communications' first efforts is the pilot program that is providing the Rodriguez family and 800 others in Laredo a glimpse of what may be the future of customer service in the power business.

Through a handheld console manufactured by Raytheon, these CSW customers can control up to five big electricity loads in their homes. For Rene Rodriguez, who has a two-story, 3200-square-foot house, the choice was obvious. He picked the two air conditioners, the two water heaters, and the clothes dryer. He says it took about half an hour with a utility representative to learn how to use the console to program the appliances. Now, these big energy users are most active when electricity rates are lowest. In fact, Rodriguez has programmed the water heaters and the dryer to shut down completely during both the high-rate and medium-rate periods. Like the other program participants, Rodriguez can read his month-to-date electric bill through the console. And he has programmed his system to turn off major appliances when it receives a price signal from his utility during very high rate emergency periods. Rodriguez says his electric bill, which averaged $150 a month before the program, has remained about the same—despite the addition of a baby and a live-in maid. He suspects it would have gone up to about $190 a month.

Kicked off last April, the Laredo program depends on an infrastructure of fiber-optic line and coaxial cable. Electronic sensors that CSW installed on the major appliances enable the consumers to track how much energy each appliance is using. The pilot will continue indefinitely. "Our customers seem to appreciate it," says Don Shahan, president of CSW Communications. "They are saving money and they are responding to our price tiers." On average, the participants are shifting 2 kW per household off-peak between 4 and 5 p.m. and saving 10% on their electric bills.

The Laredo project has received a lot of attention, in part because it is among the largest programs of its kind ever undertaken. CSW Communications has since won a contract with the city-owned electric utility in Austin, Texas, to develop and test a wireless system in a 19-month pilot program to be kicked off later this year. Also, CSW has been awarded a seven-year franchise to build a fiber-optic network that will ultimately reach into every home and business in Austin, a city of 544,000 people. The company hopes to provide energy management services over the network and to lease capacity on the system to other firms that would provide services ranging from high-speed Internet access and telemedicine to videoconferencing and home security. "One of the driving forces behind the Laredo project was looking down the road and seeing deregulation and competition coming," says Shahan. "We want to get a stronger hook into our customers and provide them with something that other potential suppliers of electricity do not have."

Other utilities, such as Boston Edison, are following suit. Last September, this utility announced that it has teamed up with RCN Inc.—a provider of integrated voice, data, video, and high-speed Internet services—to build an interactive data network for homes in 40 cities and towns in the greater Boston area. The backbone of the project is a 200-mile ring of fiber-optic cable that the utility has already established for its own communications. According to the utility, this is more fiber-optic cable than is owned by any other electric utility in the state and more than is owned by most telecommunications companies.

Boston Edison and RCN have agreed to invest about $300 million in enhancing the network over the next five years so that it can be used to deliver video, telephone, energy management, and other services to 650,000 customers. Mike Monahan, a spokesman for the utility, notes that local telephone and video services are likely to be among the first services deployed on the network, with energy management introduced later in the five-year time frame. He says the joint venture will be in direct competition with the local telephone company, New England Bell, as well as cable providers and Internet access companies.

Utility presence

Electric utilities grappling with the telecommunications challenge are trying to

Medium	Traditional Classification	Data Transmission Speed (bits per second)	Relative Cost	Sample Applications (with no compression)
Power line	Narrowband	30 to 20,000 (utility distribution) 100 to 1 million (wiring on customer premises)	Low Low	Remote meter reading Outage detection Real-time pricing Load control Security monitoring
Radio	Narrowband	1200 to 40,000	Low	
Phone line	Wideband	Up to 56,000 (analog) 64,000 to 6 million (digital)	Low Medium	Internet access Electronic mail Electronic billing and payment
Coaxial cable	Broadband	1 million to 15 million	Medium to high	Videoconferencing Telemedicine Interactive television Distance learning
Fiber-optic cable	Broadband	50 million to 1 billion	High	

DECISIONS, DECISIONS Available technology offers power companies a number of media to choose from in communicating with their customers, as indicated in this chart. Traditionally, these media have fit neatly into the categories of narrowband, wideband, and broadband—with narrowband technology offering data transmission capabilities, wideband offering both data and voice transmission, and broadband offering data, voice, and video. But sophisticated compression and delivery technologies are blurring the lines dividing these categories, allowing users to send, for example, voice signals via power lines and video signals over standard phone lines.

determine what form the customer interface should take. From the utility's perspective, this is a critical issue, for it is symbolic of the transition of the utility presence from an exterior wall of the home, where it is relegated to a decidedly user-unfriendly electric meter, to inside the home, where it will reside in a sophisticated interactive device. This interface will be the key point of contact with the customer for delivering a variety of services that are likely to extend far beyond basic energy management into home automation, text message paging, electronic mail, and—depending on the sophistication of the interface—interactive entertainment. "Electric utilities have a real market opportunity to become the providers of choice for bundled communications services," says David Cain of EPRI, manager of new business development in the Information Systems & Telecommunications Business Unit. "This is an opportunity that many are having a hard time passing up."

At this stage, power companies are considering a variety of forms for this interface, from an elaborate version of the thermostat to a television screen, a PC, or a telephone with a small screen that can be used to deliver a wide range of interactive services.

Southern California Edison is among the few utilities that are currently experimenting with the screen phone interface. At this writing, the utility is nearly finished developing energy management applications for the P100 screen phone manufactured by Philips, which offers a host of other features, such as Internet access, electronic mail, and electronic shopping and banking (a magnetic strip reader enables credit card and bank card transactions). With the energy management functions, users will be able to monitor their electricity use to date and see how much energy their biggest appliances are consuming. The system is expected to be tested in the homes of SCE employees early this year. "I think one of the reasons utilities are hesitant to rely on a screen phone interface is that they are not sure how this new type of telephone is going to get into the home," says Dukku Lee, SCE's project engineer. "Consumers are not accustomed to buying telephones to carry out these kinds of transactions. But we feel that the right blend of services will attract a wide range of customers."

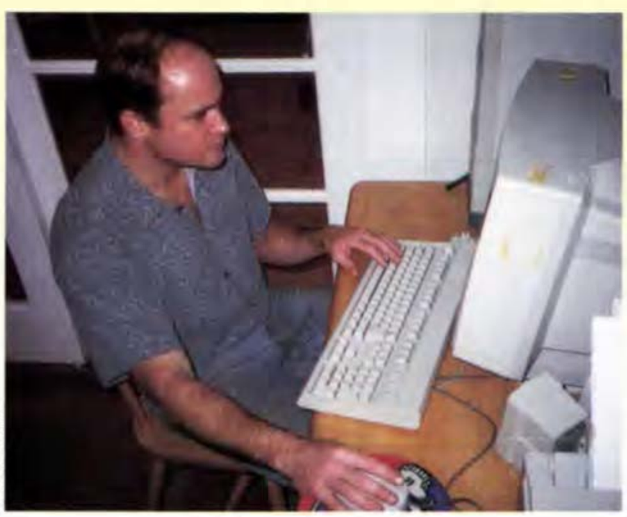
Some utilities are experimenting with a combination of approaches. For instance, Pacific Gas and Electric, which sponsors the program that enables the Grimes family and 49 other customers in Walnut Creek, California, to monitor and control their energy use through their television screens, is about to switch to a PC interface. For the initial 50-home project—a collaboration with TeleCommunications Inc. (TCI), the world's largest cable television operator, and software giant Microsoft Corporation—the existing cable infrastructure had to be upgraded to a hybrid fiber-coax network. With the help of a digital set-top box and Microsoft's "point and click" operating system, users can program certain appliances to run at specific times.

The second phase of the project, which is expected to get under way in April, will rely on a telephone connection to the Internet as an avenue for communication, therefore requiring no new infrastructure. Rather than viewing a status bar at the bottom of their television screens and making selections with a remote control, participants will log on to the Internet from their

MOVING INSIDE Offering interactive energy management services means changing the utility presence from a clunky electric meter on an exterior wall of the home to a more user-friendly device inside the house. Utilities are experimenting with a variety of interface options, from the screen phone to the television set.

COURTESY PHILIPS

Energy management will soon be added to electronic banking, shopping, Internet access, and other capabilities provided by the Philips P100 screen phone. Southern California Edison will test the phone in the homes of some employees.



LESLIE LAMARRE

Personal computers will serve as the interface for a pilot Internet-based energy management system that San Diego Gas & Electric expects to deploy in 50 homes this spring.

personal computers and access the utility's Web site, using a special personal identification number to call up their own energy information. Ultimately, they may even be able to pay their bills on-line. "We're moving away from television because it tied us to broadband networks," says Laurie Schneemann, the utility's manager for the project, referring to networks (such as those using coaxial cable or fiber-optic lines) capable of delivering video images. "In the new phase of the project, we are not creating a network at all," she says. "We already have a network—it's called the Internet." Schneemann admits that the line between computer and television is blurring, however, noting that "four to five years from now you might not be able to tell much difference between your television and a PC."

A box is a box?

This fusion of television and computer is already beginning to occur in the consumer market—a phenomenon fueled by the burgeoning popularity of the Internet and by the high cost of PCs. In fact, although talk about home PCs is pervasive, the personal computer has still made it into only 30% of U.S. homes, and many of these models are not capable of browsing the Internet at an acceptable speed. And at a cost of more than $1500 for a device that includes capabilities that aren't necessarily desirable to consumers, the PC admittedly isn't doing a great job of bringing the Internet to the general public. (See the sidebar on page 14 for information on the future of the Internet.) So in its place, some innovative electronic products are beginning to crop up.

Just last fall Sony and Philips released set-top boxes—built by a new company called WebTV—that enable consumers to access the Internet through their television sets. These set-top devices connect to television sets much as VCRs do, and they include receptacles for a telephone line, over which Internet data can flow, and for coaxial cable, as an option for those who prefer faster access to the World Wide Web. All the necessary software to hook up to and browse the Internet is built in. If consumers have the picture-in-picture feature on their television sets, they can read their e-mail or search the Web without missing any action. There's also a credit card slot for on-line purchases. Both versions of the WebTV sell for a little over $300. Each system includes an on-screen keyboard; there is an optional wireless keyboard for an additional $75.

Other forms of relatively cheap access to the Internet are coming soon. Among those in the works is the network computer (NC), a prototype of which was demonstrated by Oracle last February. Like the WebTV products being marketed by Philips and Sony, the NC does not rely on software disks. Rather, it includes a simple operating system and can retrieve any necessary applications from the Internet. In fact, the NC, which is expected to be available early this year and to sell for about $300, is in direct competition with the WebTV devices, not to mention the PC. Oracle's CEO, Larry Ellison, predicts that network computers will outsell PCs by the end of the decade.

EPRI views the network computer as an ideal vehicle for bringing the electric utility inside the home and has established a formal alliance with Oracle to ensure that the device incorporates capabilities

COURTESY HONEYWELL

Public Service Electric and Gas and Detroit Edison are using Honeywell's touchpad device, which looks like a thermostat but provides such advanced features as time-of-use rate capabilities.

COURTESY PG&E

About 50 Pacific Gas and Electric customers can monitor and control their energy use while they watch television.

COURTESY SOUTHERN DEVELOPMENT & INVESTMENT GROUP

This console, developed by Raytheon, is being deployed in pilot programs of CSW Communications and Southern Development & Investment Group.

for energy management, home and business automation, and security. "This extended network computer would have a built-in capability for communicating with electric utilities and would be able to deliver a suite of energy products and services over the Internet," says EPRI's Cain, who is managing relations with Oracle. "Users could consult it to retrieve information and carry out transactions not only on their electricity use but also on water and natural gas. It will also have energy management features similar to those offered by the Raytheon unit used by CSW Communications in Laredo."

Philips' version of the WebTV device

Network computer

ON-LINE FROM THE COUCH
The increasingly popular Internet gives electric utilities a ready vehicle for customer communications. Making it even more convenient are new devices that bring cheap Internet access to the television screen, allowing true couch potatoes to shop, bank, and send e-mail from the family room sofa. WebTV set-top devices already on the market come with all the software needed to surf the World Wide Web. Similar capabilities will be provided by the diskless network computer, expected to be released by spring. Through an alliance with Oracle, EPRI is working to add to the network computer new capabilities for energy management, home and business automation, and security.

On-line

Already, electric utilities are tapping the Internet to reach their customers. As of the beginning of this year, 180 utilities have home pages on the World Wide Web. Generally, though, utilities are using the Internet mainly for one-way communications—relaying background information on their companies and news about special customer programs—and have not deployed it for sophisticated energy management services. That is starting to change, however, as PG&E's efforts indicate.

Among the other utilities taking a more interactive approach to the Internet is San Diego Gas & Electric. From the company's home page, customers can enter the Virtual Reality Greenhouse, an image of a family room in which they can click on overhead lights, a stereo, and other energy users to find out how much electricity these devices consume. And last August, with some funding from the U.S. Department of Energy and EPRI, Enova Technologies (a sister company of SDG&E) teamed up with Pacific Bell to develop a user-friendly Internet-based energy management system that is expected to be ready for implementation this spring. "We're trying to distinguish ourselves from other potential service providers," explains Tiff Nelson, the utility's manager for the project.

As is the case with PG&E's project, about 50 SDG&E customers will be selected for participation and will be able to monitor and control their electricity use from their home PCs. Plans are for SDG&E's system to provide users a comparison of the current month's energy consumption with that of the previous month and with that of the same month the previous year. Although time-of-use rates are not expected to be in place, users will be able to control a few large appliances, and a simulated time-of-use program will allow them to determine how much money they could save if such rates were implemented. Plans are for the program to last nine months. This project is among the first efforts to apply EPRI's Customer System 2000, which is aimed at helping utilities upgrade their Web sites from browsing facilities into virtual business environments capable of supporting a variety of interactive services.

Amid all the activity involving sophisticated, user-friendly customer interfaces, some utilities are taking a different, more immediate, and far less expensive approach. Kansas City Power & Light, for instance, has opted for a wireless, cellular-based communications system. For an operational cost equal to that of manual meter reading, KCP&L is deploying a system that, by the close of 1996, was already tied in to all 420,000 residential and small commercial customers in the utility's major metropolitan area. CellNet Data Systems installed the system at no cost to KCP&L, "assuming all the risk," notes Doug Morgan, vice president of information technology for the utility. KCP&L pays a transaction fee every time data travel across the system, and the cumulative costs equal the expense of manual meter reading.

The system provides the basic benefits of the more-sophisticated hybrid fiber-coax approach, including remote meter reading, outage notification, and meter-tampering detection. But the system does not provide capacity for more-advanced services in the future, such as Internet access, electronic mail, and interactive television.

"We decided on a narrowband approach because we believe that competition and retail wheeling are going to happen soon, and we want to position ourselves for that market," says Morgan. "If we waited for broadband technology to become economical enough to be deployed throughout our service territory and to get integrated, we'd be sitting around for years." By getting its system in place now, KCP&L is gaining experience in using the electricity consumption information that's relayed to it every 5 minutes from each meter. These data are fed into computer models that estimate how much electricity specific appliances in the home are using. In a competitive environment, the marketing value of such detailed customer information is crucial, says Morgan. And because the wireless system is so economical, KCP&L can deploy the capability throughout its service territory. Early this year the utility plans to roll the service out to its large commercial and industrial sites.

Home, sweet home

Why are electric utilities focusing so heavily on the residential market? After all, the large commercial and industrial accounts are the ones at highest risk for being snatched up by competitors, as some utilities have already experienced. And with such significant electricity consumption at a single site, a utility can justify the often large monetary investments that their telecommunications endeavors require. Indeed, many electric utilities have already made such investments for their large customers, laying fiber-optic lines and installing sophisticated energy management systems in their plants. These customers have enjoyed the benefits of time-of-use pricing for years, and some of them now even have real-time pricing, through which rates vary hourly.

And therein lies the rationale for utilities to pursue the common person. The way some power companies see it, the residential arena is a market waiting to be had. After all, dollars from the residential sector make up about 35% of the utility industry's revenues. "There are already quite a few technologies out there for large industrial and commercial customers," says Tom Wick, manager of distribution and customer systems integration for Wisconsin Electric Power Company, a subsidiary of Wisconsin Energy Corporation, which teamed up with the Baby Bell Ameritech Corporation last year to establish a company, Energy Connections, to market utility automation and other advanced home services. The new company's product is a modular, turnkey system with capabilities ranging from remote meter reading to power quality monitoring to security. The system, which has been tested in 30 homes in Wisconsin Electric's service territory and is now undergoing deployment in 170 additional homes for further testing, is designed to work with a variety of infrastructure technologies, including paging and telephone line, and will be marketed to electric utilities for use with residential and small commercial and industrial customers. The tests under way involve the use of two different thermostat-like customer interfaces. The more sophisticated of the two, called the Enhanced Customer Interface, includes a display for text messages.

Some utilities emphasize that they are trying to get a better handle on the residential market to determine which energy management services are even of interest to this customer segment. "We're pretty clear on the needs of our large commercial and industrial customers, but the residential customers have always been grouped together as a single customer," says Jim Gariepy, who is managing Detroit Edison's Intelligent Link project. Since last April, the utility has been testing an energy management system with a small group of customers to see how they respond to capabilities like appliance control and time-of-use pricing. If all goes well, the system will be rolled out to serve the remainder of Detroit Edison's 1.9 million residential customers. As in the Energy Connections system, the customer interface is a thermostat (in this case, one manufactured by Honeywell) that includes a display for billing information, public service announcements, and rate information.

In a separate effort underscoring its interest in the residential market, Detroit Edison has invested $10 million in Echelon Corporation of Palo Alto, California, the company that developed a communications protocol and special electronic chips that enable devices like the Honeywell thermostat to communicate over standard house wiring.

Big numbers

The sheer volume offered by the residential market also makes it worth pursuing. Rather than having to customize a system for every user, as is typically the case with commercial and industrial customers, utilities can rely on mass-produced systems that they can deploy throughout their service territories. "The more systems or components that are sold, the more the cost of the products comes down," explains Dennis Ragone, a project manager for two-way customer communications at Public Service Electric and Gas.

PSE&G has partnered with Lucent Technologies to develop a two-way communications system that will be marketed to electric and gas utilities. Ragone emphasizes that the system was developed to serve all market segments—residential, commercial, and industrial. "We wanted a system that's inexpensive enough to be deployed everywhere," he says. "This system provides a way for utilities to cut their costs and to gear up for future business opportunities." The Lucent system relies on a hybrid fiber-coax infrastructure and could employ a variety of customer interfaces, from screen telephones to personal computers. During the trial run in PSE&G's service territory, however, the interface is a Honeywell thermostat.

A pilot system has been deployed to 930 residential, 65 commercial, and 5 industrial customers. After thorough testing and evaluation, PSE&G plans to roll the system out to 500,000 of its customers by 2002. But don't large commercial and industrial customers already have these capabilities in place? According to Ragone, PSE&G does provide load-profile metering to most of its large commercial and industrial customers. The Lucent system would enable additional capabilities like real-time pricing and load control, however—at costs well below those of the existing system.

In at least one area of the country, a portion of the residential segment—luxury multifamily housing—is already embroiled in the battle for power supply. With their health clubs, street lighting, communal trash compactor systems, and other electricity consumers, such communities can constitute a demand of more than 10 MW. In Georgia, the turf wars over providing power to luxury apartment complexes have become more aggressive in the last two years, with an array of investor-owned utilities, municipalities, rural electric cooperatives, and others all competing for the same customers. Because the apartment developers have their pick of electricity suppliers, power providers are eager to look better than their competitors.

The Southern Company, the parent company of Georgia Power, is implementing a clever business line that exploits a wide range of telecommunications technologies. Under its Premier Home label, the utility plans not only to provide sophisticated energy management services to luxury apartment dwellers but also to consolidate all utility-related charges on one bill. That includes phone service, cable television, security, Internet access, water use, and more. The plan is being piloted at a 303-unit apartment complex in Duluth, an Atlanta suburb, in cooperation with Dominion Companies, a national developer of luxury apartment homes.

A Future Vision

The year is 2005. You walk into Circuit City and open the door of a new refrigerator. Five information packets tumble onto the floor, much like the Internet access CDs that pop out of magazines today. Each packet is from a different power retailer vying to sell you the electricity that will run the appliance for five years.

When you plug in the new refrigerator at home, it will automatically purchase power from the company you selected. The appliance will also register itself electronically with the manufacturer, so there's no need to fill out and mail in a warranty card. And the warranty you purchased with the refrigerator enables the machine to diagnose itself and to report any problems to a local service contractor.

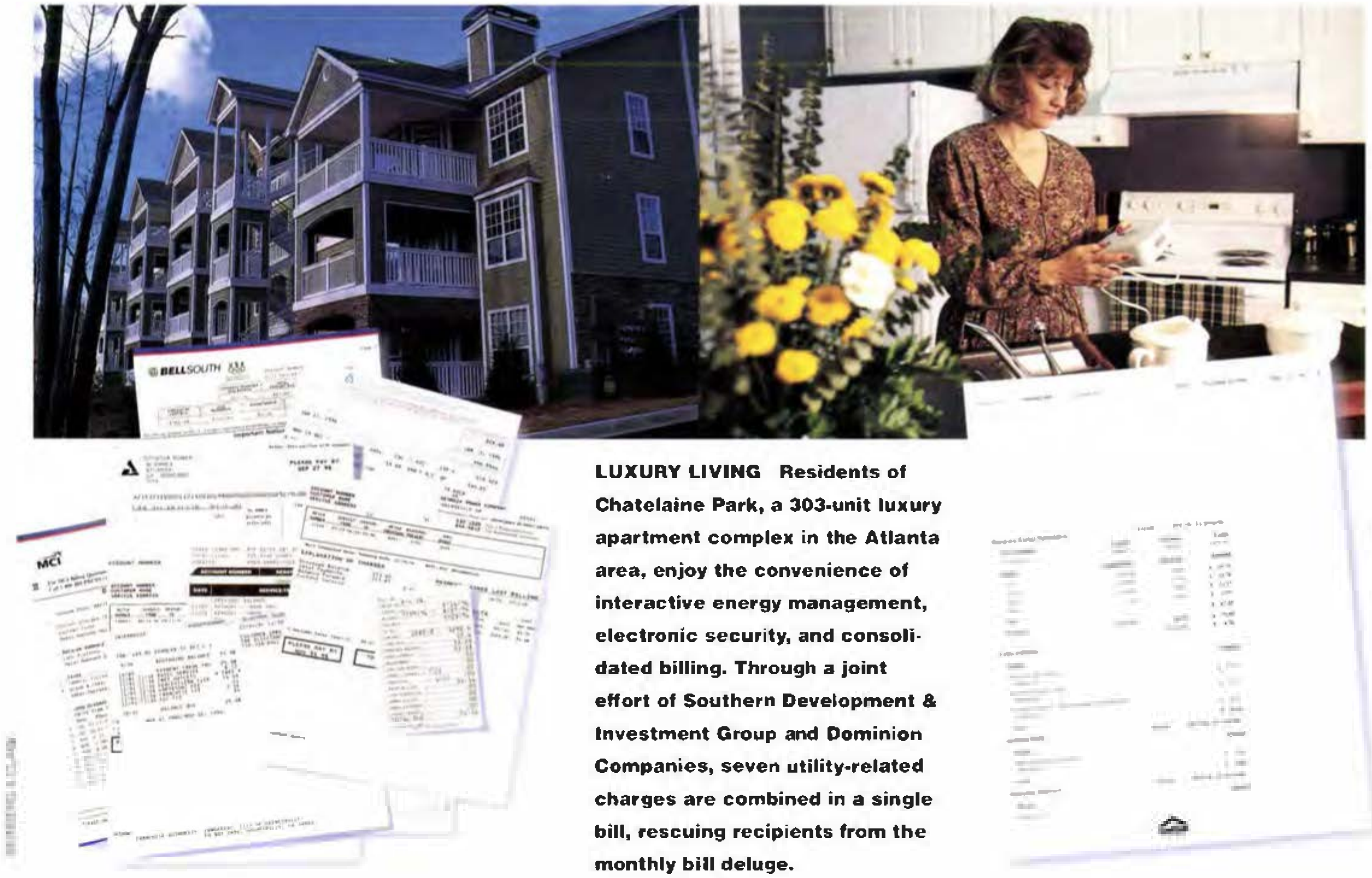
This is a future vision offered by Steve Drenker, manager of EPRI's Information Systems & Telecommunications Business Unit. "The load control and remote meter reading that utilities do today via telecommunications technologies are just the beginning," says Drenker. He believes that technological advances in telecommunications, combined with the increasingly popular and accessible Internet, are going to change how we live today—in a big way. In the not-too-distant future, he predicts, virtually everything will have an Internet address, from telephones to gas pumps and home appliances. Drenker is not alone in this assessment. The Internet's anticipated capability to handle an almost infinite number of addresses has some technological visionaries predicting that the information superhighway will undergo a radical transition from a PC-related phenomenon to a functionality that is incorporated into many consumer products, much as the microprocessor chip resides in electronic devices today.

"In the future, potentially every consumer electronic product will have an Internet address," says Drenker. "We're going to see an abundance of things communicating on the Internet, and it won't be people." In fact, EPRI is working to establish a consortium of appliance makers and telecommunications companies to develop standard messages for communications between these devices.

At this point, no one knows precisely what an appliance's Internet address would be used for. But there are lots of ideas floating around, and the business opportunities for utilities are significant. On the most basic level, a utility could monitor the power consumed by Internet-linked appliances and perform remote diagnostics as a billable service to the owners. But advances in sensor technologies that are now under way further increase the possibilities.

Some visionaries predict that the next decade will be the era of the low-cost solid-state sensor, much as the eighties was the era of the cheap and powerful processor and the nineties the era of the laser, which brought high-speed communications and mass data storage. Already, solid-state sensors are being built into appliances for all kinds of new capabilities. For instance, Maytag's IntelliSense dishwasher can detect the level of dirt in a given load and adjust its cycle, saving consumers water, detergent, and energy. In the future, says Drenker, sensors will even be able to tell when a microwave oven is heating a slice of pizza. "This kind of information can be used by marketers to develop their next generation of products," he says. "Just think of how valuable that would be." Drenker acknowledges that a potential roadblock to some of these advances is the issue of privacy; only time will tell how this unfolds. (For more information, see "Tighter Security for Electronic Information," *EPRI Journal*, November/December 1996, p. 16.)

In the meantime, EPRI is moving forward aggressively with efforts in utility-related telecommunications. Says Drenker, "Thomas Edison didn't want to sell kilowatthours; he wanted to sell value, such as a lighted room. But he couldn't charge for a lighted room. Now the capabilities are falling into place to allow us to do this." □



LUXURY LIVING **Residents of Chatelaine Park, a 303-unit luxury apartment complex in the Atlanta area, enjoy the convenience of interactive energy management, electronic security, and consolidated billing. Through a joint effort of Southern Development & Investment Group and Dominion Companies, seven utility-related charges are combined in a single bill, rescuing recipients from the monthly bill deluge.**

Bill Kirby, director of new ventures at Southern Development & Investment Group, the Southern Company subsidiary heading up this effort, says the software and systems that provide the consolidated billing and energy management services can now be used for similar projects. Kirby says he's gotten phone calls from developers "in every corner of the country" ever since the first residents moved into the complex, called Chatelaine Park, late in January of last year. The developers are all interested for the same reason, Kirby says: the advanced services and billing conveniences make their apartments more attractive than others. The Premier Home concept is undergoing a two-year trial, and if it is successful, Southern Development could deploy it in virtually any area of the country where demand exists. And indications are that there are more such projects to come. In November, Southern Energy (an unregulated subsidiary of the Southern Company) and Dominion signed a long-term agreement for the utility to act as the developer's energy provider and rate consultant. A separate agreement that allows Southern to coordinate services similar to Chatelaine's at other Dominion communities is being negotiated. Currently, the developer has 16 apartment communities complete or in development, 12 of which are in the Southern Company's service territory.

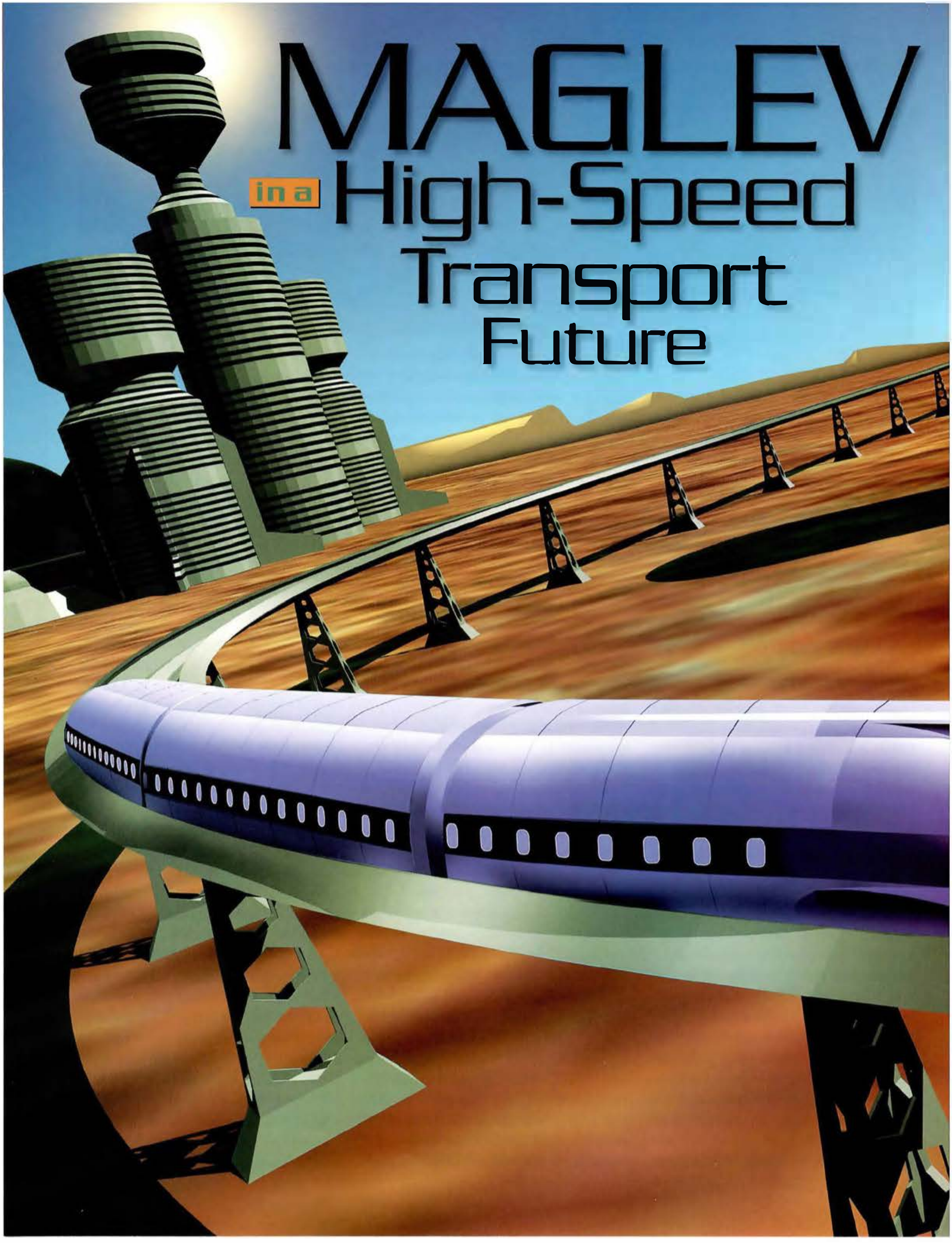
Kirby is among those who believe home automation is the wave of the future. Customers, he says, are coming to expect such advanced services. "Like putting airbags in cars, this is going to become a cost of doing business," he says. That might be debatable. But a recent EPRI survey of 30,000 electric utility customers, selected to be a representative slice of U.S. consumers, indicates a significant interest in energy management.

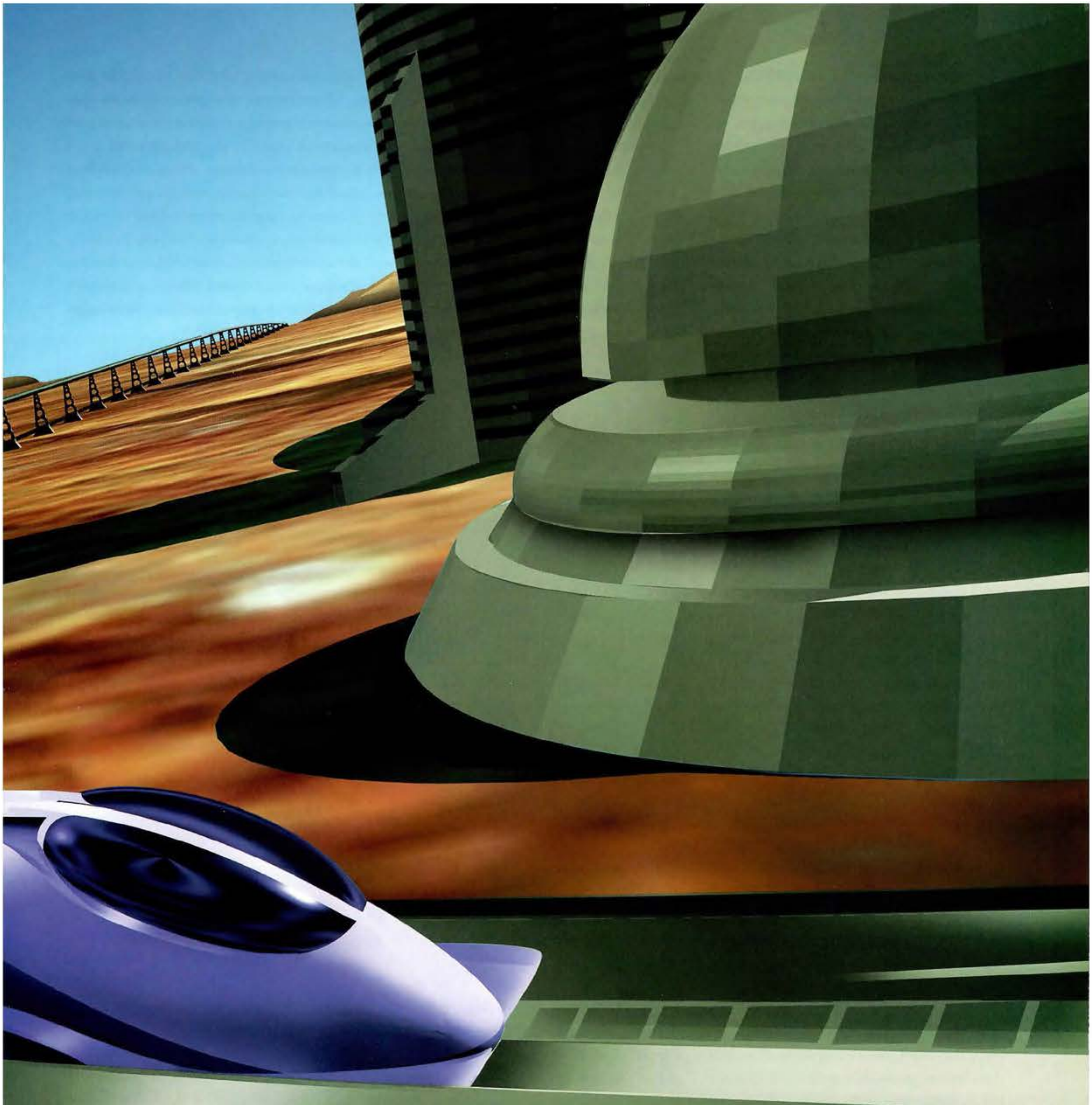
According to this survey, published late last year, 45% of respondents expressed interest in services to monitor home energy use, with 17% of the 30,000 indicating they are "very interested." Other potential market areas include whole-house surge suppressors, which drew interest from 39% of the survey respondents, and home security, which received interest from 33%. (More-detailed results from the survey are available through an EPRI report called *ReQuest III*, TR-107631.) While these results are promising, they are certainly not a guarantee that these services will be a hot commodity among consumers. And it's hard to tell whether the currently disinterested consumers can be won over. In the words of Rich Gillman, EPRI's manager of market and load research, who oversaw the survey, "It's not going to be an easy sell."

But is it possible that many consumers simply don't know what they are missing? Perhaps once they are used to the convenience and savings of energy management services, they'll begin to seek these services out. If Rene Rodriguez of Laredo, Texas, is any indication, there might be some merit to that thought. "I was the last one of my neighbors to jump on board," he says. "Now I'm trying to sell the program to everyone I know!" ■

Background information for this article was provided by Steve Drenker and David Cain of the Customer Systems Group.

MAGLEV in a High-Speed Transport Future





JAMES WILLIAM GARY

The Story in Brief Magnetic levitation technology for high-speed transport could greatly extend people's daily travel range in the next century, making intercity commutes possible and altering population settlement patterns. It could also open the way to a major new market for electricity. Maglev vehicles traveling on dedicated guideways could offer strong competition to air and automobile transport for trips of 300 to 500 miles. Technology futurists are beginning to consider the implications that a greener, high-speed mode of mobility could have for society.

by Taylor Moore

Almost a century ago, Americans Robert Goddard and Emile Bachelet conceived of frictionless trains that are levitated and propelled by the force of magnetic fields. A practical demonstration of the concept did not come until nearly a generation later, in the 1930s, by Hermann Kemper in Germany. A generation after that, in 1968, two scientists at Brookhaven National Laboratory were granted a patent on a design for a magnetic levitation, or maglev, electric train that one of them had dreamed of eight years before while stuck in traffic.

Early in the coming decade, a few years after the turn of the millennium, maglev trains traveling at speeds of 250–300 mph or higher are likely to enter commercial passenger service, approximately a hundred years after they were first imagined. When they do, it may mark the beginning of a new modern era of advanced transportation, one that could have an impact on human mobility and its environmental implications as lasting as the emergence of the internal combustion automobile in this century or the steam locomotive in the previous century.

For trips of 300–500 miles, maglev vehicles promise the ultimate realization of what has recently been called a green mobility future. In such a scenario, the enormous energy demand of air and ground transportation that is now met with fossil fuels may be at least partially decarbonized, reducing emissions of the greenhouse gas carbon dioxide and, in the United States, decreasing dependence on imported oil. At the same time, some of the ground-level pollution from vehicles and aircraft would be more effectively limited through the electrification of transportation.

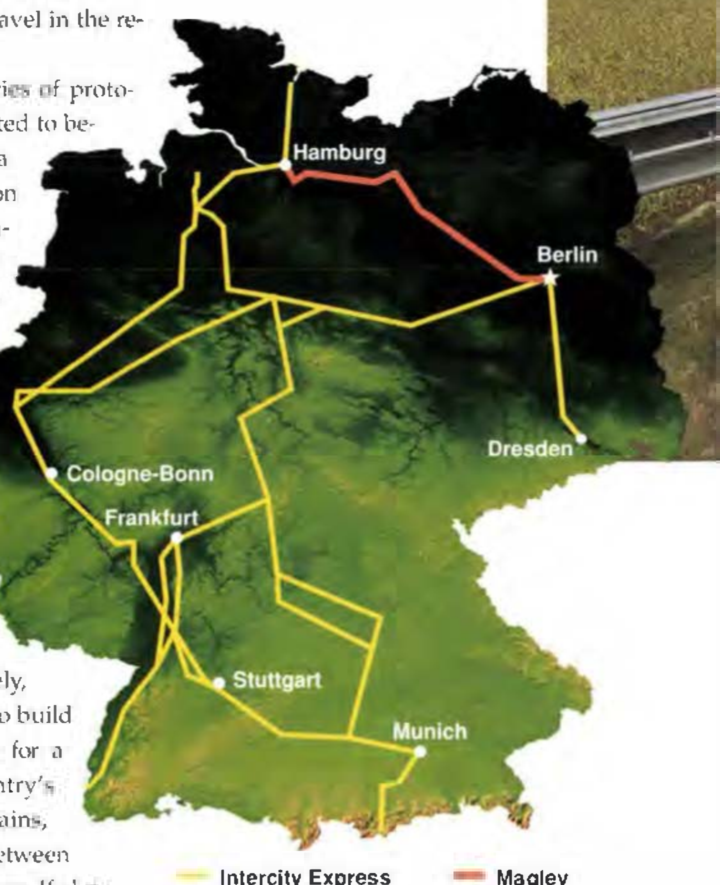
Americans will have to take a long trip by air or sea to be among the first commercial passengers to experience the quiet, smooth ride of a maglev system, however. That's because the first maglevs likely to enter commercial operation will be in Germany and Japan, each of which has invested more than $1 billion over the past 20 years to develop and demonstrate the technology for high-speed transport. Full-scale prototype maglev vehicles have been successfully tested at high speeds in both countries.

In Germany, financing and planning are proceeding apace on a project aimed at putting a 180-mile (290-km) maglev line between Berlin and Hamburg into service in 2005. The German parliament overwhelmingly passed measures last year to implement the project, estimated to cost 9 billion deutsche marks (about $6 billion) in public and private capital, and construction is scheduled to begin in 1998. The Transrapid system to be deployed—the product of a long-running joint venture that includes Siemens and Thyssen—has come to symbolize in Germany the future for high technology with great export potential. Moreover, the Berlin-Hamburg route is part of a longer-range government plan to enhance east-west travel in the reunified country.

In Japan, the last in a series of prototype maglev vehicles are slated to begin tests late this year on a 27-mile (43-km) demonstration line being constructed in Yamanashi Prefecture, south of Tokyo, by the Japan Railway Technical Research Institute. Within a year or two, the Central Japan Railway Company will decide whether to extend the test section into a commercial maglev line between Tokyo and Osaka, a distance of some 340 miles (550 km). Alternatively, the company could choose to build a new steel-wheel rail line for a faster version of the country's famed Shinkansen bullet trains, which first began running between Tokyo and Osaka 33 years ago. If chosen as the option for alleviating a growing demand for daily commute transportation capacity on the route, the Tokyo-Osaka maglev could begin operating around 2005.

In the United States, federally funded maglev R&D in the early 1970s led to the linear electric motor technology that is fundamental to all the prototype maglev vehicles developed to date, including the technically different approaches pursued in Germany and Japan. The linear synchronous motor at the heart of current maglev designs doesn't use a spinning rotor like conventional motors; rather, maglev vehicles are propelled along a linear stator (the guideway) by alternating magnet coils that are precisely controlled with high-power electronic switches.

Several proposed high-speed transportation projects in this country include maglev as either a primary or optional technology of choice. But despite this and the momentum gained during the brief existence of the congressionally established National Maglev Initiative in the early 1990s, U.S. research on maglev technology for commercial passenger use is largely dormant, a casualty of the federal budget impasse of 1994. Before it folded, the initiative did get as far as concluding, on the basis of concept definition



TRANSRAPID PLANNED FOR COMMERCIAL SERVICE IN 2005 **Construction is scheduled to begin next year on a 180-mile (290-km) maglev line between Berlin and Hamburg that will complement Germany's intercity high-speed steel-wheel rail network. Transrapid International, a consortium that includes several major technology companies, has developed and tested numerous maglev prototypes over the past decade and a half; shown here on a guideway test loop is the most recent version. Plans for the Berlin-Hamburg line call for 14 six-section train sets, each with a capacity of over 500 passengers, to operate at 15-minute intervals; total travel time, including stops at three intermediate stations, will be 1 hour. The project, which has strong government and industry support, estimates that annual ridership could exceed 17 million passengers within five years of the start of commercial service.**

TRANSRAPID INTERNATIONAL

studies by four teams of American engineering and technology companies, that an advanced domestic maglev technology is feasible and promises lower construction and operating costs than the systems being developed in Germany or Japan (see sidebar, p. 22).

Whatever the outcome of technology development and national policy commitments, it appears increasingly likely—given the limits of steel-wheel trains and the already dense urban networks that are harder and harder to service by airplane—that high-speed maglev systems will become a reality in the next century. But as with other major, transforming technologies, the infrastructure for maglev may take decades to develop to the point that it begins to have a significant impact.

Quite apart from the concerns of technologists and engineers, the prospect is beginning to lead some researchers to consider the implications that maglev and other advanced transportation technologies may hold for how we travel, where we live and work, and what we could do with increased travel speeds.

Faster, farther

Two such philosophers on the future—Jesse Ausubel, director of the Program for the Human Environment at New York City's Rockefeller University, and Cesare Marchetti, institute scholar at the International Institute for Applied Systems Analysis in Austria—have thought a lot about the prospects for maglev as an environmentally liberating, or green, transportation technology. In recent studies supported in part by EPRI, Ausubel and Marchetti have analyzed data on the time and income spent for personal travel in various countries over the past 200 years and have tried to project how changes in these patterns may become possible in the next century. Ausubel provided a preview of the results of their analyses to EPRI staff and management at an informal seminar last summer.

"Basically, the data on travel and transport show that humans are territorial animals and instinctively try to maximize territory, which is equated with opportunities and resources," Ausubel notes.

Fairly consistently in developed countries today, Ausubel and Marchetti found, people spend 1–1.5 hours per day traveling (the time budget), and they spend 10–15% of their income on travel (the money budget). Rich or poor, people make three to four round-trips per day, limiting the main daily round-trip to 40–50 minutes. Besides daily trips, people average three to four round-trips per year outside their basic home territory.

"Speed—low-cost speed—is the goal of transport systems," says Ausubel. "People allocate time and money to maximize distance—that is, territory. In turn, when people gain speed, they travel farther rather than make more trips."

Faster modes of transport have dramatically extended personal travel range over the past 200 years. In the eighteenth century, when people traveled by horseback, they could comfortably cover about 30 miles a day—the distance that separates, for example, the Spanish missions along the California coast. Now the entire 400 miles between Los Angeles and San Francisco can be driven by automobile in just under a day. Like a plane, a next-generation maglev could make the trip in about an hour.

"New technologies of transport that add speed gradually achieve market penetration as they substitute for older modes in terms of travel time allocation," says Ausubel. "As technology introduces faster means of getting somewhere, the new modes are usually not cheaper, at least at the outset, so there is only a gradual

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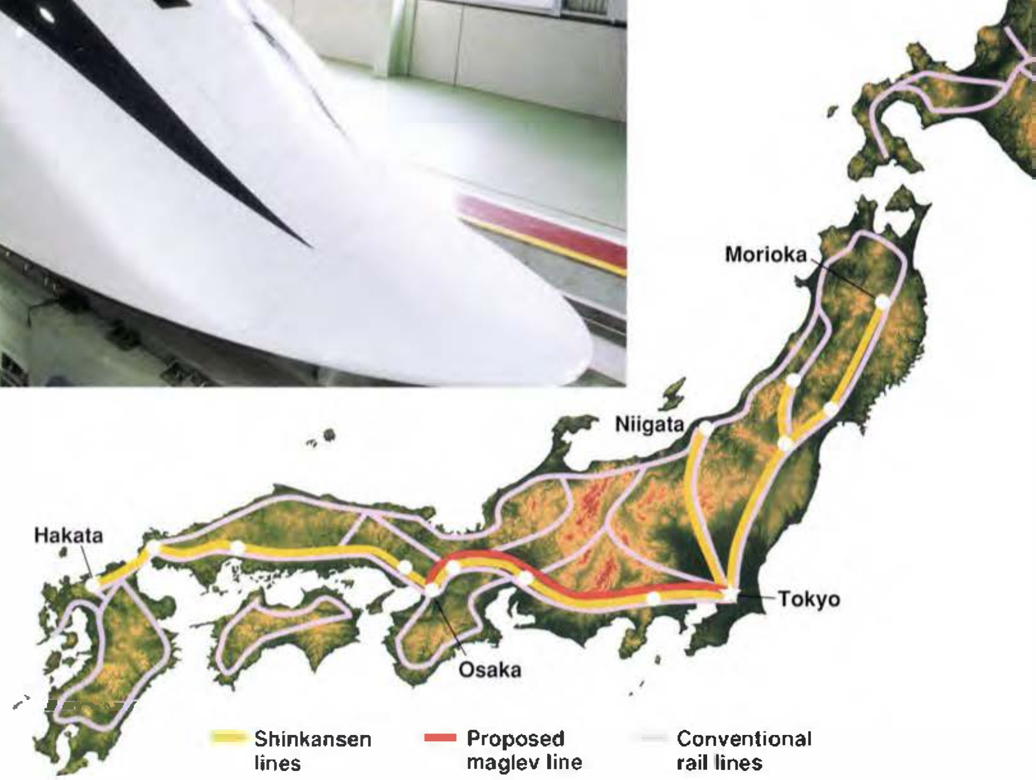


JAPANESE PROTOTYPES APPROACH FINAL TEST PHASE **Nearing completion is a 27-mile (43-km) maglev demonstration line in Yamanashi Prefecture, where the Japan Railway Technical Research Institute hopes to begin testing a final series of prototype vehicles late this year. The double-track test guideway will enable high-speed runs of the prototypes through tunnels in opposite directions. Two prototypes were unveiled in 1995—the one shown here and one with a different aerodynamic nose section. After a period of tests, the Central Japan Railway Company may decide to extend the test section into a commercial maglev line between Tokyo and Osaka, a distance of about 340 miles (550 km). This line reportedly could begin operation by around 2005.**

capture of a share of the overall transport market.

"People generally have a fixed amount of time and a fixed amount of money for travel, and they buy the most distance they can afford within their budget. When personal incomes expand, people tend to buy faster modes of travel and can thus travel farther."

The effects of faster modes of transport on personal travel range have been studied by Ausubel and Marchetti in the successive waves of penetration of canals, railroads, highways, and airways in the U.S. transportation infrastructure. "The history of transportation technology can be seen as a continual striving to increase speed as a result of a progressively expanding per capita income," they observe.

Although France's TGV (Train à Grande Vitesse), Germany's ICE (Intercity Express) lines, and Japan's bullet trains are considered moderately high speed transport, historically trains have been a slow mode when the time for stops, changes, and travel to and from stations is included in the speed-distance calculation. In fact, on average, intercity trains travel only about 60 km/h. On the basis of inclusive travel time, the speed of trains is about one-tenth the speed of air travel.

The mean speed of automobiles, combining intercity and intracity travel, is comparable: 40–50 km/h. But because they do not have to operate on a fixed schedule, autos have what could be called infinite frequency.

When people walked as much as 5 km a day, their travel range was around 20 km^2, the size of a typical village. Automobiles multiplied the linear range by a factor of 8 and in turn extended the daily personal travel area by a factor of 60—to about 1200 km^2. Towns absorbing the territory of 60 villages began to form. "The automobile effectively wiped out two levels of the old settlement hierarchy and urbanized 60% of the U.S. population," says Marchetti.

Although the per capita market for automobile travel may shrink in the future, the number of vehicles in use in the United States may reach 300 million as population and personal income grow. Increasingly stringent air quality standards mean that difficulties are likely to lie ahead for the current one-person, one-car equation, at least as far as internal combustion vehicles are concerned. Personal vehicles can be made to run cleaner, of course, but even clean, energy-efficient cars will remain slow.

The mean speeds of modern airplanes—600 km/h (360 mph)—are higher by a factor of 10 or more than those of automobiles or trains. Airplanes are projected to capture half the market for intercity passenger travel in the United States soon after the year 2000. Assuming a growth rate of 3% per year in passenger-kilometers traveled and a growing share of the overall passenger travel market, Ausubel and Marchetti say that a 30-fold increase in travel by airplanes (or their equivalents) is inevitable over the next 50 years.

Passenger travel is not the only factor driving the growth in air traffic. At first used mainly for carrying mail and people who could afford the order-of-magnitude leap in cost and speed and therefore travel range, airplanes are capturing increasing shares of the transport markets for progressively lower-value goods. There is still much potential for growth in air cargo traffic, however, and planes capable of carrying as much as 10 times the 100-ton payload of a Boeing 747 freighter are considered technically possible. But are they desirable?

As anyone traveling through a major metropolitan airport anywhere in the world can readily observe, delays are not uncommon. For a cross-country connecting flight, dwell time and delays can equal actual flying time. The International Air Transport Association says that flight delays caused by congestion in the air or at airports already cost over $15 billion a year.

According to *The Economist*, in 1995 the world's airports handled takeoffs and landings to move 1.3 billion passengers from one place to another. Many more potential passengers could be coming: Europeans flew an average of only about 1.5 hours in 1995, compared with 7 hours for the average American. For air travel alone to meet the expected demand for faster, farther travel, air transport systems will need to grow by more than 10% a year. Such growth would sorely tax the capabilities of present airports and air traffic control systems. Within the next decade and a half, more than 50 major airports, most of them in the United States, will be operating above their official capacity.

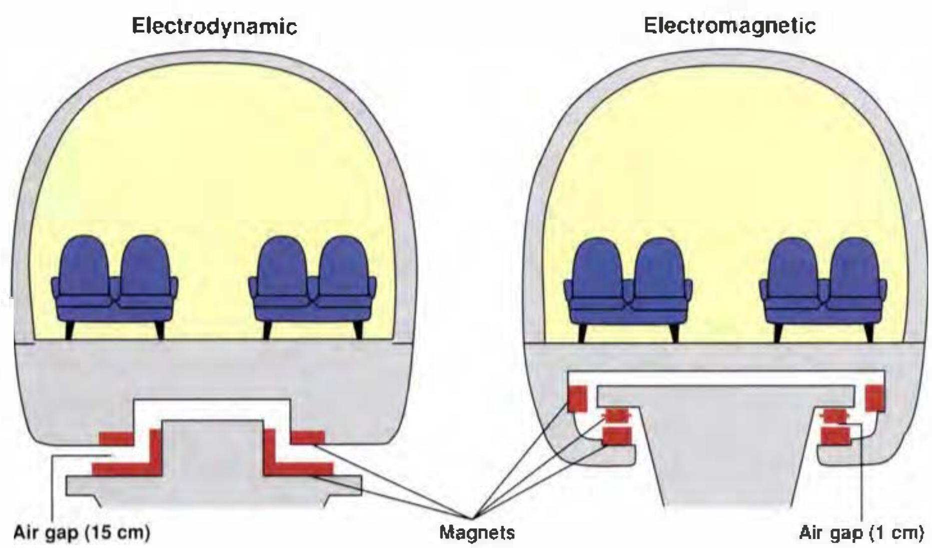
"Bigger and faster planes can resolve the air traffic dilemma in part through speed and containing the number of flights, but they do little to address the environmental and safety problems that the present level of air travel already entails," says Ausubel. "There will still be a need for a new high-speed, high-density transportation mode that offers speed and cost equal to or better than those of airplanes."

A twenty-first century express

Noting that the commercial introductions of the steam locomotive, the gasoline-powered automobile, and jet aircraft were separated by intervals of approximately 60 years, Ausubel and Marchetti say that "by recent historical cycles, a new transportation mode should enter service around 2000." The increased speed and frequency available with each new mode have made possible a higher order of magnitude in passenger flux. And to one degree or another, each mode has required the development of new infrastructure for service and support.

Maglev systems, with a capability of moving tens of thousands of passengers an hour in both directions through a corridor, not only would transform passenger flows on a grand scale but could also lead to much larger functional agglomerations of metropolitan areas, expanding the effective area of individual cities and making daily intercity commutes more

HOW MAGLEV VEHICLES FLOAT The electrodynamic, repulsion-type maglev system, originally patented by American scientists in the 1960s, is the focus of the development program of the Japan Railway Technical Research Institute. In this approach, levitation magnets on the top of a guideway—or, as is the case with present Japanese prototype designs, in the guideway sidewalls—push away superconducting magnets grouped underneath or at the bottom sides of the vehicles. Linear synchronous propulsion coils in the guideway propel the vehicles. This type of system allows for a large air gap (about 15 cm) between opposing magnets. In the electromagnetic, or attraction-type, maglev developed by Transrapid International in Germany, conventional iron-core magnets in the vehicle's wraparound arms are pulled up to magnets under the guideway. A relatively small air gap (1 cm) separates the vehicle and guideway magnets. Although not part of the present Transrapid design, superconducting magnets can be incorporated in attraction-type maglev systems.



Advanced Maglev Technology

While the pioneering maglev systems under development in Germany and Japan have different technical features, each technology is expected to be economically viable when it enters commercial passenger service around the middle of the next decade.

Considered ready now for commercial passenger service, Germany's Transrapid maglev design has been extensively tested with full-scale prototypes. It employs an electromagnetic suspension system in which conventional iron-core magnets underneath the vehicle are attracted upward to steel rails in the guideway. The close clearance (1 cm) between vehicle and guideway translates to tight tolerances that contribute to high construction costs for the guideway.

The Japanese maglev program is developing an electrodynamic system based on the repulsion-mode concept first proposed and patented by Americans James Powell and Gordon Danby in the 1960s. The system features superconducting magnets on board the vehicle that induce currents in stator coils contained in the guideway sidewalls. Once magnetic liftoff is achieved—at about 100 km/h (62 mph)—the vehicle is levitated about 15 cm; at lower speeds, it rolls on rubber tires. The new double-track test guideway in Yamanashi Prefecture will enable operational testing of full-scale prototypes, including 500-km/h (310-mph) runs through tunnels.

In the United States, R&D in the late 1960s and early 1970s at Ford Motor Company, the Stanford Research Institute, and the Massachusetts Institute of Technology (MIT) led to the development of the linear electric motor concept that underlies all maglev designs developed to date. But federal funding for the work dried up in 1975.

Government support for maglev R&D was modestly and briefly revived with the passage by Congress of the Intermodal Surface Transportation Efficiency Act of 1991. The National Maglev Initiative—established by Congress around the same time as a cooperative effort of the Department of Transportation, the U.S. Army Corps of Engineers, and the

MAGPLANE TECHNOLOGY

ADVANCED DOMESTIC MAGLEV SYSTEM CONCEPTS **Shown are two of four advanced concept definitions produced under the U.S. National Maglev Initiative in the early 1990s. The scale model is the lightweight, 140-seat vehicle of Magplane Technology (formerly Magneplane International), which would travel on a trough-shaped sheet-aluminum guideway. The drawing shows the Foster-Miller team's concept—similar to the Japanese maglev but propelled by a locally commutated linear synchronous motor.**

practical. The current 3-hour New York–Washington train ride would be reduced to well under an hour; office workers in Chicago could commute from the suburbs of Detroit or St. Louis.

Besides greater speed, maglevs offer distinct advantages over present modes of transport, both operationally and environmentally. Their linear electromagnetic motors can be precisely controlled to provide constant, smooth acceleration and deceleration between stops. (Linear induction motors are already being used in some amusement rides to hurtle thrill-seekers to a speed of 160 km/h, accelerating them for 1 second at four to five times the force of gravity.)

To be sure, maglev systems would require large amounts of electric power (in the gigawatt range) and possibly guideway energy storage to moderate demand

Department of Energy—reevaluated the potential for maglev to improve intercity transportation. The initiative funded four teams of contractors that developed detailed system concept definitions for advanced maglev designs. These concept studies were completed and incorporated in the initiative's final reports, but funding for further development was eliminated in the federal budget impasse of 1994.

Three of the advanced U.S. concepts feature an electrodynamic system in which superconducting vehicle magnets interact with passive guideway conductors. The fourth design uses an electromagnetic system similar to that of Germany's Transrapid but with superconducting vehicle magnet coils.


FOSTER-MILLER CORP.

A team led by Bechtel—which included Hughes Aircraft, General Motors' electromotive division, MIT, and the Draper Laboratories—conceived a system featuring single-car vehicles designed to tilt on curves. They would have onboard null-flux superconducting magnets and ride a box-beam guideway with null-flux coils built in. Part of the guideway would be constructed of fiber-reinforced plastic to limit energy losses from magnetic field interaction with metal in the guideway.

A team led by Foster-Miller—which included Boeing, Morrison Knudsen, Bombardier, General Dynamics, and General Atomics—designed a system that is similar to the Japanese maglev but that features an innovative propulsion concept based on a locally commutated linear synchronous motor (LSM). The vehicle is designed to tilt to allow faster speeds on curves than the Japanese system. Superconducting vehicle magnets generate lift through interaction with null-flux levitation coils in the sidewalls of a U-shaped guideway. Individual inverters in the guideway sequentially energize propulsion coils on the underside of articulated passenger modules, which have attachable aerodynamic nose and tail sections. The inverters synthesize a magnetic wave that travels along the guideway at the same speed as the vehicle. Foster-Miller's concept features a vertical electronic switch (for station ramps) with no moving parts for high reliability.

Magneplane International (now Magplane Technology) led a team that included two MIT laboratories, Raytheon, and Failure Analysis Associates. It developed a concept for a lightweight, single-vehicle electrodynamic maglev that would use a trough-shaped sheet-aluminum guideway for levitation and guidance. The vehicle would self-bank up to 45 degrees in turns. Superconducting levitation and propulsion magnets are grouped in bogies underneath the vehicle at the front and rear. Magnets at the centerline interact with conventional LSM windings for propulsion and produce some electromagnetic torque for a roll-righting keel effect. Magnets on the sides of each bogie react against the aluminum guideway for levitation. Aerodynamic control surfaces on the vehicle provide active motion damping.

A team led by Grumman (now part of Northrop Grumman) and including Parsons Brinckerhoff, Gibbs & Hill, Battelle Laboratories, and Intermagnetics General designed an electromagnetic system similar to the Transrapid. Unlike the Transrapid, however, the U.S. design uses a common set of superconducting magnets for levitation, propulsion, and guidance. Guideway rails are ferromagnetic, with LSM windings for propulsion. Tilting vehicles could run in single- or multicar configurations.

Several of the engineering and technology companies that participated in the National Maglev Initiative's system concept definitions are now contractors in Department of Defense–funded maglev R&D. This work, which aims to develop a type of maglev technology for possible rocket-testing and catapult-launch applications, is apparently the only currently active U.S. maglev-related R&D. □

surges as vehicles accelerate. But using magnetic forces for both suspension and propulsion offers the potential for a very low travel energy cost—about one-third that of airplanes of similar performance. Maglev thus offers not only high speed but speed with a lower energy cost than offered by previous new technologies.

The incorporation of superconducting, flux-canceling magnets into maglev designs could provide levitation at almost zero energy cost and almost complete recovery of propulsion energy during deceleration. Indeed, maglev is viewed by many as a sort of killer application for high-field magnets made from some of the new high-temperature superconducting compounds.

In describing the eventual physical embodiment of maglev transport, Ausubel and Marchetti invoke a vision of lightweight vehicles—perhaps the size of small buses—rushing from point to point in a variable route, stopping only at passenger-selected destinations, similar to a packet-switched digital telecommunications network.

Maglevs may be particularly suitable for linking two or more major airports, providing an intermodal connection with air as well as with urban metro transportation systems. On such routes, vehicles carrying a few hundred passengers might leave stations every few minutes. "For trips of 300–500 miles, maglevs might be competitive with current air tariffs at 50,000 passengers a day. The key to achieving high passenger flux is to functionally switch a route from intercity to intracity by bringing down the one-way trip time to below the 30 minutes people typically use for personal travel," says Marchetti.

The linear motor allows maglevs to increase speed in proportion to power demand, meaning that there is no fundamental limit on their speed other than the surface atmosphere. Engineers at Bechtel Corporation, which led a U.S. team that defined an advanced technology concept as part of the National Maglev Initiative, calculate that at 300 mph, aerodynamic drag adds about 6 MW in extra power demand per vehicle.

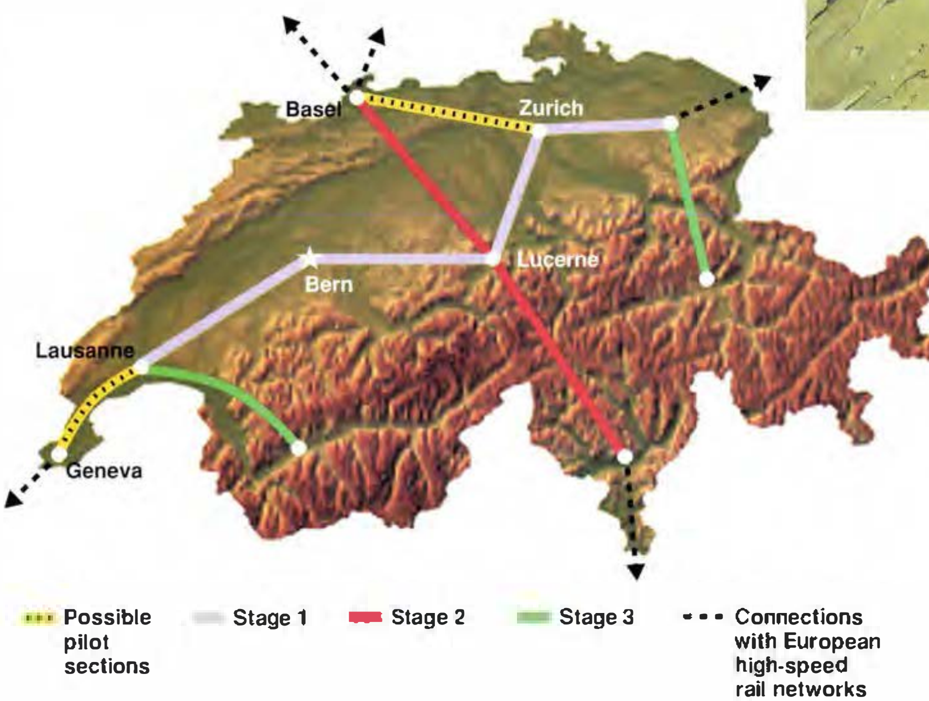
Engineers in Switzerland have in mind a solution even to that limit: they envision a network of partially evacuated steel-lined tunnels linking all the country's major cities. These partial-vacuum tubes would require about one-fifth the cross-section of conventional underground rail borings, which are designed to accommodate air return and the shock wave. Measuring 5 meters in diameter and built in straight bores through the Alps, the tubes would involve less excavation than conventional tunnels and are projected to cost much less. Theoretically, they could allow maglev craft to travel at speeds up to 1860 mph (3000 km/h). The tubes would form part of the guideway and would pose fewer security concerns than elevated or open guideways.

Since there is less air to push against in a partial vacuum, maglev energy consumption would be reduced, making speed cheaper still and thus expanding the system's operational range. The vehicles could fly almost head to tail, spaced as little as 10 seconds apart. At very high speeds and high passenger flux, such maglevs would have a power demand per passenger roughly equivalent to that of a large automobile.

At very high speeds, "maglevs could link any pair of cities up to 2000 km [1240 miles] apart in fewer than 20 minutes," Ausubel and Marchetti wrote in a 1996 *Daedalus* article. "Daily commuting and shopping trips over such distances become possible. . . . With fast, short trips, cities can coalesce in functional clusters of continental size. City pairs spaced less than 500 km [310 miles] or 10 minutes apart by maglevs, such as Bonn-Berlin, Milan-Rome, Tokyo-Osaka, and New York–Washington, would especially benefit."

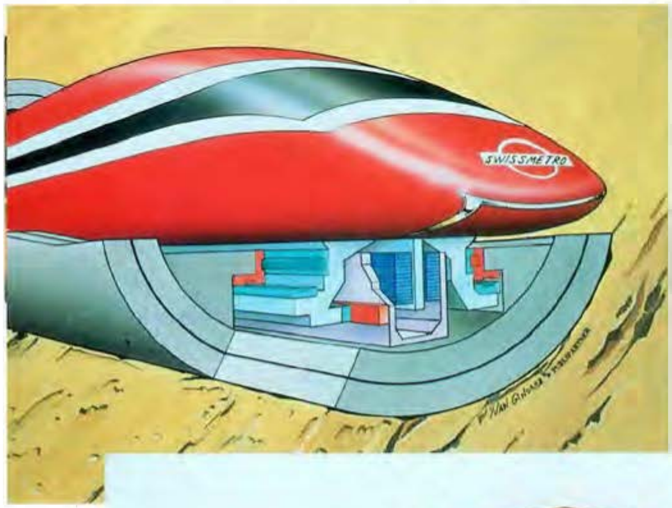
Under active study in Switzerland is a 420-mile (680-km) underground network of evacuated tubes that would carry 800-passenger maglevs at more modest speeds of over 250 mph (400 km/h) and would link 10 cities in the country's principal urban and rural areas. The Swiss government is providing financial support, and the Swiss Federal Institutes of Technology in Lausanne and Zurich are providing engineering support.

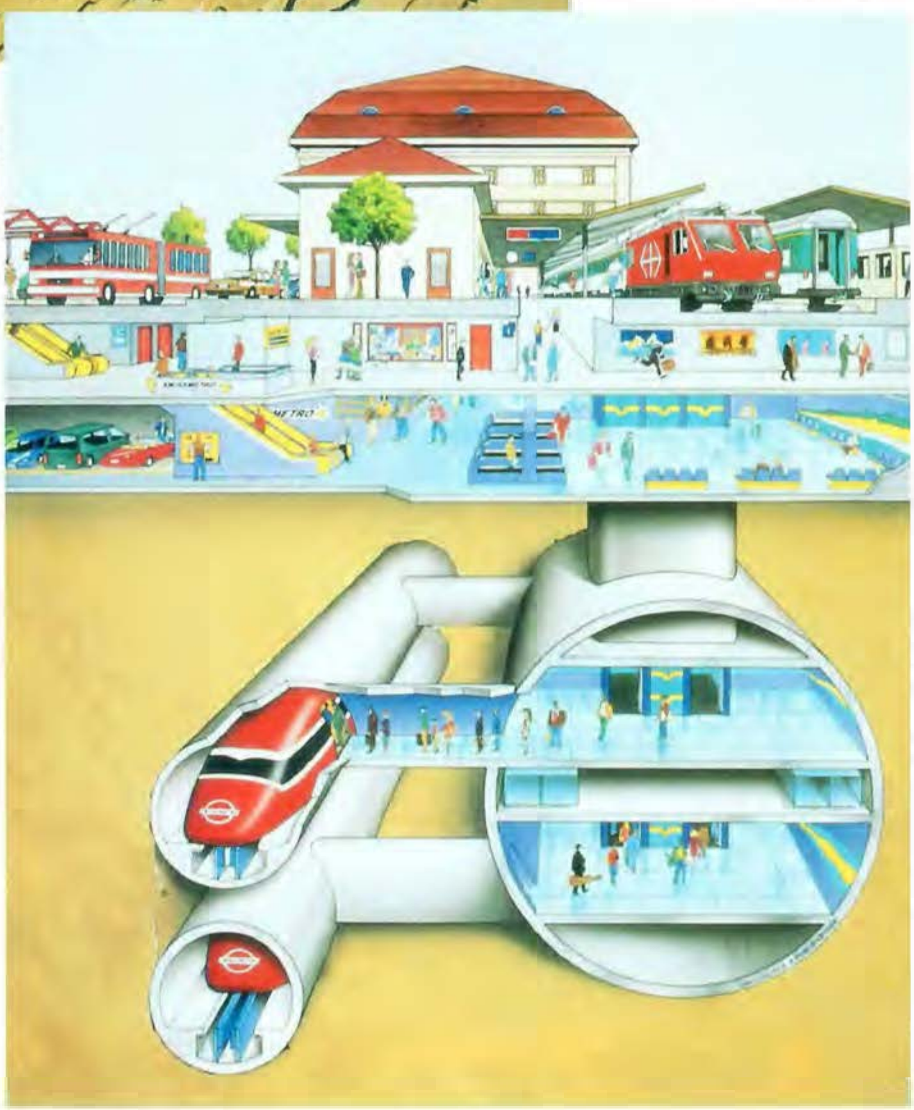
The Swissmetro project, a brainchild of engineer Rodolphe Nieth, plans to include station connections with the country's overbur-



AN UNDERGROUND MAGLEV NETWORK FOR SWITZERLAND? Initially conceived over 20 years ago, a proposed 420-mile (680-km) network of partial-vacuum steel-lined tubes in bores excavated through the Swiss Alps is the focus today of a broad government, academic, and industrial collaboration headed by Swissmetro, a Geneva-based company. With almost no air resistance in the evacuated tubes, the 800-passenger pressurized maglev vehicles would be propelled with particular efficiency. The proposed network, with vehicles operating at about 250 mph (400 km/h) and spaced 12 minutes apart, would link Switzerland's principal urban and rural areas. A ride from Zurich to Geneva would take an hour, compared with 3 hours by conventional modes. Underground stations would be linked to surface transport, primarily regional railroads. The system is projected to take 25 years to complete and to cost 28 billion Swiss francs ($21 billion); the company says construction could begin on a pilot section sometime after 2002.

dened aboveground trains and, eventually, with the high-speed rail networks in France, Germany, and Italy. It is estimated that the system will take 25 years to complete, at a cost of 28 billion Swiss francs ($21 billion). According to Swissmetro, construction of the first pilot section of the network could begin sometime after 2002.





ARTWORK COURTESY SWISSMETRO

The inescapable pull of the future

Major infrastructures of technology and transportation take 50–100 years to build and they last for centuries, Ausubel and Marchetti note. It can take over a century for new infrastructures to diffuse to distant corners—witness the half or more of the developing world's population still without access to electricity. The historical record argues that if a new, higher-speed, high-capacity mode of transportation is going to be widely available when growth projections suggest it will be truly needed, a serious long-term commitment is required now to develop and implement it.

"Most people may have to wait well into the next century to experience maglevs and other gadgets that could dominate the next major wave of electrification," says Ausubel. "But in all likelihood, by the year 2050 large parts of the world will be able to afford green mobility. Its match with the evolutionary decarbonization of the energy system is perfect. The future looks clean and fast."

Ultimately, it may be of little significance in what country or by which companies maglev is first commercially deployed. Fundamental, transforming technologies tend to diffuse inexorably, albeit slowly, like the seemingly slow but inescapable advance of the future itself. There may well be time enough for America to see how maglev evolves elsewhere before reconsidering whether to develop its own technology or to import that of others.

Still, the early adopters of previous new transportation technologies gained strategic advantages that lasted for decades and had far-reaching economic implications. The pioneering and extensive deployment of automobiles and aircraft had enormous industrial impacts in the United States; the same was true for railroads in Great Britain.

In Germany and Japan, countries with already overcrowded airspace and strained airport capacity, decisions have been made on a national level to move toward the early adoption of what could be the next century's major new transportation technology and infrastructure. Besides opening the door to the potential electrification of a larger fraction of transportation energy demand, maglev is apparently seen in these countries as a fast track to a future of boundless possibilities. ■

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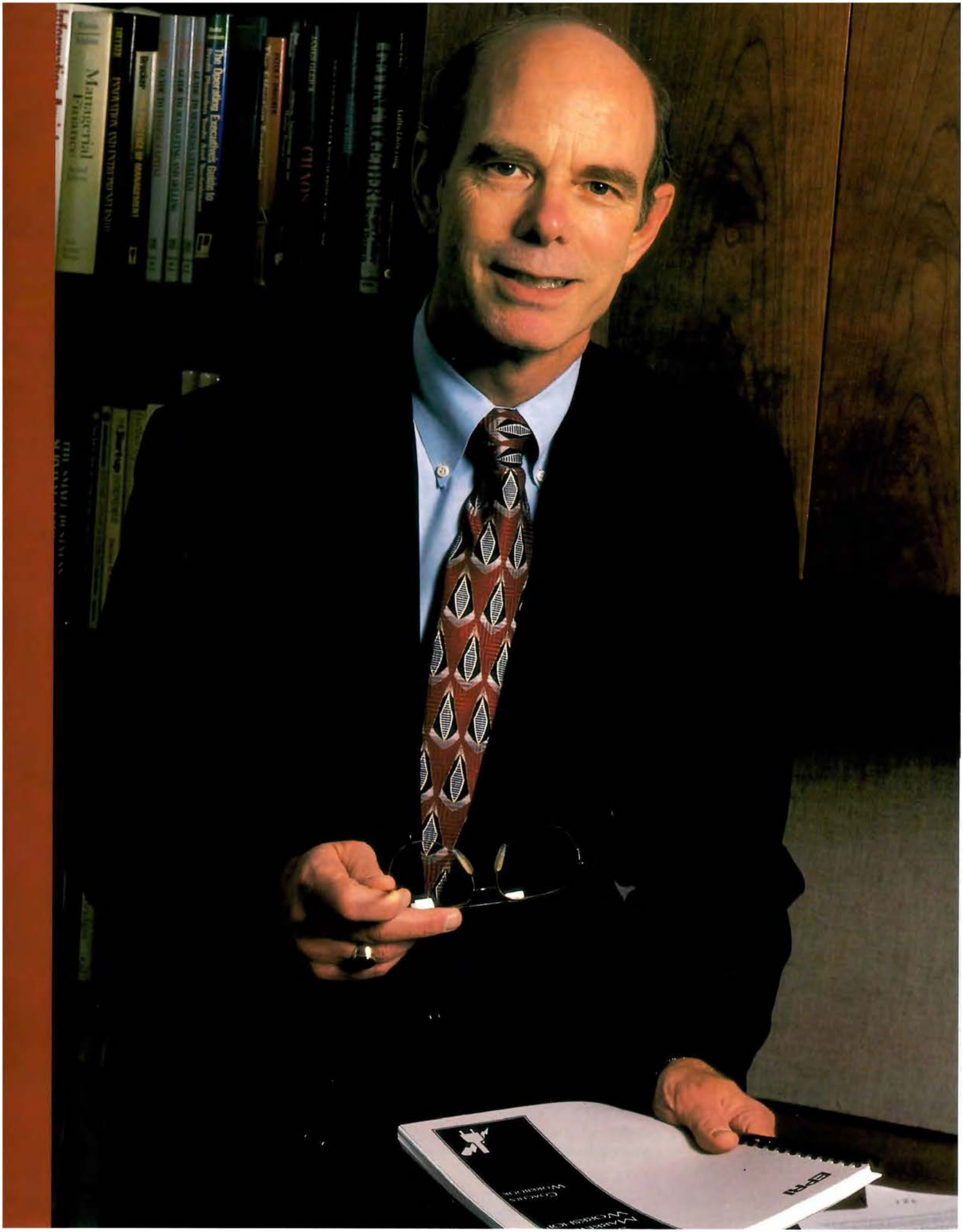


Challenge *and* Change *in* Collaborative Research

Has the new era of competition made collaborative research obsolete? Absolutely not, says EPRI senior vice president and chief operating officer Ric Rudman, who is also currently chairman of North America's influential Council of Consortia. Interviewer Peter Jaret draws Rudman out on how collaborative research organizations are changing their R&D strategies and business approaches to address today's market imperatives.

LANE ENKELIS

Peter Jaret: Many of the nation's largest collaborative organizations, including EPRI, were established under business conditions very different from today's. How will that affect the future of consortia?

Ric Rudman: The most important change, of course, is that many of the industries originally served by collaborative R&D consortia—telecommunications, gas, electricity, and so forth—are moving from regulated markets to wide-open competition. Along with that, members are seeing intensifying global competition in virtually every major industry. Motorola, for instance, expects that as much as 95% of its business will be overseas by the end of the next decade.

But the marketplace is changing in other, more subtle ways too. As the speed of technological development accelerates, we're seeing an ever-decreasing cycle time in terms of the introduction of new products. To be successful, companies must introduce new products that target narrower market segments. And there's enormous competition in terms of cost. It's not enough to introduce something newer and better; it also has to be lower in price. That's putting tremendous pressure on the companies we serve, as well as their customers down the line: first to cut costs and second to move quickly to seize new opportunities. Those are all realities that consortia must recognize and adapt to if we are to continue to provide value.

Has the prevailing view of R&D changed?

There's still a strong belief that R&D is critical to progress and economic success. But the structure of R&D has changed substantially. As recently as 15 years ago, it was accepted that manufacturers would concentrate on research that was 1 to 5 years out. Most collaborative R&D organizations focused on projects with a horizon of 5 to 10 years. The federal government took responsibility for funding the

longer-term work—the really exploratory, high-risk research.

That's rapidly changing. Under cost pressures of their own, many major manufacturers have been forced to reduce or eliminate their R&D programs. By one estimate, spending on industrial R&D in constant 1987 dollars has dropped about 6% from 1991 to 1995. At the same time, the federal government, also to cut costs, is substantially downsizing its commitment to R&D. The American Academy for the Advancement of Science recently said that the government pullback represents the deepest across-the-board reduction in funding for research and development in the post-World War II era. That means a much bigger responsibility falls to consortia. Increasingly, we're being left to fill the gaps as other major R&D players withdraw.

The demands of the companies consortia serve are also changing. As competition intensifies, many companies have shorter and shorter payback expectations. They don't want to hear what we might have to offer in five years. They want to know how we can help them compete right now. In America's telecommunications industry, for instance, R&D has shifted from its traditional focus on long-term research to short-term, bottom-line solutions. And the same thing is happening in Europe. British Telecom, for instance, now focuses about 80% of its R&D on short- and medium-term research and only 20% on long-term work.

Even Microsoft, which boasts a new basic research center, still spends an estimated 99% of its $2 billion R&D budget on updating existing software and on testing. Given increasing competition, that's understandable, but it's not always consistent with the time frame for most R&D, which typically looks at mid-term and long-term horizons. So it's become a real stress point.

Some analysts have argued that competition and cooperation are inherently at odds with each other. Does collaborative R&D have a role in a highly competitive market?

Absolutely. And I think many consortia are proving that, even in the most highly competitive markets. The myth that collaboration and competition can't coexist is a view typically held most strongly in regulated industries that are about to become unregulated. But if you look at industries where competition is very robust, you see many examples of productive collaboration. Consider the race to develop flat-panel displays—one of the most competitive areas you can find, and we're talking about competition on a global scale. Companies who are in the middle of this race have recognized that there are certain things they can achieve more effectively on a collaborative basis through the U.S. Display Consortium. Once the framework for the new technologies is built through cooperation, competitors are then free to use their own strategies to win market share.

We've seen the same thing happen in the intensely competitive market for advanced photographic systems. A handful of major, fiercely competitive companies—Kodak, Fuji, Nikon, Canon, and Minolta—agreed to an unprecedented collaboration. The goal was to develop a brand-new generation of photographic systems that would jump-start a fresh round of interest and growth in the industry. It's too early to tell how this new technology platform will do in the marketplace, but the collaborative development work went very well, and all five companies are now selling new, platform-compliant products.

Faced with international competition, a growing number of countries are recognizing that collaboration can spur national competitiveness. In Europe there's Eureka, for instance—a collaborative R&D program whose aim is to create strategic partnerships between its 24 member nations. In France, CNET—the research arm of state-owned France Telecom—has been forging international alliances with other telecommunications research centers, including Italy's CSELT, Japan's IT Labs, and British Telecom Labs. Canada's National Research Council has created the Industrial Research Assistance Program, which promotes collaboration between small manufacturers and scientific and engineering experts in government labs, universities, and research centers. The goal is to help small manufacturers with limited resources take advan-

The point is that collaboration represents a cooperative strategy for competing more effectively. Collaborative R&D broadens the playing field. Individual companies will compete fiercely in the marketplace to determine how markets are divided up, but collaborative R&D increases the size of the pie for everyone by creating new opportunities.

tage of collaborative R&D in order to become more competitive.

In the end, I think, we'll find that competition actually opens up new opportunities for collaboration. As with the photo industry project I spoke of, collaboration can build fundamentally new options that individual businesses can then take and customize in ways that create unique competitive advantage. Having the basic research done collaboratively can give companies a real head start over others that try to do all the early work from scratch.

What opportunities lie ahead?

There are still the traditional benefits of collaborative R&D. Spreading risks, pooling resources, leveraging R&D funds, shortening production cycles, and speeding innovation—all of these become even more valuable when companies are under pressure to innovate and still keep costs down. Collaboration allows you to participate in a much broader variety of R&D initiatives than going it alone would allow. And it gives you access to experts no single player could afford to support.

But that's old news. What's exciting is the prospect of new opportunities. In many industries, cost pressures are forcing companies to downsize—to eliminate business areas in order to concentrate on what they do best. That opens up opportunities for consortia to provide many services once performed in-house, whether it's troubleshooting, laboratory research, or technology demonstrations. The technical and consulting services that consortia can offer will become an increasingly needed option.

In addition to the loss of actual manpower, downsizing means the loss of a tremendous storehouse of corporate knowledge that has grown over the years within organizations. Ten years ago, utilities had large engineering staffs, and they were very stable. People tended to remain with the company for 10, 15, 20 years and represented an enormous repository of knowledge and experience—a network of expertise that companies could draw on whenever necessary. With downsizing, knowledge and expertise at the company level are being lost. That means consortia are becoming the principal repositories not just of expertise but of long-term experience in the fields we represent. When members have questions or need technical information and can no longer turn to in-house resources, collaborative organizations will be able to provide it—especially operational know-how. One of our unique strengths, in fact, is the ability to deliver knowledge—not just information, but real knowledge and insight. Especially in industries where technical innovation is crucial to growth, the real source of wealth isn't labor or financial capital, it's knowledge.

To be successful in a world of global competition, companies must participate in the world trade of ideas. And today that's a tough challenge. It's said that the volume of knowledge is doubling about every seven years—particularly in technical fields. Half of what students learn in their first year of college is obsolete by the time they graduate. One of the important strengths of a consortium is the ability to advance and share the kinds of knowledge that further the competitive enterprise. We're really in the business of knowledge innovation, as some analysts have put it—the nurturing and development of new ideas that create new markets, new opportunities, new arenas for expanding competitive options. That represents an enormous opportunity for collaborative R&D organizations.

Will the focus of collaborative R&D change?

It already has. Collaborative R&D is narrowing its focus to what are being called generic or enabling technologies—core concepts (like superconductivity and power electronics) that will create numerous new opportunities for products and services. We're also focusing on infratechnologies—fundamental advances in entire processes that pave the way for competitive development. New high-temperature materials and advanced sensor technologies are good examples. The point is that collaboration represents a cooperative strategy for competing more effectively. Collaborative R&D broadens the playing field. Individual companies will compete fiercely in the marketplace to determine how markets are divided up, but collaborative R&D increases the size of the pie for everyone by creating new opportunities.

Another change we're seeing in almost all consortia is a blurring of industry lines. The telecommunications, computer, and electric power industries, for instance, were once wholly separate; now they're beginning to merge in ways few of us would have imagined 20 years ago. For consortia, that means the R&D we conduct is becoming increasingly multidisciplinary. A good example in our own industry is global climate, a crucial issue facing electric power providers. To understand the science and produce significant research results requires expertise in fields as diverse as biology, atmospheric chemistry, meteorology, ecosystem response, power plant opera-

Collaborative R&D has a built-in technology-scanning component. Since you're able to monitor innovations in a great number of fields, you're more likely to recognize the synergies and combinational opportunities that lead to new applications and technologies.

tions, and advanced computer modeling. It's very difficult for an individual company to manage such a range of R&D. A collaborative organization is set up to do just that.

It's instructive to remember the recent report by the congressional Office of Technology Assessment that called for international partnerships for large science projects. The report admitted that without international consortia, some of the largest scientific projects simply couldn't be accomplished. But you don't have to look only at vast undertakings like the space program or global environment research. Lately, in fact, people have begun to talk about technology fusion—the idea that the big breakthroughs of the future aren't necessarily going to result from incremental advances in individual technologies so much as from the fusion of different technologies, some of which have been around for quite a while. This innovative combination and application of advanced capabilities can create wholly new results and open up new markets.

Look at fuel cells. Here's a technology that was developed as a long-lived replacement for batteries in orbiting spacecraft. Now we're adapting it for use by the electric power industry, where it is opening up new ways of generating and distributing electricity. Advanced imaging technologies developed for use in space—another NASA contribution—are now being used to locate oil reserves underground. And, of course, the Internet is a fusion of telecommunications and computer technologies that is already beginning to fundamentally change how things are done across a broad range of societal and business activities.

Technology fusion turns out to be something that a collaborative organization can do very effectively. For one thing, collaboration allows members to broaden their view, to interact with all sorts of players, and to synthesize very different perspectives. This can lead to ideas and ways of doing things that are much more powerful than any one company can come up with. Further, collaborative R&D has a built-in technology-scanning component. Since you're able to monitor innovations in a great number of fields, you're more likely to recognize the synergies and combinational opportunities that lead to new applications and technologies. And to the degree that you can anticipate where technology is going and then build your company strategy around that, you're in a much stronger position.

Will technology road maps become increasingly important?

They've always been important, of course. Motorola planted the seeds in its strategic planning efforts 25 years ago, during a time when the electronics industry was being transformed by the introduction of innovative technologies. Eventually Motorola's pioneering vision led to the creation of an industrywide road map for the semiconductor industry. The Semiconductor Industry Association currently has a road map that covers eight major areas of chip manufacture.

EPRI is working right now on the creation of a national electricity R&D road map that would lay out the essential energy, economic, and environmental needs to be addressed by R&D and would identify fundamental gaps in knowledge. The point here is that consortia are well positioned to take on the role of providing exactly this sort of long-term integrating vision, as well as organizing R&D efficiently and effectively.

Will the blurring of industry lines affect how consortia define their membership and their mission?

Almost certainly. Consider the way EPRI has evolved. The electric power marketplace has become extraordinarily turbulent, changing faster than any of us anticipated. As a consequence, we've had to define the industry we serve in progressively broader terms. Initially, EPRI served a very clearly defined set of players—the traditional, regulated electric utilities. Now, with deregulation and industry restructuring in motion, we're broadening that group to include the new players in the electricity industry, such as independent power producers and energy service companies. Other consortia are undergoing similar changes. In most cases, the marketplace is expanding rather than shrinking in terms of potential customers.

One of the toughest practical problems we face is finding ways to relate to very different kinds of members. The trick is to retain an effective research focus while broadening your sphere of influence. It's an important advantage to have broad support and representation across an industry; but the broader the membership base, the harder it becomes to identify research that everyone can collaborate in and derive value from. In addition, there's the matter of pricing our services. When a consortium represents many different kinds of customers, it becomes more difficult to find a rational formula for charging for what we offer. In terms of the R&D itself, the broader the membership, the wider the range of disciplines the members encompass. So

The trick is to retain an effective research focus while broadening your sphere of influence. The broader the membership base, the harder it becomes to identify research that everyone can collaborate in and derive value from.

that's going to mean retooling in some cases to ensure that our expertise matches our customers' needs.

But those are practical problems. The real issue we're grappling with is finding a balance between the need to provide immediate benefits to help members compete and the traditional work of collaborative view of where the industry is headed and how science and technology will lead us there. You get into trouble if you adopt the approach of "Trust us, guys, there's a lot of interesting stuff out there; we're going to go out and explore, and we'll let you know when we find something." That doesn't work in today's economic environment.

Consortia across the board are struggling to find ways of sustaining long-term, strategic work, because it is the seed corn for the future. If you lose that, you lose the future.

track program I described is part of the answer. To be really successful in delivering the value of R&D, however, we're also going to have to forge a new kind of relationship with our customers. The challenge is to be customer sensitive—to understand what our customers need right now and to find effective ways to meet those needs—organizations, which is mid- to long-term R&D. That kind of R&D is not only what we do best, it's where the real payoff is going to be. Consortia across the board are struggling to find ways of sustaining long-term, strategic work, because it is the seed corn for the future. If you lose that, you lose the future. I mentioned the turbulence of markets. If markets become too turbulent, then companies are likely to become entirely focused on near-term issues. They may recognize the value of longer-term R&D, but they're going to say, "Sure, if I'm still around in a few years to compete, we'll talk about it. But right now, I'm just trying to survive."

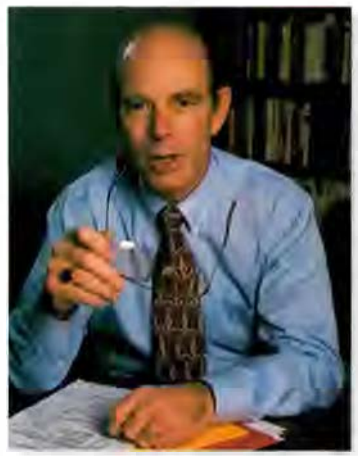
Another obstacle is the fact that in many companies, decision making is being done further and further down in the organization. When that happens, issues shift from strategic to technical, from long term to shorter term, from planning for the future to surviving in today's marketplace. Those are all perspectives that take you away from solid long-term R&D investments.

How can consortia adapt to these new imperatives?

The first step is to recognize that time frames shouldn't be an either-or decision. Certainly we must provide near-term value, working with members to help them compete today. At the same time, we must always remember that the greater part of our contribution will be in longer-term work. We've got to become better communicators of the value of the collaborative program as a whole, to find ways to sell a vision of the future that people can get excited about. We've got to have a strategic

What's emerging in many consortia is a dual-track program. On one track, you've got the longer-term research—the kind of work that will lead to brand-new products and brand-new markets. On the other, you've got the smaller, near-term results that produce immediate value. Fortunately, the two sometimes go hand in hand. Probably the best example from our industry is the development of FACTS, or Flexible AC Transmission System, technologies. Everybody agreed at the outset that it would take 10 years to achieve the vision we had of a brand-new power delivery system. But the continuous stream of technologies coming out of that effort are assuming more and more importance today, as highly unregulated markets emerge and our members have to find new and more precise ways to control transmission lines. So in that case, a long-term vision has provided intermediate-term value. It's also a good example of why we need an even greater emphasis on solid technology transfer in order to turn R&D into real value for our members.

But it doesn't always work that way. Consider research on superconductivity. We're talking about an extraordinary payoff when we get there, but it's going to take a while even to get to the point where you have significant niche markets. So how do we sustain that kind of R&D? The dual-



but at the same time not become entirely customer led. If we focus only on the problem of the week, we're in danger of losing one of the key values we offer, which is leadership. In the end, what members really look to us for is leadership, and it's crucial that we don't give that up.

How have membership policies been affected by competition?

We're all looking for ways to add greater flexibility, to combine a shared program of research with initiatives tailored to the needs of a small group of members—or in some cases, even a single member. The new model that's emerging looks like a pyramid. The base represents the research that everybody funds and whose results are shared by all. And on top of that you've got the layers that represent varying degrees of customized research and development. At EPRI, of course, we've been offering tailored collaboration for years. Now we're expanding the program to include sponsored research, whereby a member can contract for EPRI's project management services for a proprietary research project that the member fully funds.

The same layering is emerging at many other consortia. There's the traditional broad collaborative effort, in which many members fund a particular area and share in the results. Then there are arrangements in which members fund an area jointly and

In the past, many consortia operated like universities. Now we're modeling ourselves after for-profit businesses. That means a sharper focus on corporate accountability, where even long-term research must be tied to specific strategic goals.

individual members follow up with research of their own to shape the results to their specific needs. Finally, we're seeing the emergence of miniconsortia—small groups of companies getting together to fund something very specific, such as an individual product.

What about issues like control of intellectual property and licensing arrangements?

The whole ball game is changing. Let me offer just one example. Historically, utilities took the results of collaborative R&D and applied them to their own systems. Now, as the industry deregulates, members are setting up unregulated subsidiaries. An engineering group may be spun off, for instance, so that it not only can serve the parent utility's needs but also can compete for business from other companies. Suddenly that shifts the intellectual property from an internal-use-only basis to a situation where the results of collaborative R&D may end up being used for commercial purposes.

This is why consortia, across the board, are exploring new options for ownership and licensing arrangements. In general, the formula is simple: the more you customize, the more control you have over the results. But there may be different ways to carry that out. With EPRI's tailored collaboration program, for instance, investing members are granted exclusive rights to use the results for three years; then the results become available to all the members funding a particular business area. In effect, we're giving the primary investors a three-year lead time to use the results of research competitively.

The challenge is complexity. It becomes enormously more difficult to manage projects that involve many different arrangements. There are just that many more administrative issues to be juggled. But many of the same technological advances that are driving deregulation and the emergence of global markets will help us—especially electronic information and communications technologies.

Conventional ways of holding meetings and conferences seem cumbersome compared with video teleconferencing and online discussion forums. In the area of results delivery, there's a growing demand for customized information packaging that is not well served by standard report publishing. So EPRI and many other consortia are creating electronic databases and using Internet resources to provide customized information and expertise quickly and easily. In terms of actual products, we're developing analysis software and other electronic tools that can be downloaded from the Internet directly for use by authorized users. These approaches can help us remain flexible and responsive—and not just in delivering results. Even on the strategic end, consortia are exploring ways to use new information technologies to communicate their own strategic planning to industry leaders.

How do today's consortia view the future?

With high hopes, certainly, but with a keener sense of business realities. To survive and to continue to serve our members effectively, I think we all understand that we must become more businesslike in the way we operate. Here again the model is changing. In the past, many consortia operated like universities. Now we're modeling ourselves after for-profit businesses. That means a sharper focus on corporate accountability, where even long-term research must be tied to specific strategic goals. That's all to the good. I think there's a growing awareness that, if we can sustain a vision of long-term collaborative R&D and what it has to offer, the discipline of today's economic realities will help us provide even greater value. ■

The Council of Consortia

The Council of Consortia is an organization of senior executives from the nation's leading research and development and applied technology development consortia. The council's mission is to sustain the vitality of collaborative technology development, transfer, and application as a means of maintaining and advancing North American competitiveness in key industries. Members of the council are listed below.

- American Water Works Association Research Foundation
- Electric Power Research Institute
- Gas Research Institute
- Great Lakes Composites Consortium
- MCNC (formerly Microelectronics Center of North Carolina)
- Microelectronics and Computer Technology Corporation
- National Center for Manufacturing Sciences
- National Storage Industry Consortium
- Ohio Aerospace Institute
- SEMATECH
- Semiconductor Research Corporation
- Software Engineering Institute
- Software Productivity Consortium
- USCAR
- U.S. Display Consortium
- Water Environment Research Foundation

CONTRIBUTORS

Technical sources for Journal feature articles

DRENKER

CAIN

RUDMAN

At Home With Telecommunications (page 6) was written by Leslie Lamarre, *Journal* senior feature writer, with assistance from two members of EPRI's Customer Systems Group.

Steve Drenker manages the Information Systems & Telecommunications Business Unit, established in 1996 to develop advanced technology to support two-way communications between electric utility companies and their customers. Before launching this new business unit, Drenker directed the Power Quality & Information Technology Business Unit. Earlier at EPRI, he managed advanced fossil power plant technology development that led to the successful commercialization of fluidized-bed combustion. Drenker came to EPRI in 1978. Earlier, at Babcock & Wilcox Company, he held startup and troubleshooting responsibilities for fossil power plants worldwide. He received a BS degree in mechanical engineering from the University of Missouri and an MBA from the University of Santa Clara.

David Cain, manager of new business development in the Information Systems & Telecommunications Business Unit, is responsible for the unit's program design. He joined EPRI in 1974 as a project manager in the Safety Technology Program of the Nuclear Power Division. In 1989, Cain assumed responsibility for managing an EPRI-wide initiative to develop a new line of software products, and later he organized and managed EPRI's Computing Products Center. Cain was instrumental in early work on artificial intelligence products and applications at the Institute. His previous experience includes four years with Westinghouse's Naval Reactors Program. He has a BS in electrical engineering from the University of California at Berkeley and MS and PhD degrees in the same field from the University of Washington. ■

Challenge and Change in Collaborative Research (page 26) is an interview with **Ric Rudman,** EPRI senior vice president and chief operating officer. One of the Institute's first employees, Rudman came to EPRI in 1973 as assistant to the president. Serving in a series of increasingly responsible positions, he was named vice president for the Industry Relations and Information Services Group in 1983. Rudman left EPRI in 1986 to become president and chief operating officer of Aster Publishing, a publisher of eight scientific and business trade magazines, but returned in 1989 as the Institute's senior vice president for corporate services. In addition to substantial contributions to EPRI's technology transfer and information technology efforts, he was the chief architect of its Tailored Collaboration and Progressive Flexibility programs. He has held his current position as COO since August 1996. In 1995, Rudman was elected chair of the Council of Consortia, an organization of chief executives and senior officers from the nation's leading research and development and applied technology development consortia. He holds BS and MS degrees in nuclear engineering from the University of California at Los Angeles. ■

Taxable Subsidiaries Initiative Launched

With the start of a new year, EPRI has established its first wholly owned taxable subsidiary under an initiative to expand member business opportunities. In addition to yielding greater value to members from the intellectual property developed in R&D targets they fund, such subsidiaries will provide members with access to a broader range of technical and consulting services and will give them the opportunity to realize a direct financial return on target results through participation in technology commercialization ventures.

The formation of the first taxable subsidiary—epriCSG—followed the approval of management's recommendations by the Board of Directors at its December meeting. Clearing the way for this action was a favorable private-letter ruling from the Internal Revenue Service in November. The ruling confirmed that the new company can be operated and managed independently from EPRI, thereby preserving the Institute's own nonprofit, tax-exempt status.

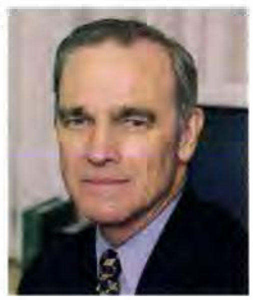

GELLINGS

The new subsidiary will officially open its doors in February under the direction of Clark Gellings, who will have a dual role as the chief executive officer of epriCSG and the vice president in charge of EPRI's Customer Systems Group. Michael Evans, formerly the manager of business operations of the Customer Systems Group, will serve as epriCSG's chief operating officer. Evans says epriCSG will launch a few new market-driven R&D targets this year and will evaluate existing Customer Systems Group targets for possible transfer to the subsidiary in 1998 as part of EPRI's annual membership offering.

"In a more dynamic industry environment, EPRI needs an organizational structure and business processes that allow it to meet the technology needs of an increasingly competitive electric power industry while continuing to conduct R&D in the public interest," says Kurt Yeager, EPRI's president and chief executive officer. The Taxable Subsidiaries Initiative is an important part of EPRI's overall corporate strategy and complements the Progressive Flexibility membership policy, introduced in 1995, which allows members to focus their membership funding on specific areas of research that best meet their changing business requirements.

EPRI's historical scientific research mission will endure, Yeager adds. "EPRI remains firmly committed to the goals and ideals on which the organization was founded and to preserving its status as a nonprofit, tax-exempt organization. The concept of taxable subsidiaries has been carefully crafted to build on the strengths of a cohesive, strategically integrated EPRI and to create an organization whose value is much greater than the sum of its parts."

In addition to the increased value that is expected to be created for members from their R&D investments, segregating the research activities of the tax-exempt parent and the taxable subsidiaries enhances the value of EPRI's overall program by offering an expanded range of technical services and by broadening its appeal to prospective members. Taxable subsidiaries also help to protect the Institute's tax-exempt status because activities that appear likely to generate unrelated business income or that are overly "commercial" can be transferred to and performed in the subsidiaries.


EVANS

The Customer Systems Group Council and each of the group's business unit councils endorsed the epriCSG subsidiary plan and advised management on implementation issues. With input from the business unit councils, the management of the Customer Systems Group has identified 10 of the group's 46 targets as potential candidates for transfer to epriCSG. Many of these targets are planned for transfer in 1998, pending further discussion with the advisory committees in February 1997; three may be added the following year.

As implementation proceeds, epriCSG will be developing opportunities to better utilize technical staff and expertise to address growing demands for technical services and customized applications work. With the support of its funders, epriCSG will also create second-tier affiliates and/or joint ventures to commercialize technology and expertise developed in the subsidiary.

EPRI management expects to consider the formation of additional taxable subsidiaries this year and beyond, using the guidelines and experience of epriCSG as a model, although specific business activities may vary. Each of the five EPRI business groups can sponsor one wholly owned taxable subsidiary, but it is unlikely that all will do so, given the varying needs of industry members.

Progressive Flexibility: Future Directions

With the record level of industry participation in EPRI suggesting that the current target level of bundling under Progressive Flexibility is effective, further development of EPRI's membership offering is focused on extending eligibility, facilitating the commercial use of results, and revising policies on access to programs and results. These are the key principles reflected in the membership policy changes developed by management with input from the Board of Directors and approved by the Board in December. The policy changes, which will be implemented in 1997 and 1998, are designed to enable EPRI to more effectively address a restructuring utility industry.

Essentially, the changes expand EPRI membership to all players in the electricity industry (i.e., organizations involved in electricity generation, delivery, and sale and related services); make it possible for EPRI to engage multiple components of a disaggregated utility; allow commercial use of certain EPRI products by domestic members; and set new entry and exit policies to protect members' prior R&D investments.

Beginning in 1997, all organizations involved in the electricity enterprise that are interested in supporting collaborative development of science and technology will be eligible for membership in EPRI. Offerings will be extended in the categories of regulated U.S. public utilities (including investor-owned, federal, public power, and rural cooperative utilities, as well as nuclear plant licensees, independent system operators, power exchanges, and transmission companies), unregulated entities (including affiliated and independent power producers, energy service companies, engineering service firms, and others), and international organizations.

In addition, to address the disaggregation of a formerly vertically integrated industry, EPRI will offer a Corporate Membership option, covering a regulated utility together with its unregulated electricity-related affiliates and subsidiaries that are at least 50% owned by the same parent or holding company.

To recognize breadth, depth, and length of membership participation, a Sustaining Member level will provide discounted target pricing, preferred advisory rights, and priority consideration for nomination to serve on the Board of Directors. Sustaining Members are defined as those utilities or other eligible entities that fund more than 60% of the current EPRI program, that participate in at least three business groups, and that have been EPRI members for the previous two years. Other changes in membership policy provide for publicly funded governmental organizations—such as agencies that manage or collect funding from utility customers for electricity R&D—to participate as members of EPRI.

An Associate/Subscription Program, previously approved by the Board in 1995, will be introduced in 1997 to provide access to certain past R&D results through a subscription package with limited technology transfer or other support services from EPRI or EPRI technology centers. The program is aimed at helping to build relationships with new electricity industry players that are eligible for membership but initially do not choose to fund one or more targets for technology development. Associates would not have certain membership rights, such as the right to participate in EPRI governance or advisory structures.

Another new membership-related policy allows for royalty-free commercial use of certain EPRI products in the United States by domestic members except when precluded by preexisting license or commercialization agreements or when such use is not in the best interest of EPRI or its members. Commercial use includes the use of EPRI software and licensable reports by a member to conduct consulting services for a customer or client. Such use by domestic members in foreign countries would be permitted under a negotiated license with EPRI, and commercial use by international members would be reviewed on a case-by-case basis.

Board-approved changes to rules on past product access are intended to protect members' prior research investments and to preserve EPRI's focus on collaborative R&D. In the past, members that were funding a target were allowed unrestricted access to all past products of the target at no additional cost. In the future, an organization that previously had access to a specific product as a result of prior member status in the relevant target or business unit maintains access as long as it is a current member of some portion of the EPRI program.

Otherwise, members will have full access to past products of a target at no extra charge if the member either has funded that target for three consecutive years (including the current year) or, in the case of a new member, commits to three consecutive years of funding. Members that did not fund a prior target may obtain, for an additional fee, access or license options to specific products designated by the relevant EPRI business groups.

Colorado Cooperative Pioneers Low-Cost Satellite Ground Station

Mountain View Electric Association (MVEA), a rural electric cooperative that serves about 23,000 customers in a 5000-square-mile area of eastern Colorado, is the first electric utility to perform substation and meter monitoring with a satellite-based data system featuring low-cost, modified ground stations. In addition to allowing MVEA to remotely control its substations and monitor customers' meters, the new satellite network enables the operation of a direct load-control program that helps minimize the need for purchased power. The low-cost ground station technology was developed through collaborative research by EPRI and the National Rural Electric Cooperative Association (NRECA).

Traditionally, MVEA technicians monitored substations and responded to operating problems by traveling to the sites. When in 1993 the cooperative considered ways to upgrade its operations, satellite communications incorporating very small aperture terminals (VSATs) appeared to be the most feasible option for a supervisory control and data acquisition system to link MVEA's headquarters, operations center, and substations. Yet the cost was considered too high.

EPRI and NRECA had been working with Nova-Net Communications (now an ICG Wireless Services company) to develop improved satellite technology for utilities. Key goals for the technology were compliance with EPRI-developed Utility Communications Architecture protocols and suitability for outdoor installation at costs lower than those of conventional technology. By the time MVEA became interested in acquiring a satellite system, the project had led to a new Nova-Net product called SCADA-SAT, a small (1.2-meter dish), environmentally rugged, Ku-band VSAT system. SCADA-SAT features a satellite transceiver from GTE Spacenet and a special outdoor enclosure, and it has the flexibility to operate on ac or dc power. It met the cooperative's data-speed requirements and offered significantly lower capital and operating costs than early-generation VSAT systems.

In operation all last year, MVEA's SCADA-SAT system includes 12 VSAT installations at 11 substations and the operations center. Spread-spectrum radio links other substations to the headquarters and the operations center; a dedicated telephone line connects the operations center to the headquarters. MVEA expects 10-year savings of over $326,000 on its initial investment, compared with the cost of a conventional satellite system. In addition, significant operating cost savings are expected to accrue through the use of the system for automated meter reading, distribution automation, and remote load monitoring and control.

■ *For more information, contact William Blair at EPRI, (415) 855-2173, or John Rowe at ICG Nova-Net, (303) 705-6900.*

SAM Raises Value of PECO's Distribution Assets

At PECO Energy, the electric utility that serves Philadelphia, distribution system planners are responsible for evaluating projects to improve the performance of an urban infrastructure that is, in part, 70 years old. Traditionally, funding decisions for system upgrades have been based on conventional engineering and reliability standards. While meeting such standards is important for system performance, an exclusive focus on engineering fixes can sometimes cause planners to overlook solutions that might result in a better use of resources. Seeking a screening method that would clarify how distribution assets create value for the company and would help identify projects offering the maximum return on shareholder investment, PECO turned to EPRI's Strategic Asset Management (SAM) decision framework methodology.

Last year, planners at PECO began applying SAM to the allocation of funding for day-to-day system improvements and future additions. The approach identified four key ways of getting more value from distribution assets: investing in the system to save future capital and operating and maintenance costs, sizing investments in proportion to problems, reducing the number of costly events on the system, and improving service to various customers. With these criteria, planners evaluated projects involving substation retirement, voltage-level conversion, maintenance issues, and customer power quality problems. By quantifying benefits, SAM enabled a more accurate comparison of the possible options.

Results from the project analyses showed that replacing distribution assets to meet conventional engineering standards would create little shareholder value. In contrast, programs involving simplification and monitoring of the distribution system were found to create significant value. SAM's documentation provided PECO management a clear record of how savings could be expected to accrue.

The application of SAM in the evaluation of about 100 distribution system O&M and capital improvement alternatives enabled PECO to reduce the expected cost of a portfolio of projects from a net present value of $180 million to $85 million. "SAM forces us to ask the hard questions and to design distribution system improvement projects that return the greatest value for the money spent," says PECO Energy's Don Fagnan.

EPRI has published a product brief (PS-106524) and a technical report (TR-102730) on SAM. These are available from the Distribution Center, (510) 934-4212.

■ *For more information, contact Charles Clark, (415) 855-2994.*

UCA Demonstrates Real-Time Advantage

Utilities can save time and money as well as enhance reliability for customers with real-time data provided through EPRI's Utility Communications Architecture (UCA), recently demonstrated at United Power Association (UPA), a rural electric cooperative headquartered in Elk River, Minnesota.

EPRI and the National Rural Electric Cooperative Association (NRECA) sponsored the project with UPA to increase interoperability between substation and distribution line equipment, communications systems, databases, and applications. UCA—a communications specification for connectivity and data transmission within a utility and with its customers—allows equipment from multiple vendors to work together via common communications media without customized hardware and software. Multiple-user stations at different locations can access real-time data for monitoring, control, and analysis.

"With UCA, utility personnel can use local PC applications for easy, immediate data access across the entire network, which enables operational decisions to be made better and faster," says Wade Malcolm, director of EPRI's distribution business area. "Utilities could reduce the number and duration of outages a customer experiences."

Two substations of UPA members—the rural Ball Club substation of Dairyland Electric Cooperative and the urban Plymouth substation of Wright-Hennepin Cooperative Electric Association—were chosen for the seven-layer UCA profile demonstration with more than a dozen vendors. Multiple communications networks integrated the equipment, controls, and databases in the automation project.

"Our project has helped define new protocols included in the soon-to-be-released UCA 2.0 upgrade," says Jim Goodin, UPA's project manager. "We've added more real-time functionality and data security to address the needs of UPA member cooperatives and the electric utility industry during this time of growing competitiveness. UCA is real. It's here and available in commercial products. UCA is even more relevant in a deregulated, competitive environment because it allows encrypted data to pass securely and quickly between utility networks."

In a related EPRI- and NRECA-sponsored demonstration at Oglethorpe Power Corporation in Georgia, a three-layer UCA profile was used to integrate a supervisory control and data acquisition system and various models of remote terminal units.

"Widespread use of UCA among vendors and implementation by electric utilities could reduce costs by 20%," says Martin Gordon, a senior program manager in energy R&D at NRECA. "Automation with UCA also helps utilities increase the communication capacity of their existing systems without compromising reliability."

■ *For more information, contact EPRI's UCA Exchange office at (800) UCA-EXCH (822-3924).*

Residential Technologies and Retail Market Tools

Horizontal-Axis Washing Machines

by John Kesselring and Richard Gillman, Customer Systems Group

ABSTRACT *Residential horizontal-axis washing machines use significantly less energy and water than the vertical-axis clothes washers that dominate the American market. In a project on high-efficiency residential laundry equipment, EPRI, the U.S. Department of Energy, and several utilities have explored the possibility of transforming the U.S. washing machine market. Project activities have ranged from laboratory testing, multifaceted market research, and the analysis of washer distribution channels to the operation of a demonstration center and the in-home monitoring of washer performance. They have helped identify possible barriers to the penetration of the residential market by horizontal-axis washing machines and have pointed to ways in which utilities can overcome those barriers. Utility activities to transform the market could give sales of horizontal-axis washers an important boost before the anticipated raising of federal efficiency standards for clothes washers.*

As wholesale and retail markets for electricity become more competitive, many utilities are focusing on enhancing customer options, often by providing new products and services or by offering rebates and other incentives for the use of commercially available energy-efficient products. Traditionally, electric utilities have not conducted much market research before introducing special offerings. Market barriers often were identified only after significant expenditures had been made in support of such offerings. In today's business environment, however, utilities must identify potential market barriers to new offerings and determine how to deal with those barriers before making a commitment to move forward with any new offerings.

EPRI launched the High-Efficiency Laundry Metering and Marketing Analysis, or THELMA, project as a direct result of increased electric utility interest in supporting the use of efficient residential laundry equipment—an interest shared by water, wastewater-processing, and gas utilities. One focus of this interest is the horizontal-axis (H-axis), or tumble-action, washing machine. H-axis washers are significantly more efficient than vertical-axis (V-axis) washers and thus could help utilities manage load growth and seasonal load levels while helping consumers lower their energy and water bills. H-axis machines dominate European markets, but V-axis machines account for over 98% of residential clothes washer sales in the United States and for almost as large a percentage of commercial washer sales. If the U.S. market could be transformed so that H-axis washers were used more widely, energy and water consumption could be reduced significantly and wastewater-processing costs could also be lowered. In fact, future energy efficiency standards set by the U.S. Department of Energy may prove too stringent for V-axis washers and may virtually ensure a market for H-axis machines. Several domestic manufacturers are producing or intend to produce H-axis washers that readily meet existing standards and could satisfy the anticipated more-stringent standards.

V-axis and H-axis washers

In V-axis washers, clothes move around a central agitator and must be fully immersed in water to be washed properly. In H-axis washers, the washtub rotates in alternate directions around a horizontal axis; rather than being fully immersed, the clothes are lifted and tumbled through a shallow pool of water in the bottom of the washtub (Figure 1). H-axis washers are often front-loading; in top-loading H-axis models, users must open more than one door to get to the tub.

In general, H-axis washers reduce water use by at least one-third. And since water heating accounts for up to 90% of the energy used in conventional residential washing machines, the use of H-axis washers is expected to reduce energy consumption by over 50%. Further, the horizontally oriented tub handles unbalanced loads better than V-axis tubs do, so H-axis washers can spin faster, extract more water, and thus save on drying energy. In addition, the tumbling action of H-axis washers gently pushes clothes through the water, reducing wear and tear on the garments.

By switching to an H-axis washer, a typical household would reduce energy, water, and detergent costs by about $80 a year, according to Arthur D. Little, Inc. On the other hand, an H-axis washer requires components—an electronically controlled direct-current motor and a sophisticated suspension system—that add to its cost and may affect its reliability. According to the THELMA project sponsors, tumble-action washers manufactured in the United States will be priced at about $210 more than agitator machines.

THELMA research design

EPRI's collaborative THELMA project involves more than two dozen electric, gas, water, and wastewater management utilities. Aimed at identifying strategies that could transform the U.S. washing machine market, the THELMA research has four primary objectives: to establish credible estimates of energy and water savings associated with the use of H-axis washers, to study customers' laundering habits, to identify potential barriers to the penetration of the residential washer market by H-axis machines, and to design incentive programs and other promotional tools likely to be effective in stimulating the purchase of efficient washers.

To meet those objectives, THELMA researchers conducted laboratory testing and field monitoring of H-axis and V-axis washers, a comprehensive market assessment, and an analysis of washing machine distribution channels. Market assessment efforts included consumer focus group discussions of laundering practices and desirable washer characteristics; a large-scale market survey; the operation of a demonstration site where utility customers could try out an H-axis washer; and in-home interviews with participants in the THELMA field-monitoring study.

These activities were interconnected in a variety of ways. For instance, focus group discussions were held early in the project and provided results that were used to design the market research survey, the in-home interview instruments, and the procedures at the laundry demonstration center. Also, the market survey gathered information on the same demographic and household characteristics that were used in classifying the field-monitoring participants. Thus, for the service areas represented by the survey respondents, it is possible to determine the number of households fitting each segment profile and to estimate their laundry-related energy and water consumption.

Laboratory test results

Early in the project, THELMA researchers conducted laboratory tests on one large-capacity, American-made V-axis machine and on six H-axis machines representing a sample of American- and European-made products. The washers were tested according to the U.S. DOE clothes washer energy test procedure, which specifies methods for measuring machine capacity, water used in wash and rinse cycles, and energy consumed in machine operation and water heating. The researchers also used industry-accepted procedures for testing washer performance in terms of soil removal and gentleness of action.

The test results varied over a considerable range for the seven machines. Normalized for tub volume, the H-axis machines used, on average, about 45% less energy and 25% less water than the V-axis machine. The tests also showed that the H-axis machines were 25% more effective in removing soil. And although complete H-axis cycles were longer, the moisture content remaining after the final spin cycle was lower with the H-axis machines. This could lead to shorter drying cycles and lower drying-related energy costs.

Focus group observations

Focus group discussions revealed consumers' initial views of H-axis washers. Group participants most often associated H-axis washer technology with front-loading machines, and one initial barrier to customer acceptance may be the bending required in machine loading and unloading. Although there are some benefits to front loading (the washer can be stacked with a dryer, for example, or its top can serve as work space), participants regularly raised concerns about bending, leaking, and child safety. In fact, the focus group results suggest that given general consumer satisfaction with current washers, H-axis washers

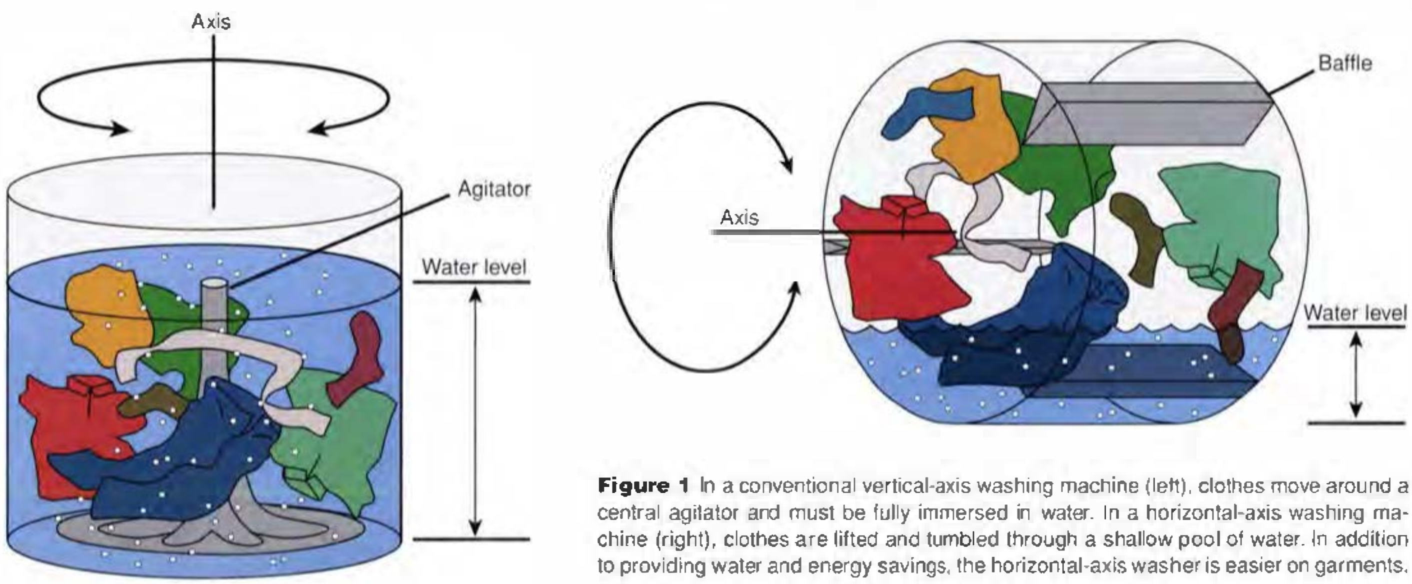
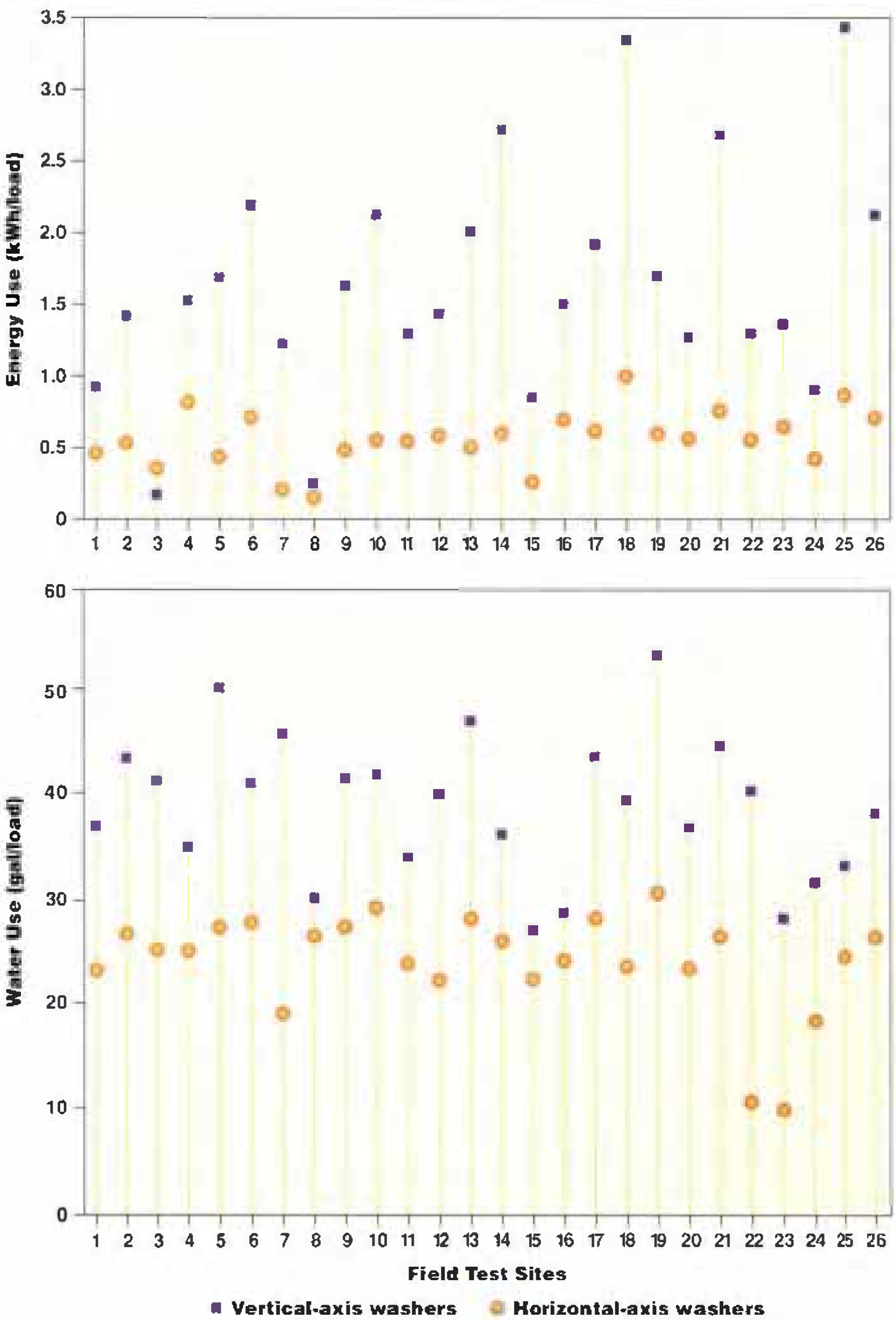


Figure 1 In a conventional vertical-axis washing machine (left), clothes move around a central agitator and must be fully immersed in water. In a horizontal-axis washing machine (right), clothes are lifted and tumbled through a shallow pool of water. In addition to providing water and energy savings, the horizontal-axis washer is easier on garments.

(perceived as unfamiliar and difficult to use) are likely to be compared unfavorably with V-axis washers. However, the results also suggest that if consumers are convinced that H-axis washers are at least as good as their V-axis washers in terms of such features as purchase price, reliability, ease of use, and cleaning ability, they may seriously consider purchasing the equipment. At that point, energy and water savings and improved soil removal could become important selling points.

Further, according to focus group participants, utilities could play a valuable role in building consumers' understanding and acceptance of H-axis washers through educational efforts and financial incentives. It remained unclear, however, whether rebates would be successful without a strong educational component. Participant responses indicate that an effective educational approach should include published product information, product demonstrations, testimonials and other evidence of real-life experience, and endorsements from utilities and other organizations regarded as impartial.

Figure 2 In clothes washer field tests at 26 residences, THELMA researchers measured energy and water use, first for the participants' vertical-axis machines and then for horizontal-axis machines temporarily installed in the homes. (Combined mechanical and water-heating energy consumption was measured.) On average, the horizontal-axis washers used 65% less energy and almost 40% less water.



Finally, a simple name is likely to be essential for successfully marketing H-axis washers. Focus group participants readily understood how the machines operate and found "tumble-action washer" and "tumble washer" appealing names because they point to the key difference between H-axis and V-axis machines, help consumers visualize the washing process, and call to mind the familiar action of clothes dryers.

Distribution system analysis

In 55 telephone interviews with V-axis and H-axis washer manufacturers, distributors, and retail outlet personnel, THELMA researchers examined ways in which these trade allies might influence washer market transformation. Techniques that might hasten market acceptance of tumble-action washers—such as rebates, advertising, education, and distribution channel incentives—were discussed.

The manufacturers expressed few concerns about the actual manufacture of tumble washers, but they did express concern that these machines would cost too much to produce and would not be priced competitively. Twenty-nine of the 50 retailers and distributors interviewed also cited the cost of the machines as a potential market barrier. Moreover, the trade allies interviewed generally felt that consumers would not be willing to pay much more for an energy-efficient machine than for a conventional washer and that a sizable rebate from utilities would be needed to promote tumble washers successfully. Nonetheless, retailers were generally enthusiastic about opportunities for selling these washers. Like manufacturers, they view the market for tumble washers as a growing niche market, expecting it to increase from the current 1–3% of residential sales to 5–20% in five years. They also noted that DOE energy standards could affect the market share for tumble washers, possibly increasing it considerably.

Market survey results

To supplement the focus group results and to begin to assess the potential market for tumble washers, the THELMA team used telephone interviews and mailed forms to conduct an extensive market survey of the general U.S. population and the populations in the service areas of the 12 electric utilities participating in the project. Like the distribution system analysis, the market survey disclosed that the biggest barrier to the purchase of H-axis washers is initial cost.

In the majority of households in the United States, women are more involved than men in shopping for washers and in making the final purchase decisions. It follows that educational efforts on H-axis washers should target women and their interests. According to the survey results, the most important factors in choosing a new washer are price, manufacturer's reputation, and warranty. It was also found that the probability of purchasing an H-axis washer goes down dramatically if the only available model is European-made. Thus, if major domestic manufacturers provide tumble-action washers, a significant barrier will be removed. Overall, the survey data suggest that the market share for tumble-action machines has good growth potential, with certain market segments likely to adopt the technology before the rest of the population.

Field test results

Although laboratory test results are important in quantifying the differences in energy and water consumption between H-axis and V-axis technologies, they may not fully represent the savings in actual households. Therefore, THELMA researchers have measured the actual performance of H-axis and V-axis machines in the residences of strategically selected market survey respondents. First, for six weeks, the researchers monitored the energy and water use of the V-axis washers currently in the participants' homes; then, for eight weeks, they monitored H-axis machines temporarily installed in the homes. The participants also kept laundry diaries during the monitoring period; information from the diaries identifies and quantifies changes in laundering behavior and will be useful in generalizing results to a broader population of users.

Metering data from the 26 homes where testing has been completed indicate that the tumble washers provided average energy savings of 65% (Figure 2). The savings were slightly higher than anticipated, even though for both V-axis and H-axis machines, the participants generally used cooler wash and rinse water than assumed by the DOE test procedure and by projections based on THELMA laboratory results. The tumble washers also reduced water consumption by almost 40%.

By participating in the in-home testing effort, consumers became familiar with H-axis washers. The THELMA project also included a demonstration center where consumers were able to see a front-loading H-axis washer, compare it with a V-axis machine, and actually wash laundry in it. Project personnel expect that because of the hands-on nature of these exposures, the data collected on consumer perceptions of the new washers and the issues affecting purchase decisions will be quite reliable. The responses of visitors to the demonstration center and of the field test participants suggest that exposure to H-axis machines in store displays could dispel doubts about washer design and use and even make people become likely to purchase the machines.

Looking ahead

The THELMA steering committee is expanding the scope of some of the project efforts. For one thing, THELMA researchers will field-test more models of H-axis washers than originally planned, and they may conduct distribution system analyses in more areas of the country.

In any case, once the THELMA research is completed and data from the many project efforts are integrated, the participating utilities will have a baseline picture of the washer market that includes data on distribution channels, availability of H-axis models, distributor stocking patterns, pricing, marketing, and purchase patterns. The project's final report on H-axis washers will also summarize findings on ways in which utilities can influence the washer market; included will be information on the strategic use of rebates, market segments to target, and promotional strategies that could speed the adoption of H-axis washer technology.

In general, as utilities adapt to changes in their business environment, the value of market research results, including information on customers' tastes and preferences, will grow. The THELMA project has already strengthened utility competence in making decisions about the adoption and promotion of new products and technologies and in designing rebate, educational, and other promotional strategies.

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. Two-page summaries of the reports announced here are available, free of charge, by fax. To receive a summary, call EPRI's Fax on Demand service (800-239-4655) from a touch-tone phone and follow the recorded instructions, using the fax identification number given in the report listing.

CUSTOMER SYSTEMS

Electric Motor Model Repair Specifications
TR-105729 Final Report (WO3673)
Contractor: Washington State Energy Office
EPRI Project Manager: B. Banerjee
Fax ID: 26637

Quality Electric Motor Repair: A Guidebook for Electric Utilities
TR-105730 Final Report (WO3673)
Contractor: Washington State Energy Office
EPRI Project Manager: B. Banerjee
Fax ID: 26636

Industrial Motor Repair in the United States: Current Practice and Opportunities for Improving Customer Productivity and Energy Efficiency
TR-105731 Final Report (WO3673)
Contractor: Washington State Energy Office
EPRI Project Manager: B. Banerjee
Fax ID: 26635

Investigation of Chlorine-Free Refrigerants for Low-Temperature Supermarket Refrigeration
TR-106076 Final Report (WO3526-3)
Contractor: Foster-Miller
EPRI Project Manager: M. Khattar
Fax ID: 25253

Analysis and Comparison of Wireless Technologies and Products
TR-106351 Final Report (WO4840)
Contractor: Plexus Research
EPRI Project Manager: R. Skelton
Fax ID: 25748

Proceedings: Heat Pump Technician Training and Certification Workshop (September 1995)
TR-106456 Proceedings (WO3245-13)
Contractor: Policy Research Associates
EPRI Project Manager: T. Statt
Fax ID: 25935

Potential Use and Benefits of Advanced Power Electronics Components in a 1993 Time-Frame Commercial Unitary Heat Pump
TR-106531 Final Report (WO3087-9)
Contractor: McCleer Power
EPRI Project Manager: B. Banerjee
Fax ID: 26037

The Environmental and Energy Benefits of Cordless Electric Lawn Mowers
TR-106559 Final Report (WO3598)
Contractor: Mills, McCarthy & Associates
EPRI Project Manager: G. Purcell
Fax ID: 26087

Profitability Primer: A Guide to Profitability Analysis in the Electric Power Industry
TR-106569 Final Report (WO4837-3)
Contractor: Energy and Environmental Economics
EPRI Project Manager: P. Sioshansi
Fax ID: 26105

Assessment of Issues and Applications in Wireless Communications
TR-106665 Final Report (WO4840)
Contractors: Plexus Research; FIND/SVP; Kaman Sciences Corp.
EPRI Project Manager: R. Skelton
Fax ID: 26286

ENVIRONMENT

Comanagement of a High-Volume Combustion By-Product and Low-Volume Utility Wastes: A Southwestern Site
TR-105673 Final Report (WO2485-9)
Contractor: Radian International
EPRI Project Managers: J. Goodrich-Mahoney, I. Murarka
Fax ID: 24593

Flue Gas Flow Rate Measurement Errors
TR-106698 Interim Report (WO2819-32)
Contractors: Fossil Energy Research Corp.; RMB Consulting and Research
EPRI Project Manager: C. Dene
Fax ID: 26329

GENERATION

Guide for Rewinding and Reconditioning Medium-Voltage Electric Motors
EL-5036-V17 Final Report (WO2308-14)
Contractor: Jarsco Engineering Corp.
EPRI Project Manager: J. Stein

Design, Operation, and Testing of the Fly Ash Carbon Burn-Out Pilot Plant
TR-102429 Final Report (WO3497-1)
Contractor: Progress Materials
EPRI Project Manager: T. Boyd
Fax ID: 07520

Advanced Gas Turbine Guidelines: Vibration Monitoring and Analysis—Durability Surveillance at Potomac Electric Power Co.'s Station H
TR-104100 Final Report (WO3125-2)
Contractor: Fluor Daniel
EPRI Project Managers: W. Plulle, G. Quentin
Fax ID: 21505

Evaluation of Carbon Burn-Out Technology Applied to Rice Hull Ash
TR-106061 Final Report (WO3497-1)
Contractor: Progress Materials
EPRI Project Manager: T. Boyd
Fax ID: 25226

Santa Clara 2-MW Fuel Cell Demonstration Design, Construction, and Permitting Report
TR-106155 Interim Report (WO3377)
Contractor: Fuel Cell Engineering Corp.
EPRI Project Manager: D. Rastler
Fax ID: 25393

Guidelines for Evaluating the Impact of Powder River Basin Coal Blends on Power Plant Performance and Emissions
TR-106340 Final Report (WO3667-1)
Contractor: PSI Energy
EPRI Project Manager: A. Mehta
Fax ID: 25723

Proceedings: 1995 EPRI Fuel Oil Utilization Workshop
TR-106697 Proceedings (WO2778)
Contractor: Carnot
EPRI Project Manager: C. Dene
Fax ID: 26330

Proceedings: Condenser Technology Conference
TR-106781 Proceedings (WO2504)
Contractor: Stone & Webster Engineering Corp.
EPRI Project Manager: J. Tsou
Fax ID: 26676

NUCLEAR POWER

Omega Version 2.2: Rule-Based Deterioration Identification and Management System
TR-103055 Final Report (WO3343-9)
Contractors: Grove Engineering; Polestar Applied Technology; Ishikawajima-Harima Heavy Industries Co.
EPRI Project Managers: J. Carey, M. Lapides
Fax ID: 19703

Monticello Lead Plant License Renewal Project Summary Report
TR-103963 Final Report (WO3075-1)
Contractors: Northern States Power Co.; Multiple Dynamics Corp.; General Electric Co.
EPRI Project Manager: J. Carey
Fax ID: 21283

Evaluation of Cable Polymer Aging Through Indenter Testing of In-Plant and Laboratory-Aged Specimens
TR-104075 Final Report (WO3427-1)
Contractor: Ogden Environmental and Energy Services Co.
EPRI Project Manager: J. Carey
Fax ID: 21469

Instrumentation and Control Upgrade Evaluation Methodology, Vols. 1 and 2
TR-104963-V1-V2 Final Report (WO3373-10, -11)
Contractors: Queue Systems; ABB Combustion Engineering
EPRI Project Manager: D. Wilkinson
Fax ID: 23485

Multivariable Analysis of the Effects of Li, H_2, and pH on PWR Primary Water Stress Corrosion Cracking
TR-105656 Final Report (WO2493-14)
Contractor: Modeling & Computing Services
EPRI Project Manager: R. Pathania
Fax ID: 24566

Improvement of the Stress Corrosion Resistance of Alloy 718 in the PWR Environment
TR-105808 Final Report (WO3154-3)
Contractor: Babcock & Wilcox Co.
EPRI Project Manager: L. Nelson
Fax ID: 24788

Evaluation of Thermal Aging Embrittlement for Cast Austenitic Stainless Steel Components
TR-106092 Final Report (WO2643-33)
Contractors: Applied Science and Technology; Framatome Technologies
EPRI Project Manager: J. Carey
Fax ID: 25285

Technical Considerations Associated With Spent-Fuel Acceptance
TR-106226 Final Report (WO3290-12)
Contractor: Energy Resources International
EPRI Project Managers: R. Lambert, O. Ozer
Fax ID: 25504

IASCC Susceptibility of Low-Fluence Stainless Steels Evaluated by In-Flux Slow Strain Rate Tests
TR-106299 Final Report (WOC101-6)
Contractor: Massachusetts Institute of Technology
EPRI Project Manager: L. Nelson
Fax ID: 25652

Evaluation of Zinc Addition on Fuel Cladding Corrosion at the Halden Test Reactor
TR-106357 Final Report (WO4023-2)
Contractor: Institutt for Energiteknikk
EPRI Project Manager: S. Yagnik
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Reduction of Oxidation Induction Time Testing to Practice as a Life Assessment Technique for Cable Insulation
TR-106370 Final Report (WO3427)
Contractor: University of Virginia
EPRI Project Manager: J. Carey
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Evaluation of Irradiated Fuel During RIA Simulation Tests
TR-106387 Final Report (WO2905-6)
Contractor: Anatech Corp.
EPRI Project Manager: O. Ozer
Fax ID: 25817

Water Hammer Handbook for Nuclear Plant Engineers and Operators
TR-106438 Final Report (WO2856-3)
EPRI Project Manager: M. Merilo
Fax ID: 25908

Development of a Quality Pedigree Process and Application to the Duane Arnold Energy Center Probabilistic Safety Assessment
TR-106575 Final Report (WO3719-4)
Contractor: ERIN Engineering and Research
EPRI Project Manager: F. Rahn
Fax ID: 26112

PWR Steam Generator Examination Guidelines, Revision 4: Vol. 1, Guidelines
TR-106589-V1 Final Report (WOS530)
Contractor: ISI Guidelines Committee
EPRI Project Manager: M. Behravesh
Fax ID: 26131

Decommissioning Economics and Risk Advisor: An Introduction to DERAD Version 2.0
TR-106788 Final Report (WO3171-4)
Contractor: Decision Focus
EPRI Project Manager: C. Wood
Fax ID: 40015

RackSaver™ Neutron Absorbing Insert Development and Testing
TR-106889 Final Report (WO3290-13)
Contractor: Siemens Power Corp.
EPRI Project Managers: R. Lambert, O. Ozer
Fax ID: 26633

POWER DELIVERY

Development of Advanced Composite Materials for Utility Applications, Phase II: Vol. 2
TR-104830-V2 Final Report (WO4159-1)
Contractor: Foster-Miller
EPRI Project Manager: B. Bernstein
Fax ID: 25689

Performance-Based Regulation: The State of the Art and Directions for Further Research
TR-106045 Final Report (WO2801)
Contractor: Christensen Associates
EPRI Project Manager: C. Smyser
Fax ID: 25199

Proceedings: Reliability-Centered Maintenance for Substation Equipment Conference
TR-106069 Proceedings (WO2747)
Contractor: Cambias & Associates
EPRI Project Managers: P. Lyons, M. Hammam
Fax ID: 40136

The Distribution System Modeling Guide for Disturbances and Cold Load Pickup
TR-106297 Final Report (WO3797-3)
Contractor: Electrotek Concepts
EPRI Project Manager: A. Sundaram
Fax ID: 25645

Evaluation of Gases Generated by Heating and Burning of Cables
TR-106394 Final Report (WO4142-1)
Contractor: Underwriters Laboratories
EPRI Project Manager: R. Bernstein
Fax ID: 26677

Reliability-Centered Maintenance Technical Reference for Substations
TR-106418 Final Report (WO3882)
Contractor: Halliburton NUS Corp.
EPRI Project Managers: P. Vujovic, M. Hammam
Fax ID: 26634

Flexible AC Transmission System (FACTS) System Studies: Southern Company Services
TR-106461 Final Report (WO3789)
Contractor: General Electric Co.
EPRI Project Manager: R. Adapa
Fax ID: 25941

Flexible AC Transmission System (FACTS) Technologies on the TVA Transmission System
TR-106462 Final Report (WO3789-6, WO3022-2)
Contractor: General Electric Co.
EPRI Project Manager: R. Adapa
Fax ID: 25943

Cable Pushing and Calculation of Pulling Tensions for Distribution and Transmission Cables
TR-106500 Final Report (WO7910-19)
Contractor: Georgia Power Co., Southern Electric International Research Center
EPRI Project Manager: T. Rodenbaugh
Fax ID: 25993

Distribution Grounding, Vol. 1: Handbook
TR-106661-V1 Final Report (WO3066-1)
Contractor: National Electric Energy Testing, Research, and Applications Center
EPRI Project Manager: H. Ng
Fax ID: 26279

Role of Formulation on the Long-Term Wet Electrical Performance of Ethylene-Propylene Rubber (EPR) Cable Insulation
TR-106680 Final Report (WO2899-2)
Contractor: University of Connecticut
EPRI Project Manager: B. Bernstein
Fax ID: 26305

STRATEGIC R&D

Framing Scenarios of Electricity Generation and Gas Use
TR-102946 Final Report (WO3201-4, -5; WO4122-2)
Contractors: Energy Ventures Analysis; Charles River Associates
EPRI Project Manager: J. Platt
Fax ID: 19557

Biomimetic Materials in the Utility Industry: A Program Plan for Research Opportunities, Vol. 2
TR-104128-V2 Final Report (WO9000-17)
Contractors: Daedalus Associates; Cornice Engineering
EPRI Project Manager: J. Stringer
Fax ID: 24504

Characterization of Mechanical and Thermal Properties of Advanced Composite Pultrusions
TR-106271 Final Report (WO8007-20)
Contractor: University of Mississippi
EPRI Project Manager: B. Bernstein
Fax ID: 25598

Generic Testability and Test Methods Guidelines for ASIC Devices
TR-106392 Final Report (WO9000-34)
Contractor: ECR Laboratory
EPRI Project Manager: J. Naser
Fax ID: 25829

Computational Algorithms for the Multirate Simulation of Power System Dynamics, Part 1: Feasibility Study
TR-106497 Interim Report (WO8014-3)
Contractor: University of Missouri, Rolla, Department of Electrical Engineering
EPRI Project Manager: M. Wildberger
Fax ID: 25997

Environment for Specification and Analysis of Sequential Process Control Systems
TR-106734 Final Report (WO8014-5)
Contractor: UniView Systems
EPRI Project Manager: M. Wildberger
Fax ID: 26390

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.

DEW: Distribution Engineering Workstation
Version 1.1 (PC-Windows)
Contractor: Electrical Distribution Design
Business Area: Distribution
EPRI Project Manager: Harry Ng

DGAP: Distribution Grounding Analysis Program
Version 1.0 (PC-DOS)
Contractor: Georgia Institute of Technology
Business Area: Distribution
EPRI Project Manager: Harry Ng

EMFWorkstation: EPRI Electric and Magnetic Fields Workstation
Version 2.51 (PC-DOS)
Contractor: Enertech Consultants
Business Area: Electric & Magnetic Fields Health Assessment & Management
EPRI Project Manager: Randall Takemoto-Hambleton

GENCAT™: Electronic Product Catalog and Benefits Estimator (Generation, Storage, and Environmental Control)
Version 3.0 (PC-DOS)
Contractor: InStep
Business Areas: All Generation Group areas
EPRI Project Manager: Rusell Owens

LAYERS: A Multilayer Magnetic Field Shielding Calculation Program
Version 1.0 (PC-Windows)
Contractor: Electric Research and Management
Business Area: Electric & Magnetic Fields Health Assessment & Management
EPRI Project Manager: Randall Takemoto-Hambleton

MANAGES™: Management and Evaluation of Groundwater Monitoring Data
Version 2.0 (PC-DOS)
Contractor: Tetra Tech
Business Area: Land & Groundwater Protection & Remediation
EPRI Project Manager: Ishwar Murarka

MEGADRIVE: Model for Evaluating Gas Compressor Drive Options
Version 1.0 (Macintosh; IBM-LOTUS; PC-DOS)
Contractor: Energy Packaging Solutions
Business Area: Industrial & Agricultural Technologies & Services
EPRI Project Manager: Ammi Amarnath

MOSES-MP
Version 1.0 (PC-DOS)
Contractor: Tetra Tech
Business Area: Land & Groundwater Protection & Remediation
EPRI Project Manager: Ishwar Murarka

POET: Piping Operability Evaluation Tool
Version 1.0.0 (PC-Windows)
Contractor: Kaman Sciences Corp.
Business Area: Nuclear Power
EPRI Project Manager: H. T. Tang

RETRAN-02-M
Version MOD005.2 (IBM-RS6000; HP-UNIX; Sun-Solaris)
Contractor: Computer Simulation and Analysis
Business Area: Nuclear Power
EPRI Project Manager: Lance Agee

RETRAN-3D
Version MOD002.0 (HP-UNIX; AIX; Solaris)
Contractor: Computer Simulation and Analysis
Business Area: Nuclear Power
EPRI Project Manager: Lance Agee

SCAAD: The Strategic Capacity and Analysis Database
Version 1.01 (PC-DOS)
Contractor: Fern Engineering
Business Area: New Generation
EPRI Project Manager: Robert Frischmuth

SGDSM (Steam Generator Degradation-Specific Management) Design
Contractor: Failure Analysis Associates
Business Area: Nuclear Power
EPRI Project Manager: David Steininger

TLWorkstation™: Transmission Line Workstation (CORRIDOR, DYNAMP, FAD, RNOISE, and UPSTUDY Modules)
Version 3.0 (PC-Windows)
Contractor: Vanguard Technology Co.
Business Area: Transmission & Substations
EPRI Project Manager: Anwar Hirany

UFIM: Utility Fuel Inventory Model
Version 3.13 (PC-DOS)
Contractor: Applied Decision Analysis
Business Area: Power Markets & Resource Management
EPRI Project Manager: Richard Goldberg

WATSMPL
Version 1.0 (PC-Windows)
Contractor: D. W. Abrams and Associates
Business Area: Residential Technologies & Services
EPRI Project Manager: Carl Hiller

WinSQUG: Windows User-Friendly Interface for the SQUG Seismic Experience Database
Version 2.0 (CD-ROM)
Contractor: EQE International
Business Area: Nuclear Power
EPRI Project Manager: Robert Kassawara

EPRI Events

MARCH

2–5
EPRI EMF Seminar
New Orleans, Louisiana
Contact: Robert Kavet, (415) 855-1061

3–4
Commercial Lighting Efficiency Training for Utilities
Dallas, Texas
Contact: Larry Ayers, (800) 525-8555

3–4
Open-Access Same-Time Information System (OASIS) Conference
New Orleans, Louisiana
Contact: Denise Wesalainen, (415) 855-2259

3–6
Intermediate Underground Transmission Course
San Antonio, Texas
Contact: Kathleen Lyons, (415) 855-2656

3–6
Power Quality Conference: PQA '97 North America
Columbus, Ohio
Contact: Lori Adams, (415) 855-8763

3–6
2d International Workshop on Corrosion in Advanced Power Plants
Tampa, Florida
Contact: Michele Samoulides, (415) 855-2127

11–14
Generator Monitoring and Diagnostics
Long Beach, California
Contact: John Niemkiewicz, (800) 745-9982

13–14
EPRI Partnership for Industrial Competitiveness
Newport Beach, California
Contact: Bill Smith, (415) 855-2415

18–20
Root-Cause Analysis
Long Beach, California
Contact: John Niemkiewicz, (800) 745-9982

18–21
Advanced Check Valve Monitoring and Diagnostics
Logan, Utah
Contact: Jeanne Harris, (800) 745-9982

24–27
Hydrogenerator Maintenance Course
Boston, Massachusetts
Contact: Denise Wesalainen, (415) 855-2259

25–27
1997 International Clean Water Conference
Baltimore, Maryland
Contact: Christine Lillie, (415) 855-2010

APRIL

6–10
1997 International Fossil Simulation and Training
Atlanta, Georgia
Contact: Amy Winn, (816) 235-5623

14–16
Predictive Maintenance and Refurbishment
Florence, Italy
Contact: Susan Bisetti, (415) 855-7919

14–18
Infrared Thermography: Level 1
Eddystone, Pennsylvania
Contact: Jeanne Harris, (800) 745-9982

15–17
Substation and Switchyard Predictive Maintenance
Long Beach, California
Contact: John Niemkiewicz, (800) 745-9982

17–18
4th Annual Strategic Marketing Conference
Orlando, Florida
Contact: Ingrid Bran, (415) 855-1064

22–25
Basic Vibration Testing and Analysis
Long Beach, California
Contact: Jeanne Harris, (800) 745-9982

22–25
Transformer Performance Monitoring and Diagnostics
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

23–25
1997 Advanced Oxidation Technology Symposium
Washington, D.C.
Contact: Jose Emmanuel, (510) 525-1205

29–May 2
Motor Monitoring and Diagnostics
Eddystone, Pennsylvania
Contact: Jeanne Harris, (800) 745-9982

MAY

6–8
Fish Passage Workshop
Milwaukee, Wisconsin
Contact: Maggie Loobey, (415) 855-2158

7–9
Midas Users Group Meeting
Phoenix, Arizona
Contact: Susan Marsland, (415) 855-2946

12–16
1997 Continuous Emissions Monitoring Conference
Denver, Colorado
Contact: Michele Samoulides, (415) 855-2127

12–16
Steam Plant Operations for Utility Engineers
Kansas City, Missouri
Contact: Amy Winn, (816) 235-5623

13–14
2d Annual Green Pricing Workshop
Corpus Christi, Texas
Contact: Lori Adams, (415) 855-8763

19–21
Substation Reliability-Centered Maintenance
Dallas, Texas
Contact: Denise Wesalainen, (415) 855-2259

20–22
Effects of Coal Quality on Power Plants
Kansas City, Missouri
Contact: Susan Bisetti, (415) 855-7919

JUNE

2–4
CHECWORKS Users Group Meeting
Myrtle Beach, South Carolina
Contact: Denise Wesalainen, (415) 855-2259

3–5
Infrared Thermography: Level 3
Eddystone, Pennsylvania
Contact: Jeanne Harris, (800) 745-9982

4
Water and Energy Conference
Cleveland, Ohio
Contact: Kim Shilling, (314) 935-8590

5–6
Municipal Water and Wastewater Program
Cleveland, Ohio
Contact: Kim Shilling, (314) 935-8590

10–12
5th International Conference on Cycle Chemistry in Fossil Plants
Charlotte, North Carolina
Contact: Michele Samoulides, (415) 855-2127

10–12
Predictive Maintenance Program: Development and Implementation
Eddystone, Pennsylvania
Contact: John Niemkiewicz (800) 745-9982

10–13
Healthcare Initiative Workshop and Conference
Chicago, Illinois
Contact: Janis Prifti, (415) 641-8332

15–18
7th International ISA POWID/EPRI Controls and Instrumentation Conference
Knoxville, Tennessee
Contact: Susan Bisetti, (415) 855-7919

16–19
Power Quality Conference: PQA '97 Europe
Stockholm, Sweden
Contact: Lori Adams, (415) 855-8763

19–20
EPRI Partnership for Industrial Competitiveness
Chicago, Illinois
Contact: Bill Smith, (415) 855-2415

JULY

14–16
6th EPRI Valve Technology Symposium
Portland, Maine
Contact: Susan Otto, (704) 547-6072

14–18
Steam Plant Operations for Utility Engineers
Castine, Maine
Contact: Ginny Commiciotto, (207) 326-2212

21–23
1997 International Low-Level-Waste Conference
Providence, Rhode Island
Contact: Michele Samoulides, (415) 855-2127

23–25
EPRI/ASME Radwaste Workshop
Providence, Rhode Island
Contact: Michele Samoulides, (415) 855-2127

29–31
Fluid-Film Bearing Diagnostics
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

AUGUST

11–14
Cooling Tower Conference
St. Petersburg, Florida
Contact: Susan Bisetti, (415) 855-7919

12–15
Generator Monitoring and Diagnostics
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

12–15
Motor Monitoring and Diagnostics
Long Beach, California
Contact: Jeanne Harris, (800) 745-9982

18–22
Steam Plant Operations for Utility Engineers
Castine, Maine
Contact: Ginny Commiciotto, (207) 326-2212

23–25
Power Plant Pumps Short Course
Eddystone, Pennsylvania
Contact: John Niemkiewicz, (800) 745-9982

25–29
SO_2/NO_x/Particulates/CEM Symposium
Washington, D.C.
Contact: Lori Adams, (415) 855-8763

EPRI JOURNAL

January/February 1997

ELECTRIC POWER RESEARCH INSTITUTE
Post Office Box 10412, Palo Alto, California 94303

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Printed on recycled paper
in the United States of America

FJ-107721