Inclining Toward Efficiency

Is electricity price-elastic enough for rate designs to matter?

BY AHMAD FARUQUI

Energy costs continue rising, driven largely by an unprecedented run-up in crude oil prices. As this issue went to press, crude oil futures were selling at more than $140 a barrel. Some analysts are projecting prices in the $200 range before year end.

More expensive oil means more expensive natural gas, with prices now exceeding $13/Mcf. Likewise, coal prices are rising dramatically, partly in a competitive response to higher oil and gas prices, and partly in response to anticipated carbon regulation. In addition, power-plant capital costs are expected to continue rising because of growing demand in China and India for basic construction raw materials, such as cement and metals. According to one study, the cost of building new power plants is up 19 percent from a year ago and up 69 percent from three years ago.[1] Another study estimates the industry might require $1.5 trillion to meet its generation, transmission and capacity needs between now and 2030.[2]

Thus, in virtually every scenario, customer utility bills will rise significantly.[3] Regulators and utilities are searching for ways to avoid a repetition of the rate-shock syndrome of the 1970s.

> Many inclining block structures are remnants of yesterday's lifeline rates, primarily focused on equity criteria.

Energy efficiency has risen to the top of potential solutions. It well may be the fastest way of helping customers cope with rising utility bills. In addition, it could help utilities and regulators deal with two related problems: greenhouse gas (GHG) emissions that induce climate change and resource shortfalls that threaten system reliability.

While many utilities and state regulators are pursuing dynamic pricing structures to improve demand-response and peak-shaving capabilities, the industry traditionally has assumed electricity is too price-inelastic for rate structures to produce meaningful reductions in total energy use. More recent studies and models, however, suggest some approaches to inclining block rates might encourage significant conservation, with long-run reductions in electricity use nearing 20 percent, and customer bills falling by more than 25 percent.

DSM Redux

The industry has begun responding to these challenges by reactivating demand-side management (DSM) programs. These programs, which have a long history going back to the late 1970s, were mothballed when industry restructuring arrived in the mid 1990s. DSM spending in the United States peaked in 1993. Industry restructuring put a halt to most DSM activities, because incumbent utilities feared that higher electric rates, which often accompanied large-scale DSM spending, would make them uncompetitive. In addition, after several utilities spun off their newly unregulated generation function from their regulated transmission and distribution functions, it was unclear who would be responsible for planning and implementing DSM programs.[4]

As utilities and commissions reinstitute DSM programs, they face the same problems that plagued the first-generation programs. The first problem is inadequate and delayed recovery of DSM expenditures. This can be redressed through better regulatory treatment of DSM spending. The second problem is the adverse effect of falling sales on utility earnings. This can be overcome by decoupling utility earnings from sales. The third problem is the lack of an incentive for engaging in what many on Wall Street find to be a counter-intuitive activity—reducing sales. This can be overcome by providing utility owners a small share of the net societal benefits created by DSM, as California has done, or by providing them a large share of the gross avoided costs, as envisioned in Duke Energy's Save-a-Watt program.

Many experts who have spoken at national conferences during the past year foresee a surge of DSM programs. They are of the opinion that one quarter to one half of the 30-percent growth in energy consumption the U.S. Energy Information Administration predicts will occur between 2008 and 2030 can be offset by utility energy-efficiency programs. This will require spending as much as 5 percent of utility revenues on DSM programs by 2030. But is that the only way of achieving energy efficiency?

A multi-faceted, portfolio approach likely will be more effective in promoting energy efficiency than will any single avenue. In the past, much DSM activity was centered on utility-funded programs that provided cash rebates to participating customers to reduce the incremental cost of buying expensive equipment. In some cases, customers also were provided zero- or low-interest financing. For a variety of reasons, DSM programs failed to reach all eligible customers and even the best programs failed to reach the vast majority. This created cross-subsidies from non-participants to participants that invariably became quite contentious. Arguably cross-subsidies were among the most important reasons the DSM industry collapsed in the mid 1990s.

A portfolio approach might prevent a recurrence of these problems and yield a least-cost solution. Such an approach may involve five lines of attack:

- **DSM**: Rebates and low-interest financing for buying efficient equipment (the traditional approach);
- **Information**: Information about efficient usage accessible to all customers through multiple channels such as the mass media, talk shows, kiosks, in-home displays and Web sites;
- **Mandates**: Governmental codes and standards set at the local, state and federal levels for efficient residential and commercial appliances, homes and commercial buildings and industrial processes;
- **Technologies**: Efficient technologies and building designs coming to fruition via research, development and commercialization; and
- **Rate design**: Intelligent rate designs that provide an incentive to use energy wisely.

In the fifth category, dynamic-pricing options are receiving widespread consideration today, especially as more and more utilities decide to pursue advanced metering infrastructure (AMI) and find difficulty justifying all the investment costs with operational benefits.[5] Dynamic pricing lowers peak-period demands and avoids expensive peaking capacity, which otherwise sits idle for all but a few hundred hours a year. One recent study quantified at $31 billion the national savings that would accrue from just a 5-percent reduction in peak demand.[6] However, by itself, dynamic pricing is not likely to have much of an impact on overall energy consumption, since the high prices prevail during critical-pricing periods only. For the same reason, it cannot make a huge dent in customer bills.

Inclining Block Rates

There is another type of rate design that can make a major contribution to a utili-

TABLE 1 **DISTRIBUTION OF RESIDENTIAL PRICE ELASTICITIES**

		Low	Most Likely	High
Short Run	Block 1	-0.01	-0.13	-0.20
	Block 2	-0.02	-0.26	-0.39
Long Run	Block 1	-0.03	-0.39	-0.60
	Block 2	-0.06	-0.78	-1.17

Source: The Brattle Group

ty's energy-efficiency goals. This is the inclining block rate, variants of which have been around for a long time. Under such a rate design, the price of electricity rises with increasing usage. But rather than rising uniformly with each kilowatt hour consumed, it rises in blocks of several hundred kWh.

The most common example is the lifeline rate created in the 1970s to mitigate the effect of rising prices on low-income users and to ensure that essential uses of electricity remained affordable for all customers. However, most customers today receive electric service under some type of energy-cost adjustment clause, which means their bills rise as energy costs rise, even though the underlying base rate in the tariff does not change. Lifeline usage, as well as usage above that amount pays more, and the issue of affordability is rendered moot.

The inclining block rate can be very effective in promoting energy efficiency if it is applied as the default rate. Unlike voluntary DSM programs, it would apply to all customers, not just to those who choose to participate. It has very small administrative or overhead costs and would cost only a fraction of the amount expended when low-interest financing or rebate programs are used to buy-down purchases of high-efficiency appliances, building materials and processes. A final benefit, for those regions that still are evaluating the economics of advanced metering, is that it does not require changing out existing meters. Of course, the availability of new technologies such as in-home displays enabled by AMI or smart-grid functionalities would further enhance the appeal of inclining block rates and magnify the energy and bill savings.

A recent survey of 61 U.S. utilities carried out by BC Hydro reveals that only a third had inclining block rates. About half had year-round flat rates and the rest had declining block rates in at least one season.[7]

Even where inclining block rates are present, they might no longer reflect current cost conditions or energy-efficiency goals. In many cases, they likely are remnants of yesterday's lifeline considerations, which primarily focused on equity criteria. These rate designs need to be re-tooled and modernized.

The process of constructing, re-constructing or modernizing inclining block rates will vary by jurisdiction, but the analytical steps will be quite similar.

The first step is to pin down the ratemaking objectives. Is the rate-design goal to reflect costs more accurately than existing rates, promote social objectives such as income re-distribution, or promote energy efficiency? Are there other goals that must be accounted for, such as revenue stability or rate continuity?

Second, begin gathering the relevant data. Depending on how the first question is answered, different data will be needed. If the desire to reflect costs is the dominant concern, then get data that shows how costs move with usage. If the desire is to conserve energy, then identify the magnitude of the energy-efficiency goal.

> Higher rates, milder temperatures, and an energy crisis advertising campaign helped reduce California's usage by 10 percent in 2001.

Third, determine the number of blocks in the rate design. Two or three blocks usually suffice to get the message on rising costs through to customers, provided the message is conveyed clearly on the monthly bill. If a rate re-design is envisioned, it would make sense to signal it clearly. It would make little sense to create a new rate where the second block only applies to a small fraction of customers, or to apply the second block to usage that exceeds last year's usage or some other historical baseline.

Fourth, determine the height of the blocks. The height between the blocks should be significant or it won't be noticed by customers. Nationally, many existing inclining block rates are much too mildly differentiated and are unlikely to lead to any energy efficiency. A notable exception is California, where the rates are much too steeply differentiated, are not cost-based and have caused numerous equity problems.

Fifth, assess the distribution of bill impacts across the full range of customers. This is a fairly straightforward exercise and can help identify how low-use customers will see a drop in their bills and how high-use customers will see a rise in their bills. The assessment initially should assume no price response and then be repeated with an assessment of likely price response, after the next step has been performed.

Sixth, assess the impact of the rate re-design on utility sales and revenues. This will require knowledge of the price elasticity of demand.

Estimating Elasticity

EPRI recently surveyed the vast literature on price elasticities,[8] concluding that residential short-run price elasticity ranges between -0.2 and -0.6, with a mean value of -0.3. Long-run elasticities range between -0.7 to -1.4 with a mean value of -0.9.

One of the studies surveyed by EPRI is noteworthy because it contains customer-level price elasticities. These are estimated using cross-sectional data on California households from the mid to late 1990s.[9] In aggregate terms, it reports a residential price elasticity of -0.39. The study finds that 44 percent of customers have no price elasticity. The price elasticity varies across households, as low as -0.08 for households with no electric space heating or central air conditioning and as high as -1.02 for households with electric space heating. Since the elasticities are derived using cross-sectional data, there is some issue concerning whether the elasticities are short run or long run in character.

The study simulates the effect of California's transition from two tiers to five tiers that took place in the wake of the energy crisis of 2000-2001. Inclining block rates first appeared in California in the late 1970s following the two oil shocks with baseline provisions providing for reduced rates for the first 50 to 60 percent of the typical household usage.[10] In 1988, the California legislature enacted Senate Bill 987 to limit the differences between baseline and non-baseline rate levels and to provide for different seasonal and geographical baseline allowances. The differentials between baseline and non-baseline rates were not established using marginal cost studies. Instead, rate affordability was the driving concern. It led to a 15-percent differential between baseline and non-baseline rates and additionally led to a 20 percent discount called CARE for low-income customers.

During the 2001 energy crisis, when average rates increased by nearly 4 cents/kWh, rate affordability again was paramount among policymakers' concerns. The legislature passed special legislation (Assembly Bill 1X) that froze rates for the existing first block (which was the baseline usage) and a second new block that was equal in size to 30 percent of the first block with rates set at the original non-baseline rate level. Three new blocks were created to pass through the incremental costs of managing the crisis, yielding a five-block rate design.[11] The energy crisis revenue allocation also shifted two-thirds of the residential customers' shares of increased costs to commercial and industrial customers. The gradual reversal of this inter-class rate subsidy, coupled with capped Tier 1 and Tier 2 rates and increasing costs, have led to upper-tier residential rates that now are between 2 and 3 times the lowest baseline rate levels. The combined effect of higher rates, milder temperatures, and a state-wide energy-crisis advertising campaign helped reduce annual usage by 10 percent in 2001.

A much earlier study used data from a controlled experiment involving inclining block rates that took place in the mid-1980s in Wisconsin. It found much smaller price elasticities that ranged between -0.02 to -0.04.[12] These estimates were not statistically significant for the summer-peaking season. However, statistically significant price elasticities of -0.04 were found in California's recent experiment with dynamic pricing that ran during 2003-2005.[13] Notably, the California price elasticities were derived when dynamic prices were superimposed on the state's exising inclining block rate design.

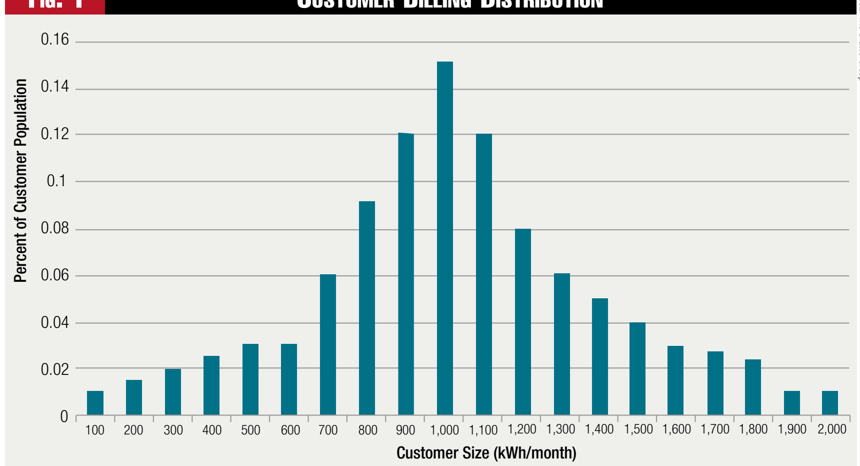
A RAND Corp. study for the National Renewable Energy Laboratory in 2005 reported price elasticities by state.[14] It used nearly 30 years of consumption and pricing data to estimate both short-run and long-run electricity price elasticities for residential and commercial customers. It estimated residential price elasticity at -0.24 in the short run and at -0.32 in the long run.

A finding common to most studies is that higher-use customers have bigger price elasticities. That may be because they have more discretionary use, higher incomes and higher education levels.

Based on a synthesis of the best available information, the Brattle Group assembled triangular probability distributions for residential price elasticities by block for both the short run and the long run (*See Table 1*). Short-run

> **Inclining block rates might reduce consumption by 6 percent in a few years and even more over the long run.**

Fig. 1 Customer Billing Distribution



SOURCE: The Brattle Group

TABLE 2 **IMPACT ON USAGE AND REVENUE**

Price Elasticity		Rate A	Rate B	Rate C	Rate D
		Avg Percent Change in Usage			
Short Run	Mean	-5.9%	-2.2%	-1.0%	-0.5%
	Std Dev	2.0%	0.8%	0.3%	0.2%
Long Run	Mean	-18.4%	-6.7%	-3.1%	-0.7%
	Std Dev	6.5%	2.4%	1.1%	0.4%
		Avg Percent Change in Class Revenue			
Short Run	Mean	-9.1%	-3.1%	-1.0%	-1.4%
	Std Dev	3.1%	1.1%	0.4%	0.5%
Long Run	Mean	-28.4%	-9.4%	-3.3%	-2.6%
	Std Dev	9.9%	3.4%	1.1%	1.0%

Source: The Brattle Group

responses are driven by behavioral changes and long-run changes by equipment and building shell changes. Long-run responses reflect customers' acquisitions of energy-efficient appliances and homes.

Generally (but not always) Block 1 price elasticities might be expected to be lower than Block 2 price elasticities. Also, price elasticities in the two blocks likely would correlate, and long-run price elasticities would be substantially higher than short-run price elasticities. Using these assumptions, analysts can estimate the magnitude of energy savings that can be realized by switching to inclining block rates.

Predicting Energy Impacts

To predict the impact of energy-efficient rate designs, the Brattle Group constructed a rate inverter module in The Prismatic Suite of models the firm built last year to analyze the economics of dynamic-pricing rates.[15] The inverter is applied to a synthetic utility, dubbed Smart Power & Light Company (SP&L). It has 1 million residential customers who currently are being served power at a flat rate of 10 cents/kWh.[16] The average SP&L customer uses 1,000 kWh a month. Customer usage is spread out between 0 and 2,000 kWh a month (*See Figure 1*). The mean value is 1,038 kWh.

Four inclining block-rate designs are developed to sketch out the possibilities (*See Figure 2*). All feature inclining rates with two blocks. But they differ in the width of the first block and in the height of the step between blocks. For three of the rates, the first block lies below the average use per customer and in one of the rates it is above average use. The rates also differ in the ratio of prices between the blocks, which range from 1.27 to 3.72.

All the inclining block rates are designed to be revenue neutral for the residential class as a whole. So, in the absence of any price response, they will yield the same class revenue (*See Figure 3*).

The amount of price response will depend on the price elasticity of energy consumption. Given the uncertainty in price-elasticity estimates, results are provided using Monte Carlo simulation.

For Rate A, the mean drop in usage in the short run is 5.9 percent, and given the standard deviation of 2.0 percent, the model provides a 95-percent confidence band ranging from 1.9 percent to 9.9 percent (*See Table 2*). This band represents the uncertainty created by lack of precision in the available knowledge about price elasticities. Customer bills decline in the aggregate by 9.1 percent. Long-run responses are much higher, with the mean drop in usage at 18.4 percent and the mean drop in customer bills at 28.4 percent.

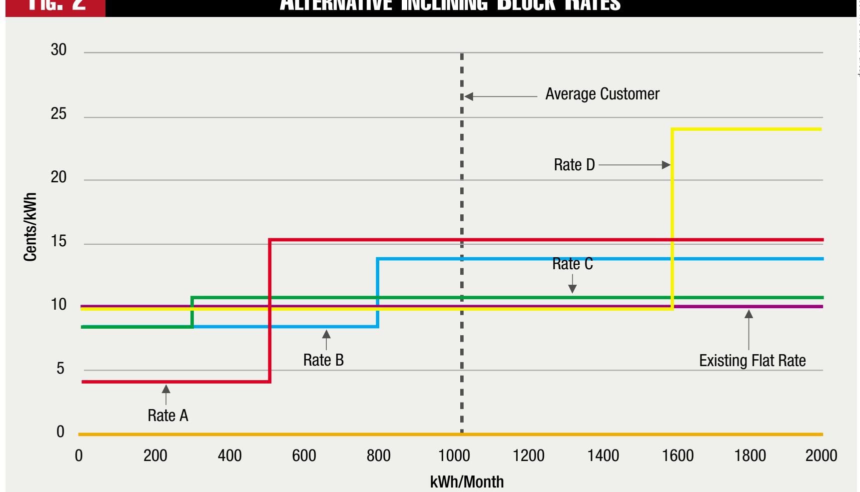
Moving from Rate A to B, C and D, the model produces lower values for usage reductions and bill reductions, because either lower amounts of class usage than those used in Rate A are being exposed to prices that exceed the current flat rate, or because the amount of the price change relative to the flat rate is smaller than in Rate A.

Optimizing Rate Design

Based on empirical estimates of price elasticity from a number of different sources, inclining block rates can provide energy consumption savings in the 6 percent range over a few years and even higher savings over the long run.

The costs associated with inclining block rates likely will be small, arising from the need to make simple modifica-

FIG. 2 **ALTERNATIVE INCLINING BLOCK RATES**



Source: The Brattle Group

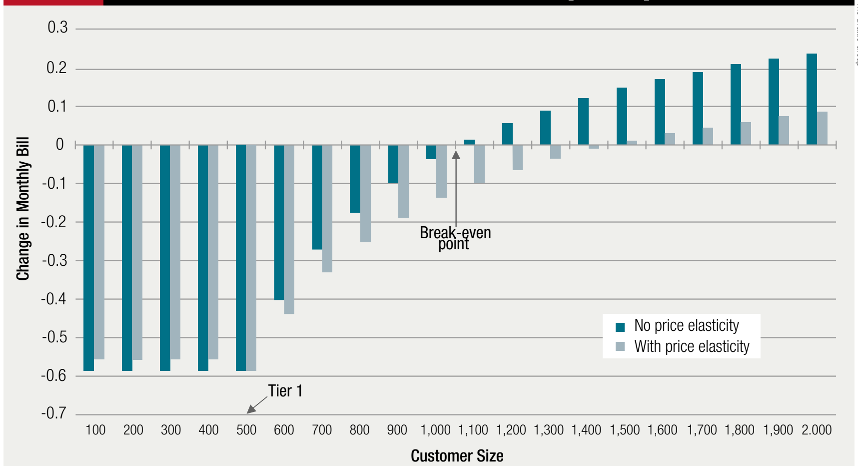
tions in billing systems, train customer-service personnel and educate customers on how to deal with the rates. It is possible to envision a bright future for energy-efficiency activities, with inclining block rates providing a complementary stimulus to DSM programming, accelerating the payback period for customers for upgrading to higher efficiency appliances and dwellings and reducing program costs.

It's important to note that no evidence shows inclining block rates can produce demand response, which is an intrinsically dynamic concept. In order to achieve the dual goals of energy efficiency and demand response, it would be useful to couple inclining block rates with dynamic pricing. This approach is increasingly interesting to regulators and utilities nationwide.[17]

Perhaps the best case study in this regard is the state of California, which, despite having a long tradition of inclining block rates, is moving in the direction of making dynamic pricing a default tariff.[18] Dynamic pricing can't be accomplished without AMI. Once AMI is in place, an important side benefit would be the ability to provide near real-time information to customers about their accumulated monthly consumption. This feature could be used to alert them as they approach the higher priced tiers. By so doing, the amount of energy efficiency obtainable through inclining block rates would be optimized.

Ahmad Faruqui is a principal with The Brattle Group in San Francisco. *He acknowledges assistance from Stacy Angel, Robert Earle, Russ Garwacki, Phil Hanser, Ryan Hledik, Roger Levy, Mike Oldak, Lawrence Oliva, Calvin Timmerman, Laura Waters and Lynda Ziegler. Special thanks to Hledik for performing the simulations described in the "Predicting Energy Impacts" section, and to Earle for insights on price elasticity simulations in general.* *Email the author at ahmad.faruqui@brattle.com.*

FIG. 3 BILL IMPACTS BY CUSTOMER SIZE (RATE A)



Inclining block rates are designed to be revenue neutral for the residential customer class, so total sales won't change if prices have no effect on demand (dark blue bars). But to the degree electricity demand is price-elastic (light blue bars), inclining block rates will encourage significant conservation by customers—particularly those whose consumption exceeds the Tier 1 rate block.

ENDNOTES

1. Rebecca Smith, "Costs to Build Power Plants Pressure Rates," *The Wall Street Journal*, May 27, 2008.
2. Peter Fox-Penner, Mark W. Chupka and Robert L. Earle, "Building to Serve: Long-Run Utility Infrastructure Investments," Edison Foundation Conference, New York City, New York, April 21, 2008.
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4. Ahmad Faruqui, Greg A. Wikler and John H. Chamberlin, "Clouds in the future of DSM," *The Electricity Journal*, July 1994.
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6. Ahmad Faruqui, Ryan Hledik, Sam Newell and Johannes Pfeifenberger, "The Value of Five Percent," *The Electricity Journal*, October 2007.
7. BC Hydro, "2008 Residential Inclining Block Rate Application," Vancouver, B.C., February 2008.
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9. Peter C. Reiss and Matthew W. White, "Household Electricity Demand, Revisited," *Review of Economic Studies,* 2005, 72, pp. 853-883.
10. In 1982, AB 2443, also known as the Baseline Act, established baseline quantities of energy equal to 50-60 percent of average residential consumption by climate zone and up to 70 percent of average consumption for all electric and gas customers. The Baseline Act required baseline quantities to be priced at 75% to 85% of the system average rate.
11. The resulting rate design is not cost based and is not recommended as an example of an inverted block rate. It has created significant cross-subsidies between customers who use less than 130 percent of baseline use and those who use about that threshold amount. Various efforts are underway to quantify these cross-subsidies at the Demand Response Research Center and the UC Energy Institute. Efforts also are underway to repeal the non-cost based features of the rate design.
12. Joseph A. Herriges and Kathleen K. King, "Residential Demand for Electricity Under Inverted Block Rates: Evidence From a Controlled Experiment," *Journal of Business & Economic Statistics*, October 1994, Vol. 12, No. 4, pp. 419-430.
13. Ahmad Faruqui and Stephen S. George, "Quantifying Customer Response to Dynamic Pricing," *The Electricity Journal*, May 2005.
14. Mark A. Bernstein and James Griffin, "Regional Differences in the Price-Elasticity of Demand for Energy," prepared for the National Renewable Energy Laboratory, The RAND Corp., Santa Monica, California, 2005.
15. This suite of models evolved from the Pricing Impact Simulation Model (PRISM), developed to synthesize results of California's Statewide Pricing Pilot in 2004-05. It includes a rate designer module that develops revenue-neutral dynamic pricing rates, a PRISM module and a benefits analyzer module that assesses the avoided costs of demand response. The suite is available from Mike Oldak of the Edison Electric Institute, *moldak@eei.org*.
16. The Inverter module also can be applied to assess the impact of switching from a declining block rate to a flat or inclining block rate.
17. Ahmad Faruqui, "Breaking out of the bubble: using demand response to mitigate rate shock," *Public Utilities Fortnightly*, March 2007; and Ahmad Faruqui and Jackalyne Pfannenstiel, "California: Mandating Demand Response," *Public Utilities Fortnightly*, January 2008.
18. Remarks by President Michael Peevey of the California Energy Commission at the National Town Meeting on Demand Response, Washington, D.C., as cited in *MW Daily*, June 3, 2008.