Exploring the Relationship Between Demand Response and Energy Efficiency: A Review of Experience and Discussion of Key Issues

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March 2005

Report Number U052

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Note: Appendix A is available for download for free along with the main body of this report, while Appendices B through D are available only in hard copy, along with the main body and Appendix A.

ACKNOWLEDGEMENTS

ACEEE thanks the following organizations for their funding support for this project:

- The California Energy Commission
- The California Institute for Energy Efficiency (CIEE)
- The Energy Foundation
- National Grid
- New York State Energy Research and Development Authority (NYSERDA)
- Pacific Gas & Electric
- Sempra Utilities
- Southern California Edison
- The U.S. Department of Energy
- Xcel Energy

We also thank the many individuals within these organizations who guided the research and provided data for and input to our work. We also thank Ed Vine, Patti Witte and Bill Prindle for important technical assistance on the project, and Renee Nida for her assistance in report editing and production.

Our work relied heavily on input from a wide and diverse set of demand response experts, including program managers, evaluators, resource planners, economists, engineers, regulatory staff, and program participants. We thank all of these individuals for their time, input, and assistance.

EXECUTIVE SUMMARY

Demand-Response Program Experience

"Demand-response" programs and technologies have been heralded in recent years as a great advancement in providing customers new options for managing their energy costs and use along with providing energy suppliers new options for assuring reliable supply at reasonable costs. Proponents of demand-response programs tout numerous benefits from such options, including improved system reliability, cost avoidance, greater market efficiency, improved risk management, reduced negative environmental impacts, improved customer service, and market power mitigation. Crisis and near-crisis conditions and events have spurred the development and practice of demand response in many states and regions.

The electric utility industry generally has shown a great deal of interest in expanding the use of demand-response programs and technologies. Utility regulators at the state and especially the federal level have shown strong support for expanded use of demand-response resources.

Demand-response programs and options have arisen in conjunction with both market and technological innovations over the past decade. Such programs and options seem to be natural developments within restructured, deregulated markets. Coincidental developments with communications, information, and control technologies have opened up a new world of possibilities for energy customers under new market structures, allowing customers access to detailed, real-time (or near real-time) energy use data and providing them options—both manual and automatic—to respond to pricing information and other communications about market conditions, such as system emergencies.

In this project we examined experience with demand-response programs in the United States to capture a comprehensive picture of the state of this practice to date. We reviewed program experiences and also identified gaps in available knowledge about such programs.

A key objective of this project was to examine the relationship between energy efficiency and demand response. Demand-response programs seek to reduce peak demands during times when reliability may be threatened or wholesale market prices are high. However, reducing demand is not the same as saving energy, although there are clearly relationships between reducing peak power demand (kilowatts [kW]) and saving energy (kilowatt-hours [kWh]). There may be "spill-over" impacts on overall, non-peak energy use from demand-response programs. Programs also may target both objectives.

Despite the wealth of information available on the theory and practice of demand response, relatively little research had been done on the relationship between demand response and energy efficiency. As we conducted the study, we were somewhat surprised to discover how little attention has been focused on that issue. We found this to be a major area in need of research, testing, and analysis.

In our review we have observed that experience to date with demand-response programs has generally been positive. Scores of the different types of demand-response programs have been offered and are in place across the United States. Many have their origins in the practice of utility demand-side management from the 1980s and 1990s. Certain states and regions have been especially active in developing and offering demand-response programs, notably California, New England, the Northwest, and New York and other Middle Atlantic states, but programs can be found in most states.

Demand-response programs are generally divided into two broad categories, "load-response" programs and "price-response" programs (PLMA 2002), a convention we follow in this report although there are clearly overlaps. Most demand-response programs offered to date have been load-response programs, which focus on providing load relief to maintain system reliability. Load-response programs comprise the largest demand-response resource in terms of their contributions to peak-load reductions. This is not surprising as these types of programs are well established and have been successfully used for decades. Interruptible and curtailment programs are the primary examples of load-response programs.

"Price-response" programs have been the focus of many recent programs and initiatives, especially dynamic pricing such as critical peak pricing and real-time pricing. There is widespread conceptual support for exposing electricity customers to prices that reflect actual market conditions and associated prices.

Despite the growing interest in price-response programs, experience with such programs to date shows mixed results. Dynamic pricing—particularly real-time pricing—is the category of price-response programs that has garnered the greatest attention and focus in recent years, although there have been a handful of such programs with a much longer history. Experience with real-time pricing (RTP) programs is mixed, however. Participation in and impacts from these programs varies widely. With a few noteworthy exceptions, only a few have achieved significant absolute or relative impacts in terms of load reductions achieved. In a recently published comprehensive review of 43 RTP programs offered to commercial and industrial customers, a surprisingly high fraction of RTP customers appear to not be very price sensitive (Barbose, Goldman, and Neenan 2004).

Experience with dynamic pricing has been limited mostly to large commercial and industrial customers. There are, however, pioneering efforts with residential dynamic pricing in a few states, including California, Illinois, Florida, Washington and New York. Some of the initial results are promising, but it is still mostly too early to assess the full impacts of these programs. These programs should reveal a great deal about how residential customers respond to time-differentiated rates that reflect wholesale market prices and conditions.

The other major type of price response, or market-based, demand-response program is demand bidding. These types of programs have remained a relatively small share of overall demand-response portfolios. They are not nearly as widespread as load-response programs, but may be a potentially important resource in those states and regions that have them.

Demand Response and Energy Efficiency

Demand response and energy efficiency both affect customer end-use of energy. How exactly these primary objectives relate to each other was a primary focus of our research and analysis.

Unfortunately, we found that there is almost no published research on the issue of how demand-response programs affect energy use during off-peak periods and overall building/facility energy use and energy efficiency. There is some mostly anecdotal evidence that suggests certain types of technologies capable of enabling demand response during peak demand periods can also realize energy and demand savings in off-peak periods. We were not able to determine the extent that customers are using these technologies actively as a means of achieving broader energy savings because this simply has not been a research focus within the industry.

We found little quantitative analysis of energy efficiency and conservation impacts from demand-response programs.[1] These impacts would be improvements made to end-uses and operations that yielded greater energy efficiency, which could be targeted to reduce energy use during peak demand, but also yield off-peak energy savings.[2] We found limited anecdotal and qualitative information about such impacts, but we found almost no quantitative evaluation of demand-response program impacts that specifically focused upon estimating and understanding energy efficiency improvements made by customers participating in demand-response programs. This is a major gap in our understanding of the relationship between energy efficiency and demand response.

Yet understanding the relationship between energy efficiency and demand response is vitally important because there are many potential synergies, as well as potential conflicts, between these types of programs. Potential synergies include:

- Energy efficiency can reduce demand permanently, at peak as well as non-peak times;
- Focusing on peak-demand reductions can help identify inefficient and non-essential energy uses that could be reduced at other times, thus resulting in broader energy and demand savings;
- Technologies that can enable demand response also can be used effectively to manage energy use year-round;
- Experience from demand-response activities can lead to greater awareness of energy savings opportunities through improved energy efficiency;

[1] Evaluations of demand response reports do quantify energy and demand reductions (for example, see Neenan et al. 2004). However, these estimates are for reductions due to program “events”—either calls for curtailments/interruptions or for high electricity prices due to high market demand and constrained supplies. This is expected since such reductions are the focus of the programs.

[2] For example, installing more energy-efficient lighting would yield energy savings (kWh) at all times the lights were on—both on and off-peak. Such systems also would reduce peak demand (kW). However, customers participating in demand-response programs typically reduce lighting levels by selectively turning off lights during peak demand periods as a primary means to achieve desired demand reductions.

- Customers who participate in demand-response programs may be prime candidates for participating in other types of DSM programs such as energy efficiency (and vice versa); and
- Program marketing could be more effective at communicating with customers about their energy use by addressing integrated approaches to energy management.

Perhaps the most important potential synergy is simply the fact that participating in a demand-response program, particularly one that features monitoring and control equipment, helps a customer to better understand their energy use and associated costs, and that process may help encourage additional actions to reduce facility energy use and costs.

Unfortunately, the nature of demand response can also create conflicts with energy efficiency objectives. For example, there is room for confusion in marketing messages and other communications to customers about programs and services. Demand response targets reducing loads during a few brief periods over the course of a year, when prices are high or reliability is threatened due to supply constraints. Energy efficiency targets energy savings at all times throughout the year, whenever the affected end-use equipment is being used. This distinction can create some confusion as different building systems, program equipment, and energy decision-making strategies are involved.

Depending on the particular program design, there also can be potential structural conflicts between demand response and energy efficiency for certain types of programs and services. For example, if customers are paid on the basis of the amount of load they can reduce when called upon, measured from a business-as-usual "baseline," there can be a disincentive to take permanent energy efficiency actions that might lower the baseline. For pricing-based demand-response programs, the nature of the conflict is different. Measurement of baselines is not an issue for dynamic pricing—customers pay for energy costs based on the rates at the time of use. However, if off-peak prices are sufficiently low in the rate design scheme, that can act as a disincentive to pursue non-peak energy efficiency measures. Demand-response programs that feature rate discounts as an incentive could have the same effect.

Institutional barriers may also create conflicts between demand response and energy efficiency. As electricity markets have been restructured and made more competitive, the respective responsibilities and incentives for certain types of actions have been fragmented among a new set of market actors. Independent system operators are most concerned with effective demand-response resources as they provide a valuable resource to ensure system reliability.[3] State regulatory commissions and/or state legislatures generally are the primary drivers behind energy efficiency programs and services. Therefore, the funding and structure of programs can occur independently—making it difficult to coordinate and integrate multiple program objectives.

Despite potential conflicts, however, there are conceptual reasons to believe that programs can be designed to target both demand response and energy efficiency. This can be accomplished by promoting either integrated or independent technologies. Some

[3] For example, the New York Independent System Operator (NYISO) has actively promoted and advocated for real-time pricing in its communications.

technologies promoted for their demand-response capabilities can also be used to achieve energy savings objectives (i.e., energy management and control systems). In most cases, however, promotion of specific energy efficiency technologies will be necessary in order to achieve true energy efficiency gains. Fortunately, most energy efficiency technologies also will yield at least some peak-demand reduction benefits. By coordinating demand response and energy efficiency elements in program design, customers could benefit from integrated solutions to their needs for energy cost reduction and related benefits, such as improved building management and control. Somewhat surprisingly, however, we were only able to find a handful of examples where this has been done to any degree. (These examples are discussed individually in the body of the report.)

Although we found that such integration of demand response and energy efficiency elements has rarely been attempted thus far, nearly all of the industry experts we interviewed felt that it was a concept worth testing.

Recommendations

Based on our observations from conducting this research, we have two principle recommendations for policymakers, regulators, and researchers interested in furthering effective demand-side policies and programs.[4]

- *Make it a research priority to study the effects of demand-response programs on overall energy usage.*

  To date, we found that almost no research has been done on this question and very little is known about this issue. We recommend research in this area that would encompass all types of demand-response programs, from load shedding to time-of-use rates, and which would both document the existence of, and make clear the reasons for, any apparent impacts on overall energy use and relative energy efficiency.

- *Make it a policy priority to design and test programs that explicitly combine demand response and energy efficiency objectives.*

  While there are some potential conflicts between demand response and energy efficiency, there are also a number of conceptual reasons why a well-designed integration of demand response and energy efficiency objectives could be a very effective strategy for capturing important demand-side resources.

Finally, it should be emphasized that while we see potential benefits from a more combined programmatic approach to achieving energy efficiency and demand response objectives, there will clearly be an ongoing role for specific program designs that target only one or the other of these objectives. While we focus on demand-response programs and their relationship to energy efficiency in this report, it is important not to overlook the fact that many utilities across the United States have offered and continue to offer effective,

[4] While we recognize that there are a few organizations that are showing some leadership in these areas, we encourage the industry more broadly to recognize these concerns.

successful demand-side management programs—typically distinct (non-integrated) load management and energy efficiency programs. Such programs are achieving significant levels of both peak-load reductions and energy savings—far greater than the estimated total national load reductions achieved by demand-response programs to date. The benefits and proven success of that type of dual-track DSM approach offers a very legitimate conceptual model for utilities to pursue, and we don't wish to discourage that approach. However, we still believe there are good reasons to consider some integration of energy efficiency and demand-response programs and services, and that integrated program designs warrant more research and testing.

In our research and review for this report, we prepared reference materials on demand response and energy efficiency. We provide these materials in the appendices of this report. In Appendix A, we present a catalog and summary information about demand response institutions, organizations, and initiatives. In Appendix B we provide an annotated bibliography of demand response references, with a focus on California and New York experiences as these two states have been at the forefront of research, development, implementation, and evaluation of demand response. Appendix C contains a comprehensive bibliography on demand response and energy efficiency. Appendix D contains a case study investigation that we performed of selected California Energy Commission demand-response programs.

Note: Appendix A is available for download for free along with the main body of this report, while Appendices B through D are available only in hard copy, along with the main body and Appendix A.

PART 1: DEMAND RESPONSE BACKGROUND AND EXPERIENCE

Section 1. Introduction

"Demand-response" programs and technologies have been heralded in recent years as a great advancement in providing customers new options for managing their energy costs and use along with providing energy suppliers new options for assuring reliable supply at reasonable costs. Proponents of demand-response programs tout numerous benefits from those programs, including such societal benefits as these cited by the Peak Load Management Alliance (PLMA 2002):

- Improved system reliability,
- Cost avoidance,
- Greater market efficiency,
- Improved risk management,
- Reduced negative environmental impacts,
- Improved customer service, and
- Market power mitigation

The electric utility industry generally shows strong support for expanding the use of demand-response programs and technologies. According to Edison Electric Institute (EEI 2004), "Demand response—enabling load to be price-responsive—is essential to assure the efficient interaction of supply and demand. It can relieve generation and transmission constraints, reduce the severity of wholesale price spikes, and lead to lower overall energy prices for all consumers."

Utility regulators also show strong support for greatly expanded use of demand-response resources. The Federal Energy Regulatory Commission (FERC 2002) recently has initiated a rulemaking process to develop a "standard market design" (SMD) for wholesale electricity markets. Provisions for using demand response are central tenets within FERC proposals for SMD. State utility regulators similarly support an expanded role for demand-response resources. The National Association of Regulatory Utility Commissioners (NARUC 2000) passed a resolution that called for state regulatory commissions to accommodate demand-side resources and to "remove any unnecessary barriers to customer responses to such wholesale market price signals."

Demand-response programs and options have arisen in conjunction with both market and technological innovations over the past decade. Such programs and options seem to be natural developments within restructured, deregulated markets. After all, the impetus and driving force for such market developments were to offer customers greater choices in meeting their energy needs and to introduce more competitive forces into markets to achieve greater innovation and reduced costs. Coincidental developments with communications, information, and control technologies have opened up a new world of possibilities for energy customers under new market structures. It is possible now to integrate automated control systems with energy information systems so that major customer end-use systems, like lighting or heating, ventilating, and air conditioning (HVAC), can respond and adjust automatically to market signals, such as prices (Shockman and Piette 2004). Customers can program such systems to reduce lighting levels or increase cooling temperature set-points to reduce peak demands and related energy use during periods of high system costs and associated prices.

In this report, we examine experience with demand-response programs in the United States. Our objective is to capture a comprehensive picture of the state of this practice to date. We review program experiences to identify lessons learned and also identify gaps in our knowledge about such programs. Part 1 of this report provides this comprehensive picture of demand response—definitions, types of programs, history, theory, and program experience.

Demand-response programs seek to reduce peak demands during times when reliability may be threatened or wholesale market prices are high. However, reducing demand is not the same as saving energy, although there are clearly relationships between reducing peak power demand (kW) and saving energy (kWh). The nature of these relationships, and the potential for integration of demand response and energy efficiency, is a key area of focus in this report. We address this issue in Part 2 of this report.

Definitions

The practice of "demand-side management" (DSM) was developed during the 1980s to describe a set of technologies, programs, and planning strategies in the electricity industry that seek to modify electric use on the customer side of the meter. To help establish a consistent conceptual framework for demand response in the broader context of DSM, we begin with definitions for three key concepts: load management, energy efficiency, and conservation.

> *Load management* programs seek to lower peak demand during specific, limited periods by temporarily curtailing electricity usage or shifting usage to other periods. These programs typically use communication and control technologies to temporarily reduce demand in specific energy-using devices or systems.
>
> *Energy efficiency* involves technology measures that produce the same or better levels of energy services (e.g., light, space conditioning, motor drive power, etc.) using less energy. The technologies that comprise efficiency measures are generally long-lasting and save energy across all times when the end-use equipment is in operation. Depending on the timing of equipment use, energy efficiency measures can also produce significant reductions in peak demand.
>
> *Conservation* involves saving energy and/or reducing demand by reducing the level of energy services (e.g., setting thermostats lower in winter and higher in summer, turning off lights, taking shorter showers, turning off air conditioners, etc.). It typically involves behavioral changes more than

> technology improvements and typically is not as lasting or reliable as efficiency measures.

In addition to these more traditional components of demand-side management, the term "demand response" has arisen to describe a set of pricing structures, programs, and related customer technologies and services that provide options for customers to change their electrical demand in response to market information, such as prices or notifications of system supply problems. The New England Demand Response Initiative (NEDRI) defines "demand response" in very broad terms:

> Demand response resources include all intentional modifications to the electric consumption patterns of end-use customers that are intended to modify the quantity [[5]] of customer demand on the power system in total or at specific time periods.
>
> —Cowart et al. 2003

The California Energy Commission and California Public Utility Commission define demand response more narrowly, with the emphasis on a response during periods when reliability is threatened:

> Demand response refers to the capacity of customers to reduce their electricity consumption as prices rise in wholesale markets or to reduce their consumption in response to emergency calls for load curtailment when reliability is threatened.
>
> —Messenger 2002

Most definitions of demand response similarly focus on short-term alterations in demand, in response to specific electric system circumstances and/or price signals. For example, the Peak Load Management Alliance defined "demand response" as "load response called for by others and price response managed by end-use customers." PLMA (2002). It added:

> Load response includes: direct load control, such as of residential air conditioners; partial or curtailable load reductions; and complete load interruptions. Those calling for load response include: independent system operators (ISOs), load serving entities (LSEs), and utility distribution companies (UDCs). Price response includes real-time pricing, dynamic pricing, coincident peak pricing, time-of-use rates and demand bidding or buyback programs.

Wholesale market and transmission system operators' two principal motivations are balancing market prices and maintaining reliability. Therefore, modern demand-response programs tend to be either reliability-based or market-based programs. The principal difference between these broad program types is that reliability-based programs are designed to reduce demand at times when system reliability is threatened, whereas market-based

[5] This includes both the level of instantaneous demand (capacity in kW or MW) and total consumption in kWh or MWh.

programs are designed to respond to and help constrain high market prices. "Reliability-based" reductions can be achieved either through voluntary responses by customers or direct action by ISOs, LSEs, or UDCs to shed load through forced service interruptions (curtailments). Emergency supply programs also fall within this category of "reliability-based programs," such as having customers run their back-up generators to support system load. Market-based programs, on the other hand, may also help address reliability problems at times of system supply constraints, but they are primarily designed to increase the economic efficiency of wholesale markets during peak times. Reliability-based programs are also known as "load-response" programs. Similarly, the term "market-based" is often used to refer to "price response" programs.

Demand response is really a large umbrella concept embracing numerous types of programs, technologies, pricing structures, and related options. As NEDRI notes, "A principal lesson of NEDRI's investigations is the realization that 'demand response' is not a one-dimensional concept, but rather a multi-faceted set of resources that can provide value to electric systems and markets in a variety of ways." (Cowart et al. 2003).

Types of Programs

Electricity suppliers and system operators[6] offer a variety of demand-response programs, and new technologies and market mechanisms are creating new opportunities for variations on the basic types of programs. Below we present a brief typology of the major types of demand-response programs. These programs fall under the two broad categories discussed above: (1) "reliability-based"—also known as "load-response" programs; and (2) "market based"—also known as "price response" programs.[7]

Reliability-Based (or Load-Response) Programs

Under reliability-based programs (or load-response programs), electricity suppliers or system operators establish service agreements with customers either to reduce load upon request or to accept control of selected end-use equipment. Generally customers receive some type of economic incentive for entering into such agreements, such as a lower rate for being enrolled in the program and/or specific bill credits should such a service interruption occur. To enable customers to reduce loads on selected end-use technologies, the suppliers or system operators

[6] By "electricity suppliers" and "system operators," we mean to encompass any entity that provides electricity to customers, which in terms of electric utility industry language may be: (1) "utility-distribution companies"—companies that provide local distribution services to customers; (2) "independent system operators"—companies that manage and supply transmission services across a given region; and (3) "load serving entities"—companies that are responsible for supplying electricity to customers. Integrated utilities may perform all three functions, but in states with restructured industries, these functions may be served by separate entities.

[7] While we use the industry convention of dividing demand-response programs into two broad categories (price response and load response), we also observe that these distinctions can be fuzzy. Programs may use pricing mechanisms to encourage load reduction to maintain reliability. And customers willing to curtail or interrupt load for reliability purposes receive an economic incentive to take such action. Perhaps it is most useful to distinguish between programs that rely on a time-varying price signal to which customers may choose to adjust consumption to varying degrees versus programs that rely on a dichotomous "switch" that reduces load in response to some non-price signal or command.

may include installation of the control technologies, which may either be remotely controlled by the companies or controlled by customers. These types of programs have been widely implemented as part of utility demand-side management, specifically targeting peak-demand reduction—also known as "peak clipping" under the nomenclature for "load management" objectives. The load response sought by the utilities or system operators is achieved by these entities invoking the actions for customers either to curtail or interrupt loads.

Reliability-based programs operate in response to system contingencies or emergencies. They include both **contractual** programs (where customers are paid a guaranteed payment per month or per kW in exchange for curtailing their consumption during curtailments, and where customers can be penalized if they do not reduce their consumption within the time frame in their contract when directed) or **voluntary** programs (where participating customers are asked to reduce their consumption when directed, however, they are not obligated to perform the curtailment; participating customers are typically provided some type of incentive to participate (e.g., special reduced rates and/or direct payments of some type).

Direct load control. Direct load-control programs involve installation of communications and control technologies that allow electricity suppliers or system operators to initiate actions directly to reduce customer demand by turning off, modulating, or cycling selected appliances or equipment, such as air residential air conditioners, water heaters, swimming pool pumps, and electric space heaters with storage capabilities. Customers generally receive some type of incentive for signing up. (This might be an initial cash rebate or a free service such as an air conditioner check-up/tune-up, and/or a reduced electric rate in exchange for participating in the program.) Utilities or system operators install remote control switches (generally radio controlled, although there's growing interest and use of other types of communications systems, such as power line carriers and the use of public or private wireless communication systems) on customers' appliances or equipment, such as central air conditioners or electric water heaters.

In direct load-control programs, customers agree to allow their utilities to shut down or cycle selected appliances or equipment during peak demand periods. Most programs offer some type of credit, discount, or other incentive to customers for any times when such cycling occurs. Once enrolled, customers generally have no control over any cycling or load shedding actions taken by utilities over the customers' equipment. However, some programs employ technologies that do allow customer over-ride of utility actions. In such cases, customers generally would incur some type of penalty for over-riding the utility action, or some programs might allow a certain number of such over-rides before imposing a penalty. Expanded control options such as these have arisen with the availability of more advanced technologies, such as Southern California Edison's Energy$mart Thermostat℠ Program (Geltz and Martinez 2004).

Interruptible programs. Interruptible programs target large commercial and industrial customers who have the capability of shutting down their operations for short periods (a few hours or a work shift) or who can switch to their own back-up generation to meet their needs. Generally these programs required customers to have loads of 1 MW or higher. These customers include manufacturing plants, refineries, water treatment plants, mining operations, and food processing plants. Other types of typical participants include large facilities with emergency back-up generation onsite that is capable of taking over the entire or critical shares of loads, such as hospitals or data centers.

In exchange for agreeing to service interruption, customers typically receive “interruptible rates,” which would be lower than standard commercial/industrial rates available. In other cases, customers might receive credits, discounts, or other direct or indirect payment for the interrupted service. These programs spell out detailed terms of the agreement, such as the length of time for advance notice and any penalties for not complying with requests to interrupt. Generally interruption is mandatory if requested and the penalties for failing to comply can be high.

Interruptible programs have been offered for decades, although any one program may only have a handful of participating customers. Such programs clearly offer a “relief valve” for utilities by providing an option to shed large amounts of load relatively quickly during emergency or supply-constrained conditions. However, experience has generally been that this option is rarely exercised. PLMA (2002) observed, “[M]any utilities rarely if ever interrupted these customers. So with the rate discount, such programs evolved more for purposes of economic development than for load management.”

Curtailable load program. These programs target commercial and industrial customers capable and willing to reduce loads, not shed completely, upon notice from the utility or system operator. It offers customers a less “extreme” option to contribute to demand reduction. PLMA (2002) cited a number of differences between curtailable load and interruptible load programs. A primary difference is that such programs typically target customers with smaller loads, such as a 100 to 200 kW minimum, although some programs still have the relatively high minimum requirements of 500 or 1,000 kW. Other differences include smaller penalties for failures to comply with reduction requests, more limited times when curtailments can be requested, and credits granted according to the amount of load reductions achieved instead of receiving a lower rate.

With generally lower minimum load requirements for participation, more types of commercial and industrial customers may qualify to participate in curtailable load programs, such as commercial offices and retail stores. Another key factor in expanding the pool of eligible and likely participants is the nature of the response requested—some type of incremental (not complete) load reduction. This affords customers an option to reduce non-critical demands, such as lighting or air conditioning.

Market-Based (or Price Response) Programs

Market-based—or price response—programs offer customers some type of pricing choice or other economic incentives to modify their loads. Market-based programs incorporate some mechanism to expose customers to some degree of actual electricity market prices. Through exposure to such prices and associated market conditions (constrained supplies), customers receive price signals or other economic incentives to adjust their demand accordingly.

Demand-bidding (or "buyback" programs). Demand-bidding programs offer customers payment for load reductions. These programs fall into two categories based on how the "bid" is structured. Under *customer bidding* programs, participants submit bids directly to the electric market administrator (utility or system operator), generally a day-ahead bid that specifies the amount of load that could be shed at a given price. The electric market administrator then considers bids in conjunction with system forecasts and supply bids and contracts to determine the most economical dispatch of supply and demand options.

Under *sponsor pricing,* the electric market administrator offers customers a price per kW or kWh of load reduction along with notification of a load reduction event (Goldberg, Michelman, and Rosenberg 2003). Customers can then respond by submitting pledges that specify the amount of load or energy reduction they will provide when requested. After any curtailment event, customers are paid according to the amount of load reduced based on the price per kW or kWh announced by the utility or system operator. Some type of measurement protocol has to be followed to determine the load reduction achieved.

Time differentiated pricing. Utility system costs vary significantly over daily, weekly, and seasonal periods. However, utility rates for most customer classes have long been based on average system costs and are not differentiated by the time of use. There have been some exceptions, mostly for large commercial and industrial customers, who may be eligible for some type of time differentiated pricing—usually some variation of a relatively simple "on- and off-peak rate" structure. A small number of real-time pricing programs were introduced in the 1980s, but a large number of RTP programs were introduced in the 1990s, coincident with the push during that time for industry restructuring and increased competition. Despite a few recent relatively high profile RTP pricing efforts and pilots, such as California's Statewide Pricing Pilot, there actually have been relatively few new RTP programs launched since 2000 (Barbose, Goldman, and Neenan 2004). While relatively few in number nationally, some of the early RTP programs have been offered for many years.

As restructuring of wholesale and retail electric markets has occurred, there has been a corresponding push to create pricing structures that better reflect actual system costs at any given time in order to give customers more accurate information about such time varying costs. In turn, customers are expected to exhibit a "price response" and adjust use according to these market signals. If supplies are tight and system costs correspondingly high, customers would face higher prices and may choose to reduce demand. Conversely, customers may take advantage of low prices during off-peak times to schedule non-time-critical operations or otherwise shift loads.

There are numerous structures for time differentiated pricing. We describe the most common types below.

1. *Time-of-Use (TOU) Pricing.* As noted above, some utilities under traditional regulation have offered some type of time-of-use pricing for many years. Such structures typically have offered large commercial and industrial customers on-peak and off-peak rates. Given metering and other associated costs, such programs typically have had a relatively large minimum demand requirement to be eligible. There also are cases of seasonal time-

of-use rates to reflect seasonal cost variations. TOU pricing generally has been a voluntary option for eligible customers, although in some cases the TOU rates have been mandatory for a given customer class.

Time-of-use pricing, while better reflecting actual system costs at different times, is still based on some type of average historical costs for the various time increments used for setting different rates. The TOU rates are pre-determined; they are not a function of actual daily market rates for electricity.

2. *Dynamic Pricing.* "Dynamic pricing" mechanisms, by contrast to TOU rates, tie customer rates to actual market conditions—generally a day-ahead forecast of such conditions, but also possibly as closely correlated as an hour or two ahead. Advances in metering, communications, and control technologies are creating new options for dynamic rate structures. In practice to date there are two principal dynamic pricing mechanisms: real-time pricing and critical peak pricing. We describe these mechanisms below.

   - *Real-time pricing.* In real time pricing, customers pay rates that are a function of actual—or day-ahead projected—market rates. Rates therefore fluctuate according to the variations that occur daily and seasonally in electricity supply (wholesale) markets. Hirst and Kirby (2001) noted that RTP generally involves supplier provision of a set of 24 hourly prices, usually one day before real time, but as close as an hour or two ahead.

   - *Critical peak pricing (CPP).* Critical peak pricing can be viewed as a simplified means to offer customers more dynamic pricing that better reflects actual market costs. Rather than pricing able to vary at all times as with RTP (such as each hour over a 24-hour period), critical peak pricing offers utilities and system operators an option to address the most constrained, high cost, peak demand conditions that typically exist for only a few hours on a few days of any given year. CPP establishes some type of "tiered" rate structure, which might consist of 2 to 3 time-of-use rates—such as a low cost hour, medium cost hour, and a high cost hour. Rates for these times would be predetermined and fixed. However, a "critical peak price" is also established for periods called by the supplier or system operator with advance notice to customers. Customers receive some kind of signal or alert of an impending critical peak period—usually a day ahead of the expected occurrence. Customers then could take actions to reduce demand during the critical peak and avoid paying the much higher rate charged during such periods. CPP then is a hybrid of fixed TOU rates with a dynamic pricing element—the critical peak price.

Section 2. History and Development of Demand Response

Using strategies and incentives to modify customer electrical demand is not a new practice. "Demand-side management" (DSM) programs were used by many utilities in the 1980s and into the 1990s as a means to shape customer demand according to utility and system needs. DSM encompasses a broad array of strategies, technologies, and programs designed to achieve specific load shape objectives—including peak shaving, load shifting, and reduction in overall energy use through energy efficiency. Under this broad DSM umbrella, utilities initiated numerous programs from which they gained a wealth of experience in managing customer loads in accordance with their system needs and objectives.

DSM generally can be divided into two broad categories of program types—load management and energy efficiency. As suggested in the earlier definitions, load management programs seek to modify electric demand (kW in a fixed period) without necessarily modifying electricity consumption (kWh over an extended period). For example, a peak-load reduction program (load management) might result in shifting customer demand from a peak to non-peak period, such as using ice produced in non-peak periods to provide cooling during peak periods. By contrast, energy efficiency programs seek to reduce overall electricity use by customers through application of energy-efficient technologies, such as switching from incandescent to fluorescent lighting. Energy efficiency programs also will reduce demand (kW), but not necessarily at peak demand periods. For example, homeowners who install compact fluorescent lamps (CFLs) will reduce both their electricity use (kWh) and demand (kW). However, if a homeowner is away during the day and not using lighting in the house, such demand reductions would occur in the evening, which may not coincide with the time when system peak occurs (generally mid-afternoon). On the other hand, certain types of energy efficiency programs (e.g., those targeting air conditioning or commercial lighting) can be very effective at reducing demand during peak periods.

DSM is still practiced by many utilities today, especially in states where restructuring has not occurred. Most of the policy and program mechanisms were developed to fit the dominant utility model of this era—regulated, investor-owned, vertically integrated utilities. Other types of utilities—municipal, rural cooperatives, and federally owned—also put DSM into practice as it provided similar benefits to them. Numerous standard practices for aspects of DSM programs were developed, from program structure to evaluation techniques and tests of cost-effectiveness.

The regulatory and analytical framework under which most DSM has occurred is generally referred to as “integrated resource planning” (IRP), also known as “least-cost utility planning” (Moskovitz 1989). It has been practiced typically at the state level, under the purview of public utility commissions (Krause and Eto 1988; NARUC 1988). In the vertically integrated utility regulatory model, IRP provided a means to evaluate supply and demand options on a comparable basis, and regulatory guidance steered utilities to choose “least-cost options” for balancing supply and demand investments (Gellings, Chamberlin, and Clinton 1987).

Affecting demand through “load management” was an important objective for many utilities practicing DSM. Consequently, these utilities developed a variety of programs to decrease system demand at selected times. Residential air conditioning load-control programs became relatively common in areas where summer peak demands strained supply and resource capacity. While specific details vary, customers typically received an incentive to sign up for the program (a reduced electric rate or a seasonal bill credit) in exchange for allowing their air conditioner to be “cycled” off for certain periods. Utilities installed remote control devices on participating customers' air conditioning cooling systems that would cycle the units off and on under the central control of the utility dispatcher.

For larger customers (commercial and industrial), interruptible rate programs became common. Customers would agree to shed load as requested by utilities or else pay a premium for power use during the requested period. In exchange for this service interruption, customers would receive a lower rate than "firm" supply customers. In many cases, the utilities never or rarely interrupted service, but had the benefit of having this option available to them should supplies and/or transmission become constrained enough to threaten service.

The DSM era of the 1980s and 1990s saw extensive investments in DSM programs—both load management and energy efficiency programs. Such spending peaked in 1993 at about $2.7 billion nationwide. Since that peak, utility DSM spending has declined significantly, largely due to industry restructuring—in 2003, this value had fallen by about half, to $1.3 billion (EIA 2004). Of this total, about $800 million was for direct costs of energy efficiency programs, about $350 million was for direct costs of load management programs, and the balance of about $140 million was for indirect costs associated with both kinds of programs. Impacts from these programs are significant. In 2003, the total actual peak-load reduction achieved from utility DSM programs was 22,904 MW; of this total, 13,581 MW is attributed to impacts from energy efficiency programs and 9,323 MW is attributed to impacts from load management programs. While utility DSM programs and spending have declined precipitously since the early 1990s, some of this decline in activity and spending has been picked up by the advent of state "public benefits programs" (see Kushler, York, and Witte 2004; York and Kushler 2002 for tracking and analysis of energy efficiency program policy and program trends, including spending and impacts). Funding for and savings achieved by non-utility public benefits programs would decrease some of the large differences noted above with the utility DSM data. However, utilities are still by far the largest providers of energy efficiency programs and related energy services.

The most significant factors driving the emphasis on demand response today revolve around the restructuring of the electricity industry and the emergence of wholesale power markets and independent transmission system operators. Until the 1990s, the U.S. electricity industry consisted primarily of vertically integrated utilities—with the principal exceptions being rural electric cooperatives and municipal utilities (and even some of these were vertically integrated). Each utility managed its own generation and distribution assets, with transmission systems coordinated through regional councils. Since restructuring, major parts of the United States have unbundled generation, transmission, and distribution functions, with traditional utilities becoming distribution companies. Transmission operations in several regions have evolved into Independent System Operators or Regional Transmission Organizations (RTOs) under the supervision of the Federal Energy Regulatory Commission. These transmission operators not only manage transmission systems, they also operate wholesale power markets.

With the evolution of these new transmission and market operators, a new focus arose regarding the potential for demand response to contribute to the efficiency and reliability of these regional power systems. In the vertically integrated utility model, individual utilities might operate load management programs to reduce demand during peak hours, with the goal of controlling costs or preventing brownouts or blackouts. These programs were essentially one-way operations: the utility typically offered a specific incentive for customers to take specific demand reductions. Customer devices were typically directly controlled through radio switches or other technologies.

In wholesale power markets, by contrast, unregulated pricing reigns. Peak-hour prices can fluctuate dramatically and can rise to high levels for short periods. Under these conditions, market operators have sought to allow customers to participate directly in these real-time markets, paying demand-response participants the same hourly prices for reducing load as they pay generators bidding into the system. Allowing customer load to participate directly in wholesale power markets can bring balance to the market, reducing price volatility by better matching supply and demand. At the same time, market operators are responsible for maintaining system reliability.

The larger size and the greater price volatility of regional power markets, combined with the opportunity for entrepreneurial activity in developing demand-response resources, has stimulated greater interest in demand response as a policy issue, a planning resource, and a business opportunity.

Section 3: The Promise and Potential of Demand Response

The literature on the theory of demand response is rich. Numerous industry analysts have presented strong cases for a greatly expanded role for demand response in both wholesale and retail electricity markets (Braithwait 2003; Hirst and Kirby 2001; Kathan 2002; PLMA 2002). The common message among all these studies and analyses is that demand response is a critical element necessary for efficient and effective market operation. Demand response provides the mechanisms necessary to inform customers about present (or very near-term, typically day-ahead) market conditions—either through pricing or communications—in order that they may choose how much electricity to use given such information. Effective demand response is not just about customers receiving market information in order to determine appropriate responses. Effective demand response also provides a means for customers to inform markets of their willingness-to-pay for services and the associated value of services to them.

Restructuring of the electric utility industry to create more competitive wholesale and retail markets for electricity has been a driving force behind the call for greater use of demand response. As PLMA (2002, p. 1) noted:

> Competitive markets are based on the interaction of supply and demand in response to appropriate price signals. Failure to harness the ability of customers to change their demand in response to prices reduces overall market efficiency, particularly given the volatility of electricity prices.

Traditional regulated cost-of-service-based rates effectively shield customers from wholesale market price volatility, particularly high price spikes that occur under constrained peak demand periods. Under most regulated rate structures, customers pay rates based on average cost-of-service for a given period—a "test year." In some cases there are even mechanisms in place to "true up" utility revenues to actual costs if such costs were beyond utility control (such as fuel costs). The net effect is that customers have no incentive to reduce use during high price periods—or conversely to increase or shift use to low price periods. The result: "This lack of a price responsive load, or demand response, robs the wholesale market of a natural mechanism for relieving temporary pressures on prices, thus exacerbating the price spike problem" (Braithwait and Eakin 2002, p. 1).

Demand response, then, is the means to link customers involved in retail markets to wholesale markets. Customers receive more accurate signals of actual wholesale market costs and conditions, and can exercise greater choice in determining consumption levels based on this information. In doing so, customers reveal the value of their choices to the market.

One Cautionary View: The Paradox of Demand Response

In the midst of considerable laudatory assessments of demand response among advocates within the industry, there is room for some cautious reflection. One perspective that we have not seen published, but which seems worthy of some thought, is what might be termed the "paradox of demand response." The essence of that concern is as follows.

The movement toward electric deregulation ("restructuring") that swept much of the country during the mid- to late-1990s was promoted as a means to use market forces to match or do better than traditional cost-of-service-based electric rates. But thus far, deregulation has produced "market" prices that at times (especially during peak demand periods) are far in excess of the costs of production. Indeed, it is those dramatic price spikes that have fueled the great interest in demand response by policymakers, industry practitioners, and demand-response program participants.

The irony is that while experience to date indicates that the presence of these price spikes is a necessary condition to sustain demand-response program participation, if deregulation ever actually works as intended (i.e., produces rates that closely track the costs of production), those excessive price spikes would diminish or disappear.[8] To some extent, the presence of a robust demand response industry is dependent upon the failure of electric deregulation to fully deliver as promised. The paradox is that if demand response was ever to succeed in helping to correct the market failures of restructuring and drive down the price of electricity to near cost-of-service levels, it would be removing its own economic foundation.[9]

[8] The key word here is "excessive." One would always expect some price fluctuation based on elevated demand levels at certain peak time periods.

[9] Taken to its logical extreme, one could assert that competitive electricity suppliers and demand response service providers have a somewhat symbiotic relationship and share a vested interest in having electric deregulation NOT deliver on its promise of beating traditional cost-of-service-based rates. But we will leave that discussion to other forums.

Notwithstanding the above conceptual paradox, however, the practical realities of the U.S. electric system as it is operating today mean that demand-response programs can be an important and effective mechanism for helping to respond to high peak period electric prices.

Demand Response Enjoys Widespread Support

Increasing demand response in electricity markets enjoys wide support as a policy objective—from local utility-distribution companies to regional independent system operators to the Federal Energy Regulatory Commission. The theory of demand response fits well within the movement towards greater competition in electricity markets and offering customers greater levels of choice. Despite demand response's appeal and the promise it offers to produce a number of benefits to society and consumers, some proponents have urged caution when considering how to enact policies and programs to realize these benefits. Ruff (2002) cautioned, "But overstating or mischaracterizing the benefits of DR [demand response] can lead to unrealistic expectations and poor policies that result in inefficient and unsustainable DR programs."

The widespread appeal of expanding the role of demand-response resources is due to the multiple benefits that proponents claim it can provide to electricity supply systems and markets. Providing customers greater choices and flexibility is itself a key benefit to many and doing so meshes well with the larger market and economic developments of our new wholesale power systems. Consumers today have a sometimes dizzying array of choices before them; creating such choices within electricity markets is a desirable objective for many within the industry.

The stakes in terms of potential impacts are huge. Several events over the past few years have demonstrated both the high value of our electricity supply systems and the high vulnerability of such systems to widespread problems. California, home to numerous high tech, modern industries, experienced thoroughly un-modern blackouts and threats of even more such events due to severely constrained electricity markets in 2000 and 2001. The widespread blackout that affected many Northeastern states and southeastern Canadian provinces in August 2003 demonstrated the vulnerability of electricity grids to seemingly small, localized problems. In this case, problems within one utility service territory quickly cascaded and escalated to affect millions of customers across major regions of the United States and Canada. This latter event is a poignant reminder of the interdependence of electricity grids and illustrates the many unique characteristics of electricity supply systems and markets.

Demand-response resources can play a key role in avoiding electric system reliability problems. While the exact contribution of demand response to alleviate emergency supply conditions will vary from case to case, clearly load reductions during such times can play significant roles in avoiding outages. A strong lesson from California's experience, in fact, is that a variety of high profile, integrated efforts to get all types of customers to reduce their electrical demand had a significant combined impact. During the California energy crisis of 2001, the state averaged a 10 percent cut in peak demand during the summer months (with a record reduction of 14 percent in June) and overall energy use declined by 6.7 percent after adjusting for economic growth and weather (Goldman, Barbose, and Eto 2002; Kushler, Vine, and York 2002). No rolling blackouts occurred in 2001, despite the rather dire forecasts that had been made prior to the onset of the spring and summer peak demand periods.

Other states and regions (such as New York, especially in the downstate, New York City area) have faced supply shortfalls and related system constraints. Such shortfalls and constraints—whether actual or forecast—appear to be major contributing factors in explaining why states like California and New York have in place the largest, most comprehensive and well-established sets of demand-response programs compared to other states and regions that have not experienced such similar circumstances. Need clearly has driven the development and implementation of programs in California and New York, and the heightened public awareness of the problems with electricity reliability has helped increase customer awareness of and participation in such programs. Demand-response programs have been slower to develop in other states and regions where these kinds of crisis or near-crisis conditions have not existed, such as New England and the Midwest, where many utilities have been still actively engaged in DSM.

The estimated cost savings that could accrue nationally from demand response are large. A recent study by the U.S. Government Accountability Office (GAO) estimated that electricity customers could realize as much as $15 billion per year in savings from greater implementation of dynamic pricing (GAO 2004). A FERC-commissioned study (cited in GAO 2004) estimated that a moderate amount of demand response could save about $7.5 billion annually by 2010.

To date nationally, demand-response programs have reduced demand by about 4,000 MW, according to an estimate by Energy Info Source, Inc. (2004). This may underestimate the total demand-response resource, as the combined amount of load registered for demand-response programs by PJM Interconnection, NYISO, and ISO New England alone is about 4,100 MW. Goldberg, Michelman, and Rosenberg (2003) estimated that the total "potential resource" for a large set of four major ISOs (California, New England, New York, and PJM) from both load-response and price programs is about 5,200 MW. By contrast, in 2001 the amount of load reductions achieved by these same ISOs via their reliability programs—both contractual and voluntary—was 1,081 MW, while the load reduction achieved in price-response programs was only about 27 MW. We caution that there is great variability in the amount of load reduction achieved by programs compared to the resource "registered" (potential); some programs have achieved much better results than suggested by these averages.[10]

Looking at national data on utility demand-side management helps to put these estimates of demand-response impacts and resource potentials into perspective. As noted earlier, according to the Energy Information Administration (EIA 2004), utility DSM programs in

[10] For example, NYSERDA's Emergency Demand-Response Program, which involves voluntary curtailment agreements, has yielded greater than 40 percent achievement levels (actual vs. registered loads) and its Installed Capacity Program/Special Case Resources Program (where performance is mandatory for those that register) has achieved about 95 percent (Neenan Associates 2003).

2003 reduced peak demand by 22,904 MW. Energy efficiency programs achieved 13,581 MW of this total; load-management programs achieved 9,323 MW. We later discuss the importance of energy efficiency as a “baseline” resource to reduce peak demand. These EIA data clearly support this view. Further, “conventional” utility load management, which likely includes interruptible/curtailable and direct load-control programs, also provides a large and significant resource to reduce peak demand. Without such contributions by these ongoing DSM programs, the types of conditions experienced by constrained supply markets—high market prices and reduced reliability—would surely have been more widespread.

We were hindered in our research by the lack of any central data source on demand-response programs. A likely contributing factor to this lack of centralized reporting is that there are different types of entities that offer demand-response programs, including local distribution companies, vertically integrated utilities, other load-serving entities, and independent system operators; these different entities do not all report to a single body, such as the EIA, that collects operations and other data. It also is difficult to get an accurate assessment of any kind of national total because demand-response resources vary in their degree of reliability—some resources are quite firm in their dependability for being available when needed, such as contractual interruptible and curtailable loads registered with ISOs or LSEs. Voluntary interruptible/curtailable loads and price responsive loads (including dynamic pricing) constitute a large potential resource in many cases, but the degree of response by definition is a function of varying pricing and market conditions. Experience to date with these types of programs has shown that there is a large potential for demand response through pricing and voluntary mechanisms, but quantifying the magnitude of this resource is difficult.

Despite the achievements to date with demand-response programs, there still is a wide gap between estimated potential contributions of such programs with actual results. The GAO (2004) cited the following three main barriers to more widespread use and expansion of demand-response programs:

- State regulations that shield consumers from price fluctuations,
- A lack of equipment at customers’ locations, and
- Customers’ limited awareness about the programs and their benefits.

Hirst (2002) similarly cited numerous customer, regulatory, cultural, and technological barriers towards greater demand response in wholesale electricity markets. Levy, Abbott, and Hadden (2002) noted “Seven Cardinal Errors” in demand-response design and challenged programs to focus on customer service and fulfilling market needs. Levy, Abbott, and Hadden (2002) proposed the following four “ideal demand response objectives:”

- Provide capability to support a range of load shape and customer cost management objectives;
- Automatically adapt and respond to changing market conditions;
- Allow customers to control how they respond; and
- Compensate customers for their individual contributions.

With this background on the history, promise, and potential of demand response in mind, we next examine how demand response has been put into practice. Rather than attempt a direct review of the huge number of individual demand-response programs that have been implemented around the nation, we focused primarily[11] on identifying leading reviews and analyses that have been conducted by others in the field. In the next section, we provide some brief highlight information from these noteworthy research efforts.

Section 4: Program Experience

Scope of Analysis

As discussed earlier, programs designed to affect customer demand have been offered by many utilities and certain other parties for over 20 years. In fact, such programs were widespread during the 1980s and 1990s when the practice of integrated resource planning and demand-side management were at their peak. Today's "demand-response" programs build on that legacy, bringing new technologies, services, and options to customers.

With this relatively long history and greatly heightened interest in demand response in recent years, reviewing the large number of demand-response programs that have been offered or are presently in place would be an enormous task, which is beyond the scope of our study. Such an effort also would be duplicative of other existing efforts that have compiled, reviewed, and presented summary information on large selected sets of demand-response programs. Therefore, in this section we present summary information from a number of broad multi-program reviews that have been conducted by other experts in the field. Our purpose in this section is to examine key experiences from the body of knowledge that exists on demand response. There are many organizations and institutions involved with demand response research, program development, and program implementation—many of these state and regional initiatives and activities involve multiple stakeholders.

Additional information on demand-response organizations and programs is included in the appendices of this report. In Appendix A, we present a catalog and summary information about demand response institutions, organizations, and initiatives. In Appendix B, we provide an annotated bibliography of demand response references, with a focus on California and New York experiences as these two states have been at the forefront of research, development, implementation, and evaluation of demand response. Appendix C contains a comprehensive bibliography for demand response and energy efficiency. Appendix D contains a case study investigation that we performed of selected California Energy Commission demand-response programs.

Note: Appendix A is available for download for free along with the main body of this report, while Appendices B through D are available only in hard copy, along with the main body and Appendix A.

[11] We do provide some individual program-level information in Appendix D. In particular, we present a rather extensive listing and brief characterization of individual demand-response programs in two states (California and New York) that are arguably the leading states in the United States in terms of examining and initiating demand-response programs.

Load-Response and Demand-Bidding Programs

Goldberg, Michelman, and Rosenberg (2003) reviewed the experience of demand-response programs in the United States since 2000, a year they noted that "witnessed severe power shortages and wide wholesale price fluctuations in California and other electricity markets." Some of their key findings help to give the magnitude of the demand-response resource:

- The total "achieved" demand-response reduction in 2001 for the ISOs in California,[12] New England, New York, and the PJM system was 1,108 MW; and
- The "potential" for these same ISOs is estimated to be over 5,000 MW.

Achieved" demand reductions for the ISO programs mean the maximum load reductions achieved for a given event (time when customers participating in demand-response programs were asked to reduce load) during the summer of 2001.

The "potential" represents the total amount of customer demand enrolled in various programs—both "reliability (load-response) programs" and "market-oriented (price response programs)." This estimate does not include contributions of time-differentiated pricing programs (another type of price-response programs), such as real time pricing. It represents the maximum capability, which may not actually be realized in any given event due to customers choosing not to interrupt or curtail load when called.

In terms of the amount of "load registered" in 2001, Goldberg, Michelman, and Rosenberg (2003) found that the load registered in demand-response programs as a portion of total peak load ranged from 0.2 percent in ISO New England (63 MW) to 6.3 percent in NYISO (1,903 MW). The amount of peak reduction achieved from demand-response programs ranged from 0.2 to 2 percent of total peak demand, according to their estimates.

Kathan (2002) reviewed ISO demand-response programs—both load response and price response—in California, New York, New England, and PJM. The programs included in Kathan's review are:

- California
    - Participating Load Program
    - Demand Relief Program
    - Discretionary Load-Control Program
- NYISO
    - Emergency Demand-Response Program
    - Day Ahead Demand-Response Program
    - ICAP Special Case Resources
- ISO New England
    - Demand-Response Program (Class 1)
    - Price-Response Program (Class 2)

[12] All California ISO programs were suspended after 2001.

- PJM
    - Emergency Load-Response Program
    - Economic Load-Response Program

Kathan concluded, "Experience with ISO demand-response programs over the last several years has been generally positive." He observed, however, that California's experience in 2001 was not as positive due to structural and organizational difficulties in coordinating demand-response initiatives among the California Energy Commission, the California Public Utilities Commission, the California Power Authority, and other participants and stakeholders in California's wholesale markets. Such problems were exacerbated by the crisis conditions. New York's experience, by contrast, was more positive because of better coordination and planning among the New York Public Service Commission, New York Power Authority, Long Island Power Authority, New York State Energy Research and Development Authority, NYISO, and the state's utilities (load-serving entities).

Kathan offered the following lessons learned and areas for improvement from the ISO's experiences with demand-response programs:

- Loss of complete cost recovery: The costs that utility-distribution companies incur to administer, collect, and process customer demand reductions necessary for customers to participate in ISO demand-response programs have not been addressed adequately in any of the jurisdictions examined. Only New York has directly addressed the cost recovery issue; UDCs in New York are able to retain 10 percent of the ISO incentive payments to program participants. However, in a cool summer with low prices and limited use of demand response, the UDCs may not fully cover their costs.
- ISO program complexity: Many of the ISO programs reviewed were complex and not "user-friendly." Payment and program participation agreements were complex, as well as other program elements, such as the requirements for customer baseline calculations. All these factors can lead to customer frustration, confusion, and ultimately limit program participation.
- Socialization of ISO program benefits is an unresolved question: The benefits of ISO programs accrue to the wholesale purchasers of electricity in the ISO, but individual customers and customer aggregators must base their investments on a more limited analysis of costs and benefits. This disparity can result in under-investment in demand response. The problem is to create mechanisms that properly value and allocate the benefits of demand response without creating subsidies and market distortions. This issue requires "further examination" as no examples or suggested approaches are offered.
- Third-party aggregation works: NYISO's experience to enable and allow "curtailment service providers" to participate in their demand-response programs as a third-party working with customers produced positive results.
- Need to fully coordinate ISO demand response with LSE demand response and load management programs: New York and PJM's experiences in 2001 benefited from coordinated LSE and ISO demand-response programs. Such coordination helped reduce customer confusion and frustration.
- Need for early program design and customer education: Programs that are designed, approved, and in-place well in advance of anticipated need can minimize customer

confusion and greatly improve program participation and results. Customers need sufficient lead-time to enroll and invest in the requisite technologies or otherwise implement system changes.
- Reduce payment delay: Customers in some of the programs reviewed experienced delays in their incentive payments, which led to complaints
- Customer retention may be more difficult if few curtailments are called—unless customers are paid for the capability to reduce (paid some incentive even if curtailment isn't called by the ISO). Part of NYISO's success with its programs is the existence of the ICAP Special Case Resources program, which paid customers for the capability to reduce and still allowed them to participate in other programs.

The Edison Electric Institute has established an online system for its members that allows program managers to input demand-response program information on a dedicated Web site. This was first established in 2000 and used in 2001 (Rosenstock 2002) and 2002 to update the data. Rosenstock (2003a) reported on results of the 2002 survey, which was revised and streamlined according to feedback that EEI got on its initial two surveys in 2000 and 2001. Summary findings reported in EEI's *Benchmarking Survey* include:

- Data were submitted from 17 companies, which included investor-owned utilities, municipal utilities, cooperative utilities, energy service companies, and curtailment service providers (CSPs). The majority of the data were received from investor-owned utilities. No ISOs or RTOs submitted data.
- The 25 companies reported data for 26 demand-response programs: 5 residential sector programs and 21 non-residential programs.
- The number of program participants ranged from 1 (poor market conditions cited) to a high of 280,000.
- The most commonly reported reason for enrolling in demand-response programs was to receive bill credits or incentive payments.
- The second most commonly reported reason for enrolling in demand-response programs was to help the company or load-serving entity during peak load conditions when reliability is threatened.
- The most commonly reported reasons for dropping out of programs were: (1) incentives or bill credits were too small; and (2) too much interference with production processes.
- Program costs (total—administrative plus any incentives) ranged from $0[13] to $40.4 million. Costs ranged from $58.90 to $321,049 per participant.
- Summer peak-demand reduction impacts ranged from zero to 500 MW. The average ratio of actual maximum load reduction results to estimated potential results was 0.54; the median of this ratio was 0.72. The ratio of average reductions achieved during program operations to potential results was 0.51; the median was 0.66.
- The top control strategy was utility warning with the customer controlling onsite equipment usage.
- The maximum number of demand-response events per year ranged from 1 to 365.
- The maximum number of hours per demand-response event ranged from 4 to 24 hours.

[13] We had limited access to these data to determine the veracity or otherwise explain a reported "zero" cost program.

- The cost per potential kW load reduction ranged from \$0.06 to \$878; the average was \$85 and the median was \$29.

The above data are all self-reported via the online system established by EEI and PLMA. These data are indicative of programs offered only by load-serving entities or utility-distribution companies since neither ISO nor RTO programs are included in the data set. As a snapshot of the utility industry, these data suggest that demand-response programs are small to moderate elements of most utility DSM portfolios. The data also reveal the great diversity in the size and scope of programs as indicated by the broad range of key program variables, such as total budgets, costs per participant, costs per kW load reduction, summer peak-demand reduction impact, and number of events and hours of demand response events.[14]

EEI also regularly gathers information from both members and non-members on their efficiency and demand-response programs offered to residential, commercial, and industrial customers. This survey (Rosenstock 2003b) collects the following information on efficiency and demand-response programs:

- Member or investor-owned utility name and states served
- Program(s) name(s)
- Program(s) summary statement(s) on services and program type
- Web site

This survey gives a good snapshot of the types and numbers of programs offered across the United States. It shows clearly that demand-response programs have become widespread. Of the 90 utilities included in this survey, 52 offer some type of demand-response program, broken down by the following categories:

- 30 utilities offer load control or other types of “traditional” load management, such as residential air conditioner cycling programs;
- 29 utilities offer curtailment programs for commercial and industrial customers;
- 10 utilities offer some type of time-differentiated pricing, generally real-time pricing;
- 5 utilities offer interruptible programs;
- 2 utilities offer demand-bidding programs; and
- 2 utilities offer emergency backup generation programs.

The trade publication *Demand-Response Programs, 3rd Edition* (Energy Info Source, Inc. 2004) provides program information for a selected set of 28 utilities that offer a variety of such programs. It also provides information on ISO programs—California, ERCOT, ISO New England, NYISO, and PJM. This publication gives brief descriptions of each utility and ISO along with the demand-response programs they offer. This information is largely qualitative, although there are some estimates for the numbers of customers participating in some programs along with estimates of the amount of capacity (kW) enrolled. The publication also surveys demand-response technology vendors—manufacturers and suppliers

[14] The summary data reported here are publicly available. Detailed data reports, however, are only available to EEI members.

of the wide variety of technologies necessary to provide metering, communications, controls, and data management for demand-response programs. The picture of the demand response "industry" portrayed is that of a small but growing industry. Many utilities across the United States offer some type of program.

Heffner (2002) reviewed U.S. and international experience with demand response. He concluded that demand-response programs played a vital role in stabilizing wholesale markets and providing a hedge against generation shortfalls throughout the United States in the summers of 1999 and 2001. Heffner found that price-responsive (interruptible and curtailable) load and other demand-side management programs reduced system peak demands throughout the East Coast by 3 to 6 percent and helped avert potential system emergencies. His review included 31 programs as case studies, offered by 23 different administrators, including IOUs, ISOs, a federal power marketing authority (BPA), a retail electricity service provider, and an electricity cooperative. For eight selected "contingency" (reliability-based) programs, the average potential curtailable load was 158 MW; the actual average curtailed load was 84 MW. For ten selected market-based programs, the average potential curtailable load was 204 MW; the actual average curtailed load was 21 MW. This much lower percentage of actual to potential curtailable load is indicative of market-based programs compared to reliability-based programs due to the differences in contractual obligations to curtail load when called and the corresponding rewards and/or penalties for failure to curtail.

Implementation models for demand-response programs vary widely, reflecting the diversity in the types of organizations offering and involved with demand response and the diversity in utility industry structure from state to state. In many cases, the implementation of demand-response programs mirrors that of DSM programs—for example, a utility (load-serving entity) provider with the possible use of contractors for selected program services, such as marketing or evaluation. In other cases, different types of entities may be involved, such as in California where the California Energy Commission has funded and administered demand-response programs, which were implemented by contractors.

A major difference from DSM programs arises from the involvement of independent system operators and their need to achieve load reductions at the bulk power transmission and wholesale market level. This may necessitate some new approaches. For example, NYSERDA (responsible for administering the state public benefits programs) offers a program (the Peak Load Reduction Program, or PLRP) designed to facilitate participation in the demand-response programs offered by the New York Independent System Operator. NYSERDA's program assists customers with acquiring technologies, such as interval meters, that enable customers to participate in the NYISO programs. NYSERDA's PLRP also has helped create a market for third-party "curtailment service providers" who enroll and aggregate customers for the NYISO programs.

Restructured retail energy service markets also may necessitate different approaches and implementation models as different entities may be involved in demand-response programs, such as distribution-only utilities. A number of different approaches and program models for demand response have been successfully utilized. Successful demand-response programs can be found, however they may be structured. A recent evaluation of demand-response programs in California included a comprehensive review of both California and non-California programs (QCI and SBC 2004). In terms of the key finding that best determines program success, the authors concluded that "staff commitment and continuity over the long-term" are critical in order "to cultivate customer relationships and the trust that goes with well-developed relationships." Other keys to successful demand-response programs cited in the evaluation include:

- Provide proactive customer service that conveys a significant long-term organization and staffing commitment;
- Customer choice is good, but too many options can be confusing to customers; strive for a simple, clearly delineated portfolio of options;
- Conduct regular, meaningful testing to assure customer awareness and overall program readiness;
- Seek to address both reliability and price factors in programs; and
- Continue to monitor market developments and conduct small-scale experiments to test conceptual and technological innovations (QCI and SBC 2004, p. 11–12).

Effective coordination among different entities involved in demand-response programs also seems to a key to success. This assures more effective delivery of program services and helps avoid customer confusion.

Real-Time Pricing

Real-time pricing has long been viewed by many as a foundation of customer demand response. RTP programs clearly expose customers to actual market conditions and associated prices, which theoretically should guide customer choice on use of energy. While real-time pricing is a type of "price response" program, the program reviews cited in the previous section did not include such programs because they are not as readily comparable as reliability programs or demand-bidding programs, which target and track specific amounts of demand reduction. Since there is a great deal of interest in real-time pricing, we examine experience to date with these programs in this section.

Barbose, Goldman, and Neenan (2004) reviewed the experience of 43 voluntary RTP programs offered in 2003 by utilities across the United States. The survey was based on interviews with key program staff and reviews of available program documentation, including regulatory documents, program evaluations, and tariff sheets.

They found that the RTP programs in their survey have achieved mixed results at best. While a few RTP programs have been quite successful in enrolling significant numbers of participants and achieving substantial load responses at high price levels, it appears most RTP programs have not been highly successful. Their findings that support this overall assessment of the relative success of RTP programs to date include:

- About one-third of the programs are being phased out, and another third will continue to be offered but won't be actively promoted. Changing market conditions maybe explain

some of this decline in program availability and promotion, but whatever the reason, it's clear that many programs have been judged not to have been successful and thus are being discontinued. Of the remaining third that are to be continued, they are roughly split into 3 categories: (1) 1990s-era programs that will continue to be actively promoted; (2) programs that will be replaced with new voluntary RTP programs; and (3) recently introduced programs that are awaiting future program development and/or evaluation.
- Participation in most RTP programs has been relatively low. Two-thirds of the programs included in the survey had fewer than 25 customers and less than 50 MW of aggregate peak demand enrolled.
- Participation in RTP programs is declining; many programs surveyed had experienced significant reductions in enrollment in recent years.

Advocates of RTP tout its potential benefits as a central element of a portfolio of demand-response resources—that RTP is a foundation upon which to build customer price response to real-time market conditions and associated costs. Given this great interest expressed by many, it is somewhat surprising to learn that Barbose, Goldman, and Neenan (2004, p. ES-2) found, "Quantitative information on participants' price responsiveness is relatively sparse. A primary reason is that program managers reported that their RTP programs were established for reasons other than load management.[15] Consequently, there was little reason to measure and quantify customers' price response. Other reasons cited for this lack of quantitative data included programs with too few participants, too short in duration, or insufficient price variability to enable rigorous assessment of the demand response. Quantitative data available on price response mirrors the less-than-successful picture painted by participation data. Below are key findings in the RTP program review by Barbose, Goldman, and Neenan (2004, p. ES-2):

- Most RTP programs with more than 20 participants have generated maximum load reductions equal to 12 to 22 percent of participants' non-coincident peak demand. A few have generated a high demand response of about 33 percent. These responses alone do not necessarily indicate the relative level of success of a program, as getting these percentages of reductions for a high value of enrolled load could yield a significant total load reduction (MW).
- The load reductions achieved have occurred over a wide range of prices, from $0.12/kWh to $6.50/kWh.
- A substantial fraction of program participants do not appear to be price sensitive. Program managers of programs with more than 10 participants reported that a range of 40 to 80 percent of their program participants did not appear to provide any discernable price response.
- Most RTP programs have not yielded significant load reductions either in absolute or relative terms. Only two program managers reported load reductions greater than 100

[15] The primary reason cited (just over 50 percent of respondents) was for customer satisfaction and retention—to build customer loyalty and build satisfaction by providing cost savings opportunities, especially among large customers. Other reasons cited were to reduce peak demand, encourage load growth (during periods when generation resources are underutilized), comply with regulatory orders, gain experience with market-based pricing, and share price risk with customers.

MW and only one program achieved a load reduction greater than 1 percent of the utility's system peak demand.

Based on these findings, Barbose, Goldman, and Neenan (2004) made numerous recommendations to improve RTP program performance, including:

- RTP implementation should be coordinated with other demand-side activities,
- RTP pilots should include provision for rigorous analysis of customer acceptance and price response;
- Programs need to devote sufficient resources to develop and implement customer education programs; and
- The costs and benefits of implementing RTP programs and achieving desired demand response impacts must be weighed against other types of demand-response programs for achieving similar impacts.

Their review suggests that actual RTP experience in many cases has fallen short of expectations held for it by utilities and policymakers, which aren't always the same. Other analyses of RTP programs generally agree with this overall conclusion, although certainly some programs have achieved greater impacts and success than others. Braithwait and O'Sheasy (2001) evaluated the results of Georgia Power Company's (GPC) real-time pricing program, which was first offered in 1992. The program had about 1,600 participating industrial and commercial customers, with a total subscribed load of about 5,000 MW. They found that "RTP customers' load response to changing prices is significant and consistent; load response is consistently larger at higher prices." GPC has generally found high satisfaction among participating customers in this program (O'Sheasy 2002). Another pioneering real-time pricing program is offered by the Niagara Mohawk Power Company (NMPC). Goldman, Barbose, and Eto (2004) found that the tariff delivered a "modest demand response" and that customers are "relatively satisfied" with the tariff. Better dissemination of enabling technologies and better customer education about response strategies might increase customer response, according to this study. Experience with residential RTP and related dynamic pricing programs is much more limited. Early results with California's Statewide Pricing Pilot are promising, but full results and evaluation are still pending. Puget Sound Energy ran a pioneering residential TOU pricing program from 2001–02, but withdrew this program after disappointing results and questions regarding the program's cost-effectiveness.

Despite somewhat mixed results with RTP to date, conceptual support for expanding RTP remains present among many regulators, utilities, ISOs, and other electricity market participants and stakeholders. RTP still is largely in its early stages of development as a way to price electricity. Advocates point out a variety of barriers towards greater implementation of RTP. Costello (2004) argued that the primary barrier is the "entrenchment of average-cost pricing in the regulatory arena." Regulatory authorities tend to be risk-averse—many regulators view RTP as too risky for most customers. Many utilities themselves view RTP as risky for their operation—it may create greater uncertainty about cost recovery as well as possibly incurring greater numbers of customer complaints. Finally, Costello suggested that customers themselves "may act as barriers to RTP," largely due to it seeming too complicated and forcing them to keep track of something most do not already do. O'Sheasy (2002) similarly cited numerous barriers to greater implementation of RTP. Principal among his reasons are "flawed" RTP designs, absence of price protection products (ways to reduce customer risk), and the differences that exist between embedded costs and marginal costs (embedded costs are used to determine utility revenue requirements; marginal costs are those actual costs of production at any given time).

PART 2: ENERGY EFFICIENCY AND DEMAND RESPONSE

Demand-response programs generally target reducing electricity demand during a few relatively short periods in the year—generally a few hours on a few days when wholesale prices are high due to constrained supply and/or transmission. By shifting, curtailing, or even interrupting load, customers reduce their demand during periods of peak system demand and thereby provide relief to the system overall, helping assure reliability and mitigating high wholesale prices. But how do programs and strategies that focus on such curtailments and interruptions relate to overall customer energy efficiency? This is an area that we found has not been investigated to any large degree. A few studies have suggested some positive relationship—that is, participation in demand-response programs also helped yield broader energy (kWh) savings. However, such claims are limited and have not been subjected to rigorous quantitative evaluation. They have largely been observations by staff involved with the programs, and in a few cases, there have been some measured impacts that suggest customers have reduced energy use.

In this part of the report, we examine the relationship between demand response and energy efficiency. We identify and discuss possible synergies and conflicts between these types of programs. We then examine selected examples of demand-response programs that also may have had some energy efficiency impacts to explore such possible synergies and conflicts. To supplement available published information on selected programs and the broader topic, we interviewed selected program staff and contractors, as well as national experts on demand response and energy efficiency.

Section 1. Key Questions, Issues and Hypotheses

The rapid growth of interest, development, and implementation of demand-response programs has occurred in parallel with a resurgence in utility sector energy efficiency programs. ACEEE research (York and Kushler 2002) has shown that funding of utility sector energy efficiency programs has rebounded modestly from its low point in 1997, largely due to recommitments by states to these programs after funding for such programs had fallen precipitously in apparent anticipation of restructuring and resulting competitive markets. The growth of “public benefits” programs has been one reason for this resurgence. Such programs are playing an increasing role in utility sector energy efficiency and related public purpose energy programs (Kushler, York, and Witte 2004).

These parallel developments raise important questions for future policy and program direction:

- *What effects, if any, do demand-response programs have on overall customer energy use and energy efficiency?*

- *Are demand response and energy efficiency objectives necessarily complementary? Or can these programs have conflicting elements? If the latter, then what aspects of program design might help maximize complementary effects and minimize potential conflicts?*

- *Are there programs that have deliberately targeted both demand response and energy efficiency? If yes, what has their experience shown?*

- *Do demand-response programs merely reduce inefficient peak demands? (For example, turning off equipment that is not actually needed?) If customers "discover" such inefficient uses, will they change operation of such equipment at non-peak times, yielding improved efficiency? If they do reduce such inefficient uses, does this "eliminate" the demand-response resource (maybe it moves from being a "peak" resource to a "baseload")?*

- *Does demand response participation lead to broader energy savings? If yes, does it lead to actual energy efficiency measures? Or just energy savings from the use of the controls to curtail/reduce use in more than just peak times?*

- *If high on-peak prices encourage peak-load reduction, do the corresponding low off-peak prices result in less motivation to save energy during off-peak periods (i.e., lessen the motivation to pursue broader energy efficiency)?*

- *Does providing greater information to customers on their energy use and market conditions result in more energy-efficient behavior? Does demand response provide an inroad for customers to better manage energy use all the time?*

- *Can demand response and energy efficiency programs sometimes work in opposition to their respective objectives? For example, does providing an incentive based on the amount of peak-load reduction delivered from a facility's energy demand "baseline" create an indirect incentive to not take energy efficiency actions that would reduce that baseline (thereby reducing the amount of demand response incentive that could be earned)?*

- *Should demand response and energy efficiency programs be considered independent? What is the potential for coordination? Or for "spill-over" of desired impacts?*

The answers to these questions are keys to understanding the relationship between energy efficiency and demand-response programs. In turn, such understanding is important in guiding policy and funding decisions, especially in an era with tight overall energy program budgets.

Some proponents cite improved customer energy efficiency as one of the benefits of demand response. For example, Kathan (2002) argued:

> Demand response…can also serve as the stimulus and platform for participating customers to undertake expanded and enhanced energy efficiency programs. By gaining access to information about their usage that was previously unavailable to them, and by gaining the means to act upon it, users can undertake energy management and efficiency practices that can provide embedded, more permanent benefits to the system as a whole.

On the other hand, conflicts may arise between demand response and energy efficiency programs in terms of their funding, especially in an era when budgets for publicly supported energy programs in some states have experienced cut-backs and come under increased scrutiny in general. There clearly could be cases in which demand-response programs compete against energy efficiency programs for funding. In other cases, there may be difficulties in trying to blend funds from different sources together for the sake of seeking combined energy efficiency and demand response objectives.

There are numerous possible synergies between demand response and energy efficiency programs and measures. These include:

- Energy efficiency can reduce demand permanently, at peak as well as non-peak times. As mentioned earlier, energy efficiency can be viewed as "baseload" demand-response resources.

- Conversely, focusing on reducing peak demand can help identify inefficient and non-essential energy uses that could be reduced at other times, thus resulting in broader energy and demand savings. One national expert we interviewed termed this the "wow!" factor—customers might discover some large anomaly in their energy use because of energy information systems, which then leads them to investigate the cause and possibly take action to address such use if it is found to be wasteful or unnecessary.

- Technologies that can enable demand response also can be used effectively to manage energy use year-round. Advanced energy information and control systems are keys to better building operation. The California Energy Commission's "Enhanced Automation Campaign" profiled in the next section is an example of a program that supports such technologies. Another program example is NYSERDA's "Enabling Technologies for Price Sensitive Load Management," which provided financial incentives to support acquisition and installation of communications, metering, and control technologies that would allow customers to participate effectively in NYISO demand-response programs.

- Experience from demand-response activities can lead to greater awareness of energy savings opportunities through improved energy efficiency.

- Customers who participate in demand-response programs may be prime candidates for participating in other types of demand-side management programs such as energy efficiency (and vice versa).

While there may be clear synergies between demand-response and energy efficiency programs and measures, there are also potential conflicts and sources of tension between them. These include:

- Demand-response programs target measures that can reduce customer demand during a few, relatively brief periods in the year when supplies and associated markets are constrained in delivering electricity as needed. Energy efficiency programs seek to reduce customer demand and resulting energy use during all hours of operation. This distinction can lead to differing areas of focus, different technologies, and different priorities for action.

- Incentives for dispatchable demand response can result in conflicts with reducing demand through energy efficiency because energy efficiency measures can reduce the "baseline" against which reduction is calculated, thereby reducing the financial incentive accordingly. At a minimum, participating in a demand-response program could tend to lessen customer interest in pursuing broader energy efficiency, and at worst, could create a perverse incentive to keep the baseline "high" and not do further energy efficiency.[16] This inherent conflict may be even more pronounced for equipment vendors and contractors delivering demand-response programs in the field, if their business success is tied solely or primarily to the amount of dispatchable load shed they can deliver.

- Demand-response programs can ask customers to take measures that reduce comfort, amenity levels, or other energy services. While such decrements may be minimal—maybe even unnoticeable—there is a measure of "sacrifice" involved. Customers are asked to do with "less" of something (cooling, lighting, etc.). Energy efficiency programs, by contrast, generally promote changes that reduce customer demand and energy use *without* any loss of comfort, amenity level, or energy service (and often with increases to those amenities). Consequently, some of the associated messages and objectives of demand-response versus energy efficiency programs can be quite different.

Experience with DSM programs—in which load management and energy efficiency programs typically are not integrated—offers some evidence to suggest that separate approaches to these distinct objectives (dispatchable peak kW reductions vs. permanent kWh and kW savings) have been very successful. This experience also suggests that some of the potential conflicts and sources of tension we discuss above may be part of the rationale for some utilities pursuing separate, non-integrated demand-response and energy efficiency programs. That is one legitimate conceptual model, and we don't seek to discourage utilities that are successfully using that approach to achieve demand-side resource objectives.

Section 2. Experience to Date

Energy Efficiency Effects on Peak-Demand Reduction

Energy efficiency programs that yield energy savings for customers clearly also have an impact on electricity demand. If customers save kilowatt-hours (energy), they also are reducing their kilowatt (power) demand. Over 20 years of experience with improving the end-use efficiency of various customer uses demonstrates that such benefits are, in fact, realized (Kushler, Vine, and York 2002; Nadel 2000). In a national review of demand response experience, Goldberg, Michelman, and Rosenberg (2003) observed, "It is interesting to note that DSM programs contributed large amounts of peak reduction where they were offered—in some cases much more than demand-response programs…." However,

[16] This may be an issue of timing of installation of energy efficiency improvements. In some cases, it may be that once baselines are set, customers install more energy-efficient equipment, thereby lowering the amount they have to reduce demand when called—the "predetermined demand level."

they went on to observe that these programs are typically much more expensive than demand-response programs when viewed solely in terms of the cost per MW of peak reduction. That is why energy efficiency is typically pursued for its total energy savings benefits, just one component of which is peak demand savings.

One way to think about energy efficiency improvements, such as lighting, HVAC or process upgrades, is that they provide "baseline" levels of peak-demand reduction, in effect, a "permanent demand response." Once a measure is implemented that reduces demand (kW) and electricity consumption (kWh), it does so for its life for all hours of its operation. For a great majority of appliances and technologies, such demand savings will occur during peak demand times, since these tend to occur during summer daytime hours when such appliances and technologies would be operating. This is especially true for commercial and industrial customers. Efficient air conditioning and commercial lighting are two technologies in particular that have clear peak-demand reduction impacts.

Schlegel (2002, p. 1) noted other key attributes of energy efficiency in the context of demand response and load management:

> Energy efficiency reduces the energy used by specific end-use devices and systems, typically without affecting the level of service and without loss of amenity. ….In contrast, load management programs lower peak demand during specific, limited time periods by either (1) influencing the timing of energy use by shifting load to another time period, or (2) reducing the level of energy use by curtailing or interrupting the load, typically with some loss of service or amenity.

In examining the role of energy efficiency in the New England region, Schlegel (2002, p. 2) concluded:

> The central conclusion of this framing paper is: cost-effective energy efficiency programs make electricity markets more competitive and more efficient, significantly improve the reliability of the electric system in New England, and reduce the costs and environmental impacts of electric service

Cowart (2001, p. 62) echoed this conclusion, "Broad-based energy efficiency measures provide multiple reliability benefits to electric systems, even when they are not dispatchable at the discretion of operations managers." The multiple benefits include: (1) reduced load, wear, and maintenance needs on electrical generation, transmission, and distribution systems; (2) reduced demand for generation fuels across both peak and non-peak periods, improving overall fuel availability at all times; (3) reduced environmental emissions from generators; (4) relieving load in strategic locations where there are transmission and distribution constraints; and (5) constant availability since they are always "on" and are automatically dispatched by customers coincident with the use of the underlying equipment or load; energy efficiency doesn't require intervention or action by system operators to schedule, purchase, or dispatch the resource.[17]

The role and benefits of energy efficiency to both customers and service providers seem clear. Over two decades of utility demand-side management and other energy efficiency programs have demonstrated their value. What is not clear, however, is how an emerging emphasis on demand response within electricity markets relates to such efforts to improve customer energy efficiency.

Another complication is that restructuring of the electric utility industry has led to the breakup of vertically integrated utilities in many states and regions into a number of separate entities, each serving a single primary function—such as generation, distribution, transmission, and retail services. Consequently, the incentives and interest in demand response and energy efficiency varies among these separate entities—generally the benefits are diffused, creating some potential difficulties in accurately capturing these benefits, structuring programs, and assessing respective costs among these disparate entities. For example, independent system operators are most interested in demand-response programs for the grid reliability and market benefits they can provide to a state or multi-state region. Any resource within that area is generally valued equally. Wires-only distribution companies, in comparison, may be most interested in demand response to provide localized load relief to distribution system constraints. A few utilities have run pilot demand-response programs that targeted localized load relief, such as Massachusetts Electric's Load Curtailment Pilot in Brockton, Massachusetts (Massachusetts Electric 2002).

Demand Response Effects on Energy Efficiency

Depending on the particular measures and program design, energy efficiency may or may not be a preferred option (or even a cost-effective option) for reducing peak demand. But at least the direction of the relationship is clear. Any effects of energy efficiency on demand will tend to be in a downward direction.

The converse is not necessarily true. A demand-response program that results in load shifting from peak to off-peak times might result in no change, or even a slight increase, in overall energy consumption. As described previously, there are a number of other ways that demand-response programs might have counterproductive effects on overall energy efficiency. On the other hand, as also described previously, there are a number of ways that demand-response programs could have beneficial effects on energy efficiency. Unfortunately, there have thus far been very few attempts to carefully research the effects of demand-response programs on energy efficiency and overall energy consumption.

[17] As Cowart noted, energy efficiency resources technically are not "dispatchable" resources—system operators cannot call on a discrete load reduction at a given time from energy efficiency. However, system planners in utilities and areas with energy efficiency programs must include energy efficiency impacts in their load forecasts to be accurate. Load forecasts built on historic loads implicitly reflect the presence of energy efficiency and other DSM program impacts—hence the reason energy efficiency can be considered a base-load resource.

Similarly, there have been extremely few attempts to specifically integrate demand-response and energy efficiency objectives and measures into a single program. The following section presents a few examples that we located in our national search.

Integration of Demand Response and Energy Efficiency: Program Examples

To explore the relationship between demand response and energy efficiency, we conducted an extensive search to identify programs that were designed deliberately to incorporate both energy efficiency and demand response. We searched through available literature (both printed and Web-based) and talked with many national experts. It proved to be very difficult to identify programs that specifically targeted both demand response and energy efficiency. We did identify a few such programs, and we profile these examples in this section. The fact that we found so few examples suggests that there may be some significant conflicts and barriers toward more integrated approaches to energy efficiency and demand response.

In the following material, we first examine programs that specifically seek to achieve both energy efficiency and demand-response impacts. We then examine selected programs that appear to have had some spillover impacts from demand-response objectives to energy efficiency improvements or that otherwise exhibit a logical connection between these two objectives. In the latter case, such programs could potentially be modified to explicitly integrate both objectives.

Commercial Industrial Programs

NYSERDA Peak Load Reduction Program (PLRP). This seeks to improve electric system reliability, improve system load factor, and reduce electric costs by reducing system coincident electric summer peak demand in New York State (Smith, Epstein, and D'Antonio 2004). PLRP takes an integrated approach to offer customers a range of strategies for reducing peak electric requirements, including information, technical support, and incentives to invest in advanced technologies through either curtailment opportunities or through permanent electric efficiency improvements and associated demand reductions. PLRP provides incentives to customers to acquire and install demand-response-enabling technologies that then allow customers to participate in NYISO demand-response programs:

- Emergency Demand-Response Program
- Day-Ahead Demand-Response Program
- Installed Capacity—Special Case Resources

PLRP is a model of how a state public benefits programs can support ISO demand-response programs. NYSERDA's PLRP was initially focused on establishing a load-management program designed to reduce summertime peak demands through load curtailments, load shifting, and dispatchable back-up generation in support of the NYISO's Emergency Demand-Response Program (EDRP). To implement long-term base-load reductions, NYSERDA also included in the scope of this program a component that seeks permanent demand reduction through efficiency improvements.

PLRP was first offered in 2001 and has been offered annually since then. The program offers incentives to participants that cover up to 75 percent (with caps) of the expenses incurred to implement measures.

The program has four main components or "paths":

- *Permanent Demand Reduction Efforts (PDRE):* Measures that result in base-load reductions and long-term (expected to be in place and operational for at least 5 years) coincident system peak-demand reduction. Program incentives under this program element are not intended to apply to any measures that take longer than 8 months to plan and install; NYSERDA has a number of other programs that address such energy efficiency opportunities that require lengthier planning and installation times.

- *Load Curtailment/Shifting (LC/S):* Measures that enable facilities to curtail loads to reduce system demand in response to either an electric system capacity shortfall or defined market signal. To be eligible to participate in this program element, customers must also register in a NYISO demand-response program, an "acceptable" load-serving entity load-management program, or a time-of-use or real-time pricing program for at least one entire summer peak-demand reduction period.

- *Dispatchable Emergency Generator Initiatives (DEGI):* (Con Edison service territory only[18]): Measures that enable owners of existing emergency generators to offload all or a portion of their electrical load to these generators to reduce system demand at times of a statewide capacity shortfall. Generator operation only occurs in response to an emergency call from the NYISO or a transmission owner.

- *Interval Meters (IM):* The program provides incentives for the purchase and installation of interval meters required by customers participating in load-reduction programs such as the NYISO demand-response programs.

The incentives offered for these different components of PLRP are given below in Table 1. The difference in the incentive amounts paid for "ConEd" versus "Non-ConEd" is due to supply and transmission system constraints that exist in the ConEd service territory (New York City area).

Table 1. NYSERDA Peak Load Reduction Program Incentives

PDRE		LC/S		DEGI	IM	
ConEd	Non-ConEd	ConEd	Non-ConEd	ConEd	Statewide PSC approved	Statewide NYISO Compliant
\$475/kW	\$225/kW	\$175/kW	\$45/kW	\$125/kW	\$2,500/meter	\$1,200/meter

PLRP offers three different types of incentives: (1) a reimbursement incentive, (2) an aggregation incentive, and (3) a controllable appliance aggregation incentive. The program caps the amount of the total program budget that can be awarded to any single contractor (20

[18] The Con Edison service territory encompasses New York City and other downstate areas.

percent) and any single facility (7 percent). The program also has a 30 percent funding cap on the amount to be allocated to DEGI. The incentive amount for any given project is the lesser of 70 percent of eligible project costs or the incentive caps shown in the Table 1. Facility owners/operators must contribute no less than 30 percent of project costs; this requirement is intended to ensure that owner/operators are vested in the project and, therefore, will deliver the demand reductions sought in the program.

The program directly places a high value on permanent demand reductions—from almost three to five times higher incentive amounts than offered for load curtailments/shifts (see Table 1). However, customers who install enabling technologies for load curtailments and shifting via PLRP can receive incentive payments from NYISO for actual load reductions when called.

Eligible measures for the permanent demand reduction path include, but are not limited to, operation and maintenance services, HVAC, lighting systems, motors, motor drives, energy management system upgrades, advanced metering controls, and scheduling improvements. Renewable energy technologies, such as building integrated photovoltaic systems, are eligible and encouraged as measures to implement under the program. Permanent demand reduction and PV measures must be activated in an automatic mode or as an integrated function of the operation of the building systems or equipment. Eligible project costs include engineering services, procurement and installation of capital equipment, metering equipment, and other services and equipment necessary to achieve the permanent demand reductions.

Evaluation results (Gowans et al. 2004) show that the PLRP has been very successful in achieving program goals for demand reduction. Table 2 shows the total demand reductions achieved by each program element for 2001–2003 along with the "realization rates" (ratio of M&V-adjusted savings to NYSERDA's initial estimates of project savings):

Table 2. NYSERDA PLRP Demand Reductions and Realization Rates 2001–2003

Program Path	M&V Evaluation-Adjusted Demand Reduction (kW)	Realization Rate
PDRE	14,993	102%
LC/S	95,912	104%
DEGI	69,729	100%
IM	174,668	88%
PLRP TOTAL	355,302	

As shown by these results, the permanent demand reduction contributes a small fraction of the total demand response resource "enabled" by PLRP—about 4 percent of the total 355 MW resource. About 96 MW or 27 percent of the total PLRP demand reductions are due to load curtailment/shifting—technologies that allow customers to curtail or shift loads off peak when called. About 175 MW or 49 percent of the total are from customers that just received interval meters from PLRP,[19] which are required to be able to participate in NYISO or other

[19] The savings attributed to "interval meters" are for those customers who only installed interval meters as part of PLRP and then took actions as necessary to be able to reduce load without receiving additional PLRP funding or other services for these actions (although they may well have received NYISO incentives). Savings

demand-response or load-management programs. Customers participating in these other programs can receive incentive payments for curtailed loads. For example, participants in NYISO's Emergency Demand-Response Program may receive payments of $500/MWh or the wholesale electricity price in the participants' area, whichever is higher. Payments for other NYISO programs vary—in the Day-Ahead Demand-Response Program customers offer bids on their load-reduction capability into the day-ahead electricity markets, where these bids compete with generators' offers. In the Installed Capacity-Special Case Resources Program, customers register their commitments to load reductions (either through onsite generation or curtailments) and face penalties for non-performance if called. Payment rates in this program vary according to the participant's location in the state and the contract period.

Because of the high incentives paid ($475/kW) for permanent demand reductions in the ConEd service territory (New York City area), many customers reportedly find this program more attractive than NYSERDA's programs that provide lesser incentives based on energy savings (kWh). Customers base their decisions to participate in one program or another based on a variety of factors, but clearly the amount of incentives paid is a primary driver. According to Lee Smith, Program Manager for PLRP (Smith 2004), customers are interested in which program—PLRP or one of NYSERDA's efficiency programs—will pay them the most. Smith added that different types of projects are best suited to demand response and others are best suited to energy efficiency. To help identify where a given project fits in, program staff and contractors try to distinguish between projects that have a large potential kWh savings spread out over many hours of use and those that have a few measures that could get large demand reductions over a few short periods. The former types of projects are best suited to energy efficiency and the latter to demand response. Energy efficiency projects that can be planned and implemented in 8 months or less can receive incentives through PLRP; those with longer implementation times may be eligible to receive incentives through other NYSERDA programs. While different contractors and program staff are involved with these different programs, NYSERDA works to coordinate available services through its program communications and among various contractors and staff so that customers receive services best suited to their circumstances and needs.

NYSERDA's experience with this program demonstrates clearly that energy efficiency and demand-response objectives can be combined into a single program package. This combined package of program services benefits customers by providing them a broader range of options for addressing their needs and reducing their energy costs. It also simplifies program participation and administration.

While permanent demand reduction through energy efficiency improvements is integral to PLRP, these projects comprise a small fraction of the total demand resources acquired through the program (about 4 percent). The main factor that likely explains this outcome is simply that the overall focus of PLRP is demand response—callable resources—since these

attributed to the other elements of PLRP—load curtailment/shifting, permanent demand reduction efforts, and dispatchable emergency generator initiatives—are for customers who received funding and/or other services under these specific PLRP elements to enable customers to take such actions to reduce load when requested. NYSERDA is assessing the "interval meter" market and this portion of PLRP specifically as part of its 2005 program evaluation.

resources are most important to NYISO. Therefore, that is the aspect that is most prominently marketed and focused upon by vendors and customers. Another factor that helps explain this result is that other types of energy efficiency projects—those that require 8 months or longer to plan and implement—are supported by other NYSERDA programs. Smith (2004) observed that most of the energy efficiency projects covered under the permanent demand-reduction path of PLRP have been lighting projects—many of them in "leftover spaces"—areas that haven't already undergone some type of lighting retrofit and upgrade from other utility or NYSERDA programs. NYSERDA has indicated that it would like to explore ways to make permanent load reductions a greater component of the PLRP in the future.

As to possible spillover energy efficiency impacts from installation of demand-response technologies, Smith reported that anecdotally one chain of big box stores that participated in the program "did start watching monthly demand and energy use much more closely after getting the better information/control systems installed." As one example, facility operators started doing selective curtailments themselves if demand rose too high during high price periods to save the stores money. While such actions reduce energy use, these types of "cutbacks" are not "energy efficiency" as we define it. Smith added, "I can't point to any specific case where having the greater diagnostic and control capability led to greater energy efficiency."

NYSERDA will be examining the spillover effects regarding installation of interval meters as part of its next evaluation of PLRP. Evaluators will be looking at spillover in terms of changes to operational procedures due to having interval metering capability.

Market developments also are affecting program participation and choices for demand response technologies. Over five annual cycles of funding for PLRP, the market has evolved so that there are now a large number of "demand-response providers" within the vendor community—businesses that are based on selling callable demand response technologies to customers. The incentives paid by NYISO for participants in its voluntary programs are relatively low. By contrast, the incentives paid by NYISO for participants in its "installed capacity" program are much higher, as the risk is much higher for non-compliance with a call to curtail (customers must pay a penalty; there are no such penalties for the voluntary program). The demand-response providers have built a business model of selling demand-response technologies—selling a turn-key service to customers who install callable technologies. The vendors get paid a fraction of the fee paid to customers for participating in the ISO program.

Another aspect of the potential demand-response technology market is vendors who provide end-use technologies and equipment—HVAC, system controls, and lighting suppliers. These vendors could readily include demand-response capabilities in their packages of technologies and services (e.g., lighting systems with control panels that readily allowing dimming). However, according to Smith (2004), "This part of the market isn't nearly as well developed yet [as the callable demand-response technologies market]."

Enhanced Automation Campaign, California Energy Commission. The California energy crisis of 2000–2001 was the impetus for a rapid expansion of both demand-response and energy efficiency programs. The California Legislature passed two bills that provided $859 million in additional funding for a wide variety of programs to be administered by utilities, third parties, public agencies, and other organizations. The California Energy Commission received funding to administer several programs. One of these, the Enhanced Automation Campaign, was a demand-response program designed to promote increasing the capability of existing building "energy management systems" (EMS) and/or "energy information systems" (EIS) to help customers better manage both energy use and the comfort of building occupants. The rationale behind the program was that most buildings have control and data systems already installed that are capable of sophisticated monitoring and control of building electrical and mechanical systems. "Enhanced automation," then, "is defined as any improvement in technology that increases the capability of an existing energy or building management system. The more automated a building's lighting and HVAC systems, the better building management can respond to demand-response opportunities and manage overall energy usage," according to Larkin et al. (2004). Through enhanced automation, building owners and operators can take full advantage of building monitoring and control systems to reduce energy use while still maintaining desired indoor lighting and climatic conditions. The systems can be programmed to respond to price signals and communications from utilities and system operators to curtail loads.

The California Energy Commission contracted with XENERGY and Nexant to implement the Enhanced Automation Campaign (XENERGY and Nexant 2002a, 2000b). A principle service offered by the program was customized technical assistance to large commercial and industrial customers who wanted to learn what options they had with their current systems for both manual and automatic demand response, as well as what enhancements to their systems they could make to expand their capabilities to yield additional savings. In Phase 1 of the campaign, there were six very large customers (including a university housing system, a large retail chain, and two large office complexes) that received technical assistance. In Phase II, the campaign targeted customers considering participation in newly initiated critical peak pricing pilot tariffs. Phase II provided technical assistance to 47 customers, mostly in the size range of 200 to 1,000 kW demand.

As part of the campaign, the contractors produced six case studies of customers who had invested in substantial upgrades as part of the demand-response program. Larkin et al. (2004) noted that these projects focused primarily on demand-response capability since that was the program's focus. However, follow-ups have shown that half of these case studies (three) "[H]ave now altered their daily practices to save energy and demand every day, while also maintaining additional curtailable load." This suggests that there have been "spillover" effects of the demand-response programs and measures in terms of energy conservation and efficiency. As part of this information and education campaign, the contractors also developed the *Technical Options Guide* (XENERGY and Nexant 2002a). This guide is designed to help customers estimate average costs and potential savings for controls upgrades. It contains estimated savings ranges for a large menu of measures; some example HVAC control system measures are given below:

Measure	Energy Savings
Night ventilation	0.1–2% of cooling energy use
Optimal start	5–10% of fan and heating/cooling costs
Variable capacity control	10–30% of fan or pump energy use
Demand responsive ventilation	20–70% of ventilation use; 2–7% of total building energy use

The above measures demonstrate the nexus between demand response and energy efficiency—measures that can be taken to achieve both objectives. The extent to which customers participating in demand-response programs, such as the Enhanced Automation campaign, take such measures is still largely unknown. An interesting aspect of this program as it has evolved (originally a "campaign" that focused on education and technical assistance, it is now offered as the "Enhanced Automation Initiative") is that financial incentives are now available to install building automation controls and upgrades *and* these incentives are paid on the basis of electricity savings (kWh). For software upgrades, the incentives are $0.07/kWh; for hardware upgrades the incentives are $0.09/kWh. In all cases, the total amount of the financial incentives paid to customers is not to exceed 50 percent of the total project costs. Vendors can receive $500 as a stipend for proposals.

Since incentives are based on kWh savings, the program tracks these data along with peak demand (kW) reductions achieved. Through March 31, 2004, the campaign had achieved 11.9 MW of demand-reduction capability and 14.5 million annual kWh of permanent energy savings. The program expects to add another 7.7 MW of demand-reduction capability and another 29 million annual kWh of permanent energy savings by December 31, 2006. Clearly the program is yielding both demand and energy savings.

The electricity savings achieved by this program are largely achieved by reducing load over peak demand periods through such measures as dimming lighting levels or raising cooling set-points—thus these savings are largely attributable to what we would call "energy conservation" versus "energy efficiency." Such savings are equally important in terms of their cost savings to customers and the benefits they provide to help alleviate supply and related reliability problems.

The Enhanced Automation Campaign published six case studies to illustrate how different types of customers have benefited from enhanced automation and related upgrades (XENERGY and Nexant 2002b). Examination of these cases studies also helps illustrate how demand-response technologies can yield energy savings directly as well as influencing facility decisions that can lead to further energy savings.

The County of Alameda Courthouse is one of the case studies. The County installed upgrades to its chiller control systems that allowed operators to "power down" incrementally and to allow near real-time monitoring and verification of such actions on facility-wide demand. The upgraded system gives operators much more precise control of chiller loads. It also centralized control of multiple decentralized HVAC systems. Comments by Matt Muniz, Energy Program Manager of the County of Alameda, reveal customer motivations and benefits. According to Muniz (XENERGY and Nexant 2002b), "More precise control over our chiller settings has allowed us to save energy, while increasing comfort." He added, "Our enhanced system has given us access to real-time electrical use data, which has been tremendously useful for monitoring and optimizing the running of our facilities." The county reduced its peak demand by 500 kW—from a baseline demand of about 1,500 kW to 1,000 kW.

A Hewlett-Packard (HP) office complex (10 buildings, 1.4 million square-feet) in Roseville, California, is another case study. Again, the enhanced automation upgrades have given facility operators much more precise control over its HVAC systems. According to the case study (XENERGY and Nexant 2002b), "Originally intending to operate their new load-shedding strategies under emergency situations only, HP found that they could actually benefit from using them on a day-to-day basis." Combined with other energy conservation efforts over the past 8 years, HP Roseville is saving $1.5 million in energy costs annually.

A third case study is that of the Comerica Building. In this case, the building owners undertook upgrades that qualified for incentives through the Enhanced Automation Campaign (for controls upgrades) and for utility rebates (for energy-efficient lighting upgrades). In combination, these measures resulted in a 34 percent reduction in energy use (kWh) during the peak demand period (June–September) in 2001 compared to 2000. This is a good example of how both energy efficiency and demand-response programs can be coordinated for a single customer to leverage resources and achieve a greater combined impact than if only a single program had been pursued.

By enrolling in the Enhanced Automation Campaign, Foothill-De Anza Community College was able to purchase and install Web-enabled, integrated metering and control technology that allows for more centralized, remote curtailment of loads. It also allows immediate access to incremental meter data. With this system the college has saved about $30,000 per year in energy costs. John Schulze, Director of Facility Operations and Construction Management at the college, credited the automation systems for this success (XENERGY and Nexant 2002b). "Access to energy usage profiles allows us to verify emergency load curtailments and monitor the performance of longer-term efficiency improvements." He added that the system "[H]as proven to be an incredibly useful tool for troubleshooting our systems."

A large hotel and conference center in Sacramento, the Doubletree®, has used enhanced automation to manage and control energy use and associated costs. Through an aggressive energy management strategy utilizing enhanced automation technologies, the hotel was able to reduce its annual energy use by more than 800 MWh in 2001 compared to 2000—a decrease of 11 percent. This helped the hotel hold their energy cost increase to 2.5 percent despite a rate increase over the same period of 15 percent. The hotel uses enhanced automation to enact a number of curtailment strategies for demand response, but also uses the system for identifying, diagnosing, and analyzing problems with its HVAC and lighting systems—including discovering wasteful or unnecessary uses of equipment and systems.

These case studies illustrate clearly how advanced metering, communication, and control technologies can be used to deliver demand response and to decrease energy use, both through more optimal management of building systems, as well as using the systems as a diagnostic and analytical tool for energy efficiency improvements. However, such spillover and integration are not automatic. The facility managers in these cases clearly were motivated to take actions to manage energy costs and help maintain overall system reliability during emergency conditions. In some cases, these facilities upgraded equipment to be more energy efficient, such as lighting.

Customers really don't distinguish between "demand response" and "energy efficiency" or "energy conservation," according to Julia Larkin (2004), a project manager with the program contractor KEMA-XENERGY. She observed, "Customers just see different ways to manage energy costs." Her experience with this and similar programs is that demand-response programs "can definitely produce energy efficiency effects, especially for commercial customers." She added that to do so requires integration of programs because they are looking for ways to manage costs, however that can be achieved, whether "demand response" or "energy efficiency" improvements. Larkin's experience is that programs in California are working toward this type of integration of demand response and energy efficiency.

Small Commercial and Industrial Demand Responsiveness Program and Demand Response Grants Program (AB 970 and SB 5X), California Energy Commission. To explore the relationship between demand response and energy efficiency, we selected two other program administered by the California Energy Commission (CEC) to examine in detail. These programs are the Sub-Element 2, Demand Response Grants Program and the Small Commercial and Industrial Demand Responsive Program. They both were funded and arose from the same legislation that created the Enhanced Automation Campaign and Initiative—AB 970 and SB 5X. The Sub-Element 2 grants targeted demand response among medium and large commercial customers with multiple sites. Sub-Element 2 grants supported installation of communications and control technologies capable of reducing demand through programmed control sequences, such as to reduce lighting levels or to raise air-conditioning set-points in building spaces. Customers installed these systems in the summer of 2001 and into 2002 (Nexant 2003a, 2003b).

The small commercial and industrial sector has been largely ignored in most demand-response programs to date. To include these customers and test their ability to achieve demand reductions in response to system emergencies and other situations when reliability is threatened, the CEC created the "Small Commercial and Industrial Demand Responsiveness Program." This targeted small business customers—those with peak loads less than 200 kW. The program was implemented in 2002 and 2003 (ICF Consulting 2004). Like the grant funding under AB 970 and SB 5X, customers received cash incentives and technical assistance to acquire and install communications and control technologies that would enable them to curtail load by initiating a programmed set of control actions, generally for lighting and/or HVAC systems. Such actions would be taken in response to either system emergencies (Stage 2 or 3) or when sharp rises occur in wholesale electricity markets. The program targeted chain stores and other types of customers with multiple facilities in order to be able to achieve significant aggregate impacts.

In addition to reviewing available published information about these two programs, we also conducted interviews with selected program participants and program contractors (for implementation and evaluation). We selected these two programs for more in-depth and primary research because of reported energy efficiency spillover impacts from the programs' principal objectives of achieving demand response. Below we present key findings from this study. Appendix D contains a full write-up of this study.

Our study of these two programs was qualitative. We were looking for insights on some of the possible synergies and conflicts that we discussed earlier. Did customer behavior and actions demonstrate the theorized potential synergies between demand-response programs and greater energy efficiency? Conversely, do customer actions reveal potential conflicts between these different types of energy use objectives? A final objective of ours was to seek to identify areas of opportunity for improving the coordination and synergy of demand-response and energy efficiency program efforts.

We found that there clearly does seem to be some synergies between demand response and energy efficiency in these particular programs. Customers who participated in these two programs generally seemed to already be reasonably savvy in terms of their interests and capabilities for effectively managing their building systems in order to control energy use and associated costs. Most of the customers we spoke with had previously participated in other energy efficiency programs in California. The types of communications, metering, and control technologies supported through the financial incentives provided by these two demand-response programs gave customers opportunities to increase their abilities to control their building systems, whether strictly for demand-response actions or for broader year-round and seasonal energy management.

As was noted in the "Enhanced Automation" program example, we also found that customers generally don't really distinguish between "demand response" and "energy efficiency" or "energy management/conservation." They see programs as providing opportunities for them to acquire equipment and take actions that will help them reduce energy costs. To the extent customers distinguish "demand response" from the other types of energy programs, it mostly seems to be that demand-response measures are actions they are asked to take during system emergencies or other severe conditions.

The data we gathered in our interviews suggests that demand-response programs may yield some "spillover" energy efficiency benefits, at least for some participants. In answering this relationship, however, it is important to distinguish between two related but distinct types of actions that customers may take to reduce energy use and associated costs. The first type of actions are measures that result in better control of building systems—turning equipment on and off to closely match occupancy needs, for example. The second type of actions are upgrades to install more energy-efficient equipment, such as high efficiency lighting or HVAC. Such measures yield energy savings during times such equipment is operating because of the higher efficiency compared to the equipment it replaced. Both types of savings are important for their demand (kW) and energy (kWh) impacts.

We found that most (about two-thirds) of the interviewees reported using the equipment installed for its demand-response capabilities to manage and control energy use throughout the year, not just for curtailing load during peak demand periods. This type of use could produce energy savings beyond simple peak-load reduction. We also found that about half of the interviewees reported taking actions of the second type—replacing inefficient equipment with energy-efficient equipment. These findings likely reflect to some extent the types of customers that chose to participate in these demand-response programs—roughly 80 percent of the customers interviewed for this study indicated that they had participated in other California energy efficiency programs prior to their participation in the demand-response programs. This suggests that many of these customers already were favorably disposed to participating in energy programs that could result in lower energy costs through investments made in energy-efficient technologies. The fact that California had such a high saturation of energy efficiency programs for many years with such an extensive history of prior participation makes it difficult to determine the extent to which participation in these two demand-response programs actually increased subsequent energy efficiency actions (beyond what would have happened in the absence of these demand-response programs).

On the other hand, there is strong anecdotal evidence that for at least some customers, the information from the energy management control systems obtained in the demand-response program helped them to identify and take further energy efficiency actions. Once these customers had the information on how much energy is used from the management control systems and how much it costs them (monthly and daily), they took action to reduce energy use and purchase more efficient lighting and HVAC systems. One specific example cited in the program evaluation (ICF Consulting 2004) is Petco, which achieved energy savings of 5–7 percent for the energy management systems installed. Customers who participated in the demand-response programs for this study generally seemed to be active in their pursuit of greater energy efficiency and optimal control of building systems as a means to keep energy costs low. (See Appendix D for a more complete write-up of our examination of these two California programs.)

Residential Programs

New York Energy $mart, Westchester $mart Homes Pilot. NYSERDA, as the primary administrator of New York's public benefits programs, initiated a two-year pilot time-of-use pricing program in the summer of 2003 in conjunction with ECONnergy and Westchester County. ECONnergy supplies electricity to customers participating in the pilot, which is open to 150 customers in Westchester County. The program is fully subscribed and all equipment was to have been installed by December 1, 2004.

A primary goal of the program is to provide customers with the ability to document their energy use patterns through the use of an advanced meter. However, a key distinguishing characteristic of this approach is the explicit incorporation of energy efficiency information and measures into this demand-response program.

Participants in the pilot program receive the following benefits:

- An advanced interval electric meter that records electricity use in 15-minute increments and is remotely read each night. Customers are billed for usage based on four blocks of time: (1) morning (6 am to 11 am); (2) afternoon (11 am to 4 pm); (3) evening (4 pm to 10 pm); and (4) overnight (10 pm to 6 am). This meter is valued at $900.
- Customers can access the next day's electricity prices (which will vary) in late afternoon.
- Customers receive a "whole house" energy assessment performed by a participating certified "Building Performance Institute/Home Performance with ENERGY STAR®" contractor.
- As part of the energy assessment, customers receive CFLs to replace incandescent lightbulbs where appropriate.

Customers interested in participating in the pilot had to complete a Web-based survey regarding their electricity-consuming equipment and their willingness to shift load to lower-priced periods. The home energy assessment provides customers information on how they might reduce energy consumption and also shift loads in response to the pricing signals, but there is no installation of control equipment associated with the program. ECONnergy "expects to add many features to this program including appliance control and home monitoring via the Internet," according to the program Web site (http://www.getenergysmart.com).

The homes included in this pilot program are not your "average" family home. Westchester County is one of the wealthiest counties in New York and the homes there are generally very large with many luxury features. For example, many of them have multiple central cooling systems. Not surprisingly then, these households have above average energy costs and likely have a much higher amount of discretionary energy use than "average" households.

NYSERDA expects that each participant in the pilot program will realize $650 per year in lower energy costs. While this may be a surprisingly high value, it is relative to the much higher than average energy costs. Of this total, $500 will result from energy efficiency measures implemented as a result of the Home Performance assessment. Customers may be eligible for financial incentives and other support services from other New York Energy $mart Programs to take actions to implement recommendations from this assessment. The remainder of the estimated savings, $150, will result from behavioral changes associated with energy use in response to the price structure.[20] Expected changes are likely to include load-shifting from discretionary end-uses of energy, such as clothes washing/drying or dishwashing, as well as adjusting heating and cooling set-points and system operation to decrease demand during peak, high price periods.

Collection of detailed energy use data using interval metering will benefit the program administrator. NYSERDA plans to use the data to evaluate the effectiveness of its residential energy efficiency programs: "[P]erhaps modifying them to maximize energy efficiency and

[20] The estimated savings attributable to behavioral and operational changes responses to variable pricing are based on a home in Westchester County that has central air conditioning, electric cooking, an electric clothes dryer, a refrigerator, and a swimming pool.

demand shifting (Stanton-Hoyle et al. 2004). NYSERDA also views this pilot as an opportunity for it to test out "smart homes" technologies, which provide detailed data that can be used to fine-tune and optimize building energy systems, such as heating and cooling systems.

Providing information about energy efficiency opportunities in conjunction with the advanced metering is an integral part of the Westchester $mart Homes Pilot. The requirement for homes to receive a home performance assessment to even enroll in the program sends a strong signal to customers as to the importance of energy efficiency upgrades. Messages promoting energy efficiency continue throughout the pilot program. Beginning in January 2005, program staff began holding a series of town meetings where they will talk to pilot program participants to get feedback on the program and to provide information on how to save energy and money in the program. NYSERDA conducted door-to-door outreach efforts to each program participant soon after they enrolled in the program. Electrical engineering interns went house to house to provide participants a list of tips for saving energy, such as changing out incandescent lightbulbs to CFLs. The interns also gave out timers to participants to allow them to schedule certain appliances for off-peak, lower price periods.

Jim Reis, NYSERDA Program Manager, observed that customers seemed attracted to this program for one of two primary reasons (Reis 2004). About half the people enrolled in the program because of the energy efficiency benefits. They saw opportunities to save money through energy efficiency and were interested in receiving the Home Performance assessment as part of the package of services offered. The other half of the people seemed most attracted to the new, high technology it offered. They were interested in the advanced metering and communications capabilities of the systems, such as access to energy and home equipment data via the Internet. Reis reports that one customer is even tracking daily energy use.

The Westchester $mart Homes Pilot should reveal a great deal about how homeowners respond to programs that offer a package of both energy efficiency and price response services. The program will be evaluated by a third party in the summer of 2005.

Energy-Smart Pricing Plan, Community Energy Cooperative, Commonwealth Edison. The Community Energy Cooperative, a Chicago-based nonprofit membership organization, launched a pilot program called the "Energy-Smart Pricing Plan" (ESPP) in November 2002. It is the first program to offer residential customers access to hourly, market-based pricing. Commonwealth Edison offers this experimental rate (the "residential hourly energy pricing or RHEP rate") through the program to participating Cooperative members (Tholin et al. 2004). The program is running as 3-year pilot. In 2003, over 750 Community Energy Cooperative members enrolled in ESPP. About 1,100 customers participated in the program in 2004. Service available under the variable rate was first available in January 2003. In addition to the hourly electricity price, customers also receive a distribution charge per kWh. The pricing structure and levels are such that ESPP participants could save about 10 percent of their present electric costs even if they do nothing to change their energy use.

The program provides customers with tools and information to be able to understand their energy use patterns and adjust them according to the price signals given by the market. Customers receive day-ahead price information, projected price patterns, and special alerts when energy prices are high. The Illinois Department of Commerce and Community Affairs is assisting the pilot program by funding installation of new equipment for participants, including electric meters and thermostats (total cost of about $140 per participant). Program participants are being tested against a control group of about 100 households that pay ComEd's flat residential rate (8.28 cents/kWh) during the summer.

ESPP is a pioneering effort to examine a real-time pricing program for residential customers. Other RTP programs have targeted commercial and industrial customers (Barbose. Goldman, and Neenan 2004), principally because of the relatively high costs of metering and the larger demand reductions possible by these customers. ESPP is seeking answers to a number of questions about residential customers and RTP. These include:

- Do participants respond to hourly prices?
- Do participants respond differently during high price periods?
- Are there common factors among those individuals who consistently have a large response to high prices?
- How do participants in ESPP differ from Community Energy Cooperative members who have chosen not to participate?

–Tholin et al. 2004

An evaluation of the first-year program impacts (Summit Blue Consulting and SERA 2004; Tholin et al. 2004) revealed that participants do respond to information about high energy prices, at least in this case where explicit, targeted information is received from a familiar and highly credible source (i.e., the well-established Chicago "Community Energy Cooperative"). Over half of the participants showed significant responses to high price notifications and the remainder showed some response.

One interesting result of the evaluation was that participants who live in multifamily dwellings exhibited the largest responses to high hourly energy prices—with those owning central air conditioners reducing their use about 30 percent during such periods and those with room air conditioners or no air conditioners reducing their overall electric use by about 16–19 percent. Participants living in single-family homes with central air-conditioning tended to reduce their consumption significantly during the first 2 hours of a high-price period; by the 3rd hour there was no reduction and in later hours consumption started to increase, indicating a "snap-back"—likely due to the cooling system "catching" up once the occupant returned to the set-point to the "normal" setting.

The actions taken by participants to reduce their energy use fall clearly in the category of "energy conservation"—measures that reduce levels of energy services or amenities. The most common actions reported by customers were turning down (or even off) their air conditioners (raising set-points) (over 80 percent of participants modified their air conditioner use in some way), turning off lights, and using clothes washers at night (over 70 percent of participants modified their clothes washing patterns). Thirty-eight percent of participants reported using air conditioning less whenever they can—not just during high price periods. Program evaluators found some level of reported activity with all the following areas (percentages given are for program participants reporting each action):

- Turn off lights more (76 percent),
- Turn up air conditioner setting (28 percent),
- Use fans more (49 percent),
- Close blinds/shades during the day (63 percent),
- Spend more time in the coolest rooms (21 percent),
- Do laundry at night (>50 percent), and
- Install insulation or weatherstripping (13 percent).

—Summit Blue Consulting and SERA 2004)

Comments from the survey respondents indicated other actions, including installing CFLs and modifying times when other household tasks are performed that use electric appliances, such as washing dishes and vacuuming.

The primary motivation for participants to enroll in ESPP was to save money, although they also were interested in achieving environmental benefits and helping to reduce the likelihood of electric outages. Average savings per participant were more than $12/month or a relative savings of about 20 percent. According to Margorie Isaacson (2004), Assistant Manager with the Community Energy Cooperative, there isn't much quantitative evidence to show decreased overall energy use; customers mostly have shifted use from off-peak to realize program cost savings. She added that they've observed that people have become much more aware of their energy use; according to the program evaluation, 78 percent of respondents felt a positive impact on their understanding of energy use as a result of the program.

As structured, the ESPP seeks demand response to electricity market prices. Using energy efficiency to achieve permanent demand reductions and cost savings is not a primary message or objective of the program. However, integrating energy efficiency objectives and services into ESPP could be done readily. In fact, a survey of participants done for the evaluation revealed a thread of comments that indicated that these customers were interested in "some sort of assistance in making longer-term 'capital' improvements such as appliance replacement and insulation services" (Tholin et al. 2004). Such energy efficiency services and objectives would complement other ESPP services, which all are directed to help customers save money and gain control over their energy costs (such control was cited as a key "non-energy benefit" by customers surveyed). Isaacson (2004) noted that program staff have observed that most participants have become much more aware of their energy use. Such awareness could establish an important foundation for promoting energy efficiency in conjunction with the pricing options.

Power Choice, Sacramento Municipal Utility District and California Energy Commission. Sacramento Municipal Utility District (SMUD) and the California Energy Commission partnered to offer, administer, and evaluate a pilot customer-controlled critical peak time-of-use program, "Power Choice," that was designed to test the feasibility of dynamic pricing in the residential sector (Wood et al. 2004). The program provided customers new load-management technology and time-of-use rates with a critical peak period. The technology allowed customers to control various end-uses in response to prescribed and called hourly prices. It also provided near real-time information about energy use to customers. The program evaluation included in-depth surveys of customer behaviors and energy use habits during on- and off-peak hours. There were 4 pricing periods—low, medium, high, and critical. See Table 3 below.

Table 3. Power Choice Summer Rate Structure

Charge	Rate
Customer charge	$10/month
Energy surcharge	0.263 cents/kWh
Energy charge	
• Low (10 pm–noon and weekends)	7.032 cents/kWh
• Medium (noon–2 pm, 8–10 pm weekdays)	12.948 cents/kWh
• High (2–8 pm weekdays)	20.070 cents/kWh
• Critical (when called)	27.000 cents/kWh

While this program clearly targeted peak-demand reductions via critical peak pricing, the program also appears to have influenced customers to take a number of measures to improve the energy efficiency of household end-uses, such as lighting, air conditioning, and heating—71 percent of participants reported that they invested in energy efficiency measures after joining the pilot program. Examples include:

- 59 percent replaced incandescent lamps with CFLs,
- 11 percent replaced singe-pane with double-pane windows,
- 9 percent replaced an old refrigerator with a new high-efficiency unit,
- 5 percent upgraded inefficient air conditioners to high-efficiency units, and
- 5 percent installed ceiling or wall insulation.

Participants also took expected actions to reduce peak demands during high price periods, such as raising room temperature settings for air conditioned spaces and shifting discretionary loads, such as laundry and dishwashing, to off-peak periods. Almost all participants (95 percent) reported that shifting usage to off-peak periods became a habit in their households during summer months.

The pilot shows a clear relationship between behavior to reduce and shift energy use and overall energy use among participants. Wood et al. (2004) reported, "Customers who say they changed their routines and made a habit of shifting actually did use less energy overall (-1,010 kWh), while those who characterize themselves as not changing actually used more energy (+1,745 kWh)." Two-thirds of all participants saved energy overall, and 86 percent saved energy during the high or critical periods. These results are promising, but the study still cannot distinguish precisely the source of such savings—whether due to behavioral change (both programmed with the energy management systems installed or simply by conscious customer actions) or investments in energy efficiency. Still there does appear to be a positive synergy between integrating demand response and energy efficiency through program education. "Most participants made investments in energy efficiency after joining the program, and those who invested saved, while those who did not invest, did not save," concluded Wood et al (2004).

Integration of Demand Response and Energy Efficiency: Other Programs and Promising Developments

We selected the programs profiled in the previous section because they were among the few programs we found in our research that either integrated energy efficiency and demand-response objectives or otherwise showed some possible positive relationships between the two, whether realized to date or not. We did find two other programs in California that also appear to fit these criteria. These are:

- *The Goodwatts™ Energy Program, California Public Utility Commission and California's investor-owned utilities (PG&E, SDGE, and SCE):* The GoodWatts™ Energy Program is an energy-saving research pilot designed by the major California electric utilities under the auspices of the California Public Utilities Commission. It began in the summer of 2004 and is offered to a limited number of residential customers. The purpose of this program is to determine if each household can successfully manage energy use, as well as conserve, under a dynamic pricing scenario and using an energy management system from Invensys Climate Controls, called GoodWatts™. This is an advanced EMS that uses high speed Internet connection to provide control and monitoring. Wireless devices are installed to control and monitor air conditioning, space heating, water heater, pool pumps, and other significant energy-consuming appliances in the home. The Goodwatts™ Energy Program also includes a new electric tariff rate, which charges a slightly higher than average price for electricity used during peak periods (weekday afternoons between 2 and 7 pm) and offers a price discount during the non-peak periods.

- *Statewide Pricing Pilot (SPP), California Public Utility Commission and California's investor-owned utilities (PG&E, SDGE, and SCE):* SPP is a pilot program designed to evaluate the demand-response capability among California's residents. The SPP involves approximately 2,000 residential and small commercial and industrial customers located in the service territories of the above utilities.

  SPP has three primary objectives: (1) Estimate average demand impacts and demand curves for electricity consumption by time-of-use period for dynamic tariffs and derive the associated price elasticities of demand; (2) Determine customer preferences for tariff attributes and market shares for specific TOU and dynamic tariffs, control technologies, and information treatments under alternative deployment strategies; and (3) Evaluate the effectiveness of customer perceptions of specific pilot features and materials, including enrollment and education material, bill formats, web information, and tariff features.

  The pilot began in the summer of 2003 and customers will be enrolled from 12–18 months. Full evaluation and impact results are not yet completed and available. Analysis of data from the first 4 months of the pilot is promising in terms of showing a relationship between the variable pricing options and energy savings. This initial analysis found modest energy conservation behavior among all pricing treatment groups in the pilot.

The above programs are promising in terms of their potential to help understand and perhaps quantify some of the relationships between energy efficiency and demand response. These pilot programs are clearly exploring these relationships, and as they are completed and evaluated, their results should be very useful toward this end.

We did not include case studies of more “traditional” DSM programs that may target peak-demand reduction, such as direct load-control programs, which as noted earlier have been mainstays of utility DSM since the 1980s. Some of these programs may include energy conservation and efficiency provisions. For example, the Long Island Power Authority offers a residential air-conditioner load-control program called LIPA*edge* that includes an energy conservation message and some information and analytical tools (a Web-based audit). Our interest and focus in this report have been more directed toward the newer generation of “demand-response” programs.

Program Experience Discussion and Conclusions

Our main conclusion from our review of program experience is that it would be beneficial to thoroughly test program design concepts that incorporate both demand response and energy efficiency objectives as an alternative to only offering distinct “demand-response” and “energy efficiency” programs. As noted above, there are efforts underway in California and New York to achieve this type of integration. For example, a demand-response program that targets lighting curtailments by reducing lighting levels might also include provisions for customers to implement lighting upgrades (more energy-efficient lighting) as part of a comprehensive package of program services. Or similarly, HVAC curtailment programs designed to shed cooling loads during peak periods might also promote energy efficiency upgrades to equipment and systems. If enhanced communication and control technologies are promoted, as was the case with the California demand-response programs we studied, programs also could emphasize permanent load reduction through energy efficiency measures as a complementary way to further reduce peak loads, as well as capture additional economic benefits from broader energy savings. In this same vein of thinking about combined approaches, programs that have been offered as energy efficiency programs could incorporate elements that also promote demand-response capabilities.

Through such combined approaches, programs might be more appealing to customers, and achieve greater cost-effectiveness and a greater collective combined impact than if separate programs were pursued. Other analysts have reached a similar conclusion on the potential benefits of integrated approaches. An evaluation of California’s demand-response programs concluded, “Integrating DR [demand response] and other programs, especially energy efficiency and basic customer services, provides opportunities for cross-marketing, makes good use of common marketing and sales resources, and helps rationalize and simplify product/service portfolios.” (QCI and SBC 2004).

One important caveat to such a combined approach, however, would be that it would be imperative to place the first priority on addressing cost-effective energy efficiency improvements. We make this recommendation for several reasons. First, "permanent" energy efficiency improvements (e.g., end-use equipment upgrades) are certain and lasting in nature, which provides key advantages over intermittent demand-response resources that require repeated behavioral compliance. Second, there are important broader system and societal benefits that arise from energy efficiency improvements (e.g., enhanced environmental and resource preservation benefits). Third, energy efficiency improvements emphasize maintaining or even improving customer amenities, which is often not the case for demand-response measures. Lastly, by addressing cost-effective energy efficiency improvements first, this would avoid the perverse incentives that could be created if financial incentives are paid for short-term demand reductions from inefficient baseline demand.

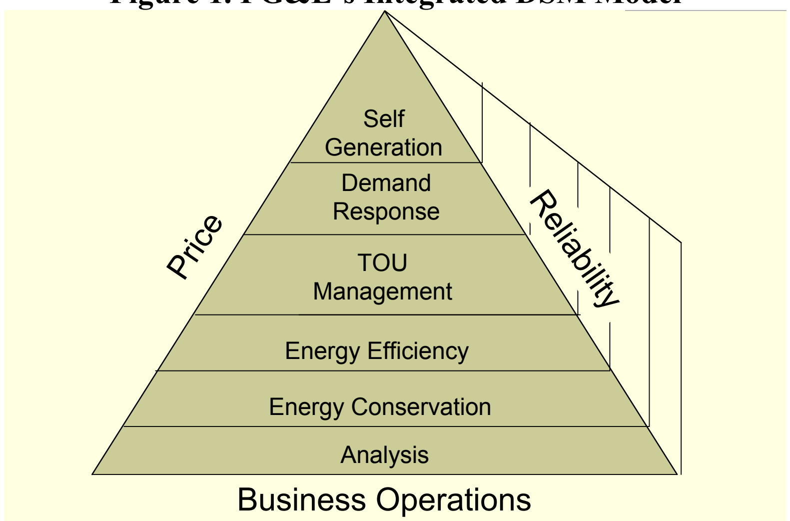
One practical way to ensure that customers have proper incentives to achieve a more efficient baseline would be to allow credit for the permanent demand reductions achieved through improved energy efficiency to be part of combined programs. This was already enacted as part of the Small C&I Demand Responsiveness Program in California. According to the program contractor, customers participating in the program were credited for permanent demand reductions achieved in parallel with the installation of the control and communication systems that enabled demand-responsive capabilities. In this way these reductions wouldn't adversely affect the baseline from which incentive credits were based. It would also be important to structure the incentives to program delivery contractors and staff in such a way that the priority emphasis on energy efficiency is reinforced.

We think it might be helpful for program administrators and implementers to identify measures that can be taken to reduce demand permanently through energy efficiency and those measures that are done as strictly limited-term demand-response measures. Programs should clearly distinguish between the two different types of measures and structure incentives accordingly.

This type of integration is beginning to occur. As an example, Pacific Gas & Electric Company has begun to integrate demand response and energy efficiency at the portfolio level (Alexander 2004; Kinnert 2004; McCarty 2004). PG&E believes strongly in DSM and DSM program integration. It also believes that optimizing market penetration of all DSM elements requires taking an integrated approach. Recently, PG&E formed the Gas & Electric Procurement, Policy and Planning Department, and the DSM planning process is now organizationally integrated into PG&E's Supply Procurement process. PG&E has a 3-year DSM Integration Plan underway through which it hopes to integrate the DSM effort in terms of both program design and marketing. Marketing integration will precede program integration, since regulatory and legislative approvals are needed for successfully integrating DSM program design.

PG&E's framework for looking at customers' perspectives on the full array of energy efficiency, demand-response, and other end-use technologies is very useful to the discussion of the relationship of demand response and energy efficiency. On the marketing side, PG&E is developing a comprehensive understanding of the customer's energy situation (accomplishments, needs, sensitivities, decision process, etc.) within the context of their business operations and their sensitivity to price and reliability, and PG&E is offering an optimal mix of programs and services best suited for the specific customer. PG&E believes that there are opportunities to leverage common technologies (especially advanced control systems) that will allow building operators to manage energy consumption. Integration will facilitate customer acceptance of demand-response and self-generation programs as customers have embraced traditional energy efficiency programs. This perspective is graphically shown below in Figure 1.

Figure 1. PG&E's Integrated DSM Model



In brief, Figure 1 analyzes the needs of a business customer by looking at the relative importance to the customer of its business operations, price of energy, and reliability of energy. PG&E looks at these "requirements" and works with the customer to see where the customer wants to go with its energy system in the future. The utility first looks at how the customer can eliminate energy waste through energy conservation (e.g., turning off lights or air conditioning when not needed) and then through energy efficiency (e.g., investing in insulation, new energy-efficient equipment, etc.). After exploring these alternatives, PG&E discusses time-of-use management options: timing of the customer's energy use relative to price during normal business operations for all weekdays. The next step after this is to see whether the customer wants to go beyond TOU, to meet occasional, critical needs: what demand-response options can be implemented that may change normal business operations to meet an environment of high prices or low reliability. For example, by employing building controls, customers can save energy by managing their loads every day and on those few critical days where extraordinary measures are required. Finally, after all of these options have been considered, the utility then sees what kinds of self-generation options are possible. PG&E realizes that fully integrated programs will take time, and they are taking steps in that direction by acknowledging the need and beginning the planning process.

Program cost-effectiveness is always an important criterion against which to judge program performance. If more combined approaches are taken, it will be important to evaluate the program cost-effectiveness considering both the benefits and costs of energy efficiency and demand-response measures. For measures that achieve both objectives, credit must be given to the value of these multiple objectives, especially accounting for the permanent reductions achieved through energy efficiency first before estimating the demand-response benefits.

Integrated approaches also may help attract customers to participate in programs. Evaluators of California's critical peak pricing and demand-bidding programs (DBP) observed that most eligible customers stood only to save modest amounts (e.g., 1 to 2 percent for the CPP program) from their annual energy bills. The evaluators recommended, "One strategy for capturing a greater share of the value proposition is by integrating programs and services to address different aspects of that proposition" (QCI and SBC 2004). Such other services would include energy efficiency. As a program manager interviewed in this evaluation said, 'Integrating EE [energy efficiency] and demand response together makes customers more likely to participate.' Another put it simply, '[the] DR [demand response] proposition may be tough to make on its own.'

Integration of demand response and energy efficiency may require coordination and integration of funding mechanisms as different entities may be involved in programs as demonstrated in some of our case studies. For example, NYSERDA is a state authority responsible for administering the public benefits program in New York. Its Peak Load Reduction Program provided services and incentives to customers in order that they might participate in the demand-response programs offered by NYISO, which offered its own incentives to participating customers. Similarly, the California Energy Commission provided services and incentives to customers to enable participation in demand-response programs offered by utilities or system operators. In such cases, assessing relative costs and benefits among the different entities and structuring the incentives accordingly may pose some analytic and administrative challenges. However, such challenges should be readily overcome with greater experience with integrated programs as different funding mechanisms and incentive structures are tried. California's and New York's experiences with some initial efforts at integrated approaches suggest that workable solutions are possible.

Taking a combined, integrated approach to energy efficiency and demand response also would simplify program participation from the customer perspective. The sheer number of programs available in California was cited as a source of confusion by some interviewees in our research on selected California Energy Commission programs. Similarly, ease of program participation was cited as a very positive attribute by a couple of the Small C&I Demand Responsiveness Program participants we interviewed in our California study because that program took special care to simplify the process for participants. Those people specifically mentioned how much they appreciated the program contractor's management of their grant.

In New York, the Peak Load Reduction Program offers support to both energy efficiency and demand-response measures. This helps customers match their needs with program services without having to shop around from program to program. Also in New York, the Westchester $mart Homes Pilot for residential customers promotes energy efficiency and demand response in a single program package of services. Customers receive both a comprehensive energy audit to identify energy efficiency opportunities and interval meters that will allow them to monitor and track their energy use in order to take advantage of the time-differentiated pricing options.

If programs do target multiple objectives, there may be a clear rationale for joint funding of such programs. For example, entities like the independent system operators that seek demand-response capabilities might partner with utilities they serve seeking to achieve energy efficiency goals to fund a common program. This also would make it easier from the customer's perspective to search for opportunities and participate in programs

Demand response and energy efficiency should be viewed as complementary resources that are valuable to an overall portfolio of demand resources. Cowart (2001, p. 62) captured this viewpoint in the following:

> A central conclusion of this report is that efficiency, load management and price-responsive load are complementary and essential components of reliable power systems and efficiency electricity markets.

Our review of experience with demand response and energy efficiency supports this "balanced portfolio" perspective. PG&E provides an example of one utility that is very deliberately taking this "balanced portfolio" approach to the full array of customer energy end-use options. Another example we found is ISO New England, which is promoting "Integrated Energy Management" in association with its marketing materials for its demand-response programs. ISO New England (2004) recommended that customers plan and implement three integrated components: (1) reducing how much electricity is used by improving energy efficiency; (2) changing when electricity is used by participating in demand-response programs; and (3) purchasing electricity from a competitive supplier who can offer a lower price for having an attractive load shape.[21]

We see clear benefits that can be realized through pursuit of both demand response and energy efficiency, although clearly much more analysis is needed of how each can contribute to both peak-demand reduction and reduced overall electricity consumption. There also is more research and analysis needed to assess impacts that can be achieved through "price response," which as a subset of demand response has not been as thoroughly tested.

Section 3. Expert Opinion on Demand Response and Energy Efficiency

We interviewed a small set of experts on both demand response and energy efficiency to explore the relationship between these two demand-side strategies. These experts included program contractors, evaluators, researchers, and analysts.

Our discussions with these industry experts were very helpful, and we appreciate their insights and experience. Below we briefly summarize their observations on two of the key issue areas we identified earlier in this report.

[21] One reviewer familiar with ISO New England commented that while this integrated approach is a desirable design concept, the ability of the ISO to implement this vision is hindered by having a limited marketing staff.

- A key factor is that energy efficiency savings can help sell the overall project [including demand response technologies] to the customer because the demand response savings alone aren't enough to motivate the typical commercial customer.

- There is some anecdotal evidence for some spillover from demand response to energy efficiency at the customer level. I've seen some examples where customers have learned about their load and then done some energy efficiency as a result. You certainly could design programs to entice customers to do both, but I don't know of any good examples where demand response and energy efficiency have been coordinated and integrated within a single program.

- Customers are most interested in saving money; providing integrated demand-response and energy efficiency services would be fine for them as long as the combined package meets their cost-saving objectives.

- Demand-response programs should be able to produce energy efficiency effects, but only if the economic signal is carefully designed to do that.

- Demand-response programs can produce energy efficiency effects, but only if there is an explicit focus on energy efficiency. Just informing customers about their energy use and costs is not enough for most customers.

- In theory. good efficient systems and good feedback systems go together—both are critical to well-run buildings. Feedback systems are critical for building operators, who don't generally have good feedback on building performance. Information systems and control systems enable both energy efficiency and demand response….In practice, building operators still largely have "stove-pipe" technology [completely separate, non-integrated systems]. There isn't much of a driver—an economic incentive—for doing more with demand response and energy efficiency.

On the issue of potential conflicts or simply the lack of a relationship between demand response and energy efficiency, the following comments were obtained in our interviews.

- Providers of demand-response "enabling technologies" are primarily motivated to sell their equipment and services, not necessarily ensuring that customers buy and use the capabilities of such systems to achieve energy savings during non-peak demand periods.

- Demand-response service providers benefit from having high market peak prices because this makes their services more valuable to customers, which leads to greater sales and resulting profits.

- Utilities involved with demand-response programs generally signal to demand-response service providers to "just get the MW drop or you'll pay for it." This could send an anti-energy efficiency message.

- Reducing the baseline through energy efficiency can in turn reduce the demand-response savings, which is a structural conflict, at least at the level of the service provider.

- A structural barrier in California and possibly elsewhere is that energy efficiency and demand-response programs are paid for out of separate funding sources, so there is a disincentive to combine them—there are restrictions on co-mingling funds.

- Time-of-use pricing definitely can induce off-peak discounts that are disincentives to energy efficiency. In addition, there may possibly be some off-peak make-up (increased energy use) from processes coming back on that are shut down during peak periods, but this is probably a minor issue.

- Demand response can send customers a mixed signal, "It's OK to use a lot of energy, just not during peak periods."

- I haven't seen cases myself [where demand-response programs have produced energy efficiency effects]. I'm aware of some reports of some overall energy-reduction effects that have resulted from DR [demand response] programs.

- They [energy efficiency and demand response] are fairly independent. Energy efficiency targets annual or seasonal energy savings—very broad, overall load reductions. Demand response targets very specific hours—often dispatchable so that it can be called on when needed. This is only for a few hours over an entire year.

- There is some difficulty getting energy efficiency integrated into demand response. ISOs focus on the active part of capacity resources. When there's a need or emergency, ISOs want to have a resource that can be called into play to address the need or emergency. The issue with integration of energy efficiency into demand response is that the energy efficiency may not be available as an increment of actionable load reduction when needed. The energy efficiency becomes part of the baseline demand and is a different type of resource.

- The different alignment of interests creates some problems for integrating energy efficiency into demand response. ISOs are mostly interested in demand response as a capacity resource—not really interested in energy efficiency. Integration of demand response and energy efficiency falls back more to the states for determining resource adequacy.

Overall, the experts we interviewed were virtually unanimous in responding that they knew of few or no examples of programs that had explicitly attempted to integrate energy efficiency and demand response objectives and measures into a single program. At the same time, most of our interviewees felt that such an integrated approach had some conceptual merit and was worth testing.

PART 3. CONCLUSIONS AND RECOMMENDATIONS

One of the core objectives of this overall study was to broadly examine and characterize experience with demand-response programs in the United States. Over the past 5 years, interest in demand-response programs has increased dramatically. Numerous programs and initiatives have been launched by utilities, states, independent system operators, regional collaboratives, national research institutions, regulators (both state and federal), and industry trade groups. We sought to identify, categorize, and summarize these efforts to provide an overall description of demand-response activities in the United States and help point readers to other sources of more detailed information.

Our other primary objective in this study was to explore the relationship between demand response and energy efficiency. One of the reasons we launched this project was because we knew that, despite the wealth of information available on the theory and practice of demand response, relatively little research had been done on the relationship between demand response and energy efficiency. As we conducted the study, we were somewhat surprised to discover how little attention has been focused on that issue. We found this to be a major area in need of research, testing, and analysis.

We present our specific conclusions below according to major areas of our review, research, and analysis.

Section 1. Demand-Response Program Experience

Demand response has arisen in parallel with the movement towards greater competition in wholesale and retail electricity markets. Demand response is viewed by many as a critical element of competitive markets, providing a mechanism to assure efficient interaction of electricity supply and demand. Its benefits include the ability to relieve generation and transmission constraints, moderate wholesale price “spikes,” and reduce long-term energy prices across all customer sectors. Crisis and near-crisis conditions and events have spurred the development and practice of demand response.

Experience to date with demand-response programs has generally been positive. Scores of demand-response programs of different types have been offered and are in place across the United States. Many have their origins in the practice of utility DSM of the 1980s and 1990s. Certain states and regions have been especially active in developing and offering demand-response programs, notably California, New England, and New York, but programs can be found in most states. To date nationally, demand-response programs have reduced demand by about 4,000 MW according one estimate (Energy Info Source, Inc. 2004). The potential resource is clearly much larger, but defining and quantifying this resource potential is difficult because some of it is a function of varying pricing and market conditions. Goldberg, Michelman, and Rosenberg (2003) estimated the total potential demand-response resource for four large ISOs (California, New England, New York, and PJM) to be 5,200 MW.

Most demand-response programs offered to date have focused on reliability, largely interruptible and curtailment programs. Goldberg, Michelman, and Rosenberg (2003) in their study of the four major ISOs found that reliability programs—both contractual and voluntary—"achieved" a load-reduction impact of 1,081 MW, while the load reduction achieved in price-response programs was only about 27 MW. Load-response (reliability) programs comprise the largest demand-response resource in terms of their contributions to peak-load reductions. This is not surprising as these types of programs are well established and have been successfully used for decades. These load-response programs provide system planners and operators a relatively well defined (in terms of its magnitude) and reliable resource to call into play under emergency conditions or other times of significant system constraints or high prices.

Price-response programs have been the focus of many recent programs and initiatives, especially dynamic pricing such as critical peak pricing and real-time pricing. There is strong support among certain groups and in certain states and regions for exposing electricity customers to prices that reflect actual market conditions and associated prices—especially for commercial/industrial customers although some would extend this to residential customers, too. This support comes from federal regulators (FERC), state regulators (NARUC and individual regulatory commissions), industry organizations (e.g., EEI, PLMA, and EPRI), independent system operators, utilities (load serving entities), and at least some customers.

Despite the growing interest in price-response programs, experience with such programs to date shows mixed results. Dynamic pricing is the category of price-response programs that has garnered the greatest attention and focus in recent years, although there have been a handful of such programs with a much longer history. Experience with real-time pricing programs is mixed, however. Barbose, Goldman, and Neenan (2004) found in their review of 43 real-time pricing programs that most of them have not achieved significant absolute or relative demand reductions—with only one program achieving greater than a 100 MW reduction and only one program achieving a load reduction greater than 1 percent of peak demand. They also found that a relatively large number of customers enrolled in RTP programs are not very price sensitive. Another finding was that most RTP programs with more than 20 participants have generated maximum load reductions equal to 12 to 22 percent of participants' non-coincident peak demand. A few have generated a high demand response of about 33 percent. RTP programs do work well for some customers, however, and some programs have been largely successful in achieving significant load reductions and meeting other program goals, such as those programs offered by Niagara Mohawk Power Corporation and Georgia Power Company. RTP programs have achieved load reductions over a wide range of range of prices, from $0.12/kWh to $6.50/kWh.

Experience with dynamic pricing has been limited mostly to large commercial and industrial customers. There are, however, pioneering efforts with residential dynamic pricing occurring in California, Illinois, Florida, and New York. Some of the initial results are promising, but it is still too early to assess the full impacts of these programs. These programs should reveal a great deal about how residential customers respond to time-differentiated rates that reflect wholesale market prices and conditions.

The other major type of price response—or market-based—demand-response program is demand bidding. These types of programs have remained a relatively small share of overall demand-response portfolios. They are not nearly as widespread as load-response programs, but seem to have the potential to be an important and effective resource in those states and regions that have them.

Section 2. Demand Response and Energy Efficiency

Demand response and energy efficiency both affect customer end-use of energy. How exactly these primary objectives relate to each other was a primary focus of our research and analysis. This section is segmented according to key issues that we identified on the relationship between demand response and energy efficiency—issues that would help to define this relationship.

Impacts of Demand-Response Programs on Overall Customer Energy Use and Energy Efficiency

Unfortunately, we found that there is almost no published research on the issue of how demand response affects energy use during off-peak periods and overall building/facility energy use and energy efficiency. There is some mostly anecdotal evidence that suggests certain types of technologies capable of enabling demand response during peak demand periods can also realize energy and demand savings in off-peak periods (Larkin et al. 2004; XENERGY and Nexant 2002a, 2002b). This is especially true for building energy information and control systems, which can adjust lighting levels and HVAC settings in response (manually or automatically) to price signals or other communications calling for load reductions. These advanced information, communications, and control systems can also be used to better manage and control systems at all times—not just during peak demand periods. Building owners or operators can use these systems to "fine-tune" building operation—eliminating or reducing unnecessary energy use and closely matching building loads such as lighting and cooling to occupant needs. We found this to be true of a few of the customers we interviewed who had participated in CEC demand-response programs that targeted enhanced automation and building energy information systems, but others had not yet used the capabilities of the systems in this way.

While these types of advanced building systems are available and are being installed and used by an increasing number of building owners, their use as an active energy management tool is by no means automatic. Like any tool, it is up to the operator to make the best use of the tool's capabilities. For some customers, getting such technologies through participation in demand-response programs was a springboard to establishing an active and targeted campaign to monitor and manage their energy use more effectively year-round. However, other customers did not seem to take that step. Some customers still lacked resources (human and other) to devote to such a step. Others simply did not find sufficient economic incentive to do so. These observations are based on a few anecdotes and selected case studies. We were not able to determine the extent that customers are using these technologies actively as energy management tools because we found virtually no demand-response program evaluations that have systematically evaluated this kind of impact or spillover effect on a program-wide basis.

Overall we found little quantitative analysis of energy efficiency and conservation impacts from demand-response programs. We found limited anecdotal and qualitative information about such impacts, but we found no quantitative evaluation of demand-response program impacts that specifically included or targeted estimation of such impacts. This is a major gap in our understanding of the relationship between energy efficiency and demand response.

Synergies between Demand Response and Energy Efficiency

Demand response inherently requires customers to develop some understanding of how they use energy in their homes, businesses, institutions, or factories. In order to reduce demand upon price signals or other communications, they need to know exactly how they can reduce their loads—what energy-using equipment they can turn off or adjust to lower their power demand. As customers gain such awareness and understanding of their energy use, they can use this information to manage their energy use at all times if they see how such changes can benefit them—typically the primary motivation would be to reduce energy costs. However, information alone is generally not sufficient to produce significant change. Customers have to have both the motivation and ability to enact change. Demand-response technologies can provide the means to enact certain changes, such as controls to reduce lighting levels or adjust HVAC settings, but without sufficient motivation such changes won't occur. And some kinds of changes to reduce energy use, such as through improved end-use equipment efficiency, may take additional investment and actions to implement. Customers may become aware of opportunities to improve energy efficiency of key end-use equipment and technologies, but may lack technical information, financial and other resources, and/or sufficient incentives to capitalize on such opportunities.

As a number of the experts we interviewed commented: "Customers don't really distinguish between 'demand response' and 'energy efficiency' or 'energy conservation.' Customers simply view various technologies and services in terms of how they can reduce energy costs and yield other possible benefits." Some program examples we found in California and New York are taking a more integrated approach to energy efficiency and demand response—helping customers identify and implement changes of either type that best meet their needs of helping control energy costs. In some cases, separate technologies and actions may be required. In others, the technologies and changes made may be able to achieve both demand response and improved energy efficiency of the operation.

Conflicts between Demand Response and Energy Efficiency

The nature of demand response compared to energy efficiency can create conflicts in marketing messages and other communications to customers about programs and services. Demand response targets reducing loads during a few periods over the course of an entire year when prices are high or reliability is threatened due to supply constraints. Energy efficiency targets energy savings at all times throughout the year when equipment is being used. As shown by the programs we profiled as case studies, demand response often involves reducing demand by reducing energy service or amenities—such as the amount of lighting in a space or allowing internal temperatures to rise during cooling periods. Whether noticed by occupants or not, there clearly is a measure of "sacrifice" or "doing with less" involved.

Energy efficiency, by contrast, seeks to reduce energy use through application of more efficient technologies that provide the same or better levels of energy service or amenities. These differences can lead to conflicts and confusion for customers as to what actions they should take. Customers may get the message that reducing peak demand is most important; that their energy use at off-peak times doesn't matter so much, an impression that can especially be supported if customers receive time-differentiated rates whereby off-peak energy use is very inexpensive compared to on-peak use.

A number of the program experts we interviewed agreed that there can be potential structural conflicts between demand response and energy efficiency for certain types of programs and services. For example, if customers are paid for load decrements below an established energy use "baseline" achieved when called by system operators, there can be a disincentive to do anything that might lower the baseline. The nature of energy efficiency improvements is that they would lower baseline energy use of a building or facility.

Institutional barriers may also create conflicts between demand response and energy efficiency. The simple fact that we found so few examples of programs that integrated demand response and energy efficiency suggests that such barriers exist. As electricity markets have been restructured and made more competitive, the respective responsibilities and incentives for certain types of actions have been fragmented among a new set of market actors. Independent system operators are most concerned with effective demand-response resources as they provide a valuable resource to ensure system reliability. State regulatory authorities generally are the primary drivers behind energy efficiency programs and services. Therefore, the funding and structure of programs can occur independently—making it difficult to coordinate and integrate multiple program objectives.

Integration of Demand Response and Energy Efficiency

Programs can be designed to target both demand response and energy efficiency. We found a handful of examples where this has been done to some degree. This can be accomplished by promoting either integrated or independent technologies. Some technologies promoted for their demand-response capabilities can also be used to achieve energy savings objectives. In most cases, however, promotion of specific energy efficiency technologies will be necessary in order to achieve true energy efficiency gains. Fortunately, most energy efficiency technologies also will yield at least some peak-demand reduction benefits. By coordinating demand-response and energy efficiency elements in program design, customers could benefit from integrated solutions to their needs for energy cost reduction and related benefits, such as improved building management and control.

Although we found that such integration of demand response and energy efficiency elements has rarely been attempted thus far, nearly all of the industry experts we interviewed felt that it was a concept worth testing.

Section 3. Recommendations

Based on our observations from conducting this research, we have two principal recommendations for policymakers, regulators, and researchers interested in furthering effective demand-side policies and programs.[22]

- *Make it a research priority to study the effects of demand-response programs on overall energy usage.*

To date, almost no research has been done and very little is known about this issue. We recommend research in this area that would encompass all types of demand-response programs, from load shedding to time of use rates, and which would both document the existence of, and understand the reasons for, any apparent impacts on overall energy use and relative energy efficiency.

There are a number of economic and societal reasons why it is undesirable to promote programs that lead to unnecessary increases in the consumption of energy resources. If certain types of demand-response programs are having that effect (even unintentionally), steps should be taken to seek to correct that problem. Conversely, if certain types of demand-response programs are producing additional positive effects on reducing overall energy consumption, they should receive credit for achieving those effects.

- *Make it a policy priority to design and test programs that explicitly combine demand response and energy efficiency objectives.*

While there are some potential conflicts between demand response and energy efficiency, there are also a number of conceptual reasons why a well-designed integration of demand-response and energy efficiency objectives could be a very effective strategy for capturing important demand-side resources. As many of the experts we talked with noted, the concept certainly is worthy of experimentation and careful field testing. We heartily endorse such experimentation and testing.

Programs featuring such combined approaches have the potential to be more appealing to customers, achieve greater cost-effectiveness, and achieve a greater collective combined impact than if separate programs were pursued. One important caveat to such a combined approach, however, would be that it would be imperative to place the first priority on addressing cost-effective energy efficiency improvements.

We make that corollary recommendation for several reasons. First, "permanent" energy efficiency improvements (e.g., end-use equipment upgrades) are certain and lasting in nature, which provides key advantages over intermittent demand-response resources that require repeated behavioral compliance. Second, there are important broader system and societal benefits that arise from energy efficiency improvements (e.g., enhanced environmental and resource preservation benefits). Third, energy efficiency improvements emphasize

[22] While we recognize that there are a few organizations that are showing some leadership in these areas, we encourage the industry more broadly to recognize these concerns.

maintaining or even improving customer amenities, which is often not the case for demand response measures. Fourth, by addressing cost-effective energy efficiency improvements first, this would avoid the perverse incentives that could be created if financial incentives are paid for short-term demand reductions from inefficient baseline demand.

Finally, it should be emphasized that while we see potential benefits from a more combined programmatic approach to achieve energy efficiency and demand-response objectives, there will clearly be an ongoing role for specific program designs that target only one or the other of these objectives. We cannot overlook the fact that many utilities across the United States have offered and continue to offer effective, successful demand-side management programs—typically distinct (non-integrated) load management and energy efficiency programs. Such programs are achieving significant levels of both peak-load reductions and energy savings—far greater than the estimated total national load reductions achieved by demand-response programs to date. Indeed, until "integrated" demand response/energy efficiency programs are thoroughly tested and proven, separately targeted programs will continue to be the norm. Even then, however, many types of specific programs will still make sense as single-purpose programs (e.g., large industrial load-shed programs, residential lighting programs, etc.). Consistent with principles that have been acknowledged since the integrated-resource planning era first began, we encourage the use of a diverse portfolio of demand-side resource programs.

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APPENDIX A: DEMAND-RESPONSE INSTITUTIONS, ORGANIZATIONS, AND INITIATIVES

Demand-response programs and initiatives offer numerous potential benefits to customers, load-serving entities, independent system operators, and other key stakeholders in electricity markets. Interest in demand-response programs has grown rapidly in recent years because of the great potential benefits.

Despite the promise of demand response, experience with programs designed to harness this potential is relatively limited, at least for the more market-based types of programs, such as real-time or other dynamic pricing. Utility industry restructuring and deregulation efforts have greatly complicated the structure and operation of electricity markets. Federal efforts to develop a "standard market design" in order to bring greater uniformity across regional and national electricity markets also has added complexity and uncertainty to this more complicated picture.

The tremendous promise of demand response combined with the variety of institutional, market, and technological barriers that exist toward greater utilization of these resources has led to numerous state and regional initiatives to examine key demand-response issues and develop appropriate policy responses to address these. In this appendix, we survey key international, national, regional, and state initiatives that address demand response.

National and International Organizations and Initiatives

Demand Response and Advanced Metering Coalition

A national group that was formed recently is the Demand Response and Advanced Metering Coalition (DRAM), which is an association of public interest groups, demand response technology companies, utilities, and other parties focused on education and outreach in the area of demand response. DRAM's mission "[I]is to be a source of information, data and expertise in demand response and to provide a diverse forum for ideas and experience to be exchanged among policy makers, DR practitioners, DR providers and other interested parties." DRAM advocates for increased use of advanced metering and communications technologies to support demand-response programs and to provide energy consumers with time-of-use information in order to guide energy use decisions.

DRAM specifically supports a variety of mechanisms and policies to achieve its mission, including:

- Giving consumers access to energy information to enable them to make informed decisions about electricity use and energy efficiency; participate in demand-response programs; take advantage of lower off-peak rates to save on their bills; receive the full value of alternative energy and energy efficiency products that reduce demand during high price on-peak periods; and be rewarded for wise and efficient use of energy.

- Ensuring that regulatory policy provides for recovery of implementation costs for advanced meters, as well as to provide financial incentives to help offset the costs of advanced meters, such as tax credits and accelerated depreciation.
- Using existing national technical standards and existing data protocols applicable to advanced metering to minimize costs for equipment, data communications, and data management.
- Promoting the development and implementation of price-based demand-response programs, along with promoting voluntary participation in these programs.
- Requiring that federal facilities be metered individually or submetered with interval or other time-of-use metering technology.

To enact such policies, DRAM has testified at both federal and state regulatory proceedings. DRAM also has participated in the New England Demand Response Initiative (NEDRI), described further below, under "Regional Organizations and Initiatives."

Edison Electric Institute

The Edison Electric Institute, the association of U.S. shareholder-owned electric companies and industry associates, views demand response as "essential to competitive markets." EEI noted:

> While wholesale electricity prices fluctuate hourly, retail customers generally do not see these price changes. Without clear price signals, customers have no incentive to reduce usage during infrequent periods of high wholesale prices.

In recent years, EEI has collaborated with the Peak Load Management Alliance (see below) to track demand-response program development. Together EEI and PMLA have conducted two annual "Benchmarking Surveys;" the first was for 2001 data, the second for 2002. The survey is part of a system that the two organizations have established to help program managers benchmark their demand-response programs. This benchmarking system is an on-line database that allows program managers to input program information on a dedicated site. The system operators "scrub" data before it is available to users of the system, who can view results of data surveys or download results for their own analysis. As of May 2003, the EEI/PLMA Benchmarking Survey had received partial or complete information from 17 companies (or other entities) for a total of 26 demand-response programs. The majority of these data were received from investor-owned utilities; no ISO or RTO submitted data in 2002.

Only direct participants in the benchmarking survey have full access to the data submitted by all participants. EEI and PMLA, however, do publish summary data that is available to non-participants and non-members. Below are summary data available publicly for the 26 programs covered in the most recent survey.

Program target sectors	5 residential, 21 non-residential (commercial, industrial, agricultural)
Program costs	\$0 to \$40.4 million
Summer demand reduction results	0 to 500,000 kW
Maximum/potential demand reduction achieved	0.54 mean 0.72 median
Summer energy impacts (kWh savings)	0 to 4.9 million kWh
Top control strategy	C/I: utility warning with customer controlling onsite use
Top methods of communications	Internet, direct email, and telephone/paging (no ranking given of these three)
Operational parameters	• Number of DR events: 1 to 365 • Maximum hours/event: 4 to 24 hours

EEI also regularly gathers information from both members and non-members on their efficiency and demand-response programs offered to residential, commercial, and industrial customers. The latest of these annual surveys was updated in June 2003. This survey collects the following information on efficiency and demand-response programs:

- Member or investor-owned utility name and states served
- Program(s) name(s)
- Program(s) summary statement(s) on services and program type
- Web site

This survey gives a good snapshot of the types and numbers of programs offered across the U.S. It shows clearly that demand-response programs have become widespread. Of the 90 utilities included in this survey, 52 offer some type of demand-response program, broken down by the following categories:

- 30 utilities offer load control or other types of "traditional" load management, such as residential air conditioner cycling programs
- 29 utilities offer curtailment programs for commercial and industrial customers
- 10 utilities offer some type of time-differentiated pricing, generally real-time pricing
- 5 utilities offer interruptible programs
- 2 utilities offer demand bidding programs
- 2 utilities offer emergency back-up generation programs

EEI also has published a number of policy papers that analyze key demand response issues, including:

- "Barriers to Price Responsive Demand in Wholesale Electricity Markets"
- "Economic Principles of Demand Response in Electricity"
- "Retail-Load Participation in Competitive Wholesale Electricity Markets"
- "The Role of Demand Response in Electric Power Market Design"

Federal Energy Regulatory Commission (FERC)

As the regulatory authority that has jurisdiction over wholesale, interstate electricity markets, FERC is a key driver specifically for encouraging players in these markets to use demand response. On July 31, 2002, FERC issued a "Notice of Proposed Rulemaking" (NOPR) on "Standard Market Design" (SMD). Development of SMD is an objective of FERC in order to help achieve its objective of "wholesale electricity markets that produce just and reasonable prices and work for customers." Key features proposed as part of SMD include:

- The formation of regional transmission organizations (RTOs);
- Ensuring that all independent transmission organizations have sound wholesale market rules; and
- Varying implementation schedules depending on regional needs and regional differences.

FERC's SMD proposal notes several weaknesses in existing wholesale markets that effective demand-response programs could address. These weaknesses include:

- Recent incidents of supply shortages;
- Demand that does not respond to high prices; and
- Lack of price transparency in the marketplace.

In its "Strategic Plan for Fiscal Years 2003–2008," one of FERC's objectives is to "Establish balanced, self-enforcing market rules." FERC sees demand-side participation as a key element to achieving this objective. It notes that states have direct jurisdictional authority over many demand-side measures. However, FERC is working to encourage more demand response by addressing issues within its jurisdiction. FERC's efforts include:

- Ensuring that wholesale markets facilitate equal participation by demand-side and supply-side resources;
- Encouraging states to adopt programs that let customers respond to changing prices; and
- Helping to remove any impediments that prevent full demand-side participation in electricity markets.

FERC's specific activities to support demand response include:

- Supporting NEDRI (New England Demand Response Initiative);
- Developing region-wide demand-response programs;
- Frequent outreach on demand response and advance metering; and
- Working with the Department of Energy to develop and implement a demand-response research program.

Decisions that FERC makes regarding the structure, rules, and operation of wholesale electricity markets will play a critical role in determining how various market participants—load serving entities, local distribution companies, and independent system operators—can use demand response in working with customers to forge more direct links to these wholesale markets.

International Energy Agency: Demand Side Management Program, Demand Response Project

Ten countries to date—Australia, Denmark, Finland, Italy, Japan, Korea, Norway, Spain, Sweden, and the United States—are working under this umbrella project. The objective is to develop demand response business and regulatory models that can be implemented under various regulatory and market structures. Each country will develop its models based on a common template to be developed by IEA.

Lawrence Berkeley National Laboratory (LBNL)

LBNL's "Energy Analysis" Division has long been active in research and analysis of a variety of issues associated with electricity markets and policies, including demand response. In the area of demand response, LBNL's work includes:

- Analysis of demand-response policies and programs;
- Adoption of demand-response "enabling technologies;"
- Technical assistance to ISOs, utilities, and regulatory agencies on demand-response program design, implementation, evaluation, and measurement & verification; and
- Analysis of dynamic pricing programs.

LBNL has been at the forefront of research and analysis of demand response. Its publications are a rich source of information on such programs. It is also home to the Public Interest Energy Research (PIER) Demand Response Research Center (see below).

National Association of Regulatory Utility Commissioners (NARUC)

NARUC has initiated a number of demand-response activities in order to increase member understanding and ensure coordination among state regulators and the various entities involved with demand-response programs. NARUC received funding from the U.S. Department of Energy for a project to "enhance coordination between building and power system operators in terms of demand-side responses to Location Based Marginal Pricing (LBMP)." NARUC cites the potential benefits of this work as:

- improved power system reliability,
- enhanced environmental quality,
- mitigation of high locational prices within congested areas, and
- reduction of market barriers for demand-side market participants.

NARUC also has completed a white paper on policy and technical issues associated with ISO demand-response programs and has worked to develop guidelines for the interaction of ISO programs with state public utility regulation.

Peak Load Management Alliance

The Peak Load Management Alliance is an organization of utilities, consultants, manufacturers, and research institutions. According to PMLA's By-laws:

> The Corporation has the additional purposes of increasing consumer participation in electric load management for the purpose of achieving a strong competitive energy market, a more reliable electrical system, promoting and actively sharing information about the development, demonstration and evaluation of applicable technologies and products, educating consumers and suppliers about load management's value as a response to market price signals and as a risk management technique.

PMLA's activities include organizing an annual conference and publishing policy papers. Together with EEI it has established a system to help program managers benchmark their demand-response programs as described above under EEI. It also published a policy and program guide for demand-response initiatives, *Demand Response: Principles for Regulatory Guidance.*

PIER Demand Response Research Center

The Public Interest Energy Research Demand Response Research Center was created in 2004 with funding from the California Energy Commission's PIER Program. The center's main objective "[I]s to develop, prioritize, conduct and disseminate research that develops broad knowledge that facilitates DR [demand response]." The center seeks to develop, prioritize, conduct, and disseminate multi-institutional research to facilitate the development and practice of demand response. The center's research agenda covers four principal areas of research:

- Policies, programs and tariffs;
- Utility markets, technology, and systems;
- Customer and end-use technology and systems; and
- Consumer and institutional behavior.

The center seeks to involve a variety of stakeholders, including industry trade associations; researchers; building owners, engineers, and operators; and building equipment manufacturers in its planning and research projects.

Initial projects at the Center include:

- Evaluation of real-time pricing for large users,
- Demand shifting with thermal mass, and
- Automated demand response.

The center also has initiated a scoping study (begun in the fall of 2004) to build on current CEC research and development and related California demand-response activities.

United States Demand Response Coordinating Committee (DRCC)

The committee was formed in July 2004 to work on demand-response issues. DRCC's efforts will be focused on developing information and tools needed to increase the use of demand response as an option to address national, regional, and state electricity issues and challenges. DRCC's members include utilities, ISOs, research institutions, and regional transmission operators. Representatives from state and national regulatory authorities (NARUC and FERC) as well as the U.S. Department of Energy will serve on DRCC in advisory capacities.

An initial effort of DRCC will be to review existing demand-response activities in the U.S. to identify "best practices" among these programs. DRCC also will identify gaps in the knowledge base about demand response.

Regional Organizations and Initiatives

ISO New England and NEPOOL Demand Response Working Group

ISO New England offers two reliability-based programs: (1) Real Time Demand Response and (2) Real Time Profile Response, as well as one price-based program: Real Time Price Response. In addition to offering these programs, ISO New England has worked to promote awareness and understanding of demand response among its customers, as evidenced by "Demand Response Summits" it has held in 2003 and 2004.

ISO New England works closely with the New England Power Pool (NEPOOL), which is a voluntary association of entities that are engaged in the electric power business in New England. Participating entities include investor-owned utility systems, municipal and consumer-owned systems, joint marketing agencies, power marketers, load aggregators, generation owners, and end-users. NEPOOL created the "Demand Response Working Group" in May of 2003, which is a subgroup of the NEPOOL Markets Committee. The fundamental mission and purpose of the Demand Response Working Group are:

- Serve as a forum for demand-response stakeholders to discuss program implementation issues and ideas, business process improvements, marketing activities, and resolution of problems and issues.
- Provide input to the NEPOOL Markets Committee and ISO New England on demand-response program policy, cost allocation of demand-response programs, program evaluation and market assessments, and changes to program design and rules.

Mid-Atlantic Demand Response Initiative (MADRI)

MADRI was formed in 2004, partially based on the NEDRI experience (below). Its focus is on the PJM power system, which along with ISO New England is one of the two most developed transmission system operators in the U.S. FERC has been working closely with these organizations to ensure that demand-response and other distributed resources are effectively treated in the development of these markets and their planning processes.

New England Demand Response Initiative (NEDRI)

This initiative was a ground-breaking regional collaborative with a broad spectrum of participants carried out in 2002–03 via a series of 16 plenary meetings and numerous smaller working group and ad hoc meetings. Its primary focus is on the transmission system and power market operated by the Independent System Operator of New England (ISO New England). NEDRI's overall objective was to "devise an effective long-term strategy for demand responsiveness, which includes load response resources and efficiency investments, in New England's power systems and markets."

NEDRI's participants included state utility commissions; system operators; environmental regulators; state energy offices; utility, demand response, and market participants; consumer and environmental advocates; and federal agencies (non-voting members).

NEDRI organized its work around the following program areas:

- Regional reliability and demand-response programs
- Pricing, metering, and default service reform
- Energy efficiency as a demand-response resource
- Opportunities for load participation in contingency reserve markets
- Demand-response resources and power delivery systems

NEDRI first established basic principles around which programs should be designed for the region and then worked to establish consensus on specific policy recommendations for programs. NEDRI adopted a total of 38 policy recommendations to support comprehensive development of cost-effective demand-response resources throughout the region. The recommendations largely represent consensus of all NEDRI members with the exception of the regulatory agencies, which abstained from endorsing the recommendations so as not to compromise their neutrality as regulatory agencies possibly facing cases involving the issues covered by NEDRI.

NEDRI's work yielded a final report and a set of "framing" papers on the principal program areas its participants covered. This documentation is a valuable and in-depth resource on the theory, experience, and issues associated with demand-response programs. The NEDRI process provides a useful model of a multi-stakeholder collaborative created to develop effective regional demand-response programs.

PJM Interconnection—Demand Response Working Group

PJM is a regional transmission organization that operates the transmission system in a large region of the Northeast and Middle Atlantic and into the Midwest, including areas in Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia. PJM established a demand-side response working group in about 2001, which remains active today. This group covers a wide variety of issues pertinent to demand response for PJM and its 300-plus member organizations. These issues include:

- Analysis and estimate of demand-resource potential,
- Regulatory barriers and opportunities,
- Market-enabling mechanisms,
- Metering and communications infrastructure,
- Pricing policies,
- Coordination of regional policies and technical standards,
- Load response and other demand-response program results,
- Principles for demand response, and
- Surveys of member demand response activities.

State Organizations and Initiatives

California Energy Commission and California Public Utilities Commission

California has been at the forefront of demand response research, program development, and implementation. The California Energy Commission and California Public Utilities Commission have been leading these efforts in California, working closely with California's utilities. Much of this recent activity stems from a joint "Order Instituting Rulemaking on Policies and Practices for Advanced Metering, Demand Response and Dynamic Pricing, R.02-06-001," issued in the summer of 2002. As the Order states:

> We open this rulemaking proceeding to address, in a comprehensive manner, policies to develop demand flexibility as a resource to enhance electric system reliability, reduce power purchase and individual consumer costs, and protect the environment.
>
> Through this proceeding, we hope to craft a comprehensive policy in the three investor-owned utility territories of Pacific Gas & Electric, San Diego Gas and Electric (SDG&E), and Southern California Edison (Edison), to provide options to individual consumers for reducing cost, while providing overall system benefits.

This Order has been the genesis for numerous activities supporting the development of demand response in California, including research, workshops, multi-stakeholder working groups, program development, and evaluation protocols. The Statewide Residential Dynamic Pricing Pilot underway is one example of a development from these activities. The CEC also funds the PIER Demand Response Research Center and its activities, described above.

Prior to the activities stemming from the California energy crisis of 2000–01 was the impetus for a rapid expansion of both demand-response and energy efficiency programs. The California Legislature passed two bills—SB 5X and AB 29X—that provided $859 million in additional funding for a wide variety of programs to be administered by utilities, third parties, public agencies, and other organizations. The California Energy Commission received funding to administer several programs, including demand response.

Coordinated Demand Response Working Group, New York

New York has a Coordinated Demand Response Working Group (CDRWG) that has been operating since 2001. The CDRWG members are the New York State Energy Research and Development Authority, New York Power Authority, the Long Island Power Authority, the New York Public Service Commission, and the State Department of Environmental Conservation. The CDRWG tracks eight categories of programs, including energy efficiency and voluntary and contracted callable loads during events called by the New York Independent System Operator. The CDRWG coordinates closely with the NYISO and local utilities, like Con Edison. At the end of late fall of each year, the CDRWG starts planning for the next year's impact (based on forecasted need, available budgets, lessons learned from the past summer, etc.). As spring and summer come along, the CDRWG meet periodically and report on a monthly basis (sometimes weekly if the energy situation is serious).

New York State Energy Research and Development Authority

NYSERDA has played and continues to play a leading role in demand-response initiatives, research, and programs in New York. Two current NYSERDA programs target demand response: (1) Comprehensive Energy Management (CEM) for residential customers, and (2) the Peak Load Reduction Program for business customers. These programs assist customers who wish to participate in NYISO demand-response programs (see below).

NYSERDA works with key stakeholders in New York's electricity markets to coordinate programs that reduce peak demand. These other key stakeholders include the New York Department of Public Service, the New York Independent System Operator, the Long Island Power Authority, the New York Power Authority, the New York State Department of Environmental Conservation, curtailment service providers, representatives of electricity customers, and utilities. NYSERDA and this extensive group of stakeholders in New York's wholesale electricity markets worked together to develop emergency curtailment and price-responsive load programs in New York in order to allow end-use customers to participate more fully in wholesale electricity markets.

New York State Independent System Operator—Price Responsive Load Working Group

The New York State Independent System Operator offers several demand-response programs. In addition, NYISO created the Price Responsive Load Working Group (PRLWG) in 2000 "to develop rules and guidelines that facilitate and encourage the participation of load resources in New York's demand-response programs." PRLWG has played an active role in guiding the development and improvement of NYISO's demand-response programs. Its activities have included training, program design, implementation, and evaluation. This working group has provided a forum for market participants interested in the development of demand-response programs to provide input to NYISO.