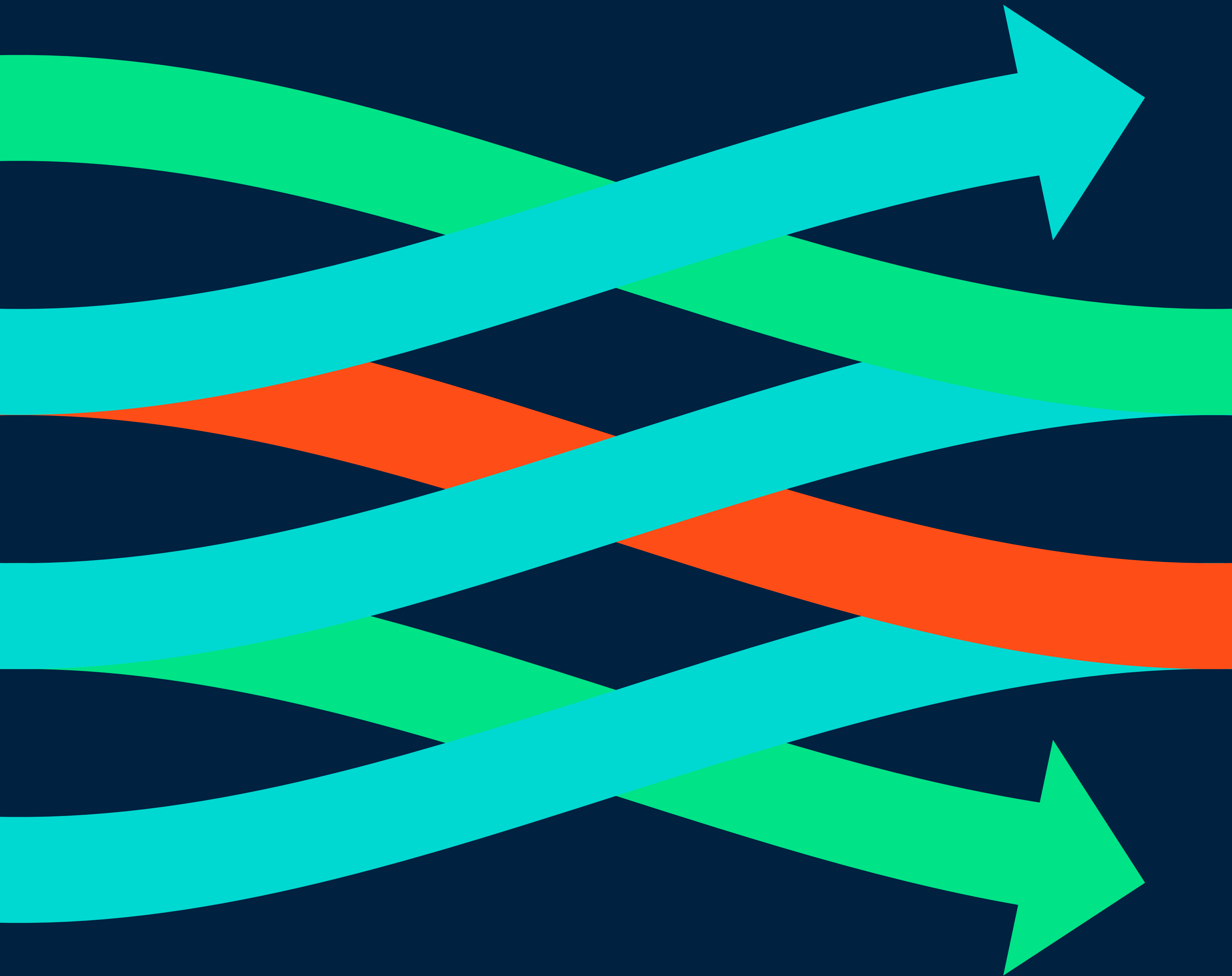
THE STATE OF

DEMAND FLEXIBILITY

FEBRUARY 2024



AESP zpryme DOER/MAKER

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ABOUT **THE REPORT**

Welcome to the "State of Demand Flexibility Report" for 2024, a collaborative endeavor by AESP, ZPRYME, and DOER/MAKER. This report represents a comprehensive exploration of the dynamic landscape of demand flexibility, examining its historical evolution, contemporary significance, tangible benefits, inherent challenges, key terminologies, pivotal technologies, ongoing pilot programs, and the intricacies of program implementation. This collaborative survey is the result of concerted efforts by key stakeholders deeply committed to understanding and harnessing the transformative potential of demand flexibility in shaping the future of sustainable energy.

By synthesizing the collective knowledge and expertise of industry leaders, we aim to facilitate informed decision-making, inspire innovative approaches, and drive progress within the energy sector. Our goal is to empower policymakers, utilities, businesses, and consumers with the knowledge needed to navigate the evolving energy landscape effectively.

COMPERHENSIVE UNDERSTANDING OF **DEMAND FLEXIBILITY**

HISTORY

Traces the historical trajectory of demand flexibility, from its nascent stages to its current prominence in the energy sector

TERMINOLOGY

Familiarizes readers with essential terminologies and concepts that underpin the demand flexibility paradigm

IMPORTANCE

Explores the contemporary significance of demand flexibility in the context of renewable energy adoption, grid resilience, and environmental sustainability

KEY TECHNOLOGY

Provides insights into the pivotal technologies that are driving demand flexibility and shaping the future of energy management

BENEFITS

Identifies the tangible benefits that demand flexibility offers to individuals, businesses, utilities, and the broader society

PILOT PROGRAMS

Highlights ongoing pilot programs that serve as real-world testbeds for demand flexibility initiatives

CHALLENGES

Examines the challenges and obstacles faced in implementing demand flexibility programs in an ever-evolving energy ecosystem

IMPLEMENTATION

Explores the intricacies of implementing demand flexibility programs, from planning to execution

KEY STAKEHOLDERS **BEHIND THE REPORT**

The Demand Flexibility Report for 2024 is a result of collaboration among key stakeholders who recognize the transformative potential of demand flexibility.

AESP

Association of Energy Services Professionals (AESP), founded in 1989, is a dynamic, inclusive community of energy professionals that are essential to advancing a more resilient, sustainable energy future. AESP achieves our important work through professional development, education, and collaboration. For more information, visit aesp.org.

DOER/MAKER

A forward-thinking, certified-woman-owned marketing agency committed to driving innovation in energy and sustainability, DOER/MAKER stands as a thought leader driving innovation, change, and results through marketing campaigns, customer engagement, stakeholder communications, and internal change management. For more information, visit doermaker.com.

zpryme

A prominent research and advisory firm specializing in energy, ZPRYME leverages its deep industry insights to provide strategic guidance and insights into the evolving energy landscape. For more information, visit zpryme.com.

A BRIEF HISTORY OF **DEMAND FLEXIBILTY**

In 2012, a landmark study sparked hope for renewable energy. More than 110 experts from 35 organizations were brought together by the U.S. Department of Energy (DOE). Their task: Examine future scenarios in which most of the United States is powered by renewable electricity.

The report claimed that renewable energy could supply 80% of U.S. electricity by 2050. A decade later, the estimate was even more optimistic. The National Renewable Energy Laboratory (NREL), which released the study, now thinks we could hit 80% by 2035[1]. That means, if current trends continue, in just over 10 years it could be technically and economically possible for the vast majority of Americans to rely on mostly renewable energy.

Before, studies had looked at "renewable energy technologies individually," Sam Baldwin, chief science officer at the DOE's Office of Energy Efficiency & Renewable Energy, said in an NREL statement. But no large-scale study had considered the "natural synergies between solar and wind and other resources like bioenergy, hydropower, and geothermal."

> Even more remarkably, the study showed multiple paths to
> **REACHING 80% RENEWABLES.**
> And it modeled a more resilient power system able to balance energy supply and demand at all hours in every part of the country.

But all of this increased load available from renewable energy also brings an urgent need: to integrate intermittent generation resources into a grid that wasn't originally designed for them, and utilize them to balance load via demand flexibility.

Demand flexibility is the only currently extant solution to balance the grid in a cost effective, nimble, and on-demand manner.

In a landmark 2015 paper by Rocky Mountain Institute (RMI) entitled *The Economics of Demand Flexibility How "Flexiwatts" Create Quantifiable Value for Customers and the Grid*, they defined demand flexibility in the following way[2]:

"Demand flexibility uses communication and control technology to shift electricity use across hours of the day while delivering end-use services (e.g., air conditioning, domestic hot water, electric vehicle charging) at the same or better quality but lower cost. It does this by applying automatic control to reshape a customer's demand profile continuously in ways that either are invisible to or minimally affect the customer, and by leveraging more-granular rate structures that monetize demand flexibility's capability to reduce costs for both customers and the grid."

In the face of rising temperatures—as wildfires, storms, and other natural disasters strain energy infrastructure—there is accelerating momentum toward a more sustainable future. It won't be easy, however. As the grid increasingly relies on renewable energy, which varies with weather conditions, more system flexibility will be key. That will require new technology, evolving business models, workforce development, and updated regulations.

WHY GRID FLEXIBILITY IS **MORE IMPORTANT THAN EVER**

Today, as cities and states across the country continue adopting aggressive decarbonization goals the implications for the electric grid are enormous. In a nutshell, it puts a massive demand on the grid, while simultaneously phasing out the carbon-intensive but reliable fuels that have historically powered it. Additionally, beneficial or strategic electrification has brought about even more focus on decarbonized electricity—especially the growing adoption of electric vehicles and transition away from gas heating.

Additionally, interconnection represents significant challenges for many utilities. The interconnection process for utilities, referring to the integration of distributed energy resources (DERs) such as solar panels or wind turbines into the electrical grid, poses several challenges. These challenges can vary based on factors like the scale of the interconnection, regulatory frameworks, and the specific technologies involved. Here are some common challenges associated with interconnection processes for utilities:

Technical Challenges for Interconnection:

Grid Stability and Reliability: Integrating intermittent energy sources like solar and wind can impact grid stability. Fluctuations in power generation may require additional measures, such as energy storage or advanced grid management systems, to maintain reliability.

Voltage and Frequency Regulation: DERs can introduce voltage and frequency variations, which must be carefully managed to ensure the overall stability of the grid.

Lack of Uniform Standards: Inconsistent or unclear interconnection standards and regulations across different regions can create challenges for utilities and project developers. A lack of standardized processes may lead to delays and increased costs.

Regulatory Complexity: Complex regulatory frameworks can hinder the smooth integration of DERs. Utilities and developers must navigate various rules, procedures, and requirements, which can be time-consuming and resource-intensive.

Capacity and System Upgrades:

Infrastructure Limitations: In some cases, existing grid infrastructure may lack the capacity to accommodate the increased load from distributed generation. Upgrading infrastructure may be necessary, requiring significant investments and coordination efforts.

Cost Allocation: Determining how to allocate the costs of necessary system upgrades among utilities, developers, and consumers can be a contentious issue.

Coordination and Communication:

Communication Protocols: Establishing effective communication protocols between utilities and DERs is crucial for grid management. Inconsistent communication standards can impede real-time monitoring and control.

Coordination Challenges: Coordinating the activities of multiple stakeholders, including utilities, regulators, and project developers, is essential. Lack of coordination can lead to inefficiencies and delays.

Grid Planning and Forecasting: Accurate Forecasting: Utilities need accurate forecasts of the expected power output from DERs to plan for grid operation effectively. Inaccurate forecasts can lead to challenges in maintaining a reliable and balanced grid.

Security Risks: The increased connectivity between various components in the grid introduces cybersecurity risks. Safeguarding the grid against potential cyber threats is a continuous challenge for utilities.

Resource Adequacy and Redundancy:

Resource Planning: Ensuring an adequate and diverse mix of energy resources, including both centralized and distributed generation, is crucial for maintaining a resilient and reliable grid.

Addressing these challenges requires a collaborative effort among utilities, regulators, policymakers, and technology providers to develop clear standards, streamline processes, and invest in necessary infrastructure upgrades. Effective interconnection processes are essential for realizing the full potential of distributed energy resources and transitioning to a more sustainable and resilient energy system.

These complexities feed directly into the importance of Demand Flexibility (DF), which refers to the ability of demand-side loads to change their consumption patterns across hours of the day or on another timescale—allowing for a more dynamic and flexible grid.

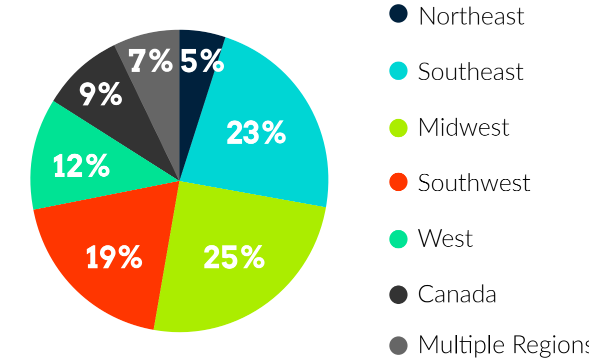
Grid flexibility offers a range of benefits to society, extending beyond the advantages it provides to utilities and individual consumers. As the electric grid undergoes this rapid transformation involving the adoption of grid-interactive technologies and changes in consumer usage patterns, finding ways to better match renewable energy generation with energy demand can reduce carbon emissions and overall system costs, while also increasing reliability by avoiding system capacity constraints, at generation, transmission, and distribution levels.

THE STATE OF DEMAND FLEXIBILITY: **AN OVERVIEW OF THE RESEARCH STUDY**

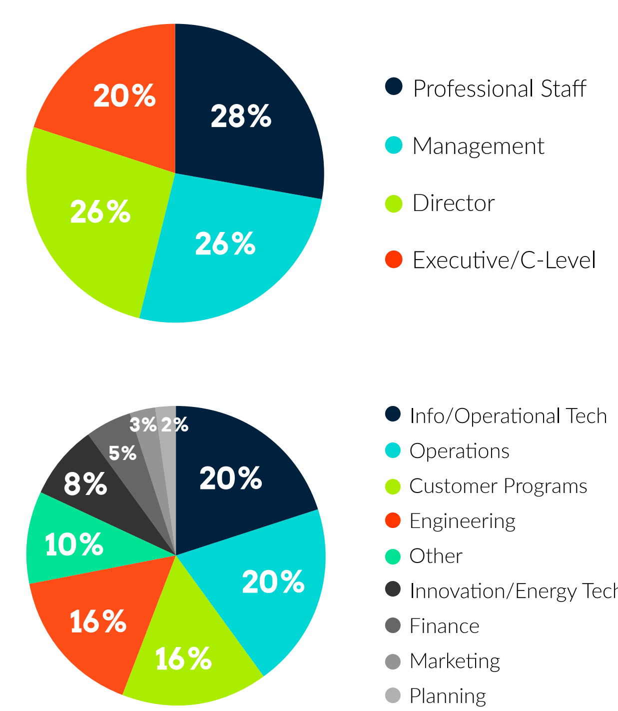
As the focus of the industry continues to shift to the strategy and implementation of demand flexibility programs and offerings, AESP, in partnership with ZPRYME and DOER/MAKER, wanted to establish a benchmark for where utilities stand currently in their process, and the challenges and opportunities that demand flexibility is presenting. Beginning in the summer of 2023, we conducted a national survey of utilities, with over 60 utility executives and thought leaders represented from across the North America.

This survey was complemented by in-depth interviews with utility professionals who shared insights that helped to formulate the State of Demand Flexibility. Bellow is a summary of survey respondent key demographic information.

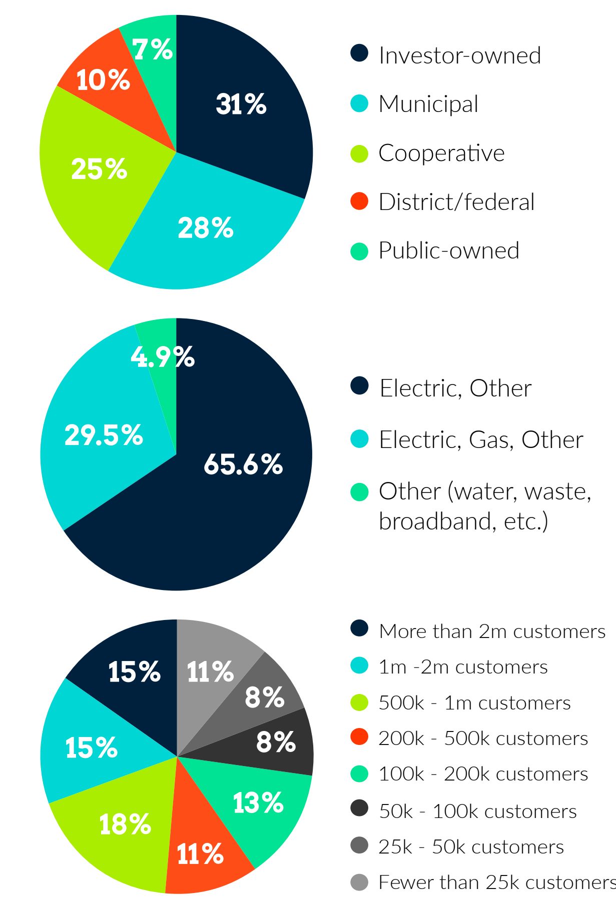
Survey Respondents by Region



Respondents Job Level & Primary Role



Respondents Utility Type, Services Provided & Size



KEY FINDINGS + TRENDS

As we move into the research findings, you'll note some significant trends emerging.

The importance of demand flexibility for the future of the grid: 93% of respondents consider demand flexibility to be a medium-to-high priority for their organizations for the next three years. 85% of respondents are actively implementing DF programs right now, have within the last three years, or plan to within the next two years.

Perceived benefits of demand flexibility: From resilience to sustainability to lower costs and customer satisfaction, the real and perceived benefits of demand flexibility programs present unique opportunities for utilities.

Not just grid resiliency, but business resiliency: A major theme that echoed throughout the research findings was the need for workforce development and up-skilling. As the utility workforce ages, in-house systems for DER management are in danger of becoming stranded assets within the business, introducing significant risk to operational functionality. And as more and more innovation and technologies enter the market, utilities need to be investing in new skillsets and internal teams to integrate them into operational realities.

A varied state of the value chain: There really wasn't consistency or consensus between respondents on where their organization was in the value chain process, from very early stage strategy all the way through to implementation, evaluation, and measurement.

An opportunity to educate: A resounding theme throughout the responses was the need for both internal education of utility employees, external education of stakeholders, regulators, policy-makers, and beyond—and perhaps most importantly, a much more robust and intentional plan for interacting with customers.

93% of utilities consider demand flexibility to be a medium-to-high priority for their organization for the next three years.

BENEFITS OF **DISTRIBUTED ENERGY RESOURCES (DERS)**

Individual consumers represent a significant opportunity: DERs can help them save money on their electric bills, solar PV helps homeowners reduce their reliance on the grid (and avoid rising energy costs) by generating their own electricity. And with the help of energy storage solutions, they can leverage excess stored solar energy in times of greater need. Electric vehicles (EVs) can provide significant cost savings compared to traditional gas-powered vehicles—and contribute to grid stability. And of course, these benefits impact the individual consumer and the utility, allowing individual consumers, municipalities, and neighborhoods to contribute to resiliency at large, enabling the utility to optimize grid performance and deliver enhanced reliability.

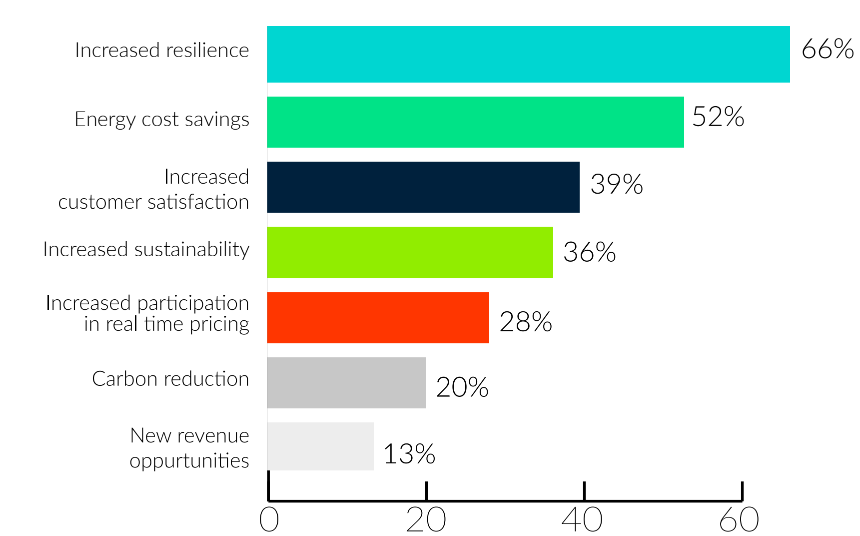
For businesses, DERs can help reduce consumption and lower their bills through a few different mechanics. In a June 2023 report issued by BOMA and Steven Winters Associates entitled "Electrification in Commercial Buildings," they defined building electrification as a major opportunity to drive savings and resiliency[3].

"Building electrification is the act of replacing fossil fuel powered boilers, domestic hot water heaters, and commercial grade ovens with all electric appliances such as heat pumps, ground-source heat pumps, and induction stoves. The adjectives "beneficial" or "strategic" may be used to further define that replacements only take place when they benefit the end-user and reduce overall emissions. Strategic electrification means considering a holistic approach to building retrofits, including energy efficiency measures, demand response programs, solar PV, and other interventions that reduce energy demand."

Building Automation Systems (BAS) can help businesses optimize their energy use by providing real-time data on energy consumption and enabling them to adjust their energy use.

Through demand response programs, customers are incentivized to reduce electricity usage during times of peak demand, which can help ensure the reliability of the grid and shift load. In addition to reducing demand, key technology advancements now allow excess renewable energy to be stored and discharged during times of higher demand, while microgrids—or self-contained power systems—that can disconnect from the central grid in the circumstance where it begins to fail, such as a large storm, increased demand on other parts of the grid, or even cyber attack, such that a utility can continue to provide service to customers.

WHAT ARE THE BIGGEST BENEFITS TO IMPLEMENTING A DEMAND FLEXIBILITY PROGRAM?



Virtual Power Plants: The Next Frontier and Significant Opportunity

A Virtual Power Plant (VPP) is composed of numerous households and businesses, totaling in the hundreds or thousands, which contribute the untapped capabilities of their thermostats, electric vehicles (EVs), appliances, batteries, and solar arrays to bolster the grid. These devices possess the flexibility to be charged, discharged, or controlled in accordance with grid requirements.

When these devices are aggregated and synchronized, they can deliver a range of energy services (including capacity, energy, and ancillary services) comparable to those offered by a conventional power plant. The constituents of a VPP encompass a variety of elements such as electric vehicles (EVs) and their charging stations, heat pumps, household appliances, HVAC systems, batteries, plug loads, and industrial machinery. Participation in a VPP is open to diverse settings, including single-family homes, multi-family residences, offices, retail establishments, factories, as well as various modes of transportation such as cars, trucks, and buses.

Virtual Power Plants (VPPs) can play a crucial role in assisting regulatory bodies, utility planners, operators, and other participants in the grid in tackling significant challenges like ensuring reliability, enhancing affordability, advancing decarbonization, promoting electrification, and addressing health and equity considerations.

CHALLENGES FACING THE IMPLEMENTATION **OF DEMAND FLEXIBILITY**

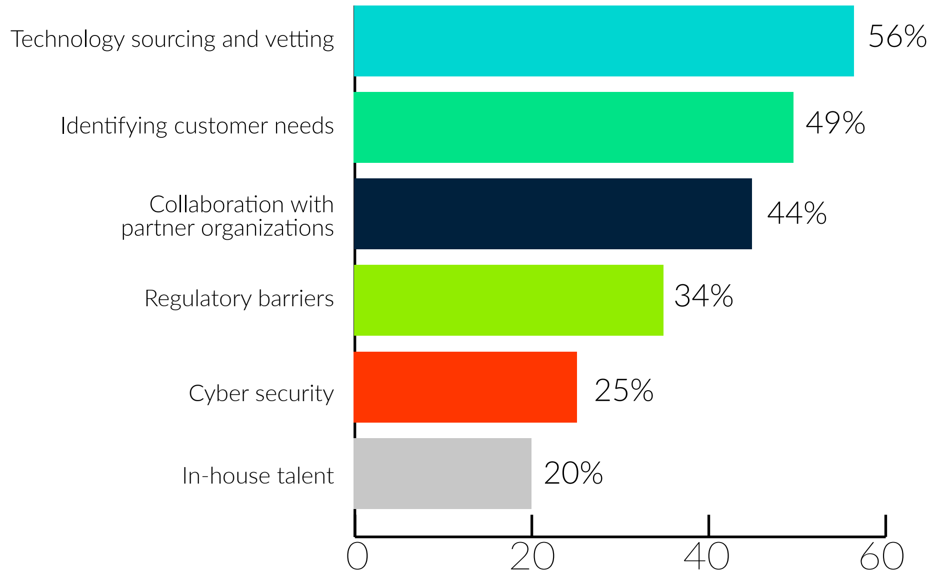
Cities, states, and corporations are adopting aggressive decarbonization goals. At the same time, consumers are electrifying their lives with electric vehicles, smart appliances, and more. The implications for the power grid are enormous. In fact, the Brattle Group estimates that fully electrifying heating and transportation could nearly double U.S. electricity demand by 2050[4].

The grid will need to be able to handle the added demand—especially during severe weather. The American Council for an Energy-Efficient Economy (ACEEE) studied a polar vortex that hit the Midwest and Northeast in 2017[5]. Peak power demand in the area was 275 gigawatts. If the region was fully electrified, that number would have jumped to 690 gigawatts. Needless to say, massive blackouts in that scenario could have been deadly. So not only do utilities need to prepare for higher loads, they also need to be ready for changing and sometimes unpredictable patterns of energy use.

In 2021, the White House set an ambitious target: half of vehicles sold in 2030 should be emissions-free[6]. General Motors, Ford, and Chrysler parent company Stellantis said they shared that goal. But the real shift could come when massive fleets of vehicles—including buses, 18-wheelers, and delivery vans used by Amazon, FedEx, and the U.S. Postal Service—go electric. Charging sites for those fleets will need to be seriously upgraded, and the distribution grid at these sites will require serious upgrades.

As homes and businesses increasingly interact with the power grid, it has the potential to become more resilient and flexible—but also more complex. With power increasingly being generated by households and businesses, the industry will need to find inventive ways to make sure the grid stays reliable as the U.S. enters a new era of energy.

WHAT ARE THE BIGGEST CHALLENGES TO IMPLEMENTING A DEMAND FLEXIBILITY PROGRAM?

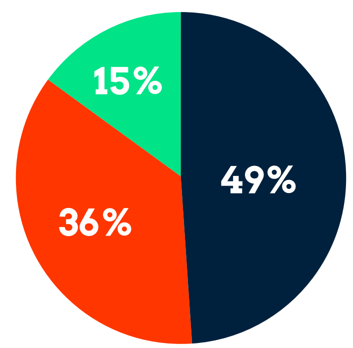


Even with the mounting need and pressure to meet these ambitious goals, implementing a demand flexibility program presents challenges spanning various crucial aspects that were identified in the survey. While the cost of implementing these programs will always be a main concern, there are several other challenges that are top of mind for organizations. In terms of technology, keeping pace with rapid advancements while vetting reliable vendors poses a substantial hurdle. Program design requires a delicate balance between meeting diverse customer needs and regulatory compliance. Meanwhile, program evaluation entails managing vast data volumes, ensuring data integrity, and gauging the program's impact accurately. Implementing advanced metering infrastructure and interpreting data effectively contribute to the complexity of program measurement. Program implementation faces challenges in customer engagement, resource allocation, and integration into existing operations. Lastly, program marketing necessitates educating customers, fostering behavioral change, and sustaining marketing efforts.

In addition to the complex challenges mentioned, workforce development needs are another needed focus when implementing demand flexibility programs. As the energy landscape evolves rapidly, there is a growing demand for a skilled workforce capable of managing and maintaining these advanced technologies. Utilities and organizations need to invest in training and development programs to equip their employees with the necessary skills to operate, troubleshoot, and optimize demand flexibility solutions effectively.

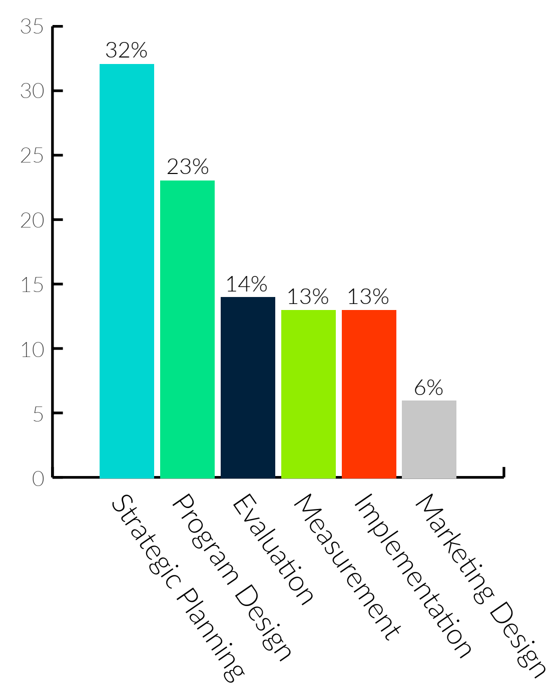
Addressing these multifaceted challenges demands a multidisciplinary approach and collaboration among stakeholders, including utilities, technology providers, regulators, and consumers. Adaptability and continuous monitoring are essential, along with a commitment to staying abreast of technological innovations and evolving energy policies to ensure the successful establishment and maintenance of a demand flexibility program.

HAS YOUR ORGANIZATION BEGUN DEVELOPMENT OF A DEMAND FLEXIBILITY PROGRAM?



- Utilities that plan on implenting demand flexibility programs within 3 years
- Utilities that have implement demand flexibility programs within the last 3 years
- Utilities that have no plan to implement demand flexibility programs

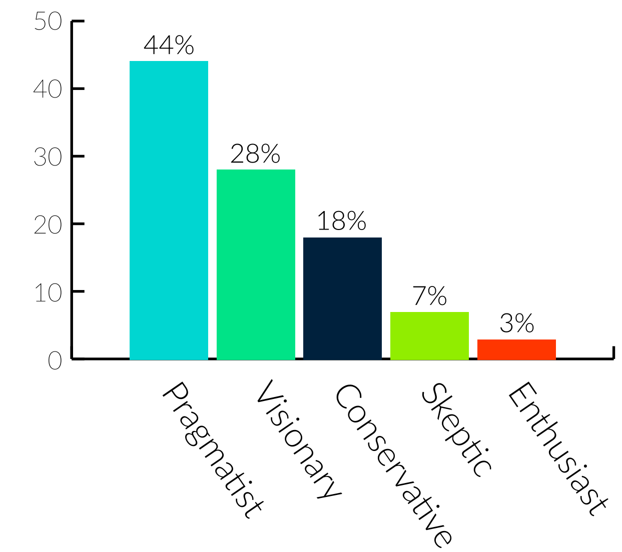
HAS YOUR ORGANIZATION BEGUN DEVELOPMENT OF A DEMAND FLEXIBILITY PROGRAM?



DEMAND FLEXIBILITY PATHWAYS TO ENSURING A DYNAMIC & RESILIENT GRID

To achieve a grid that is able to handle the complexity and increased demands being placed on it, multiple concepts will need to be fully developed and successfully implemented. The concepts in this section are just some examples of ideas that will be increasingly important to achieving a carbon-neutral electric grid. And as you can see from the graphic below, utilities are currently taking a mixed but mostly pragmatic approach to adopting new technologies and programs.

WHERE IS YOUR ORGANIZATION ON THE ADOPTION CURVE FOR NEW TECHNOLOGIES AND PROGRAMS?



Distributed Energy Resources (DERs)

Typically producing less than 10 megawatts (MW) of power, DER systems can usually be sized to meet particular needs and installed on site. DER technologies include wind turbines, photovoltaics (PV), fuel cells, microturbines, reciprocating engines, combustion turbines, cogeneration (combined heat and power), and energy storage systems (such as batteries). DERs are also often deployed in close physical proximity to the local energy need, meaning that the source and the utilization are generally geographically close.

Demand Side Management

Demand Side Management (DSM) programs consist of the planning, implementing, and monitoring activities of electric utilities which are designed to encourage consumers to modify their level and pattern of electricity usage. In the past, the primary objective of most DSM programs was to provide cost-effective energy and capacity resources to help defer the need for new sources of power, including generating facilities, power purchases, and transmission and distribution capacity additions. However, due to changes that are occurring within the industry, electric utilities are also using DSM to enhance customer service.

Scalability is a key aspect of demand-side management, broadly categorized into four scales: national, utility, community, and individual household.

At the national scale, energy efficiency emerges as a pivotal strategy within demand-side management, with potential implementation through legislative measures and standards affecting various sectors like housing, construction, appliances, transportation, and machinery.

On the utility scale, during peak demand periods, utilities wield control over storage water heaters, pool pumps, and air conditioners in extensive regions to mitigate peak demand, as exemplified in countries such as Australia and Switzerland. Ripple control, employing a high-frequency signal (e.g., 1000 Hz) superimposed onto standard electricity (50 or 60 Hz), is a common technology for device activation or deactivation. In service-oriented economies like Australia, peak demand typically occurs in the late afternoon to early evening, emphasizing the significance of managing residential demand for storage water heaters, pool pumps, and air conditioners.

Moving to the community scale, also referred to as neighborhood, precinct, or district, central heating systems for communities have existed for decades in cold winter regions. Similarly, in summer peak regions like Texas and Florida in the U.S., demand-side management is crucial for handling peak demand for heating or cooling. Another goal at the community scale is achieving net zero-energy buildings or communities.

Implementing demand-side management at the community level proves more practical and viable due to collective purchasing power, bargaining capabilities, a wider range of options for energy efficiency and storage, and increased flexibility and diversity in energy generation and consumption, such as using photovoltaics to offset daytime demand.

Demand Response

Demand response refers to a change in electricity consumption by consumers to help keep the supply and demand of electricity in balance. Demand response provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives.

Demand response programs are being used by electric system planners and operators as resource options for balancing supply and demand. Such programs can lower the cost of electricity in wholesale markets, and in turn, lead to lower retail rates.

Methods of engaging customers in demand response efforts include offering time-based rates such as time-of-use pricing, critical peak pricing, variable peak pricing, real time pricing, and critical peak rebates. It also includes direct load control programs which provide the ability for power companies to cycle air conditioners and water heaters on and off during periods of peak demand in exchange for a financial incentive and lower electric bills. It is also worth noting that all of these time-based and direct load control programs are complex and nuanced value props, and require customer education and marketing support, as well as internal change management around communications.

Non-Wires Alternatives (NWA)

This is an inclusive term defined as any action or strategy that could help defer or eliminate the need to construct or upgrade a transmission system and distribution substations. The reasons for NWA actions could include lowering costs, satisfying reliability goals, or meeting public policy objectives.

NWA options include, but are not limited to: demand response, solar, energy storage, combined heat and power (CHP), microgrid, conservation or energy efficiency measure, and other distributed energy resources (DERs) or distributed generation (DG). NWA projects can include these and other investments individually or in combination to meet the specified need in a cost-effective manner. Some examples of non-wires alternatives include smart and/or intelligent appliances and devices, load shedding, load shaping, and interruptible load.

Interruptible Load (IL) Programs

Interruptible load (IL) programs serve as valuable tools for the ISO, enabling them to be activated during critical system conditions to provide essential demand reduction and activate operating reserves within approximately 30 minutes. The primary objective is to incentivize customers to curtail their power consumption during peak load periods.

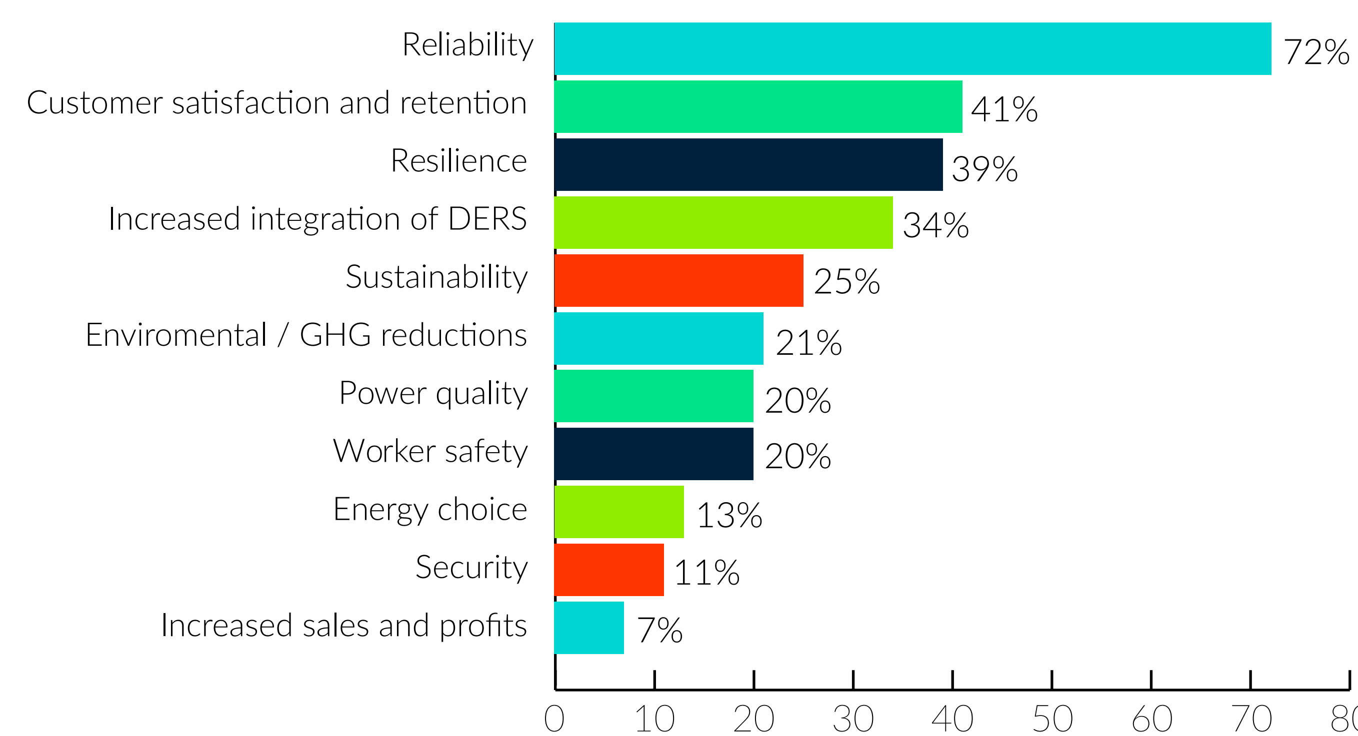
In participation with an interruptible load program, customers enter into agreements with either their local utility or the ISO to lower their electricity demand whenever required. This approach benefits the utility by reducing peak load, leading to savings on expensive generation reserves, restoring service quality, and enhancing overall system reliability. In return, customers experience reduced energy expenses, particularly through incentives offered by the local utility or the ISO.

KEY TECHNOLOGIES
SUPPORTING DEMAND FLEXIBILITY

In addition to the concepts above, and often directly supporting them, are multiple new technologies that are rapidly being developed and implemented. Each one of these technologies bring their own value to grid resiliency. For example, battery storage devices and smart heat pump water heaters can store excess energy and utilize it when required, reducing wastage, and optimizing energy usage; electric vehicle charging equipment can enable electric vehicles to be charged efficiently, and interactive HVAC can regulate temperature and airflow, optimizing energy usage. These emerging technologies are also helping to make buildings become smarter about the amount and timing of energy use and emit less carbon.

These emerging technologies are also helping to make buildings become smarter about the amount and timing of energy use and emit less carbon. In fact, the U.S. Department of Energy's Building Technologies Office created the concept of Grid-Interactive Efficient Buildings (GEBs). The GEB Initiative works to remake buildings into clean and flexible energy resources by combining energy efficiency and demand flexibility with smart technologies and communications to inexpensively deliver greater affordability, comfort, productivity, and performance to America's homes and buildings.

WHAT ARE THE KEY FACTORS DRIVING YOUR ORGANIZATION TO ADOPT NEW TECHNOLOGIES?



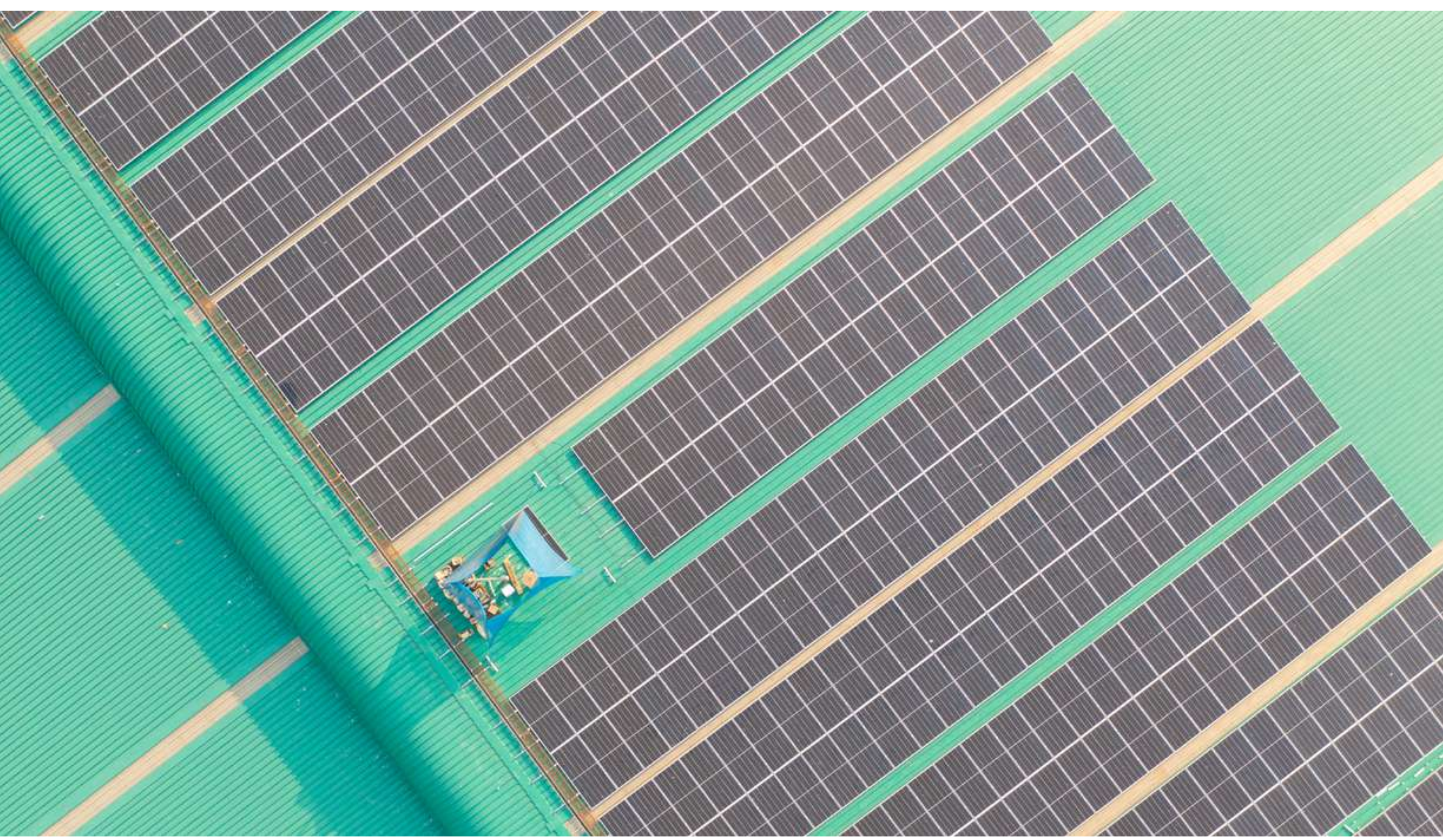
Energy Efficiency: “The First Fuel”

Energy efficiency is often referred to as the “first fuel” due to its significant impact on meeting energy demands and addressing environmental concerns. The concept emphasizes the idea that maximizing the efficiency of energy use should be prioritized before exploring additional energy sources or increasing production capacity. In essence, energy efficiency is considered the primary and foundational element in the overall energy landscape since the 1970’s.

The “first fuel” concept recognizes that by improving the efficiency of energy consumption in various sectors such as residential, commercial, industrial, and transportation, a substantial amount of energy can be conserved and unnecessary waste reduced. This, in turn, leads to several benefits, including cost savings, reduced greenhouse gas emissions, and enhanced energy security.

Implementing energy-efficient practices involves adopting technologies, policies, and behavioral changes aimed at getting more useful work or services from the same amount of energy input. This can include upgrading appliances, improving insulation in buildings, using energy-efficient lighting, and optimizing industrial processes. Governments, businesses, and individuals play crucial roles in promoting and adopting energy-efficient measures.

Investing in energy efficiency as the “first fuel” aligns with sustainability goals, mitigates environmental impacts, and contributes to a more resilient and reliable energy system. Recognizing the importance of energy efficiency underscores its pivotal role in achieving a balanced and sustainable energy future.



EMERGING TECHNOLOGIES

The following technologies have great potential to benefit consumers, building owners, and utility and wholesale market operators. Each technology provides unique opportunities—and has specific limitations—when it comes demand flexibility. Taken together, they have the potential to drive down energy costs for customers, reduce our carbon footprint, and improve overall health and wellbeing.

Pumped-Hydro Storage
Utility-scale storage, also commonly referred to as large-scale or grid-scale storage, has historically been provided by resources such as pumped hydro.

Battery Storage
Generally, grid-scale batteries are either paired with a generating resource, such as a wind farm, or placed on the transmission and distribution system, such as at substations, to help balance local electric supply and demand. The most common grid-scale battery solutions today are rated to provide either two, four, or six hours of electricity at their rated capacity.

Solar Battery Storage
Residential solar battery storage is a technology that allows homeowners to store excess energy generated by their solar panels for later use. This system typically involves the installation of rechargeable batteries that store electricity during periods when solar panels produce more energy than is immediately needed, such as during sunny days. The stored energy can then be utilized during times when the solar panels are not producing electricity, such as at night or on cloudy days.

Key components and features of residential solar battery storage include:

- **Solar Panels:** The system starts with solar panels installed on the roof or property to capture sunlight and convert it into electrical energy.
- **Inverter:** Solar inverters are used to convert the direct current (DC) generated by the solar panels into alternating current (AC) that can be used to power household appliances.
- **Battery System:** The heart of the residential solar battery storage system is the battery itself. These are usually lithium-ion batteries, known for their high energy density and longer lifespan. The batteries store excess energy generated by the solar panels.
- **Battery Management System (BMS):** BMS monitors and manages the charging and discharging of the batteries to optimize their performance and ensure their longevity.
- **Energy Monitoring Systems:** Many solar battery storage systems come with monitoring tools that allow homeowners to track energy production, consumption, and storage. This information helps users make informed decisions about their energy usage patterns.

While the technology is advancing, it is essential for homeowners to consider factors such as system cost, capacity, and local regulations when deciding to invest in residential solar battery storage.

Electric Vehicle Charging
Electric vehicles (EVs) offer significant benefits for the users of these vehicles, especially if they choose to charge at times when energy demand is low. From a utility’s perspective, EV adoption presents financial opportunity in terms of additional electric sales, but with the potential to dramatically increase demand on the grid.

As we move from residential vehicle charging to fleet EV transformation, the draw on the grid becomes even more significant. Public transportation, school buses, and private fleets all represent significant carbon emissions savings opportunities, but the grid must be able to support this demand. And the charging infrastructure has to be in place to support the needs of the drivers.

Smart Thermostats
Many smart thermostats learn a customer's temperature preferences and establish a schedule that automatically adjusts to energy-saving temperatures when they are asleep or away, while the connectivity of smart thermostats allows customers to easily participate in Demand Response programs.

Intelligent Advanced Heat Pumps
Advanced Heat Pumps are made intelligent by their controls and smart thermostats. Advanced features allow these heat pumps to improve on both occupant comfort and reduced energy consumption. There are three main types of heat pumps connected by ducts: air-to-air, water source, and geothermal.

Smart Heat Pump Water Heaters
Heat pump water heaters (HPWH) use electricity to move heat from one place to another instead of generating heat directly. Therefore, they can be two to three times more energy efficient than conventional electric resistance water heaters.

Grid Interactive Water Heaters
Grid interactive water heating (GIWH) adds bi-directional control to electric resistance water heaters allowing the utility or third-party aggregator to turn them rapidly and repeatedly on and off, or incrementally ramp their power up and down. This functionality turns a fleet of water heaters into a flexible energy-storage medium, capable of increasing and decreasing the load on the grid on a second-by-second basis.

Whole Home Intelligent Energy System/Whole IoT Systems
A Whole Home Intelligent Energy System (WHIES), or Whole Home IoT system, is a smart home energy management system that connects and manages various energy-consuming devices in a home, such as lights, appliances, heating and cooling systems, and renewable energy sources like solar panels. Some examples of components that make up the WHIES include a smart service panel, intelligent or connected lighting Systems, and intelligent pool pumps.

Building Envelope
The integrity of the building envelope is an important element in Grid Interactive Building (GIB) design. For the cooling season, the concept is that the building can be subcooled during off-peak hours by lowering the thermostat. Once the on-peak begins, the thermostat can be set up, causing the AC units to not operate during those peak hours.

CURRENT **PILOT PROGRAMS**

A critical element in discovering the best ways to implement new technologies and concepts on our path towards a flexible, stable grid are through innovative pilot programs. These programs provide an opportunity to better understand how consumers react to changing technology—and how this technology changes consumer behavior. Thankfully, utilities across the country have already begun implementing pilot programs, which can be grouped into three different levels, with each level escalating in both complexity and potential return on investment.

Level 1: Isolated

As demonstrated by the peak rewardsSM program from BGE, a Level 1 intervention is switch or device based. In this example, participants elect to have a programmable thermostat or outdoor switch installed at their homes as part of a reward program that offers credits toward their energy bill. The installed devices receive a signal from the utility to start cycling air conditioners on and off when energy demand in the area peaks.

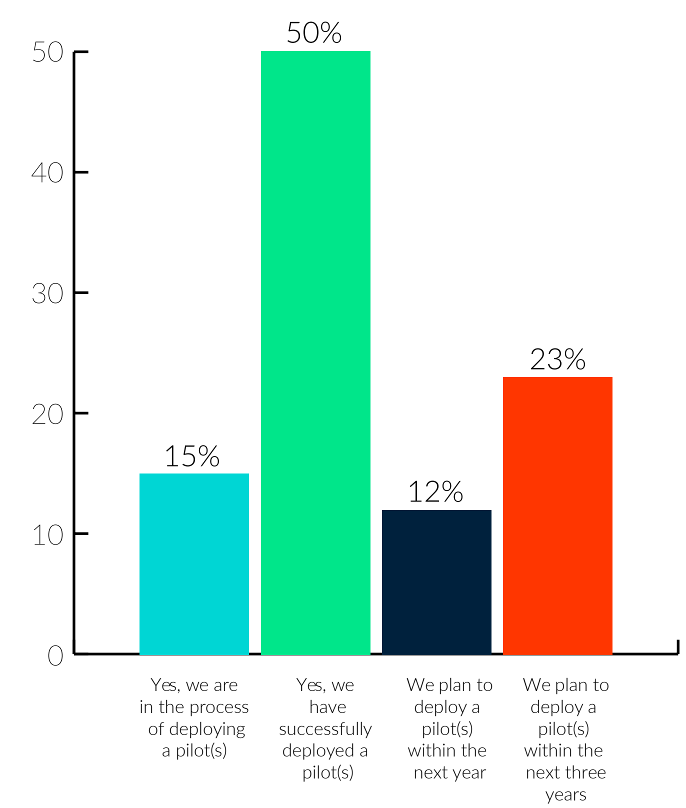
Level 2: Paired

In paired programs, consumer enrollment is encouraged by pairing programs with other offerings or rates. An example of a paired program is PG&E and Uplight, which offer a SmartAC™ Smart Thermostat program. This program offers consumers an incentive for installing a new smart thermostat in their home, or for enrolling if they already have a smart thermostat in the home, plus an additional incentive at the end of each summer for program participants. The goal of this program is not to use less electricity, but to shift energy use to times when there is less demand on the grid.

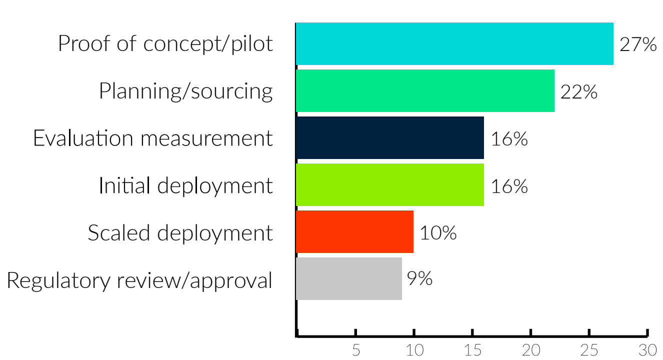
Level 3: Multi-functional

A multi-functional program is a cross-device, cross-customer segment program enabling Virtual Power Plant (VPP)-style, centralized management. Puget Sound Energy and AutoGrid have launched a VPP that they plan to grow to 100 MW capability by 2025. This VPP program is composed of five key elements, including energy efficiency, demand response, distributed energy resources, energy storage and electric vehicles. The plan for the VPP is to manage—or orchestrate—these distributed resources in a way that balances electricity loads and provides grid services.

HAVE YOU DEPLOYED ANY PILOTS OF NEW TECHNOLOGIES AT YOUR ORGANIZATION?



IF SO, WHAT STAGE IS YOUR ORGANIZATION AT IN THE PILOT DEPLOYMENT(S)?



A few crucial elements regarding demand flexibility program planning not identified by survey respondents were customer education and outreach. Effective customer education is a pivotal element in implementing new energy technologies and concepts for a flexible and stable grid. It involves clear and strategic communication with consumers to inform them about the benefits of pilot programs and how these initiatives align with their interests. Tailored messaging for different program levels, from isolated device-based interventions to multi-functional Virtual Power Plants (VPPs), is crucial to ensure consumers understand their role and the potential impact on their energy consumption and savings.

Maintaining ongoing engagement through newsletters, webinars, and user-friendly platforms keeps participants informed and connected. Feedback mechanisms should be in place to gather input and continuously improve the programs. By integrating customer education into these initiatives, utilities can empower consumers to make informed choices, contribute to grid stability, and accelerate the adoption of sustainable energy solutions, fostering a smoother transition to a more efficient energy landscape.

SUCCESSFUL DEMAND FLEXIBILITY **PROGRAM IMPLEMENTATION**

Buildings account for more than 70% of U.S. electricity use and at least one-third of U.S. economy-wide CO2 emissions[7]. Improving the way electricity is consumed and reducing the overall amount of electricity consumption in buildings would significantly reduce energy costs to consumers and facilitate the transition to a decarbonized economy. This is the reason why Grid-Interactive Buildings (GEBs)—with the potential to lower electricity consumption and bills, improve system reliability, and improve the satisfaction of building owners and occupants—are such a critical element in Demand Flexibility.

It is so important, in fact, that the Department of Energy's Buildings Technology Office created a roadmap for GEBs, with the goal of tripling energy efficiency and demand flexible in residential and commercial buildings by 2030, relative to 2020 levels. To accomplish this, however, the Department of Energy will need a high level of consumer buy-in and a significant number of demand flexible programs will need to be implemented to be successful.

Ten Categories of Effective Demand Flexibility Program Implementation

1. Clear Program Objectives

Utility planners need to determine whether the goal is to reduce peak demand, optimize energy consumption, enhance grid reliability, or achieve other specific outcomes such as customer satisfaction, serving environmental justice communities, and carbon reduction. Defining clear objectives helps guide the design, implementation, and evaluation of the DF program.

2. Stakeholder Engagement

By engaging stakeholders early—including utilities, grid operators, building owners, facility managers, end-users, technology providers, and regulatory bodies—one can foster buy-in, facilitate collaboration, and ensure that project design and implementation align with each stakeholder's needs and expectations. Customer and internal education are crucial for conveying the significance of the issue, its urgency, and how demand flexibility programs can effectively address the problem.

3. Robust Data Collection + Analysis

Through the implementation of robust data collection systems, it becomes feasible to acquire precise and timely data concerning energy consumption, load patterns, system effectiveness, as well as customer contentment, equity measures, and the reduction of carbon emissions.

4. Technology Infrastructure

Evaluating the present technology infrastructure enables the identification of potential upgrades or improvements essential for accommodating demand flexibility. A notable hurdle in this process revolves around ensuring business resilience and workforce development. As the existing generation of IRP planners, utility distribution planners, security experts, and IT professionals retire, there arises a need to nurture new talent and assess fresh infrastructure. The traditional approaches of relying on internally developed and custom utility solutions prove inadequate for the scale required to seamlessly integrate DERs into contemporary grid systems.

5. Regulatory + Market Considerations

For compliance with regulations and market regulations concerning demand response, energy pricing, and grid interactions, it is vital to collaborate closely with regulatory authorities and market operators. This collaboration helps align program design and implementation with relevant guidelines, while also focusing on educating stakeholders about the current system and program constraints, the advantages of integrating DERs, adopting demand flexibility practices, and understanding the impact on customers.

6. Community Outreach & Diversity Equity + Inclusion (DEI)

At first glance, it might seem that DEI and community outreach are not as critical to demand flexibility as the development of new, cutting-edge technologies capable of ensuring a dynamic and stable grid. However, even the most advanced technology is useless if consumers are unwilling or unable to use it in their daily lives. For that reason, promoting customer participation and educating end-users about the benefits and value of demand flexible load programs cannot be overstated.

Clearly communicating program details, incentives, and expected outcomes will encourage active engagement. It is important to provide user-friendly tools, information, and resources to facilitate customer understanding and active participation. And keep in mind that a large percentage of utility customers fall within a customer segment that may have been historically underserved and will require additional resources, support, and education.

HOW IS YOUR ORGANIZATION PRIORITIZING DEI IN YOUR DEMAND FLEXIBILITY PROGRAMS?

36%
We are not currently pursuing DEI initiatives within our demand flexibility program

33%
Community engagement (surveys, interviews, etc.)

28%
Engagement with community stakeholders and organizations

23%
Internal steering committee(s)

21%
Appointed internal DEI specialist to assist with program design and implementation

20%
External consultant to assist with program design and implementation

Incentives + Rewards

Financial incentives, bill credits, time-of-use pricing, and other incentives can motivate customers to adjust their energy usage patterns and participate in demand response activities. Tailoring incentives to align with customer preferences will optimize program outcomes.

Scalability + Flexibility

Program scalability and flexibility can help account for potential growth, changes in technology, and evolving market dynamics. Program implementers should ensure that the program framework and infrastructure can accommodate future expansions, technological advancements, and integration with new energy resources.

Performance Monitoring + Evaluation

Implementers need to continuously monitor key performance indicators (KPIs), such as peak demand reduction, energy savings, customer satisfaction, and grid reliability improvements. Regularly evaluate program outcomes, identify areas for improvement, and make data-driven adjustments to optimize program effectiveness.

Collaboration + Partnerships

Foster collaboration and partnerships with relevant stakeholders, such as technology vendors, research institutions, policy makers, higher education providers and workforce development programs, and industry associations. Leverage expertise and resources from these partnerships to enhance project implementation, leverage best practices, and stay informed about emerging trends and innovations in demand flexibility.

SUMMARY & **CONCLUSION**

The history of demand flexibility has shown remarkable progress and potential for a more sustainable future in North America. As the grid increasingly relies on renewable energy, it faces the critical challenge of ensuring resilience and reliability. This necessitates the development of new technology, evolving business models, and updated regulations to balance energy supply and demand effectively, especially considering the variability of renewable sources. The journey towards a more resilient and sustainable power system is promising but not without challenges. Demand flexibility solutions can help us overcome these hurdles.

Furthermore, the importance of grid flexibility is more crucial than ever, as cities and states across the U.S. are adopting aggressive decarbonization goals. Distributed Energy Resources (DERs) play a pivotal role in this transformation, allowing consumers and businesses to reduce energy consumption, lower bills, and contribute to grid stability. By embracing DERs and implementing demand flexibility programs, we can better match renewable energy generation with energy demand, thereby reducing carbon emissions, lowering system costs, and increasing reliability. Electric utilities also benefit through demand response programs, reducing peak demand, ensuring grid reliability, and storing excess renewable energy. However, the path forward is not without its challenges, including addressing the increasing demand for electricity, upgrading charging infrastructure for electric vehicles, and adapting to the complex nature of interacting with DERs. The implementation of demand flexibility programs and the adoption of emerging technologies will be key in achieving a dynamic and resilient grid in the future.

In summary, demand flexibility is essential for a sustainable energy future. It offers numerous benefits to individuals, businesses, and utilities, but it also presents challenges that need to be addressed. By prioritizing clear objectives, stakeholder engagement, data collection, technology infrastructure, regulatory compliance, community outreach, incentives, scalability, performance monitoring, and collaboration, successful demand flexible programs can be implemented. These programs have the potential to significantly reduce electricity consumption, lower energy costs, enhance grid reliability, and ultimately contribute to a more sustainable and resilient energy ecosystem.

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