

ENERGY EFFICIENCY AND DEMAND RESPONSE: WORKING TOGETHER IN AN INTEGRATED APPROACH TO MANAGING ENERGY



Issue Brief

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INTRODUCTION

Policymakers, utilities and building owners now recognize the energy used in buildings as a valuable resource with the potential to create economic and environmental benefits. The opportunity to save is vast: Nonresidential buildings in the United States spent \$136 billion in electricity in 2010.¹ This expenditure breaks down into two components:

- 1. Capacity** – The fixed costs of producing and distributing electricity, including capital investments in power plants, transmission lines, and distribution networks. The maximum capacity of the system relative to the instantaneous peak demand is critical, as overstrained grids lead to suboptimal performance, interruptions in service and, eventually, expensive infrastructure improvements.
- 2. Energy** – The variable cost of producing a unit of electricity. The economic and environmental attributes of generating and delivering a kilowatt-hour vary widely between regions, depending on the fuel source (hydroelectric, nuclear, coal, gas) and other parameters.

Policy and program innovation, along with technological advances on both sides of the electricity meter, have allowed buildings to contribute value to the electricity system along both of these dimensions, using the popular techniques of energy efficiency (EE) and demand response (DR). This paper explores the technology, business and policy issues required to combine these techniques and thereby unlock greater benefits for building owners, grid operators, and the electricity system as a whole. First, the current and future roles of EE and DR are outlined. Next, the benefits of integrating EE and DR are explored from the perspective of both grid operators and building owners and operators, including the behavioral links between the two. Further, the challenges to integration are discussed. Finally, solutions and recommendations are explored.

EE AND DR TODAY

The modern concepts of energy efficiency and demand response have evolved over decades of demand-side management activities by utilities and regulatory bodies. Behind both concepts is the premise that reductions in the consumption of electricity are often more cost-effective and environmentally beneficial than increasing supply.

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

Energy Efficiency: Using less energy to provide the same or improved level of service to the energy consumer in an economically efficient way²

Demand Response: 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 payments³

Note that these definitions do not map perfectly to the capacity and energy constructs presented above. Indeed, both energy efficiency and demand response are capable of delivering benefits across the electricity system, including alleviating capacity constraints and achieving a cost-optimal balance of supply and demand.

¹ EIA, Electric Power Monthly, Table 5.2

² National Action Plan for Energy Efficiency, 2006

³ U.S. Dept of Energy, 2006

Nevertheless, the common programmatic approaches to both energy efficiency and demand response are narrower in scope: The former focuses on reducing the total kilowatt-hours used, and the latter on reducing kilowatt demand during a small number of peak hours. Figure 1 illustrates this generalization, where energy efficiency shifts the entire load profile downward and demand response represents a temporary curtailment for a few hours during a peak day. Note that while energy efficiency provides sustained reduction in consumption, demand response is temporary.

Figure 1a: Effect of energy efficiency on the load profile

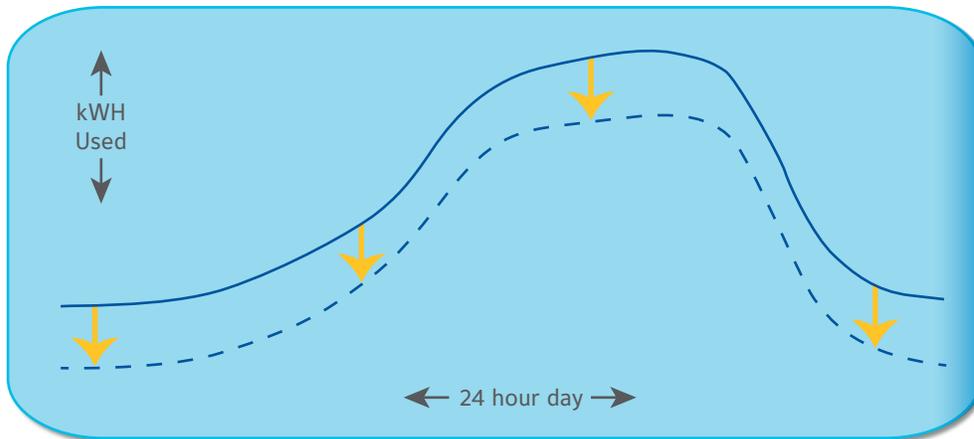
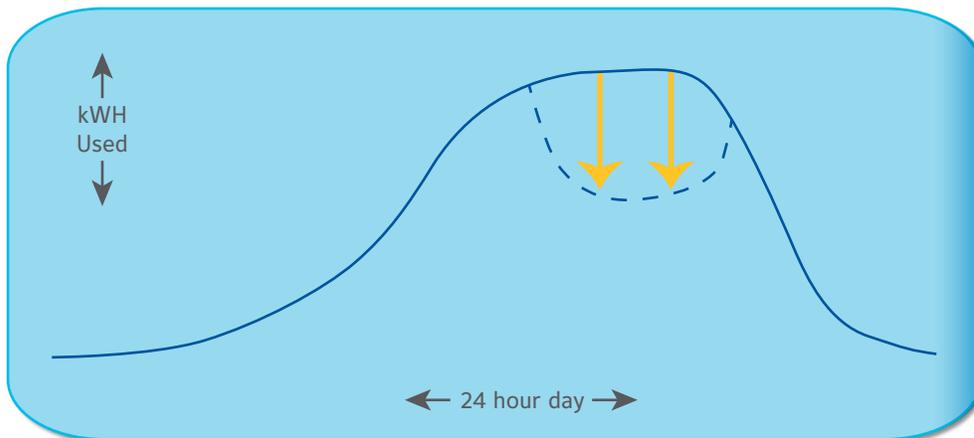


Figure 1b: Effect of demand response on the load profile



As the marketplace moves toward a broader and more comprehensive vision of energy efficiency and demand response, the two concepts will blend together and require an integrated framework for both policy and implementation.

GRID PERSPECTIVE

Utilities, system operators and others responsible for “keeping the lights on” are under increasing pressure to meet growing demands for electricity with minimal new investment. In addition to the ever-present requirement to keep rates low, grid operators today must account for the environmental impact of building and operating power plants, and they often face resistance to expansion of transmission and distribution infrastructure.

For these reasons, many grid operators are turning to demand-side resources. From the perspective of the electric grid, a reduction in demand has the same effect as an increase in supply: The balance between generation and load is maintained, and the lights stay on. Demand-side resources can contribute to this balance on all of the timescales at which the electric system operates.

- **Energy efficiency and base-load generation** – The majority of electricity produced in areas with mature power systems can be categorized as base load, typically generated by large coal or nuclear power plants. Because of the low marginal cost associated with their large scale and the high costs of switching these plants on and off, base-load generation is provided 24 hours a day, 365 days a year. Similarly, energy efficiency projects such as motor improvements, lighting equipment and building controls can deliver reductions in electric demand over all or most hours of the year.
- **Demand response and peaking capacity** – In addition to base-load generators, the electric system is equipped with various assets standing by to provide power when needed. Sometimes referred to as peaker plants, these generators have a higher marginal cost of producing electricity and are dispatched during periods of higher demand.
- **Fast DR and ancillary services** – Because electricity travels at very high speeds and today’s grid has not fully integrated advanced energy storage technologies, ancillary services such as spinning reserve and frequency regulation are necessary components of a balanced system. These markets operate on timescales of minutes or seconds, requiring continuous communication and advanced telemetry between participating equipment. Often, there are no humans in the loop. Automation in buildings and an increase in communication and metering technology are now allowing demand reductions to contribute to grid stability through ancillary services markets. So-called fast DR requires careful planning and pre-engineering, end-to-end automation, and real-time data to provide visibility throughout the participation process.
- **Transmission and distribution and all forms of demand-side resources** – In addition to the challenge of generating adequate power to meet demand, load-serving entities must consider the ability of grid infrastructure to deliver the electricity from the power plant to the end user. In some regions, transmission and distribution (T&D) congestion is a more pressing concern than generation capacity. Energy efficiency, traditional demand response and fast DR can all alleviate T&D constraints by reducing the load requirements of the grid during times of peak demand and congestion.

Demand-side resources promise substantial benefits to the electricity grid at all its relevant timescales. For a more thorough investigation of the utility perspective on integrating demand response and energy efficiency, see a recent report from the National Action Plan for Energy Efficiency.⁴

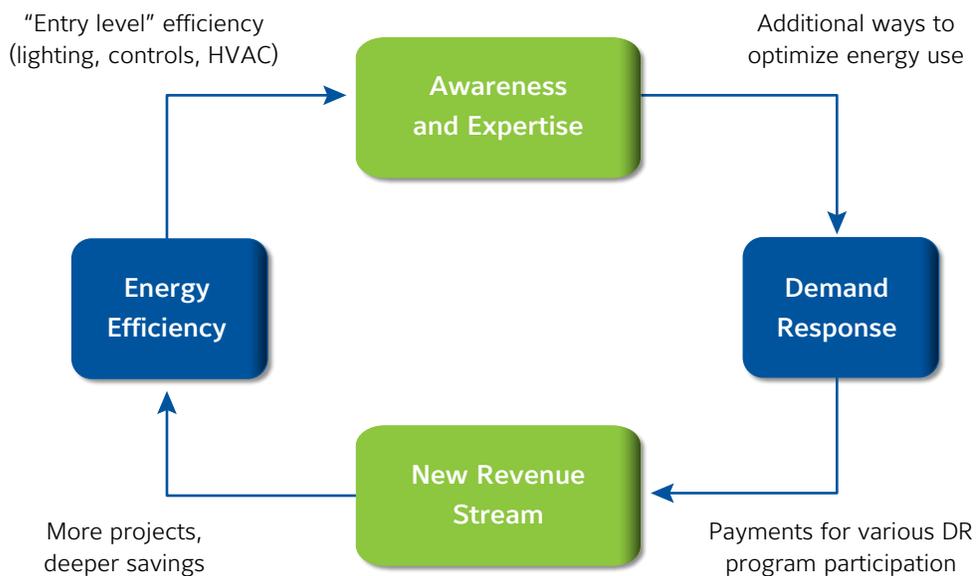
⁴ “Coordination of Energy Efficiency and Demand Response,” A resource of the National Action Plan for Energy Efficiency, January 2010: http://www.epa.gov/cleanenergy/documents/suca/ee_and_dr.pdf

CUSTOMER PERSPECTIVE

Even a well-designed utility program will be unsuccessful without interest and engagement from the building owners and operators responsible for energy decision-making in their facilities. This section explores the potential for an integrated approach to energy efficiency and demand response from the customer perspective. Specifically, how do EE and DR fit together from financial, technological and behavioral dimensions?

- **Financial** – Energy efficiency and demand response both provide customers with economic benefits as a result of changes to their facilities or operations. EE typically involves some level of initial investment, repaid over time through reduced energy bills. In contrast, most DR in practice today provides payments to customers in exchange for a commitment to reduce load during events. By combining the revenue stream of DR with the energy savings provided by EE, a customer can see better financial outcomes than would be possible with either approach alone.
- **Technological** – Both DR and EE require the measurement and verification (M&V) of savings: peak-demand reduction during specific hours of the day in the case of DR, and lower energy use over the months and years of a contract in the case of EE. The underlying data structure for both EE and DR could be shared, providing a synergy that improves the economics of a combined project. In addition, the availability of timely interval energy consumption data creates a platform from which other energy-reducing opportunities may be discovered.
- **Behavioral** – Customers pursuing either energy efficiency or demand response are likely to be monitoring data more closely, bringing the subject of energy spend into focus, and engaging teams around the challenge to reduce. A building operator who has had success in one area is likely to look for additional opportunities, providing a natural flow from EE to DR, and vice versa. Figure 2 illustrates a “virtuous cycle” in which customers build on successes with EE or DR and move toward higher levels of energy performance.

Figure 2: The “Virtuous Cycle” linking EE and DR through increased attention to energy



While there are substantial benefits available to customers through the combination of energy efficiency and demand response, this type of integration has yet to reach the mainstream. Building on early successes,⁵ the private sector and customers will likely develop new models for integrating DR and EE and thereby unlock the financial, technological and behavioral benefits promised.

CHALLENGES TO INTEGRATION

The integration of energy efficiency and demand response promises real benefits to both utilities and their customers. However, there are also several challenges that threaten to impede the successful combination of EE and DR. These issues, ranging from technical to organizational, must be addressed in order to unlock the benefits and synergies outlined above.

- **Timescales** – While the data backbone for both EE and DR is made up of energy consumption information, there are important technical differences relating to timescales. First, the resolution of data required for demand response (most programs require meter readings every 5 minutes, 15 minutes or hourly) is different than for energy efficiency, where engineers are accustomed to working with one or two data points per month. In addition, the ability of systems to deliver data to decision-makers in a timely fashion is necessary for DR, yet is uncommon in the energy efficiency world. To achieve true integration, customers would need to be equipped with near-real-time data, and energy analysis tools and processes would need to be modified to incorporate this substantially larger data volume.
- **Customer organization** – Demand response has traditionally been the domain of the facility operators and building engineers. Integrating with energy efficiency requires buy-in from the financial organization, and the new technology solutions require IT departments to be included as well. Achieving coordination across various groups and disciplines within customer organizations will present additional complications.
- **Policy silos** – Even though both EE and DR contribute to the goals of regulators and policymakers, they address different objectives. In addition, EE and DR have evolved somewhat independently in the policy arena, leading to the creation of organizational silos that limit opportunities for a combined approach to what some are calling integrated demand-side management.⁶ Policymakers and others are working to overcome these silos and enable productive, cross-functional collaboration between policy groups promoting both EE and DR. This collaboration can flow down to utility departments, program administrators, and designers of codes, standards, and building energy labeling programs.
- **Programmatic structures** – Most demand-response resources today are enrolled under event-based programs: dispatchable load reductions that are measured in comparison to a baseline load profile. The customer is paid for the load shed, or the difference between what was used and what *would have been* used in the absence of load-curtailing actions. Because of this structure, some have worried that taking steps to improve energy efficiency would reduce the baseline load profile, thus reducing the amount of curtailable load.

This list is not comprehensive; thorough investigation will reveal additional obstacles to integrating demand response and energy efficiency, particularly from the programmatic point of view.

⁵ Carmen Baskette Hendrickson and Kristin Brief, "Integrating Energy Efficiency and Demand Response: Employing Advanced Technologies to Unlock Operational Efficiency in Commercial Buildings." Presented to ACEEE Summer Study, 2010

⁶ See presentation at GovEnergy, August 2010: http://www.govenergy.com/2010/Files/Presentations/Metering/Metering%20and%20EMCS_Session%204_Haeri.pdf

RECOMMENDATIONS FOR FUTURE WORK

Despite the challenges, there are significant benefits to merging energy efficiency and demand response. While not exhaustive, the following list of recommended additional work can lead the market to a more comprehensive approach to energy and demand management.

- **Project case studies** – Successful implementation of the concepts discussed here will build credibility and encourage an integrated view of EE and DR in the marketplace. Ideal case studies will reveal details of project financing, demonstrating the blending of two or more distinct revenue streams in a single financial model. In addition, case studies can provide practical insights into the technical and behavioral issues associated with a combination of EE and DR.
- **Utility pilot programs** – Building on the integrated demand-side management concept, the experience of a few utilities and their customers and stakeholders could add considerable value to integration efforts at the programmatic level. Specific areas to be explored include leveraging an integrated marketing approach, coordinating with a diverse set of vendors and service providers, and streamlining incentives to support both EE and DR.
- **Integration of Energy Efficiency in Wholesale Power Markets** – In addition to the efforts by utilities and regulators, some wholesale power entities have made significant progress integrating energy efficiency, demand response, and other demand-side options. For the past decade, it has been possible to bid the peak megawatts created through demand response curtailments into the auctions that balance electric supply and demand. In the past several years, the markets run by regional system operators PJM and ISO-NE have allowed bidding for the peak demand reductions associated with energy efficiency projects, providing an additional source of peak capacity for the market as well as a novel revenue stream for many energy-conserving projects.⁷
- **Assessment of M&V protocols** – Different timescales, different units and different calculation methodologies present a complex landscape for both customers and program administrators. In spite of all the complexity, both DR and EE provide customers with benefits in the one unit of measure that is most important to them: dollars. To understand and avoid potential conflicts, cannibalization of savings and unnecessary complexity, a dialogue between M&V experts from both the EE and DR sides could support integration at both the program and the project levels.

⁷ *The Role of Forward Capacity Markets in Increasing Demand-Side and Other Low-Carbon Resources: Experience and Prospects* by Meg Gottstein and Lisa Schwartz, RAP, May 2010

The Institute for Building Efficiency is an initiative of Johnson Controls providing information and analysis of technologies, policies, and practices for efficient, high performance buildings and smart energy systems around the world. The Institute leverages the company's 125 years of global experience providing energy efficient solutions for buildings to support and complement the efforts of nonprofit organizations and industry associations. The Institute focuses on practical solutions that are innovative, cost-effective and scalable.

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