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Coordination of Energy Efficiency and Demand Response

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Environmental Energy Technologies Division

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Disclaimer

About This Document

This paper, *Coordination of Energy Efficiency and Demand Response,* is provided as a resource to assist those advancing the National Action Plan for Energy Efficiency's goal of achieving all cost-effective energy efficiency by 2025.

This paper summarizes existing research on the relationship between energy efficiency and demand response. Using information gathered through interviews with program administrators, customers, and service providers, this paper discusses the coordination of energy efficiency and demand response programs, with a particular focus on current practices and opportunities. It also discusses barriers to coordinating these two types of programs.

This paper was developed as a resource for a variety of audiences that may be interested in the nexus between energy efficiency and demand response. Intended audiences include policy-makers, program administrator staff, regulatory staff, service provider organizations, and stakeholders who provide input on the design and implementation of energy efficiency and demand response programs and tariffs.

Coordination of Energy Efficiency and Demand Response

A RESOURCE OF THE NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY

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The Leadership Group of the National Action Plan for Energy Efficiency is committed to taking action to increase investment in cost-effective energy efficiency. *Coordination of Energy Efficiency and Demand Response* was developed under the guidance of and with input from the Leadership Group. The document does not necessarily represent a consensus view and does not represent an endorsement by the organizations of Leadership Group members.

Coordination of Energy Efficiency and Demand Response is a product of the National Action Plan for Energy Efficiency and does not reflect the views or policies of the federal government. The role of the U.S. Department of Energy and U.S. Environmental Protection Agency is limited to facilitation of the Action Plan.

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List of Abbreviations and Acronyms

AMI	advanced metering infrastructure
BAS	building automation system
Btu	British thermal unit
CAISO	California ISO
CEC	California Energy Commission
CSP	curtailment service provider
CPP	critical peak pricing
CPUC	California Public Utilities Commission
DRRC	Demand Response Research Center
DOE	U.S. Department of Energy
DSM	demand-side management
EIS	energy information system
EMCS	energy management control system
EMS	energy management system
EPA	U.S. Environmental Protection Agency
ESCO	energy service company
ESPC	energy savings performance contract
FERC	Federal Energy Regulatory Commission
GE	General Electric Company
HVAC	heating, ventilating, and air conditioning
ISO	independent system operator
ISO-NE	ISO-New England
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
NYISO	New York ISO
O&M	operations and maintenance
PCT	programmable communicating thermostat
PG&E	Pacific Gas and Electric
RTO	regional transmission organization
RTP	real-time pricing
SMUD	Sacramento Municipal Utility District
TEM	total energy management
TOU	time of use rate

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Executive Summary

This paper reviews the relationship between energy efficiency and demand response and discusses approaches and barriers to coordinating energy efficiency and demand response. The paper is intended to support the 10 implementation goals of the National Action Plan for Energy Efficiency's Vision to achieve all cost-effective energy efficiency by 2025.[1] Improving energy efficiency in our homes, businesses, schools, governments, and industries—which consume more than 70 percent of the nation's natural gas and electricity—is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change.

While energy efficiency is an increasingly prominent component of efforts to supply affordable, reliable, secure, and clean electric power, demand response is becoming a valuable tool in utility and regional resource plans. The Federal Energy Regulatory Commission (FERC) estimated the contribution from existing U.S. demand response resources at about 41,000 megawatts (MW), about 5.8 percent of 2008 summer peak demand (FERC, 2008). Moreover, FERC recently estimated nationwide achievable demand response potential at 138,000 MW (14 percent of peak demand) by 2019 (FERC, 2009).[2] A recent Electric Power Research Institute study estimates that "the combination of demand response and energy efficiency programs has the potential to reduce non-coincident summer peak demand by 157 GW" by 2030, or 14–20 percent below projected levels (EPRI, 2009a).

This paper supports the Action Plan's effort to coordinate energy efficiency and demand response programs to maximize value to customers. For information on the full suite of policy and programmatic options for removing barriers to energy efficiency, see the *Vision for 2025* and the various other Action Plan papers and guides available at www.epa.gov/eeactionplan.

Energy Efficiency and Demand Response

Energy efficiency refers to using less energy to provide the same or improved level of service to the energy consumer in an economically efficient way; it includes using less energy at any time, including during peak periods. In contrast, demand response entails customers changing their normal consumption patterns in response to changes in the price of energy over time or to incentive payments designed to induce lower electricity use when prices are high or system reliability is in jeopardy. Because most demand response programs in effect today are event-driven, customers tend to assume that demand response events occur for limited periods that are called by the grid operator; but critical peak pricing (CPP) and real-time pricing (RTP) are growing in prevalence and impact. Many demand response programs are designed primarily to curtail or shift load for short periods of time; however, those programs that educate customers about energy use with time of use (TOU) rates, dynamic rates, and energy use feedback can also produce measurable reductions in customers' total energy use and cost (EPRI, 2009b).

There are significant differences in how energy efficiency and demand response are measured, what organizations offer them, how they are delivered to customers, and how they are rewarded in the marketplace. Reducing these differences and coordinating energy efficiency and demand response could be beneficial. Better coordination of energy efficiency and demand response programs at the provider level could bring about cost efficiencies and more rational allocation of resources for both program providers and customers. Coordination could help customers, as most customers do not understand or care about the difference between energy efficiency and demand response and would be receptive to an integrated, packaged approach to managing their energy usage. Greater customer willingness could also increase demand response market penetration and capture energy savings and customer bill-reduction opportunities that might otherwise be lost.

Over the long term, customer and utility smart grid investments in communications, monitoring, analytics, and control technologies will blur many of the distinctions between energy efficiency and demand response and help realize the benefits of this integration.

Coordinating Energy Efficiency and Demand Response

Coordinating energy efficiency and demand response could provide customers with better tools to understand, manage, and reduce their electricity use. Such coordination can occur in at least four ways:

- **Combined program offerings.** Customers could be offered both energy efficiency and demand response opportunities under the same program and provider umbrella; separate programs are the norm today.

- **Coordinated program marketing and education.** Without merging the delivery of services at the program level, program sponsors (e.g., utilities) could package and promote energy efficiency and demand response in a closely coordinated or unified way. Energy efficiency and demand response can be complicated topics, requiring sophisticated customer effort and action, so program sponsors should offer education that addresses both topics under a broad energy management theme.

- **Market-driven coordinated services.** Coordination need not occur only within the context of programs offered by utilities, public benefit organizations, or independent system operators (ISOs). Coordination of energy efficiency and demand response could also come about through the initiative of private firms that find a market among customers who are interested in reducing their energy costs. Our research and interviews with selected energy service companies (ESCO) and curtailment service providers (CSP) suggests that they are interested in this approach; we describe their initial steps in this direction.

- **Building codes and appliance standards.** Building codes and appliance efficiency standards can incorporate preferred energy efficiency and demand response features directly into building design and infrastructure and appliance designs, enabling significant reductions in the costs to customers of integrating energy efficiency and demand response strategies and/or measures (e.g., global temperature setback controls, automated demand response, embedded controls in appliances).

At the provider level, utilities and grid operators should coordinate energy efficiency and demand response through the resource, budget planning, and rate design processes. Such coordination is needed because energy efficiency affects how much load shift is available from a given customer; chosen energy efficiency measures affect how much money the customer and utility have available to spend on demand response (and vice versa); and rate design, efficiency, and demand response affect the load levels and profiles that supply resources need to serve.

Today, few entities combine energy efficiency and demand response into an integrated program. In December 2009, out of 2,016 U.S. and Canadian energy efficiency, demand response, and load management programs in the E Source database, only 56 were identified as serving both energy efficiency and demand response purposes. Some examples of these combined programs include:

- Austin Energy, Kansas City Power & Light, Long Island Power Authority, and others that offer residential "smart" thermostat programs that provide customers with communicating programmable thermostats in return for participation in a demand response program that curtails load during a limited number of summer hours by raising the thermostat's set point. Properly used, programmable thermostats can also provide daily energy savings.

- Sacramento Municipal Utility District (SMUD) implemented the Small Business Summer Solutions Research Pilot in summer 2008 targeted to small commercial customers with peak demands less than 20 kilowatts (kW). Building on an energy efficiency audit and conservation and efficiency options, the demand response component gives customers critical peak rates, options to install communicating programmable thermostats, and a variety of pre-cooling and conventional control strategies. This integrated approach led to a 23 percent reduction in weather-adjusted energy use and a 20 percent average peak load reduction on critical peak event days.

- The New York State Energy Research & Development Authority offers incentives for prequalified measures and performance-based incentives to customers and ESCOs for electric and gas efficiency, as well as incentives that offset the cost of demand response-enabling equipment, such as load-shedding controls and automation equipment.

The capability and potential for energy efficiency and demand response at a customer site are derived from four elements—the building, its electro-mechanical systems, appliances, and customer behavior. Building design, materials, and orientation are primary determinants of building energy consumption and usage patterns, but that use can be modified and managed by new technology and systems integration tools. Energy control technologies can also enable both energy efficiency and demand response. For example, programmable communicating thermostats (PCTs) can automate energy management; embedded controls, like those being explored with white goods appliances, can enable demand response without significant effort by the consumer; and residential and commercial building energy management systems (EMS) can deliver automated demand response and improve building energy and operational efficiency. Other critical enabling technologies include advanced metering infrastructure (AMI)—essential for dynamic pricing—and energy information systems (EIS) that provide customers feedback on their energy use.

Concerns and Barriers Affecting Coordination

Several factors complicate the process of coordinating energy efficiency and demand response. First, some market and regulatory structures separate responsibility and funding for energy efficiency from that for demand response. Second, some customers with energy management program experience express reservations about demand response. Recent interviews with customers indicate the following concerns:[3]

- Demand response benefits are uncertain, changing with market prices and reliability circumstances, even though energy efficiency impacts are predictable and long-lived.

- Demand response programs vary widely across regions and utilities, and in some cases the inconvenience of participating might outweigh the potential payoff.

- Demand response primarily appears to benefit the utility rather than the customer.

- Participating in demand response might reduce the amount of funding or staff resources a customer can devote to energy efficiency efforts.

Demand response program designers, and those working to design coordinated energy efficiency and demand response programs, should be aware of these concerns and work to mitigate them.

Third, it is important to align retail rates with energy efficiency and demand response objectives.[4] Well-designed tariffs based on dynamic, time-varying prices facilitate demand response without compromising energy efficiency opportunities, and they better reflect the true cost of generating electricity. Many regulators and utilities have been reluctant to place customers on such tariffs. Widespread deployment of an AMI, other enabling technologies, and broad educational efforts will remove one of the major barriers to dynamic pricing among residential and small commercial customers.

Fourth, developing utility staff and contractor capabilities in both energy efficiency and demand response will take time. Many utility employees have expertise in one field or the other, but not both. ESCOs specialize in delivering energy efficiency and sell large, capital-intensive technology solutions, such as boiler and heating, ventilating, and air conditioning (HVAC) replacements; this is a very different business model from that used by CSPs, which focus on less capital-intensive operation and control solutions with shorter contracts.

Facilitating Coordination

There are several ways to encourage better coordination of energy efficiency and demand response:

- Regulators can direct utilities and grid operators to coordinate the programs more effectively and support rate designs that facilitate energy efficiency and demand response.

- Demand-side management (DSM) program goals can be articulated more specifically to address both energy efficiency and peak load reduction goals.

- Customer education about energy efficiency can be broadened to explain demand response and its benefits to the customer.

- Government “lead by example” programs can demonstrate the value of coordinating energy efficiency and demand response, particularly with respect to the impact of enabling technologies that serve both purposes.

- Building codes and appliance efficiency standards can incorporate technology improvements and functionalities that integrate and improve both efficiency and load controllability.

While coordinating energy efficiency and demand response can provide benefits, it will not be easy or swift due to many market, human, financial, and institutional obstacles. Executives and policy-makers should articulate some direction and clarity for utilities and program sponsors with respect to priorities for energy efficiency and demand response programs, their coordination, and overall goals. This is particularly important given the long-lasting nature of utility and customer capital investments, the time and effort it takes to change customer behavior and expectations, and the rapid pace of technological change. Program sponsors and customers alike need guidance regarding the best ways to commit their resources to achieve effective, energy management.

In a few years, as electricity prices and information are delivered more effectively to users and control and communication technologies become more widely accessible, demand response will become more automatic and customer-friendly, allowing customers to identify and more easily target discretionary loads that can be curtailed or shifted. These same technologies will enhance energy efficiency through continuous site commissioning simultaneous with more efficient new buildings—including zero net energy sites—reducing the amount of electricity available for load-shifting. The nature of demand response is also likely to change. While today the bulk of demand response programs are triggered by reliability events, in 10 years, most demand response might be price-driven (and possibly linked to congestion management), enabled by automated onsite energy controls fed by near-real time pricing information without significant customer effort or intervention.

Large-scale deployment of cost-effective energy efficiency resources has the potential to provide significant bill savings for customers and reduce and defer the need for more expensive baseload or intermediate generation resources. Similarly, cost-effective demand response resources have the potential to reduce or defer the need for expensive peak generation and to enhance electric system reliability while also increasing the system's ability to absorb intermittent renewable resources through sophisticated real-time monitoring, analytics, and load controls. Effective coordination of energy efficiency and demand response—by policy-makers, utilities, and third-party program providers—will be necessary to increase the effectiveness and utilization of energy management resources. While progress has been made in recent years, more work and effort are needed to achieve the full promise and potential of the synergy between energy efficiency and demand response.

Notes

1 This paper supports the National Action Plan's *Vision for 2025* Implementation Goal Nine, which encourages program administrators to implement state-of-the-art efficiency information sharing and delivery systems and to coordinate energy efficiency and demand response programs to maximize value to customers (National Action Plan for Energy Efficiency, 2008). For information on the full suite of policy and programmatic options for removing barriers to energy efficiency, see the *Vision for 2025* and the various other Action Plan papers and guides available at www.epa.gov/eeactionplan.

2 The Achievable Potential scenario estimates the cost-effective demand response potentially available if AMI were universally deployed; dynamic pricing were the default tariff; and other demand response programs, such as direct load control, were available to those who opt out of dynamic pricing.

3 Some primary research was conducted for this study, including interviews with 16 utilities and ISOs; 14 large commercial, industrial, and institutional energy consumers; and five large ESCOs and CSPs that operate nationally.

[4] For more information on energy efficiency and retail rates, see National Action Plan for Energy Efficiency (2009)..

1: Introduction

Across the United States, electric utilities and independent system operators (ISOs)[1] are devoting increasing attention and resources to demand response. While energy efficiency is the most prominent component of growing efforts to supply affordable, reliable, secure, and clean electric power, demand response is a key pillar of utilities' and ISOs' resource plans, and its importance is growing. The Federal Energy Regulatory Commission (FERC) estimated the contribution from existing U.S. demand response resources was about 41,000 megawatts (MW), which represents about 5.8 percent of 2008 summer peak demand (FERC, 2008), close to a 10 percent increase from 2006. Moreover, FERC recently completed a national study that estimated demand response potential and identified an achievable potential of 138,000 MW (14 percent of peak demand) by 2019 (FERC, 2009).[2] A recent Electric Power Research Institute study estimates that "the combination of demand response and energy efficiency programs has the potential to reduce non-coincident summer peak demand by 157 GW [gigawatts]" by 2030, or 14–20 percent below projected levels (EPRI, 2009a).

Energy efficiency and demand response are closely related concepts. The 2006 *National Action Plan for Energy Efficiency* defined energy efficiency to include some types of demand response that do not compromise the level of energy service received by consumers and reduce total energy consumption and peak demand.[3] Yet, while both energy efficiency and demand response are means to reducing energy consumption and utility bills, there are significant differences in the way these resources are tapped. Market structures have evolved in some regions to vest responsibility for energy efficiency and demand response in separate organizations. Companies that contract to provide energy efficiency or demand response services to utilities and ISOs generally work in one area but not the other. With rare exceptions, energy efficiency and demand response are marketed and delivered to customers in entirely separate programs.

Reducing this degree of separation would be beneficial. Better coordination of energy efficiency and demand response programs at the provider level, or even full integration of programs, could bring about cost efficiencies and more rational allocation of resources. Coordination might be beneficial at the customer level, as customers might be receptive to a packaged, rather than piecemeal, approach to managing their energy usage. And greater customer willingness could translate into higher market penetration for programs and capture energy savings and customer bill reduction opportunities that might otherwise be lost.

However, relatively little work has been done to date on coordination. Accordingly, the Action Plan's Year Two Work Plan called for exploring the energy efficiency/demand response relationship:

> Particular focus will be to determine how to incorporate energy efficiency (EE) and demand response (DR) in complementary ways such that customers have increased tools at their disposal to understand and manage and reduce their electricity use (National Action Plan for Energy Efficiency, 2007).

This paper was commissioned in support of the above objective.

1.1 Purpose

This paper was developed as a discussion document and resource for those utilities, utility regulators, energy efficiency and demand response service providers, consumer advocates, and others interested in the energy efficiency/demand response nexus. It aims to:

- Summarize existing research on the relationship between energy efficiency and demand response.
- Present new information, gathered through interviews with program administrators, customers, and service providers, on the coordination of energy efficiency and demand response, focusing in particular on current practices and opportunities.
- Discuss barriers to coordinating energy efficiency and demand response programs.

The target audiences for this report include:

- Policy-makers who need a short and concise higher level summary of the issue.
- Program administrator staff members who are involved in designing, marketing, and implementing energy efficiency and demand response programs.
- Regulatory staff members who are responsible for overseeing and approving energy efficiency and demand response program and tariff offerings.
- Service provider organizations that are involved in energy efficiency and/or demand response and are considering strategies to facilitate increased coordination of service offerings.
- Stakeholders who provide input on the design and implementation of energy efficiency and demand response programs and tariffs.

1.2 Scope of Research and Approach

This paper includes a literature review and attempts to synthesize findings of the existing studies on coordinating energy efficiency and demand response. Approximately 40 interviews were conducted with program administrators, customers, and service providers to explore their perspectives on coordinating energy efficiency and demand response. Other experts in energy efficiency and demand response were also consulted, and preliminary findings were discussed at the January 2008 meeting of the Action Plan's Leadership Group.[4]

For reasons of time and budget, the scope of new primary research for this paper was limited. The utility managers interviewed were from a geographically diverse set of utilities, but the sample size (16) was small. The interviewees included representatives from 11 large, investor-owned utilities, three municipal utilities, and two ISOs. Fourteen large commercial, industrial, institutional, and governmental customers were interviewed; no small business or residential customers were surveyed. Interviews were conducted with five large energy service companies (ESCOs) and curtailment service providers (CSPs) that operate nationally. These limitations should be taken into consideration when reading this paper.

1.3 Notes

[1] U.S. regional electric grid management organizations are classified as either ISOs or regional transmission organizations (RTOs). While there are technical differences between ISOs and RTOs, for the purposes of this paper, they are essentially the same. For simplicity, we sometimes use “ISO” as shorthand for “ISOs and RTOs.”

[2] The Achievable Potential scenario estimates the cost-effective demand response potentially available if advanced metering infrastructure (AMI) were universally deployed; dynamic pricing were the default tariff; and other demand response programs, such as direct load control, were available to those that opted out of dynamic pricing.

[3] The National Action Plan for Energy Efficiency (2006) defines “energy efficiency” as follows on p. 1-1: “The term energy efficiency as used here includes using less energy at any time, including at times of peak demand through demand response and peak shaving efforts.”

[4] This paper has also benefited from review by the Action Plan Leadership Group and members of the Demand Response Coordinating Council.

2: Relationship Between Energy Efficiency and Demand Response

For the purposes of this paper, the following definitions are used:

Energy efficiency refers to permanent changes to electricity usage through installation of or replacement with more efficient end-use devices or more effective operation of existing devices that reduce the quantity of energy needed to perform a desired function or service.

Demand response refers to "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." (DOE, 2006)

From a policy perspective, many states have committed to recognize demand-side resources and energy savings as the first or priority resource; some specify that energy efficiency is the priority resource while others address both energy efficiency and demand response (National Action Plan for Energy Efficiency, 2008).

2.1 Energy Efficiency

York and Kushler (2005) describe energy efficiency as follows:

> 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 time of equipment use, energy efficiency measures can also produce significant reductions in peak demand.

This definition of energy efficiency makes three key assumptions: (1) existing consumer devices are replaced with devices that use less energy, assuming no change in operating practice; (2) new energy-using devices should perform their functions using less energy; and (3) actual kilowatt-hour usage is reduced, irrespective of when that reduction occurs (i.e., it is not time-sensitive). These attributes are very important to understanding efficiency, how it differs from demand response, and ultimately how energy efficiency and demand response might be coordinated.

As stated, energy efficiency does not entail sacrifice or reduction in comfort; rather, installation of high-efficiency equipment and/or measures is assumed to result in "the same or better levels of energy services." This definition implicitly distinguishes energy efficiency from conservation (although some people use the terms interchangeably). Conservation often implies a reduction in energy use and services through such actions as lowering thermostats during the heating season and dimming lights below the level presumably preferred by building occupants. Often, conservation is assumed to occur through behavioral changes that are considered short-lived, whereas energy efficiency occurs through installation of long-lasting technologies.

Energy efficiency programs are initiatives that encourage— and in many cases provide financial incentives and services to customers or contractors for—the acquisition, installation, and use of energy efficiency measures in customer facilities. Currently, such programs are administered by electric and gas utilities, state energy or regulatory agencies, and/or nonprofit or for-profit organizations; models for energy efficiency program administration vary by state.

Programs that provide rebates to customers who install energy-efficient equipment are perhaps the most popular, but there are several other types of energy efficiency programs (see Table 2-1 for a sampling).[1]

Table 2-1. Types of Energy Efficiency Programs and Strategies

Rebates **for customers who install energy-efficient lighting, motors, HVAC equipment, building shell measures, etc.**
Financing**, often at a subsidized rate, to offset the upfront cost of energy efficiency measures.**
Trade-ally incentives **paid to businesses that stock, sell, or install energy efficiency measures.**
Commissioning services **that help ensure that buildings' energy-using systems are operated and maintained properly.**
Education **for end-users and building/construction trades and other trade allies on the benefits of energy efficiency measures.**
Appliance standards **to incorporate energy efficiency design and embedded demand responsive controls.**
Building codes **to require construction, design, and operational standards that build in energy efficiency and/or demand response capability.**

HVAC = heating, ventilating, and air conditioning.

Energy efficiency is also delivered outside the framework of utility or public-benefit programs. For example, ESCOs design, install, service, and often finance efficiency projects, most often for large public sector institutions (e.g., K-12 schools, universities) and government agencies (e.g., local, state, and federal agencies). Contractors who do not necessarily call themselves ESCOs offer analogous services for residential and business customers. In states with retail energy competition, retail service providers may offer efficiency services in addition to commodity electricity and gas. Some state and federal governments have also offered tax credits to promote installation of high-efficiency equipment and appliances.

2.2 Demand Response

Demand response programs are designed to elicit changes in customers' electric usage patterns. Some types of demand response, implemented through approved utility tariffs or through contractual arrangements in deregulated markets, vary the price of electricity over time to motivate customers to change their consumption patterns; this approach is termed price-based demand response. Other demand response programs reward customers for reducing their electric loads upon request or for giving the program administrator some level of control over the customer's electricity-using equipment. These are termed incentive- or event-based demand response.

Within these two broad categories of demand response programs (price-based and incentive-based), there are several different program types (see Table 2-2).

Table 2-2. Common Types of Demand Response Programs

Price Options	Incentive- or Event-Based Options
TOU rates: Rates with fixed price blocks that differ by time of day.[a]	**Direct load control:** Customers receive incentive payments for allowing the utility a degree of control over certain equipment.
CPP: Rates that include a pre-specified, extra-high rate that is triggered by the utility and is in effect for a limited number of hours.	**Demand bidding/buyback programs:** Customers offer bids to curtail load when wholesale market prices are high.
RTP: Rates that vary continually (typically hourly) in response to wholesale market prices.	**Emergency demand response programs:** Customers receive incentive payments for load reductions when needed to ensure reliability.
	Capacity market programs: Customers receive incentive payments for providing load reductions as substitutes for system capacity.
	Interruptible/curtailable: Customers receive a discounted rate for agreeing to reduce load on request.[b]
	Ancillary services market programs: Customers receive payments from a grid operator for committing to curtail load when needed to support operation of the electric grid (i.e., ancillary services).[c]

CPP = critical peak pricing; RTP = real-time pricing; TOU = time of use.

[a] Some analysts do not consider TOU rates to be a dynamic demand response option because the rating periods and prices are fixed, and utilities typically do not regard customers on TOU as a resource that can be dispatched similar to a generator when needed to support grid operations. A well-designed TOU rate, however, may induce customers to make long-term investments that reduce peak demands.

[b] Some utilities also regard interruptible tariffs as a “price-based” option, particularly if their interruptible tariff includes dynamic pricing provisions during emergency events (e.g., some tariffs give customers the option of “riding through” a curtailment event by paying higher real-time prices and still receiving electricity).

[c] Ancillary services demand response arrangements can also be viewed as a pricing program, because real-time pricing signals can be set up under a tariff to trigger event-specific customer behavior.

More utilities offer some type of price-based demand response tariff (including time of use [TOU] rates) to customers than incentive-based demand response programs; however, price-based demand response accounts for just a small part of the total existing demand response resource base. In 2008, customers enrolled in existing incentive-based demand response programs were capable of providing 38,000 MW of potential peak load reductions, while price-based demand response programs were expected to provide another 2,700 MW. In percentage terms, about 93 percent of the peak load reduction from existing demand response resources in the United States is provided by various types of incentive-based, event-driven demand response programs (Cappers et al., 2009).

Incentive- or event-driven demand response can be invoked in response to a variety of trigger conditions, including local or system temperature, local or regional grid congestion, system economics, or operational reliability requirements. As an example of relevant events that justify a demand response, Table 2-3 shows the trigger criteria for Southern California Edison's 2009–2011 demand response programs. Trigger conditions reflect a key difference between demand response and energy efficiency, as energy reductions for demand response are time-dependent whereas reductions for energy efficiency are not.

Table 2-3. Demand Response Trigger Criteria: Southern California Edison Example

Demand Response Program	Event Trigger Criteria
Demand Response Contracts	Varies
Capacity Bid/Demand Bid	Power Plant Thermal Heat Rate 15,000 Btu/kWh (as a proxy for high spot market electricity prices and limited generator availability)
CPP	System conditions, temperature, and price
Base Interruptible	CAISO stage 2 alert
Air Conditioner Load Control	CAISO stage 2 alert, storm alert

Btu = British thermal unit; CAISO = California ISO; CPP = critical peak pricing; kWh = kilowatt-hour.

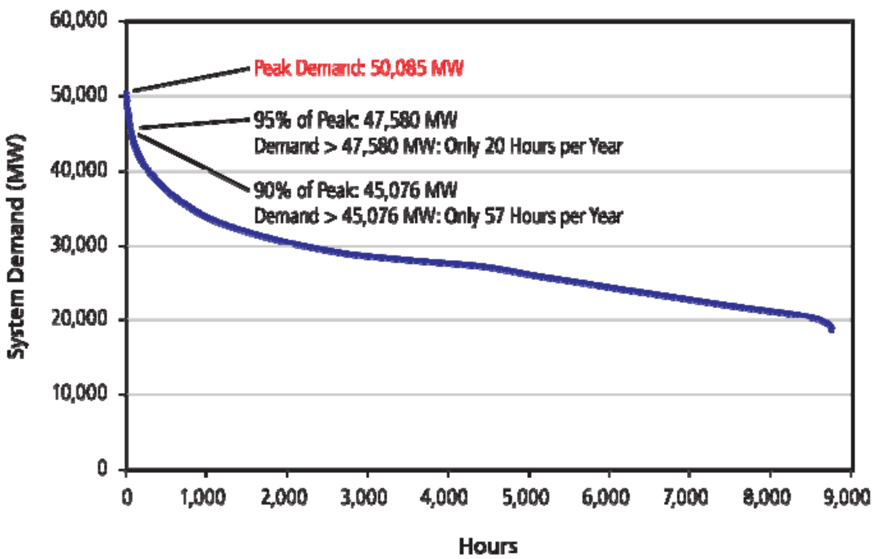
Demand response events may be triggered by economics (e.g., a spike in the wholesale price of electricity) or by reliability requirements (e.g., a major power plant trips offline, and customer load must be reduced to prevent blackouts). It is common for event-driven programs to have upper limits on the duration of individual events and the total number of event-hours per year. Some definitions of demand response incorporate assumptions that programs will be used no more than 40 to 100 hours per year (Faruqui et al., 2007).[2]

The frequency and duration of demand response events can vary substantially from one year to the next, and by utility system and application. The 40 to 100 hour example from the preceding paragraph is generally applicable to bulk-power reliability applications when reserve margins dip below threshold conditions or when wholesale prices spike. Figure 2-1 provides a load duration curve for the California ISO (CAISO) that illustrates the potential target hours and value for a demand response application. CAISO estimates that 15 hours of well-targeted demand response could reduce 5 percent of the CAISO peak load and the associated costs, and 55 hours could reduce 10 percent of its peak load (Goodin, 2008).

Event frequency and the value of demand response can vary substantially when targeted to load balancing and other ancillary service applications. Where bulk power reliability and economic applications may prescribe a maximum of 10 to 15 events per year with durations of 4 to 8 hours each, ancillary service applications may necessitate 80 to 120 events per year with durations of 10 to 20 minutes each. The customer impacts, communication and equipment options, and approach to coordination of demand response and energy efficiency will be quite different under these two applications.

Limits on the number of hours that customers can be called for demand response programs reflect the limitations of current demand response technologies and capabilities and perceived customer acceptance. As long as customer demand response involves disruptive activities like dimming lights, raising temperatures, or shutting down production operations, participating customers will want strict limits on the extent to which they can be subjected to such inconvenience. These limits have two consequences. First, they affect the degree to which system operators can count on the availability and magnitude of demand response resources for reliability operations. Second, they highlight the value of evolving automation, monitoring, and control technologies for building and energy use process management. As these control systems are integrated and aggregated across multiple facilities and energy applications, they can be operated in a fashion that makes demand response less obstructive and inconvenient for the customer (particularly if DR resources are aggregated by a load aggregator). At that point, operational limits on the amount of demand response resources that grid operators are willing to include in ancillary service markets may become less restrictive, and demand response could be used more broadly as a tool for reliable power system operations.

Figure 2-1. Reliability-Based Demand Response: California ISO Opportunity



Source: Data derived from California ISO (CAISO).

The event- vs. non-event-driven distinction is important. Customers and program administrators alike are usually referring to event-driven programs when they talk about demand response. (Our interviews with customers, which are discussed later in this paper, reflect this distinction.) On a conceptual level, critical peak pricing (CPP) and real-time pricing (RTP) are under the demand response umbrella, but these options often are discussed and treated separately from discussions about event-driven demand response program options. However, when high wholesale prices or reliability shortages are used as the activation variable for event-driven demand response options, they are proxies for and may be highly correlated with high prices in the real-time energy market.

Demand Response Comes in Many Flavors

The greatest number and variety of demand response programs are found in California and New York. Table 2-4 shows the breadth of demand response programs that are available to business customers by one California utility, Pacific Gas & Electric (PG&E). The table is not meant to suggest that every demand response portfolio needs this many options—only that there are many ways to structure demand response programs.

Table 2-4. PG&E's Demand Response Programs for Business Customers

Program Name	Description (Partial)
Incentive- or Event-Based Demand Response	
Base Interruptible Program	Provides monthly or per-event incentives for curtailing load with either 30-minute or 4-hour advance notification. Curtailments limited to 120 hours per year.
Capacity Bidding Program	Offers monthly payments from May through October for curtailing nominated load on either a day-ahead or day-of basis, up to 24 times per month, when load conditions require the use of generators with heat rates of 15,000 Btu/kWh or greater.
Demand Bidding Program	Provides payments of $0.50–0.60 per kWh to customers who submit day-ahead or day-of offers to curtail load.
Optional Binding Mandatory Curtailment Plan	Allows customers to be exempt from rotating outages in return for agreeing to reduce load by 5 to 15 percent within 15 minutes of notification.
Peak Choice	Allows customers to customize their demand response by selecting from a range of advance notice, timing, load reduction, and number of day options, where incentives are determined by option combinations.
Scheduled Load Reduction Program	Pays $0.10 per kWh for commitments to reduce load one to three times per week, 4 hours at a time, from June through September.
SmartAC (Air Conditioner Load Control)	Offers $25 to customers who allow installation of either an air conditioner compressor switch or a smart thermostat that can be used to control load up to 100 hours per year when CAISO declares emergency or near-emergency conditions. This program is also offered to residential customers.
Price-Based Demand Response	
CPP	Provides lower rates during on-peak and partial-peak hours in exchange for higher (three to five times normal) rates on up to 12 days between May and October when system demand is high.
Demand Response Technical Assistance	
Technical Assistance and Technology Incentive Programs	Provide engineering assistance and cash incentives to support installation of equipment or software supporting demand response.
Integrated Energy Audit	Offer audits that comprehensively address opportunities in energy efficiency, time-of-use management, demand response, self-generation, and renewables.

Sources: <http://www.pge.com/mybusiness/energysavingsrebates/demandresponse/>; <http://www.pge.com/mybusiness/energysavingsrebates/analyzer/integrated/>.

Btu = British thermal unit; CAISO = California ISO; CPP = critical peak pricing; kWh = kilowatt-hour; TOU = time of use.

Most demand response programs are sponsored by electric utilities; in some markets they are sponsored by ISOs. Customers can participate directly with the utility or ISO, or they can work through an intermediary. The intermediary role is commonly filled by firms specializing in demand response services, sometimes called curtailment service providers (CSPs) or simply "aggregators." In states with retail energy competition, retail service providers may serve as intermediaries in addition to supplying commodity electricity and gas.

When customers participate in demand response, there are three possible ways in which they can change their use of electricity (DOE, 2006):

- Customers can **forego** or reduce some uses of electricity. Raising thermostat settings, reducing the run time of air conditioners, dimming or reducing lighting levels, or taking some elevators out of service are common customer load curtailment strategies.

- Customers can **shift** electricity consumption to a time period outside the demand response event or when the price of electricity is lower. For example, an industrial facility might employ storage technologies to take advantage of lower cost off-peak energy, reschedule or defer some production operations to an overnight shift, or, in some cases, shift production to companion plants in other service areas. Similarly, with enough notice, commercial or residential customers could pre-cool their facilities and shift load from a higher to lower cost time period. Residential and commercial customers could also choose to delay running certain appliances until prices are lower. Most successful demand response programs have a customer override capability that allows the customer to choose not to adjust its energy use when a specific demand response event is called.[3]

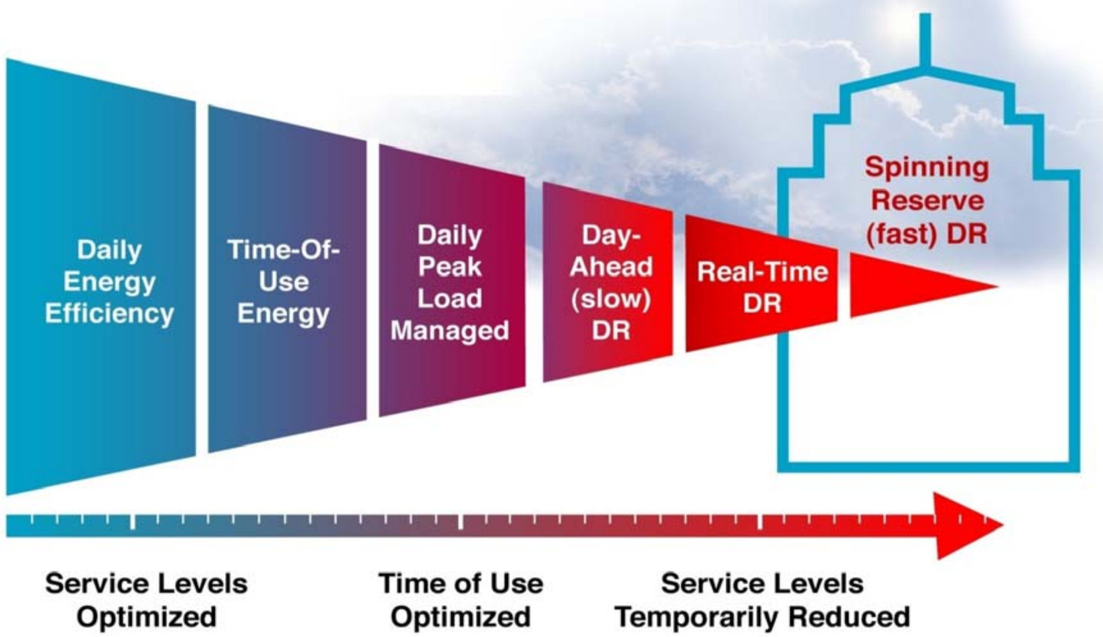
- Customers can **self-generate** electricity using onsite standby generating equipment, thus reducing their reliance on utility-delivered power.[4]

2.3 Continuum of Customer Options

From a conceptual perspective, distinctions between energy efficiency and demand response are somewhat artificial and not always as well understood as they may seem to program administrators. Figure 2-2 depicts efficiency and demand response as more of a continuum and shows the potential impact on customer service levels. The customer's existing building and equipment infrastructure establish the opportunities and potential for both energy efficiency and demand response.

In Figure 2-2, the progression of customer options from left to right presumes that the customer should begin first with "daily energy efficiency" improvements. Succeeding stages involve more sophisticated demand response behavior on shorter timescales, likely requiring additional investment to execute real-time or "fast demand response" options (which the power system views as ancillary services, such as spinning reserves). To the degree that it is cost-effective to do so, making the underlying infrastructure as efficient as possible creates permanent load reduction impacts.

Figure 2-2. Conceptual Perspective of Efficiency and Demand Response



Source: DRRC, 2008.

The "daily energy efficiency" category of actions in Figure 2-2 incorporates both short-term conservation actions and long-term investments in energy efficiency. While it is always desirable that customers undertake all appropriate efficiency investments and behaviors before they undertake load management and demand response activities, it is not always feasible for them to do so. There are many well-documented barriers to energy efficiency, including limited funding, the split between owners and beneficiaries, lack of information, and extended payback periods, among others (National Action Plan for Energy Efficiency, 2006). Thus, it is common for a customer to enter into a demand response opportunity because it is available and feasible, even though further efficiency improvements could be made. In fact, the wide spectrum of unfinished efficiency has created many current demand response opportunities; for instance, inefficient buildings and inefficient, uncommissioned heating, ventilating, and air conditioning (HVAC) systems create a large resource for demand response providers who offer peak load reduction strategies. While efficiency-driven load reductions often improve overall electric system effectiveness, they may also reduce the degree to which electricity uses remain available for cost-effective demand response.

Figure 2-2 also illustrates that end-use customers have a range of options for managing their electric service requirements and costs: they can invest in energy efficiency, manage the timing of discretionary energy use, or participate in a variety of demand response activities. Movement along the continuum tends to be incremental—signing up for a TOU rate may incent a customer to shift loads to off-peak hours to achieve "daily peak load management," taking actions such as changing air conditioner settings and setting a pool pump to operate off-peak. Integrating or "embedding" demand responsive controls in the basic electronics of an appliance can also facilitate movement along this continuum. For example, air conditioners or water heaters with embedded demand responsive controls can be designed to automatically provide day-ahead and real-time response capability.

Key attributes and distinguishing features of various customer options include the required frequency of response, underlying motivation and drivers, required customer actions, supporting infrastructure required to enable customers to participate, and potential impact on level of energy services (see Table 2-5). Daily peak load management involves efforts by customers on tariffs that include demand charges (typically commercial and industrial customers) to minimize peak demand usage (see middle column of Table 2-5). Some customer demand-side strategies blend elements from more than one customer option. For example, storage, a strategy that shifts loads using active thermal storage or passive building-mass storage, can be used either for daily peak load management or for event-driven demand response (Kiliccote and Piette, 2005). Similarly, installation of energy-efficient equipment or appliances may reduce the customer's peak demand charge and typically reduces the peak demand on the utility system.

Table 2-5. Customer Options for Managing Electric Service Requirements and Costs

Attributes	Energy Efficiency	Daily Peak Load Management	Demand Response
Why Participate	▪ Bill savings ▪ Energy savings ▪ Highest environmental benefits	▪ Bill savings ▪ Likely environmental benefits	▪ Bill savings ▪ Improve reliability ▪ Potential environmental benefit
Equipment or Infrastructure Required	▪ Energy-efficient equipment ▪ Energy-efficient building infrastructure (e.g., insulation levels, high-efficiency windows)	▪ Timers and controls ▪ Energy storage	▪ Remote control switch ▪ Embedded controls ▪ Building EMS ▪ Communications ▪ Standby generation
Who Buys/Owns the Infrastructure or Equipment	Customer	Customer	▪ Utility owns control switch ▪ Customer owns EMCS
Required Customer Actions (What must be done to participate?)	▪ Purchase ▪ O&M	▪ Purchase ▪ O&M ▪ Shift loads	▪ Limiting loads ▪ Shifting loads ▪ Shedding loads ▪ Displacing grid power (Any/all of the above)
Who Controls	Customer	Customer	For event-based demand response: ▪ Distribution utility ▪ ISO ▪ Aggregator (depending on program option) For price-based demand response: ▪ Customer
Impact on Energy Services (How does participation affect comfort, production levels, etc.)	None	None to slight	Barely noticeable to substantial

Source: Adapted and expanded from Motegi et al. 2007.

EMCS = energy management control system; EMS = energy management system; ISO = independent system operator; O&M = operations and maintenance.

2.4 How Energy Efficiency and Demand Response Overlap

Energy efficiency programs yield energy savings, and demand response programs yield reductions in demand at critical times, which usually correspond to times of peak power demand (although demand response events can be triggered by occurrences at non-peak times, such as transmission problems). But the programs have overlapping effects: energy efficiency can permanently reduce demand, and demand response, with proper control strategies, also produces some energy savings.

Energy Efficiency's Effects on Demand

The effect of energy efficiency on electricity demand is clear. Buildings and equipment that use less energy (fewer kilowatt-hours) because they are more efficient impose smaller power loads (lower kilowatts of demand) on the system. Over 20 years of data on efficiency programs document this effect. Because the majority of technologies that are promoted by energy efficiency programs (e.g., lighting, air conditioning) operate during hours of peak demand—typically hot summer afternoons across most of the United States—they contribute to reductions in system peak (York and Kushler, 2005).

Demand Response's Effects on Energy Consumption

Whether demand response programs provide energy savings depends on the customer strategy chosen and the timing of the response. As mentioned above, customers participating in demand response can forego electricity consumption, shift it to another time, or displace grid power with self-generation. A commercial building customer that participates in a demand response program might dim its lighting when an event is called; because there is no opportunity to "make up" the lost light output, there is a net reduction in energy usage.[5] With sufficient advance notice, that same building might shift some of its load from peak to off-peak hours by using its air conditioning system to pre-cool the building in the early morning hours and letting the temperature rise above the normal setting during peak hours; many pre-cooling strategies reduce both energy usage and peak load (CEC, 2006).[6] Engaging self-generation for demand response does not, in and of itself, produce any energy savings at the customer end but may reduce load on the utility's system.[7]

York and Kushler (2005) reviewed studies addressing the effect of demand response programs on overall energy efficiency and found that, while some studies have suggested that demand response programs generally yield energy savings, most descriptions of this effect are anecdotal and have not been carefully evaluated. This suggests a need for more systematic evaluations of the energy savings impacts from demand response programs.

King and Delurey (2005) conducted a meta-review of studies and reported that dynamic pricing (including TOU rates, RTP, and CPP) produced an average savings effect of 4 percent of energy used, while reliability-oriented demand response programs, generally corresponding to the incentive-based programs in Table 2-2 and operating less than 100 hours per year, reduced energy consumption by 0.2 percent. They found stronger savings effects, on the order of 11 percent, among information/feedback programs, which provide customers with usage information over the Internet or via in-home displays but do not involve equipment controls or commitments to reduce load when called upon.[8] The range of effects reported in the studies they reviewed varied considerably, from -5 percent (i.e., an increase in consumption) to savings in excess of 20 percent. A 2007 update added a few data points, further supporting savings effects of 3 to 5 percent for pricing-based demand response programs. One new information-only program reported savings of 6.5 percent (Nemtzow et al., 2007).

To summarize, most demand response programs are likely to either produce some energy savings or have no net effect on consumption. Although certain demand response strategies and technologies may increase energy consumption during off-peak hours, and in limited cases may increase total energy consumption, this is not necessarily a drawback—increased off-peak usage is less costly for the electric system and society as a whole, improving plant performance, decreasing fuel use, generating lower line losses, and potentially mitigating congestion on the transmission and distribution system.

Energy Efficiency, Demand Response, and Environmental Impacts

There is extensive documentation on the environmental benefits of energy efficiency, recounting the fact that with every unit of electricity not generated, the nation reduces its consumption of energy resources, air pollutant emissions, water use, and associated land uses. The environmental impacts of demand response are less conclusive because (1) the effects are specific to the time and place where energy use was avoided and (2) the effects depend on whether the electricity use was offset to another time—and if so, what power sources were used to generate that electricity.

Various considerations affect whether a specific demand response measure offers net environmental benefits or costs:

- If demand response is used to shift electricity use from on- to off-peak, it may cause a net reduction (or increase) in air emissions. The environmental impact of a demand response-driven load shift will be determined by local utility and regional generation portfolios used during peak and off-peak periods (e.g., nuclear, coal) and actual operations during the demand response event.

- Some demand response measures have small "rebound" or "snap-back" effects, in that after the load reduction is over, the customer consumes more electricity to catch up for the suppressed use (as with air conditioning). However, control improvements may soon alleviate many of these problems.

- Some demand response measures may cause a net increase in the customer's energy use, and that increase could negate any efficiency benefits from the electricity time shift.

- If demand response is used to integrate intermittent renewable generation in the future, it can have a net environmental benefit because the additional wind, solar, and other renewable sources are likely to displace fossil fuel-fired generation with higher emissions of pollutants (e.g. NOx, SOx and CO2).

- Substituting onsite fossil fuel-fired self-generation (e.g., diesel-fired generators) for grid-supplied power may cause a net increase in fuel use and local air pollution.

As smart grid technologies, widespread energy price and use information, and dynamic rates become more accessible for consumers, these tools that facilitate demand response will also enable customers to become more energy-efficient and deliver greater overall environmental benefits from this synergy.

2.5 Notes

[1] For more information on energy efficiency program types, see National Action Plan for Energy Efficiency (2006) and National Action Plan for Energy Efficiency (2009).

[2] The difficulty for the utility or ISO is targeting the limited events or hours of control to the right time period to obtain customer response when needed and to make sure the annual allocation of demand response resources is not exhausted prematurely.

[3] Shifting energy usage may increase or decrease total emissions from electricity, depending on regional differences in types of generators used.

[4] Onsite generation avoids emissions from supply-side generators but has adverse effects on local air quality when fossil fuel backup generators are used.

[5] Additionally, dimming lights may reduce air conditioning requirements, further reducing peak load and consumption.

[6] In some cases, a pre-cooling strategy might increase overall energy consumption even while curbing the peak. However, research by the Demand Response Research Center and Purdue University has identified pre-cooling strategies that reduce energy usage and peak load.

[7] The net effect of self-generation on fuel consumption depends on the efficiency of onsite generation relative to that of grid-supplied power, including the effects of transmission and distribution losses.

[8] King and Delurey (2005) consider information/feedback programs a form of demand response. Referring back to DOE’s definition of demand response, which we have adopted for this paper, pure information/feedback programs fall outside the scope of demand response because they do not involve changing price signals or providing incentives to motivate changes in usage. The systems and devices used in information/control programs, however, can be used as enabling technologies in demand response programs.

3: What Might Coordination of Energy Efficiency and Demand Response Look Like?

As envisioned in the Action Plan's Work Plan, coordinating energy efficiency and demand response is worth exploring because it could provide customers with "increased tools ... to understand and manage and reduce their electricity use" (National Action Plan for Energy Efficiency, 2007). From the customer perspective, coordinating energy efficiency and demand response provides an opportunity to make better use of their time and consider operational changes and investments that minimize their total energy costs. We therefore looked at coordination primarily in terms of what it would mean for retail customers, and we also examined the programs and services retail customers can take advantage of.

3.1 Types of Coordination

Energy efficiency and demand response could be coordinated at the customer level in at least four ways:

- **Combined program offerings.** Customers could be presented with both energy efficiency and demand response opportunities; separate programs are the norm today.

- **Coordinated program marketing and education.** Without merging the delivery of services at the program level, program sponsors (e.g., utilities, state energy agencies) could package and promote energy efficiency and demand response in a closely coordinated or unified way. There is some activity along these lines occurring through regulatory and utility initiatives. Energy efficiency and demand response can be complicated topics that require sophisticated customer effort and action, so program marketing must include a strong educational component. Program sponsors could offer education that addresses both topics under a broad energy management theme.

- **Market-driven coordinated services.** Coordination need not occur only within the context of programs offered by utilities, public benefit organizations, or ISOs. Coordination of energy efficiency and demand response could also come about through the initiative of private firms that find a market among customers who are interested in reducing their energy costs. Our research and interviews with selected ESCOs and CSPs suggests that they are interested in this approach; we describe their initial steps in this direction.

- **Building codes and appliance standards.** Building codes and appliance efficiency standards can incorporate preferred energy efficiency and demand response features directly into building design and infrastructure and appliance designs. Building these features into the building and appliance infrastructure through codes and standards can lead to significant reductions in the costs to customers of integrating efficiency and demand response strategies and/or measures. For example, global temperature setback,[1] OpenADR,[2] and standard reference designs that facilitate embedded controls in appliances can lower the customer's cost of integrating demand response and energy efficiency.[3]

Coordination could (and does) occur in other ways that are mainly upstream from the retail service level. For example, utilities could (and often do) utilize coordinated planning processes, such that they choose target levels of energy efficiency and demand response resources in a unified process rather than separate planning processes. Energy efficiency and demand response efforts could be (and often are) funded from a single budget rather than separate budgets, and program staff members could be (and in some cases are) trained to provide customer assistance in both energy efficiency and demand response. These types of coordination play supporting roles; ultimately, their purpose is to affect the choices that customers have for managing and reducing their energy use, which is why our primary focus in this study is on retail-level coordination.

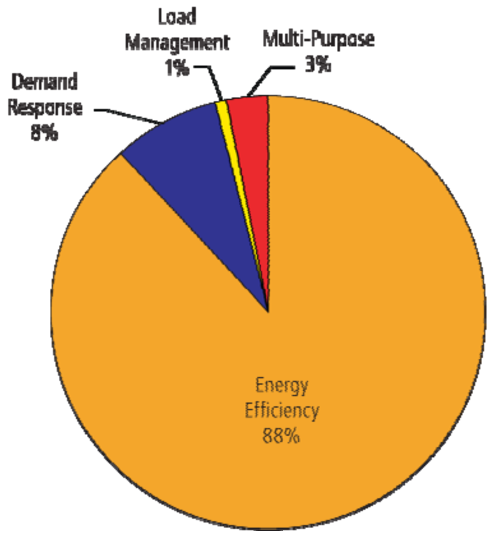
3.2 Examples of Coordination—Current and Planned

Combined Programs That Provide Both Energy Efficiency and Demand Response

Currently, energy efficiency and demand response are seldom combined at the program level. To help uncover combination programs, DSMdat™, an E Source database of programs in the United States and Canada, was analyzed. Programs listed in DSMdat are tagged with their apparent purpose—energy efficiency, demand response, peak load management,[4] or multi-purpose—based on analysts' interpretation of program descriptions and marketing materials posted on the sponsors' Web sites.

As of December 2009, out of 2,016 active programs in DSMdat, just 56, or 3 percent, are tagged as serving more than one purpose (see Figure 3-1). The vast majority of those combination programs are ones that subsidize installation of energy efficiency equipment, provided it can be shown that the equipment will reduce the customer's peak load during the likely peak hours (for example, from 2 to 5 p.m. during summer afternoons). In other words, they support energy efficiency and daily load management (as described in Table 2-5) rather than demand response. In short, DSMdat confirmed that there are very few points of intersection between today's energy efficiency and demand response programs.

Figure 3-1. Distribution of Energy Efficiency, Demand Response, and Peak Load Management Programs



Source: E Source, DSMdat™.

Using the detailed program entries in DSMdat plus Web and literature searches, we found several existing programs that clearly combine energy efficiency and demand response (as distinct from load management) objectives. Examples include:

- Residential "smart" thermostat programs that provide customers with programmable communicating thermostats (PCTs)—an energy efficiency technology—in return for participation in a demand response program that curtails load during a limited number of summer hours by raising the thermostat's set point. Such programs are offered, for example, by Austin Energy,[5] Kansas City Power & Light,[6] Long Island Power Authority,[7] and many other utilities, a few of which also allow businesses to participate.

- Sacramento Municipal Utility District (SMUD) implemented the Small Business Summer Solutions Research Pilot in summer 2008 targeted to small commercial customers with peak demands less than 20 kW. The demand response component provided customers with critical peak rates, options to install PCTs, and a variety of pre-cooling and conventional control strategies. Pre-project focus groups indicated that customers understood basic demand response concepts; however, the customers' highest priority was for assistance in reducing energy use. SMUD capitalized on this need in its marketing by offering to help customers reduce their energy use if the customer would in turn help SMUD by volunteering for the demand response pilot. As a first step, SMUD technicians performed energy audits and provided advice to each customer regarding a range of lighting, efficiency, and conservation options. The integrated efficiency/demand response approach was very successful, and SMUD reported a 23 percent reduction in weather-adjusted energy use (see Table 3-1), along with a 20 percent reduction in average peak load on critical peak event days, with no load rebound measured on top of the reduced energy baseline (Herter, 2009).

Table 3-1. Sacramento Municipal Utility District Small Business Summer Solutions: Energy and Demand Impacts

Business Type	Program Option	Monthly Energy Savings		Peak Period Demand Impact		Monthly Bill Savings		
		kWh/ Month	Weather Adjusted % 2007 Baseline	Average Peak kW Reduced	% 2008 Baseline	Energy Efficiency	Demand Response	Total
Office	4 ACC	254	-27%	-0.8	-38%	$29	$10	$39
	CPP	344	-32%	-0.6	-24%	$39	$7	$46
Retail	4 ACC	254	-15%	-0.8	-22%	$29	$10	$39
	CPP	344	-19%	-0.8	-14%	$39	$7	$46
Combined		**316**	**-23%**	**-0.7**	**-20%**	**$36**	**$8**	**$43**

Source: Herter, 2009.

ACC = air conditioning control; CPP = critical peak pricing.

The Marshfield Energy Challenge

- A pilot program from NSTAR in Massachusetts, launched in spring 2008, which jointly markets energy efficiency, demand response, and distributed generation (photovoltaic systems) to residential and business customers in one community to alleviate overloading of the local distribution system (see sidebar, "The Marshfield Energy Challenge").

- The New York State Energy Research and Development Authority (NYSERDA) Existing Facilities Program offers incentives for prequalified measures and performance-based incentives to customers or ESCOs for electric and gas efficiency and incentives that partially offset the cost of equipment that enables demand response (e.g., load-shedding controls and automation equipment, load-shedding ballasts if enrolled in a New York ISO [NYISO] demand response program).[8]

- PG&E's Integrated Energy Audit, a program for businesses that encompasses analysis of energy efficiency, load management, demand response, distributed generation, and renewable energy opportunities.[9]

- PG&E's Federal Advanced Lighting Technology Program, which works with U.S. government agencies to maximize savings through installation of high-efficiency lighting systems that can also be controlled for demand response.[10]

- The City of Ames Electric Service requires customers to agree to participate in its Prime Time Power air conditioner load control program to receive ENERGY STAR incentives for purchasing more efficient air conditioners. In some cases, the control equipment is installed on the air conditioner before the unit leaves the store. This approach simplifies marketing and recruitment for the utility, and it also reduces their installation costs. It also integrates the energy efficiency and demand response incentives, which encourages customers to consider upgrading to even more efficient units.

With funding from the Massachusetts Technology Collaborative, NSTAR has launched a pilot project in the town of Marshfield, Massachusetts, aiming to test whether an intensive program of energy efficiency and demand response can improve the reliability and capacity of the local 25 MW distribution network. The program aims to provide energy efficiency services to 1,200 homes and 100 businesses. Five hundred customers will be enabled for demand response via smart thermostats. Additionally, 30 photovoltaic systems with a projected capacity of 250 kW will be installed. NSTAR has obtained extensive community involvement in the design of the program and has developed a coordinated marketing approach, including local newspaper ads, local radio spots, direct mail, an energy program curriculum in the schools, and presence at town events. To rally support, the entire effort is named "The Marshfield Energy Challenge" and even includes its own logo (NSTAR, 2007).

Other utilities are planning to offer combination programs. For instance, an integrated resource plan filed jointly in January 2008 by Connecticut Light & Power and United Illuminating (The Brattle Group, 2008) envisions two business-sector programs that will deliver both energy efficiency and demand response to begin in 2009:

- **Business Energy Services.** "The goal of this program is to provide a holistic, one-stop energy solution to businesses through integration of energy efficiency, load management, load response, direct load control, distributed generation, renewable energy systems, CHP [combined heat and power] and other initiatives...."

- **Business Energy Challenge.** “This program calls for businesses to make commitments to aggressive energy efficiency and load reduction goals.... In exchange for accepting this energy challenge, businesses will receive a custom tailored package of the entire CEEF [Connecticut Energy Efficiency Fund] conservation and load management offerings into one cost-effective bundle, technical consulting services, and other support necessary to make the transition.”

The California Public Utilities Commission (CPUC) issued a long-term strategic plan for energy efficiency that includes a goal for demand-side management (DSM) coordination and integration: “Deliver integrated DSM options that include efficiency, demand response, energy management, and self-generation measures through coordinated marketing and regulatory integration” (CPUC, 2008).

Continuation and expansion of pilot programs that explore strategies to integrate and coordinate efficiency and demand response is one of four overarching strategies listed by the CPUC to achieve the DSM integration goals (CPUC, 2008). These pilots “will offer a bundled product that includes elements of energy efficiency and conservation, customer generation, demand response, and the best available AMI [advanced metering infrastructure] technology” (CPUC, 2008). In their 2009–2011 program filings, the California investor-owned utilities proposed a number of pilot programs in response to this CPUC strategic priority.

There are likely other integrated energy efficiency-demand response programs underway that have not been widely publicized. The roster of DSM programs undergoes continual change, but to date the number of current programs that combine energy efficiency and demand response elements is relatively small.

3.3 Marketing That Ties Together Energy Efficiency and Demand Response Programs

Even while maintaining distinct energy efficiency and demand response programs, program sponsors can achieve a measure of coordination through marketing that combines both types of offerings.

Utility interviews conducted for this study revealed examples of utilities marketing separate energy efficiency and demand response programs in a coordinated fashion. One approach involves using key account managers—the utility representatives who handle relationships with the utility’s larger commercial, industrial, and institutional customers. Key account managers are well-positioned to market both energy efficiency and demand response services to their assigned customers. “Our customer people can walk into a facility and talk about our entire portfolio of energy efficiency and demand response,” according to an Otter Tail Power executive.

Reaching beyond the subset of customers served by key account managers, sponsors can unify their presentation of programs to the entire customer base through advertising and messaging that covers both types, sometimes under an “umbrella” name or slogan. Some examples:

- Austin Energy recently adopted “Power Saver Program” as the name for its entire program portfolio of energy efficiency and demand response programs.

- Duke Energy is using the name “Save-a-Watt Plan” for the energy efficiency and demand response programs it has proposed or is implementing in several jurisdictions.

- NYSERDA has for years used “New York Energy $mart” as the umbrella name for its energy efficiency and demand response programs.

- Otter Tail Power strives to use complementary messages for energy efficiency and demand response, and sometimes “doubles up” its advertising to cover both types of programs.

- Xcel Energy markets both energy efficiency and demand response as “environmental programs that will save you money.”

- All of Texas’s electric utilities market a peak demand-targeted load curtailment program (called the Load Management Standard Offer Program) to commercial customers in conjunction with a suite of energy efficiency programs.[11]

These marketing and branding strategies ignore the distinctions between energy efficiency and demand response. Instead, the pitches focus on broader objectives that resonate with customers—saving energy, saving money, helping the environment—because it is believed that most customers do not care which “bin” a program falls in (nor should they). However, it is not clear whether all utilities that are marketing and branding energy efficiency and demand response together are designing and offering the underlying energy efficiency and demand response programs in ways that are coordinated to help both the utility and its customers.

Additionally, some utilities are using the term “energy efficiency” internally and externally to describe the full breadth of their DSM programs. Austin Energy, for example, changed the name of its Demand-Side Management Division to the Energy Efficiency Division. Duke Energy describes all of its proposed programs as energy efficiency efforts, and they are managed by its Energy Efficiency business unit. Even though it may not be the most technically accurate term, energy efficiency is believed to have more favorable associations for customers than “demand response,” “load management,” or “demand side management.”[12]

In California, the CPUC Energy Efficiency Strategic Plan proposes a strategy to “carry out integrated marketing of DSM opportunities across all customer classes,” with utilities conducting the following near-term implementation activities (CPUC, 2008):

- Adopt marketing integration plans by sector.
- Streamline and integrate energy efficiency, demand response, and distributed generation program outreach.
- Coordinate integrated marketing with AMI deployment.
- Offer technical assistance and audits that address combined DSM opportunities.

3.4 Market-Driven Coordination by Service Providers

Commercial and industrial energy management services represent a well-established offering from building control and energy management system (EMS) vendors, energy and facility management companies, and ESCOs. Historically, energy management services generally focused on maintaining facility operating conditions and providing energy efficiency and other options to minimize customer utility costs. ESCOs expanded this role by pioneering the use of energy savings performance contracts (ESPCs), which use verified energy savings as the basis for financing customer investment in new, more efficient systems and equipment (or onsite clean energy options). In performance contracts, ESCOs have to verify and document multiyear energy savings that result from installing a broad set of measures/strategies; the customer uses the value of these savings to make debt service payments on its contract with a third-party financial institution. In terms of size, the U.S. ESCO industry had annual revenues of approximately $3.6 billion in 2006, with energy efficiency accounting for about 75 percent of those revenues—and renewables, onsite generation, and consulting accounting for the remaining 25 percent.[13]

Starting in the early 1980s, a number of utilities offered “group load curtailment” programs that were developed and implemented by third-party aggregators as part of utility load management portfolios. These programs were the genesis for today’s third-party demand response aggregators—CSPs. CSPs grew with the recent expansion of ISO/regional transmission organization (RTO) and utility demand response programs after 2001. There are about 40 active CSPs that are committed to providing more than 10,000 MW of peak demand reductions to ISO/RTOs (and utilities).[14]

A number of ESCOs and CSPs are currently assessing how to adapt and enhance their existing business models to coordinate energy efficiency and demand response in their service offerings. Interviews with selected ESCOs and CSPs indicated that “total energy management” (TEM) (i.e., integrating energy efficiency and demand response) is an attractive concept for many commercial, institutional, and industrial customers. Providing TEM involves optimizing energy management control systems (EMCS) and strategies to manage and control facility energy use, minimize peak demand charges, and maintain comfort conditions; providing energy information services; and serving as the customer’s energy advisor. However, both ESCOs and CSPs acknowledged that these enhancements to their existing business models are in their infancy.

For example, CSPs stated that demand response provides the “foot in the door” to engage with customers, and that some customers have used revenues from participating in demand response programs to fund energy efficiency improvements. A few CSPs said that their organizations were expanding and providing energy efficiency services through acquisitions of companies that provide energy efficiency services. One CSP is offering a monitoring-based commissioning service to large commercial and institutional customers. Through this service, the CSP analyzes interval meter, EMCS, and energy information system (EIS) data to provide demand response services and identify energy efficiency opportunities.[15]

Several ESCOs indicated that their energy efficiency products are regularly used for building automation and temperature control in buildings, and that existing high-efficiency EMCS or controls typically have demand response capabilities. However, the ESCOs have historically not emphasized or marketed demand response as a key feature of EMCS. A few ESCOs were exploring partnering arrangements with CSPs as a way to become more familiar with demand response programs in organized markets, as well as examining strategies to more effectively integrate energy efficiency and demand response. The interviewed ESCOs view demand response as a niche market with a relatively steep learning curve, given varying market rules and program participation requirements in organized wholesale markets and the fact that fewer customers are familiar with demand response compared with energy efficiency.

3.5 Developments in Wholesale Markets That Facilitate Coordination of Energy Efficiency and Demand Response

While this study focuses primarily on opportunities for effectively coordinating energy efficiency and demand response at the retail level, recent developments in organized, wholesale, forward capacity markets offer new opportunities for customers and service providers to offer load reductions from energy efficiency investments and/or demand response capabilities to offset grid capacity requirements.

In December 2008, ISO-New England (ISO-NE) reported the results of its 2011/2012 electric capacity auction, where nearly 3,000 MW of demand resources won capacity contracts. The market rules define demand resources by the way in which they reduce load, not by the technology used to achieve load reductions. ISO-NE recognizes five types of demand resources. Critical Peak, Real-Time, and Real-Time Emergency Generation require participants to be "dispatchable" and primarily include demand response resources. On-Peak and Seasonal Peak are designed for non-dispatchable measures and include energy efficiency. Energy efficiency resources accounted for about one-third (approximately 980 MW) of the total demand resource commitment.

In May 2009, PJM announced results of its electric capacity auction for the 2012/2013 capacity year and reported that demand resources will increase its contribution by 5,680 MW, to 7,050 MW in total.[16] For the first time, energy efficiency resources were explicitly eligible to participate in this auction, with PJM accepting 569 MW of efficiency resources.

Market rules require load aggregators to treat and account for different types of demand resources separately for purposes of measuring and verifying load reductions. As a result, load aggregators end up bidding demand response and energy efficiency resources separately to ISO-NE and PJM. The ISO/RTO program rules do not prevent load aggregators from jointly marketing both energy efficiency and demand response services to customers, but as a practical matter, the separate tracking and measurement and verification of savings for different types of demand resources creates additional challenges for load aggregators.

3.6 Notes

1 In 2008, the California Energy Commission (CEC) adopted global temperature setback as a Title 24 nonresidential standard and required that temperature settings in all zones in a commercial building be controllable from a single central point. This facilitates the centralized automation of demand response.

2 CEC is considering OpenADR under Title 24 to mandate that all targeted commercial buildings have the capability to receive price, reliability, and event signals via the Internet or other standard communications media.

3 Some energy efficiency strategies that can be incorporated into building codes may reduce the need for demand response because they reduce the need for peak load reductions to remedy building-design-based temperature extremes. These strategies include building orientation and other passive solar design features, daylighting, high-efficiency windows, and enthalpy standards.

4 "Demand response/load management" is a single tag in DSMdat. A program is tagged with this description if the stated purpose is load reduction (either continually or during demand response

events) or if there is a requirement that energy efficiency measures installed under the program provide load reductions during system peak hours.

[5] See <http://www.austinenergy.com/Energy%20Efficiency/Programs/Power%20Partner/index.htm>.

[6] See <http://www.kcpl.com/residential/acc.html>.

[7] See <http://www.lipower.org/cei/lipaedge.html>.

[8] See <http://www.nyserda.org/programs/Existing_facilities/howto.htm>.

[9] See <http://www.pge.com/mybusiness/energysavingsrebates/analyzer/integrated>.

[10] See <http://www.pge.com/mybusiness/energysavingsrebates/incentivesbyindustry/government/incentives/>.

[11] See <http://www.texasefficiency.com/>.

[12] A 2007 national survey found that the term “demand response” elicits negative connotations in a large percentage of consumers. Adjectives respondents selected to describe demand response included “unpopular” (44 percent), “annoying” (42 percent), and “unhelpful” (40 percent). In comparison, “energy conservation,” “energy efficiency,” “smart energy,” and “clean energy” were rated much more positively (Cogar, 2007).

[13] See Hopper et al. (2007). There are about 40 ESCOs that offer performance contracting in the United States, although eight to 10 firms account for 75 to 80 percent of the revenue and projects.

[14] Many CSPs only work in organized markets (e.g. PJM, ISO-NE, NYISO), and many of these companies are relatively new and small.

[15] See <http://www.enernoc.com/solutions/energy-efficiency.php>.

[16] One reason for the sharp increase in demand response contribution in PJM’s Reliability Pricing Model was PJM’s elimination of the Interruptible Load for Reliability product beginning in the 2012/2013 capacity year. This action drove load aggregators with several thousand megawatts of demand response into the forward-capacity market.

4: Enabling Technologies for Energy Efficiency and Demand Response

The capability and potential for energy efficiency and demand response at a customer's facility are derived from a combination and interaction of four distinct elements: the building infrastructure, building electro-mechanical systems, appliances, and customer behavior. New technology and systems integration are key building blocks to enable greater coordination of efficiency and demand response (CPUC, 2008). To illustrate the potential promise of enabling technology to facilitate coordination of demand response and energy efficiency, we describe technology trends in selected customer market segments.

4.1 Residential Market

In the residential market, demand response technologies are evolving through a three-stage process, with implications for coordination of energy efficiency opportunities.

- **Stage 1: Retrofit control switches.** Historically, utilities targeted selected loads like air conditioners and water heaters through direct load control. The utility installed a control switch on the customer's air conditioner or water heater that allowed the utility to cycle or shed this load for relatively short time periods (e.g., several hours) during a system event. The control switch adds a new demand response capability onto the existing customer appliance.

- **Stage 2: Replacement transition devices.** PCTs, or smart thermostats, are an example of a replacement transition device, replacing a customer's existing appliance or control with one that has more utility as an energy efficiency and/or demand response controller. Smart thermostats eliminate the need for a separate control switch and provide a single point of integration between efficiency and demand response actions. When properly set up to match occupants' daily schedules, smart thermostats provide efficiency and conservation benefits by ensuring that heating and cooling systems operate only as much as is needed to maintain the desired temperature. They provide demand response capability by allowing a customer (or a utility or CSP, via a communications channel) to adjust the occupant's temperature setting a few degrees to curtail load.

  Some smart thermostat models now include functionality to act like a bridge device or repeater and pass price, reliability, and event signals on to other appliances and loads. This capability lets smart thermostats act like small-scale, limited-purpose versions of a building automation system (BAS).[1] When produced in large volumes, PCTs have the potential to reduce equipment costs for demand response devices and give customers more control over load sheds and curtailments.

- **Stage 3: Embedded controls.** Appliance and white goods vendors are beginning to incorporate demand response functional and engineering logic developed for smart thermostats into other major residential appliances.[2] For example, General Electric (GE)[3] and Whirlpool[4] have announced that they will provide their most efficient washing machines, dryers, dishwashers, refrigerators, water heaters, range tops, and other selected appliances with integrated electronics that provide customers with the capability to let them “listen” and respond automatically to price, reliability, and other demand response event signals. Menus of built-in options will enable customers to automatically shift or defer operations and to modify settings to take advantage of low-price periods. Building embedded controls into manufacturers’ highest efficiency products represents a strong integration of energy efficiency and demand response. This move will substantially reduce demand response equipment technology and installation costs, while appliance-specific, factory-developed control strategies will make it easier for customers to perform demand response operations customized to their family, lifestyle, and business needs.

This approach should facilitate customer education because energy efficiency, demand response, and efficiency capability become transparent functions of customer appliances. There are also numerous efforts underway to develop complementary, low-cost energy monitoring systems that further facilitate customer education. Google “Power Meter,” Microsoft “Hohm,” Greenbox, Tendril, Control4, OpenPeak, and several other companies are pioneering Internet-based software and hardware to support customer monitoring and control.

The combination of these control technologies with better customer information about energy costs and usage is expected to enable customers to adopt more energy-efficient behaviors and invest in more energy-efficient end-use devices, as well as to participate in price- or event-based demand response programs.

The “white goods” manufacturer and vendor community has indicated that embedded controls are likely to be economically feasible if (1) there is widespread introduction of dynamic pricing to create a market for demand response and a value function for consumers to purchase more capable smart appliances and (2) policies are put in place that open the market to price responsive demand, where customers, rather than the utility, determine what, when, and how to respond.[5]

4.2 Commercial and Institutional Market

Automation is the key to commercial and industrial sector energy efficiency and demand response, incorporating monitoring, communications, and control technologies. Many medium to large commercial and institutional buildings have installed enabling technology that has the potential capability to support both energy efficiency and demand response (see requirements of ASHRAE 90.1 Energy Code). Facility managers typically use EMCS to manage and control their HVAC and lighting loads. EMCS can provide efficiency and reduce energy costs by monitoring equipment and enabling ongoing device control, turning equipment on or off at appropriate times or modulating equipment operation. Another example of an EMCS function that supports energy efficiency is “optimum start”—control of the HVAC system based on weather conditions so that heating or cooling of the building occurs just in time to make the building comfortable for the start of the work day. Similarly, specific HVAC control features (e.g., global zone reset, duct static pressure reduction) and lighting control options (e.g., central dimming) can simultaneously support both energy efficiency and demand response (see Table 4-1). EMCS can effect daily load management, reducing demand charges by managing and scheduling equipment loads. EMCS can also improve building equipment efficiency by using monitoring and analytics to perform continuous commissioning, identifying any mis-performing or broken equipment and maintenance needs. Continuous commissioning has been shown to produce energy savings in building and equipment performance of as much as 10 to 15 percent.

Table 4-1. How Building Automation Systems (i.e., EMCS) Support Both Energy Efficiency and Demand Response

Function: Energy Efficiency	Function: Energy Efficiency and Demand Response	Function: Demand Response
Lighting Control Features of BAS		
▪ Centralized on/off controls, timers	▪ Central dimming ▪ Bi-level/zonal switching	▪ Demand limiting ▪ Lighting sweep ▪ Overrides
HVAC Control Features of BAS		
▪ Optimal start ▪ Variable speed drive control ▪ Demand-controlled ventilation ▪ Chilled water temperature control ▪ Condensing temperature control ▪ Cooling tower/evaporative condenser fan control	▪ Global zone reset ▪ Duct static pressure reduction	▪ Equipment lockout ▪ Pre-cooling ▪ Thermal energy storage ▪ Cooling reduction ▪ Fan, pump, or chiller quantity reduction

Source: Based on Kiliccote and Piette, 2005.

BAS = building automation system; EMCS = energy management control system;
HVAC = heating, ventilating, and air conditioning.

In terms of demand response capability, building operators identify what they can do to reduce load and put their buildings in "low power mode" during demand response events. These actions are then programmed into their BAS, thus automating the customer's ability to curtail and/or shift load in response to demand response events or high prices. Table 4-2 shows three levels of demand response automation: manual, semi-automated, and fully automated. Even though many large commercial and institutional buildings have EMCS with the capability to fully automate and support both energy efficiency and demand response, the reality is that currently, relatively few large buildings are operated in a fashion that optimizes performance to achieve both energy efficiency and demand response objectives.

Table 4-2. Levels of Demand Response Automation

Level	Uses BAS?	How Response Occurs
Manual demand response	No	People manually turn off lights and equipment when asked to do so.
Semi-automated demand response	Yes	A person initiates a control strategy—preprogrammed into the BAS—when a demand response event is called.
Fully automated demand response (“AutoDR”)	Yes	Receipt of an external price, reliability, or event signal automatically triggers a BAS control sequence that switches the building to low-power mode; no human intervention is required.

Source: Based on Kiliccote and Piette, 2005.

BAS = building automation system.

California’s Demand Response Research Center (DRRC) has pioneered an approach that links utility or ISO/RTO price- and incentive-based demand response event signals directly to a BAS. Through 2008, the three California investor-owned utilities reported 141 participating customers enrolled in AutoDR, representing approximately 54 MW of dispatchable demand response (DRRC, 2009).[6] In aggregate, AutoDR peak load reductions are typically in the 10 to 20 percent range, without any complaints of occupant discomfort (DRRC, 2006; Kiliccote and Piette, 2005). AutoDR has significant potential as a demand response strategy, in part because of the prevalence of BAS.[7] AutoDR provides the facility manager with the capability to re-engineer the existing building to better achieve efficiency and demand response objectives. AutoDR facilitates coordination with energy efficiency because the facility manager can pre-specify operational modes for high-efficiency performance and also specify “low power” modes that are implemented in response to demand response event signals.[8]

4.3 Notes

1 BAS is also referred to as EMCS and EMS.

2 GE announced that it has re-engineered several of its appliances to further reduce their peak load footprint and provide additional demand response control capability that allows them to automatically change temperature settings or go into low-power mode.

3 See: GE “Smart” Appliances Empower Users to Save Money, Reduce Need for Additional Energy Generation. <http://www.genewscenter.com/content/Detail.asp?ReleaseID=6845&NewsAreaID=2>.

4 See: Whirlpool Corporation to Make All Electronically Controlled Appliances “Smart Grid Compatible” by 2015. <http://online.wsj.com/article/PR-CO-20090506-904825.html>.

5 Private communication with appliance vendors and GE testimony at the California Energy Commission, Integrated Energy Policy Report Committee Workshop, Smart Grid Technologies to Support California’s Policy Goals, May 13, 2009.

[6] Initial AutoDR pilot research was conducted from 2003 through 2006. In 2006 the CPUC issued a ruling that effectively began the commercial rollout of AutoDR to the largest commercial and industrial customers (>200 kW peak load) in the PG&E, Southern California Edison, and San Diego Gas & Electric service territories.

[7] As of 2003, nearly one-third of floor area in commercial buildings had a BAS (DOE, 2003); that percentage is growing because BAS are common in new commercial buildings.

[8] DRRC researchers cite several benefits of AutoDR: (1) more consistent load response; (2) decrease in time needed to prepare for an event; (3) increased number of times building managers are willing to participate in events; and (4) potentially larger demand reductions (DRRC, 2006).

5: Constraints on Coordination of Energy Efficiency and Demand Response

There are several reasons why coordinating energy efficiency and demand response may be challenging and may not come about swiftly.

5.1 Some Market and Regulatory Structures Divide Responsibilities and Funding for Energy Efficiency and Demand Response

Opportunities for coordinating energy efficiency and demand response among regulated entities are heavily influenced by market structure and design and regulatory policies regarding the administration of demand-side programs. For example, coordination of energy efficiency and demand response is probably easiest for traditional, vertically integrated utilities that are subject to integrated resource planning requirements and are responsible for procuring all demand-side resources.

In some markets and states, however, responsibilities for administering energy efficiency and demand response are divided. For example, ratepayer-funded energy efficiency programs might be administered by state agencies (e.g., in Maine and New York) or third-party, non-utility entities (e.g., in Vermont, Oregon, Wisconsin, Delaware, and Hawaii). In nearly all of these states, utilities or ISOs are the primary entities administering demand response programs. Coordination of energy efficiency and demand response is still possible under these institutional arrangements, but it involves coordination across organizations that might require active oversight and support by utility regulators.

Many states provide separate funding sources for energy efficiency and demand response. Most of the states with a public benefits fund charge limit use of those funds to energy efficiency. Demand response programs must be funded from other charges to ratepayers, typically involving separate regulatory processes. For example, in California, some energy efficiency programs are funded through a public benefits charge, where restrictions prohibit energy efficiency dollars from being used to support demand response. In this situation, the California utilities must obtain regulatory approval for their energy efficiency and demand response programs in separate regulatory proceedings, and coordination of energy efficiency and demand response requires utilities and other parties to adopt consistent approaches in multiple regulatory processes.

In those states with retail competition, the choice of whether and how to offer energy efficiency or demand response services may be wholly up to retail electricity providers and competitive ESCOs rather than the regulated utility. States like Texas and Maryland have addressed this in part by requiring the regulated transmission and distribution utility to meet energy efficiency and/or demand response goals, acquiring the savings from competition between ESCOs.

5.2 Aligning Retail Rates with Energy Efficiency and Demand Response Objectives

Customers see energy prices through their rates.[1] Rate design has played a central role in the electricity industry since its inception. In developing retail rates, regulatory commissions and utilities are typically balancing multiple criteria: promoting economic efficiency and equity, facilitating customer choice, and clearly and simply communicating prices and costs (Faruqui and Hledik, 2009). Other goals that often enter rate design proceedings include bill stability for customers and revenue stability for utilities. In many states, regulators and utilities have been reluctant to require that customers be placed on default tariffs based on time-varying prices that fully reflect the cost to produce and deliver electricity.

Large-scale deployment of an AMI removes one of the major barriers to dynamic pricing among residential and small commercial customers (i.e., the inability of existing meters to measure time-varying usage at hourly or shorter intervals). The availability of advanced meters, however, does not ensure that electricity customers will see prices that are sufficiently detailed and informative to motivate appropriate changes in energy use behavior. Well-designed tariffs based on dynamic, time-varying prices (e.g., real-time prices, CPP) facilitate demand response. For more information on rate designs for energy efficiency, including increasing block rates, see National Action Plan for Energy Efficiency (2009).

Conceptually, it is possible to develop tariffs for residential customers that include both an increasing block structure and time-varying pricing (e.g., CPP), which may facilitate both energy efficiency and demand response policy objectives. However, few examples exist to date of that type of rate design. Given the challenges, many utilities and regulatory commissions have opted for alternative approaches that rely primarily on providing financial incentives through energy efficiency and/or demand response programs (e.g., rebates for high-efficiency equipment, bill credit for participating in a direct load control program). Over the long term, more use of well-designed dynamic pricing tariffs would facilitate the development of price responsive demand without adversely impacting energy efficiency opportunities.

Whatever the rate design, with or without advanced meters, tariffs and demand response programs work best when supported by extensive customer education. There are many examples of rate designs that work well on paper but failed in the field because customers did not know that rates had changed or did not understand the new rate and how to modify their energy use. A poorly explained, poorly publicized rate can lead to high customer bills, loud protests, and public backlash, regardless of the merits of the underlying goals.

5.3 Customers Have Reservations About Demand Response

Among the 16 companies that responded to our questions from the end-user point of view, all reported having active energy management programs, and nearly all said they participate in demand response programs on at least a limited basis. Although these customers seem familiar with demand response, many said that customers find demand response less compelling than energy efficiency and, in some cases, problematic.[2] As a result, customers were frequently less than enthusiastic about the notion of coordination, especially if programs try to deliver energy efficiency and demand response together. Customers voiced the following concerns about demand response, which are worth understanding in the context of coordinating energy efficiency and demand response.[3]

- **Demand response benefits are uncertain.** Customers who invest in energy efficiency, as is the case with all of the companies we interviewed, have confidence that those investments will yield steady benefits for many years, assuming proper maintenance of installed equipment. The benefits of demand response, in contrast, are heavily dependent on programs and markets that are outside customers' control. A demand response program sponsor may change the terms of the program from year to year or even eliminate the program entirely. Customers' monetary benefits from participating in demand response are usually tied to the number of curtailment events and/or wholesale electricity market prices, both of which are highly uncertain. For these reasons, customers see demand response as less than a "sure bet."

> "Most demand response programs are performance-based. If your energy performance is already progressive, as ours is, your benefits will be small."
>
> *- Energy manager, retail chain*
>
> "If I put in more efficient systems and equipment, the benefits don't go away, regardless of what rate I'm on."
>
> *- Energy manager, commercial property management firm*

- **The payoff from demand response is "not worth the hassle."** Participating in demand response, especially for organizations with national footprints, means dealing with a myriad of program requirements and terms that vary significantly. For some customers, aggregating medium-size facilities (e.g., grocery stores) to reach minimum curtailment requirements can be challenging. When these considerations are coupled with the uncertainty regarding whether demand response events will be called, the financial benefit might not be great enough to justify participation.

> "It's hard for us to aggregate to reach participation requirements when we can't run standby generators [due to environmental rules] and about all we can do is reduce lighting. More and more, our lighting is very efficient... and it's a struggle to find what we can turn off without making it difficult to sell stuff."
>
> *- Energy manager, grocery store chain*

- **Demand response is "something done for the utility's benefit," not for customers' benefit.** Some customers think that the direct benefits of demand response accrue mostly for the program sponsor, and, while a customer might be willing to participate on a limited scale upon request, it is not something they will seek out for their organization's benefit.

> "Demand response is what the utilities desire, not what the market is demanding or needing. If everybody got 1 percent more efficient, demand response would be totally unnecessary."
>
> *- Energy manager, commercial property management firm*

- **Demand response may unacceptably reduce energy services below acceptable levels.** This issue was raised by a property management firm which noted that curtailing lighting and raising temperatures during demand response events may violate tenants' lease agreements.

> "Demand response programs raise life-safety issues. We won't do anything that would jeopardize the safety of our pets or associates."
>
> *- Energy manager, pet store chain*

- **Participating in demand response may crowd out the pursuit of energy efficiency.** Given manpower and budget constraints, some energy managers are reluctant to pursue demand response because they believe it will detract from their energy efficiency activities, to which they give higher priority.

> "We've got a certain amount of time we can spend on these things, and we think the best paybacks are in things like tune-ups or better controls that save energy all the time, rather than in demand response."
>
> *- Energy manager, university*

None of the above concerns directly confronts the issue of coordinating energy efficiency and demand response. But policy-makers or program administrators who want to encourage coordination should take note of these concerns and be prepared to address customers' misperceptions about demand response. For one thing, the concerns suggest that program designers should be careful about packaging energy efficiency and demand response in inflexible ways. Pushing demand response on reluctant participants could backfire and even impede energy efficiency programs.

5.4 Developing Utility Staff and Contractor Capabilities in Both Areas Will Take Time

Some utilities expressed reservations about their current ability to deliver energy efficiency and demand response services jointly because their employees are more skilled or experienced in one area over the other. For example, account representatives who are more comfortable with energy efficiency concepts and opportunities than with demand response will spend most of their time with customers helping them identify efficiency opportunities. At one utility, we were told that the engineering support staff members who analyze customer opportunities tend to specialize in either energy efficiency or demand response. These are not insurmountable problems—they should be fixable through training and, in some cases, reconfiguration of employee responsibilities and performance goals—but addressing them might take some time.

Similar issues arise with respect to the local, often small, consulting firms and contractors that utilities depend on to help carry out components of programs such as marketing and outreach, energy audits, and installation verification. A few utilities mentioned that, as with their internal staff, it will be challenging to find contractors who are able to perform successfully in both energy efficiency and demand response, because at present few are qualified in both areas.

5.5 Barriers to Private Sector Business Models that Combine Energy Efficiency and Demand Response

In Section 3.4, we describe how some ESCOs and CSPs are beginning to explore new business strategies and service offerings that move beyond their current areas of focus on energy efficiency and demand response, respectively. While these initiatives are promising, it is too soon to know whether or when market-based coordination will firmly take hold. In our interviews, ESCOs and CSPs identified "internal" barriers (e.g., limited interest within their company, concerns about whether there was a "fit" with their basic business model) as well as "external" barriers (e.g., limited customer interest; complex, fragmented regulatory and market structures and program rules) to more effective coordination.

It is also unclear whether the business models of these two specialties are compatible with one another. Many ESCOs tend to concentrate on selling capital-intensive technology solutions (e.g., new chillers, boilers, onsite generation, renewables) and prefer large projects using long-term performance contracts. In contrast, demand response projects tend to have relatively low upfront costs with short contract terms. So far, those CSPs that are exploring and/or offering energy efficiency services are taking a different approach from the ESCO performance contracting business model: analyzing information from EMCS as a means to identify energy efficiency savings opportunities that primarily involve improvements in building operations and controls rather than major capital investments in new equipment.

Finally, several organized wholesale markets (e.g., ISO-NE, NYISO, PJM) now allow participation by demand resources. Thus far, various types of demand-side service providers have been aggressively pursuing this new business opportunity with much success. There is little evidence yet, however, to suggest that service providers are leveraging the ISO-NE and PJM forward capacity market to offer coordinated energy efficiency and demand response programs to customers; this is one area that ISO/RTO administrators should assess in evaluating demand-side participation in these markets.

5.6 Notes

[1] A rate is typically embedded in a tariff, which is a legal document approved by a regulatory commission that defines the prices to be paid for defined classes of customers under defined terms of service (National Action Plan for Energy Efficiency, 2009).

[2] Customers' issues and concerns with demand response centered on incentive-based programs. See Table 2-2 for definitions of program types.

[3] Text in quotation marks is from interviews; in some cases the remarks have been edited or paraphrased for clarity and to preserve respondents' anonymity.

6: Developments That Would Support Coordination of Energy Efficiency and Demand Response

Coordination of energy efficiency and demand response would be fostered by any of the developments described below.

6.1 Clear Policy Signals That Coordination Is Important

To date, the most effective policy signals have been legislative or regulatory statements that energy efficiency and demand response resources and programs are both valuable and should be coordinated. Such statements can change the course of regional and utility integrated resource planning activities and approaches and the nature of utility, grid operator, and third-party efficiency and demand response offerings.

California has been on a path to encourage coordination of energy efficiency and demand response programs since 2005. The state's *Energy Action Plan II*, an "implementation roadmap" jointly issued by CEC and the CPUC, listed "Integrate demand response programs with energy efficiency programs" among the "key actions" required in the area of energy efficiency (CEC and CPUC, 2005). In October 2007, the CPUC directed California's three investor-owned utilities to "prepare a single, comprehensive statewide long-term energy efficiency plan" and to "integrate customer demand-side programs, such as energy efficiency, self-generation, advanced metering, and demand response, in a coherent and efficient manner" (CPUC, 2007). Finally, in the CPUC's Long Term Energy Efficiency Strategic Plan, its vision for DSM coordination and integration is:

> Energy efficiency, energy conservation, demand response, advanced metering, and distributed generation technologies are offered as elements of an integrated solution that supports energy and carbon reduction goals immediately, and eventually water and other resource conservation goals in the future (CPUC, 2008).

Connecticut has not specifically directed utilities to propose integrated programs, but it has legislatively mandated that that the utilities put energy efficiency and demand response on an equal footing, and it requires that each resource type be developed to the fullest extent practicable: "Resource needs shall first be met through all available energy efficiency and demand reduction resources that are cost-effective, reliable and feasible."[1] In response, utilities in Connecticut have proposed integrated commercial and industrial programs.

Other states could take similar approaches.

6.2 Establishment of Peak Load Reduction Goals in Addition to Energy Savings Goals

A number of states have set ambitious energy reduction goals; often, those goals are expressed solely in terms of energy savings (kilowatt-hours). Examples include:

- The New York State Public Service Commission established an Energy Efficiency Portfolio Standard to implement the governor's "15 by 15" goal, aiming for a 15 percent reduction in electricity consumption below forecasted levels by 2015.

- Minnesota's Energy Efficiency Portfolio Standard calls for statewide annual energy savings goals equal to at least 1.5 percent of retail sales.[2]

Goals established at the state level or for individual utilities that include peak demand (kilowatt) reduction targets can signal that demand response is an important resource that should be pursued alongside energy efficiency. Several states have adopted this approach.

- In Maryland, the legislature passed the Empower Maryland Energy Efficiency Act of 2008, which calls for a 15 percent reduction in per capita electricity consumption and peak demand by 2015.
- In Ohio, the legislature passed SB221, which requires utilities to reduce electricity use by 22 percent by 2025 and reduce peak demand by 1 percent in 2009, and to continue achieving an additional 0.75 percent reduction in peak demand per year until 2018.
- Pennsylvania has adopted legislative goals for both energy efficiency and peak reduction savings.
- Texas's energy efficiency goal is expressed in terms of a required reduction from annual peak load growth, and thus requires the state's utilities to acquire both kilowatt and kilowatt-hour savings.

The development of joint goals would not necessarily ensure coordination—utilities could pursue the two types of programs on separate tracks—but it would encourage joint planning and possibly joint marketing and/or joint programs, on the theory that coordinated programs would have synergistic effects. The potential downside of peak reduction targets is that they might not reflect actual electric system needs (e.g., load/resource balance), which could change significantly over time. States that have specified peak reduction targets have also had to confront significant policy and implementation issues. These include: (1) defining the scope and type of demand-side resources that can be used to satisfy a peak reduction target (e.g., energy efficiency, event-based demand response programs, dynamic pricing); and (2) policy basis and rationale for a peak demand reduction target, (3) methods used to estimate and verify peak demand impacts: demonstrated capability to reduce peak demand and/or actual peak load (e.g., for event-based demand response programs, what happens if event programs are not called during summer; for dynamic pricing, what if wholesale market energy prices remain low or if CPP events are not called).

6.3 Educating Customers on Demand Response

Our interviews showed that even sophisticated business customers who are clear on the benefits of energy efficiency can be uncertain about the purposes and benefits of demand response. Coordinated programs will stand a better chance of succeeding if customers are clear about the benefits of both types of resources.

One educational challenge is to counter the view held by some customers that demand response is primarily a reliability tool that is largely for the utility or power grid's benefit. Lieberman (2005) suggests framing demand response as a resource that can improve the functioning of power markets, provide clean and reliable capacity, and provide new opportunities for customer choice.

Customer education can also address specific concerns about demand response, such as those related to comfort, hassle, and uncertain payoffs. Case studies of successful customer participation should help. Additionally, as well-designed demand response tariffs and demand response-enabling technologies (e.g., smart thermostats, automated controls and smart appliances, energy information feedback tools) become more widely available, customers' views may evolve and become more positive.

6.4 Support for Combined Programs That Promote Both Energy Efficiency and Demand Response

In Section 3.2, the review of existing ratepayer-funded programs suggests that there are relatively few examples of coordinated, customer-focused energy efficiency and demand response programs. A number of utilities and other program administrators (e.g., NYSERDA) have begun to offer combined or coordinated demand-side programs in the last several years, but regulatory commissions need to encourage their utilities to conduct pilots and program offerings in various market segments that explicitly attempt to coordinate energy efficiency and demand response service offerings. In so doing, commissions need to examine and address institutional and regulatory barriers that discourage innovation in coordinated approaches to deploying demand-side resources.

In commercial and institutional markets, utilities and private sector providers are exploring coordinated offerings that involve monitoring-based commissioning and demand response capability. A key to the success of this approach is developing well-established measurement and verification protocols for the energy efficiency savings that are achieved through monitoring-based commissioning, as well as documenting best practices in this field, given that the savings tend to be driven by changes in operational practices (Mills, 2009).

6.5 Strategies that Enable Deployment of Advanced Technologies and Systems

Chapter 4 describes how emerging technologies and systems integration represent key building blocks for enabling greater coordination of energy efficiency and demand response and provides examples of these technologies in residential and commercial and institutional markets. State and federal regulators and policy-makers and utilities can support strategies that will emphasize testing and deployment of new technologies and systems that support integration and coordination of energy efficiency and demand response.

Examples include:

- **Government "lead by example" demonstrations.** With their large inventories of office buildings, hospitals, military bases, and housing, federal and state government agencies provide an important opportunity to lead by example and make investments that will develop effective coordinated energy efficiency and demand response options. Government facilities can provide a foundation for research and development to support the technologies, education, training, and case studies to guide other market sectors.

- **Emerging technology and demonstration programs.** In some states, regulatory commissions encourage utilities to develop programs that demonstrate emerging technologies as part of ratepayer-funded energy efficiency programs, particularly as market transformation efforts. It is possible to also include technologies that enable demand response, particularly those technologies that offer both energy efficiency savings and demand response capability. In light of the growing interest in smart grid technologies, state regulators should consider supporting demonstration programs that deploy emerging technologies that integrate both energy efficiency and demand response.

- **Building codes and appliance efficiency standards.** Historically, building codes and appliance efficiency standards have focused primarily on energy-efficient technologies and equipment. Standards can provide common functionality in equipment that lowers cost and increases availability and can eliminate barriers that inhibit the integration of energy efficiency and demand response. Two examples include the global temperature setback and OpenADR standards referenced earlier.

- **Ongoing programs.** As demand response technologies and practices evolve and consumers realize the benefits, there should be an increased emphasis on programs that encourage consumer adoption of both energy efficiency and demand response capability.

- **Existing policies.** Existing policies, such as tax incentives (e.g., credits), can be expanded to accelerate the adoption of demand response technologies and devices.

6.6 Notes

[1] Connecticut Public Act 07-242, Section 51, effective July 2007.

[2] In May 2007, the Minnesota legislature passed the New Generation Energy Act of 2007.

7: Conclusion

In 5 to 10 years, demand response potentially could look much different from both the customer's perspective and the utility's perspective compared with today, given advances in enabling technology, metering, and communications. As demand response-enabling technologies (control and communication systems) and price information become more sophisticated and widely accessible, customers should realize direct benefits, and their perceptions of demand response should shift from the belief that demand response involves extra effort and sacrifice to the realization that it is discretionary and easy for chosen applications. Moreover, as energy-using devices become more efficient and easier to monitor and control, and as real-time energy information becomes more accessible, there will be less of a distinction between energy efficiency and demand response. In a few years, customers may be able to manage their energy use without caring whether their energy management falls under an "energy efficiency" or "demand response" label.

Program administrators and policy-makers need to be increasingly cognizant of the impact of energy efficiency on demand response and vice versa, particularly as we move toward a future of low-to-zero net energy buildings and continuous commissioning. The potential for demand response will certainly be impacted (and may be reduced) as buildings and equipment become more energy-efficient and better operated. At the same time, the monitoring and control technologies that enable demand response can produce real energy savings. Both individual building managers and load aggregators aggregating and managing thousands of buildings for demand response have the potential to use that monitoring capability for site-based continuous commissioning, achieving additional energy efficiency in addition to event-specific demand response.

Studies on the potential of demand response indicate that price-based demand response may well become increasingly common, facilitated by better customer access to energy usage and price information (FERC, 2009). As advanced meters are installed at accelerated rates across the nation, more utilities will be offering TOU or dynamic pricing rates and price signals. As a result, there will be more customer load responding to dynamic prices by leveraging behind-the-meter enabling technologies such as energy control systems and price-responsive devices. . Many of these individual customer responses and choices could be opaque to the utility or grid operator, which will see only total load net of the price response. It will be necessary to study and document the long-term load reduction impacts of price-based demand response to understand its net load and system impacts.

Program administrators and policy-makers are encouraged to start planning for this future when thinking about the evolution of energy efficiency and demand response. The above capabilities will eventually change the way utilities and grid operators do business and relate to their customers, as expressed by the manager of the Bluebonnet Electricity Cooperative:

> Giving members an anywhere-anytime, Internet-based ability to control how and when they use their appliances, respond to price signals or peak load emergency situations to save money and conserve energy, and sell their own distributed energy back to the utility, allows them to become meaningful players on the grid…. We think it is the distribution grid of the future. We don't sell kilowatts, we sell the service of bringing electricity to your house (McGowan, 2009).

Large-scale deployment of cost-effective energy efficiency resources has the potential to provide significant bill savings for customers and reduce and/or defer the need for more expensive baseload or intermediate generation resources. Similarly, cost-effective demand response resources have the potential to reduce and/or defer the need for more expensive peak generation and enhance electric system reliability, while increasing the system's ability to absorb low-cost intermittent renewable resources through sophisticated real-time monitoring, analytics, and load controls. Effective coordination of efficiency and demand response—by policy-makers, utilities, and third-party program providers—is a necessary step to increase the effectiveness and utilization of energy management resources. While progress has been made in recent years, more work is needed to achieve the full promise and potential of the synergy between energy efficiency and demand response.

While coordinating energy efficiency and demand response is necessary, it will not be easy or swift due to the many market, human, financial, and institutional obstacles. Executives and policy-makers should articulate some direction and clarity for utilities and program sponsors regarding priorities for energy efficiency and demand response programs and their coordination and overall goals. This is particularly important given the long-lasting nature of utility and customer capital investments, the time and effort it takes to change customer behaviors and expectations, and the current rapid pace of technological change. Program sponsors and customers alike need guidance on the best ways to commit their resources to achieve effective energy management.

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