The smart grid and the promise of demand-side management

The next generation of DSM technologies will enable customers to make more informed decisions about their energy consumption, adjusting both when they use electricity and how much they use.

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The next evolution of smart grid technology will allow customers to make more informed decisions about their energy consumption, adjusting both the timing and quantity of their electricity use. This ability to control usage is called demand-side management (DSM), and it could translate into as much as $59 billion in societal benefit by 2019. It offers the promise of cutting costs for commercial customers, saving money for households, and helping utilities operate more efficiently, in turn reducing emissions of greenhouse gases.

Demand-side management: What is it?

Demand-side management is a set of interconnected and flexible programs which allow customers a greater role in shifting their own demand for electricity during peak periods, and reducing their energy consumption overall. DSM programs comprise two principal activities, demand response programs or "load shifting," on the one hand, and energy efficiency and conservation programs on the other (see Exhibit 1 on the following page).

- *Load shifting.* Demand response (DR) programs transfer customer load during periods of high demand to off-peak periods and can reduce critical peak demand (the 20-50 hours of greatest demand throughout the year) or daily peak demand (the maximum demand during a 24-hour period). Shifting daily peak demand flattens the load curve, allowing more electricity

to be provided by less expensive base load generation. DR programs can also save the cost of building additional generation capacity to meet future critical peak demand.

- *Energy efficiency and conservation.* Energy conservation programs encourage customers to give up some energy use in return for saving money, such as turning up the thermostat a few degrees in summer to reduce air conditioning. Energy efficiency programs allow customers to use less energy while receiving the same level of end service, such as when they replace an old refrigerator with a more energy efficient model. Pilots have shown that real-time access to information provided through smart grid networks can cut energy consumption by up to 18 percent. Additional gains in energy efficiency are possible through technologies that can provide targeted education or real-time verification of customer demand reduction.

Demand-side management programs have existed across the globe since the 1970s. California utilities have used such programs (in tandem with a changing customer mix) to hold per-capita energy consumption nearly constant over the past 30 years. McKinsey research has found that successful DSM programs incorporate some or all of the following six levers: rates, incentives, access to information, utility controls, education and marketing, and customer insight and verification (see the box on the following pages, "The Six Levers of Effective Demand-Side Management").

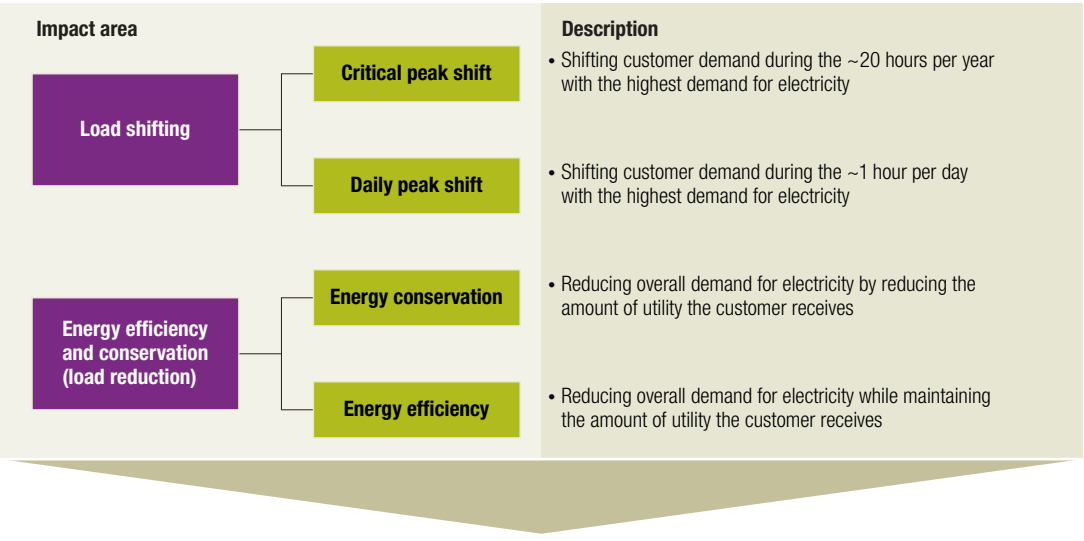
The first wave of DSM programs were limited by the technology available –measurement and verification efforts were time-consuming and

Exhibit 1

How it works

DSM means load shifting, energy efficiency, and energy conservation

The major impact areas of demand-side management



The six levers of effective demand-side management

Based on our work with major utilities, we have identified six key levers of successful DSM initiatives: rates, incentives, access to information, technology and controls, education and marketing, and customer insight and verification. Each lever has a distinct impact on customer behavior, and, depending on the circumstance of the particular utility, such as its customer base and geography, certain combinations of actions within and across levers will produce greater results.

- **Rates.** Utility tariffs are already designed to achieve a range of objectives, from making electricity more affordable for lower-income customers to making electricity prices better reflect the cost of generation. Fully 60 percent of the benefit from demand response predicted by FERC for 2019 will come from altered pricing programs. Utilities will need carefully to tailor their tariff designs, including opt-in or opt-out participation, to yield the desired behavior. Utilities (and their regulatory partners) must also account for the winners and losers in any rate design and ensure that particular segments, such as socio-economic classes, do not bear unnecessary costs.

- **Incentives.** To encourage participation in demand-side management programs, utilities have found that rebate checks, compensation for participating in a pilot, or free technology such as an in-home display can increase customer adoption.

- **Access to information.** When consumers have access to real-time information they become much more aggressive about managing their usage. In a series of pilots conducted by Hydro One in Canada, customers reduced their electricity consumption by 6.5 percent based on information provided through an in-home display. OPower, a smart grid information services company, has developed software that analyzes a customer's bill and compares usage to other customers in the area with similar attributes such as house size. The utility can then provide recommendations on how to reduce energy use. This software has been piloted by the Sacramento Municipal Utility District (SMUD) and has produced energy savings of 3 percent.

- **Utility controls.** Direct load control programs are used to curb demand, such as air conditioning, during critical peak periods. The smart grid will enable customers to manage their own demand (and distributed generation resources) based on price or other signals from the utility. These controls could be integrated with programmable communicating thermostats, home energy controllers, or other automation tools to match customer preferences. Increasing levels of control by utilities will enable automated demand response programs, ensuring load shed and enabling utilities to bid this capacity into markets as a resource.

- **Education and marketing.** Customer education on the benefits and the technology of DSM programs can be targeted to different market segments, different education goals, or different channels.

- **Customer insight and verification.** To drive improvements, it is essential to verify DSM program results and collect feedback, regardless of whether the targets are broad or narrow. A powerful benefit of the smart grid is that it enables verification of the impact of DSM programs over different time horizons.

A sample of design options for each of the levers is summarized in Exhibit 2.

Successful pilots indicate complementary effects interact across the levers and design options. Providing both in-home displays (IHDs) and pre-pay options, for example, resulted in energy conservation benefits of 13 to 15 percent, while IHDs alone yielded a median impact of 7 percent.

Exhibit 2

Successful demand-side management

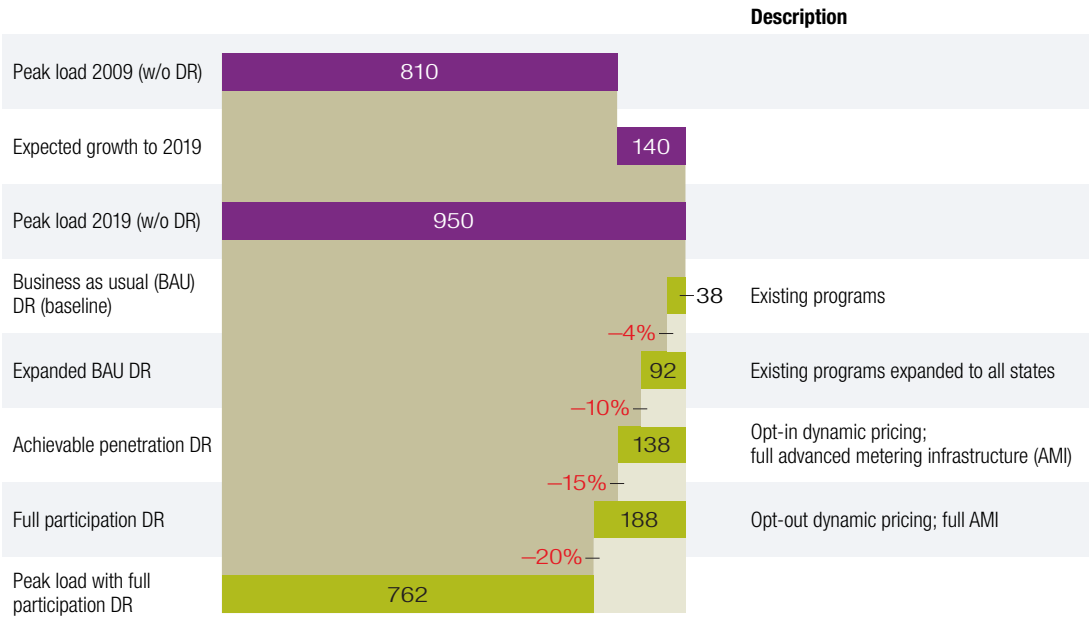
Successful DSM optimizes multiple design options across 6 levers

DSM lever	Design options	Description
Rates	• Flat rate • Critical peak pricing (CPP) • Time of use (TOU) • Real-time pricing (RTP) • Interverted block pricing	• Same rate at all times • Extremely high rates during critical peaks • Variable pricing for prescheduled blocks of time • Variable pricing at all times, informed close to instantaneously • Increase rate for higher use customers
Incentives	• No incentives • Provide rebates on bill • Provide cash compensation	• Base case • Debit bill based on degree of behavior change • Provide separate check to encourage behavior change
Information	• None • Event notification • Real time usage • Historical usage • Comparative usage • Device-specific usage • Billing usage	• Monthly paper bills and consumption information • Notification of DR events under way • Consumption at a given moment (e.g., kW, light bulb equivalents) • Consumption compared to previous period of time • Consumption compared against last month's or peers' • Individual device usage in real time; can be paired with above • Real-time billing information
Controls	• None • Programmable communicating thermostats (PCTs) • Smart appliances/plugs • Home energy controller • PHEV smart chargers • DG/S control devices	• No automation of devices to reduce energy consumption • Automated AC control • Automated appliance on/off • Centralized control & automation of major home appliances • Optimized charging of PHEVs • Optimized usage, storage, and later discharging of energy
Education	• No education • Educate by segment • Educate by channel • Educate by positioning	• Base case • Vary by income, consumption behavior, attitudes • Use various means: e-mail, bill inserts, newspaper, etc. • Emphasize different HAN benefits (reduced energy costs and carbon emissions, increased competition with neighbors, etc.)
Customer Insight and verification	• None • Verification of benefits capture	• Base case • Verify DSM (EE, EC, and DR) and economic utility captured by customers

Exhibit 3
Reducing demand

Customer demand response can reduce U.S. peak demand by 20 percent

Impact of demand response (DR) on U.S. peak load
Gigawatts of peak load



Source: Federal Energy Regulatory Commission (FERC), "A National Assessment of Demand Response Potential"

expensive, causing programs often to be focused on only the largest customers. The next wave of DSM programs promise to change the face of energy savings throughout the global economy. McKinsey estimates that by 2020 the United States could cut end-use energy consumption by 9.1 quadrillion BTUs, over one-fifth of its total projected demand.[1] FERC estimates that demand response programs could cut peak demand by up to 20 percent within 10 years (Exhibit 3).

The growing role for smart grid

Smart grid provides the scale and scalability—to make demand-side management cost-effective and convenient. The pieces are falling into place: the increasing penetration of smart meters, which may allow homes to connect to data on usage and price; the promise of ubiquitous data networks; and an intelligent grid that gives utilities visibility into real-time supply and demand balancing. These technologies give the DSM programs now being designed by utilities a number of crucial advantages over those of the past.

- *Real time information.* U.S. utilities alone have committed to the purchase of over 40 million smart meters over the next 5 years. The inevitable prevalence of smart meters will allow utilities to collect and analyze usage information at intervals as narrow as 1 hour or even 15 minutes, rather than relying on a manual monthly reading. This data can be transmitted to consumers in their homes via a home-area network (HAN), allowing real-time feedback on consumption.

[1] *Unlocking Energy Efficiency in the U.S. Economy,* McKinsey Global Energy and Materials, July 2009.

- *Two-way networks.* Smart grid networks allow utilities to collect usage data and verify reduced demand (load shed), as well as send time-of-use rates and other information to the customer. Network costs are low enough to justify near-ubiquitous deployment, allowing utilities to communicate in near real time with their entire customer base.

- *Integration of utility information systems.* The smart grid is driving utilities to stitch together many disparate information technology solutions into highly capable decision engines. By communicating the underlying cost of electricity, utilities can begin to develop a comprehensive view of their customer base, and build targeted programs to appeal to specific segments of customers.

- *Shifts in customer behavior.* The availability of real-time data on energy costs and consumption comes at a time when customers are increasingly aware of the cost and environmental impact of their energy usage, and have begun to expect price fluctuations and an ability to respond to price.

- *Regulatory changes.* Some states, including California, have enacted decoupling regulations that allow utilities to recover revenues lost due to DSM programs. Utilities and regulators have also explored opportunities to use demand response as another source of generation through "negawatts," or the ability to reduce load upon request. Some states and regional grid operators, such as the New England ISO's Ancillary Services Market Project, allow utilities to bid demand response capacity into the wholesale market as if it were generation. This encourages utilities to pursue DSM opportunities, and may improve the efficiency of the market as a whole.

Capabilities required

While smart grid technologies will make these savings possible, utilities will have to build new capabilities to capture the potential benefits fully. A primary focus will be on augmenting program design functions to enable the micro-targeting of customers.

- *Increase the number of products and programs.* Smart grid technology will slash the cost of developing, managing, and refining DSM programs. Smart meter networks provide near-ubiquitous connectivity to electric meters, which increases the ability to verify impact, and makes it easier to test and refine different design options. Lowering the cost of deploying DSM programs not only will make it cost effective to provide offerings to the mass market, but it will also enable utilities to use the demographic data they gather to target micro-segments of their customer base with tailored programs.

- *Manage a partner ecosystem.* Many utilities and regulators predict smart grid networks will become open platforms that allow third-party development of energy management applications. In this world view, utilities will need to develop the capability to manage and coordinate a wide variety of complementary partners, and will need to clearly define their role in the ecosystem.

- *Accelerate the pace of testing.* The two-way reach of smart grids will allow utilities to speed and widen the testing cycle for new products. They will be able to "test and learn" to understand which program features are most effective for specific segments, thereby reducing the time to market for new ideas. Some day,

utilities may be more like Capital One Bank, whose rigorous analytics and iterative marketing strategy measure the relative impact of hundreds of thousands of different offers (rates, card designs, promotional materials), to determine which ones have the greatest effect on customer behavior.

- *Build account management capabilities.* The Federal Energy Regulatory Commission estimates that two-fifths of the DSM opportunity in the U.S. lies in about 262,000 large commercial and industrial customers. While many of these customers participate in fledgling DSM programs such as curtailment and direct load control, some have never been directly affected by these programs. Utilities will need to develop full-service support for customers to navigate and manage what will likely be increasingly complicated DSM programs.

- *Educate residential customers.* Almost half of the demand reduction potential for 2019 comes from the highly fragmented residential market. To reach this market, utilities will have to develop easy to understand programs that give customers the tools (and the incentives) to better manage their energy use.

Even with these new capabilities being brought to market as part of the smart grid, two hurdles remain for DSM to become a reality: the right blend of technology and program design must be adopted to optimize results; and, importantly, regulatory reforms that will allow utilities to capture value from demand-side management need to be established.

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Utilities have every reason to be skeptical about projections of demand-side management results. Since the 1970s, they have tried to capture load shifting and load reduction benefits, with mixed results. These efforts, however, were limited in scope and relied on costly, proprietary technology solutions.

The good news is that there has been significant progress in areas vital to the success of DSM. Utilities are using federal stimulus funding opportunities to deploy statistically significant pilots to measure the impact of various DSM program designs. And regulators are considering reforms that credit utilities for demand-side reductions. Still, much work at all levels remains to be done if the economic and social promise of DSM is to be fully realized in the next decade.

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