Next Generation Demand Response: Responsive Demand through Automation and Variable Pricing

Executive Summary

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Executive Summary[1]

This paper provides a snapshot of existing demand response (DR) programs, examines developments that are shaping the future of demand response, and explores how to create the next generation of responsive demand.

Demand response programs have been important in reducing peak demand and customer costs. Most existing utility, Independent Transmission System Operator (ISO) and Regional Transmission Organization (RTO) DR programs target large customers and provide incentives for reducing demand during energy emergencies or other triggering events. However, such programs do not engage most consumers or directly address many of the daily challenges facing grid operators. Generation, transmission, and distribution still must meet demands that occur in only a few hours of the year. As a result, asset utilization in the power sector remains highly inefficient.[2] This inefficiency adds billions of dollars per year to customer bills, damages the competitiveness of American companies, leads to overbuilding infrastructure, and requires operation of less efficient generators.[3]

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[2] Average generation capacity factors are below 50 percent and the average utilization of transmission and distribution facilities is often lower. A generator's capacity factor is a measure of how much electricity a generator actually produces relative to the maximum it could produce at continuous full power operation during the same period. U.S. Energy Information Administration, *Electric Power Monthly with Data for December 2013,* (February 2014), Tables 6.1, 6.2, and 6.7.) By contrast, in other capital-intensive industries that can increase prices when supply is short and discount to sell excess inventory, average rates of capacity utilization generally exceed 75 percent. U.S. Federal Reserve Board of Governors, *Industrial Production and Capacity Utilization* (August 15, 2012).

[3] Using the Cost of New Entry – the annual cost of recovering capital investments and fixed operating and maintenance expenses – for a combustion turbine ($138,000/MW – yr.), the annual generation capacity cost alone of a one percent (7.7 GW) change in U.S. peak demand is in excess of one billion dollars per year. S. Newell, et al., *Cost of New Entry Estimates for Combustion Turbine and Combinend Cycle Plants in* PJM (May 15, 2014); U.S. EIA, *Electric Power Annual 2012* (December 12, 2013) at Table 8.6A Non-Coincident Peak Load.

The paper examines three key developments in demand response:

- **Emerging Technology:** Smart thermostats and other smart devices are becoming affordable and can respond to changing prices to reduce energy bills without compromising comfort or service. Smart devices can help us use energy more efficiently. And, they can tap hidden sources of energy storage: our homes and buildings heat up and cool down slowly and many uses of electricity have flexibility in when they need to take power from the grid. The integration of these devices with power markets and system operations could greatly reduce costs, make the power system more resilient, and facilitate the low cost integration of wind and solar energy. Smart devices that manage their energy use are starting to make demand response automatic and continuous, deepening its impact, and extending choice and control to millions more customers.

- **Variable Pricing:** Over the last twenty years, ISOs and RTOs developed dynamic, location-based wholesale markets. An organized wholesale market, such as PJM Interconnection LLC (PJM), will calculate 5-minute real-time interval prices for more than ten thousand points across its regional grid. Prices can range from less than zero to more than $2,000 per MWh.[4] However, most consumers never see or have the opportunity to respond to the information conveyed in these price signals. Most pay a flat rate[5] for every kilowatt-hour consumed with little idea what their various energy uses actually cost. Some utilities have experimented with time-varying rates or dynamic retail pricing and achieved significant demand reductions with high levels of customer satisfaction. And, a few companies are making a time-varying or dynamic rate their default service option. Affordable smart devices that help customers optimize the timing of energy use could enhance customer acceptance, provide them more control over their bills, and expand the use of smart pricing.

- **Wholesale Demand Response Compensation:** The Federal Energy Regulatory Commission (FERC) recognized that demand participation is essential for efficient

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[4] Changing wholesale prices are a result of ISOs and RTOs committing and dispatching generating units, on an economic basis, taking into account constraints on power flows, to meet forecasted demand. Negative prices can occur when there is excess generation in areas upstream from a transmission constraint that is limiting the export of power. They also may occur when baseload generators cannot ramp down sufficiently in periods of low demand or when suppliers are willing to generate at negative prices to qualify for a production tax credit. Prices in excess of $1,000 per MWh are permitted when there is a shortage of operating reserves.

[5] For purposes of this paper, the term "flat rate" is used to identify retail pricing that does not change with the changing marginal cost of providing service at different times and locations, including with changes in market prices in organized markets. The term "flat rate" is intended to include, for example, inclining block rates that change with total monthly consumption, but not with changes in the short-term cost of providing service.

wholesale markets. ISOs and RTOs introduced DR programs that incent customers to reduce demand or operate customer-sited generation when additional capacity is needed.[6] ISO and RTO capacity and energy market DR programs have provided substantial incentives for demand reductions. In May 2014, the Federal Court of Appeals for the D.C. Circuit overturned FERC Order 745 on compensation for demand response in wholesale energy markets.[7] If upheld, the decision could significantly restrict FERC's jurisdiction, leaving the long-term future of RTO and ISO demand response programs uncertain.

The paper considers the anticipated consequences and logical implications of each of these three developments.

A core finding is that intelligent devices, such as thermostats that automate customer preferences for savings and comfort, are poised to create broader and deeper levels of demand response. Utilities and energy service companies, technology and controls companies, cable and telecom providers, big box retailers and start-ups are starting to offer products and services that use data analytics and enable thermostats and other energy using devices to respond to projected periods of high electricity prices, individual customer preferences, and usage patterns. Google's $3.2 billion purchase of Nest and Apple's announcement of its HomeKit platform for energy applications are part of a growing supplier base. The underlying technology is already cost-effective and becoming less expensive. Breakthroughs in the performance and energy efficiency of sensors and batteries; advances in data analytics; and cloud computing; near ubiquitous wireless networks; and Internet Protocol Version 6 (IPV6), the internationally accepted standard for how devices connect to the internet, that opens 340 undecillion, which is 340 followed by 36 zeros, new internet addresses for connected devices, supports enhanced security, and simplifies network connections, are making smart, connected devices technologically feasible and affordable.[8] We soon will reach the tipping point when network connected devices in millions of homes and businesses could efficiently time their use of electricity to minimize costs consistent with customer preferences.

This intelligent device-driven demand response is a fundamentally different form of responsive demand. In contrast to conventional DR programs that enable a system operator to dispatch a large customer-sited generator or defined load reduction by a large customer, smart devices can

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[6] NRDC and the Sustainable FERC Project are generally opposed to the use of back-up diesel generation and other polluting on-site generation as demand response resources, except in the instance of avoiding imminent blackouts. NRDC's position is explained more fully in *Small and Clean is Beautiful: Exploring the Emissions of Distributed Generation and Pollution Prevention Policies*, Electricity Journal June 2000; and more recently in California Public Utility Commission Rulemaking 13-09-011, *Response by the NRDC to Phase Two Foundational Questions*, filed on September 19, 2013.

[7] *Electric Power Supply Association v. FERC*, 753 F.3d 216 (D.C. Circuit May 23, 2014).

[8] M. Porter and J. Heppelmann, "How Smart, Connected Products are Transforming Competition," *Harvard Business Review* (November 2014).

continuously and autonomously optimize the timing of power use. They can do so all of the time, automatically, in the background, in near real-time, based on both modest and more significant interval-to-interval changes in grid conditions or anticipated prices. Unlike most demand response programs that may be called upon only a few times a year, intelligent devices could:

- Expand demand participation and reduce customer costs by lowering the cost of building energy management for commercial and industrial customers; providing choice and control to millions of residential customers; and reducing the energy wasted by cooling, heating, and lighting unoccupied spaces;[9]

- Improve utility asset utilization on a continuous basis, not just for a limited number of peak demand events, thereby enabling more efficient operation of existing generation, and reducing overall capacity needs;

- Facilitate the affordable integration of renewable and variable resources and loads by offsetting variations, reducing the need for back-up generation or electricity storage, and moderating the ramping of generation; and

- Improve electric system security and resilience by providing system operators location-specific, rapidly responding options to address reliability events that occur within an operating day.

The potential impact of technologies that automate customer energy choices is large. And, the barriers to faster realization of a future in which smart devices implement the preferences of ordinary consumers for comfort and lower bills are largely regulatory, not technological or economic.

The final sections of the paper discuss two sets of recommendations for the future of demand response. First, given the potential impact of emerging technologies, the paper recommends that state regulators, utilities, retail energy suppliers, ISOs, RTOs and FERC pursue one or more of the following avenues to support the adoption of smart devices and development of a next generation of responsive demand:

- **Demand-Side Management Programs:** This approach extends to intelligent thermostats and other smart devices utility incentive or financing mechanisms that are used to support the adoption of cost-effective energy efficiency measures. An incentive

[9] This paper identifies energy savings from smart technologies and discusses policy options some of which might be used to accelerate the adoption of energy efficient technologies. However, a broader review of end use energy efficiency is beyond the scope of this paper. An analysis of the environmental impacts of demand response, while a key consideration, is also outside the scope of this paper. The impact of changes in demand on criteria pollutant and greenhuse gas emissions is a function of both total energy used and the mix of generation and energy sources.

also may be offered for enrolling the devices in a utility program that, for example, triggers thermostats to pre-cool and then reduce air conditioner use during summer peak events. Incentive or financing programs may be used to demonstrate the potential impacts of smart devices, make devices available to low-income customers, and accelerate their introduction into the market.

- **Wholesale Market Incentives:** By providing information and improving wholesale settlement practices, ISOs, RTOs, and FERC could provide incentives and, in retail access jurisdictions, foster competition among retail suppliers to help customers more efficiently manage their energy bills. Utilities would be able to reduce costs and competitive retail suppliers could gain market share by offering packages that include both energy supply and smart devices that optimize energy usage. To provide such incentives:
  - Wholesale settlements should reflect the actual interval loads of the customers of each retail supplier, providing suppliers the opportunity to compete based on their ability to help customers manage their demand and energy costs. States and utilities can evaluate options for how best to provide interval usage data to support such wholesale settlements.
  - System operators or FERC should make information on anticipated interval prices, which may be based on the ISO's and RTO's indicative "look ahead" price forecasts, available in a standard format to influence the timing of energy used by intelligent devices, help position responsive demand for anticipated system conditions, and minimize costs. FERC has an existing statutory requirement to make price information available the public in a timely manner.

  Dynamic retail prices are not required for suppliers to flow through to retail customers the savings produced by intelligent devices. For example, suppliers could offer customers who allow their smart thermostats a degree or two of temperature flexibility a lower fixed price or other incentives.

- **Smart Retail Pricing:** While dynamic retail prices may not be essential for smart devices to provide benefits, smart devices make it easier for customers to accept and benefit from smart pricing. Pricing plans that include a dynamic component can modify behavior, boost customer savings, and improve power system efficiency. The paper identifies steps that could facilitate customer consideration of dynamic pricing options:
  - Place those customers who could benefit and have not chosen an alternative plan on default rates with a dynamic component on an opt-out basis;
  - Offer two-part pricing packages that combine a dynamic price signal and a component that provides protection against unusually high bills; and
  - Provide customer education and bill comparison tools that make it easier for customers to evaluate dynamic pricing options.

The second set of recommendations addresses integration of responsive demand into system operations, planning, and the determination of resource requirements. Smart devices will automate customer energy choices in millions of homes and businesses. Each customer may have multiple devices that autonomously implement small interval-to-interval changes in energy usage based on individual customer preferences, building and equipment conditions, and information on anticipated prices or grid conditions. Although smart devices in the aggregate will provide predictable demand response and operators will be able provide information to influence that response, it will be impractical for a system operator or aggregator to dispatch all these devices. As a result, system operators will have to forecast the impacts of smart devices and price response on demand and should incorporate their adjusted forecasts in system operations, planning, and in setting resource requirements.

This reality leads to three recommendations. First, system operators should develop and enhance their ability to forecast the demand impacts of smart devices and price responsive demand.

Second, in setting resource and reserve requirements for ISO and RTO capacity mechanisms, system operators will need to forecast how responsive demand will respond to the peak prices. The forecasting methodologies typically used to set capacity requirements will not reflect how growth in responsive demand would impact usage in high price periods. Moreover, the largest potential source of price responsive demand is residential and other small customers. The costs of enforcing standard DR program requirements on millions small customers and aggregating their responses makes it unrealistic to expect the responses of these customers to be offered into capacity auctions.

Third, if the Court of Appeals decision in *EPSA v. FERC* becomes the applicable precedent, ISOs and RTOs should consider new approaches for enabling demand participation in emergency conditions. In an emergency, the system (or a transmission constrained portion of the grid) approaches the point where prices are at the maximum allowed under market rules and there are insufficient resources to meet all demand plus minimum operating reserve requirements. By definition, price responsive demand can respond only to the prices allowed under market rules and, at the maximum allowed price, would be fully curtailed. Moreover, maximum prices generally exceed the marginal start up and operating costs of generators in the region. Additional demand reductions would be needed to maintain reliable operations. Providing demand reductions in an emergency is a key objective of most DR programs.[10] In the absence of their existing emergency DR programs, there are two ways in which ISOs and RTOs could bring demand and supply back into balance. First, FERC could lift the ceiling on market prices, while continuing to apply market mitigation rules to prevent any abuse of market power. This is a straightforward and efficient option. Alternatively, ISOs and RTOs could create a market mechanism that performs a function comparable to emergency DR without intruding on state

[10] K. Managan, *Demand Response: A Market Overview,* Institute for Building Efficiency (February 2014); NERC, 2012 State of Reliability (May 2012).

retail jurisdiction. The paper describes a capacity option repurchase mechanism that could accomplish this objective consistent with the Court of Appeals decision. The repurchase mechanism would allow Load Serving Entities (LSEs), or their agents or assigns, to resell an option derived from the LSE's wholesale capacity obligations creating an opportunity to provide additional incentives for demand reductions during energy emergencies and permiting ISO and RTO markets to match demand to available supply.

By pursing these policies, regulators, utilities, and system operators could achieve large economic and reliability benefits and reduce costs for millions of consumers.

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