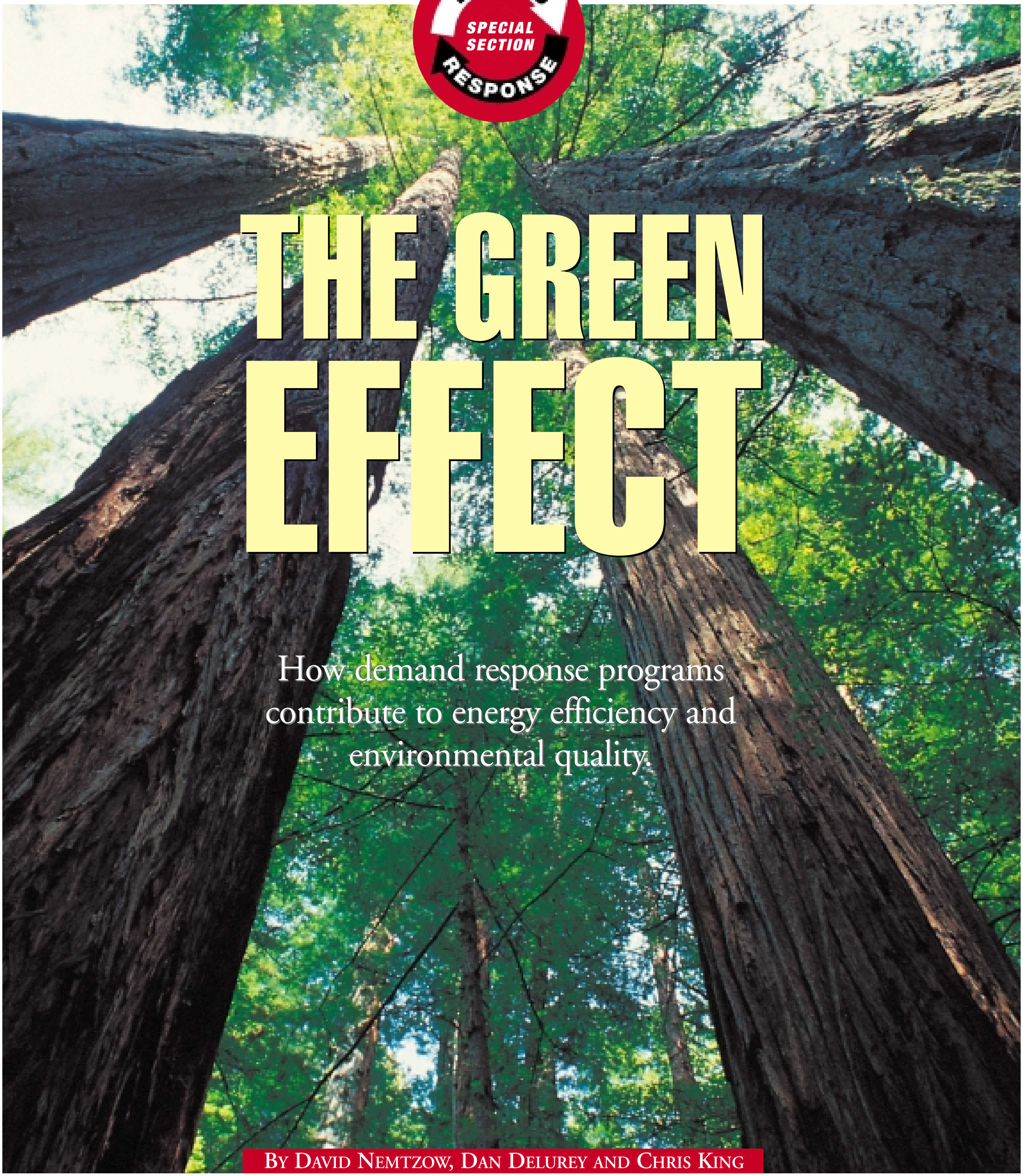
DEMAND RESPONSE SPECIAL SECTION



THE GREEN EFFECT

How demand response programs contribute to energy efficiency and environmental quality.

By David Nemtzow, Dan Delurey and Chris King

Demand response (DR) is rapidly gaining ground in the electricity industry and among its regulators, but its establishment may not be going as smoothly or robustly as it could. This is in part because of different views as to where DR fits into the electricity industry. Is it about reliability? Prices? Or is it all about load control?

DR is about all of those things, but it also is about other important policy and business areas that do not jump to mind for most people when they think about DR—energy efficiency and the environment.

Some of the lack of association of DR with these areas may be caused by a lack of information, but there also may be a presumption among some key audiences that there is no relationship between DR and these areas— or if there is one, it is negative.

Record-breaking temperatures and demand, sharper system peaks, expiration of price caps, and rapid technological advances all have contributed to the growth of DR. As global climate change heightens the profiles of energy efficiency and renewable energy, two questions stand out:

- Does DR increase or decrease overall electricity usage, or just shift it to another time with no impact on energy efficiency?
- What is, or can be, DR's effect on emissions and other environmental impacts?

To understand these inter-related issues we look at theory, modeling, and empirical evidence, some of which is as-yet unpublished and some of which goes back three decades. We find that in nearly all cases, DR decreases overall usage—several percent on average—and DR improves energy efficiency; the evidence refutes the perception that DR only shifts, rather than decreases, consumption. We also find that DR and its enabling technologies can lead to an increase in energy-efficient behavior by customers and can help support the growth of renewable energy. As for the environment, DR's impact is situation specific. It is likely to be positive but could be mixed or negative in certain situations depending on the effect on emissions. Finally, we offer suggestions to improve the relationship between DR and both energy efficiency and the environment such that multiple desirable goals have a better chance of being achieved.

In a 2005 *Public Utilities Fortnightly* article,[1] we (King and Delurey) referred to DR and energy efficiency as "siblings," citing their common lineage as demand-side measures to provide new choices for customers to manage and lower their bills. Efficiency and DR, like so many siblings, have an intertwined and permanent relationship, often collaborating and working together toward their individual goals, while at other times competing for money and attention, proceeding independently or even at cross purposes.

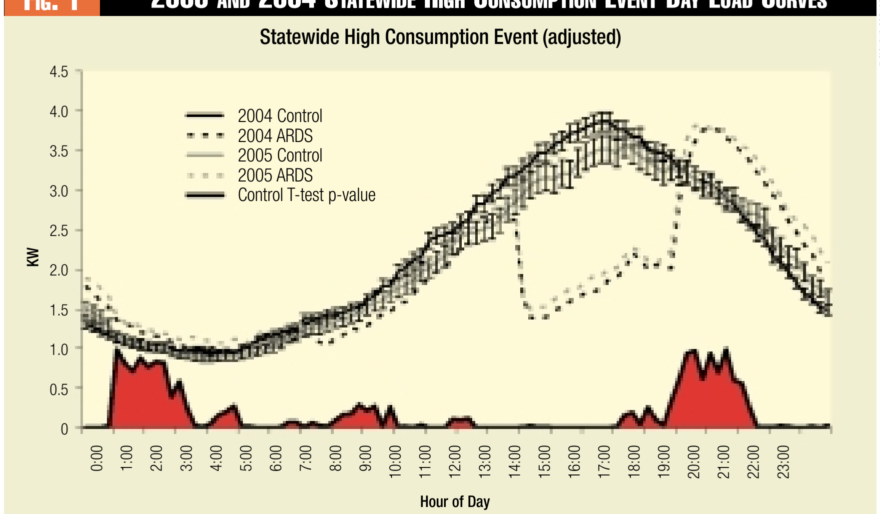
DR and Improving Energy Efficiency

Our 2005 *Fortnightly* article reviewed results from more than 100 DR programs around the country for more than a quarter century and found that these programs have a "conservation effect," cutting energy consumption from more than 20 percent to minus 5 percent (an increase in use).

The new evidence from around the United States and abroad that has become available in the two years since that review further increases confidence in the conclusion that DR reduces total electricity consumption, principally (but not exclusively) during peak periods, but consistently, and has the potential to be a major indirect factor in increasing overall energy efficiency nationally. The new results are included in Table 1.

Important new findings on DR's conservation effect come from a day-ahead hourly pricing pilot run by the Community Energy Cooperative in Chicago. The 1,400 households who have been in the Energy-Smart Pricing Program (ESPP) pilot for three years "are not just shifting their time of use, they're using less electricity … a reduction in [kWh] usage of 3 to 4 percent, relative to what their usage was estimated to be had

FIG. 1 **2005 AND 2004 STATEWIDE HIGH CONSUMPTION EVENT DAY LOAD CURVES**



Source: See endnote 2

Typical Impact of Demand Response on Load Curve Showing Savings and Rebound (2005 and 2004 Statewide California Residential High Consumption Event Day Load Curves) [2] they not received hourly electricity prices"[3] [emphasis added]. Furthermore, lower-income participants were "as demand responsive" as higher-income participants, and participants are buying certified efficient EnergyStar appliances as replacements more often than are the control group. And it should be noted that these reductions occurred in a program that did not have energy conservation as a major design goal (as is all-too-common in DR efforts). Following this pilot, the Illinois legislature and Commerce Commission ordered that statewide real-time tariffs be available to Illinois customers—utilities' proposals have been approved and took effect Jan. 2, 2007.

Table 1 Energy Savings from Demand Response Programs

("Savings" represents percentage cuts in overall kWh consumption)

- Meta-review of **100 Demand Response programs** (over 25+ years, U.S. and abroad)
  >20% to -5% savings
  - Dynamic Pricing programs: **average 4%** savings
  - Customer Feedback programs: **average 11%** savings
  - Reliability programs: ~**0.2%** savings (calculated)
- **Energy-Smart Pricing Plan** (Real-Time Pricing, 1,400 Chicago residences, 2003-05)
  3-4% savings
- **California ADRS** (Automated Demand Response System for residences, summer months only, 2004-05)
  Several %
- Gulf Power's **Good Cents Select** (Critical Peak Pricing)
  3.8% savings
- **Hydro One** (Real-Time Feedback, 500 homes, 2003-2006, in-home displays but non-differentiated tariffs)
  6.5% savings
- Country Energy/Bayard Group (Feedback/Smart Metering/RTP, 200 homes in NSW, Australia, 2004-present)
  ~5% savings

How Does DR Reduce Electricity Consumption?

Several aspects of DR reduce consumers' overall energy usage, the magnitude of which depends not only on the DR technologies and practices used, but whether they are developed and deployed with efficiency in mind. Education and support to the customer, important in energy-efficiency programs, also are important to DR programs.

One of the most common DR applications (particularly in commercial buildings and particularly for short periods) is the dimming of lights or switching off of certain fixtures. Lighting-based DR does not shift load, it eliminates the load without a rebound because post-event, the area won't be "overlit" to compensate for the earlier "under" lighting. (Additionally, the reduced lighting may lead to a reduction in air conditioning during peaks.)

Another source of DR-driven load cuts that don't rebound are those that take place at the end of the work day, which often is the case as summer peaks can commence in the late afternoon. If reduced air conditioning is used for DR late in the work day of an office building, by the time the event or price signal is over, the workers may have left and the air conditioning will move to the (warmer) evening-hours setting. Finally, a familiar source of non-rebounding shifts are those in which the consumer chooses to not (or forgets to) rebound, such as the homeowner who reduces air conditioning but doesn't fully re-cool afterwards.

An analysis of two commercial-sector programs in California revealed that less than one-fourth of participants reported compensating for DR with higher usage either before or after the DR event (5 percent and 17 percent of all participants respectively).[4]

We believe that the most significant and positive relationship between DR and energy consumption is that DR increases energy awareness and provides feedback for consumers on their usage behavior. There is an extensive body of experience with utility programs that influence behavior by providing feedback; *EPRI Solutions'* March 2006 meta-review sums it up well:

> Numerous studies have demonstrated that customers do indeed respond to feedback on their energy use. … A review of literature from the past three decades … found savings ranging from 1 to 20 percent when customers were given real-time feedback. Most of the studies, however, found savings in the 4 to 15 percent range. … Direct feedback is what makes the link between cause and effect obvious for electric consumers.[5]

In fact, the more direct the feedback is (that is, provided in real time) and the more it is offered with the provision of other influences (such as energy-saving information or dynamic prices),[6] the better it influences behavior.

The conservation effect of awareness and feedback of DR is part economics and part psychology: Consumers who are made better aware of energy use, its price tag and environmental costs tend to use it more carefully and frugally. One now-familiar example is found outside the power sector, namely the panel display in the Prius hybrid car that prompts more fuel-efficient driving for many drivers by graphically showing the rate gasoline is consumed. All of this also speaks to the oft-heard question "How can you manage what you can't measure?"

Energy Efficiency and DR

Many DR technologies and practices also work well for energy efficiency, even when doing so is unintentional. Aggregators and other third-party providers of DR often start by conducting audits of facilities to determine DR opportunities and the audits—like Columbus searching for an Atlantic route to India—likely will find some efficiency benefits and opportunities to seize upon.

Also, it is important to recognize that two of the technologies that have played a prominent role in energy efficiency for decades are lighting and energy management systems (EMS). In the case of lighting, remote controlled dimmable ballasts allow it to be part of a DR program, and DR companies have built business models on this. In the case of EMS systems, these systems are intended to optimize the efficient ongoing operation of a building. They are thus a platform, not only for efficiency, but for DR as well. Each is a good example of a technology serving both business areas and, as should be the case, providing maximum benefits to the customer.[7]

Compelling evidence of this synergy is found in the Automated Demand Response System (ADRS) pilot program in California homes during the summers of 2004 and 2005.[8] ADRS homes had very significant cuts in consumption compared with the control group during the 2 p.m. to 7 p.m. peak period: 47 percent cuts during super-peak-event days, and 30 percent cuts on non-event days. However, a share of those savings rebounded during the post-7 p.m. period. In the aggregate, during the summer months the homes with ADRS used more than 6 percent less electricity than those without ADRS.

While energy efficiency and DR alone very often are cost-effective in their own right, neither may be seen as adequately valuable to get the attention of consumers—even sophisticated ones—because of time and transaction barriers. But if the addition of DR's value stream gets a consumer to participate in energy-efficiency programs that they otherwise would not have, energy efficiency from that customer will be greater.

It is important to recognize that in some circumstances DR can increase electricity usage. For example, a common DR strategy is to shift the timing of thermally related equipment, such as air conditioning or water heating, which can lead to energy losses since thermal energy dissipates over time. (Fortunately, several factors can mitigate this, including increased insulation and taking advantage of the inherent Carnot efficiency of cooling at night rather than during daytime.)

Finally, the competitive aspect of the efficiency vs. DR relationship must be noted. Many view the two as engaged in a zero-sum situation where money (or personnel or corporate or political will) can result in support for DR not being available for energy efficiency. This is, of course, an issue between many other energy areas as well. It should also be noted that in many cases, such as with many state-system benefit funds, that DR currently is unfunded or precluded from being funded. But this is mitigated when a holistic approach is taken at the demand-side management (DSM) level, such that demand-side projects and program portfolios that address both efficiency and DR are pursued. Additionally, the zero-sum argument assumes that available funding remains capped, and does not grow thanks to the success or popularity of these activities. Instead, all resources—demand- and supply side alike—should compete, as is already the case in some ISOs and in the California resource loading order. To put it in a different perspective, if and when efficiency and DR are treated as utility resources, not just as programs, they will be acquired whenever they are cost-effective based on total need, not based on pre-determined budgets.

Does DR Lessen Environmental Impacts?

One of the most important yet inadequately investigated elements of DR is its impact on the environment. There are numerous reasons to expect a positive environmental impact (and others that lead one to expect the opposite), but the results always will be very system- and generation-fleet specific. For example, DR in a diesel-peaking, gas-baseload system that is facing supply constraints will affect the environment differently (and positively) than it will in a hydro-peaking, coal-baseload system with large power reserves.

As described earlier, in most cases DR modestly reduces total electricity consumption, which subsequently diminishes the range of environmental impact associated with electricity generation, from CO_2 and other pollutants.

It is also important to acknowledge that some DR is enabled by back-up generators. For years, customers have participated in interruptible-type tariffs and programs by utilizing such generators, which may be fossil-based. Obviously, when a customer leaves the grid in a DR exercise involving such distributed generation (DG), there are emissions in play even if there is a net kWh and emissions reduction from resources on the grid.

This should not be seen, however, as reason to dismiss DG-based DR out of hand. First, the use of DG units in DR programs has not escaped the notice of state environmental regulators. Second, as DR grows as a business, the efficiency and cleanliness of the DG units deployed in DR programs will improve, in order to improve the economics and competitiveness of such DR resources. Just as more efficient and cleaner generation has been seen by many in the environmental community as something to support, the same will increasingly hold true for generation used in DR. Third, it is important to look at the forest as well as the trees. Modeling done on the New England region shows that even with DG in a regional DR scenario, there can be net benefits.

Furthermore, by shifting consumption from peak to off-peak, DR can shift plant utilization and fuel type with attendant environmental consequences. This effect, while potentially dramatic, is challenging to measure or even model since it is both utility/ISO-specific as well as time-of-day and season-specific. Therefore, many combinations of generation fuel-switching and individual unit-shifting exist. And, as always, DR doesn't just shift consumption (and therefore generation), but usually reduces it. But emissions tracking and measurement will continue to develop in the years to come and will allow better analysis of this issue.

At the heart of this issue is the magnitude of the DR-driven shift and the difference in environmental performance between the units less utilized and those more utilized. Furthermore, it is marginal performance that counts: The number of shifted megawatts alone will understate the avoided particulate emissions if, for example, the shift avoids cold-starting a diesel generator at peak. And a given shift may worsen one environmental problem while simultaneously moderating another or shifting its location with regard to a population center or an environmentally sensitive area.

While system-specific factors make it impossible to generalize, many systems use open-cycle natural-gas plants at peak and coal or nuclear for baseload. Therefore, a shift from peak to off-peak is likely to decrease the use of gas and likely to increase coal use (assuming that nuclear utilization does not fluctuate with demand). This scenario leads to an increase in CO_2 emissions and mixed changes in other emissions. Once again, however, the magnitude of the increase is low due to the low number of kilowatt-hours that are "in play."

The shift in generation and emissions from peak to off-peak times also may improve air quality modestly because certain pollutants are sunlight and temperature sensitive. DR can shift the emission of the precursors of ground-level ozone and smog (NOx, SOx, and particulates) from very hot summer afternoon peaks to early evening when smog and ozone are less likely to form.[8] This has begun to be investigated in the northeast United States, where the Ozone Transport Commission and individual state environmental agencies are looking at DR as a new tool to use in non-attainment areas. DR may one day be seen as a potential dynamic emissions tool.[9]

Because DR trims load at peak times it leads to the more efficient utilization of existing supply-side resources and potentially defers or decreases the need to develop additional generation, transmission and/or distribution. These facilities —particularly transmission lines—can face significant environmental, land use and aesthetic challenges.

Importantly, DR's contribution to renewable energy is now beginning to be explored and recognized because DR is well suited to facilitate higher utilization of intermittent power generation, especially wind, as it can readily be used for load balancing as the intermittent source ramps up or down. This will be valuable in systems where the additional utilization of

TABLE 2 Modeling DR's Impact on Air Emissions in New England

(Synapse Energy Economics, 2003[1])

Assumptions:

- large and mature DR program (plus two efficiency program scenarios).
- modeling includes distributed generation.

Key findings:

- When DR is used to meet reserve requirements, net impact is a reduction in criteria pollutant emissions. When DR is not used to meet reserve requirements, impact is much smaller.
- Reductions largest in summer months.
- NOx, SO_2 and CO_2: reduced. Mercury: negligible change. Small increases in air toxics associated with internal combustion engine generators.
- Varying the assumed mix of diesel- and gas-fired generation utilized has "small but significant" impacts on emissions. In specific locations impacts could exacerbate non-attainment problems and pose significant health risks.
- Best case: will reduce most, but not all, emissions.
- Modeled efficiency provides a higher volume of emission reductions than modeled DR.

Modelers' caveats:

- results are specific to New England and "should not be extrapolated" to other areas.
- to realize the NOx and SO2 reductions, air regulators must ensure that they are not "leaked" through emissions trading where DG is outside scheme.

1 "Modeling Demand Response and Air Emissions in New England", Synapse Energy Economics, (Revised) Sept. 4, 2003.

renewables already is constrained by their intermittency, thereby allowing additional use of renewables and the attendant reduction of emissions. This is an issue that is only beginning to be explored, but one where it may be that DR becomes an important part of the support infrastructure for renewable energy development.

Looking Forward: Improving the Family Business

Siblings though they may be, DR and energy efficiency have been raised in separate households. Until recently, efficiency and DR programs rarely were developed with regard to the other, and unfortunately, respective opportunities to save energy and to reduce peak demands (nevermind lessening environmental impacts) have been missed. We are not suggesting that all efficiency efforts should maximize peak reductions, nor that all DR should focus on overall energy savings. Rather, utilities and government should consider the implication of these efforts on the other—and, ideally, strive to optimize reductions in energy consumption, peak demand and environmental degradation.

Specifically we recommend that the following be considered:

■ Conduct system and time-specific analyses including the time-of-use of efficiency savings from DR to calculate accurately the financial value of the savings (both short and long-run) and the environmental effects. For starters, building codes should be based upon the time that savings will occur. California's Title 24 recently was updated to reflect time-differentiated value of electricity savings from required efficiency measures: Other jurisdictions also can update their building codes based upon time-of-savings valuations and even the local geography of transmission constraints.

■ Maximize approaches that do "double duty" of both efficiency and peak reduction, such as advanced meters and advanced lighting controls. Doing so not only enhances the cost-effectiveness of demand-side resources, but can be thought of as a "No Regrets" approach if the value from one side of the equation is large enough to justify the activity even without the other side. Smart appliances that recognize and act upon DR rates or signals will make growing contributions to peak management if their deployment is accelerated by market-transformation programs that recognize the combined value of DR and efficiency.

■ Recognize the contribution to electric reliability that can be made by both DR and efficiency: More action is needed by utility commissions and industry groups to take steps on DR as a key element toward bringing about a modern, and more reliable, grid.

■ Ensure that air-quality rules and programs, such as state implementation plans, fully recognize efficiency and DR's value in reducing emissions. Often overlooked is DR's potential contribution to slowing climate change. In part this is understandable because its contribution is smaller than efficiency's very important role, but in part DR is underappreciated, in this country at least, as a climate strategy. By contrast, it is valued in Europe to lessen CO_2 emissions; for example, the U.K. government-sponsored Energy Savings Trust considers advanced meters to be an energy efficiency technology and attributes significant savings to their use.

■ Appreciate that consumers rarely are interested in the distinctions among demand-side measures discussed in this article but rather in bottom-line results—lower power bills, rebates on new equipment, lessened risk and better environmental performance. Energy efficiency and DR advocates may well find that working together to promote overall demand-side management may yield political results that could not be achieved by either side alone.

In the famous parable of the blind men feeling different parts of an elephant, each one envisions a different animal. In the same way, some view DR as a way to ensure reliability, some see it as a way to avoid costs and reduce peak prices, some see it as a way to mitigate market power, and some see it as a way to get a new modern grid infrastructure in place. All of these observers are correct—DR can do all of those things. But other parties also must grab the elephant. DR and its enabling technologies are also a way to help customers reduce their overall energy use and move to a new era of energy efficiency—both at the individual customer level and overall. Moreover, DR can make an important contribution to broader environmental issues like global warming, air emissions and renewable energy. DR offers much—and offers different things to different parties. It is important as national and state energy policy and utility practices develop in the coming years that Demand Response be viewed comprehensively and robustly and be given a full seat at the table.

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Endnotes

1. Chris King and Dan Delurey "Twins, Siblings or Cousins? Analyzing the conservation effects of demand response programs," *Public Utilities Fortnightly*, March 2005.
2. "Are Smart Homes More Efficient? Energy Impact of California's Residential Automated Demand Response Program," Katherine *(Cont. on p. 66)*

CIOs Under Pressure

(Cont. from p. 39)

grown application that we make available to the constituents.

Fortnightly: What portion of BPA's budget goes to IT?

LB: Our expense budget for 2007 is $58 million for IT. For 2006, our total operation revenues were $3.4 billion. After expenses, our net operating revenues would be $872 million.

Fortnightly: If you had a blank check to change anything at your organization, what would you do?

LB: I think this enterprise GIS movement is the way I would answer that. GIS holds so much potential for us, and I think it is very appealing to IT folks because it's exciting. It's new and impressive technology. It gets that information into the hands of people in the field, and I think it will allow them to make better decisions and make better use of their time. In the long run, that should be good for the agency.

The other thing that's important to state is how important security is to us. If you look into the future and ask what concerns us the most, I'd have to say security is becoming more and more of an issue for us to keep our eyes on.

Because we're part of the government, protection of personally identifiable information is just critical to us. We have to make sure our systems comply with all of the requirements from the Department of Energy as well as the White House. It's not a small issue. Cyber-security, protection of our grip ops, SCADA security—that's the one thing I want to make sure we do a good job of in the future.

The leadership here supports this. We have a cyber-security group now within IT that reports up to me, and that group is being challenged to do more and more. Staffing in that group will increase in 2007.

The Green Effect

(Cont. from p. 45)

Wang and Joel Swisher, Rocky Mountain Institute, August 2006.

3. "Changing How People Think About Energy," Marjorie Isaacson, Larry Kotewa, and Anthony Star, Community Energy Cooperative and Michael Ozog, Summit Blue Consulting, August 2006.
4. Quantum Consulting, "Working Group 2 Demand Response Program Evaluation – Program Year 2004 Final Report," December 2004
5. "Direct Energy Feedback Technology Assessment for Southern California Edison Company," prepared by Lynn Fryer Stein and Nadav Enbar, EPRI Solutions, March 2006. It should also be noted that there is a risk of self-selection bias toward those more interested in conservation.
6. Sarah Darby, Oxford University, "Making It Obvious: Designing Feedback into Energy Consumption," in Energy Efficiency in Household Appliances and Lighting, edited by Bertoldi et. al., Springer, 2001. Also see "Advancing the Efficiency of Electricity Utilization: Prices to Devices," Background Paper for 2006 EPRI Summer Seminar.
7. Wang and Swisher, *op. cit.*
8. "A Survey of Time-Of-Use (TOU) Pricing and Demand-Response (DR) Programs" Energy and Environmental Economics Inc., for U.S. Environmental Protection Agency, July 2006.
9. "Analysis of NOx Emission Reduction Potential From Demand Side Resources" Art Diem, U.S. Environmental Protection Agency, presentation at Ozone Transport Commission, September 2006.

The Missing Link

(Cont. from p. 57)

utility offers a variety of programs targeted at different classes of customers.

17. On 20 July 2006, Pacific Gas & Electric Co. received approval from the CPUC to convert its entire system—5.1 million electric meters—by 2011 at a cost of $1.74 billion. CPUC wants the other two IOUs to follow a similar path within a similar time frame.
18. Province of Ontario has proposed to convert all electric meters to digital variety by 2010.
19. For example, the state of California has established the Demand Response Research Center (DRRC) at the Lawrence Berkeley National Laboratory (LBNL) singly devoted to DR issues.
20. There are, of course, a myriad of other promising solutions, including one developed at DRRC called AutoDR.
22. The project was successfully demonstrated during a field demonstration at the California Energy Commission (CEC) in mid August with participation of the California ISO and California's three IOUs.
22. DRBizNet Press Release, 11 Aug 2006 available at www.DRBizNet.org.

Advertising Index