Smart Electric Power Alliance

2018 Utility Demand Response Market Snapshot

IN PARTNERSHIP WITH

NAVIGANT

PLMA™
Load Management Leadership

SEPTEMBER 2018

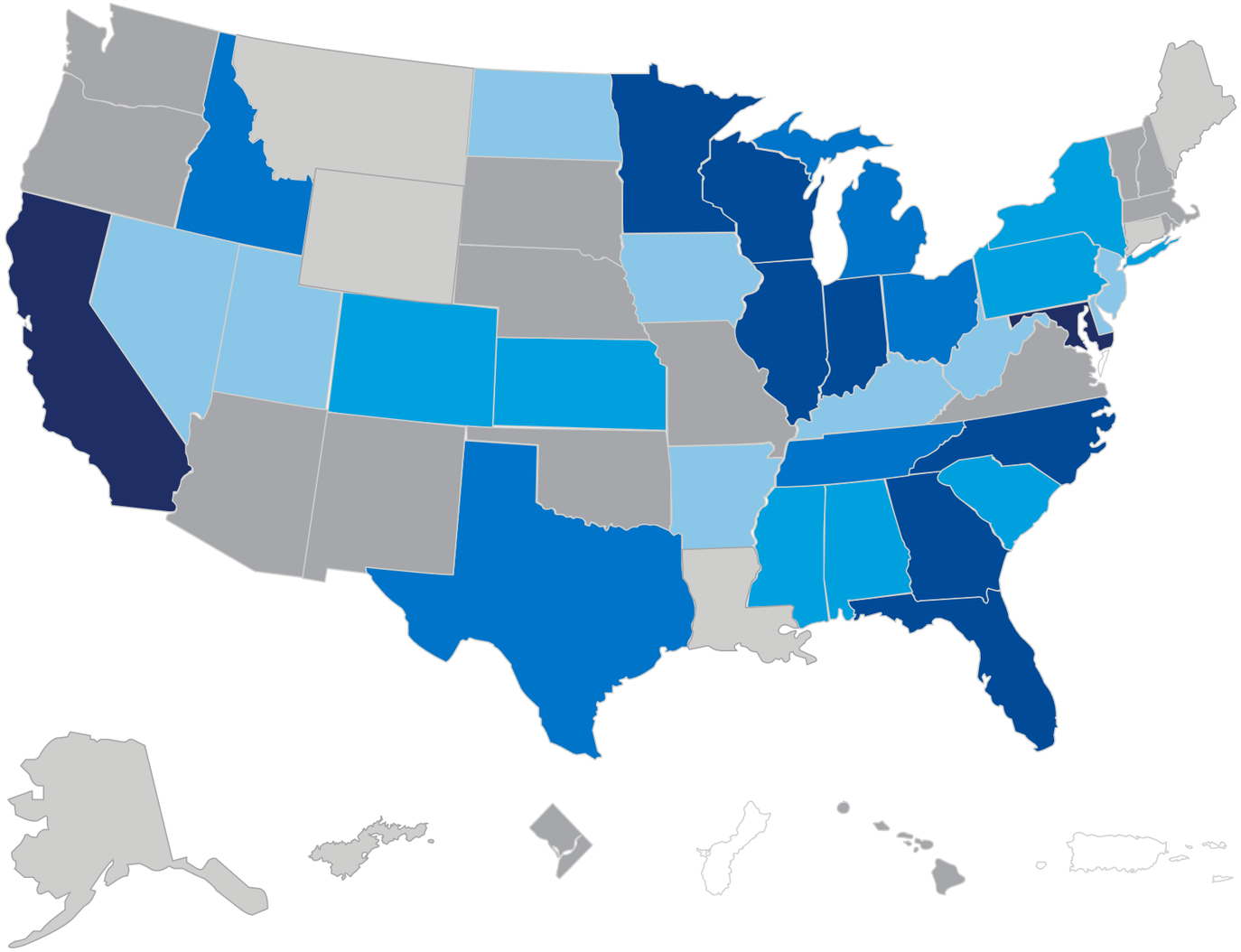

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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DISCLAIMER

SEPA does not claim that this report is entirely complete and may be unintentionally missing information. SEPA advises readers to perform necessary due diligence before making decisions using this content. Please contact SEPA at research@sepapower.org for additional information.

About the Report

The 2018 Utility Demand Response Market Snapshot is the result of a collective partnership among the Smart Electric Power Alliance (SEPA), Navigant, and Peak Load Management Alliance (PLMA) staff. Data collected from SEPA's 2018 Utility Survey (in partnership with PLMA) seeks to provide deeper insight into utility demand response programs throughout the U.S., and represents 62.4% of total U.S. customer accounts (or 89.5 million customers). Please see the SEPA Survey Methodology for more information on scope and coverage.

SEPA began its annual survey of electric utilities in 2007, to track the capacity of new solar power interconnected to the grid each year. Now in its 11th year, the survey, which was expanded two years ago, has collected two years of demand response deployment data.

Navigant Consulting has been tracking and producing reports on the demand response industry for seven years, and has been involved in DR program design and evaluation for over a decade. Navigant has collected data on DR programs, interviewed grid operators, vendors and regulators, and followed retail and wholesale demand response programs around the world. Key market insights from Navigant Consulting's research team are shared in this report.

PLMA was founded in 1999 as the voice of load management practitioners and has over 135 utility and allied organization members. PLMA staff and leadership helped increase utility survey participation, provided peer review of report findings, and enhanced awareness of industry activities.

SEPA SURVEY METHODOLOGY

SEPA conducted its annual Utility Survey between January and March 2018 using an online survey platform to collect data on utility demand response programs through December 31, 2017.

SEPA and PLMA 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 representing 155 utilities from across the U.S. Utilities with service territories in multiple states reported data from each state separately. Generation and transmission companies and a federal utility were counted as single responses.

Survey data was categorized into two main customer segments and respective DR programs: (1) **mass market** and (2) **commercial and industrial** (C&I) 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' electric water heaters from running for a set time during the day. Water heater programs may also incorporate other DR strategies, such as storing hot water by shifting load from on-peak to off-peak periods.
- **Behavioral**—Programs that incentivize customers to reduce use during peak periods with and without a supporting technology like those listed above. These programs may not have direct financial incentives for participation but usually are tied to a time-varying rates program. Such prices include time-of-use, critical peak pricing, peak time rebates, and variable peak pricing. 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 ice storage, pool pumps, an electric vehicle smart charging program, or behind-the-meter generation combined with electric storage.

Commercial and industrial represents DR programs or agreements offered to medium to large commercial and industrial customers.

- **Automated**—A program in which a utility can remotely and automatically reduce a customer's load, or increase the output of behind-the-meter generation or storage, during a demand response event.
- **Customer initiated with notification**—A program that allows a utility to send a signal or other notification informing its customers of a demand response event and asking them to reduce their load or increase the output of behind-the-meter generation or storage by a specified amount over a set period of time.
- **Other**—A DR program for large consumers that does not fall under any of the above defined categories (e.g., irrigation control).

Results in each of these market segments are reported in terms of megawatts (MW) of enrolled and dispatched demand reduction capacity:

- **Enrolled capacity (MW)**—The total potential demand reduction available to the company for dispatch, based on customer enrollment in this demand response program during 2017.
- **Dispatched capacity (MW)**—The average actual demand reduction achieved during a dispatch of this demand response program during the past year.

Foreword

This second annual Utility Demand Response Market Snapshot represents two significant milestones for the Smart Electric Power Alliance (SEPA). First, it builds upon the expansion of SEPA's flagship Utility Market Snapshot series to reflect the expansion of our solar-focused scope to clean energy and grid modernization. Second, it showcases our recent efforts to expand our industry partnerships, better coordinating with aligned nonprofits and the subject matter experts among our membership, to leverage what is an important—but sometimes overwhelming—set of resources for the industry to navigate. Both of these milestones are increasingly important, especially as demand response (DR) experiences a renaissance, potentially unlocking profound market dynamics between supply and demand in the electric power industry.

SEPA's first utility survey on solar interconnection was in 2007, resulting in the Utility Solar Market Snapshot. With the expansion of our mission in 2015, we determined similar reports covering energy storage would be popular. That proved an understatement, with the inaugural Utility Energy Storage Market Snapshot exceeding 2,500 unique downloads last year. What was less clear was how our membership would respond to a report covering DR. We set a more modest target—which was subsequently surpassed three times over, with more than 1,000 downloads. That was not only a pleasant surprise, but revealed an unmet demand for market intelligence on the state of DR across the industry.

In parallel with SEPA's mission expansion, we have increased our work with other industry subject matter experts to enhance our content quality. This report directly benefited from assistance by members of SEPA's Advisory Council on Demand Response and Smart Grid (one of our many working groups) and partnerships with both the Peak Load Management Alliance and Navigant Consulting.

Of course, this work is only meaningful because of the DR renaissance we observe across the country, which is being unlocked by entrepreneurs utilities, grid operators, SEPA members and customers. This new or renewed focus on electricity demand, commercialization and deployment of new sensing and control technologies, and new insights from the wealth of consumer and operational data is bridging gaps between grid operations and consumers in exciting ways.

Collectively, the industry has opened up the possibility—or at least a line of sight—into active market participation of demand-side energy, whether it be for delivering non-wires alternatives, integrating variable-generation renewable energy sources, operating virtual power plants, or delivering resilience benefits at the distribution system level. Such developments are as profound as the achievement of cost-competitive wind and solar power generation, or the sustained decoupling of economic growth from electricity demand. It is also inherently complementary to those developments, which collectively offer a path to the clean and modern grid our world needs.

I'm very proud of the efforts of SEPA's research team over the past two years to deliver these market insights for solar, energy storage, and demand response as a foundational element of our content strategy. We want to continually improve upon our work, however. For demand response, that includes increasing the breadth of our survey collection, deepening our insights on best practices for consumer engagement and on the role of advanced metering infrastructure (AMI). We are eager to have more of you work with us to realize those improvements, and to better understand the potential for demand dexterity to empower consumers across electric power markets. Please send us an email (research@sepapower.org) if you are interested in sharing your insights as SEPA continues to facilitate this exciting transition to a clean and modern grid.

Best,

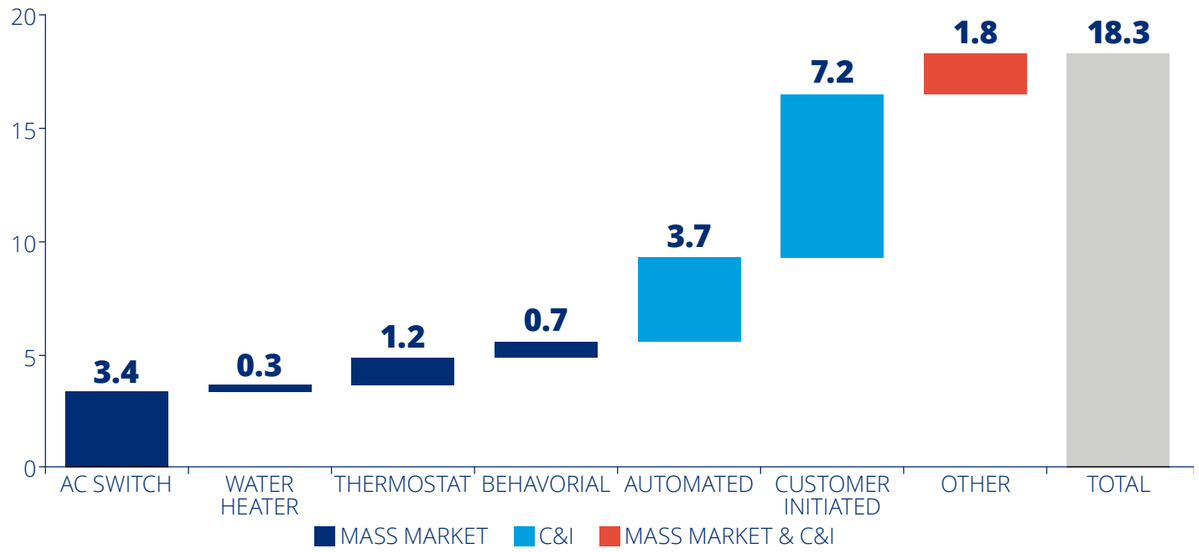
Tanuj Deora
Chief Strategy Officer
Smart Electric Power Alliance

Executive Summary

NATIONAL UTILITY DEMAND RESPONSE MARKET SUMMARY

- Utilities reported a combined enrolled capacity of 18.3 GW and 10.7 GW of dispatched capacity (58% of total enrolled capacity) in 2017, across 155 utilities' programs and market segments (see Figure below).[1]

2017 ENROLLED DEMAND RESPONSE CAPACITY (GW) BY PROGRAM TYPE



Source: Smart Electric Power Alliance, 2018. N=155.

- AC switch programs account for the largest portion of enrolled mass market DR capacity (3.4 GW), followed by thermostat, behavioral, and water heater programs.
  - While traditional DR programs (e.g., air conditioning switches and water heaters) continue to be available today, a handful of utilities are updating air conditioners with two-way switches and exploring grid-interactive water heater (GIWH) capabilities.
  - Forty-seven utilities reported calling on thermostats for DR events. Some utilities are offering a combination of switch-based and connected (oftentimes referred to as "smart" WiFi) thermostats to satisfy different customer preferences.
- Over half of reported enrolled DR capacity in SEPA's survey came from the commercial and industrial (C&I) market segment (12.0 GW).
  - Customer-initiated DR programs account for approximately two-thirds of C&I DR enrolled capacity. The remaining one-third falls under automated and other programs.
  - Customer-initiated DR was used primarily by deferring process loads, HVAC, lighting, and pumps.
  - In automated DR programs, customers leveraged pumps, HVAC, and energy storage to reduce their demand.

1 Data is based on responses from 155 utilities in SEPA's 2018 Annual Utility Demand Response Survey.

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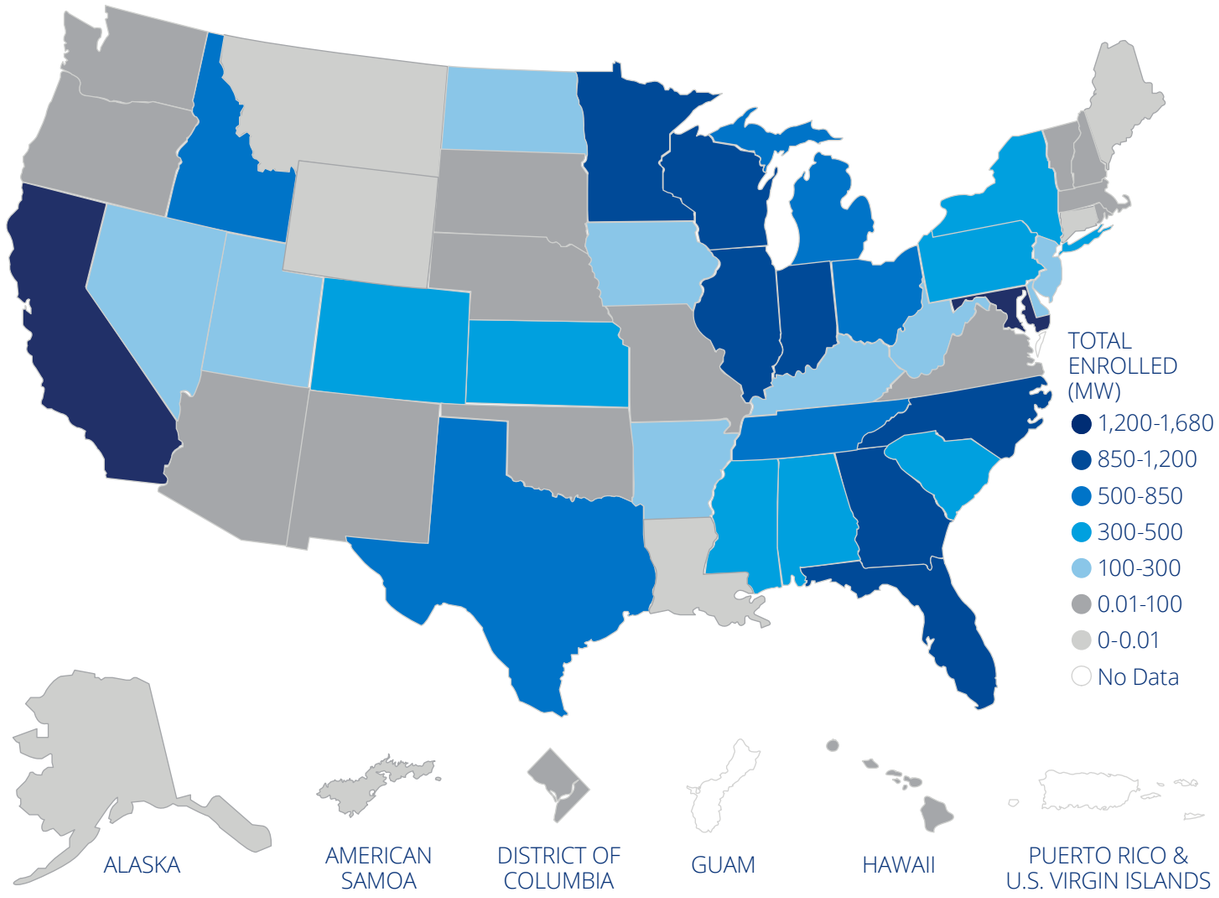
POLICY UPDATE

- A handful of states (i.e., Arizona and Massachusetts) are proposing clean peak standards designed to expand the amount of clean energy deployed during peak load hours, thus expanding opportunities for DR to play a greater role.
- Regulatory mandates are helping drive utilities to integrate programs that have typically been siloed (i.e., energy efficiency and DR). A few states, specifically New York, Hawaii, and California, are at the forefront of integrating distributed energy resources (IDER).

WHOLESALE DEMAND RESPONSE DEVELOPMENT

- DR continues to participate in wholesale markets to provide energy, capacity, and ancillary services. Recent market changes include:
  - Price Responsive Demand in ISO New England was fully integrated into energy and operating reserve markets on June 1, 2018.
  - While 2017's 2020/2021 auction in PJM Interconnection showed a drop in capacity bids in the market due to the start of the 100% capacity performance requirement and low prices—2018 capacity auction bids for 2021/22 delivery year rebounded.

TOTAL 2017 ENROLLED DEMAND RESPONSE CAPACITY BY STATE



Source: Smart Electric Power Alliance, 2018. (Note: This map represents total capacity collected in SEPA's Annual Utility Survey for calendar year 2017. Results are based on responses from 155 utilities. See Methodology in the appendix for more details and a list of participants.)

INTERNATIONAL DEMAND RESPONSE HIGHLIGHTS

- Markets are becoming more open and attractive for DR resources outside of the U.S.
  - Japan opened a new DR market in 2017 called the "NegaWatt Market."
  - The Australian Energy Market Operator announced 10 pilot projects under its DR initiative.
  - In the UK, National Grid launched the Power Responsive program with the goal of stimulating participation of flexible technologies in the electricity system.

DEMAND RESPONSE MARKET TRENDS

- Deployment of innovative time-of-use (TOU) rates to residential and small and medium business (SMB) customers is widening due to a number of factors, including growth in smart meter rollouts, utilities' needs to manage the net load curve on a dynamic basis, efforts to integrate distributed energy resources (DERs), and opportunities to mitigate generation and transmission-distribution capacity costs.
- The electric vehicle (EV) landscape is rapidly evolving, with forecasts predicting that EVs' annual energy consumption will rise from a few terawatt-hours (TWh) a year in 2017 to over 100 TWh by 2030.[2] Utilities have thus far taken a conservative approach to EV deployment, but SEPA research indicates movement in managed charging and vehicle-to-grid (V2G) pilots.
- Two-way electricity storage is playing a growing role in DR as utilities begin testing the use of storage systems in response to DR events. Batteries are being paired with other DR technologies, and behind-the-meter batteries are being aggregated to participate in DR events.
- The industry has been making efforts over the past decade to integrate programs that have typically been siloed; this effort is known as integrated demand side management, or IDSM. As deployment of DERs becomes more widespread, this term has come to embody a broader set of technologies, programs, and customer behavior strategies, also sometimes referred to as IDER.
- A number of non-wires alternative (NWA) projects in the U.S. are using DR alongside other technologies (energy efficiency and storage) to offset peak load growth and defer distribution system investments.
- DR is playing a growing role in helping to balance fluctuations in energy production in areas with high levels of renewable generation (e.g., reverse DR and load shifting pilot measures). Planning at the utility level is expanding to examine locational DR deployment and pairing DR with other technologies.
- In addition to electric DR, a growing number of natural gas DR programs are cropping up—especially in winter—to alleviate pipeline capacity constraints during periods of peak usage driven by extreme weather or logistical issues.
- Widespread adoption of smartphones, mobile apps, and smart home devices is changing the way consumers are interacting with their service providers. Changes in consumer expectations have led utilities to seek DSM software solutions that can lower the costs of service and improve customer satisfaction and engagement.

2 Bloomberg New Energy Finance, 2018, https://about.bnef.com/electric-vehicle-outlook/#toc-download

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INTRODUCTION

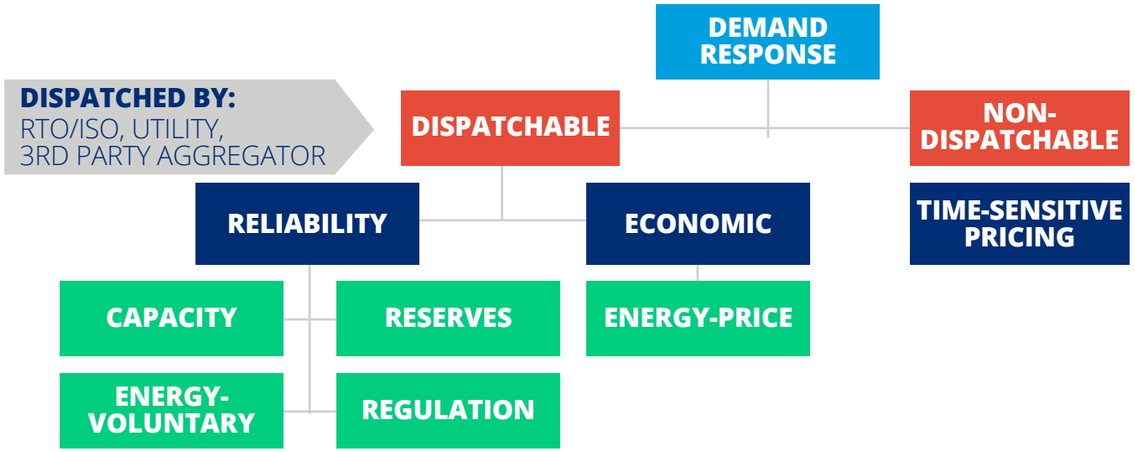
Last year's 2017 Utility Demand Response Market Snapshot was SEPA's first Market Snapshot on the topic area, and thus served as more of a DR primer. The 2018 report builds upon that content with expanded utility coverage (from 105 to 155 survey participants), updates on DR in the wholesale markets, and a fresh take on market trends in the industry. While readers may choose to read this report cover to cover, the material here is broken out in a format to allow readers to reference content quickly.

Key topic areas include:

- **Utility DR Market Summary:** This section includes results from SEPA's annual Utility Survey, updates by utility DR program type and customer segment (e.g., thermostat programs, water heaters), and policy updates.
- **Wholesale DR Market Summary:** This section draws from Navigant's research and includes a market summary and analysis on DR changes in the wholesale markets.
- **DR Market Trends:** The last portion of this report provides short summaries on DR market trends, such as time-varying rates, electric vehicles, energy storage, non-wires alternatives (NWA), natural gas DR, and customer engagement.

Coverage: The survey effort continues to focus on capturing controllable and dispatchable DR resources deployed by utilities through December 31, 2017 for this year's report. This year's 155 utility survey participants represented 62.4% of total U.S. customer accounts—89.5 million customers. Data collected through this survey did not include third-party providers or aggregators, regional transmission organizations (RTOs), or independent system operators (ISOs). However, a more complete picture of the demand response market, including efforts by third-party providers, and ISOs and RTOs, is provided in this report through Navigant Research, content from PLMA's 36th and 37th conferences, and secondary research.

FIGURE 1: SEPA 2018 DEMAND RESPONSE SURVEY SCOPE



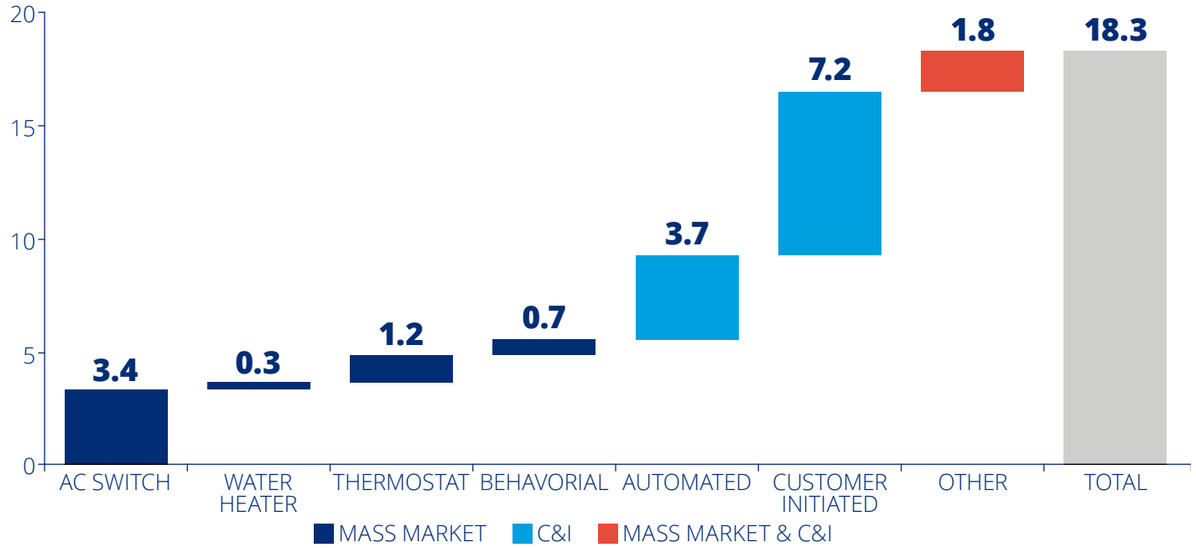
SEPA DEFINITION FOR DEMAND RESPONSE

Changes in electric load— reductions, increases, or shifts—by end-use customers or by control from the utility from 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.

National Utility Demand Response Market

SEPA's 2018 Utility Survey captured dispatchable DR across the mass market and commercial and industrial (C&I) customers representing approximately 648.6 GW of aggregated peak demand.[3] Utility participants reported 18.3 GW of enrolled DR capacity in 2017, broken down by program and market segment in Figure 2.

FIGURE 2: 2017 ENROLLED DEMAND RESPONSE CAPACITY BY PROGRAM TYPE (GW)



Source: Smart Electric Power Alliance, 2018. N=155. (Note: This figure represents total capacity collected in SEPA's Annual Utility Survey in 2018. Results are based on responses from 155 utilities. See Methodology for more details.)

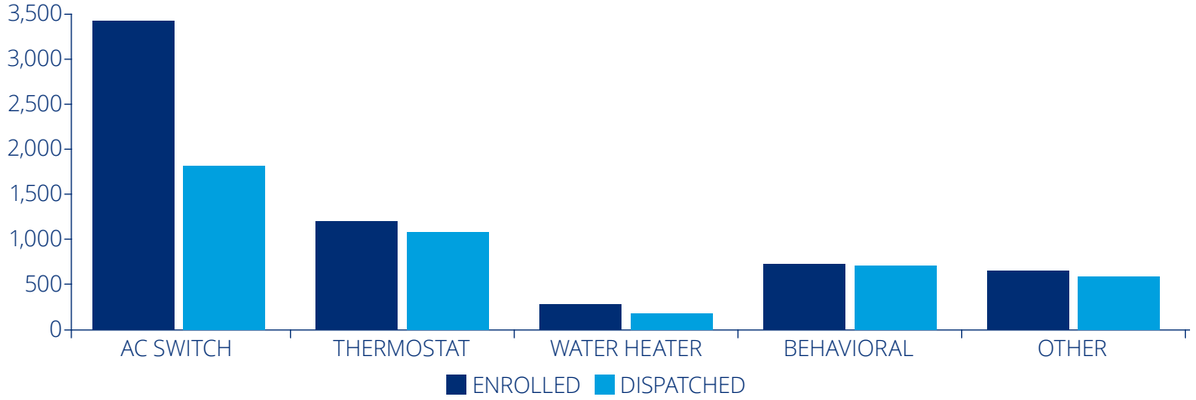
- **Enrolled capacity:** 18.3 GW, representing 2.8% of peak demand across the 155 utilities surveyed.[4]
- **Dispatched capacity:** 10.7 GW, or 58% of enrolled capacity.[5]
- **Mass Market:**
  - The mass market reported a total of 6.3 GW, and 35% of total reported enrolled capacity.
  - AC switch programs accounted for the largest portion of enrolled mass market DR capacity (3.4 GW), followed by thermostat, behavioral, and water heater programs.
  - Small to medium business (SMB) customers, typically folded into the mass market segment, have become a growing market segment of interest for DR program recruitment. While SEPA's survey did not collect data on this segment alone, feedback from industry experts indicates that this is a market opportunity that may deserve more attention in the future.
- **Commercial and Industrial (C&I):**
  - Over half of reported enrolled DR capacity fell within the C&I market segment.
  - 39.2% of total reported enrolled capacity fell under customer-initiated C&I DR programs.

3 Aggregated peak demand was determined based on 155 utilities' reported peak demand in EIA 861.

4 Percentage peak demand was calculated based on the enrolled DR capacity that 155 utilities reported in SEPA's survey and utilities' reported peak demand in EIA 861.

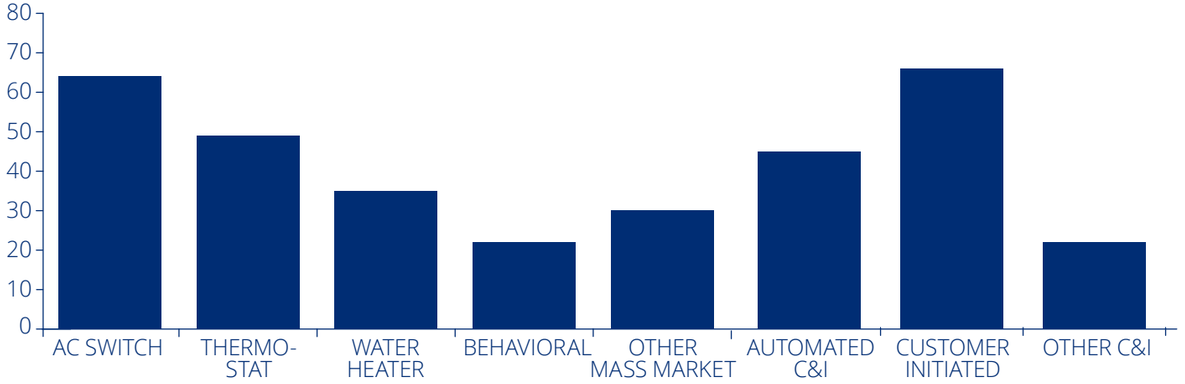
5 Note that a number of utilities were unable to report dispatched capacity due to challenges in measurement and verification or lack of dispatch in 2017.

FIGURE 3: 2017 REPORTED MASS MARKET DEMAND RESPONSE CAPACITY (MW)



Source: Smart Electric Power Alliance, 2018. N=155, N denoting utility responses. (Note: This figure represents total capacity collected in SEPA's Annual Utility Survey in 2018. Results are based on responses from 155 utilities. See Methodology for more details.)

FIGURE 4: UTILITIES' DEMAND RESPONSE PROGRAM OFFERINGS BY TYPE



Source: Smart Electric Power Alliance, 2018. N=155.

- **Other:** Due to the wide range of utility DR programs that exist, utilities reported additional programs under the "other" category, which included a range of mass market and C&I programs, including ice thermal storage, electric storage, heat pumps, pool pumps, irrigation control, emergency dispatch, and electric vehicle (EV) smart charging programs.
- Within the mass market segment, AC switch programs continue to make up 54.4% of total enrolled mass market capacity.
- Approximately 1.38 million customers were enrolled in thermostat programs across 49 utilities, a total of 1.2 GW of capacity.
- The large majority of respondents indicated that utilities are calling on most mass market programs (e.g., AC switch, thermostats, thermal storage) primarily to defer or replace generation capacity. Additional reasons include: encouraging economical energy use and deferring transmission and distribution (T&D) capacity. The exception to this general trend is mass market behavioral programs, in which economical energy use—rewarded through time-varying rates—was cited as the primary purpose.
- Of the 155 utilities that participated, only 34 utilities (21.9% of survey participants) had no DR programs.
- Furthermore, of the 121 utilities with a DR program, 97 utilities had a Mass Market program and 95 had a C&I program.
  - 71 utilities had both C&I and mass market programs.
  - 26 utilities had only mass market programs.
  - 24 utilities had only C&I programs.

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AC SWITCH PROGRAMS

AC switch programs are an established and traditional form of DR available to utilities for the past few decades. Many of these legacy programs rely on one-way communicating devices (e.g., one-way radio paging).

KEY TRENDS:

- Enrolled AC switch capacity: 3,428.2 MW.
  - Almost 18.7% of total enrolled capacity came from mass market AC switch programs.
- Dispatched AC switch capacity: 1,821.3 MW.
- Out of the 64 utilities indicating they had AC switch programs in SEPA's Utility Survey, utilities reported calling on these programs on average eight times in 2017.
- Six utilities indicated they are piloting programs.
- The average duration of an event called was 2.8 hours.
- Utility respondents indicated these programs function predominantly to help defer or replace generation capacity.
- Utilities also mentioned that AC switch DR served to defer or replace transmission and capacity, encourage economic energy use, and provide operating reserves.

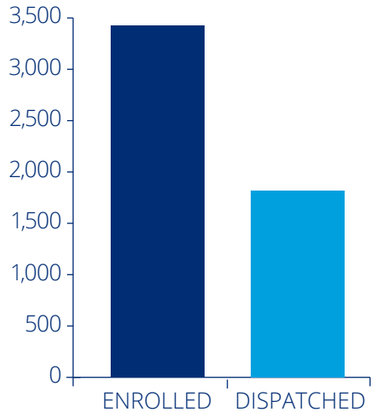
FIGURE 5: 2017 UTILITY AC SWITCH PROGRAM SUMMARY

52 UTILITIES CALLED ON AC SWITCHES DURING DR EVENTS IN 2017

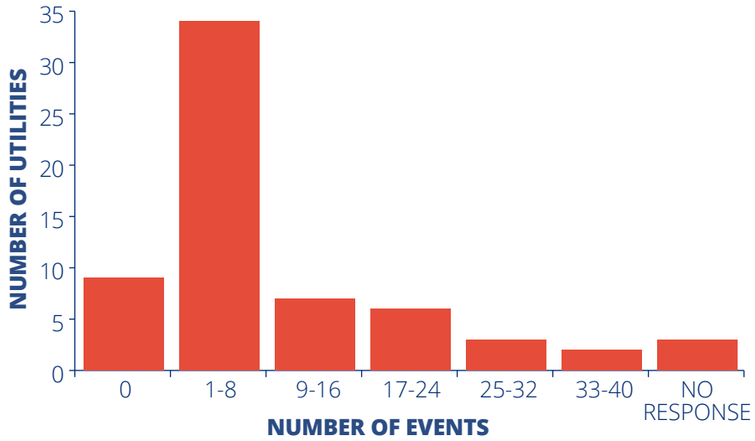
8 THE AVERAGE NUMBER OF EVENTS CALLED BY UTILITIES IN 2017

4,061,306 CUSTOMERS ENROLLED IN AC SWITCH PROGRAMS

2017 REPORTED AC SWITCH CAPACITY (MW)



NUMBER OF AC SWITCH EVENTS CALLED BY UTILITIES IN 2017



Source: Smart Electric Power Alliance, 2018. N=64.

LEGACY AC SWITCH PROGRAMS MOVE INTO THE 21ST CENTURY

A number of utilities are beginning to upgrade one-way switch technologies to increase system reliability and improve processes. These upgrades are expanding utilities' ability to call on these devices and track their performance.

TABLE 1: 2017 AC SWITCH PROGRAM UPGRADE HIGHLIGHTS	
DETROIT EDISON (DTE)	For over three decades, DTE has used legacy AC-switch programs, with technology based on a one-way radio paging communication system to cycle air conditioners on and off in 15-minute increments. In 2013, in response to changing market forecasts, DTE began investigating the system and found that 30% to 40% of these devices did not have power or did not respond to paging. In 2015, DTE began to take one-way switches out of the field to update with two-way Zigbee devices on an Itron AMI network. DTE continues to replace all of the 275,000+ existing switches.[6]
DAIRYLAND POWER COOPERATIVE	Dairyland Power Cooperative, a G&T electric cooperative, coordinates the operation of a load management system as a shared service for its member cooperatives to enable both demand and energy-based strategies. The load management system employs digital, one-way paging communications to approximately 130,000 receivers that can respond to an event and achieve demand reductions ranging from 8-12% of Dairyland's seasonal system peaks. Recent integrations between its load management system and SCADA system have allowed Dairyland to improve visibility of system health and leverage advanced controls for event-based conservation voltage reduction.[7]

Source: Smart Electric Power Alliance, 2018.

Benefits realized:

- Avoiding the need to roll a truck to control and dispatch localized loading issues along the distribution system, resulting in reduced costs.
- The ability to call on these devices and customers' load every day, providing expanded operational resources, as opposed to only calling on DR for emergency events.
- Greater control down to the feeder level, enabling greater flexibility along the distribution system.

Challenges ahead:

- Developing business cases and determining when programs are cost-effective (e.g., minor retrofit versus full swap).
- Improving interoperability and getting disparate, proprietary systems to work in unison with one another.
- Overcoming silos within utility groups.
- Keeping up with the continuing evolution of DR and the industry itself.

6 Derek Kirchner, DTE, Leveraging Legacy Technology Platforms for the New DR World, 37th PLMA Conference, April 2018, www.peakload.org/37th-conf-resources.

7 Mitch Vanden Langenberg, Dairyland Power Cooperative, Leveraging Legacy Technology Platforms for the New DR World, 37th PLMA Conference, April 2018, www.peakload.org/37th-conf-resources.

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ELECTRIC WATER HEATER PROGRAMS

Electric water heaters with switches constitute a widespread and low-cost storage opportunity. However, participants in SEPA's Utility Survey indicated that electric water heater DR programs only account for a small portion of total reported enrolled DR capacity (1.5%), with total enrolled capacity across over 150 utilities of 280.6 MW.

KEY TRENDS:

- Enrolled water heater capacity: 280.6 MW.
- Dispatched water heater capacity: 180.6 MW.
- Thirty-five utilities indicated having electric water heater programs. Water heaters were called on significantly more frequently on average than any other DR program type (average of about 61 times per utility in 2017).
- Five utilities indicated they are piloting programs, and three indicated programs are planned for 2018 or later.
- The utilities with water heater programs that responded to SEPA's survey reported that the primary purpose for calling on water heaters was to defer or replace generation capacity.

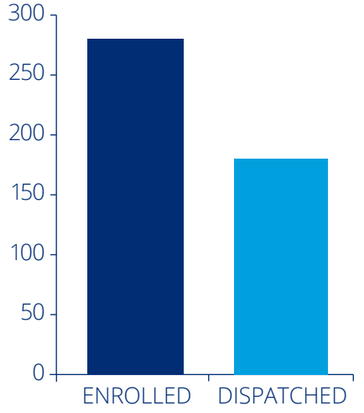
FIGURE 6: 2017 UTILITY ELECTRIC WATER HEATER PROGRAM SUMMARY

24 UTILITIES CALLED ON ELECTRIC WATER HEATERS DURING DR EVENTS IN 2017

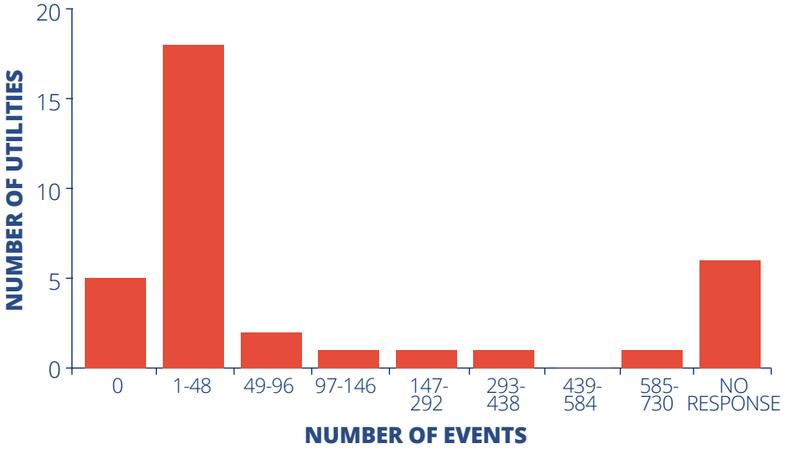
61.3 THE AVERAGE NUMBER OF EVENTS CALLED BY UTILITIES IN 2017

1,256,032 CUSTOMERS ENROLLED IN WATER HEATER PROGRAMS

2017 REPORTED ELECTRIC WATER HEATER (MW)



NUMBER OF ELECTRIC WATER HEATER EVENTS CALLED BY UTILITIES IN 2017



Source: Smart Electric Power Alliance, 2018. N=35.

UNLOCKING THE POTENTIAL OF WATER HEATERS

A number of utilities with existing water heater programs are exploring the value of two-way communication through grid-interactive water heater (GIWH) pilots. Beyond utilities, third-party aggregators are also beginning to dispatch residential electric water heaters directly from consumers to the grid, independent of utilities, to participate in the wholesale markets. As utilities and third-party aggregators continue to adopt GIWHs, they will have the opportunity to retrofit or replace existing water heaters with these new systems.

TABLE 2: ELECTRIC WATER HEATER TECHNOLOGY OPTIONS

TRADITIONAL WATER HEATERS	GRID-INTERACTIVE WATER HEATERS (GIWHs)
Standard one-way, direct load control of water heaters. ▪ Allows the utility to shift load and turn water heaters on and off during desired time periods.	Bi-directional communications added to electric water heaters. ▪ Enables charging of water heater before and after an event. ▪ Allows rapid control in response to market prices and renewable generation availability. ▪ Enables quick scaling of water heater fleet into flexible energy storage.

Source: Smart Electric Power Alliance, 2018.

TABLE 3: WATER HEATER PROGRAM HIGHLIGHTS

HAWAIIAN ELECTRIC	Technology type: one-way water heaters	Hawaiian Electric's EnergyScout program is currently fully subscribed, installing free devices that turn off customers' water heaters during peak usage, typically for an hour or less. Customers get a bill credit each month for participating regardless of events called. Over 30,000 customers have participated to date, contributing to approximately 12 MW of enrolled DR capacity.
MOSAIC POWER	Technology type: GIWH	Mosaic Power currently aggregates 15,000 residential water heaters to provide up to 11 MW of regulation services to 11 of PJM's 17 pricing zones. Mosaic shifts the electricity used by thousands of water heaters by seconds, minutes, and hours, and uses behavioral analytics to keep customers comfortable while dispatching their load.[8]
GREEN MOUNTAIN POWER & AQUANTA	Technology type: GIWH	Green Mountain Power's eWater program has over 500 subscribers and leverages Aquanta's smart water heater controller to aggregate water heating for grid services. Conversely the device also has the capability to override utility commands to account for customer preferences.[9]

Source: Smart Electric Power Alliance, 2018.

8 Mosaic Power, 2018.

9 Herman Trabish, Utility Dive, "Utilities in hot water: Realizing the benefits of grid-integrated water heaters," June 20, 2017, https://www.utilitydive.com/news/utilities-in-hot-water-realizing-the-benefits-of-grid-integrated-water-hea/445241/

THERMOSTAT PROGRAMS

Utilities have been operating thermostat-based DR programs for years. These programs typically include:

- Programmable communicating thermostats (PCTs) receiving paging signals from the utility.
- Connected thermostats capable of receiving DR control signals.

KEY TRENDS:

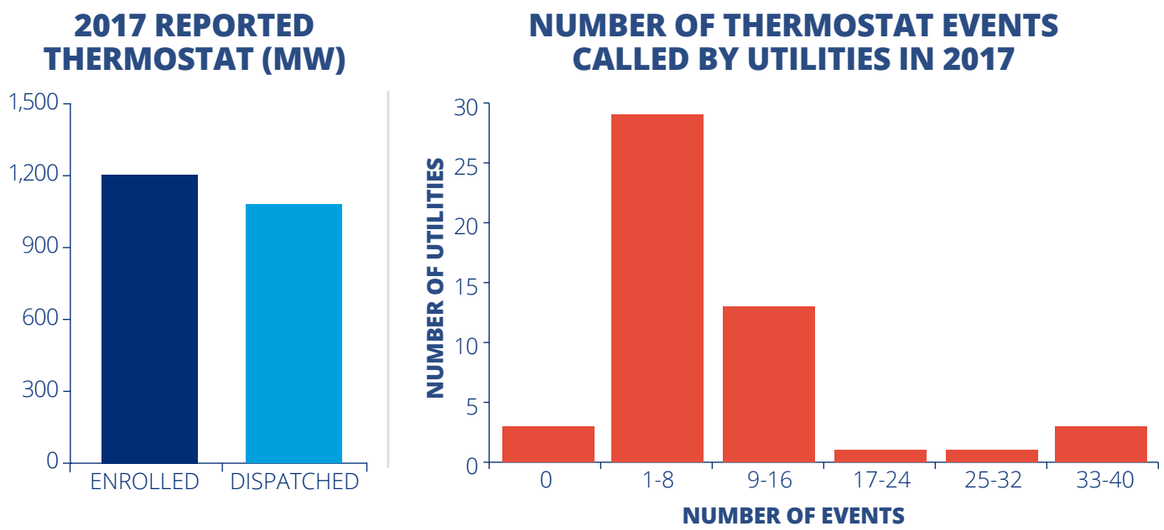
- Enrolled thermostat capacity: 1,204 MW.
- Dispatched thermostat capacity: 1,080.6 MW.
- On average, thermostat programs were called on nearly eight times by utilities in 2017.
- In SEPA's annual Utility Survey, 49 utilities indicated having a thermostat program, with 47 calling on thermostats for DR events.
  - Reported programs represent a range of thermostat technologies and delivery models, including PCT, smart-communicating, direct install, and bring your own thermostat (BYOT) programs.
- Some utilities offer combinations of switch-based and WiFi thermostat programs to satisfy different customer preferences in addition to different delivery models (i.e., direct-install, self-install, BYOT).
- Survey participants indicate adoption of thermostat programs will continue to expand, with 13 utilities reporting thermostat pilot programs and eight utilities indicating programs will be implemented in 2018 or beyond.

FIGURE 7: 2017 UTILITY THERMOSTAT PROGRAM SUMMARY

47 UTILITIES CALLED ON THERMOSTATS DURING DR EVENTS IN 2017

8.39 THE AVERAGE NUMBER OF EVENTS CALLED BY UTILITIES IN 2017

1,375,859 CUSTOMERS ENROLLED IN THERMOSTAT PROGRAMS



Source: Smart Electric Power Alliance, 2018. N=49. (Please note that two utilities indicated having multiple thermostat programs with different data associated with each program.)

SMART THERMOSTATS CHANGING THE GAME FOR DR PROGRAMS

Trends and Opportunities

- **Increasing trend of consumers purchasing "smart," or connected, thermostats capable of receiving DR control signals.** The proliferation of customers with smart thermostats, coupled with BYOT programs, is expanding the pool of DR-eligible participants much more than the direct-install approach. In addition, WiFi networks have become nearly ubiquitous.
- **Customer enrollment barriers are lower in a BYOT approach**, which in turn provides opportunities for expanding program participation beyond what DR programs traditionally achieved with only a direct-install approach. BYOT also allows for customer choice of thermostat type and brand.
- **The SMB market:** Connected thermostats are now making it possible for small and medium-sized business customers to avoid expensive energy management systems previously required for these customers to participate in DR programs through the installation of multiple thermostats in their facilities connected through the cloud.
- **Residential customers:** The draw for this market is that direct-install and BYOT programs may appeal to residential customers who do not want an outside electrician to install a switch on their AC unit and want the ability to opt out of DR events.
- **Use cases are increasing, and implementation costs are declining**, which make smart thermostats more attractive for DR. Substantial energy efficiency (EE) savings could also be realized through the coordination of multiple connected smart thermostats at a business location.
- **Smart thermostats are becoming a part of connected, "whole home" or "whole building" solutions.** Smart thermostats are increasingly being bundled with customized packages of other non-energy smart home products and services. At the same time, BYOT is evolving to include connected "things" (e.g., grid-connected water heaters, EV charging stations, and smart plugs). For commercial facilities, thermostats can be connected to other services, such as weather feeds and building management services.
- **Utilities can jointly market EE and DR programs:** Smart thermostats provide opportunities for utilities to market EE and DR programs jointly under an integrated demand-side management (iDSM) banner, instead of as separate, siloed programs. These devices provide significant joint benefits for EE and DR customers, which in turn expands the DR target market base to a wider pool of energy efficiency participants.

Ongoing Challenges

- **Higher opt-out rates with BYOT:** BYOT programs typically have higher opt-out rates than traditional direct install DR programs, creating associated challenges for customer recruitment and retention.[10]
- **Customer choice and flexibility:** Cellphone and tablet apps for controlling smart thermostats open up significant, wider opportunities for customer engagement. Customers can manage their energy consumption in response to TOU rates via pre-cooling and pre-heating strategies, for example.[11]

10 While results from SEPA's survey indicated a small difference between dispatched and enrolled capacity for thermostat DR programs, this information was aggregated. Individual utility responses offering both PCT programs and BYOT programs indicated higher opt-out rates for BYOT programs.

11 Summarized from the PLMA report on "The Future of Utility BYOT Programs- A Compendium of Industry Viewpoints," edited by PLMA Thermostat Interest Group, March 2018. https://www.peakload.org/assets/Groupsdocs/PractitionerPerspectives-UtilityBYOTPrograms-March2018.pdf

NEST THERMOSTATS SUPPLEMENTING THE SUN—WIDESPREAD OPT-IN DURING KEY EVENT

During the solar eclipse on Aug. 21, 2017, many grid operators feared that solar energy production would be reduced, by as much as 9 GW. Leading up to the eclipse, Nest launched a wide-reaching marketing campaign to recruit hundreds of thousands of its customers in an initiative to reduce their cooling energy use during the eclipse by opting into a special Rush Hour Rewards event with one click on their Nest thermostat. As a result, 700 MW of energy was saved across the country.[12]

TABLE 4: 2017 THERMOSTAT PROGRAM HIGHLIGHTS

XCEL ENERGY AC REWARDS SMART THERMOSTAT PROGRAM	**Multipronged enrollment channels** Xcel Energy in Colorado and Minnesota offers its AC Rewards Smart Thermostat program. The program stands out for its multipronged enrollment channels—BYOT, and direct and self install options.	**Program details:** ▪ BYOT customers with qualified thermostats receive a one-time, $75 bill credit on enrollment. ▪ Direct-install customers get a thermostat and installation for free. ▪ Self-install customers can purchase qualified thermostats via Xcel Energy's online marketplace for an instant, $75 rebate applied at checkout, and receive a one-time, $50 bill credit once installation and enrollment are completed. ▪ All customers get an annual, $25 bill credit for program participation. ▪ Customers can opt out of DR events any time, either through a mobile app, web portal or the thermostat. ▪ Customer AC is typically controlled between 3 p.m. and 7 p.m., from June through August. Only select ecobee and select Honeywell models currently qualify for participation. AutoGrid is the demand response management system (DRMS) provider for Xcel Energy.
BALTIMORE GAS & ELECTRIC (BGE) PEAKREWARDS SMART THERMOSTAT PROGRAM	**Dual enrollment and successful customer engagement** BGE successfully piloted a smart thermostat program in 2015, followed by the launch of its PeakRewards Smart Thermostat program in 2017. Customers in this direct install program get a free thermostat installed in their homes. The utility uses direct mail, email, and digital advertising to market and conduct outreach to customers.	**Program details:** ▪ Customers can receive a bill credit of between $50 and $200 for AC control from June through September. The incentive level varies by the cycling level—50%, 75%, or 100%. ▪ The program has enrolled 11,200 customers, representing 14,000 thermostats, and delivering 21 MW of demand reduction.[13] ▪ Participants report a high level of program awareness and satisfaction. ▪ BGE customers can simultaneously enroll in PeakRewards and another peak-time rebate program, called Smart Energy Rewards. The Smart Energy Rewards program provides a bill credit of $1.25 per kilowatt-hour (kWh) for energy savings compared to baseline usage during the peak period. If customers are enrolled in both programs, they receive whichever credit is higher each month.

Source: Navigant, Smart Electric Power Alliance, 2018.

12 Nest, 2018.

13 BGE Peak Rewards Smart Thermostat Program", presented by Amanda Janaskie, BGE Product Manager, at 37th PLMA Spring Conference, www.peakload.org/37thconf.

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BEHAVIORAL PROGRAMS

As behavioral DSM has matured over the last 10 years, a growing body of evidence is showing that these types of programs work and that the savings persist over time. This experience and evidence are increasing the confidence of utilities and regulators in the effectiveness of behavioral DSM programs more generally. The increased confidence has led to more utility behavioral programs, as well as more vendors offering behavioral solutions.

KEY TRENDS:

- Enrolled behavioral capacity: 734.5 MW.
- Dispatched behavioral capacity: 710.9 MW.
- Twenty-two utility survey respondents offered behavioral DR programs to their customers in 2017.
- Utilities use a wide range of methods to communicate with customers. Survey respondents indicated email was the most popular communication method, followed by text message, phone calls, utility apps, and social media.

BEHAVIORAL DR DEFINITION

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

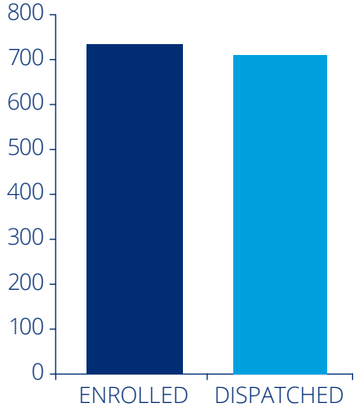
FIGURE 8: 2017 UTILITY BEHAVIORAL PROGRAM SUMMARY

20 UTILITIES LEVERAGED BEHAVORIAL PROGRAMS DURING DR EVENTS IN 2017

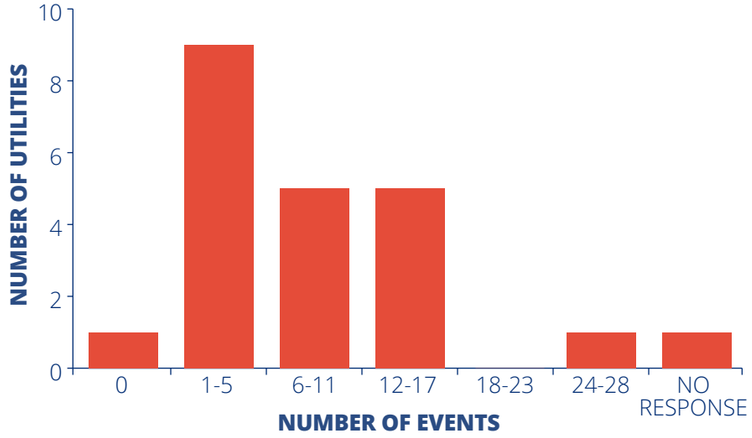
7.4 THE AVERAGE NUMBER OF EVENTS CALLED BY UTILITIES IN 2017

2,824,054 CUSTOMERS ENROLLED IN BEHAVIORAL PROGRAMS

2017 REPORTED BEHAVIORAL PROGRAMS (MW)



NUMBER OF BEHAVIORAL EVENTS CALLED BY UTILITIES IN 2017



Source: Smart Electric Power Alliance, 2018. N=22.

TABLE 5: 2017 BEHAVIORAL PROGRAM HIGHLIGHTS	
NATIONAL GRID AND ORACLE INCENTIVIZE CUSTOMERS WITH POINTS AND REWARDS	National Grid partnered with Oracle in 2017 to carry out a behavioral pilot program at Clifton Park in New York that combined National Grid's Peak Time Rebates program with points and rewards. Over the 2017 summer, seven peak events were called and customer satisfaction and participation rates were measured. Customers received personalized tips to save energy during events. This pilot boosted customer engagement with a number of customers opting-in to the program. This pilot gave customers incentives without having to change their billing system. This combined approach led to higher average reduction than typical behavioral-only programs.[14]
PACIFIC GAS AND ELECTRIC (PG&E) HOME ENERGY REPORTS AND BEHAVIORAL DR STUDY	PG&E partnered with Opower (now part of Oracle) to implement its Home Energy Reports (HER) program, which provides approximately 1.5 million residential customers with an online platform to view their energy usage and alert customers when their bills are approaching certain high levels. PG&E leveraged the platform to implement a two-year, behavioral DR study in early 2017, which sought to encourage customer participation during peak hours on high-demand days. The study found behavioral DR can provide relatively small load reduction (1-2%) but can make sense when deployed across large numbers of customers. Other lessons include: ▪ Utilities should avoid calling events on consecutive days. ▪ Email is an easier and quicker communication method. ▪ Behavioral DR can be launched relatively quickly in targeted areas if needed.[15]

Source: Smart Electric Power Alliance, 2018.

KEY TRENDS:

- Utilities notify their customers of upcoming events predominantly through email, text message, and by phone, with a smaller subset leveraging utility apps and social media.
- Program administrators are leveraging new apps and in-home displays that provide real-time feedback and energy savings tips.
- Some utility program administrators are gamifying energy savings in their behavioral programs to increase customer engagement.[16]
- Solution providers are helping to pioneer new ways of engaging customers.

14 Customer Motivators: Demonstrating the Value of Smart Meters with Peak Time Rewards, Fouad Dagher, National Grid, and Caitlin Hewlitt, Oracle Utilities, April 2018, 37th PLMA Conference, www.peakload.org/37thconf

15 Evaluation of PG&E's Two-year Behavioral Demand Response Study, Wendy Brummer, PG&E, and Josh Schellenberg, Nexant, April 2017, 35th PLMA Conference, www.peakload.org/35thconf.

16 Gamification of energy savings is defined as when utilities turn saving energy into a game (i.e., using features of games to accomplish real-world objectives). For example, when customers answer a question about ways to save energy correctly, they receive points as they compete with other customers to get the highest score. Some players in these games may win a reward, but it is not a guarantee for all participants. Part of the goal of gamification of energy savings is to make it fun and provide entertainment for the customer.

C&I DEMAND RESPONSE PROGRAMS

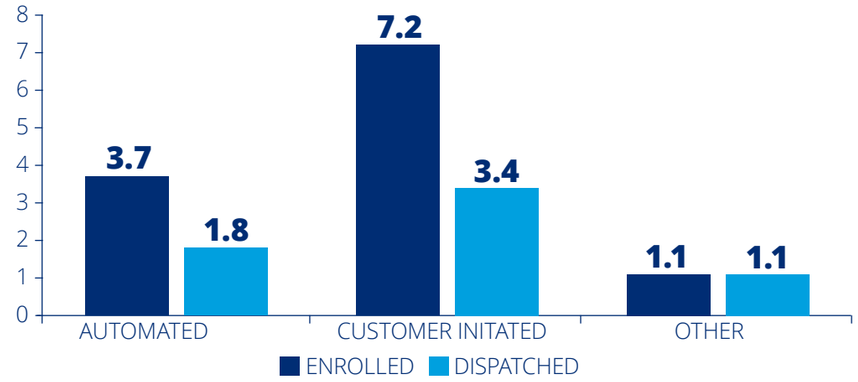
Commercial and industrial (C&I) customers contributed to a significant portion (65.5%) of enrolled DR in 2017, with reported enrolled capacity from automated and customer-initiated programs totaling 12 GW.

KEY INSIGHTS:

- Forty-five utilities reported automated commercial and industrial (C&I) demand response programs in their service territories totalling 3,717 MW of enrolled capacity (20.3% of total reported 2017 enrolled capacity in SEPA's Annual Utility Survey). Thirty-six utilities called events in 2017, with an average of 26 events called.
- Sixty-six utilities reported customer initiated C&I DR programs, contributing to 39% of total reported 2017 enrolled capacity in SEPA's annual Utility Survey (7.2 GW).[18] Forty-four utilities called events, with an average of 9.1 events called.

Case Study: Hawaiian Electric Company's fast DR program allows customers to participate in the program if they are able to curtail load with as little as 10-minute notice. The program has two activation methods: semi-auto DR and auto DR. For the semi-auto DR activation method, the building operator will receive notification and can then adjust their loads accordingly. For the auto DR activation method, Hawaiian Electric sends a signal to the building through a Demand Response Automation Server. After receiving the signal, the building initiates a predefined routine to curtail demand. At a minimum, each customer must commit 50 kW for load reduction. There are financial benefits for committing load and actual load reduced during an event. Maui Electric Co., a subsidiary of Hawaiian Electric, received regulatory approval in July 2017 to increase its fast DR pilot program from 0.2 MW to 5 MW.

FIGURE 9: REPORTED C&I DEMAND RESPONSE CAPACITY BY PROGRAM TYPE (GW)



Automated N = 45, Customer Initiated = 66, Other = 22.[17]

TABLE 6: C&I PROGRAM SUMMARIES

	AUTOMATED	CUSTOMER INITIATED	OTHER
NUMBER OF UTILITIES CALLING EVENTS	36	44	12
TOTAL NUMBER OF CUSTOMERS	59,873	29,745	7,365
AVERAGE NUMBER OF EVENTS CALLED	26.1	9.1	5.9

Source: Smart Electric Power Alliance, 2018. N=155.

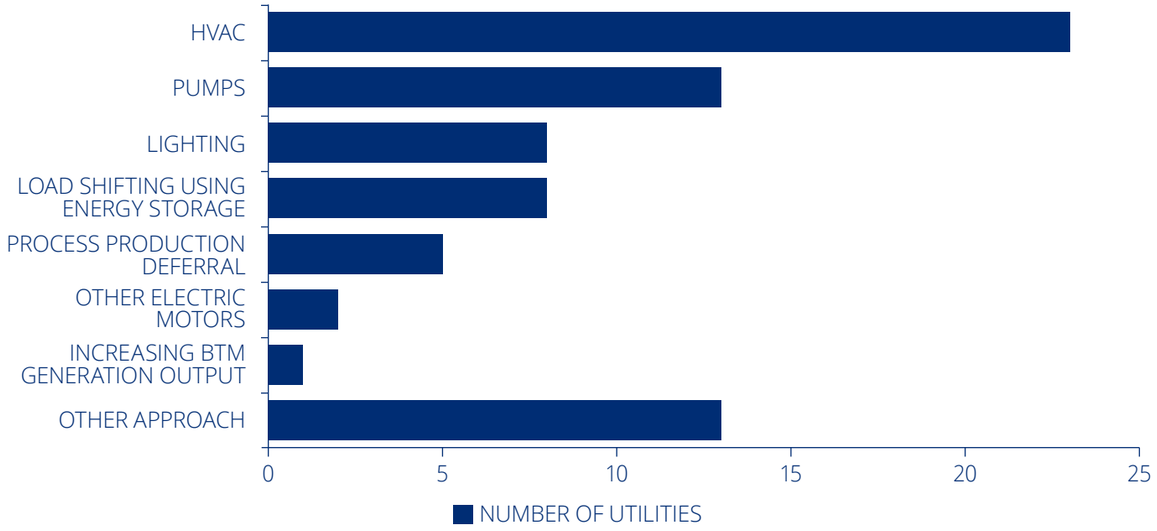
17 Note: Aggregated dispatched capacity in Figure 9 appears significantly lower than enrolled capacity based on this year's survey respondents. While some respondents reported a lower dispatched capacity than enrolled, others could not or did not report dispatched capacity numbers.

18 Note, one large respondent included TVA, accounting for 150 utilities in their service territory.

AUTOMATED DEMAND RESPONSE

C&I customers enrolled in automated DR predominantly reduced their demand through HVAC and pumps, followed by lighting, and load shifting through energy storage, as illustrated in Figure 10.

FIGURE 10: AUTOMATED DEMAND REDUCTION APPROACH BY PROGRAM TYPE



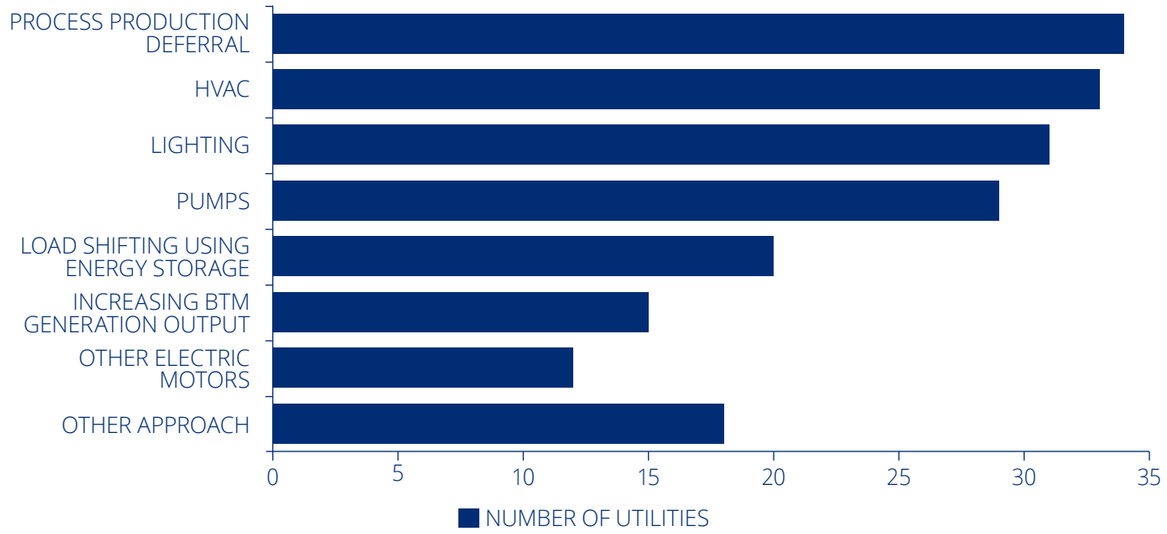
Source: Smart Electric Power Alliance, 2018. N=37. (Note that not all utilities that have automated programs responded to this survey question.)

The primary purposes for calling on automated DR programs were to defer or replace generation capacity, as well as to provide operating reserves.

CUSTOMER INITIATED C&I

In contrast with automated C&I DR programs, the majority of customers are achieving their demand reduction through process or production deferral, followed by lighting, HVAC, and pumps.

FIGURE 11: CUSTOMER-INITIATED DEMAND REDUCTION APPROACH BY PROGRAM TYPE



Source: Smart Electric Power Alliance, 2018. N=55. (Note that not all utilities that have customer-initiated programs responded to this survey question.)

The primary purposes for calling on customer-initiated DR programs were to defer or replace generation capacity, followed by providing operating reserves, encouraging economical energy use, and for regulation services.

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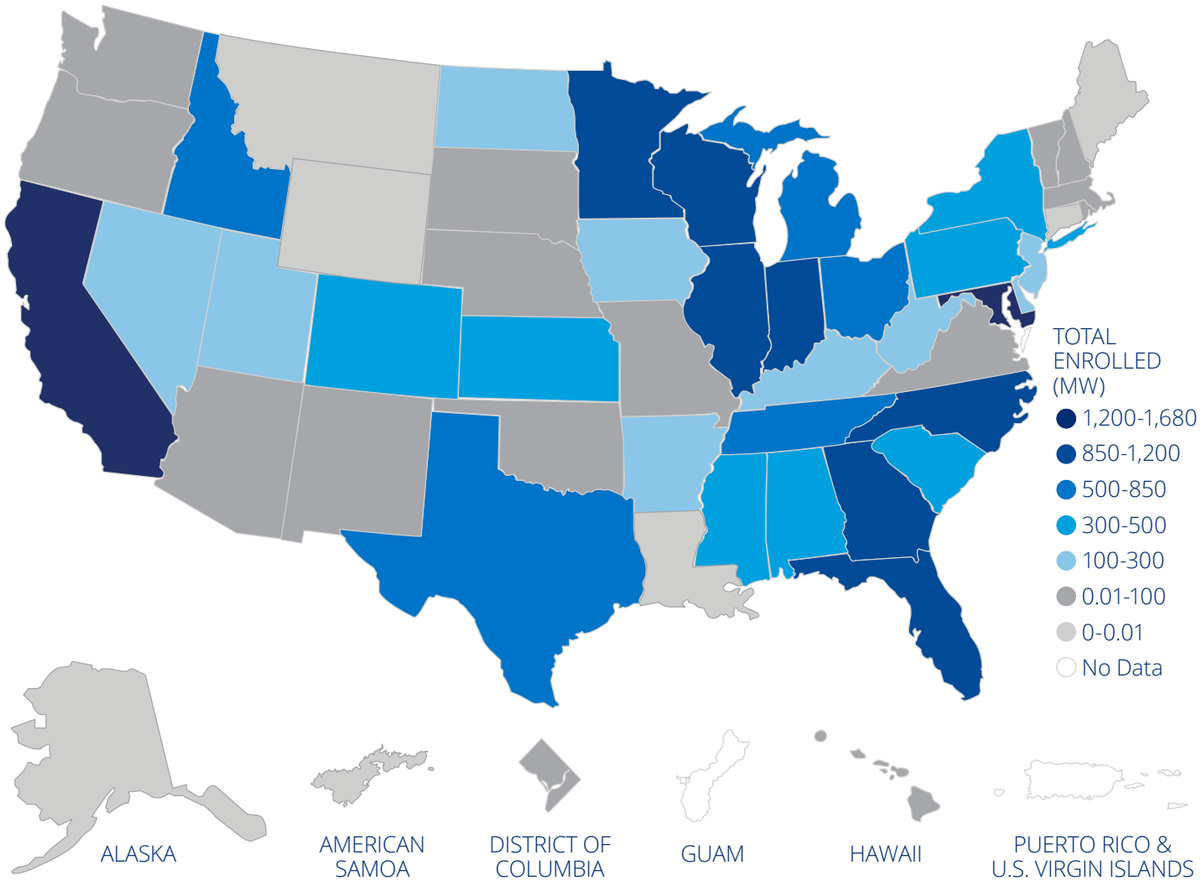
STATE-LEVEL HIGHLIGHTS

- California utilities contributed to 8% of total reported enrolled capacity nationwide, with most of the capacity enrolled through AC switch, thermostat, behavioral, and C&I programs.
- In the Southeast, Florida utilities (e.g., Florida Power and Light, Tampa Electric) and the Tennessee Valley Authority are dispatching a significant amount of DR capacity from C&I customers. Florida dispatched 753.6 MW of C&I demand reduction in 2017. TVA dispatched a total of 665 MW of C&I demand reduction across their six-state service territory.
- Utilities in Maryland (i.e., Baltimore Gas & Electric and Pepco) have a significant amount of behavioral DR enrolled capacity (529 MW).
- Texas municipal utilities continue to lead the way in "Bring Your Own Thermostat" (BYOT) programs, taking advantage of the competitive retail electric supply market in the state.



Source: Smart Electric Power Alliance, 2018. (Note: This map represents total capacity collected in SEPA's Annual Utility Survey for calendar year 2017. Results are based on responses from 155 utilities. See Methodology in the appendix for more details and a list of participants.)

STATE-LEVEL POLICY HIGHLIGHTS

Several states are beginning to propose Clean Peak Standards, a new concept that builds upon the idea of Renewable Portfolio Standards (RPS). This concept aims to expand the percentage of energy deployed during peak-load hours coming from clean energy resources. It was introduced in Arizona and Massachusetts this past year.

- Arizona's Energy Modernization Plan, proposed on January 30, 2018, included a Clean Peak Standard requiring utilities to deliver renewable energy during peak electricity demand hours.[19]
- Massachusetts filed legislation on March 15, 2018 that requires retail suppliers to provide "a minimum percentage of kilowatt-hour sales to end-use customers" using clean peak energy resources. The legislation states that a Clean Peak Standard can include "Class I renewable energy generating sources, demand response resources, and energy storage systems."[20,21]

19 Gavin Blade, Utility Dive, "Arizona regulator proposes 80% clean energy mandate, 3 GW storage target," Jan. 30, 2018, http://utilitydive.com/news/arizona-regulator-proposes-80-clean-energy-mandate-3-gw-storage-target/515872/

20 Robert Walton, Utility Dive, "Massachusetts governor seeks Clean Peak Standard with $1.4B bond bill," March 15, 2018, https://www.utilitydive.com/news/massachusetts-governor-seeks-clean-peak-standard-with-14b-bond-bill/519254/

21 From "An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection, and Investment in Recreational Assets and Opportunity," Admin. Of Governor Charles Baker, March 15, 2018

DEMAND RESPONSE CAPACITY BY REGIONAL TRANSMISSION ORGANIZATION AND INDEPENDENT SYSTEM OPERATOR

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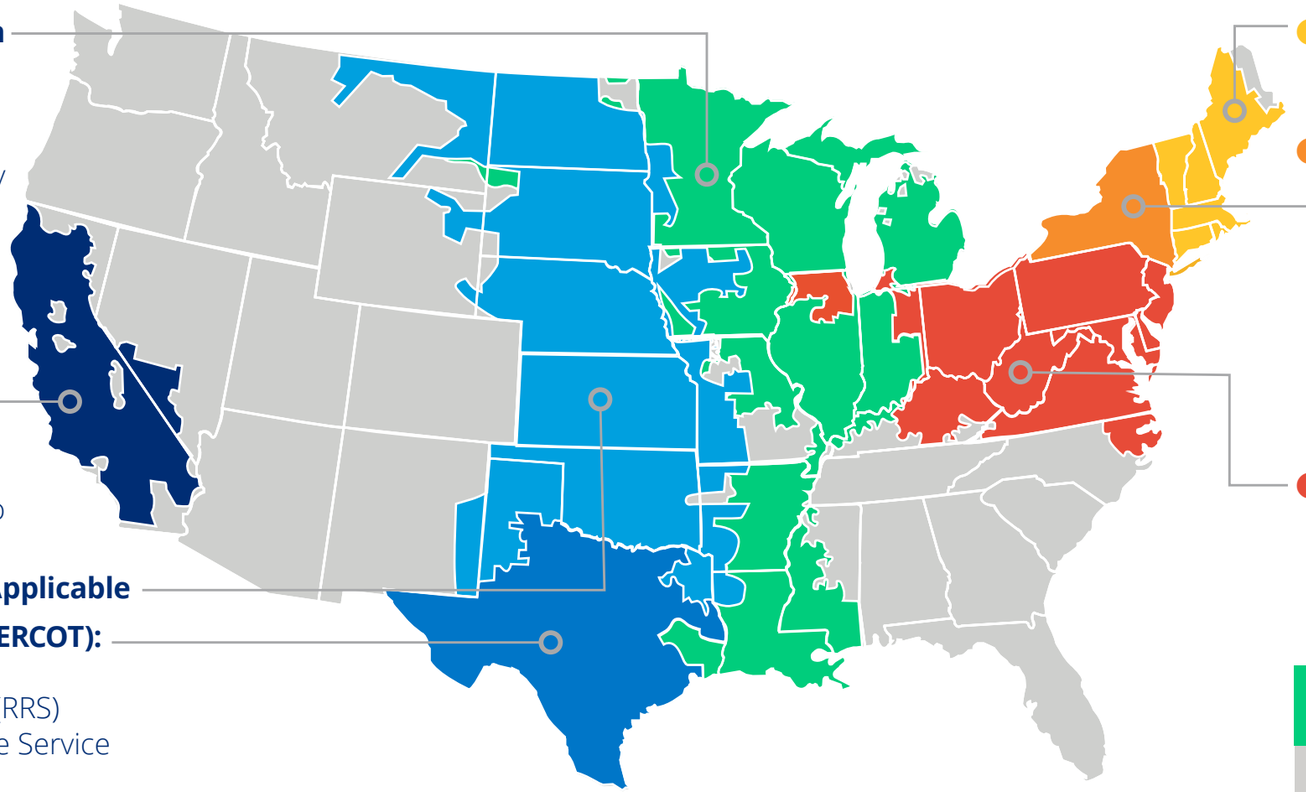
- **Midcontinent Independent System Operator (MISO): 6,014 MW** of demand response was cleared in the 2017-2018 planning resource auction results for meeting resource adequacy requirements. Note however that DR in the MISO market is primarily retail DR with utilities and is not actively traded in wholesale power markets unlike the other ISOs/RTOs.[22]
- **California Independent System Operator (CAISO): 1,023 MW** of total available capacity from reliability DR resources in 2017 was integrated into the CAISO market.[23]
- **Southwest Power Pool (SPP): Not Applicable**
- **Electric Reliability Council of Texas (ERCOT): 2,170 MW** in combination awarded in ERCOT's Responsive Reserve Service (RRS) and procured in Emergency Response Service (ERS) programs as of end of 2017.[24]



- **ISO New England: 750 MW** of DR assets were enrolled in the ISO-NE market in the summer of 2017.[25]
- **New York Independent System Operator (NYISO): 1,237 MW** of capacity was enrolled (as of July 31, 2017) in the two reliability-based programs, Emergency Demand Response Program (EDRP) and Installed Capacity-Special Case Resources (ICAP/SCR), offered by NYISO. The total enrolled amount represented 4.2% of the 2017 summer peak demand for NYISO.[26]
- **PJM Interconnection (PJM): 8,120 MW** of demand response was committed in the PJM market for the 2017/18 delivery year, which represents 4.2% of the total PJM committed capacity in that year.[27]

Source: Navigant, 2018.

NAVIGANT'S METHODOLOGY FOR ISO AND RTO DR CAPACITY

These numbers are based on publicly available data from the ISOs and RTOs and communication with ISO and RTO members. For PJM, NYISO, and ISO New England, the numbers shown are capacity market obligations. For MISO, ERCOT, and CAISO, they are a combination of the enrollment in the different DR programs that each RTO offers.

22 2018/2019 Planning Resource Auction Results April 13, 2018; MISO. This was the total amount of Demand Response cleared in the MISO market in 2017-2018.

23 2017 Annual Report on Market Issues and Performance, CAISO, page 37.

24 2017 Annual Report of Demand Response in the ERCOT Region; ERCOT. Includes approx. 1300 MW of awarded Responsive Reserve Service (RRS) and around 870 MW of ERS-30 and ERS-10 products.

25 Based on communication from ISO-NE.

26 NYISO 2017 Annual Report on Demand Response Programs. The total amount of enrolled MWs in EDRP and ICAP/SCR is reported on page 4 and represents the amount of enrolled capacity as on July 31, 2017.

27 2017 Demand Response Operations Market Activity Report: April 2018; Figure 15 on page 14 of the report shows the PJM Demand Response Committed MWs by Delivery year. We reported the numbers from 2017/18 Delivery Year.

DEMAND RESPONSE CAPACITY BY REGIONAL TRANSMISSION ORGANIZATION AND INDEPENDENT SYSTEM OPERATOR

Smart Electric Power Alliance

Demand response continues to participate in wholesale markets to provide energy, capacity, and ancillary services. Updates by region include:

- In **CAISO**, DR providers or aggregators and retail customers participate in the day-ahead and real-time energy markets, as well as the ancillary services market. The recently announced results for the 2019 Demand Response Auction Mechanism (DRAM) pilot for bidding retail DR into the wholesale market reported a total bid of 167 MW for both residential and non-residential DR. DRAM auctions are conducted by the utilities, but DRAM resources are required to bid into the CAISO market. CAISO continues to work with stakeholders to simplify wholesale market participation rules as DR integrates with CAISO's market operations. The California market is in the early stages of developing a load shift product that could be expanded to a load consumption product to facilitate increases in energy use by behind-the-meter resources, especially during hours of high solar generation.
- In **ERCOT**, loads controlled by high-set, under-frequency relays continue to dominate the number and capacity volume of DR resources that participate in the ancillary service market (Responsive Reserve). The market is also seeing a growing participation from energy storage in providing Fast Responding Regulation Services (FRRS). Both loads and small generators continue to participate in Emergency Responsive Services (ERS) that include 10-minute and 30-minute ramp products.
- In **NYISO**, the integration of DERs into markets continues to be the main driver in DR innovation for 2018. NYISO is engaged with stakeholders to develop detailed market designs and rules. The integration process was initiated in 2016. In 2017, NYISO published a DER Roadmap that describes its vision for integrating DERs into wholesale markets. Under NYISO's proposed DER market design concept, dispatchable DER resources are those that can respond in real time within 5-minute intervals.

  Existing DR assets participating in the Special Case Resources (SCR) and Emergency Demand Response (EDRP) programs do not qualify as dispatchable. They do qualify as non-dispatchable resources and can provide energy and capacity. In contrast, behind-the-meter generators and energy storage qualify as dispatchable resources. NYISO is currently working on tariff enhancements to facilitate dispatchable DER integration.

FIGURE 12: NYISO FUTURE WHOLESALE DER PARTICIPATION

		CAPACITY	ENERGY	ANCILLARY SERVICES
RELIABILITY	NON-DISPATCHABLE	**Special Case Resource (SCR) Program** ▪ Manual Activation ▪ Receives Capacity Payment	**Emergency Demand Response Program (EDRP)** ▪ Manual Activation ▪ Voluntary Load Reduction	
ECONOMIC	NON-DISPATCHABLE	**Load Modifier** ▪ Self-Manage Load Reductions to Reduce Capacity Obligation	**Price Capped Load Bid** ▪ Economic Day Ahead Load Procurement	
ECONOMIC	REAL-TIME DISPATCHABLE	**Behind-the-Meter Net Generation** ▪ Comparable to a Generator ▪ Fully Integrated in both Capacity and Energy Markets ▪ Capacity with Daily Energy Must-Offer Obligation		
ECONOMIC	REAL-TIME DISPATCHABLE	**Dispatchable Distributed Energy Resources** ▪ Comparable to a Generator ▪ Fully integrated in Energy, Ancillary Services and Capacity Markets ▪ Capacity with Daily Energy Must-Offer Obligation ▪ Flexibile Performance & Payment Options		

Source: "Distributed Energy Resources Market Design Concept Proposal"; NYISO, December 2017.

DEMAND RESPONSE CAPACITY BY REGIONAL TRANSMISSION ORGANIZATION AND INDEPENDENT SYSTEM OPERATOR

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- In **MISO**, DR is eligible to provide energy, capacity, and ancillary services. Most of the DR in the MISO market is delivered through utilities. Direct, third-party aggregator participation remains limited. The total amount of DR cleared in MISO's 2018-2019 Planning Resource Auction (PRA) was almost 15% greater than the previous year's amount. The clearing price, and consequently the amount of capacity cleared, was higher than last year due to an increase in the planning reserve margin requirement, a decrease in supply, and changes in market participants' offer behavior. The current DR amount in the PRA represents 5% of MISO's total planned resource for 2018-2019.
- In **ISO New England**, DR—referred to as Price Responsive Demand (PRD)—was fully integrated into energy and operating reserve markets on June 1, 2018. PRD replaces the previously existing Real Time Demand Response (RTDR) and Real Time Emergency Generation (RTEG) resource programs and is subject to security-constrained economic dispatch in Day-Ahead and Real-Time Energy Markets through the submission of energy market offers, thereby integrating them fully with generation supply offers. Also, PRD will be eligible to provide operating reserves in real-time and in the Forward Reserve Market. PRD is subject to the same capacity market opportunities and obligations as other resources participating in wholesale markets.
- In **PJM**, DR rebounded in the most recent capacity auction, for the 2021/22 Delivery year. In the 2020/21 auction last year, DR had dropped by about 20% due to low prices and the start of the 100% capacity performance (CP) requirement, which meant that DR had to sign up for a year-round commitment for the first time. Prices almost doubled in many zones, and DR bidders may have become more comfortable with the CP process, so DR volumes came back up to pre-CP levels. In addition, PJM continues to investigate the role of seasonal DR resources within its capacity market to see if resources, such as air conditioning-based DR, can participate in the future.

CHALLENGES AND OPPORTUNITIES

- Complex market participation rules, which are at times not very transparent in certain jurisdictions, continue to restrict full integration of DR into wholesale market operations.
- Stricter market participation requirements, especially in terms of resource availability and response time, pose challenges for end-use loads, thereby limiting their contribution.
- Coordination and alignment of retail and wholesale DR activities continue to be challenging in some areas, primarily due to lack of coordination between federal and state policies and non-uniformity of requirements and rules for resource participation at the two levels.
- Although the diversity of DR products adds another level of complexity to the challenges of DR, these varying products also provide a diversity of benefits, such as peak shaving, reducing the slope of system ramps, firming the intermittency of renewable energy resources, and relieving congestion on the electric grid. Advances in smart grid technology provide emerging opportunities and can pave the way for DR to play a greater, faster, and more diverse role in addressing emerging grid needs.
- In many areas, the market is working toward new rules and regulations to develop new products and to integrate DR within a broader DER framework. Developing simple, transparent rules that consider the diverse nature of DR resources and encourage greater participation will be necessary to realize maximum benefits from these resources.

INTERNATIONAL DEMAND RESPONSE

A number of markets outside the U.S. are becoming more open and attractive for DR resources. Market structures are being reformed in Canada, Europe, and the Asia-Pacific to allow DR to compete against generators for revenue.

AUSTRALIA

The summer of 2017-2018 broke heat records around the continent, leading to record energy prices[28] in some areas. The Australian Energy Market Operator (AEMO) had several initiatives underway to support reliability, including a DR trial run in cooperation with the Australian Renewable Energy Agency (ARENA)[29] and with the support of the New South Wales Government.

Over three years, pilot projects in Victoria, South Australia, and New South Wales will be tested to free up short-term supply during extreme weather—such as prolonged summer heatwaves—and unplanned outages. The pilot projects will engage large-scale C&I businesses, such as cold storage facilities, manufacturing plants, and commercial buildings.

JAPAN

Japan has been dabbling in DR for several years, primarily after the tsunami in 2011 that wiped out much of the country's nuclear capacity. It had a number of small pilot programs with various DR providers, but activity ramped up in 2017. The timing coincides with the opening of competitive retail power markets, which adds more momentum to growth.

Japan's regulators opened a new DR market called the "NegaWatt Market" effective April 2017. Tokyo Electric (TEPCO) is partnering with multiple DR providers to utilize DR resources to ensure grid reliability during severe weather conditions and to reduce procurement costs for power resources, especially replacement of aging thermal power stations.

The programs are designed to meet Tokyo Electric's capacity program needs, which include capacity dispatchable within two hours and fast-response programs with capacity response times under 30 minutes. These DR assets can activate flexible load in case of grid emergency, or at times of high electricity demand. Fast frequency control is expected to open to DR in 2019, as well.

UNITED KINGDOM

The United Kingdom (UK) continues to have a range of markets open to DR participation. Almost all ancillary services programs in the UK are open to DR. Programs dedicated specifically for DR are the Demand-Side Balancing Reserve (not procured in season 2016/17), Demand Turn Up, a new service which is currently being tested for a trial period, and Frequency Control by Demand Management. Aggregated DR has access to the UK's Capacity Mechanism. Participation rules are considered to be strongly biased in favor of generation, however.

National Grid has launched a program called Power Responsive, with the goal of stimulating participation of flexible technologies in the electricity system. The program focuses on distributed generation, storage, and DR from C&I users.

28 https://www.linkedin.com/pulse/victoria-sets-new-record-electricity-prices-marija-petkovic/

29 https://arena.gov.au/news/aemo-arena-demand-response/

TIME-VARYING RATES

Time-varying rates encourage changes in energy use through price signals to the consumer. They are effective in managing peak demand by shifting energy use from higher to lower price periods, or reducing demand during peak periods. They are significant DR contributors, especially in jurisdictions with a sizable enrollment in these rates. Historically, utilities have offered time-of-use (TOU) rates to their large C&I customers. Increasingly, we see innovative TOU rate offers to residential and small and medium business (SMB) customers. Along with TOU, utilities offer other types of time-varying rates, such as critical peak pricing (CPP), real-time pricing (RTP), variable peak pricing (VPP), peak-time rebate (PTR) or critical peak rebate (CPR).

The progressively wider deployment of time-varying rates is driven by growth in smart meter rollouts, the need for utilities to manage the net load curve on a dynamic basis, integrate distributed energy resources (DERs), reduce peak load to mitigate generation or T&D capacity costs, and take advantage of opportunities to provide greater customer choice and engagement.

TABLE 7: EXAMPLES OF INNOVATIVE RESIDENTIAL TIME-OF-USE RATES

Arizona Public Service (APS) has over half of its residential customers enrolled in TOU rates. APS revised its TOU rate design to include a three-tier TOU rate (Saver Choice) for residential customers with a super-off-peak winter price between 10 a.m. and 3 p.m., peak period from 3-8 p.m., and off-peak from 8 p.m. to 10 a.m. The price ratio for the on-peak to the super off-peak winter rate is around 7:1, while the on-peak to off-peak ratio is around 2:1. The winter super off-peak rate is meant to encourage customers to use energy during times of low prices when there is excess generation from solar and shift load from peak periods to these super off-peak hours using energy storage technologies.
Three **California IOUs** will start transitioning residential customers to default TOU rates from 2019-2020. The rates incorporate a delayed, five-hour peak period from 4 p.m.—9 p.m. instead of the previous peak period, which started from 11 a.m. due to the widespread penetration of solar energy. Pacific Gas and Electric (PG&E) has an alternative rate for customers with a shorter peak period (4 p.m.—9 p.m.), but with a higher peak-to-off-peak price differential. The utilities have been conducting pilots and customer outreach in preparation for the default TOU rate transition and examining different DR technologies to help address customer concerns.

Source: Navigant, Smart Electric Power Alliance, 2018.

INNOVATIVE RESIDENTIAL TOU RATES

Around 14% of all U.S. utilities offer residential TOU rates.[30] Most of these have two-period pricing with a peak to off-peak price ratio of slightly greater than 2:1. Historically, enrollment levels in these rates have been less than 5%. However, solar PV adoption is causing some utilities to rethink the design of residential TOU rates to manage the "duck curve."[31] The TOU peak-period price is being shifted to later in the evening, or the price is being reduced in the middle of the day. Volumetric TOU rates are increasingly being proposed by environmental advocates to address grid cost-recovery issues associated with rooftop PV adoption as an alternative to fixed charges or demand charges.

Utilities commonly offer Electric Vehicle (EV)-TOU rates to their customers. They have a choice of being on a "whole house" TOU rate or only placing their EV on the TOU rate.[32]

30 The Brattle Group, "The National Landscape of Residential TOU Rates"; November, 2017.

31 Navigant, 2018.

32 A "whole house" TOU rate refers to the entire household's energy use being on the TOU tariff instead of placing only the EV energy use on a TOU rate.

TIME-VARYING RATE OFFERS

Two other common types of time-varying rates are critical peak pricing (CPP) and real-time pricing (RTP). CPP is commonly offered to business customers. They receive a discount on most days in exchange for being charged high "critical" prices on event days. Under RTP, customers are offered variable hourly prices based on the real-time cost of electricity. Some examples of these two types of offers are presented below.

CHALLENGES AND OPPORTUNITIES FOR DEPLOYMENT OF TIME-VARYING RATES

Time-varying rates are increasingly being deployed by utilities, yet barriers to implement these rates remain, contributing to low overall enrollment.

- Limited or no marketing of the rates, inconvenient design (i.e., long peak-period), and additional charges to cover the cost of metering have been shown to limit deployment.
- Customers are often unwilling to enroll in time-varying rates due to fears of bill volatility. Moreover, the way rates are designed is often complex, and customers have difficulty understanding them.
- Regulators in some cases are not favorable toward dynamic rates due to apprehension of the harm they may have on low-income customers and small users.
- Deployment of dynamic rates requires new meters and billing systems that could pose implementation challenges, as well as an extra burden on customer service staff.

TABLE 8: EXAMPLES OF CRITICAL PEAK PRICING
DTE Energy offers a Dynamic Peak Pricing (DPP) rate to residential and C&I customers with smart meters. It is a three-tier TOU rate with a CPP period. The CPP event period is from 3 p.m. to 7 p.m. on weekdays, with a maximum of 20 occurrences. Customers are provided day-ahead notification. For residential customers, the critical peak rate for energy is 95c/kWh, while the on-peak rate for energy is 14.2c/kWh.
Xcel Energy in Colorado offers a CPP rate to C&I customers under which events might be called up to 15 times a year from noon—8 p.m. with an event duration not exceeding 4 hours. These events cannot be called more than once a day and receive day-ahead event notification.
In **California**, three **IOUs** offer CPP as the default rate to large (>200 kW) customers. CPP is offered as a voluntary rate to SMB customers, but the utilities are in the process of transitioning these customers to default CPP. Customers receive day-ahead notification of CPP events. Events are called during a 2 p.m. to 6 p.m. peak period.

Source: Navigant, Smart Electric Power Alliance, 2018.

TABLE 9: EXAMPLES OF REAL TIME PRICING
Commonwealth Edison has ~16,000 residential customers and ~9,000 C&I customers on hourly RTP. Customers get a monthly email comparing what they paid under this rate to what they would have paid under their default rate. Participants are also able to track their energy use using an online portal. Hourly-pricing participants get both day-head and real-time text and email alerts.
Georgia Power has a very well established RTP rate offer to large commercial and industrial customers. It has 2,300 C&I customers (representing ~20% of retail revenues) on two-part, hourly RTP pricing. Customers consuming more than 5 MW are on hour-ahead RTP pricing. Customers consuming more than 250 kW are eligible for day-ahead RTP pricing.

Source: Navigant, Smart Electric Power Alliance, 2018.

ELECTRIC VEHICLES AND DEMAND RESPONSE

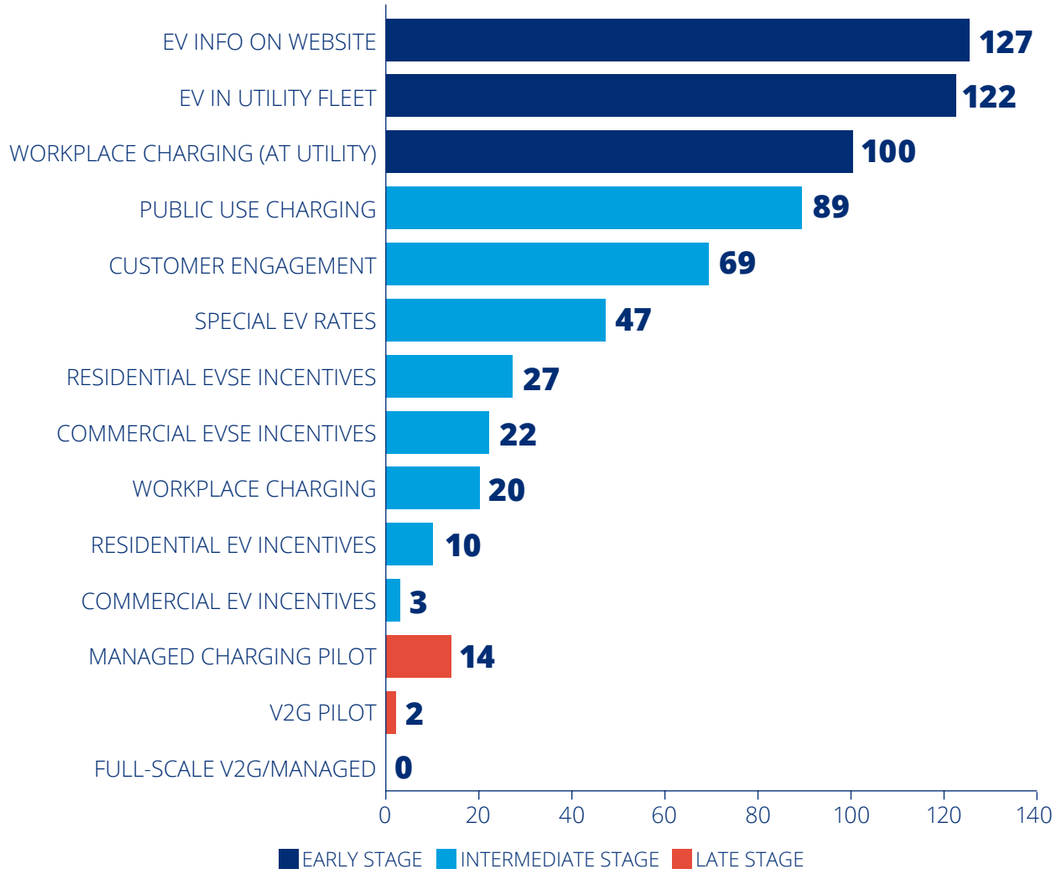
The electric vehicle (EV) landscape is rapidly evolving, with forecasts predicting that EVs' annual energy consumption will rise from a few terawatt-hours (TWh) a year in 2017 to over 100 TWh by 2030.[33] Utilities have thus far taken a conservative approach to EV deployment, but SEPA research indicates movement in managed charging and vehicle-to-grid (V2G) pilots.

Managed charging and V2G may play a significant role in DR in the future as EV energy consumption continues to grow.

Managed charging is a form of demand response in which communication signals are sent to a vehicle or charger to directly control a charging event. The communications signals from a utility, load balancing authorities, or other interested parties, can direct a vehicle to reduce the rate of charge or curtail charging altogether, such as during a peak event. Further, these signals can direct a vehicle to start charging to absorb excess generation from renewable energy resources, like solar and wind.

V2G dispatch uses a plugged-in EV with available charged battery capacity to feed power back to the grid. V2G can potentially provide services to the grid in exchange for financial compensation to the vehicle owner. While still in the early stages, V2G may have the potential to provide significant value for utilities and balancing authorities if technical barriers can be overcome. Despite a lot of work, V2G is still more conceptual than commercial. While V2G technology is likely to develop over time, it will require additional elements for widespread adoption. These elements include approval or consent of vehicle manufacturers so as to not invalidate warranties and usage guidelines additional hardware expense for AC-DC conversion and control, interconnection permits, and engineering and technical requirements of local grid operators and utilities.[34,35]

FIGURE 13: UTILITY EV ACTIVITIES AND PROGRAMS BY TYPE AND STAGE



Source: Smart Electric Power Alliance, Utilities and Electric Vehicles: Evolving to Unlock Grid Value, 2018; N=486.

33 Bloomberg New Energy Finance, July 2017, Long-Term Electric Vehicle Outlook 2017, Figure 59.

34 At the date of publication, no vehicle manufacturers provide a warranty for V2G activities due to concerns about battery life and safety.

35 AC= alternating current, DC = direct current

SAN DIEGO GAS & ELECTRIC COMPANY (SDG&E), CALIFORNIA

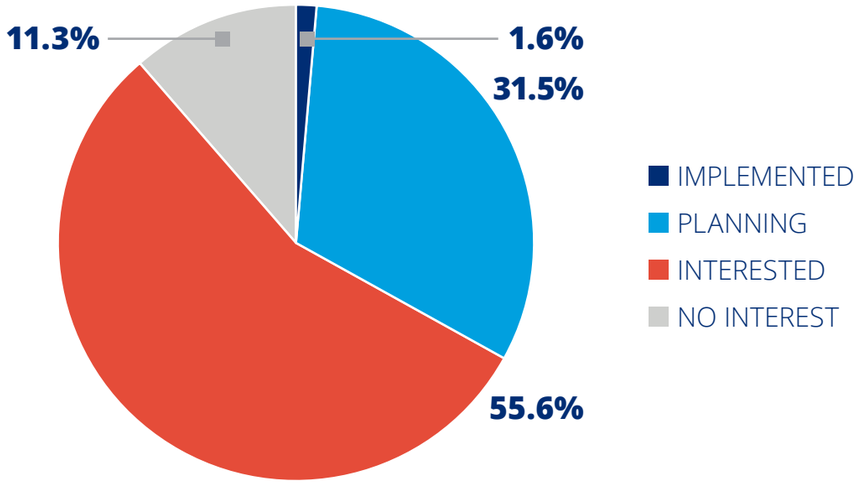
SDG&E has shown a strong commitment to EVs through the Power Your Drive program in which customers in apartments, condominiums, and workplaces have access to charging stations with an EV rate structure that reflects the hourly cost of electricity. Dynamic Hourly pricing is set the day before, and customers use a phone app to enter their preferences for maximum energy price and/or amount of hours to charge. SDG&E's dynamic "Vehicle Grid Integration" rate will vary to reflect the market price of producing electricity, making it cheapest to charge when renewable resources like wind and solar are plentiful. Up to 3,500 Level 2 chargers will be installed through Power Your Drive, with over 300 ports installed as of January 2018. The utility also offers TOU rates for residential customers and annual bill credits for EV drivers and owners. In 2018, the California Public Utilities Commission approved SDG&E's Residential Charging Program, which will provide rebates for up to 60,000 Level 2 chargers to encourage managed charging and EV adoption.

MAUI ELECTRIC, HAWAII

Maui Electric offers residential customers a discounted TOU rate from 9 a.m. to 5 p.m. when solar and other renewable energy options are readily available. This rate requires customers to install a separate meter at no cost to the customer. Additionally, commercial customers can qualify for a pilot rate program for EV public charging infrastructure on a TOU rate with a higher volumetric charge rather than a demand charge. The utility also owns and operates publicly accessible DC fast chargers, collects information for a workplace managed charging pilot, incorporates EVs into its own fleet, and conducts customer outreach and education events.

Through the JUMPSmartMaui pilot with Hitachi and Nissan Leaf owners, volunteer drivers were provided with EV Power Conditioning Systems (EVPCS) in their homes. This Hitachi technology charged the vehicles during off-peak periods and discharged power to the volunteers' homes. The purpose of this EVPCS system is to allow utility operators to manage EV charging to balance generation and power demand.

FIGURE 14: UTILITY INTEREST IN OFFERING EV MANAGED CHARGING PROGRAMS

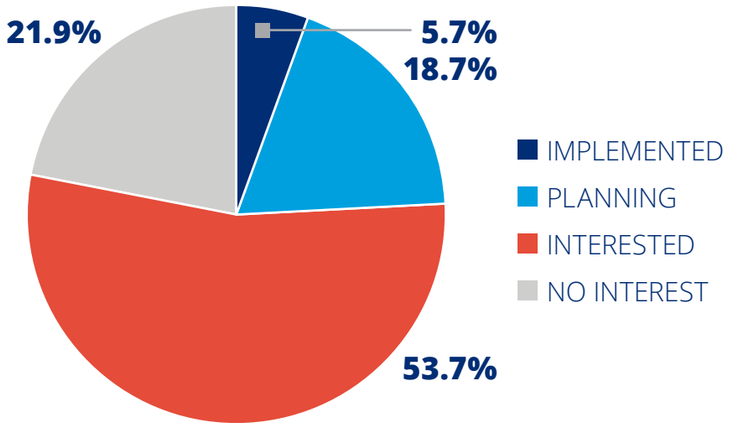


Source: Smart Electric Power Alliance, 2018. N=124.

ENERGY STORAGE PLAYS GROWING ROLE IN DEMAND RESPONSE

The energy storage market is developing rapidly, yet remains a nascent industry. As the energy storage market grows, its role in demand management will continue to expand. Energy storage participating in DR can be broken down into two main categories: one-way and two-way storage.

FIGURE 15: UTILITY INTEREST IN PAIRING DR WITH SOLAR, STORAGE, OR OTHER TECHNOLOGIES TO PROVIDE MORE RELIABLE DEMAND REDUCTION



Source: Smart Electric Power Alliance, 2018. N=123.

TABLE 10: ROLES ENERGY STORAGE PLAYS IN DEMAND RESPONSE

ONE-WAY THERMAL ENERGY STORAGE	TWO-WAY ELECTRICITY STORAGE
One-way storage can be represented by the use of thermal energy storage which is the consumption of electricity to shift load. Water heaters, ice thermal energy storage, and pre-cooling homes are examples of one-way storage. Beyond water heater programs, utilities are leveraging forms of one-way energy storage to provide demand response by shifting electricity consumption off peak. **Example:** Austin Energy has a district cooling program that serves 70 customers. This program has chiller plants with thermal energy storage components that allow them to meet customers' HVAC requirements through a network of underground pipes. These plants are run during off-peak hours and take care of their customers' cooling needs during on-peak hours.	Two-way or electricity storage is a system that can consume electricity from the grid as well as discharge that electricity back to the grid. Examples include flywheels, electrochemical battery storage, flow batteries, and gravitational storage. Two-way electricity storage is playing a growing role in DR as utilities begin testing storage systems in response to DR events, batteries are paired with other DR technologies, and BTM batteries are aggregated to participate in DR events. **Example:** STEM deployed 85 MW of aggregated storage capacity at multiple C&I sites in 2016, becoming the first storage provider to meet reliability and performance requirements.

Source: Smart Electric Power Alliance, 2018.

Smart Electric Power Alliance

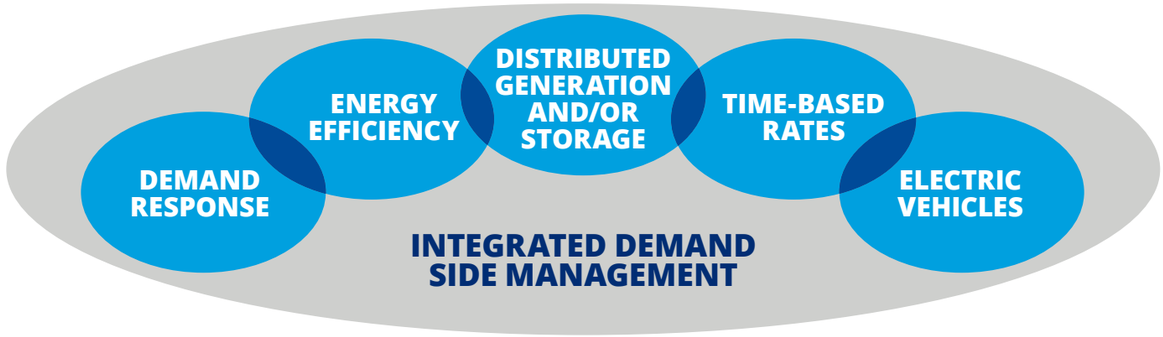
INTEGRATED DEMAND SIDE MANAGEMENT (IDSM) OR INTEGRATED DISTRIBUTED ENERGY RESOURCES (IDER)

The industry has been making efforts over the past decade to integrate programs that have typically been siloed (i.e., EE and DR)—this effort is known as integrated demand side management, or IDSM. As deployment of DERs become more widespread, this term has come to embody a broader set of technologies, programs and customer behavior strategies, also sometimes referred to as Integrated Distributed Energy Resources (IDER). IDER activities are becoming more of a reality as utilities are realizing that they need to take advantage of the synergies across multiple offerings and package them holistically for the end-use customer.

DRIVERS:

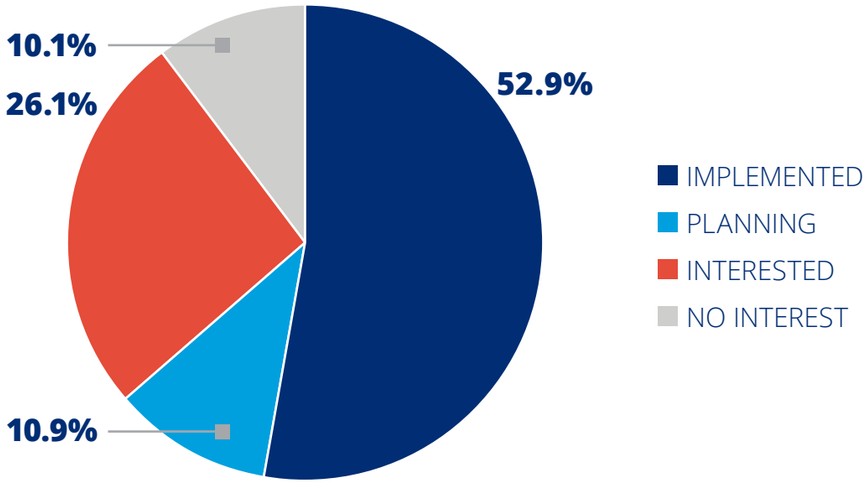
- **Regulatory mandates related to IDSM** are driving utilities to move away from current, siloed offers.
- **Enhance customer service and satisfaction** by offering a holistic package of energy related products and services that help increase customer engagement and reduce confusion around multiple product and service offerings.
- **Rapidly changing customer energy and load profiles** from new and advanced technologies and changing customer preferences require a portfolio of programs with combined product and service offerings.
- **Leverage synergies** across different program offerings to improve cost-effectiveness and avoid replication of efforts in the process.
- **Provide grid benefits**—system, locational, and temporal—through an integrated package of a combination of products, services and rates.

FIGURE 16: IDSM BUILDING BLOCKS



Source: "Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management at Electric Utilities", Energy Technologies Area, Lawrence Berkeley National Lab; March 2018.

FIGURE 17: UTILITY INTEREST IN JOINTLY OFFERING DR AND ENERGY EFFICIENCY TO CUSTOMERS



Source: Smart Electric Power Alliance, 2018. N=119.

CURRENT ACTIVITIES

Across the nation, New York, Hawaii, and California are at the forefront of IDER efforts and activities.

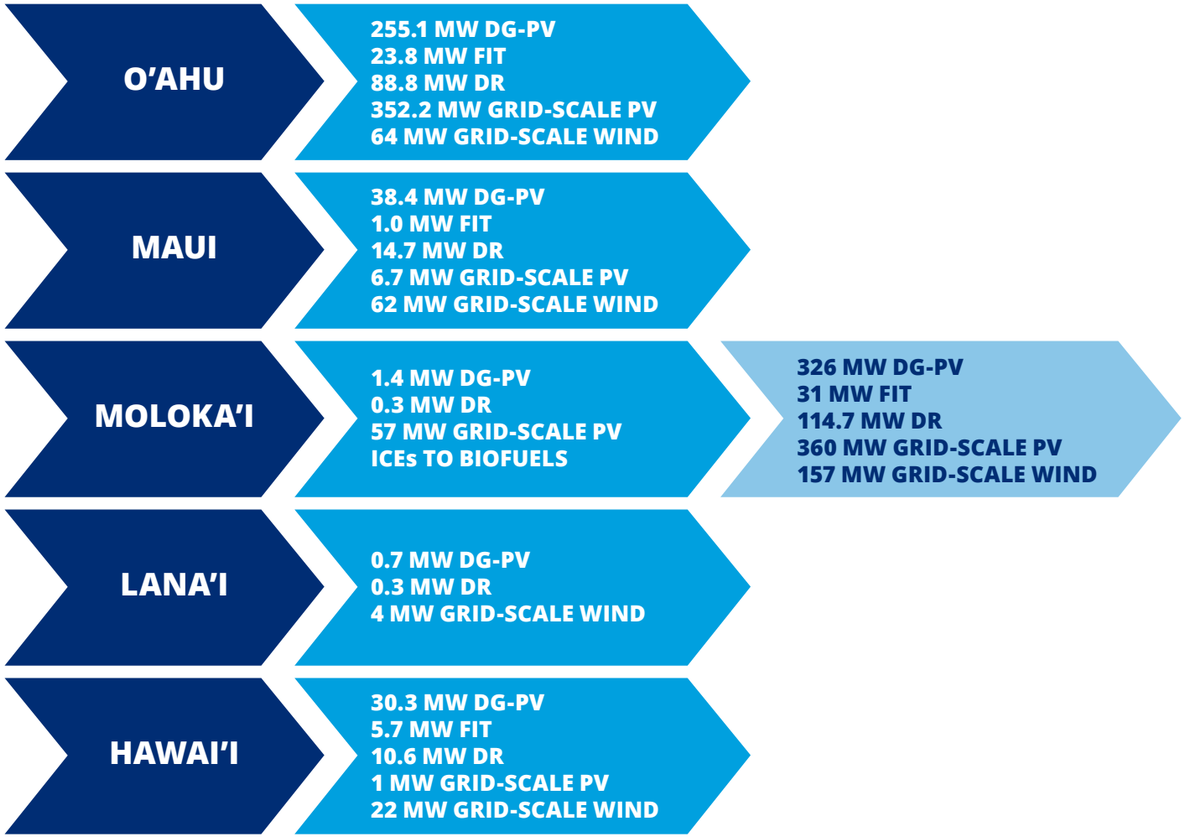
New York

New York's Reforming the Energy Vision (REV) process led to several, ongoing DER demonstration projects that are integrating DERs. For example, PSEG's Long Island Super Saver Program plans to deploy an array of DER technologies (EE, DR, storage) to help meet local capacity constraints in Long Island (North Bellmore area). All customers in this program have smart meters. An evaluation, measurement, and verification (EM&V) framework has been developed to assess the impacts associated with each component of the multipronged program.

Hawaii

In Hawaii, integration of different resources through DER activities are underway to help manage the state's journey towards attaining 100% renewable by 2045. The Hawaiian Electric Companies' Power Supply Implementation Plan (PSIP) was approved by the Hawaii PUC last year. The PSIP outlines a detailed plan charting the specific actions the companies need to undertake to 2021 to meet 100% RPS by 2045. In the aggregate, Hawaiian Electric's action plans estimate achieving a 52% RPS by 2021 by adding 326 MW of rooftop solar, 31 MW of Feed-In Tariff (FIT) solar generation, 115 MW of DR, 360 MW of grid-scale solar, and 157 MW of grid-scale wind resources across all five islands.[36] The Hawaii PUC also directed the Hawaiian Electric Companies to develop a Grid Modernization Strategy, which was filed in 2017. A core component of the strategy is to utilize customer DER and energy conservation as instrumental resources to efficiently manage the power system.

FIGURE 18: RENEWABLE ENERGY AND DEMAND RESPONSE ADDITIONS IN THE HAWAIIAN ELECTRIC COMPANIES' POWER SUPPLY IMPLEMENTATION PLAN (2017-2021)



Source: Hawaiian Electric Company, 2016. Executive summary to the Companies 2016 PSIP update. https://www.hawaiianelectric.com/Documents/about_us/our_vision/psip_executive_summary_20161223.pdf

36 Executive summary to the Companies 2016 PSIP update. https://www.snl.com/interactive/newlookandfeel/1031123/HawaiianElectricCompaniesPSIPUpdateDec2016ExecutiveSummary.pdf

California

Since 2007, the California Public Utilities Commission (CPUC) has sought to integrate demand-side energy solutions and technologies through utility programs offerings. A CPUC decision directed that utilities: "Integrate customer demand-side programs, such as energy efficiency, self-generation, advanced metering, and DR in a coherent and efficient manner."[37] The IDSM concept has been addressed in previous EE proceedings and pilots funded since 2010, but now has resurfaced with a specific deliverable through a CPUC proposal for driving additional DR benefits in EE business plans. Additional IDSM efforts include:

- **California's Distribution Resources Plan (DRP) and Integrated Distributed Energy Resources (IDER) proceedings** require utilities to "identify optimal locations for the deployment of distributed resources."[38] It defines distributed energy resources as distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, and demand response technologies.
- CPUC recently issued a proposed decision to **incorporate DR in third-party EE projects and fund limited integration of DR and EE** in three areas: (1) residential HVAC controls; (2) non-residential HVAC and lighting controls; and (3) integration of DR and EE potential studies to support analysis under the integrated resource planning (IRP) process.[39]

CHALLENGES

- **Organizational silos** in utilities with separate budgets allocated to the different resource types.
- **Different vendors and service providers** by service offering.
- **EM&V and cost-effectiveness** assessment frameworks for IDSM are not always very well-defined.
- **Regulatory restrictions** that prohibit value stacking which could leverage multiple programs with the same end user.

OPPORTUNITIES:

- **Time-variant retail rate offers can help drive resource integration** as customers look toward a combination of solutions to help manage rates and electricity costs.
- **Outsourcing of programs and services to third-party market providers** provides an impetus as the energy service providers and technology vendors cut across the different silos and follow an energy-as-a-service model.
- **Market adoption of technologies that provide multiple benefit streams**, such as smart thermostats, advanced lighting controls, and battery storage, could help drive integration. Interoperability across products offered by multiple vendors will be critical for achieving integration.

37 CPUC, Integrated Distributed Energy Resources (IDER). http://www.cpuc.ca.gov/General.aspx?id=10710

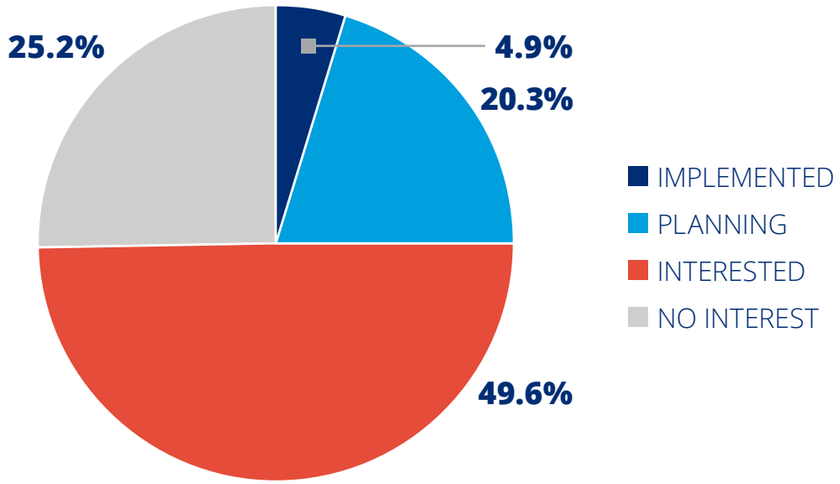
38 CPUC, Distribution Resources Plan (R.14-08-013) http://www.cpuc.ca.gov/General.aspx?id=5071

39 Energy Division Straw Proposal on Limited Integration of Demand Response and Energy Efficiency Activities under Energy Efficiency Applications (A.17-01-013 et al.) and Demand Response Applications (A.17-01-012 et al.); California Public Utilities Commission, June 2017. http://www.cpuc.ca.gov/General.aspx?id=7032

NON-WIRES ALTERNATIVES

Deploying locational forms of DR to meet the needs of the grid and avoid costly infrastructure upgrades is an emerging trend. Fifty percent of SEPA's utility participants are interested in leveraging DR for non-wires grid upgrade deferrals, with 20% planning to implement and 5% indicating they have already implemented locational forms of DR (see Figure 19).[40]

FIGURE 19: UTILITY INTEREST IN DEPLOYING DEMAND RESPONSE LOCATIONALLY FOR NON-WIRES GRID UPGRADE DEFERRALS (DR AS A LONG-TERM SOLUTION)



Source: Smart Electric Power Alliance, 2018. N=123.

NWA projects throughout the U.S. are leveraging DR in a range of technologies (e.g., energy storage, distributed generation, EE, DR, etc.). Today, a few projects specifically using DR in their NWA projects include:

- **Central Hudson—Peak Perks Program:** Central Hudson is coordinating a DR program as part of its electric transmission and distribution planning to offset peak load growth in three distinct zones. The program targets all customer classes that include residential direct load control equipment using two-way communicating Wi-Fi thermostats, load control switches, and customized curtailment agreements with C&I customers. The program uses Itron's IntelliSOURCE cloud-based software and Comverge services for recruitment and program support. Central Hudson exceeded the first-year MW target of 5.3 MW, achieving 5.9 MW.[41]
- **Consumers Energy—Energy Savers Club Swartz Creek:** This pilot kicked off in 2017 at the request of the Natural Resources Defense Council (NRDC) to investigate opportunities using EE (residential and C&I) and residential DR to avoid or defer distribution system investment and provide cost savings to customers. The project, still in progress, aims to reduce peak load by 1.4 MW by the end of 2018, or 1.6 MW by the end of 2019.[42]
- **National Grid—Rhode Island's Tiverton-Little Compton:** This 330 kW pilot project kicked off in 2012 with the goal to defer a $2.9 million feeder project for four years. To reach the 330 kW goal, National Grid provided incentives for WiFi thermostats, heat pump water heaters, and window AC purchases, as well as marketing to encourage customers to complete EnergyWise Smart Business Direct Install energy assessments.[43]

40 Non-wires alternative (NWA), also known as non-wires solutions (NWS), is defined as "an electricity grid investment or project that uses non-traditional transmission and distribution solutions, such as distributed generation, energy storage, energy efficiency, demand response, 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." Source: Navigant, Non Wires Alternatives 2017

41 Central Hudson, NWA Case Study in SEPA-PLMA Joint NWA Study, November, 2018.

42 Consumers Energy, NWA Case Study in SEPA-PLMA Joint NWA Study, 2018.

43 National Grid, NWA Case Study in SEPA-PLMA Joint NWA Study, November 2018.

DEMAND RESPONSE FOR RENEWABLE INTEGRATION

Small amounts of intermittent renewable generation, such as solar and wind power, have almost no measurable effect on overall system stability. Yet, anticipating the degree to which generation goes up and down rapidly—called ramp events—is critical to supporting grid stability in a cost-effective manner when penetration exceeds 10%-15%. Maintaining the balance in supply and demand is an important way to increase the reliability of the electricity grid. One method to sustain this balance is to use DR for renewables integration solutions, which increase or decrease customer loads based on renewables output as shown in Table 11.

MARKET DRIVERS

- Increased penetration of renewable energy.
- Expansion of DR capabilities to include ancillary services.
- Time-varying rates.

MARKET BARRIERS

- Uncertain customer adoption.
- Load availability.
- Regulatory barriers.

TABLE 11: DEMAND RESPONSE PROGRAM ATTRIBUTES REQUIRED TO SUPPORT VARIABLE RENEWABLE ENERGY

ATTRIBUTE	SPINNING/NON-SPINNING RESERVE	REGULATION	CONTINUOUS RAMPING/LOAD FOLLOWING
TELEMETRY	Required	Required	Required
RESPONSE TIME	<10 minute, <10 second to begin ramping is desirable	<1 minute	<1 hour
AUTOMATED RESPONSE	Required	Required	Required
EVENT LIMITATIONS	10-100 events, at least 1 hour each	Continuous availability	10 hours or more duration, at least one hour
DAILY/SEASONAL AVAILABILITY	24x7 year-round	24x7 year-round	24x7 year-round with some seasonal variation

Source: Navigant Consulting, Inc., 2018.

CALIFORNIA

Pacific Gas and Electric (PG&E) has been conducting the Excess Supply DR Pilot (XSP) since 2015. Findings from the pilot point to the challenges associated with customer outreach and recruitment, and conveying the value proposition to the customer. XSP is focused on testing the capabilities of demand-side resources to increase load as a service to the grid during times of over-generation on transmission and distribution lines, as well as in the case of negative prices. The intention of the pilot is for participants to shift energy use and not to simply use more energy during excess supply periods. Both individual customers and aggregators are eligible to participate in the pilot. All residential and non-residential customers are eligible to participate.

ARIZONA PUBLIC SERVICE

Reverse DR (as discussed in the call-out box) is part of the APS demand-side management plan for 2018. This plan proposed reverse DR and load-shifting pilot measures, including a pilot for large customers with dispatchable load of at least 30 kW. The objective of the pilot is to help smooth system load shapes and shift energy use into midday hours when energy prices are low or negative. The duck curve for APS is prominent during the winter months. During high solar hours in the middle of the day, APS faces challenges in keeping enough generation online to be able to meet evening ramp and peak needs. Customers do not have opportunities to take advantage of negative priced events, which in turn can bring down rates and help integrate solar.

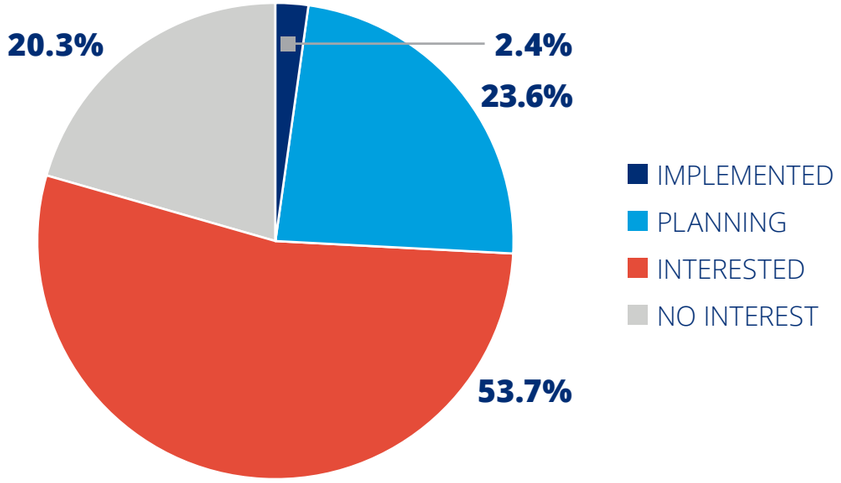
The pilot plans to work with qualifying non-residential facilities to identify opportunities for dispatching loads in response to negative pricing events. Customers would identify beneficial but non-essential loads that could be operated in response to an event signal. These loads would be submetered and provided with no-cost energy during these event periods.[44]

44 Arizona Public Service, 2018.

REVERSE DR HELPING TO INTEGRATE RENEWABLES

The need for **Reverse DR** is cropping up in areas with excess renewable generation and is emerging as an opportunity to incentivize customers to increase demand during periods of over-generation of renewable energy. Specifically at APS, the Reverse DR pilot incentivizes new dispatchable loads to increase their demand for electricity as a preventative measure to curtailment created by an excess of renewable generation.

FIGURE 20: UTILITY INTEREST IN USING DR TO MANAGE FLUCTUATIONS OR GRID IMPACTS IN A LOCATION WITH HIGH RENEWABLE ENERGY PENETRATION



Source: Smart Electric Power Alliance, 2018. N=123.

NATURAL GAS DR

Natural gas DR is being used to address constraints on fuel delivery to gas-fired generators, particularly during cold weather. In the past five years, natural gas has become the predominant fuel source for electricity generation in many areas of the United States, often replacing coal and nuclear plants as they retire. However, the gas pipeline system was mainly designed to accommodate gas usage for end uses like cooking, heating, and cooling. The pipeline capacity did not anticipate large volumes flowing to power plants—especially in the winter when heating demand is highest. Some utilities and grid operators have instituted winter electric DR programs to address this concern, but curtailing natural gas usage is another option.

A key area of opportunity for natural gas DR lies in alleviating pipeline capacity constraints during periods of peak usage, which are typically spikes in demand driven by extreme weather or logistical issues.

- **Southern California Gas Company (SoCalGas)** developed a program for winter 2016/2017 using smart thermostats connected with gas meters. The program makes small adjustments in temperature set-points during the heating season to provide natural gas demand savings when aggregated over a large area, similar to electric smart thermostat DR programs. SoCalGas operates this program along with EnergyHub and various participating thermostat vendors. It offers a $75 rebate to customers ($50 at sign-up, $25 after the heating season). SoCalGas enrolled approximately 10,000 thermostats in the 2017-2018 winter program and is targeting enrollment of 50,000 thermostats for the 2018-2019 program.[45]
- **National Grid** is currently conducting a pilot with 16 large C&I customers in New York City and on Long Island (the target was 30 customers). National Grid will provide the enrolled customers with 48 hours' notice to reduce natural gas consumption between 6 a.m. and 9 a.m. Enrolled customers have provided National Grid with a predetermined amount of consumption they are willing to forego if they are called upon to reduce consumption. The customers will have an opportunity to earn an incentive each time a demand event is called. The utility anticipates about six events during the heating season. To measure the actual reduction during the 6–9 a.m. time window, National Grid installed interval meter reading capability on the customers' natural gas meters.[46]
- **Consolidated Edison (Con Edison)** has identified a need for Non-Pipeline Solutions throughout its natural gas service territory to address a 9% shortfall in Peak Day pipeline capacity by November 2023, which is equivalent to more than 100,000 decatherms on a Peak Day. The traditional solution would be the acquisition of incremental interstate pipeline capacity to address this requirement. Con Edison will place a higher value on proposed solutions that reduce the need for pipeline capacity in the zones with the highest assigned value, and will prioritize projects in those areas for inclusion in the final portfolio. DR projects must be able to provide relief for a minimum of 24 consecutive hours on the coldest days of the year to be useful to Con Edison, and are more valuable if deployable for multi-day consecutive periods of cold weather.[47]

45 Southern California Gas Company, 2018.

46 National Grid, 2018.

47 Consolidated Edison, 2018.

INCREASING CUSTOMER ENGAGEMENT

Navigant Research describes smart homes as "homes that act intuitively and intelligently through an ecosystem of communicating devices, software, and services that can enrich customers' lives by fostering increased comfort, convenience, control, awareness, and cost and energy savings." Table 12 provides an overview of the various connected devices that may be found in a smart home, from small devices, such as connected lighting, to large devices, such as solar panels and EV chargers. Many smart home products focus on customer convenience and comfort by giving customers easy and remote control of devices, or by automating services.

Many utilities and program administrators in North America have added smart home measures to their EE and DR programs, or are testing these measures through pilot projects. Residential programs and pilots predominantly target air conditioning savings through smart thermostats, and control systems for room-level AC or water heaters. Some program administrators are building on their behavioral programs with apps or in-home displays that provide real-time feedback and energy-savings tips.

Smart home products also provide opportunities for combining EE and DR while promoting ongoing customer engagement. Traditional EE incentives have focused on the purchase or installation of equipment, with customer engagement ending once a rebate has been received. Further, such incentives have rarely connected customers to DR programs. However, customers' continuous interactions with smart home products create opportunities for ongoing EE, DR, and customer engagement.

TABLE 12: SMART HOME MEASURE EXAMPLES AND BENEFITS

DEVICE	END USE	DR	EE
SMART HOME HUB*	None	-	-
SMART THERMOSTATS	HVAC	✓	✓
ROOM AC SMART PLUGS	HVAC	✓	Unclear†
CONNECTED LIGHTING	Lighting	✓	Unclear†
SMART PLUGS/POWER STRIPS	Plug load	-	✓
SMART WATER HEATER CONTROLLERS	Water heating	✓	Unclear†
SMART APPLIANCES	Appliances	✓	Unclear†
CONNECTED SENSORS (TEMPERATURE AND OCCUPANCY)	HVAC and Lighting	-	✓
SMART ELECTRIC VEHICLE CAR CHARGERS	Transportation	✓	-

* The smart home hub is commonly incentivized as part of a smart home program for its ability to connect and control other smart devices. Some smart thermostats can also serve as the smart home hub and control other devices. One example is the Nest thermostat and "Works with Nest" products.

† Energy savings may occur if the customer utilizes the smart functionality of these devices to set schedules or connect them to other sensors such that their new operation is more efficient than before. However, limited research exists on the amount of energy savings from smart devices, leading to a lack of clarity on energy savings.

Source: Navigant, 2018.

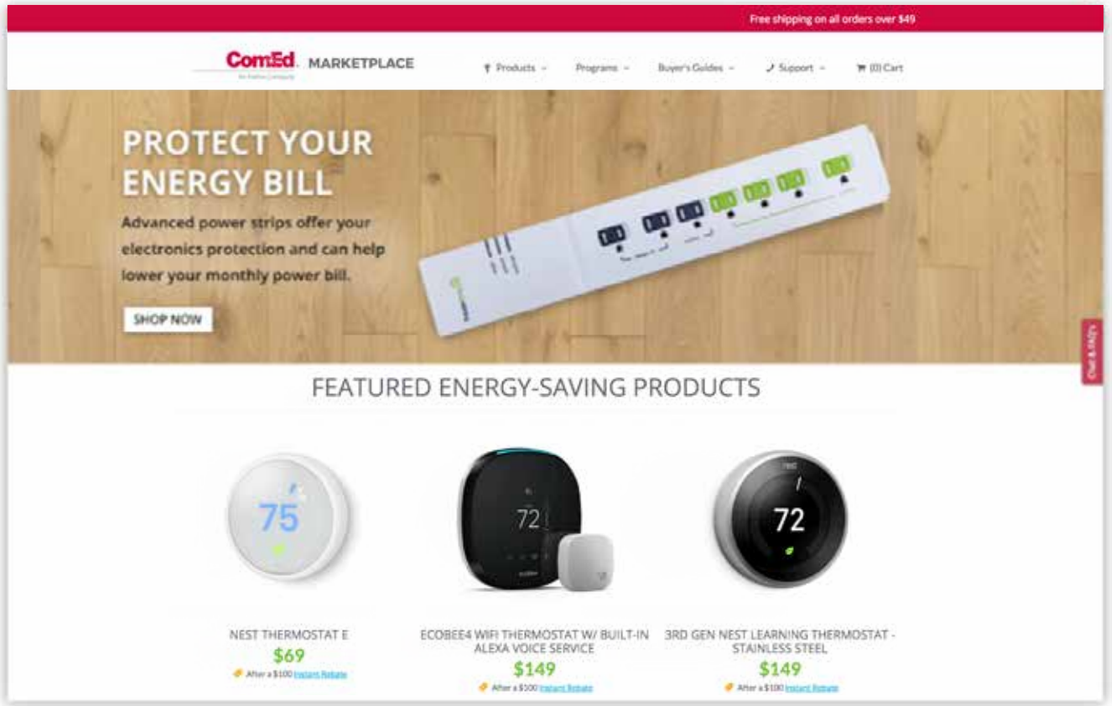
CUSTOMER ENGAGEMENT THROUGH DEMAND SIDE MANAGEMENT TOOLS

The widespread adoption of smartphones, mobile apps, and social networking tools has changed the way consumers interact with their service providers. Yet, direct communications between utilities and their customers have been largely limited to a monthly bill and negative events, such as power outages or unexpectedly high bills. Changes in consumer expectations have led utilities to seek DSM software solutions that can lower the costs of service, and improve customer satisfaction and engagement.

Additionally, in regulated markets, public utility commissions are driving DSM by rewarding utilities for improving customer satisfaction and reducing service costs. Utilities in these markets often need approval for capital expenditures and the rates they charge customers. They are also under pressure to build fewer power plants, procure cleaner sources of fuel, and keep rates low. As a result, regulators are placing higher priority on better customer service, incentivizing utilities to pursue DSM and improve customer relationships.

Drivers

- The changing demographics of utility customers affect engagement strategies. Millennials have grown up with highly interactive forms of customer service based on multiple channels of communications. Utilities need to serve a more diverse set of interests from seniors to millennials. Customers differ in their understanding of technologies, their level of interest in being engaged, and the ways they want to be engaged with their utilities.
- Regulatory (e.g., commission metrics on utility customer satisfaction) and competitive forces are driving utilities to increase customer satisfaction and find new ways to engage customers. U.S. utilities typically gauge customer satisfaction through reports from J.D. Power or through program evaluation. J.D. Power has found that utilities with the highest customer satisfaction scores may earn the highest levels of return in rate-making processes.



Source: ComEd, 2018.

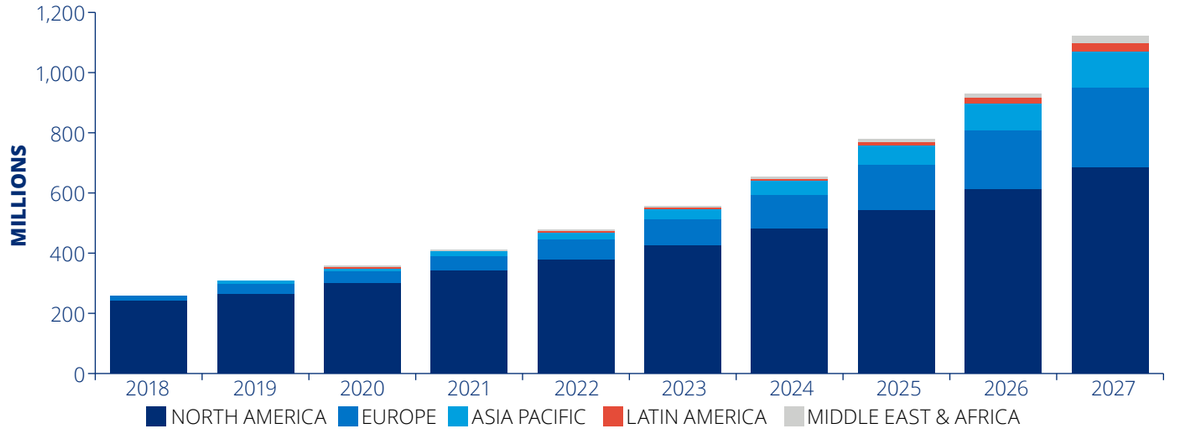
CUSTOMER ENGAGEMENT THROUGH DEMAND SIDE MANAGEMENT PROJECTED TO GROW

Navigant Research expects roughly $270.5 million to be spent by utilities and energy suppliers on customer engagement on a global basis in 2018, with robust growth expected over the next decade. As Figure 21 shows, by 2027, global spending on customer engagement is anticipated to total $1.1 billion. North America will lead this trend, reaching $688.2 million in 2027, primarily in the U.S. This pattern is expected to hold true throughout the forecast period, though other regions will start to implement customer engagement programs, specifically, Europe and the Asia Pacific.

Key trends

- Utilities are increasingly using online marketplaces to enable customers to buy energy efficient products and appliances for their homes. However, helping customers reduce their energy consumption is not the only benefit of marketplace platforms. Such online platforms also help utilities engage and educate customers, introduce and promote additional programs, and tap into potential new revenue streams, for example, advertising and referral fees from third-party vendors.
- Increased confidence in behavioral DSM is leading more utilities to roll out behavioral programs, as well as more vendors offering such solutions.
- Smart energy technologies, such as smart thermostats and appliances, are creating the means for both customers and utilities to exercise greater control within DR programs and for general grid management.
- Customers also want more control over their use of energy through mobile access to data (e.g., apps, text message alerts). They value alerts that provide information about high energy use or DR events, and they want the ability to remotely change settings for lighting, thermostats, and water heaters.

FIGURE 21: CUSTOMER ENGAGEMENT DEMAND SIDE MANAGEMENT FORECASTED SPENDING BY REGION, WORLD MARKETS (2018-2027)



Source: Navigant Research, Customer Engagement Through Demand Side Management, 2018.

- Energy disaggregation is a process that combines customer meter data, machine learning algorithms, and customer-provided information on specifics of a home to itemize the customer's energy consumption into distinct appliance categories. Utilities have found that itemization-related emails are a successful way to engage customers. Click-through rates on such emails are often much higher than typical benchmarks.
- Gamification of energy savings (turning energy saving into a game) is found to be a fun and entertaining way to engage with the customer in a positive way that is different from the standard utility interaction.

Appendix A: Survey Participants

AEP Texas Central
AEP Texas North
Alliant Energy
Alliant Energy - Iowa
Ameren Illinois Company
American Samoa Power Authority
Ames Municipal Electric Service
Anza Electric Cooperative, Inc.
Appalachian Power
Arizona Public Service
Atlantic City Electric
Austin Energy
Austin Utilities
Avista Utilities
Baltimore Gas and Electric
Black Hills Energy - Colorado Electric
CECONY
City of Anaheim, Public Utilities Department
City of Grand Island
City of Palo Alto Utilities
City of Rock Hill
City of Tallahassee
City Utilities of Springfield, MO
Commonwealth Edison Company
Consumers Energy
CPS Energy
Cumberland Valley Electric
Dairyland Power Cooperative
Delmarva Power
Denton County Electric Cooperative, Inc., d/b/a CoServ Electric
Dominion Energy North Carolina
Dominion Energy Virginia
DTE Energy
Duke Energy Carolinas
Duke Energy Florida
Duke Energy Indiana
Duke Energy Kentucky
Duke Energy Ohio
Duke Energy Progress (Duke)
East Grand Forks Water and Light
El Paso Electric Co
Entergy Arkansas, Inc.
Entergy Louisiana, LLC
Entergy Mississippi, Inc.
Entergy New Orleans, Inc.
Entergy Texas, Inc.
Farmers Electric Cooperative
Flint Energies
Florida Keys Electric Cooperative
Florida Power & Light Company
Gainesville Regional Utilities
Georgia Power Company
Green Mountain Power
Guadalupe Valley Electric Cooperative, Inc.
Gulf Power Co.
Hawaii Electric Light Company
Hawaiian Electric
Heber Light & Power
Henderson Municipal Power and Light
Horry Electric Coop
Idaho Power Company
Indiana Michigan Power
Indianapolis Power & Light Company
Jersey Central Power & Light
Kansas City Power and Light
Lincoln Electric System
Los Angeles Department of Water and Power
Madison Gas and Electric
Maui Electric Company
Medina Electric Co-op
Memphis Light, Gas and Water
Metropolitan Edison Company

Modesto Irrigation District
Monongahela Power Company
Moreno Valley Utility
National Grid
New Hampshire Electric Cooperative, Inc.
Northern States Power Minnesota - MN
Northern States Power Minnesota - ND
Northern States Power Minnesota - SD
Northern States Power Wisconsin - MI
Northern States Power Wisconsin - WI
NV Energy
Ohio Edison Company
Orange and Rockland Utilities
Orlando Utilities Commission
Otero County Electric Cooperative Inc.
Otter Tail Power Company
Pacific Gas & Electric
Pacific Power
Palmetto Electric Coop
Pedernales Electric Cooperative
Pennsylvania Electric Company
Pennsylvania Power Company
Pepco
Platte River Power Authority/Fort Collins Utilities
Portland General Electric
PowerSouth Energy Cooperative
PPL Electric Utilities
Public Service Colorado
Public Service Company of Oklahoma
Public Service Electric & Gas Company
Public Utility District No. 1 of Benton County
Puget Sound Energy
Randolph EMC
Rappahannock Electric Cooperative
Riverside Public Utilities
Rocky Mountain Power
Roseville Electric
Sacramento Municipal Utility District
Salt River Project
San Diego Gas and Electric Company
Seattle City Light
Snohomish County Public Utility District
Southern California Edison
Southern Maryland Electric Cooperative
Southwestern Electric Power
Southwestern Public Service - NM
Southwestern Public Service - TX
Sterling Municipal Light Dept
Tampa Electric Company
Tennessee Valley Authority
The Illuminating Company
The Potomac Edison Company
Toledo Edison Company
Traverse City Light & Power
Trico Electric Cooperative, Inc.
Truckee Donner Public Utility District
Tucson Electric Power
Turlock Irrigation District
Vectren Corporation
Vernon Electric Cooperative
Vineland Municipal Electric Utility
WEC Energy Group
West Penn Power Company
Westar Energy, Inc.
WPPI Energy

Appendix B: 2017 Demand Response Capacity By State and Select Territories (MW)

TABLE 13: TOTAL DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE AND SELECT TERRITORY		
OPERATING STATE/TERRITORY	**SUM OF TOTAL ENROLLED CAPACITY**	**SUM OF TOTAL DISPATCHED CAPACITY**
ALABAMA	419.8	117.0
ALASKA	-	-
AMERICAN SAMOA	-	-
ARIZONA	48.3	35.9
ARKANSAS	177.6	197.6
CALIFORNIA	1,462.9	318.4
COLORADO	441.3	237.2
CONNECTICUT	-	-
DELAWARE	138.2	135.2
DISTRICT OF COLUMBIA	23.0	21.0
FLORIDA	1,138.2	952.2
GEORGIA	884.5	123.0

TABLE 13: TOTAL DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE AND SELECT TERRITORY		
OPERATING STATE/TERRITORY	**SUM OF TOTAL ENROLLED CAPACITY**	**SUM OF TOTAL DISPATCHED CAPACITY**
GUAM	-	-
HAWAII	32.5	21.2
IDAHO	638.5	550.0
ILLINOIS	1,043.5	128.5
INDIANA	1,001.7	997.4
IOWA	258.2	
KANSAS	348.0	89.0
KENTUCKY	137.1	95.6
LOUISIANA	-	-
MAINE	-	-
MARYLAND	1,628.4	1,569.9
MASSACHUSETTS	21.7	20.1

Note: This data is based on the 155 utility responses to SEPA's Annual Utility Survey in 2018.

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TABLE 13: TOTAL DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE AND SELECT TERRITORY		
OPERATING STATE/TERRITORY	SUM OF TOTAL ENROLLED CAPACITY	SUM OF TOTAL DISPATCHED CAPACITY
MICHIGAN	616.7	93.2
MINNESOTA	1,000.6	339.1
MISSISSIPPI	418.0	68.0
MISSOURI	61.0	60.0
MONTANA	-	-
NEBRASKA	9.3	7.7
NEVADA	273.0	170.5
NEW HAMPSHIRE	6.2	5.5
NEW JERSEY	121.0	57.0
NEW MEXICO	4.6	0.6
NEW YORK	458.2	463.7
NORTH CAROLINA	1,181.2	832.6
NORTH DAKOTA	132.7	55.0
OHIO	734.5	721.0
OKLAHOMA	66.6	66.6

TABLE 13: TOTAL DEMAND RESPONSE ENROLLED AND DISPATCHED CAPACITY BY STATE AND SELECT TERRITORY		
OPERATING STATE/TERRITORY	SUM OF TOTAL ENROLLED CAPACITY	SUM OF TOTAL DISPATCHED CAPACITY
OREGON	25.6	25.5
PENNSYLVANIA	355.2	341.2
RHODE ISLAND	11.8	11.8
SOUTH CAROLINA	440.7	349.1
SOUTH DAKOTA	60.0	19.3
TENNESSEE	729.0	401.0
TEXAS	500.8	456.8
UTAH	257.0	144.0
VERMONT	0.3	4.1
VIRGINIA	17.0	31.8
WASHINGTON	5.1	0.8
WEST VIRGINIA	127.0	127.0
WISCONSIN	830.2	191.7
WYOMING	-	-
GRAND TOTAL	18,286.7	10,653.6

Source: SEPA, 2018. Note: Electric utility data from the U.S. territories Puerto Rico and Virgin Islands was not available to SEPA due to the territories' focus on infrastructure recovery as a result of the 2017 hurricane season.

2018 UTILITY DEMAND RESPONSE MARKET SNAPSHOT

Smart Electric Power Alliance

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