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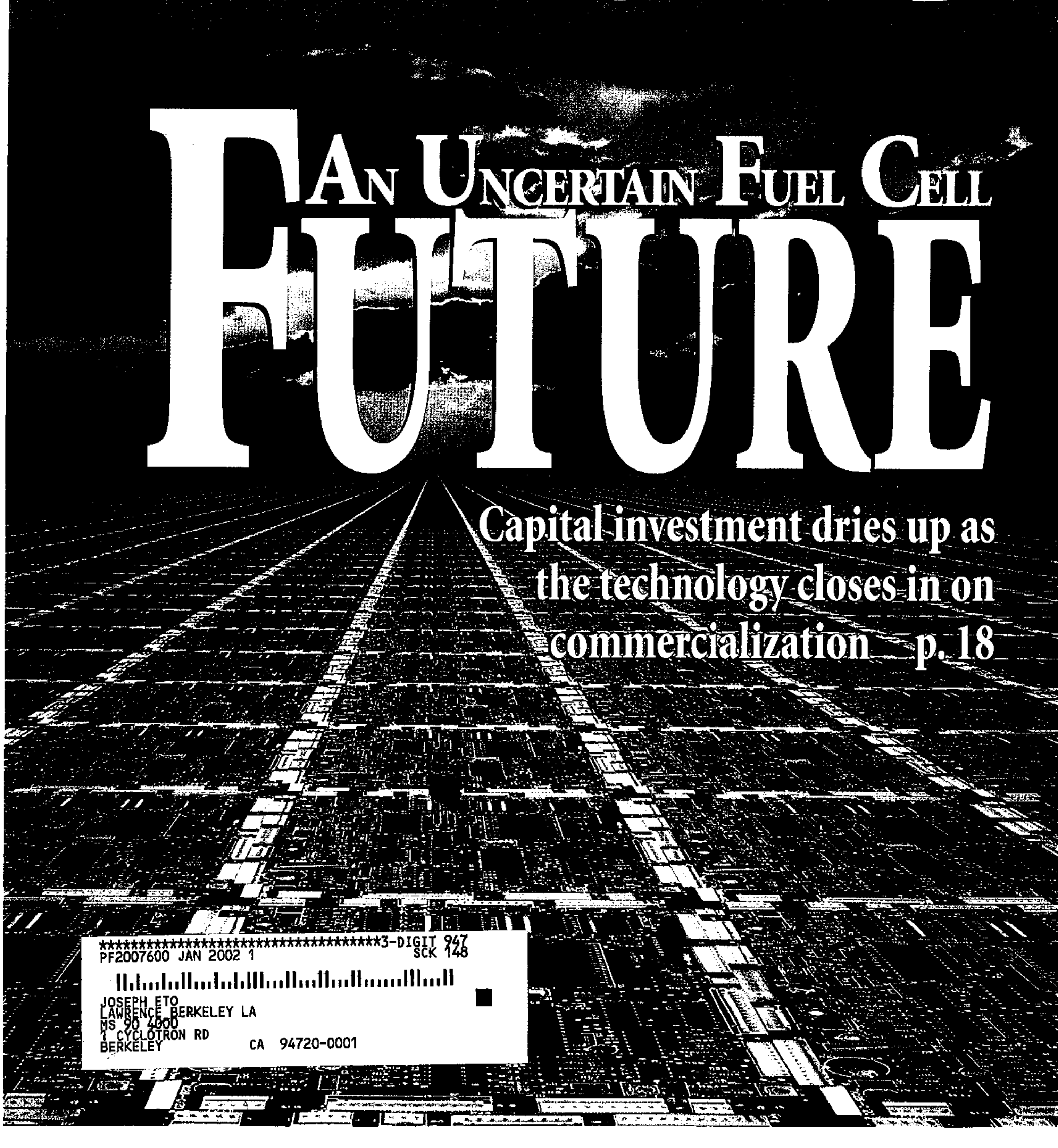
AN UNCERTAIN FUEL CELL FUTURE

Capital investment dries up as the technology closes in on commercialization p. 18



Demand Response: An Overview

Oak Ridge National Laboratory engineers say residential and commercial customers must bear the true price of power, through new technologies, for electric competition to work.

By Robert H. Staunton, John D. Kueck, Brendan J. Kirby, and Joe Eto

RECENT ELECTRICITY PRICE SPIKES IN CALIFORNIA are a painful example of how customers are overly impacted by the changing electricity markets. Unfortunately, these customers have little or no control over the electricity market. In general, the present U.S. electricity markets are not typical by any standard, at least not for small customers. While both homeowners and small businesses freely shop around for many commodities and buy items on sale or at quantity discount prices, this has not been possible in the case of electricity. And why not? If the markets were open, available on a "real-time" basis, and users could avoid blindly purchasing during price spikes, it would not only benefit them financially, it would greatly reduce the spiking and improve the availability of electricity. Allowing customers to actively manage/change their loads in response to system conditions might be thought of as the ultimate reliability resource.

Customers presently do not experience directly the time-varying costs of their consumption choices. While electricity suppliers may be riding a wild roller coaster of rapidly changing prices, the customers may see only a fixed rate that rarely increases. Consequently, they have no incentive to modify their choices in ways that might lower their bill, enhance reliability, or improve the efficiency of the markets in which electricity is traded. Even if they were not so thoroughly isolated from the gyrating price swings, they would need additional tools such as, (1) a communications link to inform them of real-time prices, (2) accurate metering, and (3) a control system that facilitates either manual or automatic modification of their consumption. Drawing from a recent study,[1] much of this article will describe these technologies.

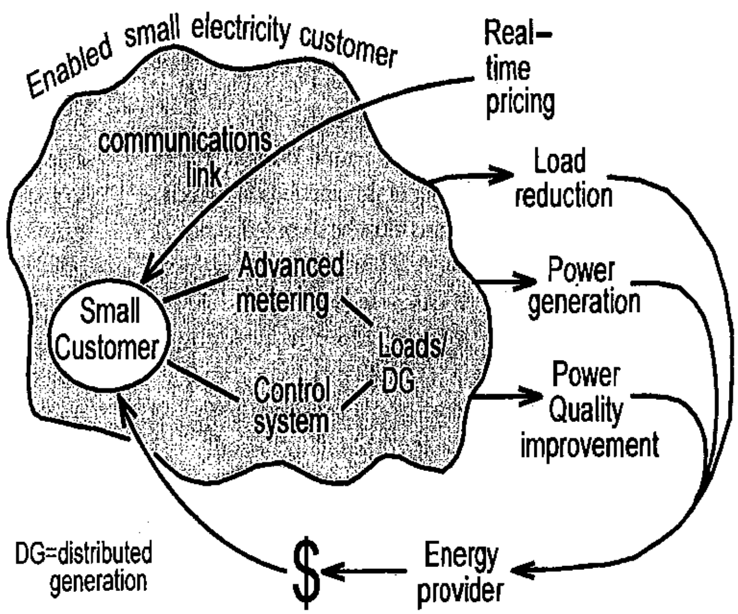
If a large aluminum smelter can drop 100 megawatts (MW) of load in an afternoon when price spiking exists and save over $50,000, clearly there must be some attractive potential savings for small businesses and homeowners. In a future market, hotel managers could have a control system programmed to monitor the Internet for market spikes and shut down water heaters and air conditioners in selected rooms (i.e., unoccupied and/ or occupied and time-of-day dependent), and homeowners could shut off the hot water heater, turn down the air conditioning, and turn off the pool pump for a few hours.

# of Enabling Technologies

Load as a Resource: Can Energy Shortages Really Be Made Up Through Customers?

Power companies need help from the customers whether they know it or not. Many companies have come to acknowledge this out of desperation and others may simply succumb to changing market forces. Ancillary services include a wide array of load reduction, power generation, and power quality improving actions. Ancillary services can be provided by electricity customers to the power companies and are of monetary interest to the power companies or, to be precise, they should be of interest. For the sake of argument, let us assume that the difficult issues (i.e., barriers) of protecting turf, loosening up the bureaucracy, high tariffs, etc. are fully behind us. This view is reasonable because, once

A Review of Enabling Technologies



enabling technologies and products are available that make providing an ancillary service as easy as programming a VCR (or easier!), then the pressure will build and remaining bureaucratic barriers will rapidly erode.

Communications can be initiated by the meter at set times or by the energy service provider whenever necessary.

As a final note to illustrate the opening markets, it should be mentioned that utility load management programs, such as direct load control, already exist for large blocks of customer loads as system resources. Programs such as this are financially attractive to businesses; otherwise, they would not have signed up! A mention or two was made of "enabling technologies."

Smart Metering: Has its Time Come?

The proof of the service is in the metering—however, not the metering that has been in use for decades, but smarter metering that provides proof of the customer's energy consumption or ancillary service over some period of time. The information gleaned from improved metering may be needed by one or more of several entities including the utility, load aggregator, energy service provider, or customer's central location. The length and number of time periods for which energy transactions must be recorded varies depending on how the customer and the energy supplier choose to interact.

The energy-related information of most common interest includes:

- Energy—record the customer's energy consumption over the billing period.
- Demand—record the highest demand (energy consumption over a 15-, 30-, or 60-minute period)
- Time-of-Use—record energy consumption in set time frames (bins) when the system is typically experiencing high prices (on-peak) and low prices (off-peak).
- Interval—record energy consumption every 5, 15, 30, or 60 minutes.

An *interval data meter* is one that can provide not just kilowatt (kW) usage, but a kW profile versus time. This type of meter is absolutely necessary for capitalizing on load response opportunities unless there is direct control by the utility. In many areas, interval data meters are required for all loads with demands greater than 20 to 50 kW. Although "real-time" interval data can be made available to the user within seconds, most utilities consider daily, weekly, or monthly communications satisfactory. The meters may communicate the data using a variety of methods such as telephone, cellular phone, radio and fixed network. The data is typically accessible at a password-protected Web site.

The cost of upgrading an existing meter to an interval meter is remarkably inexpensive, $90 to $245, if a phone line is already available.[2] New interval data meters range in cost from $200 to $3,700 depending on sophistication and features, such as true real-time data updated every few seconds, and continuous power quality monitoring. Many new meters are designed to several different modes of communication, such as pagers or cellular phones.

Interval data meters allow energy managers to see an energy profile of a building and to evaluate the effects of operational changes such as control systems and compact fluorescent lamps. If the building demand can be shaped to fit the Energy Service Provider's best rates, large savings can be achieved by negotiating better prices.

Improved metering? The New Approach

- **Meter Upgrade**—An existing induction disc electromechanical meter can be upgraded to a full remotely readable interval meter. A pulse initiator is installed in the meter to generate a pulse for every revolution of the disc. Pulse initiators range from $25 to $45. A data recorder counts the pulses and converts to energy consumption for the appropriate interval (5, 15, 30, or 60 minutes). The data recorder also contains the communications interface. Options on the data recorder include the number of channels it can accommodate (for watts, vars, water, gas, etc.), the amount of data it can store, the number of communications ports (one for the energy service provider, one for the customer, and a third for outage notification), and the communications medium. Data recorders range in price from $80 to $200.
- **Advanced Meters**—ABB, General Electric, Schlumberger, and Siemens dominate the electric meter market. Advanced

meters from these manufacturers include the interval data collection and communications interface. Options with advanced meters also include the number of channels, the amount of data that can be stored, the number of communications ports, and the communications medium. Each manufacturer also offers meters that monitor power quality. Prices range from $250 to over $3000.

Further integration of data recording and communications into the meter itself will likely continue. As with most electronic systems that gain acceptance and mature, hardware costs will likely decrease while functionality increases.

- **Automatic meter reading**—Focusing down to more localized communications needs brings us to the important field of automatic meter reading (AMR). Utilities have been interested in AMR for many years, even apart from interest in responsive load. Electric and gas utilities have 164 ongoing and scheduled AMR projects. The projects include 12.4 million units using CellNet fixed radio networks.[3] Much of the technology available today was originally designed with only AMR in mind. Not only does AMR overcome the need for reading meters in bad weather or when access is difficult or dangerous, it also provides improved accuracy, collection of greater amounts of information, reduced need for estimated readings, theft detection, and automatic outage notification.

One option taken by some utilities is to let a metering communications company install and operate the meters and the communications network. It could then sell the information back to the utility and the customers. Planergy, a load aggregator, uses this industry model. Their sometimes-elaborate methods include data loggers, phone lines, and even orbiting satellites which may be of limited interest for small customers. However, it is important to understand that, based on utility curtailment requests, Planergy notifies each of its loads and monitors their response. Loads that do not respond are contacted. Replacement loads are available to respond if necessary.

Another company, CellNet, provides data collection and data management services.[2] It uses fixed networks that it does not sell. Instead an energy service provider enters a long-term contract and CellNet installs and operates a network. A MicroCell Controller communicates via radio with up to 2000 CellNet communications modules placed on meters in a 1/3-mile radius (greater in rural areas). A CellMaster routs the signals from 200 MicroCells to the system controller located at a CellNet data center. The system controller converts the data to an appropriate format and presents it to the energy service provider over the Internet.

Communications in a Real-Time Market: The Missing Link to Real-Time Metering?

Several technologies are available for moving data collected by meters to the utility, load aggregator, energy service provider, or customer's central location.The Power line carrier (PLC) sends communications signals over the power lines. PLC has the advantage that the communications network already exists directly to the meter. However, the following describes a few somewhat more conventional types of network communication schemes:

- **Fixed Radio Networks** place radio transmitter/receivers throughout the geographic area to be covered, typically mounted on utility poles or buildings. Each meter also has a radio transmitter/receiver. The network can communicate with any meter at any time. It provides the capability to support real-time energy prices, facility monitoring, daily meter reading, load profiling, time-of-use pricing, etc. Metering and sub-metering (non-billing) can give customers a better view of their facilities.
- **Mobile Radio Networks** use technology that is similar to fixed radio networks except that the utility side transmitter/receiver is portable (either hand held or vehicle mounted) and used to make periodic contact with the meters. This reduces the cost of installing a fixed radio network but it also greatly reduces the ability of the system to support real-time operations.
- **Telephone Communications** are also used to communicate with meters. The meter is supplied with a telephone modem. Communications can be initiated by the meter at set times or by the energy service provider whenever necessary. If a shared phone line is used, the meter modems recognize if the line is in use and, if so, try to make the call later. If a standard telephone line is not

available a cell phone (+$800) or a satellite phone (+$2000) can be used.

An advantage to telephone communications is that all of the loads in the aggregation do not need to be in the same geographic area. Another advantage is that no expensive infrastructure is required. A disadvantage is that communications take longer to initiate. It takes about half a minute to read each non-interval (monthly) meter. Reading 1 hour interval meters requires about one and a half minutes each while 15 minute interval meters require about 4 minutes each when read monthly. These times are not long if you are reading a few meters but add up if you need to contact thousands.

The inherent differences between fixed network radio and telephone communications have interesting market structure implications. Fixed radio provides faster communications but it requires high geographic customer density. It is also cheaper when installed in mass. This gives it characteristics that are similar to the distribution system; it may be a natural monopoly. This could give the incumbent distribution company a significant technical and economic advantage in supplying advanced metering services.

Communications via Wireless Systems: A Brief Overview

Cell phones—Cell phone technology is advancing from strictly voice to supporting a range of data applications. Many of these applications are price sensitive. Price and metering communications may be an ideal fit in the not-too-distant future.

Ninety-five million people in the US use mobile phones, resulting in wide (though not total) geographic coverage and volume-based cost reductions. Competing wireless networks employ different technologies for transmitting signals. Telecommunications companies are now working on third-generation wireless networks that could deliver data to and from mobile devices at up to 2 Mbps.[4] The Wireless Application Network allows cell phones to talk to the World Wide Web. The wireless carrier operates the server making the transition from the cell phone to the Internet. This is certainly greater data transmission than responsive loads require. Since the wireless carrier provides the server connection the infrastructure requirements for the energy service provider are greatly reduced. The problem of monopoly service provision is also eliminated since the wireless carrier can route each individual communication to any selected energy service provider without the delay of telephone system dialing.

Standards for wireless network components are advancing with the adoption of IEEE 802.11b last year. The cost of wireless network components has started to fall, also contributing to growth in wireless networks.[5]

- **Bluetooth, wireless LAN, and home RF short-range wireless technologies**—Several currently available, wireless communications technologies (e.g., see www.xircom.com) may be useful for interconnecting the various metering, load, control, and communications devices that a price-responsive customer needs such as the hot water heater, air conditioner, and pool pump. The advantage to this type of technology is that it, (1) avoids the cost of wiring these devices together, (2) provides a universal communications interface between various types of devices and various manufacturers devices, and (3) automatically reconfigures the communications network whenever a new device is added. This new device may include a computer, printer, etc. in the computing environment or a meter and/or load controller in the case we are contemplating here. Another interesting local wireless communications and control technology with the advantage of high commercial volume and low price is the X10 series of products that allow a PC to control various appliances (X10 Wireless Technologies Inc.). This is not a robust, industrial-grade technology but it does perform required local communications and control tasks. The X10 system communicates through the immediate existing power line to individually control up to 256 devices. This system gives small electricity customers the functionality to allow load control based on the price of power if such data are available to the PC. Prices range from $10 to $40 per device.

Load control management—Telephones, cellular phones, and radio communications each provide their own advantages for communications and load control. Of particular interest are communications and control systems that have arrived on the market. A few are discussed in the Communications and Control Systems box.

- **Analysis features**—Many of the communications providers have designed into their systems the capability to provide meter data to customers for their analysis. Any number of graphical formats are available. Some provide the ability to directly compare costs that would result from various tariffs. Many allow the customer to download meter data into a convenient tool such as Excel for the customer to do his own analysis.

Customer Responses to Opportunities: How They May React

Customers can approach information-based action in different ways. Based on the information, they can invest in equipment and modifications to their facilities that reduce their energy cost. They can take immediate manual action, automatic action, or a combination of the two based on current conditions. They can invest in equipment and modifications to their facilities that give them flexibility to respond to future events in real-time. The immediate manual response requires little capital investment and can be effective if the number of events is not too great. The automatic response accommodates numerous events but involves greater cost. Equipping for future real-time responses may have the greatest initial cost but will provide the greatest life-cycle profitability.

As a result of these new technologies, the small customer will soon be able to pursue attractive opportunities in the open electricity market just as large customers do. Strong evidence of this arriving opportunity is evident by new metering, communications, and control technologies/products that are appearing on the market. The small customer of electricity services needs to use these tools to become "enabled" with improved metering, load control, and real-time pricing data. The enabled customer will be able to not only manage load in response to notices/requests from the electricity provider but also provide load control and other important ancillary services in response to real-time prices. Ⓕ

Robert H. Staunton, John D. Kueck, and Brendan J. Kirby are research engineers at ORNL who lead a range of studies for the Department of Energy designed to characterize and anticipate new direction in the restructured electricity markets.

Joseph H. Eto is a Staff Scientist at LBNL where he manages the program office for the Consortium for Electric Reliability Technology Solutions (CERTS), a national laboratory, university, and industry public interest R&D consortium.

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