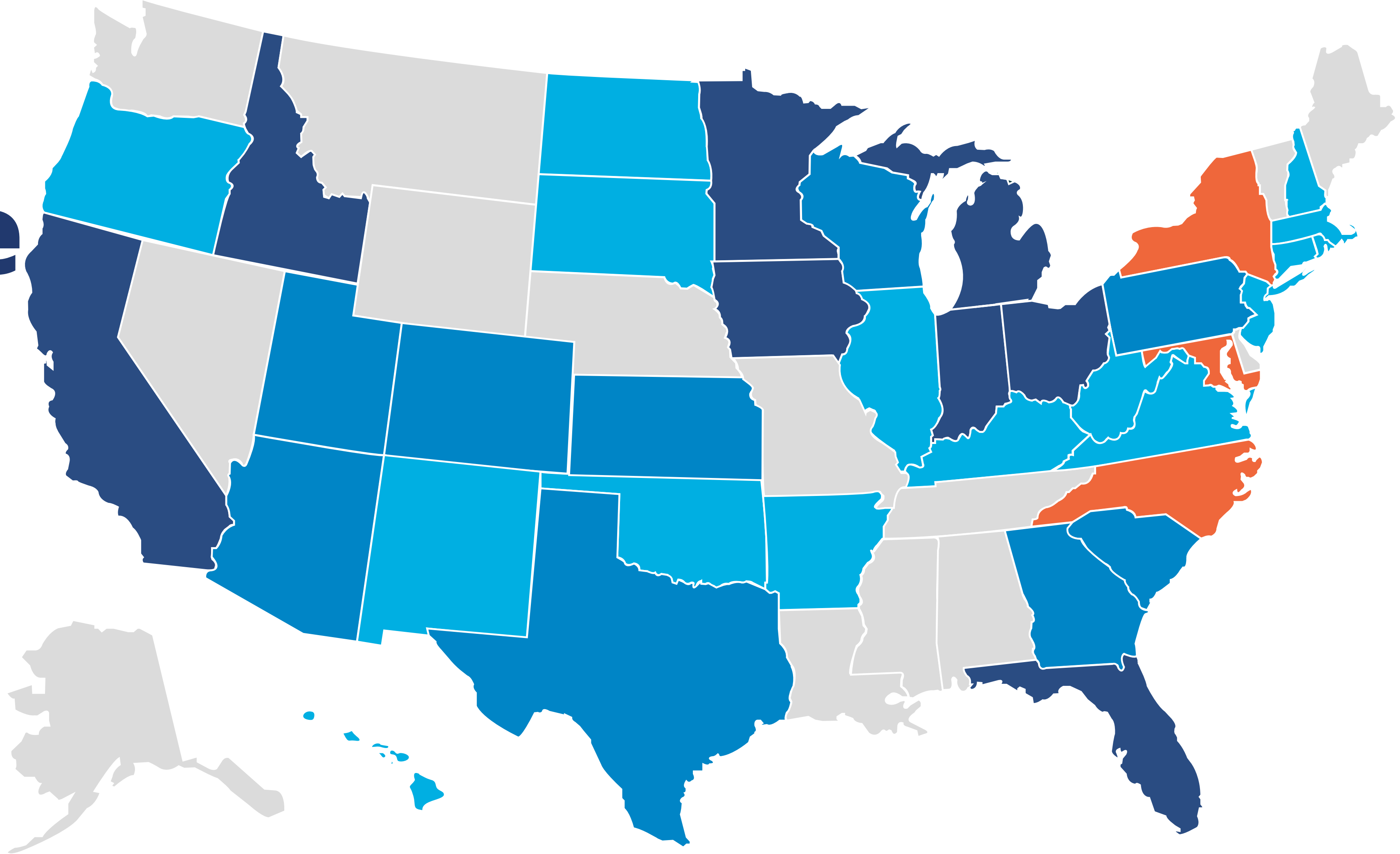
Smart Electric Power Alliance

2017 Utility Demand Response Market Snapshot

IN PARTNERSHIP WITH

NAVIGANT

OCTOBER 2017



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About the Report

The Smart Electric Power Alliance (SEPA) began its annual survey of electric utilities in 2007, to track the capacity of new solar power interconnected to the grid each year. With the survey now in its 10th year, SEPA has expanded the scope of this initiative to include the demand response (DR) market. Content in this report draws on data from SEPA's 2017 Utility Survey as well as key market insights from Navigant Consulting's research team.

Navigant has been tracking and producing reports on the DR industry for six years, and has been involved in DR program design and evaluation for over 10 years. Its work has included all customer segments, hardware and software technologies, vendor landscape, and retail and wholesale demand response programs around the world. Navigant has collected data on DR programs, interviewed grid operators, vendors and regulators; and followed and analyzed technology, market, and policy issues.

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Executive Summary

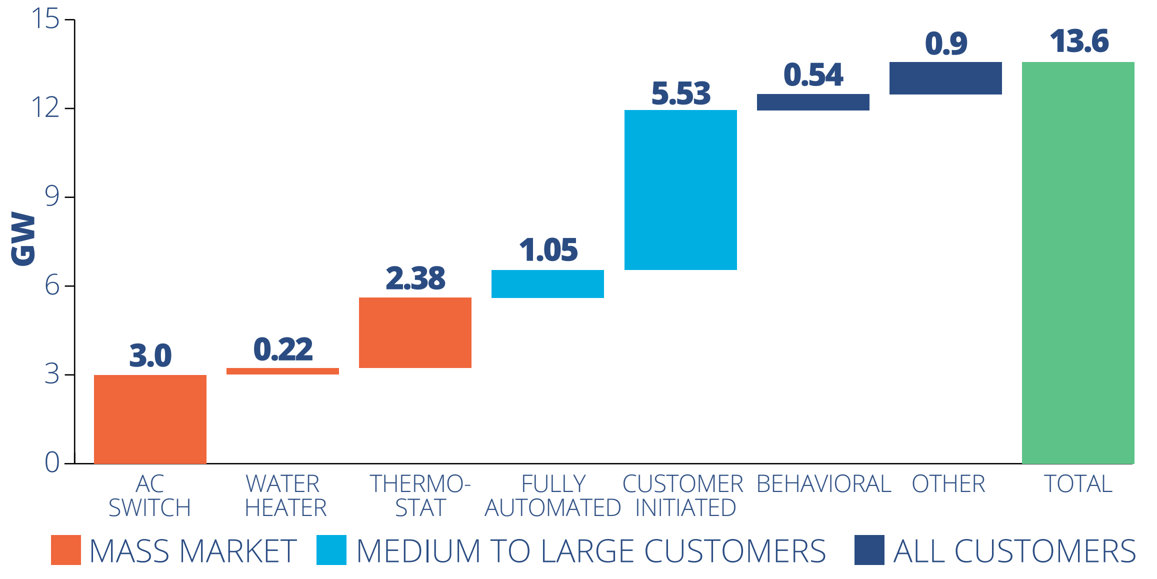
DEFINING DEMAND RESPONSE

- Demand response (DR) is not a new concept; utilities have been enrolling customers in cycling programs for air conditioning (AC) and water heaters for decades. However, changes in technology have propelled traditional demand response into a period of transition that requires a broader, more flexible definition.
- The Smart Electric Power Alliance has adopted the following working **definition of demand response**:
  - *Changes in the electric load—such as reductions, increases, or shifts—by end-use customers from their normal consumption patterns in response to specific market or system conditions. Such conditions could include time-varying changes in the cost of producing energy, shortages of distribution, transmission, or generation capacity, or unusually high or low voltage or frequency.*

DEMAND RESPONSE MARKET INSIGHTS FROM SEPA'S SURVEY

- Utilities reported a **total enrolled capacity of 13,629 MW** and a **dispatched capacity of 10,696 MW** (78% of enrolled capacity) available for reduction through their DR programs in 2016.
- Traditional demand response programs, such as load control switches for air conditioners and water heaters, are still being used today, with **41% of utility respondents offering AC switch programs** and **16% offering water heater programs**. Some utilities are switching from traditional one-way control to two-way communications technologies (e.g., DTE, Duke Energy).
- Newer demand response technologies and approaches are gaining traction in the industry, with 24% of utility respondents offering thermostat programs and 9% offering behavioral programs to their residential customers.
- DR is allowed to participate in wholesale markets to varying degrees across the U.S., with DR most commonly participating through capacity markets or through emergency-based programs for areas without capacity markets.[1]

FIGURE 1: TOTAL 2016 ENROLLED DEMAND RESPONSE CAPACITY (MW)



Source: Smart Electric Power Alliance, 2017. Data reported in SEPA's DR Survey—results are a sampling of 104 utilities.

1 Navigant Research, "Market Data: Demand Response, 2016", https://www.navigantresearch.com/research/market-data-demand-response.

POLICY UPDATE

- The **U.S. Supreme Court upheld the Federal Energy Regulatory Commission's (FERC) Order 745**, which established DR compensation in the wholesale energy markets does fall under FERC's jurisdiction, essentially leaving the DR market as it was before earlier legal challenges.
- **Rules for DR in Northeast wholesale markets are growing stricter.**
  - PJM Interconnection (PJM) is now requiring year-round performance.
  - ISO-New England (ISO-NE) is penalizing capacity resources (including demand response resources that take on a capacity obligation) for not producing energy or reserves when capacity is scarce.

DR PROGRAM TRENDS

- **Demand response programs using smart thermostats are growing in popularity** as utilities expand their offerings to include direct install, self install and bring your own thermostat programs. These programs increase customer choice, allow greater visibility into customer devices, and provide energy savings to both customers and utilities.
- **Utilities are continuing to adopt behavioral programs** as a way to increase customer engagement, provide customers with energy savings, and curb energy usage during peak hours.
- **A number of efforts are under way to better coordinate energy efficiency and demand response at the utility level**. Examples here include combined program offerings and incentives, coordinated program marketing and education, market-driven coordinated services, and building codes and appliance standards.

ADVANCED DR APPLICATIONS AND TRENDS

- **Electric vehicles are quickly becoming one of the largest flexible loads on the grid**, with annual electricity consumption by EVs expected to reach 400 terawatt-hours (TWh) annually by 2040.[2] These vehicles have the capability to absorb excess renewable energy production and minimize peak impacts through managed charging.
- **Utilities are increasingly looking to target DR in specific distribution-level areas with high load growth or infrastructure constraints.** Ten percent of the utilities providing DR data for SEPA's Utility Survey have leveraged locational deployment of DR for non-wires grid upgrades (commonly known as non-wires solutions or alternatives). Another 60% are planning, researching, or considering such an approach.

DR AND DER CONVERGENCE

- While traditional forms of demand response continue to be deployed today, newer forms of DR are emerging in the industry and being integrated with other distributed energy resources (DERs). This transition and expansion in demand response markets are being driven by a few key trends.
  - **Needs at the grid edge:** DER growth and constraints along the electric system are opening up opportunities for demand response to play a greater role along the grid edge.
  - **Consumer products entering the power space:** Newer demand response technologies (e.g., smart thermostats and other complementary technologies) are enabling easier deployment for certain demand response programs.
  - **Integration:** New platforms and programs are combining DR with other DERs. Examples include deploying energy storage for demand response applications, and using demand response to buffer renewable generation variability along the grid.

2 Bloomberg New Energy Finance, July 2017, "Electric Vehicle Outlook 2017", https://about.bnef.com/electric-vehicle-outlook/.

Introduction

When the Smart Electric Power Alliance (SEPA) first decided to expand our annual Utility Market Survey to include demand response (DR), we envisioned a process similar to our annual research on new solar interconnected by utilities in the previous year. We would ask utilities to provide us with data on their total megawatts of DR capacity and then quantify the results into specific market segments and a Utility Demand Response Top 10.

However, we quickly ran into obstacles related to both survey design and data collection. At a high level, we realized that demand response encompasses a wide range of programs, has varying definitions across the industry, and continues to evolve even as you read these words. Boiling down DR into a single working definition and a set of market segments, and then standardizing the data we received from across the industry proved challenging.

Further, collecting data solely from utilities, as we always have done, produced inherently limited results, since third-party providers and aggregators play an increasingly critical role in the DR market.

Consequently, the purpose of this report is to capture both the current state of demand response as well as the emerging trends that are driving transition and unlocking new DR capabilities and value—in particular, the convergence of DR and distributed energy resources (DERs). For that reason, the report is divided into two sections.

The first, based on survey responses submitted by 104 utilities, provides a sample of the existing demand response market, including basic data on key market segments and trends to the extent we were able to collect and quantify them. However, the limited nature of survey results meant we were unable to compile Utility Demand Response Top 10 lists.

The second section lays out a fuller picture of the demand response market, its current state and ongoing evolution, including key developments and trends in DR policy and technology.

HOW WE DEFINE DEMAND RESPONSE

To quantify and describe the DR market, we first had to establish a working definition of demand response. Certainly, DR is not new to utilities; they have been enrolling customers in cycling programs for air conditioning (AC) and water heaters for decades. However, changes in technology have propelled traditional demand response into a period of transition that requires a broader, more flexible definition.

Thus, based on discussions with SEPA's Advisory Council on Demand Response and Smart Grid, SEPA adopted the following definition of demand response for this report:

> *Changes in the electric load—such as reductions, increases, or shifts—by end-use customers from their normal consumption patterns in response to specific market or system conditions. Such conditions could include time-varying changes in the cost of producing energy, shortages of distribution, transmission, or generation capacity, or unusually high or low voltage or frequency.*

This definition encompasses diverse DR technologies, programs, and practices that can support a grid operator's ability to respond to real-time electricity supply conditions and market pricing.

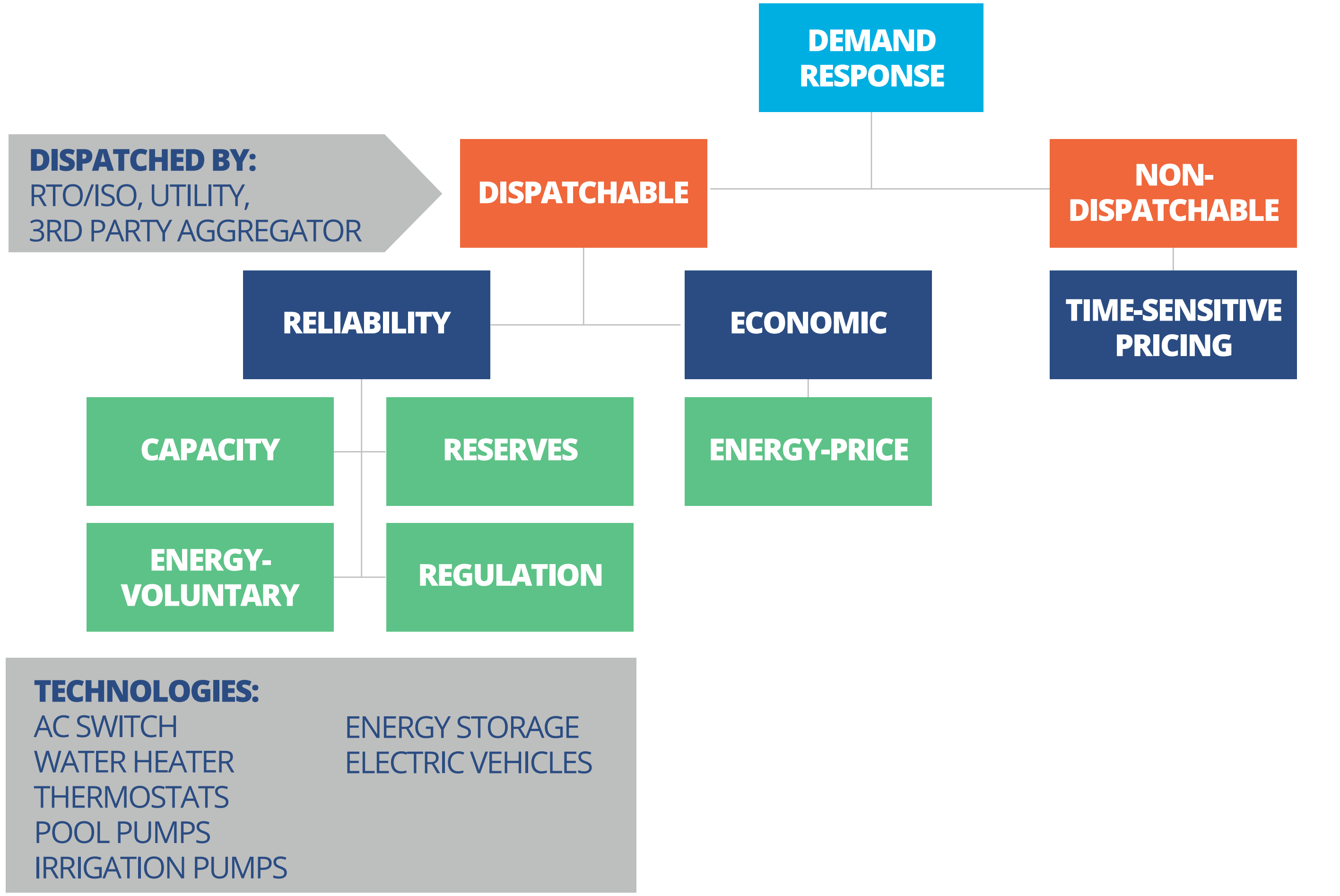
For example, DR can quickly respond to the availability of low-cost renewable resources at times when production is abundant, or it can quickly reduce load when production decreases. A key example is the managed charging of electric vehicles (EVs) at mid-day to absorb excess solar generation.

SCOPE AND ORGANIZATION

While recognizing the evolving nature of demand response, SEPA's survey focused primarily on controllable and dispatchable DR resources deployed by utilities through December 31, 2016. As previously noted, it did not include third-party providers or aggregators, or regional transmission organizations (RTOs) or independent system operators (ISOs).

We maintain a similar focus in this report, that is, on demand response as a dispatchable, controllable and evolving resource for both utilities and wholesale power markets. Figure 2 provides an outline of the current DR market, its key participants and programs, and the range of uses and values demand response can provide to the market.

FIGURE 2: SEPA 2017 DEMAND RESPONSE SURVEY SCOPE



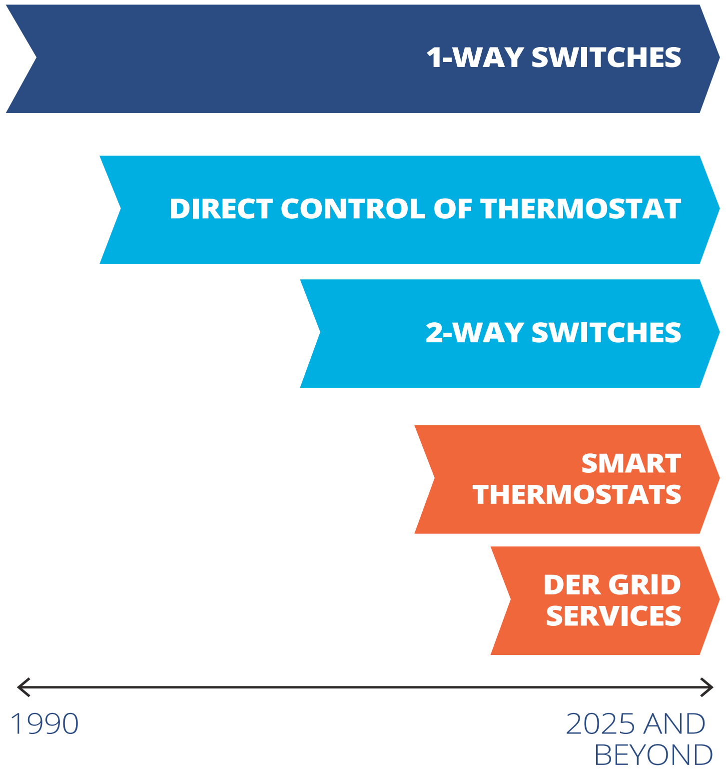
Source: North American Electric Reliability Corporation (NERC), 2013 with modifications by Smart Electric Power Alliance and Navigant, 2017[3].

3 NERC, "2011 Demand Response Availability Report", 2013, http://www.nerc.com/docs/pc/dadswg/2011%20DADS%20Report.pdf.

Our approach to demand response technologies and business models also incorporates the three-phase model of DR evolution developed by the Peak Load Management Alliance (PLMA), as summarized in Figure 3.

Recognizing the evolving nature of DR, SEPA expects our approach to demand response will also change with technology, policies and business models. We invite any interested parties to collaborate with us and provide feedback for next year's survey.

FIGURE 3: THE EVOLUTION OF DEMAND RESPONSE



DR 1.0	Represents the original demand response initiatives in which utilities notify customers through a pager or telephone message to manually change energy consumption. Alternatively, utilities may leverage one-way communication load-control devices to modify usage of residential air conditioning units and water heaters. Older forms of DR allow some customers to use certain types of diesel generators to temporarily shift some load away from the grid. DR 1.0 is predominantly used for emergency events or when wholesale prices are high. A significant amount of DR 1.0 remains in use today and will continue to be used into the future.
DR 2.0	Reflects the increase in bilateral communications, and greater locational capabilities to call DR without curtailing every customer. This may also include the integration of automated demand response that allows increased participation in wholesale electricity markets and grid operations by providing ancillary grid services. 2.0 extends to include shifting of load to low-cost off-peak times when renewable resources are abundant.
DR 3.0	Represents the evolution of demand response as a component in the larger field of DERs. Along with electric vehicles, energy storage, and solar photovoltaics, for example, DR can provide services to the grid in renewable energy integration and distribution congestion management. DR 3.0 can be applied to highly refined and localized problem solving.

Source: Smart Electric Power Alliance, Navigant, and Peak Load Management Alliance[4], 2017.

4 PLMA, Evolution of Demand Response in the United States Electricity Industry, May 2017, http://www.peakload.org/default.asp?page=DefiningEvolutionDR.

DR AND DER CONVERGENCE AND CAPABILITIES

While traditional forms of demand response continue to be deployed today, newer forms of DR are emerging in the industry and being integrated with other DERs.

This transition in demand response markets is being driven by a few key trends.

- **Needs at the grid edge:** DER growth and constraints along the electric system are opening up opportunities for demand response to play a greater role along the grid edge (see Demand Response at the Distribution Level).
- **Consumer products entering the power space:** Newer demand response technologies (e.g., smart thermostats) are enabling easier deployment for certain demand response programs (see Smart Thermostat Programs).
- **Integration**: New platforms and programs are combining DR with other DERs. Examples include deploying energy storage for demand response applications, and using demand response to buffer renewable generation variability along the grid (see Advanced Demand Response Applications).

The emerging trend is toward convergence of DR and DER. In other words, DR is defined as a DER that is available to control the operability, reliability, and resiliency of grid operations. At the same time, other DERs—such as energy storage, electric vehicles, and distributed generation—can be used as a form of demand response (i.e., flexible load), depending on their application and ability to respond to market conditions.

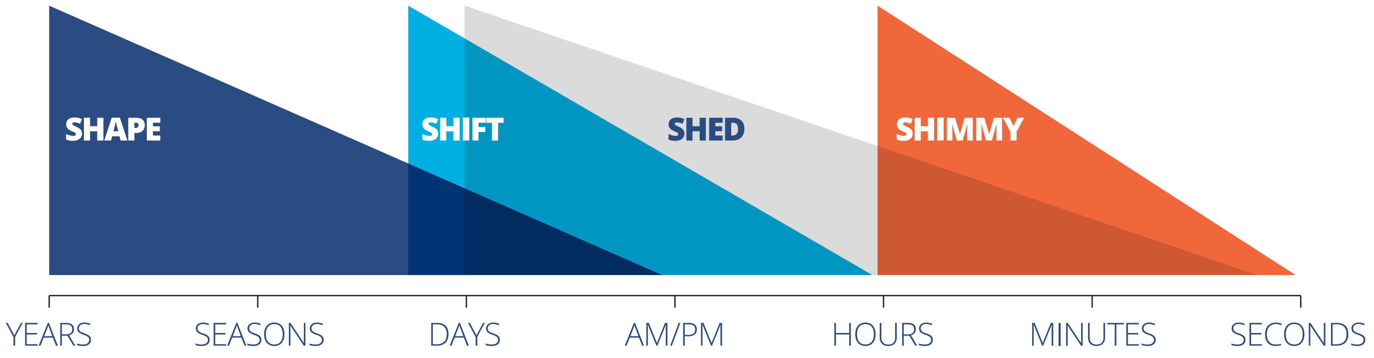
DEMAND RESPONSE CAPABILITIES

The convergence of demand response and DERs is leading DR practitioners to re-think frameworks understanding the existing and potential capabilities for these technologies and associated programs. To better understand how existing and emerging programs and technologies fit within the context of demand response, we look to a recent conceptual framework California has developed, grouping demand response into four categories:

- **Shape:** Reshaping customer load profiles over a longer period of time through time-varying rates, energy efficiency (EE), and behavioral programs.
- **Shift:** Movement of energy demand from high-demand times to periods of surplus generation. Examples include energy storage or managed EV charging.
- **Shed:** Traditional forms of DR that can help reduce load during peak capacity events. Examples include AC switch programs.
- **Shimmy:** Dynamically adjust load within shorter time frames (i.e., minutes to seconds) in response to grid disturbances and short-run ramps. Examples include grid-interactive water heaters used for ancillary services or frequency regulation.

The potential capabilities of these DR categories are laid out in Figure 4.

FIGURE 4: DEMAND RESPONSE CAPABILITIES



INCENTIVIZE EE AND BEHAVIOR CHANGE

MITIGATE RAMPS AND CAPTURE SURPLUS RENEWABLES

MANAGE CONTINGENCY EVENTS AND COARSE NET LOAD FOLLOWING

FAST DR TO SMOOTH NET LOAD AND SUPPORT FREQUENCY

SERVICE TYPE	ANCILLARY SERVICES MARKET	ENERGY MARKET	CAPACITY AND RESOURCE ADEQUACY PAYMENTS	FLEXIBLE (RAMPING) CAPACITY PAYMENTS	REVERSE DR (FUTURE)
SHED		■	■		
SHIFT	*	*	*	*	*
SHIMMY	■				

* Denotes a market where participation may be possible in the future, but due to uncertainty in the expected prices and markets not calculated in this study.

Source: Southern California Edison, PLMA 35th Conference, 2017.[5]

5 Mark Martinez with Southern California Edison, Emerging Technologies for Demand Response (DR)—Shape, Shift, Shed, and Shimmy, 2017, www.peakload.org/resource/resmgr/35th_conf/7MartinezSclafaniLaneFlander.pdf.

SEPA SURVEY METHODOLOGY

SEPA conducted its annual Utility Market Survey between January and March 2017 using an online survey platform. As noted above, an expanded section of the survey asked participating utilities for data on their demand response programs as of December 31, 2016.

SEPA encouraged participation through marketing efforts and direct outreach to key utility contacts, as well as through partner organizations' listservs and newsletters. SEPA received DR data from 104 utilities across the U.S. Utilities with service territories in multiple states reported data from each state separately, so that in total, SEPA received 122 sets of data on demand response.

Survey data was categorized into two main customer segments and respective DR programs: (1) **mass market** and (2) **medium to large customers**.

Mass market includes DR programs offered to residential and small business customers.

- **AC switch**—A program allowing a grid operator to shed air conditioning load by using a control switch that can remotely interrupt or cycle AC compressors.
- **Thermostat**—A program that uses smart thermostats to cycle air conditioners or home heating on and off or to adjust the temperature setting during different times of the day.
- **Water heater**—A program that restricts customers' hot water heaters from running for a set time during the day. Water heater programs may also incorporate other DR strategies, such as creating and storing hot water by shifting load from on-peak to off-peak periods.
- **Behavioral**—Programs that may not have direct financial incentives for participation but may be tied to a dynamic pricing program. Examples of programs falling into this category include asking customers to reduce consumption through email, texts, social media, or other lines of communication during a system peak event.
- **Other**—Programs that do not fall under any of the above category definitions. An example could be an electric vehicle managed charging program.

The medium to large customer market segment represents DR programs or agreements offered to medium to large commercial and industrial customers or bundled, smaller energy consumers acting as a single entity (e.g., third-party aggregators).

- **Fully automated**—A program in which a utility can remotely, automatically reduce a customer's load during a demand response event.
- **Automated or customer-initiated**—A program that allows a utility to send a signal notifying its customers of a demand response event and asking them to reduce their load by a specified amount over a set period of time. Customers may allow their load to be reduced or take actions internally to reduce their demand to the required level.
- **Other—**Programs for medium to large customers that do not fall under any of the above defined categories (e.g., irrigation pumps).

Results in each of these market segments are reported in terms of megawatts (MW) of enrolled and dispatched capacity[6]:

- **Enrolled capacity:** Total potential DR capacity available to utilities for dispatch during a DR event, based on total enrollment in one or more DR programs.
- **Dispatched capacity:** The actual DR capacity reduction that is dispatched by a utility during a DR event.

Utility Demand Response Capacity

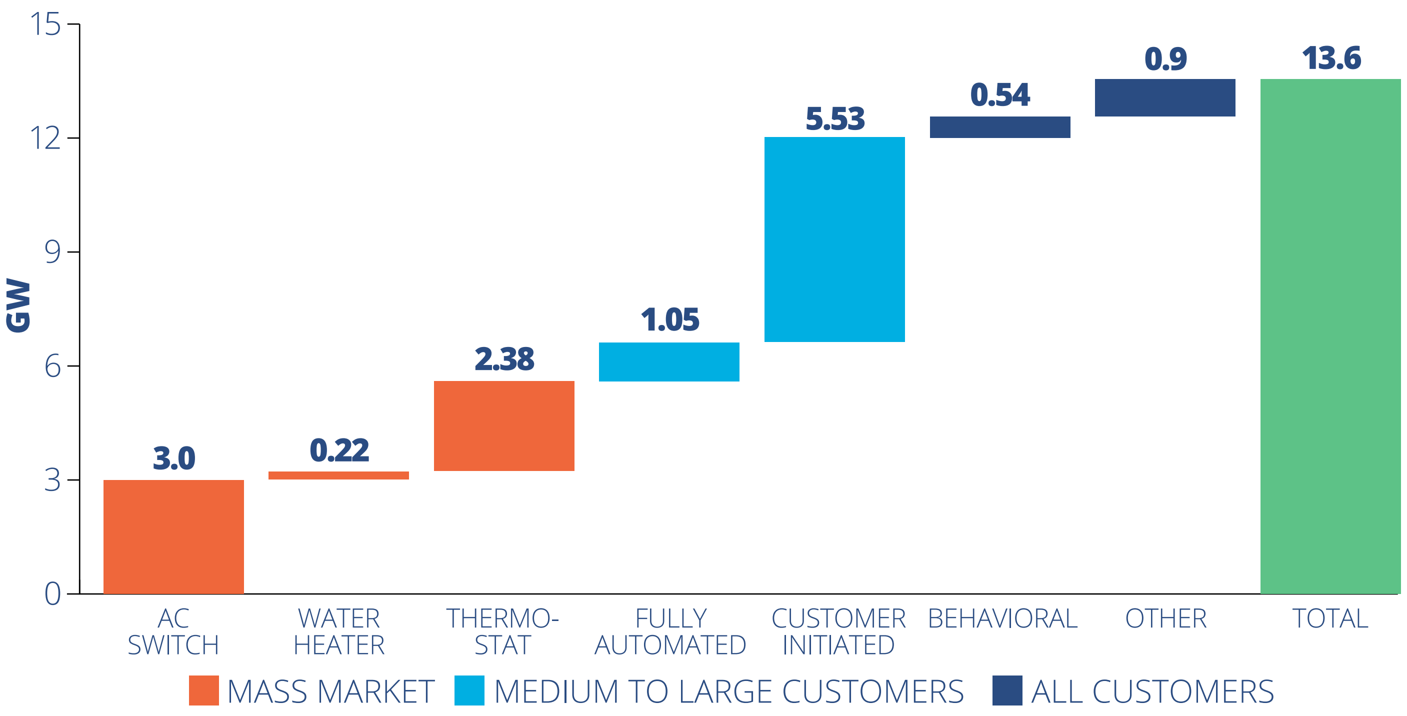
Utilities responding to the demand response section of SEPA's Utility Market Survey reported significant amounts of dispatchable demand response across both the mass market and medium to large customer classes as of Dec. 31, 2016:

- **Enrolled capacity: 13,629 MW**
- **Dispatched capacity: 10,696 MW**, or 78% of enrolled capacity

MASS MARKET DEMAND RESPONSE ACTIVITY

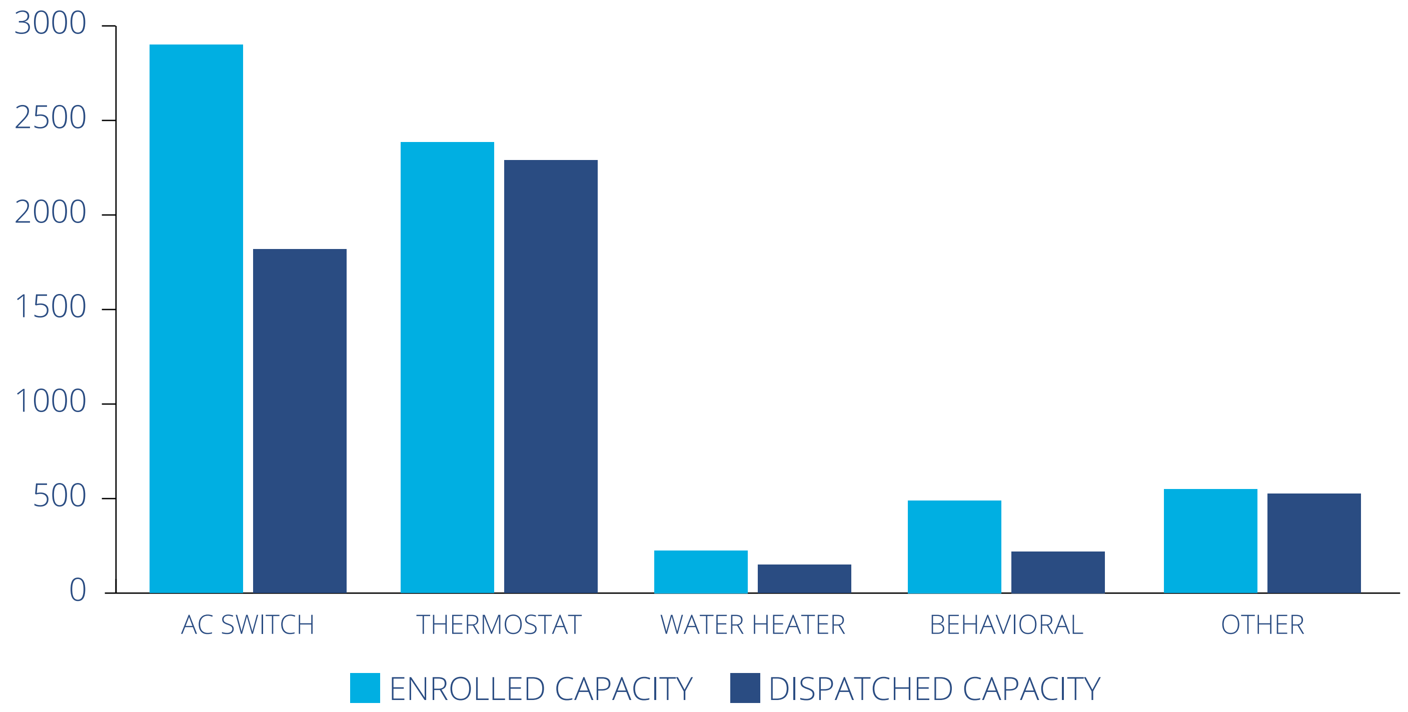
The mass market represented **49% of total enrolled DR capacity** in SEPA's survey and **47% of total dispatched DR**. Approximately 5.7 million residential and small business customers are enrolled in DR programs within this market segment. In the mass market, traditional forms of DR (i.e., AC switches, water heaters) are still deployed by utilities.

FIGURE 5: TOTAL 2016 ENROLLED DEMAND RESPONSE (MW)



Source: Smart Electric Power Alliance, 2017. Data reported in SEPA's DR Survey—results are a sampling of 104 utilities.

FIGURE 6: MASS MARKET REPORTED CAPACITY (MW)



Source: Smart Electric Power Alliance, 2017.

AC SWITCH PROGRAMS

Utilities with **AC switch programs** reported a total enrolled capacity of 3,000 MW and a dispatched capacity of 1,823 MW.

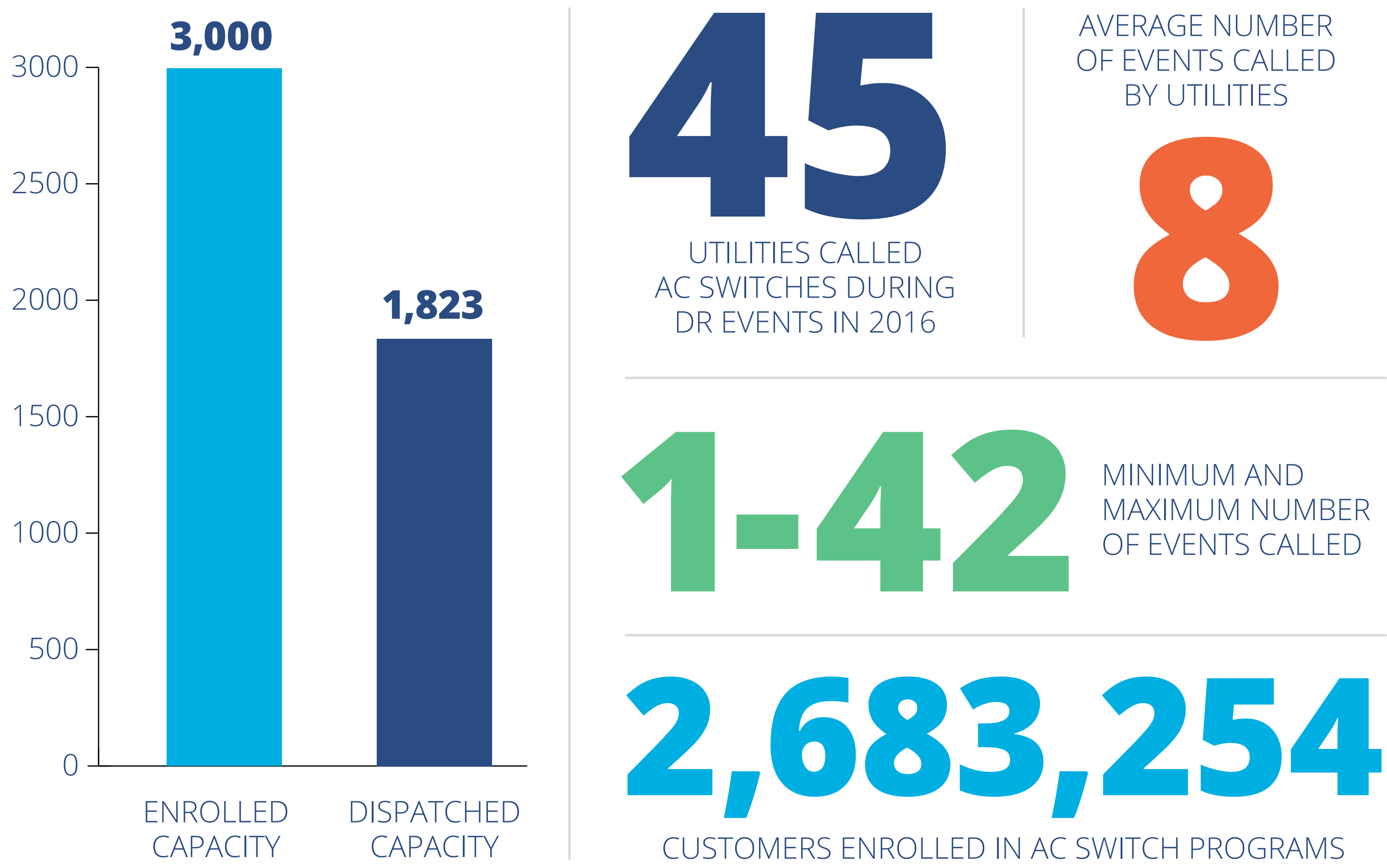
- The 39% difference between enrolled and dispatched capacity seen here is far higher than for other DR programs. This gap indicates a substantial portion of AC switch technology was either not called upon during the year or connected improperly for receiving communication signals from utilities during an event.

Key Trends:

Utilities (e.g., DTE, Duke Energy) are beginning to shift from traditional one-way control switches to two-way communications technologies.

- Utilities consider many one-way switch technologies increasingly unreliable and unable to provide them with the desired level of visibility and information (e.g., status during events). Additionally, both utilities and telecom providers increasingly see one-way paging technologies as obsolete, leading to challenges in signaling older equipment.

FIGURE 7: AC SWITCH REPORTED CAPACITY[7]



Source: Smart Electric Power Alliance, 2017.

7 Utility respondents listed **other** forms of demand response technology in the mass market to reduce capacity, such as pool pumps and dual fuel. The total enrolled capacity reduction reported for other forms of DR was 596 MW and a dispatched capacity of 555 MW.

WATER HEATER PROGRAMS

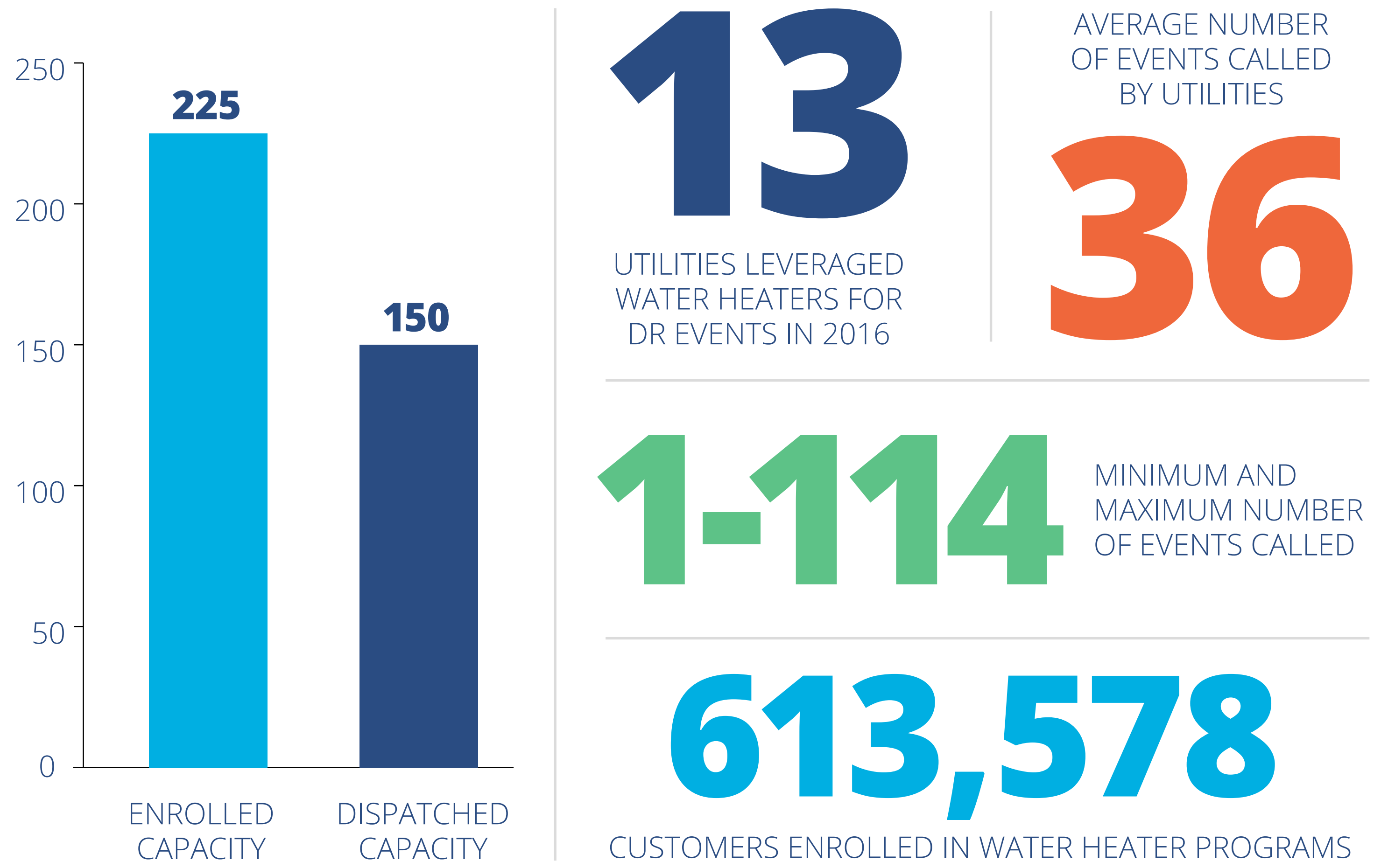
Water heaters are one of the smallest categories of reported DR. They represent a total enrolled capacity of 225 MW and a dispatched capacity reduction of 150 MW.

At the same time, because water heaters are considered non-disruptive to customers, they are called upon more frequently than other devices, as indicated by the high average number of events.

Key Trends:

A number of utilities (e.g., Green Mountain Power[8]) are shifting away from traditional water heaters with one-way controls to faster-responding, grid-interactive water heaters that use two-way communications and can provide ancillary services.

FIGURE 8: WATER HEATER REPORTED CAPACITY



Source: Smart Electric Power Alliance, 2017.

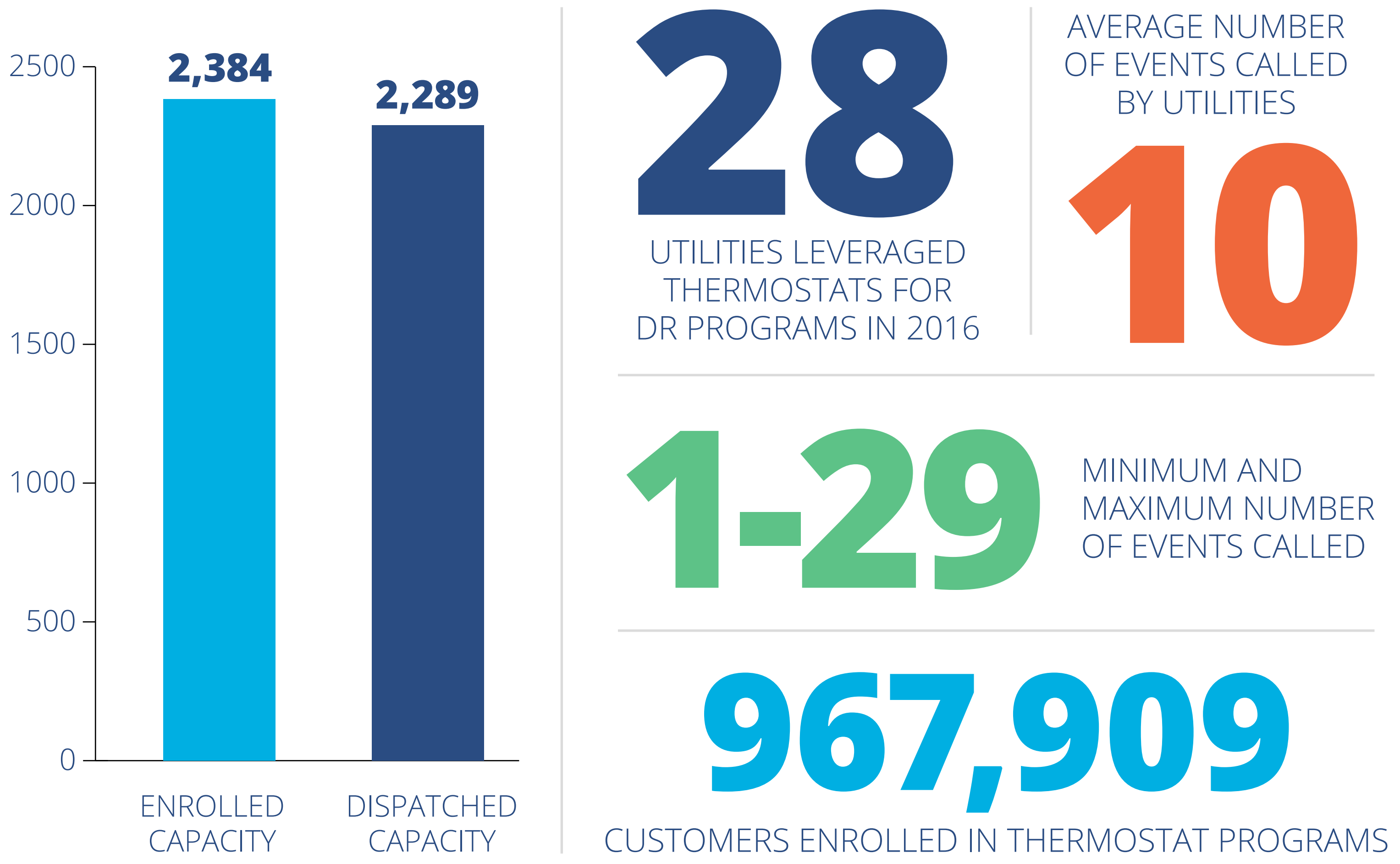
8 http://www.greenmountainpower.com/press/green-mountain-power-launches-smart-water-heater-program-help-customers-save-money/

THERMOSTAT PROGRAMS

Utilities are continuing to adopt **smart thermostat programs**. SEPA survey participants reported a total enrolled capacity of 2,384 MW and a dispatched capacity reduction of 2,289 MW (96% of enrolled capacity) for 2016.

- The small difference between enrolled and dispatched capacity could reflect the high reliability of two-way communicating smart thermostats, changes in rates encouraging customer participation, and utility efforts to provide "set it and forget it" options to customers.

FIGURE 9: THERMOSTAT REPORTED CAPACITY



Source: Smart Electric Power Alliance, 2017.

8 http://www.greenmountainpower.com/press/green-mountain-power-launches-smart-water-heater-program-help-customers-save-money/

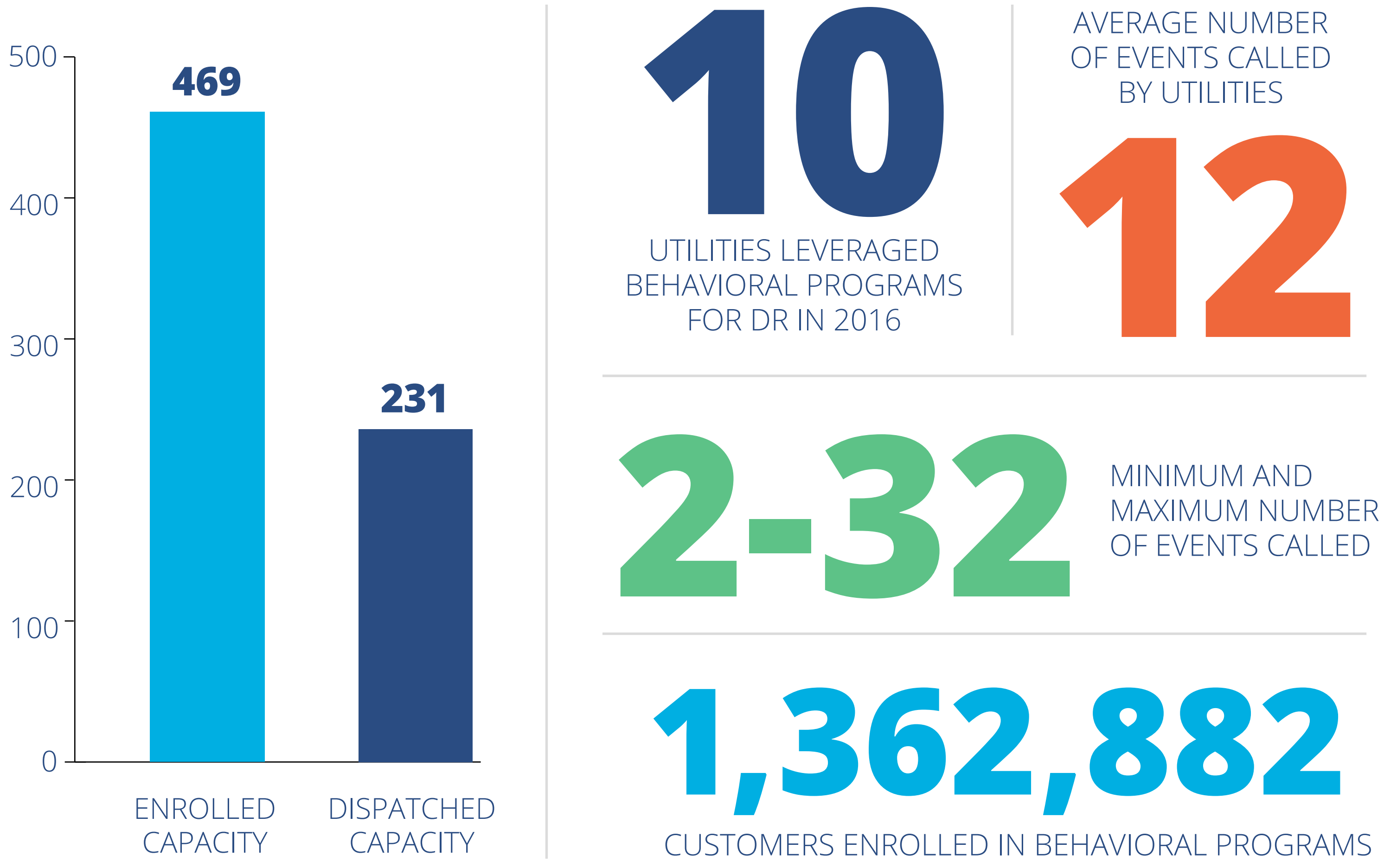
BEHAVIORAL PROGRAMS

Behavioral programs—such as asking customers to reduce consumption via email, text, and social media—reported a total enrolled capacity of 469 MW and a dispatched capacity of 231 MW in the mass market.

Key Trends:

- Behavioral programs are still fairly new and are undergoing pilot studies across the U.S. (e.g., Portland General Electric, Baltimore Gas and Electric—see Behavioral Demand Response for more details).
- Behavioral programs are more popular in the mass market segment. The medium to large customer market segment reported a total enrolled capacity of 69 MW (that is 2% of mass market reported enrolled behavioral DR) and a dispatched capacity reduction of 23 MW.

FIGURE 10: BEHAVIORAL PROGRAMS REPORTED CAPACITY



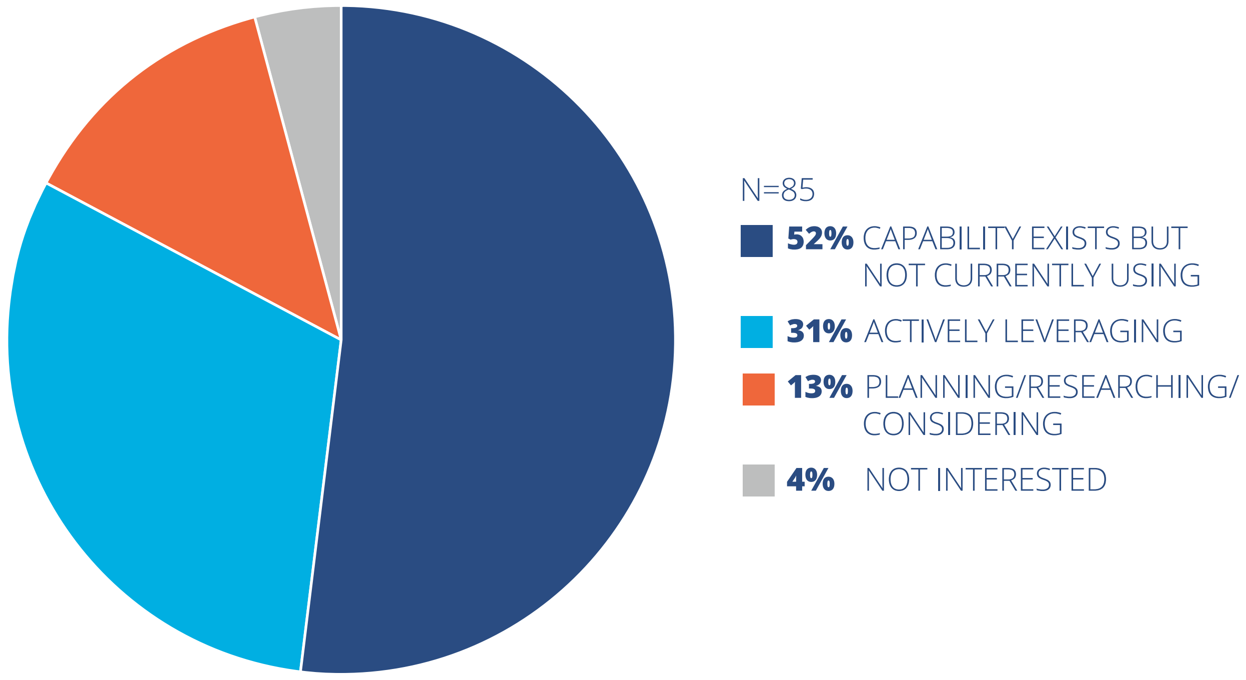
Source: Smart Electric Power Alliance, 2017.

ADVANCED METERING INFRASTRUCTURE AND DEMAND RESPONSE

Advanced metering infrastructure (AMI) combines smart meters, communication networks, and data management systems that can all be used to establish two-way communication between utilities and customers. AMI enables utilities to obtain and use real-time data, offer dynamic pricing, and provide price signals back to customers. The ability to provide real-time data and price signals to customers through AMI has paved the way for smart thermostat programs and other advanced demand response programs.

As seen in Figure 11, almost one-third of utility participants responded that they are actively using AMI technologies in their DR programs. The remaining 65% were either considering implementing AMI or had access to the resources, but were not currently using them. Only 4% of utilities were not interested in using AMI capabilities.

FIGURE 11: UTILITIES USING ADVANCED METERING INFRASTRUCTURE DATA FOR DEMAND RESPONSE PROGRAMS



Source: Smart Electric Power Alliance, 2017.

MEDIUM TO LARGE CUSTOMER DEMAND RESPONSE ACTIVITY

Based on SEPA's survey, DR activity in the medium to large customer market segment is strong and growing.

- In 2016, medium to large customers represented almost half of total reported enrolled and dispatched capacity.
- 130,191 medium to large customers were enrolled in demand response programs.

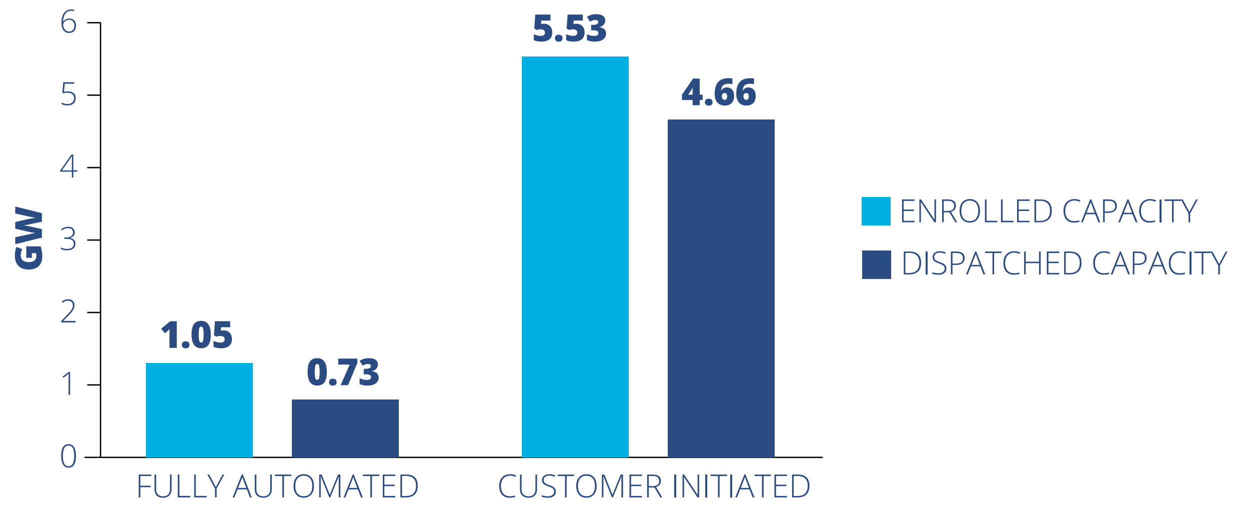
Fully automated DR had a total enrolled capacity of 1,048 MW and a dispatched capacity of 734 MW (70% of total enrolled capacity).

- The number of reported customers enrolled in fully automated programs (17,969) was nearly one-fifth of those enrolled in customer-initiated programs.

Customer-initiated DR had a total enrolled capacity of 5,533 MW and a dispatched capacity of 4,655 MW.

- Utilities reported 97,755 customers were enrolled in customer-initiated programs.
- Customers have a number of reasons for preferring some level of manual control over the operations in their facilities. For example, some commercial-industrial processes cannot be automated, and health and safety considerations may prevent heavy machinery from being automated.

FIGURE 12: MEDIUM TO LARGE CUSTOMER REPORTED CAPACITY (MW)[9]



Source: Smart Electric Power Alliance, 2017.

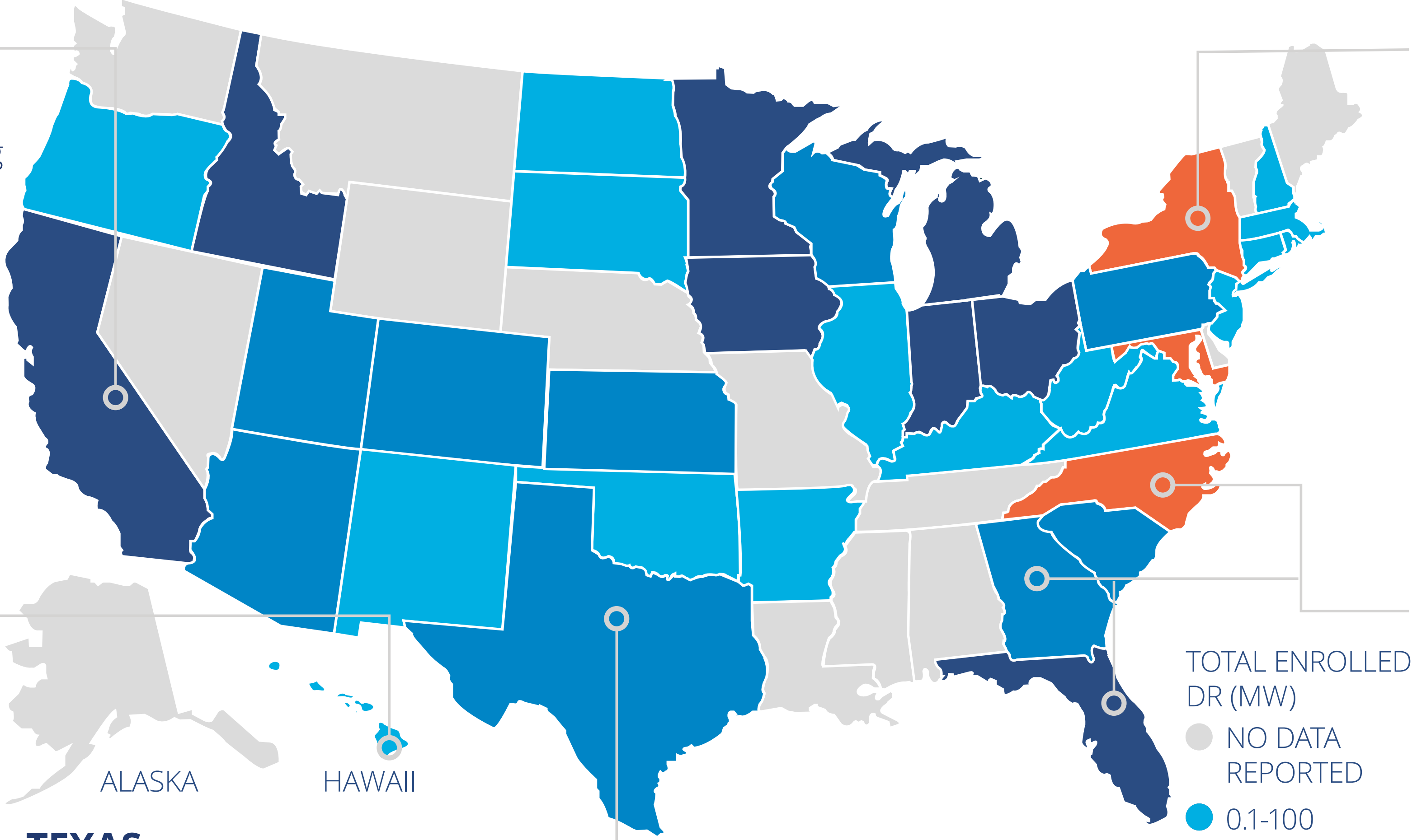
TABLE 1: MEDIUM TO LARGE CUSTOMER DEMAND RESPONSE EVENTS CALLED IN 2016

	FULLY AUTOMATED	CUSTOMER INITIATED
NUMBER OF UTILITIES CALLING EVENTS	15	33
AVERAGE NUMBER OF EVENTS CALLED	20.6	8.7
MINIMUM AND MAXIMUM NUMBER OF EVENTS CALLED	3-95	1-95

Source: Smart Electric Power Alliance, 2017.

9 **Other** forms of medium to large demand response programs reported a total enrolled capacity reduction of 335 MW and a dispatched capacity reduction of 266 MW. These programs include irrigation pumps, conservation voltage reduction (CVR) at feeder levels, pilot programs for C&I customers, and transmission/distribution losses through spinning reserves.

Regional Utility Demand Response Snapshot



CALIFORNIA

Investor-owned (IOUs) and municipal utilities in California are playing a large role in running DR programs for reliability and economic purposes. The California Public Utilities Commission (CPUC) imposed requirements for IOUs to establish a firm budget amount of third-party DR to participate in the state's Demand Response Auction Mechanism (DRAM) program and bid capacity into the California Independent System Operator (CAISO) day-ahead markets.

HAWAII

Hawaii's heavy adoption of DERs is leading utilities to examine ways to best leverage DR for renewable energy integration. Hawaiian Electric is consolidating DR programs into an integrated portfolio, and incorporating third-party providers in its response to an initial Integrated Demand Response Portfolio Plan Order put out in 2014.

TEXAS

Due to special rules attractive for DR, the competitive retail electric supply markets in Texas provide opportunities for electricity retailers to offer DR alongside distribution utilities. A number of utilities (e.g., CPS Energy, Austin Energy, and CenterPoint Energy) are taking the lead on Bring Your Own Thermostat (BYOT) programs.

NEW YORK

In New York, IOUs have a full suite of DR programs for mass market and medium and large customers as part of the New York Public Service Commission's Reforming the Energy Vision proceeding. IOUs (e.g., Consolidated Edison, Orange and Rockland) are offering customers payments through Smart Usage Rewards programs to reduce electricity use during reliability events and to provide load relief on hot days.

SOUTHEAST

Utilities in the Southeast are vertically integrated and operate within the traditional regulated utility model. Utilities in these regions continue to run their own DR programs. Some large utilities are taking the lead in adopting new enabling DR technologies (e.g., Duke Energy, Southern Company, and Florida Power & Light).

Source: Smart Electric Power Alliance, 2017.

Demand Response in Wholesale Power Markets

Demand response is allowed to participate in wholesale power markets across North America to varying degrees. The most common types of DR participation are through capacity markets and emergency-based programs for areas without capacity markets. These types of markets require annual or seasonal bidding, and generally dispatch DR a few times per year during peak periods.

DR participation in the day-ahead and real-time energy markets is usually most appealing to large commercial and industrial customers that have the capability to respond to price signals on a regular basis. Participation in ancillary services markets, such as spinning reserves or frequency regulation, has historically been limited to industrial customers with automated controls. More recently, in PJM residential customers have participated through aggregated loads, such as water heaters.

TABLE 2: DEMAND RESPONSE PARTICIPATION IN THE WHOLESALE MARKETS

	EMERGENCY/ CAPACITY	ENERGY/PRICE RESPONSE	SPINNING RESERVES	FREQUENCY REGULATION
CALIFORNIA (CAISO AND UTILITIES)	■ (Utility not ISO)	■	■	
ERCOT	■	■	■	■
NYISO	■	■	■	■
PJM	■	■	■	■
ISO-NE	■	■	2018	■

Source: Smart Electric Power Alliance, Navigant, 2017.

Smart Electric Power Alliance

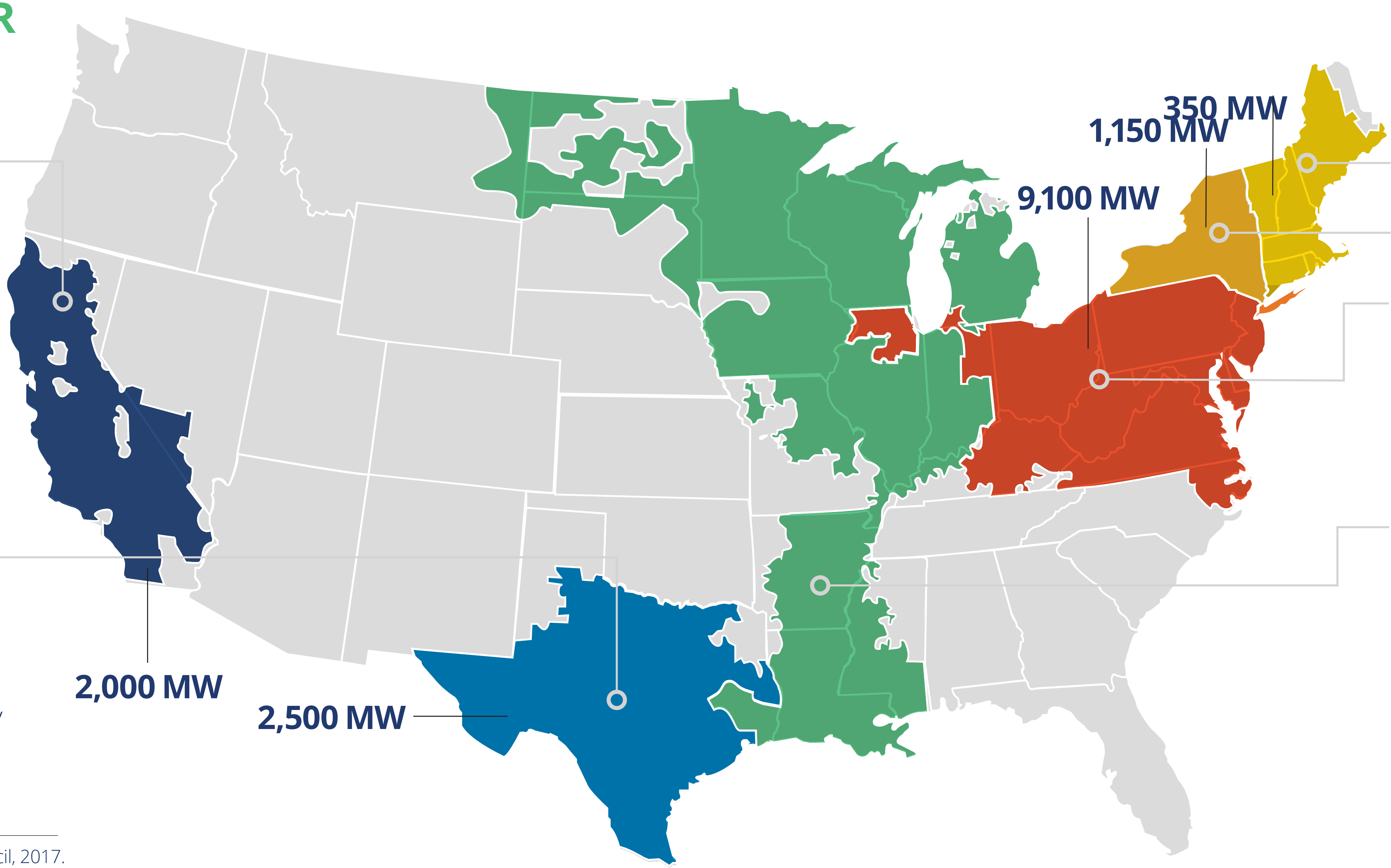
U.S. DEMAND RESPONSE CAPACITY BY REGIONAL TRANSMISSION ORGANIZATION AND INDEPENDENT SYSTEM OPERATOR

CAISO

Utilities are the main players in demand response in California. However, DR is becoming more integrated with California ISO (CAISO) as market rules become more attractive for DR and the state's Demand Response Auction Mechanism (DRAM) continues to expand.

ERCOT

Capacity-like programs in Electric Reliability Council of Texas (ERCOT) as well as energy, spinning reserves, and frequency regulation.



ISO-NE

NYISO

PJM

Capacity, energy, spinning reserves, and frequency regulation markets in PJM Interconnection, New York Independent System Operator (NYISO), and ISO New England (ISO-NE).

MISO

Capacity markets exist in the Midcontinent Independent System Operator (MISO), but annual capacity prices have been low and many states prohibit aggregators, limiting DR participation primarily to the utilities.

Source: DR Capacity, Navigant & ISO/RTO Council, 2017.

California MW numbers are based on IOU reported numbers to the California PUC and removes capacity accounting for time-of-use (TOU) programs. CAISO numbers also include data from SMUD.

MISO DR capacity is not included in this chart. While MISO does report data, because the ISO rarely dispatches DR in this area and DR is predominantly dispatched through utilities, Navigant determined not to include these numbers in the image above.

BARRIERS TO DEMAND RESPONSE PARTICIPATION IN WHOLESALE MARKETS

- DR markets in the PJM, NYISO, and ISO-NE service territories have matured and plateaued. DR participation rules have become stricter as the grid operators have attempted to make the rules more comparable between DR and generators. For example, the PJM market has recently revised its rules to effectively limit seasonal peaking resources in its capacity market.
- Emergency and capacity programs in ERCOT have set budgets that limit growth potential.[10]
- Lack of coordination between third-party and utility DR programs, dynamic pricing, and utility operating practices hinder the potential for value stacking in both types of opportunities.
- Legacy rules, systems, and processes in wholesale markets are based mostly on centralized power generation and do not readily support aggregations of small resources, especially those provided by third parties.
- Wholesale prices have recently been low and stable due to low natural gas prices and increased penetration of renewable generation resources, hindering traditional DR growth.
- There has been significant penetration into the large commercial and industrial market, leaving smaller, harder-to-reach commercial and industrial customers to be acquired.
- In the past, backup diesel generation constituted up to 20% of DR capacity in some markets. New state and federal environmental rules limiting diesel generation eligibility have decreased such capacity and required costly retrofits to maintain participation.

10 Markets like PJM, ISO-NE, and NYISO do not have set budgets for DR—allowing DR to participate like any other resource. ERCOT has set aside programs with limited budgets so DR cannot have unlimited growth.

Regulatory Overview

FEDERAL UPDATE

- **FERC**'s intent when it issued **Order 745** in 2011 was to have DR paid the same price as generators in the day-ahead and real-time energy markets. FERC's order was challenged in the U.S. Court of Appeals in a case that argued DR was a retail product and as such beyond FERC's jurisdiction. The case eventually went to the U.S. Supreme Court, which ruled in 2016 that DR compensation in the wholesale energy markets does fall under FERC's jurisdiction, essentially leaving the DR market as it was before the legal challenge.
- On November 7, 2016, **FERC** published a **Notice of Proposed Rulemaking** (NOPR) that would require RTOs and ISOs to facilitate energy storage and DER aggregation in the competitive wholesale markets. If finalized as proposed, the market potential for demand response and other DERs would expand.
- In 2012, the **U.S. Environmental Protection Agency** passed regulations to limit the number of hours that diesel backup generators can operate as DR. This ruling was challenged in federal courts, where it was upheld in May 2016. Diesel-powered generators historically constituted 10% to 20% of total DR capacity, depending on the region, and the affected markets saw a 15% to 20% decrease from 2015 to 2016 across the U.S.[11]

STATE AND REGIONAL UPDATE

- As part of the **Reforming the Energy Vision (REV) proceedings**, New York IOUs now offer residential and commercial and industrial (C&I) DR programs, modeled on Consolidated Edison's existing programs.
- **Massachusetts IOUs** are undertaking residential and C&I DR pilot programs as part of their three-year energy efficiency plans. The Massachusetts Department of Energy Resources also awarded almost $5 million in grants to nine utility-backed and third party-managed peak demand reduction projects.[12]
- In September 2017, the **Michigan Public Service Commission** completed a demand response potential study and market assessment for the state.[13]

11 Navigant Research, "Market Data: Demand Response, 2016", https://www.navigantresearch.com/research/market-data-demand-response.

12 http://www.mass.gov/eea/pr-2017/4-6-million-grants-for-peak-demand-reduction-projects.html

13 http://www.michigan.gov/mpsc/0,4639,7-159-80741_80743-406250--,00.html

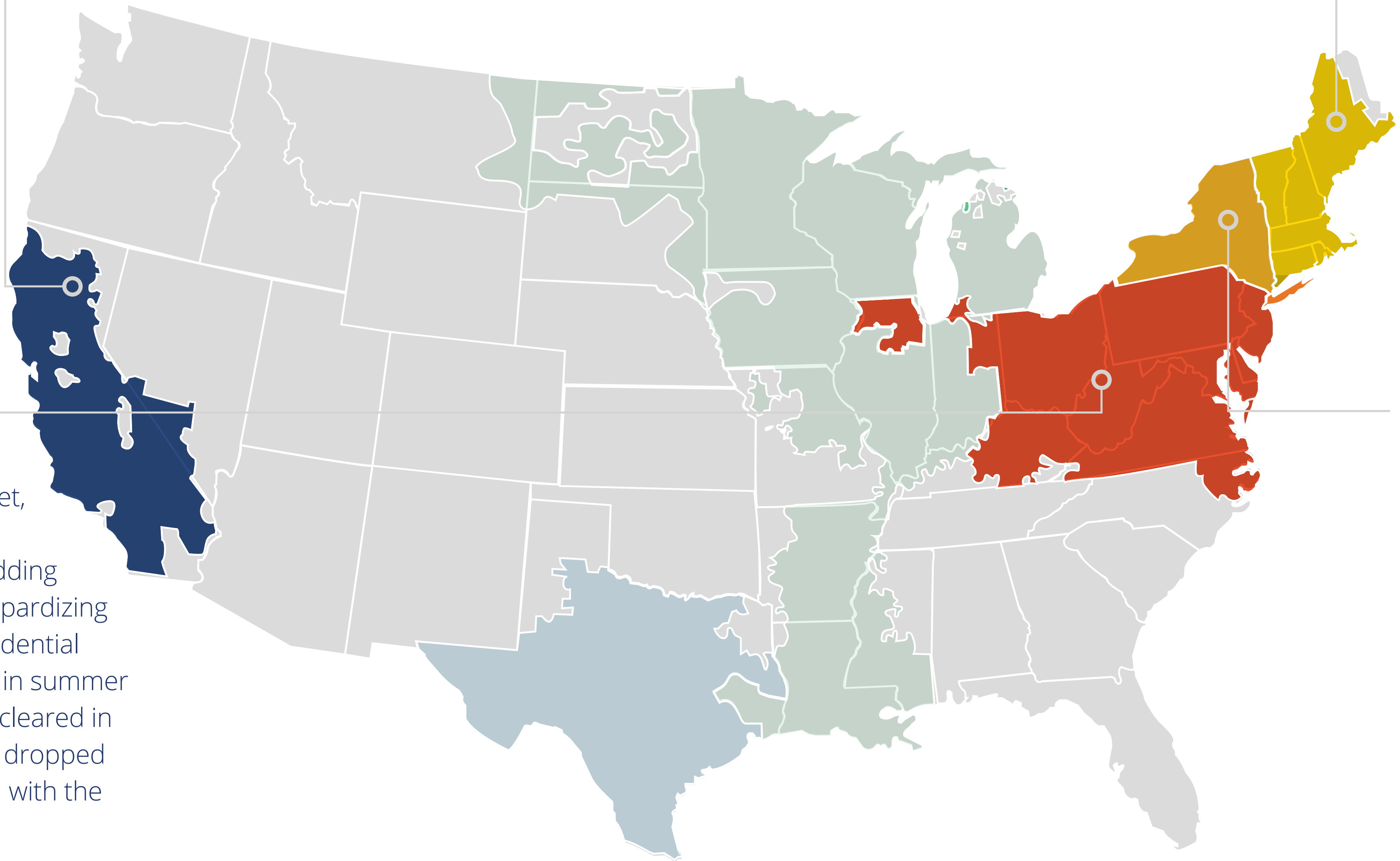
WHOLESALE POWER MARKET REGULATORY UPDATE

CAISO

The California Public Utilities Commission (CPUC) is looking to integrate demand response into the CAISO market through the DRAM program, which allows IOUs to procure DR competitively. The 2018-19 auction procured 200 MW, and the state's goal is to expand the DRAM to 1,000 MW by 2020

PJM

PJM has instituted capacity performance in its capacity market, a rule that requires year-round performance for all resources bidding into the market. This action is jeopardizing most seasonal DR (especially residential HVAC load that only provides DR in summer months). The amount of DR that cleared in the most recent capacity auction dropped by approximately 20% compared with the prior year.



ISO-NE

ISO-NE is implementing a requirement for DR (and all other resources including generators) in 2018 that will significantly penalize capacity resources that do not provide energy or reserves when capacity is scarce. This change could increase operational resource needs and risk for DR aggregators and customers.

NYISO

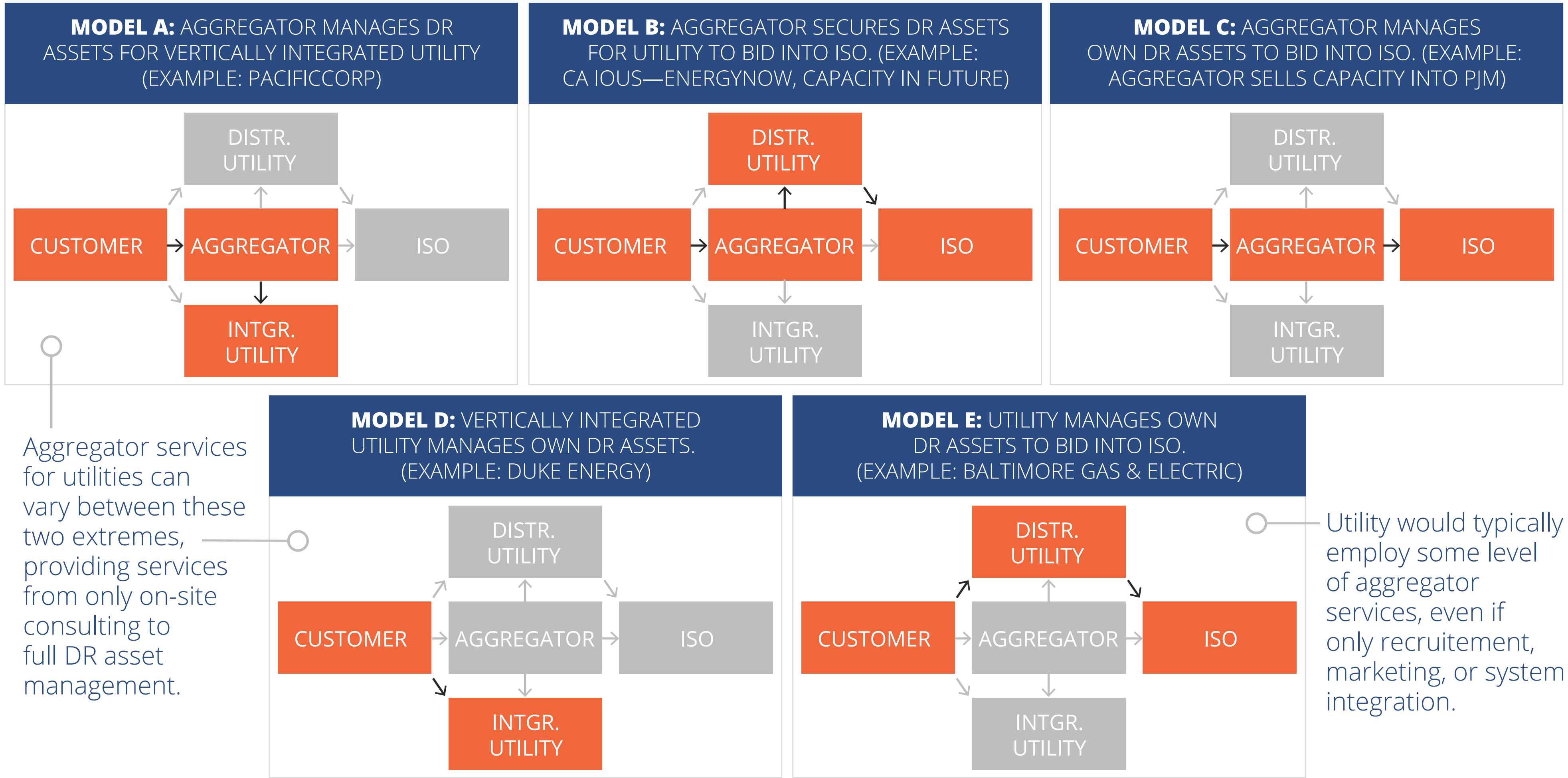
NYISO is undertaking a DER integration project to design market rules for all types of DERs to participate in its markets. This process could result in the existing rules for DR becoming stricter in terms of metering, communication, telemetry, and baselines, potentially leading to higher barriers to participation.

Source: Smart Electric Power Alliance, Navigant, 2017.

Operational Models

Demand response efforts vary widely across the U.S., in part due to differences in regulatory contexts, utility initiatives, and needs of the grid. The varying roles of utilities, aggregators, and wholesale power markets are described in Figure 13. In some cases, customers work directly with the utility, while in other cases they work with aggregators and the utility has no involvement.

FIGURE 13: ROLE OF UTILITIES, AGGREGATORS, AND WHOLESALE POWER MARKETS

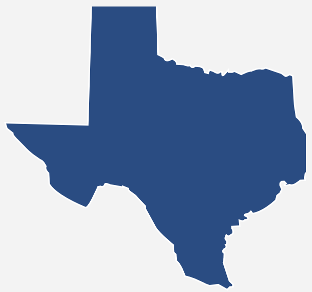
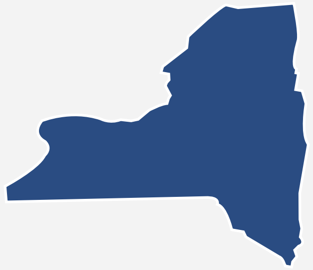
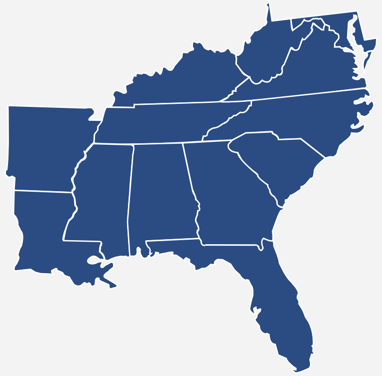


Source: Navigant, 2017.[14]

14 Navigant Research, 'Market Data: Demand Response, 2016', 2016, https://www.navigantresearch.com/research/market-data-demand-response.

Table 3 illustrates regional examples of these variations. Some states have one primary model, while multiple models coexist in other states.

TABLE 3: REGIONAL EXAMPLES OF OPERATING MODELS

CALIFORNIA 	IOUs and municipal utilities run mass market DR programs with third-party vendors (Model A). They have a mix of medium to large customer DR programs, some offering direct customer participation (Model D) and others working through aggregators (Model A). They have recently initiated the Demand Response Auction Mechanism (DRAM) to facilitate more participation in the CAISO market (Model B). Currently, there is limited direct participation in the CAISO market through aggregators (Model C).	**TEXAS** 	The unbundled utilities run mass market DR programs with third-party vendors (Model A). Municipal utilities like CPS (San Antonio) and Austin Energy have C&I DR programs with single turnkey vendors and residential DR programs with third-party providers (Model A). ERCOT also offers market opportunities for aggregators and large customers to provide DR without the utility (Model C).
NEW YORK 	IOUs run mass market DR programs with third party vendors (Model A). Medium to large customer DR programs operate as open programs where any aggregator can register and participate to enroll customers (Model A). NYISO also offers market opportunities for aggregators and large customers to participate without the utility as DR resources (Model C).	**SOUTHEAST** 	Southeast IOUs generally have direct C&I DR programs without aggregator involvement (Model D). For residential programs, they use third-party vendors for some aspects of program implementation, but not full turnkey (Model A).

Source: Navigant and Smart Electric Power Alliance, 2017.

Smart Electric Power Alliance

Smart Thermostat Programs

Over the past decade, smart thermostats have developed and grown in popularity with consumers and utilities. As of September 2017, there are over two million smart thermostats installed in the United States. Navigant forecasts that Bring Your Own Thermostat (BYOT) DR program participants will reach six million by 2024.[15]

DRIVERS FOR NEW SMART THERMOSTAT PROGRAMS

- Better positions utilities in an evolving technology landscape (e.g., smart home, internet of things)
- Increases customer engagement and choice
- Provides visibility into status of customer devices (e.g. know when devices are active)
- Creates opportunity to streamline operations (e.g. third-party providers offer these services)
- Reduces costs for participants and utilities (many thermostats are self-installed saving installation costs; costs can be shared between EE and DR budgets)

TABLE 4: DEMAND RESPONSE AIR CONDITIONING AND THERMOSTAT TECHNOLOGY CHARACTERISTICS

	1-WAY CONTROL SWITCH	2-WAY CONTROL SWITCH	UTILITY/DIRECT INSTALL THERMOSTAT	BRING-YOUR-OWN-THERMOSTAT (BYOT)
MARKET STATUS	**Declining:** Programs replacing legacy installs, or utilities who own paging network or want lowest cost switch option	**Steady Growth:** Majority of operating installations. Given option, ~50% of customers choose switch over thermostat	**Growth:** Popular with utilities who need more load reduction than the BYOT-only market can provide	**Accelerated Growth:** Small part of operating market but some new or expanded programs are offering BYOT exclusively
INSTALLED COSTS	\$125 - \$175 paid by program or vendor	\$150 - \$200 (wi-fi or cellular) paid by program or vendor	\$225 - \$300 paid by program or vendor	\$150-250, about \$100-200 paid by customer
TECHNOLOGIES	AC, Heat Pump, Heat Strips, Water Heating, or Pool Pump	AC, Heat Pump, Heat Strips, Water Heating, Pool Pump	AC, Heat Pump	AC, Heat Pump
EVENT OPT OUT RATES	~1% (call or use website)	~2% (call or use website)	~2% (call, use website or onsite option)	~20% (use thermostat)
TEMPERATURE OPTIMIZATION	N/A	N/A	Precooling option + optimization from temp data	Precooling option + optimization from temp data
MEASUREMENT & VERIFICATION	Statistical sampling from AMI or metered subset	AMI or population runtimes	AMI or population runtimes	AMI or population runtimes

Source: Smart Electric Power Alliance, 2017[16]

15 Navigant Research, "Bring Your Own Thermostat Demand Response", 2016, https://www.navigantresearch.com/research/bring-your-own-thermostat-demand-response.

16 Consolidated Edison, "Program Performance and Cost Effectiveness of Demand Response Programs," December 1, 2015 pp 80, 103 & CPS Energy Nest Pilot Evaluation FY2015-Final, submitted by Nexant 11/21/2014 authors Greg Sidorov and Jesse Smith p2.

Smart Electric Power Alliance

SMART THERMOSTAT PROGRAM DEFINITIONS

- **Direct Install Model:** Utility manages the program process from start to finish, including the selection of thermostat devices, oversight of implementation, recruitment of customers, installation of devices, dispatch of devices, and maintains customer engagement.
- **Self Install Model:** Utility manages the program process including the selection of the thermostat devices, overseeing implementation, recruiting customers, running programs (events) and maintaining customer engagement. The utility looks to the customer to install the thermostat in their home, providing guidance and technical support as needed. Should the customer need professional installation, it can be provided on an as needed basis.
- **Bring Your Own Thermostat (BYOT) Model:** Customers are allowed to purchase their own thermostat devices from pre-selected vendors and participate in utility or electricity supplier managed demand response and/or other load curtailment programs. Utilities implementing BYOT programs today are grappling with new systems, relationship structures, and changing competencies for handling technology, distribution, and customer service, but save significantly on installation costs. Moreover, BYOT programs can recruit customers that have already purchased and installed a thermostat allowing programs to start with a larger scale.

TABLE 5: UTILITY SMART THERMOSTAT BUSINESS MODELS

	DIRECT INSTALL MODEL	SELF INSTALL MODEL	BYOT UTILITY MODEL
STEP 1	Select device/s	Select device	Determine desired device portfolio
STEP 2	Select implementation vendor	Develop implementation plan (utility or vendor delivered program)	Select DR management system (DRMS) and program coordination vendor
STEP 3	Recruit customers	Recruit customers	Market program to new and existing owners of thermostats
STEP 4	Install devices	Send devices to customers to self-install; provide self-install follow-up services	Track device enrollment
STEP 5	Run program	Run program	Run program
STEP 6	Customer service	Customer service	Coordinate customer service with device vendor
EXAMPLES OF UTILITIES	Duke, Pepco, NV Energy, Georgia Power	KCP&L	ComEd, Austin Energy, KCP&L, APS, CPS Energy, SCE, El Paso Electric

Source: Navigant, 2016 with updates by SEPA.[17]

17 Navigant Research, "Bring Your Own Thermostat Demand Response", 2016, https://www.navigantresearch.com/research/bring-your-own-thermostat-demand-response.

CUSTOMER PROGRAM HIGHLIGHTS

TABLE 6: CUSTOMER PROGRAM HIGHLIGHTS

DIRECT INSTALL MODEL	NVEnergy	**NV Energy** partnered with Ecobee to offer customers smart programmable thermostats and smart thermostat services. Equipment (e.g., thermostats, gateway devices, energy efficiency software) and services (e.g., installation) are provided free of charge to eligible customers.
SELF INSTALL	KCP&L energizing life	**KCP&L**, Nest, and CLEAResult partnered up to allow customers options to self-install (at a 98.5% success rate), pro-install by technicians at no cost, or enroll a pre-existing thermostat. DR events were called with consideration to customers' thermal profiles and preferences. KCP&L shipped thermostats to self-install participants—upon successful self-installation, customers received an additional $50 incentive.
BYOT MODEL	AUSTIN ENERGY	**Austin Energy** launched a BYOT program in 2013 allowing customers to choose from 18 pre-approved thermostat devices and enroll through a vendor portal. Customers are provided incentives and a wide range of choices, as well as a streamlined application process.
	ComEd An Exelon Company	**ComEd** teamed up with Comcast, Ecofactor, Ecobee, and Nest Labs to provide a vendor-led BYOT program with options to participate in dynamic pricing programs and direct load control (DLC) emergency DR programs. Vendors provided outreach and recruited customers.

CHALLENGES AND OPPORTUNITIES

- **Customer acceptance/reducing DR event opt-out rates:** Smart thermostat participants have an average DR event opt-out rate of 21%.[18] SEPA's survey yielded similar results, with thermostat programs stating opt-out rates ranging from 1% to 25%.
  - Program managers are finding participants frequently opting out part way through events. These participants contribute to a portion of demand reduction, but are not fully engaged.
  - Allowing customers to opt out through their device or mobile app may increase retention since customers have the choice of whether to participate on a case-by-case basis.
- **Control room buy-in:** Technology and thermostat programs are still relatively young and, due to high opt-out rates, can often be viewed with skepticism by control room operators tasked with maintaining grid reliability. As these programs mature, control room operators may become more comfortable with estimating opt-outs and forecasting load shed based on program analytics in order to rely on thermostats to help operate the grid.
- **Customer engagement:** Recruiting customers to participate in thermostat programs is a resource intensive effort; maintaining customer service through the lifetime of the program can prove challenging. Partnerships with vendors and further studies on thermostat programs will help to ensure these programs are positively viewed by customers and able to achieve desired penetration levels.
- **Interoperability of devices:** Thermostat programs are introducing a range of new devices and systems/platforms. The interoperability of these devices and systems are necessary to avoid the need for multiple platforms.

18 Cole Willis, Indianapolis Power & Light and Olivia Patterson, Opinion Dynamics, 2017, "Switches vs. Thermostats: How much does customer behavior play a role?" www.peakload.org/resource/resmgr/35th_conf/B2WillisPatterson.pdf.

Behavioral Demand Response

Behavioral demand response can be defined as changes to end-use customers' energy demands as a result of personal adjustments based on signals from utilities through a variety of communications, such as text messages, email, and phone calls. These can result in temporal or quantitative changes by the consumer.

UTILITY DRIVERS FOR BEHAVIORAL PROGRAMS

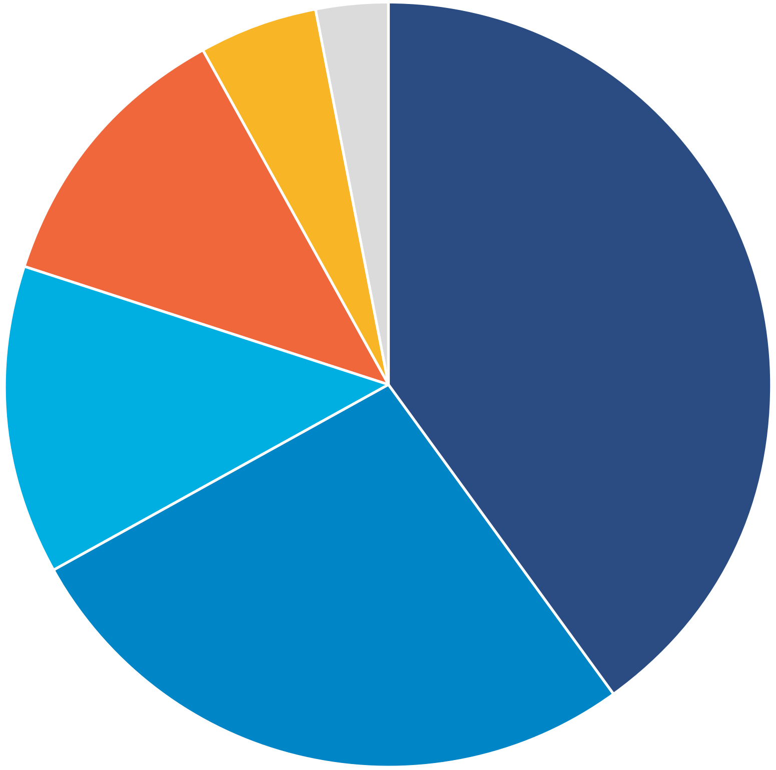
- Curb energy usage during peak hours
- Increase customer engagement
- Provide customers with possible energy and bill savings
- Reduce the cost of engaging large customer bases
- Launch relatively quickly

TABLE 7: UTILITY CUSTOMER PROGRAM INSIGHTS

Portland General Electric	**Portland General Electric** deployed and evaluated the relative effectiveness of 12 distinct behavioral demand response (BDR), time of use (TOU) pricing, and peak time rebate (PTR) test programs reaching 300,000 residential customers. During the summer and winter of 2016, PGE called 14 demand response (DR) events that achieved an average of 1.1 MW of load shed per event across all 12 programs. Reminder notifications that were delivered the day of an event, rather than 24 hours before the event, saw read messages increase by as much as 50%. This and other insights are helping PGE discover new ways to increase program participation rates.[19]
BGE	**Baltimore Gas & Electric** found success engaging customers through the utility's behavioral demand response program. Through frequent communication with customers before and after events, BG&E was able to raise response rates.

19 PLMA, 2016, "PLMA Recognizes Portland General Electric and AutoGrid with Program Pacesetter Award for Innovative Residential Dynamic Pricing and Behavioral Demand Response Project", http://www.auto-grid.com/news/4680-2.

FIGURE 14: BEHAVIORAL DEMAND RESPONSE CUSTOMER COMMUNICATION METHODS BY TYPE, 2016



Source: Smart Electric Power Alliance, 2017.

CUSTOMER COMMUNICATION

In order to reach customers about demand response opportunities, utilities use a wide range of methods of communication. As shown in the figure at left, email is the most widely used technology for alerting customers about demand response opportunities, followed by text messages, phone calls, social media, and utility apps. Some of the other methods in the 'other' category included radio broadcasts, company websites, television advertisements, and sporting events.

EXISTING CHALLENGES FOR BEHAVIORAL DEMAND RESPONSE

- **Calling on events strategically:** Customer participation has been shown to drop off after consecutive event days or when called upon frequently.[20] In order to optimize customer participation and effectiveness of BDR programs, utilities are examining ways to target high usage customers and optimal timing for calling events.
- **Retaining customers:** Customer engagement is key to ensuring customers are aware of how the program works, why the utility is calling events, and how to participate.
- **Customer communication:** Providing customers advanced notice is required (in the case of PG&E, at least 24 hours) before an event is called.

20 Wendy Brummer (PG&E), John Schellenberg (Nexant), 2017, "Evaluation of PG&E's Two year BDR study", PLMA 35th Conference, 2017.

Dynamic Pricing and Demand Response

Through dynamic pricing, the electricity industry can provide an even more accurate way to price electricity. With the proliferation of advanced meters that record interval usage data, new pricing models can be developed to help customers and utilities save money.

The **key drivers for advancing dynamic pricing** include technical, policy, and economic factors:

- **Advanced metering infrastructure (AMI):** Smart meters, or AMI, are able to provide short interval data that can help with the implementation of dynamic pricing programs and move utilities beyond traditional pricing.
- **Utility and customer costs:** Offering a dynamic pricing program to reduce peak demand may be cheaper and faster for a utility than building a peaker plant to meet increased demand. For customers, these programs can encourage them to modify their consumption behavior and reduce electric bills. In the long run, all ratepayers will avoid paying for the increased capacity and infrastructure associated with peaker plants, generation plant costs, and other T&D infrastructure costs.
- **Enabling technologies:** In addition to AMI, enabling technologies such as smart thermostats, smart appliances, and associated home energy management applications are becoming more commonplace, allowing consumers to more easily manage their energy demand.
- **Distributed energy resources (DER):** Another major market driver for dynamic pricing is the proliferation of DER. Distributed renewables can make net loads more variable and can make the daily load curve steeper at certain times of the day (e.g., the loss of solar PV generation as the sun sets). As DER capacity grows in the United States, so does the opportunity to shift load and accrue the cost savings from dynamic pricing programs.

21 Navigant Research, "Dynamic Pricing: Real-Time Pricing, Critical Peak Pricing, Peak Time Rebates, and Variable Peak Pricing: Global Market Analysis and Forecasts", 2016.

TABLE 8: TYPES OF DYNAMIC PRICING

TIME-OF-USE (TOU) PRICING	TOU programs set prices for specific periods of time. Electricity prices for energy consumed during these periods are known to the consumer, allowing them to adjust their usage.
REAL-TIME PRICING (RTP)	RTP programs reflect the real-time cost of electricity. These rates most often change on an hourly basis, though in some cases they can change more frequently.
VARIABLE PEAK PRICING (VPP)	VPP programs are a hybrid between TOU and RTP; specific periods of electricity price fluctuations are defined in advance, but the price established during a peak period varies by utility and market conditions.
CRITICAL PEAK PRICING (CPP)	CPP programs raise the price of electricity during periods of anticipated high wholesale market prices or excessive demand. This rate can either be predetermined, or designed to vary based on the need to reduce load on the grid.
CRITICAL PEAK REBATES (CPR)/ PEAK TIME REBATES (PTR)	CPR/PTR programs anticipate high wholesale market prices or excessive demand, and price critical period consumption at a set rate. Customers receive refunds or credits for any reduction in energy consumption relative to expected consumption. This gives customers the benefit of saving through conserving without the risk of increased peak prices.

Source: Navigant, 2016.[21]

TABLE 9: EXAMPLES OF DYNAMIC PRICING UTILITY PROGRAMS

BGE	**Baltimore Gas & Electric**'s (BGE) PTR program, Smart Energy Rewards Program, enrolls customers with a smart meter for the PTR rate and gives a rebate during peak hours. BGE notifies its customers by phone, email, or text before an energy savings day. Customers also get enabling technology, such as a thermostat, to augment any behavioral changes they make. BGE has teamed with Opower/Oracle which sends pricing signals to residential customers the night before an energy savings day.
OG+E	**Oklahoma Gas and Electric**'s (OG&E) SmartHours dynamic pricing program is a voluntary program offered to residential and small commercial customers to reduce on-peak energy use by offering lower rates during off-peak periods and by enabling use of smart grid technology. The program uses a VPP model which involves an off-peak rate, a standard on-peak rate, a high on-peak rate, and a critical on-peak rate, adding an extra layer to CPP. Pricing events are communicated via email, text message, and/or voicemail. OG&E has deployed smart meters throughout its service territory. All SmartHours customers use in-home technology, program communicating thermostats, or an energy information website (MyOGEpower.com) to manage their usage.

Source: Navigant, 2016 with edits by SEPA.[22]

CHALLENGES

While there are many drivers for dynamic pricing, the slow rate of program development indicates that barriers and obstacles exist.

- **Resistance to change:** The lack of adequate electricity can bring up issues of public health, security, and safety. Dynamic pricing rates could potentially send a harmful signal to at-risk residential groups, barring them from electricity access or minimum requirements.
- **AMI integration:** Systems integration plays a huge role in the success of advanced metering techniques and poses a significant cost to utilities. It is well accepted by utilities that there must be some level of AMI in order for time-based rates to become widespread; ensuring AMI provides flexible and extensible solutions is paramount.
- **Lack of customer education and demand:** Most customers are unfamiliar with real-time electricity pricing. Dynamic pricing programs depend on modulating customer habits, which may be difficult to change.
- **CPR and PTR programs require the computation of a customer baseline against which to measure the reduction in energy consumption.** Determining accurate and transparent baselines is subject to controversy and care must be taken to minimize opportunities for the creation of inflated baselines that increase participant energy credits that produce no market benefits.

22 Navigant Research, "Dynamic Pricing: Real-Time Pricing, Critical Peak Pricing, Peak Time Rebates, and Variable Peak Pricing: Global Market Analysis and Forecasts", 2016.

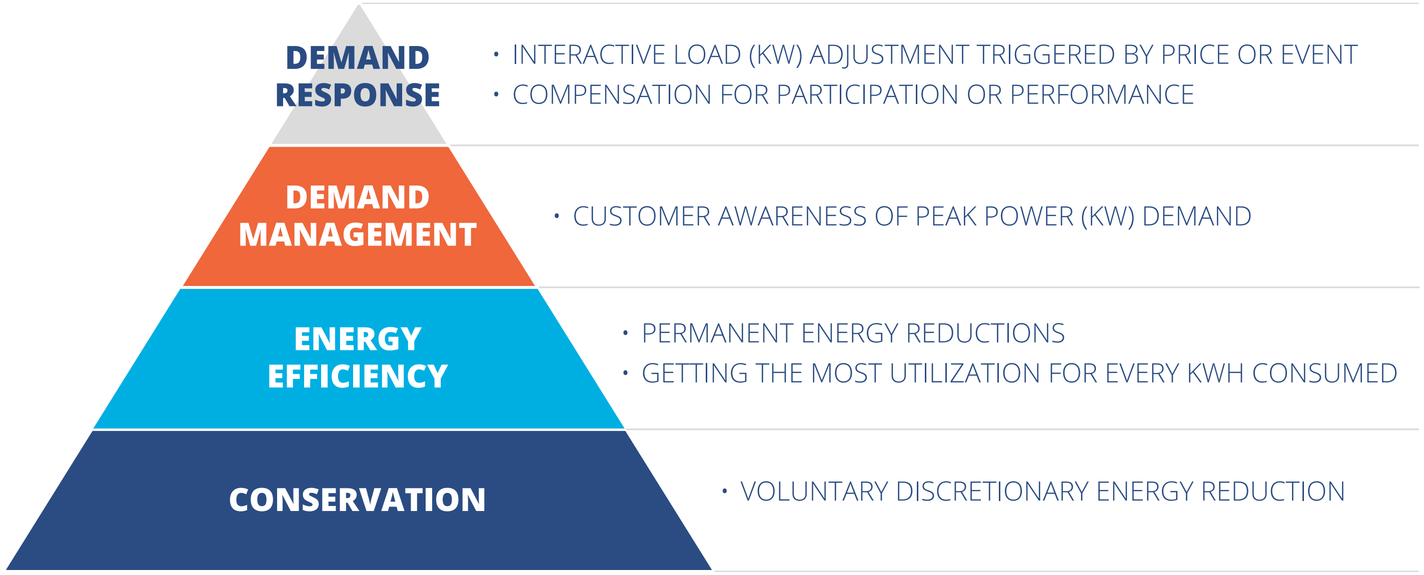
Integrated Demand Side Management

Integrated Demand Side Management (IDSM) refers to the comprehensive integration of services and programs that include energy efficiency, demand response, and other advanced services.[23] While it has been part of the norm to keep energy efficiency and demand response separate (e.g., market and regulatory structures often separate responsibility and funding for EE and DR), initiatives are under way seeking to further marry these programs together.

Better coordination of energy efficiency and demand response programs at the provider level could bring about cost efficiencies and better allocation of resources for both program providers and customers. According to EPA's report, *Coordination of Energy Efficiency and Demand Response*[24], the following four ways can help with such coordination:

1. Combined program offerings,
2. Coordinated program marketing and education,
3. Market-driven coordination services, and
4. Building codes and appliance standards that help companies with this integration.

FIGURE 15: DEMAND SIDE MANAGEMENT PROGRESSION



Source: Madison Gas and Electric, Focus on Energy, 2017.[25]

23 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 or to incentive payments designed to induce lower electricity use when energy prices are high or system reliability is in jeopardy.

24 EPA, *Coordination of Energy Efficiency and Demand Response*, 2010, https://www.epa.gov/energy/coordination-energy-efficiency-and-demand-response

25 Robert Connor (MG&E), Matthew Matenaer (Focus on Energy), On Demand Savings: Introducing Demand Management in an Efficiency World; 35th PLMA presentation, 2017, www.peakload.org/resource/resmgr/35th_conf/B5ConnorMatenaer.pdf.

TABLE 10: EXAMPLES OF UTILITIES COORDINATING ENERGY EFFICIENCY AND DEMAND RESPONSE PROGRAMS

FORMS OF EE + DR COORDINATION	DESCRIPTION	EXAMPLES
COMBINED PROGRAM OFFERINGS	Customers are offered both energy efficiency and demand response opportunities under the same program and provider umbrella.	NV Energy
COORDINATED PROGRAM MARKETING AND EDUCATION	Program sponsors (i.e., utilities) package and promote energy efficiency and demand response programs together to streamline information to customers, while keeping the delivery of these services separate at the program level.	California and New York utilities
MARKET-DRIVEN COORDINATED SERVICES	Beyond programs offered by utilities, ISOs, and public benefit organizations, EE+DR programs could also be coordinated through private firms with separate market opportunity with customers (e.g., energy service companies and DR aggregators).	Retail energy providers, energy service companies, DR/ DER aggregators
BUILDING CODES AND APPLIANCE STANDARDS	Building codes and appliance efficiency standards represent an opportunity to incorporate EE and DR features into building infrastructure and design to pass on program benefits to customers.	California Title 24

Source: Smart Electric Power Alliance, Navigant, EPA, 2017.[26]

TABLE 11: UTILITY JOINT DEMAND RESPONSE AND ENERGY EFFICIENCY PROGRAM HIGHLIGHTS

SMUD®	**Sacramento Municipal Utility District**'s (SMUD) demand response programs provide C&I customers opportunities to install communicating programmable thermostats, and a variety of pre-cooling and conventional control strategies. This integrated approach led to a 23% reduction in weather-adjusted energy use and a 20% average peak load reduction on critical peak event days.
MGE® Madison Gas and Electric	**Madison Gas and Electric** conducted a pilot study between June and September of 2016 in partnership with 42 C&I participants to provide education on demand reduction strategies, monetary incentives, and access to a real-time energy dashboard. This pilot was designed to collect data for on-peak demand savings. Results from the pilot study found an average total monthly savings of 2,760 kW.[27]

Source: Smart Electric Power Alliance, 2017.

26 Smart Electric Power Alliance, Navigant, Environmental Protection Agency, Coordination of Energy Efficiency and Demand Response, 2010.

27 Robert Connor (MG&E), Matthew Matenaer (Focus on Energy), On Demand Savings: Introducing Demand Management in an Efficiency World; 35th PLMA presentation, 2017, www.peakload.org/resource/resmgr/35th_conf/B5ConnorMatenaer.pdf.

INTEGRATED DEMAND SIDE MANAGEMENT CHALLENGES

- Utility structures and budgets are often organized such that collaboration is not fostered; similar information-sharing difficulties occur with regulatory staff
- Energy audits for EE do not address DR
- Existing regulatory structures sometimes explicitly prohibit inter-mingling of EE and DR programs, resources, and/or budgets
- Cost effectiveness and measurement and verification protocols differ
- Aggregators do not frequently offer both EE and DR and are not incentivized to cross market

MOVEMENT FROM INTEGRATED DEMAND SIDE MANAGEMENT (IDSM) TOWARD INTEGRATED DISTRIBUTED ENERGY RESOURCES (IDER)

The industry term IDSM is often considered a classification of behind-the-meter load reduction and reshaping with a focus on traditional DR and EE programs.[28] More recently, the industry is shifting toward integrated offerings expanding beyond EE and DR to also include distributed generation and energy storage. This newer term, integrated distributed energy resources (IDER), represents a broader set of technologies, programs, and customer behavior strategies that can be leveraged to reduce electric load and respond to needs along the grid. Value from IDER offerings is continuing to grow as the industry transitions toward deriving value from avoiding location-specific costs and balancing bidirectional power flows with a holistic portfolio of DERs (for more information see Demand Response at the Distribution Level).

Examples:

Austin Energy SHINES program: Austin Energy received a $4.3 million award from the Department of Energy's Sunshot Initiative to pilot a platform for integrated distributed energy resources with a goal of integrating solar PV at a system levelized cost of energy (LCOE) below 14 cents/kWh. Under this project, Austin Energy is testing an advanced control system platform with a fleet of DERs as well as a cost metric reflecting solar, energy storage, demand response, and other grid assets.[29]

28 https://www.caiso.com/Documents/May15_2015_Responses_Questions_Apr15_2015Ruling_IntegratedDemandSideResource_R14-10-003.pdf

29 http://www.utilitydive.com/news/how-austin-energy-is-looking-to-manage-solar-plus-storage-on-its-grid/413524/

Energy Storage and Demand Response

Energy storage, depending on the technology and application, can act as a form of demand response.

- Energy storage, such as thermal storage (e.g., distributed thermal batteries, water heaters), has the ability to shift load consumption to an optimal time.
- Energy storage, such as batteries, flywheels, and compressed air energy storage (CAES), has the ability to charge and discharge to the grid in response to the needs of the grid operator.

TABLE 12: TWO TYPES OF ENERGY STORAGE

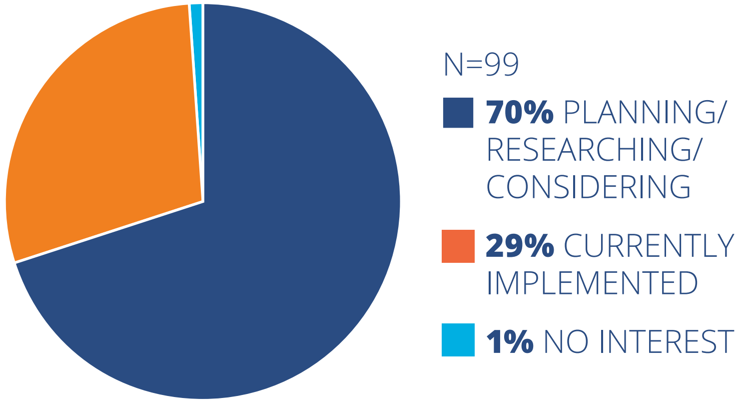
WHAT IS BEING STORED?	THERMAL ENERGY	ELECTRICITY
TECHNOLOGIES	Distributed thermal batteries (e.g. Ice Bears) and Water Heaters	Battery storage, CAES, Kinetic
TYPE OF GRID INTERACTION	One-way interaction: Water heaters and Ice-Energy storage convert electricity into thermal energy at a time that is ideal for the grid. The thermal energy is then stored to be used at a more optimal time later in the day. This form of energy storage is known as **demand flexibility**.	Two-way interaction: Electricity is stored via a chemical or mechanical process. Since electricity is being stored, these assets can act as a **flexible load**, charging with electricity and allowing them to participate in (and even back up) DR aggregation. However, the stored electricity can also be discharged to the grid as needed, therefore, the energy storage device can also act as a **generator**.

LOAD SHIFTING/DEMAND FLEXIBILITY

Advancements in technology have enabled DR to expand capabilities beyond peak load reduction to load shifting. As renewable energy adoption continues to increase, DR provides a key benefit in its ability to help integrate renewable resources by taking advantage of low-cost, off-peak energy when wind and solar are abundant. In some cases, such resources are actually being curtailed during low demand periods; demand response can allow use of this power instead of discarding it, and reduce demand when this power is no longer being produced. Such load shifting, or demand flexibility, is a growing and increasingly important element of demand response. SEPA's survey found almost 70% of utility respondents are planning, researching, or considering leveraging DR to help manage these fluctuations along the grid in areas with high penetration of renewable energy.

FIGURE 16: UTILITY INTEREST IN LEVERAGING DEMAND RESPONSE TO SUPPORT RENEWABLE ENERGY INTEGRATION

TARGETING DR SPECIFICALLY TO MANAGE FLUCTUATIONS OR GRID IMPACTS IN A LOCATION WITH A HIGH PENETRATION OF RENEWABLE ENERGY?



Source: Smart Electric Power Alliance, 2017.

Electric Vehicles and Demand Response

Electric vehicles (EVs) are quickly becoming an important form of flexible load. Innovative utilities are experimenting with new business models and programs to incentivize their customers to purchase EVs and charge their vehicles during optimal times of the day.

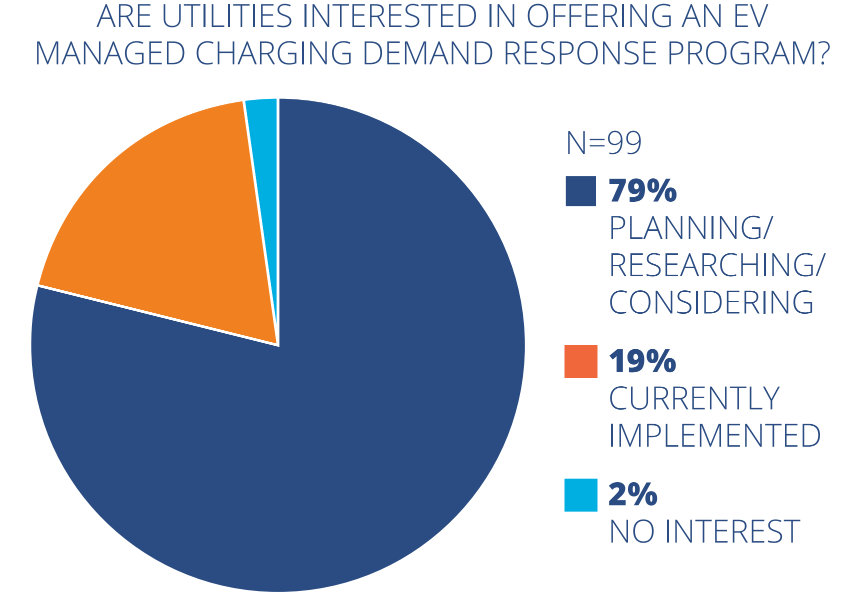
CHALLENGES AND OPPORTUNITIES

While EVs are not creating grid issues today, as EV penetration expands, the charging profile of these vehicles may create impacts on the grid without proper management. The challenge for utilities will be to smooth the charging load, to leverage the vehicles as a type of storage device to absorb excess renewable energy production and to minimize peak impacts via managed charging.

Managed charging is a combination of infrastructure and communication signals sent directly to a vehicle or, via a charger, to control a charging event. Indirect efforts to manage charging patterns rely on customer response behavior.

When surveyed, utility respondents were overwhelmingly planning, researching, or considering managed charging as part of their demand response programs. EV managed charging can provide a robust opportunity for not only load reduction, but flexible capacity, with the annual consumption of EVs expected to reach 400 TWh annually by 2040.[30]

FIGURE 17: UTILITY INTEREST IN OFFERING EV MANAGED CHARGING DR PROGRAMS



Source: Smart Electric Power Alliance, 2017.

30 Bloomberg New Energy Finance, July 2017, "Electric Vehicle Outlook 2017", https://about.bnef.com/electric-vehicle-outlook/.

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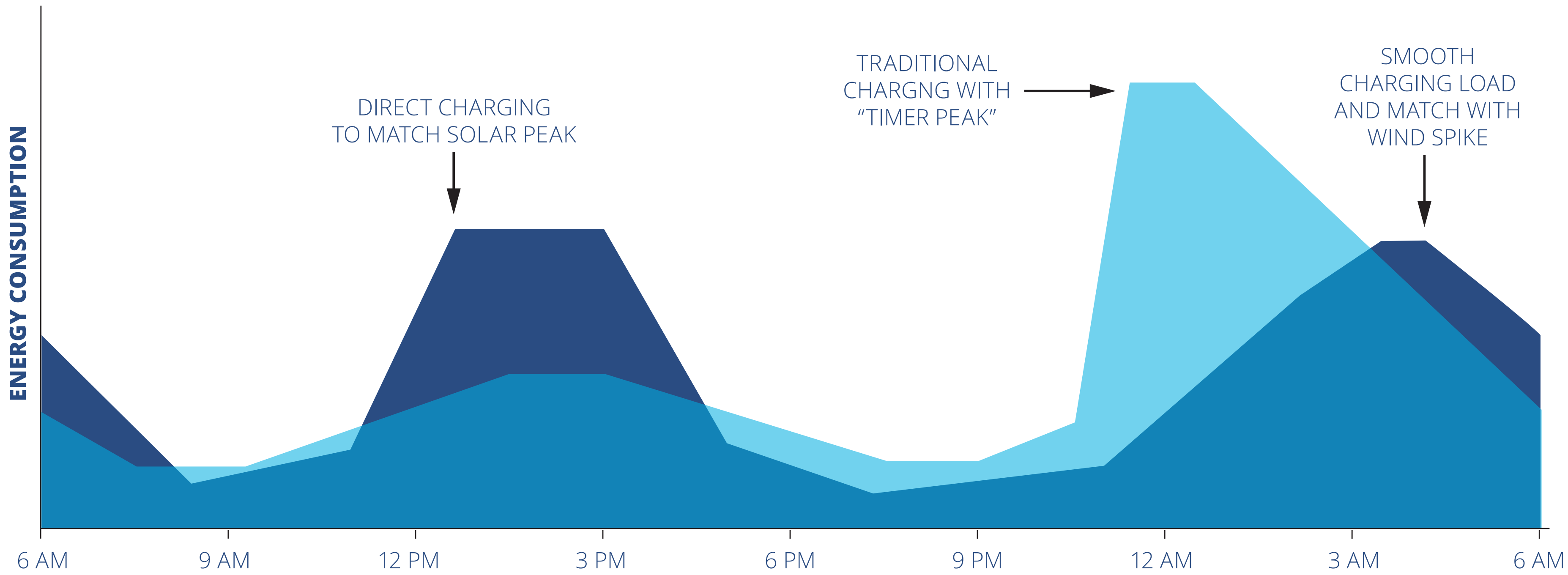
The communications signals used in managed charging enable a utility or third party to reduce the rate of charge or curtail it entirely. Examples include times during a high-load event or periods of high real-time prices on the grid, or to increase the rate of charge when capacity is plentiful and real-time prices are low or negative.

Further, these controls can be leveraged by utilities, load balancing authorities via aggregators, or other interested parties to provide grid services, such as capacity, emergency load reduction, reserves, or regulation, or to absorb excess generation from renewable energy resources, like solar and wind.

FIGURE 18: OPPORTUNITIES FOR ELECTRIC VEHICLE MANAGED CHARGING



Note: The light blue area illustrates the impacts of a hypothetical TOU residential charging rate with the lowest rate period beginning at 11 pm. The dark blue area shows how managed charging loads with peaks in renewable energy generation.

Source: BMW of North America 2016 with edits by Smart Electric Power Alliance, 2017[31]

31 Adam Langton of BMW of North America LLC, "BMW Electric Vehicles and the Grid," April 2016, Smart Charging Workshop presentation, hosted by the Union of Concerned Scientists, https://www.dropbox.com/sh/zmkca2v9cdiu9os/AAB4BMGmFKBzhrOHDqEWKOyGa/The%20OEM%20Perspective?dl=0&preview=Langton_June2016_v2.pdf.

Demand Response at the Distribution Level

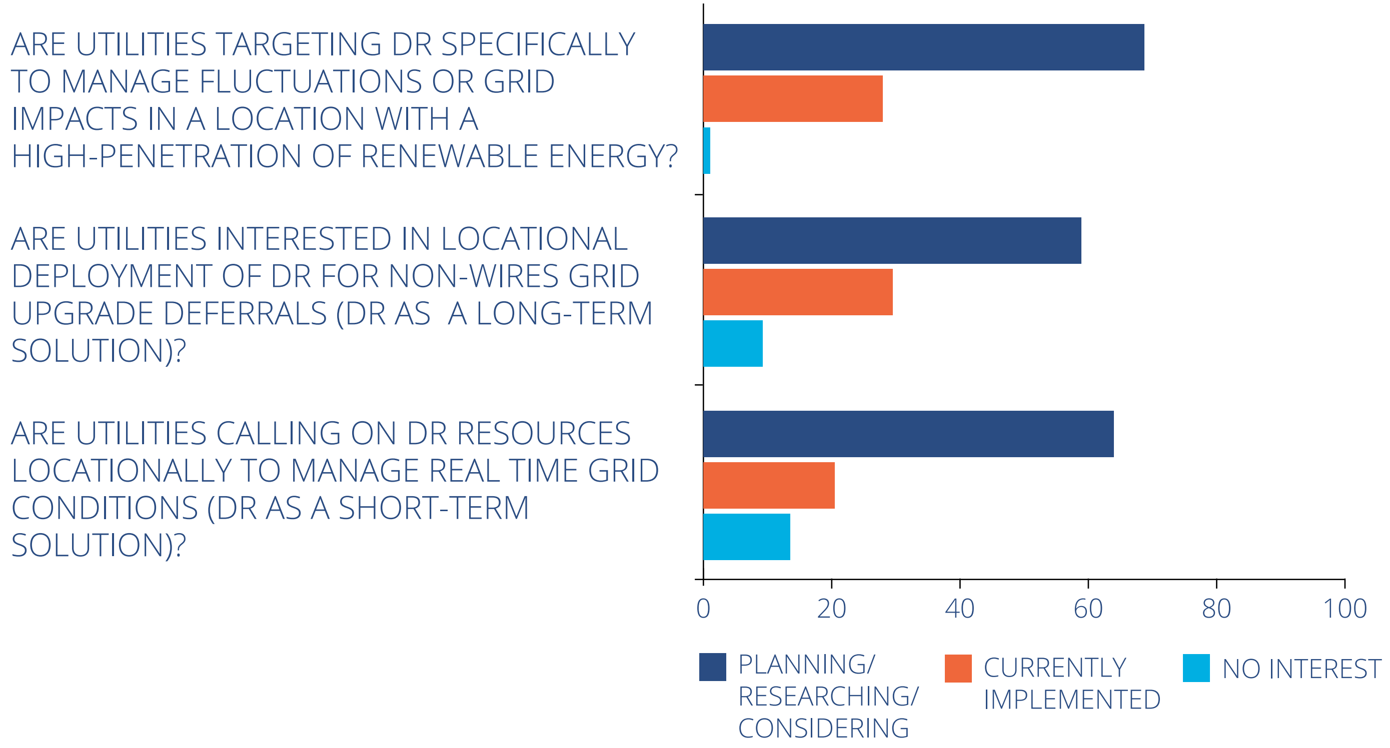
Locational forms of DR may provide a more targeted and efficient resource for meeting infrastructure and grid needs as the electric grid ages, load growth slows, and large-scale system-wide DR programs continue to expand. The move toward targeting DR to specific distribution-level areas with high load growth or infrastructure constraints is playing a growing role in grid planning.

The terms **non-wires alternative** (NWA) or **non-wires solutions** (NWS) describes such targeted projects. NWS can be defined as:

> *An electricity grid investment or project that uses non-traditional transmission and distribution (T&D) solutions, such as distributed generation (DG), energy storage, energy efficiency (EE), demand response (DR), and grid software and controls, to defer or replace the need for specific equipment upgrades, such as T&D lines or transformers, by reducing load at a substation or circuit level.*[32]

SEPA's survey found over 10% of utility respondents are leveraging demand response at targeted distribution circuits, as opposed to system-wide, levels, and 14% of utilities are already calling on DR resources to support real-time grid conditions. Just 1% of respondents are targeting DR to help manage grid fluctuations resulting from high penetration of renewables. An overwhelming number of respondents have expressed interest in leveraging DR capabilities for these purposes in the future.

FIGURE 19: UTILITIES LEVERAGING DEMAND RESPONSE FOR GRID SERVICES



Source: Smart Electric Power Alliance, 2017.

32 Navigant Research, Non Wires Alternatives, 2017.

Various technical, economic, policy, and customer factors drive NWS growth, such as:

- Grid management and distributed energy resource (DER) technologies have improved as has the ability to cheaply communicate with them.
- Utilities are looking to engage customers more and provide more value-added services.
- Alternatively, customers have shown a desire to engage with the grid and have driven deployment of DR and DER.
- Policy concerns related to T&D costs and the environmental impacts of energy consumption have grown.

Policies in states such as New York, California, Michigan, and Massachusetts promote the exploration of NWS as alternatives to traditional grid investment in order to reduce costs to the customer. By far the most significant economic benefit of a NWS is the deferral of a large capital T&D investment.

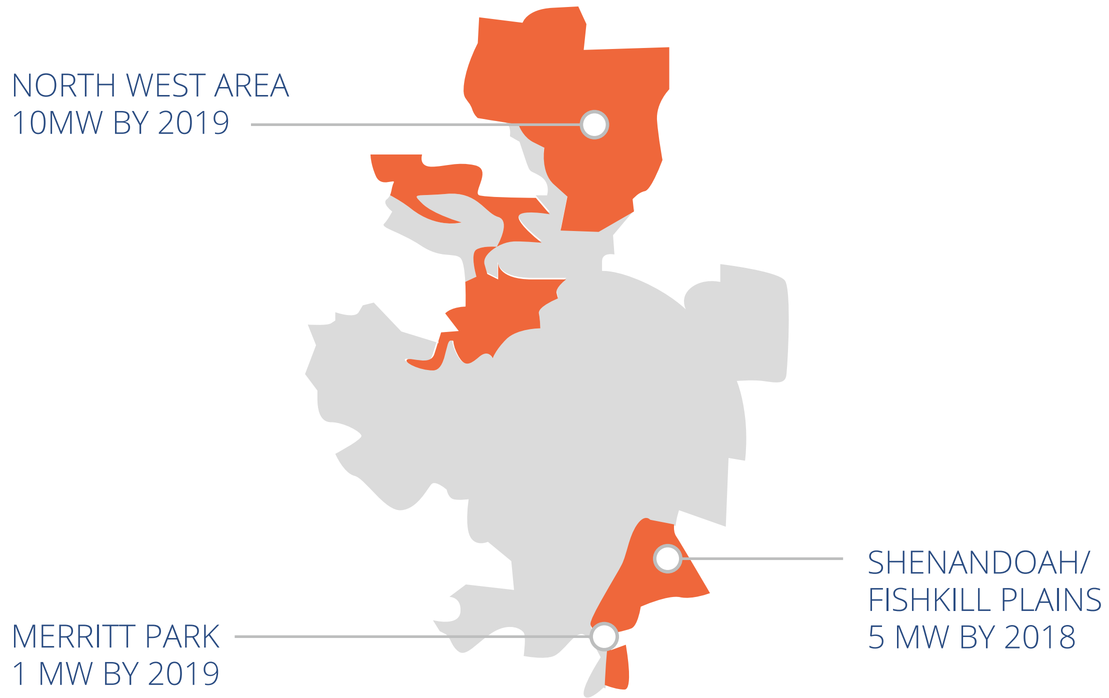
There is no standard business model and procurement process for utilities to implement NWS. Currently, there are four models being considered and tried by utilities:

- Request for proposal (RFP),
- Auction,
- Procurement from current implementation contractors, or
- Internal utility resource deployment.

Further, policies need to be developed addressing how a NWS, which is used to offset transmission or distribution investment and is financed through a utility's rate base, participates in an organized wholesale market in which merchant resources (generation and demand response) compete.

Central Hudson, a gas and electric utility in New York State, deployed an NWS project in partnership with Comverge in 2016 called Peak Perks. The program used targeted DR to defer traditional system upgrades in three different areas within its service territory, as shown in Figure 20.

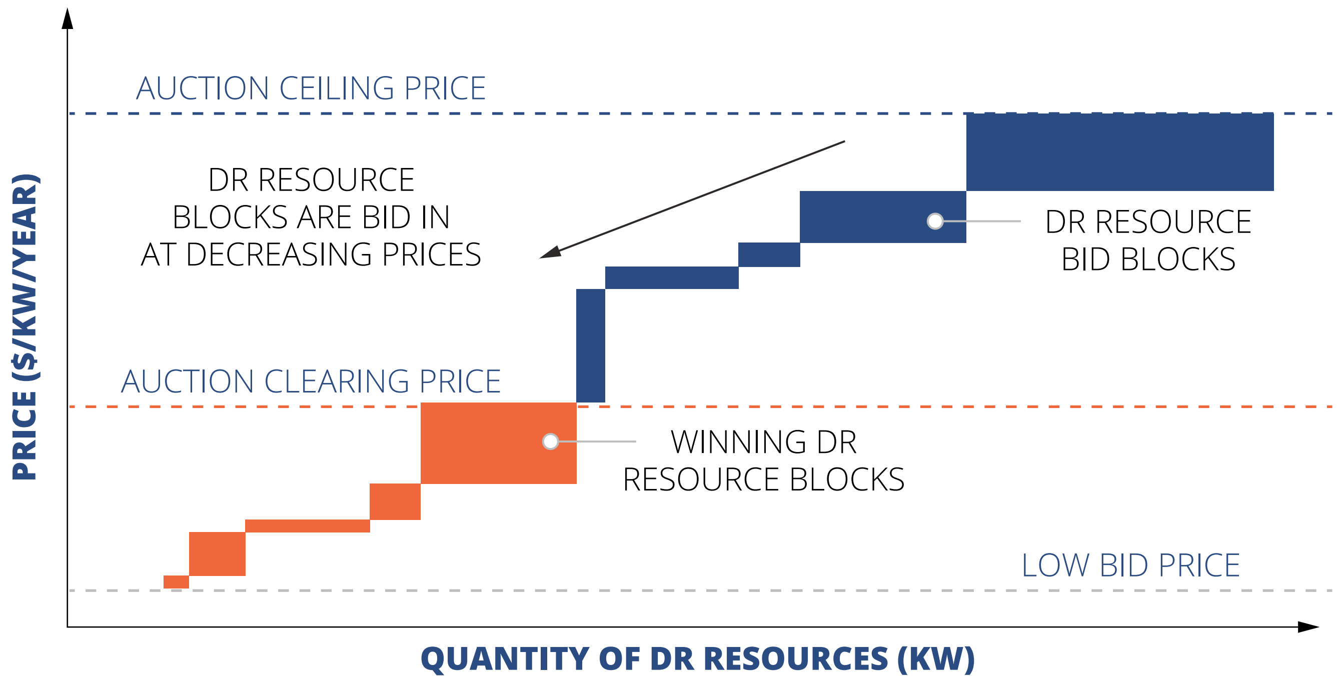
FIGURE 20: CENTRAL HUDSON PEAK PERKS NWS PROJECT



Source: Central Hudson, 2016[33]

Consolidated Edison (Con Edison), the electric utility in New York City, conducted an auction for part of the Brooklyn Queens Demand Management (BQDM) NWS project. The auction was only held for DR measures after projects for other types of resources had been selected as illustrated in Figure 21.

FIGURE 21: ILLUSTRATION OF BQDM DR AUCTION MECHANICS

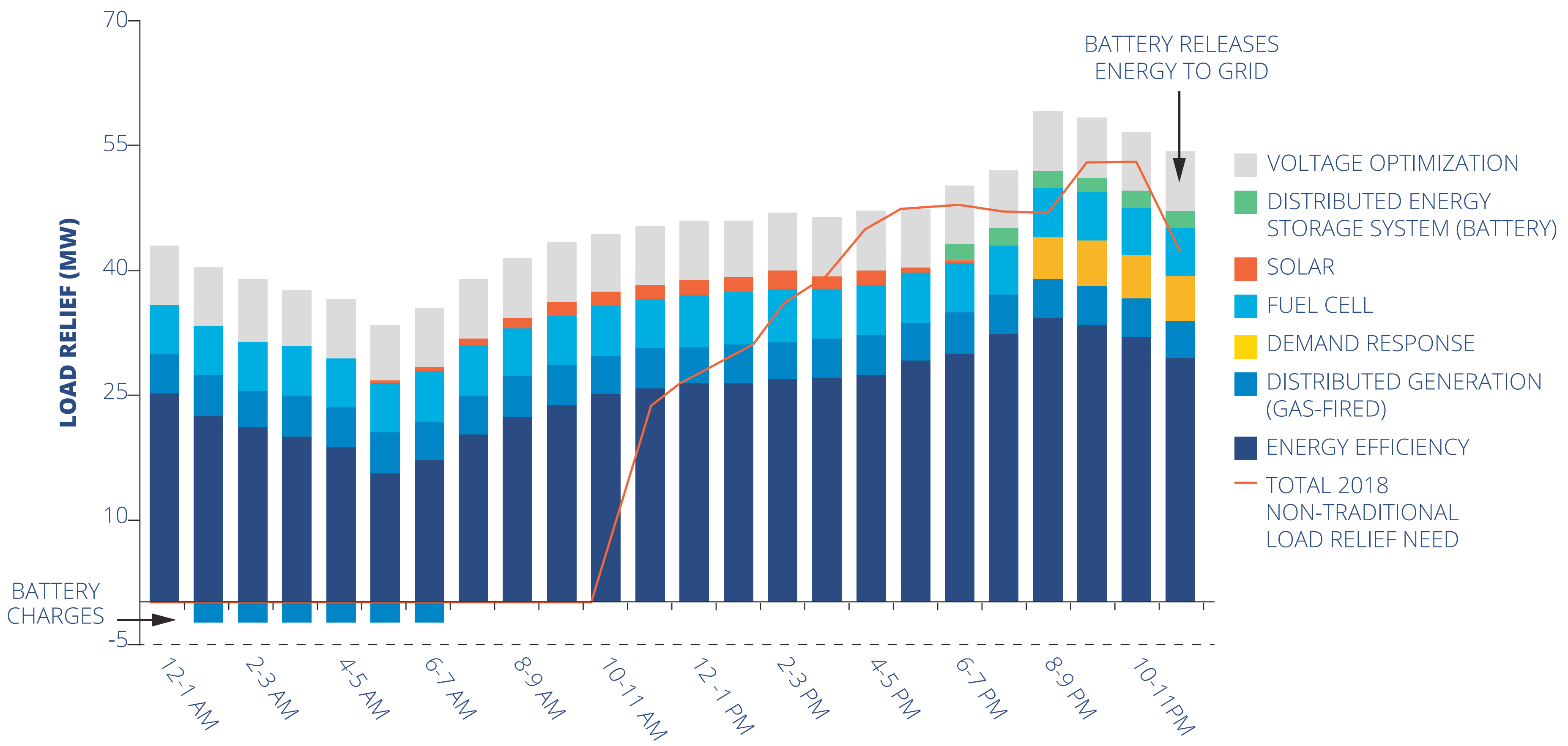


Source: Central Hudson, 2016[34].

33 https://www.cenhud.com/EnergyEfficiency/Peak-Perks
34 https://conedbqdmauction.com/

ConEd's program relies largely on EE measures, from traditional incentives for replacing inefficient appliances and AC units to new building management systems to battery systems and microgrids. However, the program also relies on other unique DERs such as fuel cells, DR, and energy storage. In addition, the program has a focus on customer engagement. ConEd actively reaches out to small-to-medium-sized businesses to address the challenges in enrolling that customer segment. The anticipated resource portfolio is shown in Figure 22.

FIGURE 22: CONED BDQM RESOURCE PORTFOLIO



Source: Consolidated Edison, 2016.

Appendix A: 2016 Reported Demand Response Capacity by State

TABLE 13: TOTAL REPORTED DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE

	TOTAL ENROLLED CAPACITY (MW)	TOTAL DISPATCHED CAPACITY (MW)
ALABAMA	0	0
ALASKA	0	0
ARIZONA	143	44
ARKANSAS	76	66
CALIFORNIA	815	555
COLORADO	228	9
CONNECTICUT	0	0
DELAWARE	0	0
FLORIDA	976	768
GEORGIA	127	118
HAWAII	49	24
IDAHO	653	542
ILLINOIS	8	8

TABLE 13: TOTAL REPORTED DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE

	TOTAL ENROLLED CAPACITY (MW)	TOTAL DISPATCHED CAPACITY (MW)
INDIANA	841	835
IOWA	591	511
KANSAS	293	258
KENTUCKY	31	31
LOUISIANA	0	0
MAINE	0	0
MARYLAND	1202	1037
MASSACHUSETTS	1	1
MICHIGAN	605	582
MINNESOTA	987	409
MISSISSIPPI	0	0
MISSOURI	0	0
MONTANA	0	0

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TABLE 13: TOTAL REPORTED DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE	TOTAL ENROLLED CAPACITY (MW)	TOTAL DISPATCHED CAPACITY (MW)
NEBRASKA	0	0
NEVADA	0	0
NEW HAMPSHIRE	40	10
NEW JERSEY	73	0
NEW MEXICO	4	0
NEW YORK	2032	2004
NORTH CAROLINA	1213	935
NORTH DAKOTA	79	48
OHIO	664	657
OKLAHOMA	70	56
OREGON	19	16
PENNSYLVANIA	152	40

TABLE 13: TOTAL REPORTED DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE	TOTAL ENROLLED CAPACITY (MW)	TOTAL DISPATCHED CAPACITY (MW)
RHODE ISLAND	0	0
SOUTH CAROLINA	476	398
SOUTH DAKOTA	41	19
TENNESSEE	0	0
TEXAS	451	378
UTAH	254	123
VERMONT	0	0
VIRGINIA	37	37
WASHINGTON	0	0
WEST VIRGINIA	95	95
WISCONSIN	302	84
WYOMING	0	0

Source: Smart Electric Power Alliance, 2017.

Appendix B: Survey Participants

AEP Ohio
AEP Texas
Alliant Energy
Appalachian Power
Arizona Public Service
Austin Energy
Avista Utilities
Baltimore Gas and Electric
Big Bend Electric Cooperative, Inc.
Brunswick Electric Membership Corp.
Central Hudson Gas & Electric
City of Ottawa, Kansas
City of Tallahassee
Clark Public Utilities
Colorado Springs Utilities
Consolidated Edison Company of New York
CoServ Electric
CPS Energy
Dominion North Carolina Power
Dominion Virginia Power
DTE Energy
Duke Energy Carolinas
Duke Energy Florida
Duke Energy Indiana
Duke Energy Kentucky
Duke Energy Ohio
Duke Energy Progress
Eau Claire Energy Cooperative
El Paso Electric Co
Emerald People's Utility District
Entergy Arkansas, Inc.
Entergy Louisiana, LLC
Entergy Mississippi, Inc.
Entergy New Orleans, Inc.
Entergy Texas, Inc.
Flint Energies
Florida Keys Electric Cooperative Association, Inc.
Gainesville Regional Utilities
Glendale Water & Power
Habersham EMC
Hawaii Electric Light Co.
Hawaiian Electric
Heber Light & Power
Holy Cross Energy
Horry Electric Coop
Idaho Power Co.
Indiana Michigan Power
Indianapolis Power & Light Co.
Jersey Central Power & Light
Kauai Island Utility Cooperative
Kentucky Power
Los Angeles Dept. Water and Power
Lumbee River EMC
Madison Gas and Electric Co.
Maui Electric Inc.
Medina Electric Cooperative
Metropolitan Edison Co.
MidAmerican Energy Co.
Middle Tennessee Electric Membership Corp.
Monongahela Power Co.
National Grid
New Hampshire Electric Cooperative
Northern States Power Michigan
Northern States Power Minnesota
Northern States Power North Dakota
Northern States Power South Dakota
Northern States Power Wisconsin
Ohio Edison Co.
Orange and Rockland Utilities, Inc.

Orlando Utilities Commission
Ouachita Electric Cooperative Corp.
Pacific Gas and Electric
Palmetto Electric Cooperative
PECO
Pedernales Electric Cooperative
Pennsylvania Electric Co.
Pennsylvania Power Co.
Portland General Electric
PPL Electric Utilities

Public Service Colorado
Public Service Electric & Gas Co.
Public Service Co. of Oklahoma
Public Utility District No. 1 of Benton County
Puget Sound Energy
Riverside Public Utilities
Rockland Electric Co.
Rocky Mountain Power
Roseville Electric

Salt River Project
San Diego Gas and Electric Co.
Southern Maryland Elec Cooperative
Southwestern Electric Power Co.
Southwestern Public Service
Sulphur Springs Valley Electric Cooperative, Inc.
Tampa Electric Co.
The Illuminating Co.
The Potomac Edison Co.

Toledo Edison Co.
Trico Electric Cooperative, Inc.
Truckee Donner Public Utility District
United Illuminating Co.
United Power
Victoria Electric Cooperative
Wadsworth Utilities
West Penn Power Co.
Westar Energy, Inc.
Xcel Energy – New Mexico

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