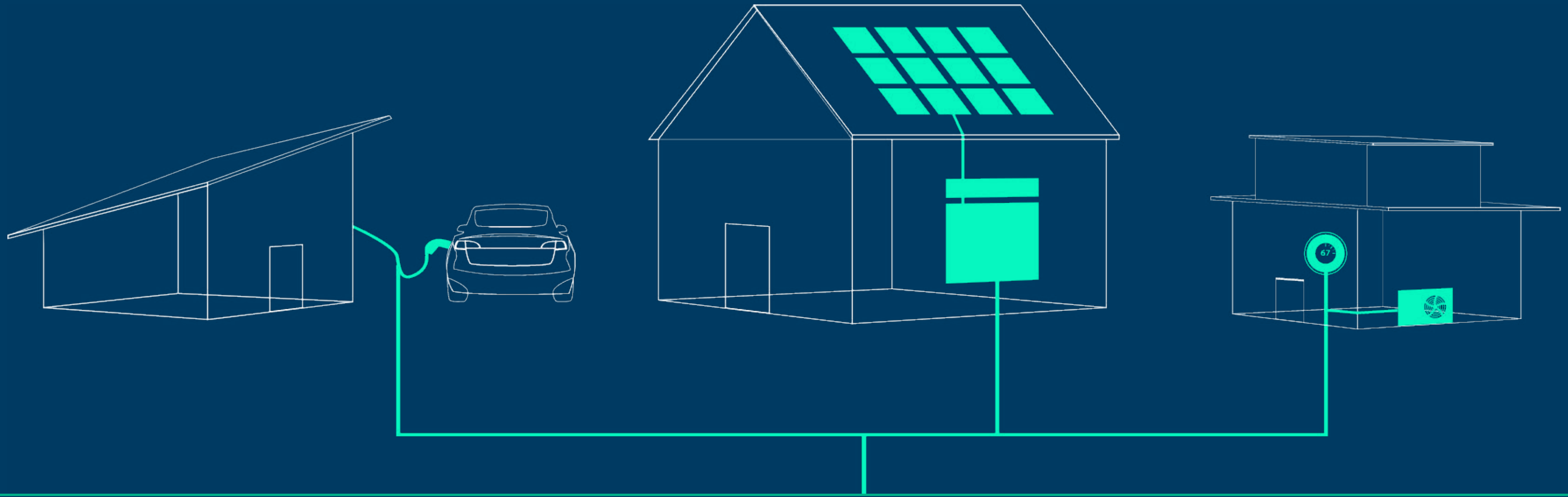
VIRTUAL POWER PLANT

FLIPBOOK



How utilities and their customers are already benefiting from VPPs and insights for future implementation

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Table of Contents

Each year more utilities are developing virtual power plants.

In the face of mounting challenges from load growth and extreme weather, each year more utilities are developing virtual power plants (VPPs) to maintain and enhance grid reliability, resilience, safety, and affordability. VPPs are grid-integrated aggregations of distributed energy resources such as batteries, electric vehicles, smart thermostats, and other connected devices. Utilities use or develop VPPs to provide critical grid services in a rapidly changing power system, including:

- As an alternative to procuring energy, peaking capacity, or ancillary services from utility-scale resources
- To alleviate stressed transmission and distribution systems
- To support grid resilience, especially with increasingly dynamic and extreme weather patterns
- To add flexibility to integrate more renewable energy and decarbonize energy supply

Developing a VPP can be challenging. VPPs often require the development of new program structures, customer engagement strategies, and ways of working with public and private partnerships.

Fortunately, we do not need to start from scratch. There is a wealth of experience that utilities and industry partners can tap as they seek to develop a new program or refine existing programs.

The VPP Flipbook is intended to help utilities and utility stakeholders design and implement efficient and impactful VPPs. We hope that utilities can use this flipbook as a starting point to then reach out to other utilities and VPP providers for further insight on what worked and what didn't.

In this flipbook, we feature VPPs that provide 1,500 MW of capacity from 3.9 million enrolled customers.

This flipbook contains four sections:

1. VPPs and Their Benefits – An overview of VPPs, the benefits they can provide utilities and customers, and roles utilities play in VPPs.

2. VPP Features – Profiles of VPPs from more than 15 utilities. Each profile includes background context, a program overview, impact, and lessons learned.

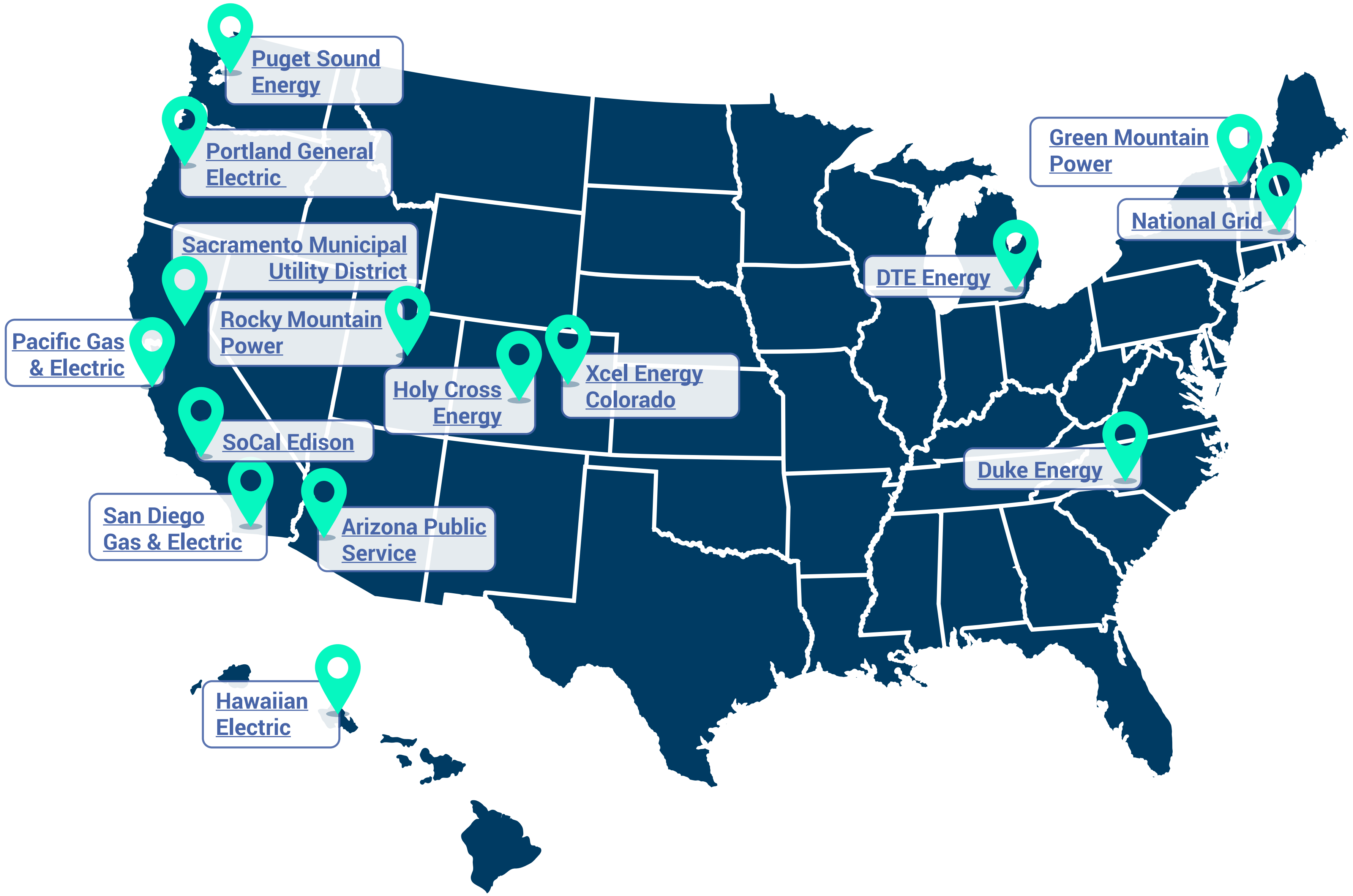
3. Takeaways for Future VPPs – Leading practice for VPP design and utility practices.

4. Appendix – VPP Comparison Matrix that summarizes and compares key metrics across programs, and overviews available tax credits to support customer DER adoption and subsequent activation into VPPs.

The list of VPPs is not comprehensive, but instead a useful start for utility program managers, grid operators, grid planners, and other stakeholders as they implement VPPs at their utility. We also encourage readers to visit the websites of the VPPs featured to understand how the utilities are describing and defining their VPPs.

We look forward to developing and expanding this resource periodically as VPPs continue to evolve. Please don't hesitate to reach out with any suggestions, additional VPPs to feature, or questions about VPP implementation.

Use utility names below to link directly to corresponding feature:



Executive Summary

Virtual power plants (VPPs) — grid-integrated aggregations of distributed energy resources such as batteries, electric vehicles, smart thermostats, and other connected devices — can help balance electrical loads and provide several grid and community benefits, such as supplying critical grid services (including capacity, energy, ancillary services, and resilience), alleviating stressed transmission and distribution systems, and integrating more renewables for a cleaner energy supply.

Utilities and their regulators are increasingly turning toward VPPs as a key tool, alongside traditional infrastructure investment, to ensure safe, reliable, resilient, and affordable power in the face of near-term challenges created by load growth, extreme weather, and retirement of thermal generators.

VPP design and implementation involves six main steps for utilities. Developing a VPP begins with asking questions to understand current utility needs and identifying how available resources can be leveraged as a resource. From there, a program can be continuously iterated upon over time to incorporate learnings and meet evolving grid needs.

1. **Define objectives and priorities**
2. **Baseline resources and constraints**
3. **Initial draft program design**
4. **Engage stakeholders and solution providers**
5. **Updated design, procurement, implementation, and operation**
6. **Program assessment, iteration, and expansion**

Throughout the VPP process, successful implementation is supported by effective program design and reimagined utility practices.

Effective Program Design

- **1.1 Open access in a VPP to integrate multiple technologies, vendors, and programs.**
- **1.2 Develop partnerships that leverage third-party capacity and complementary capabilities.**
- **1.3 Streamline customer experience during enrollment and participation.**
- **1.4 Execute long-term programs (5+ years) with enrollment and operating terms to improve cost-effectiveness.**
- **1.5 Incentivize DERs to enable additional customer participation.**

Reimagined Utility Practices

- **2.1 Incorporate VPPs into planning of generation and distribution.**
  - Iteratively integrate DERs into planning processes.
  - Evaluate VPPs transparently with defined metrics.
- **2.2 Proactively engage policymakers, including regulators, around effective VPP policy.**
  - Work with regulators to ensure policies allow for innovative and iterative approaches to DERs.
  - Consider whether components of performance-based regulation can support VPP deployment.
- **2.3 Transform business practices.**
  - Implement cross-functional teams including customer programs, operations, distribution, and planning teams.
  - Automate VPP administrative and operational processes.

VP3
VIRTUAL POWER PLANT PARTNERSHIP

Virtual Power Plants and Their Benefits

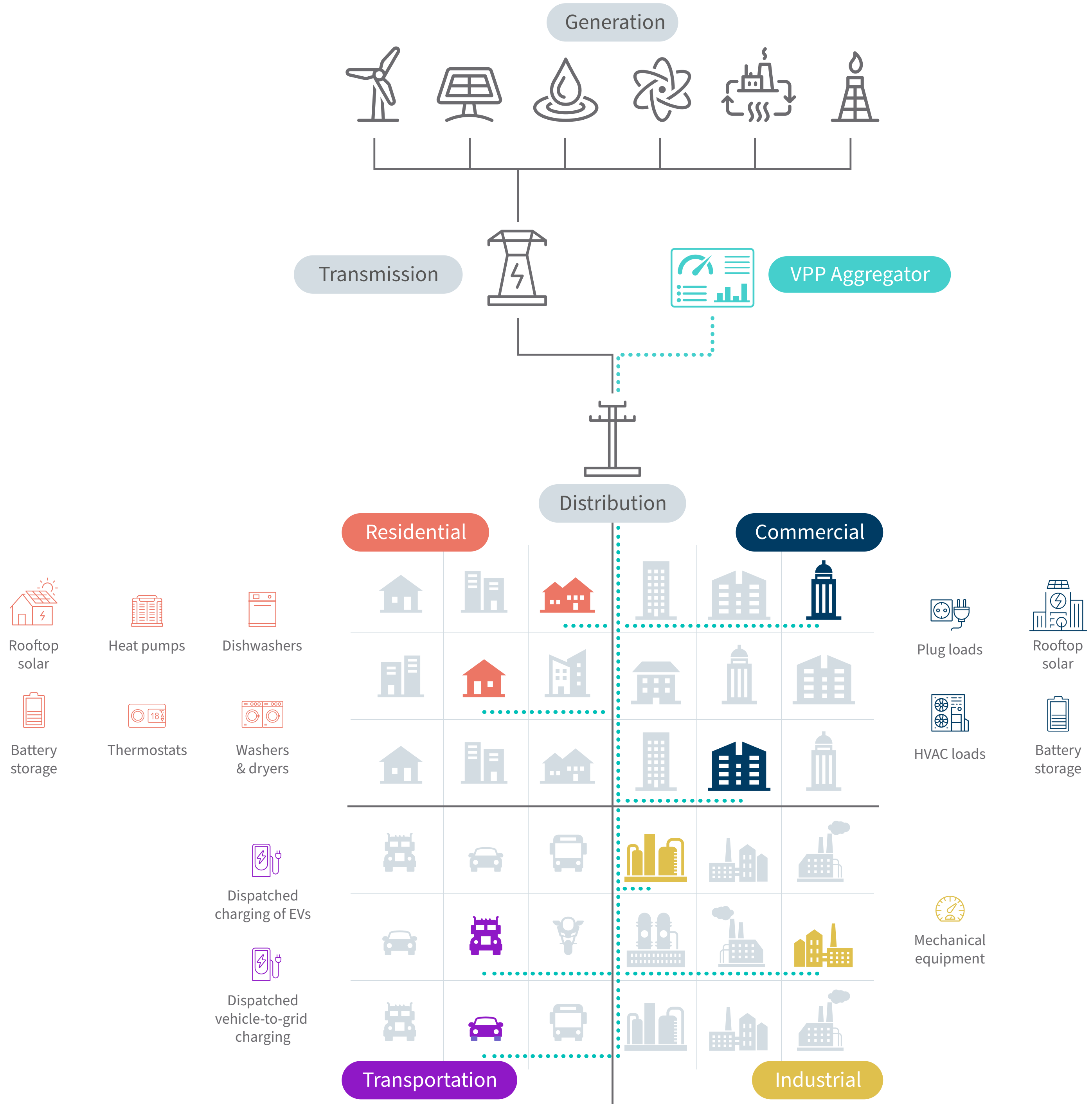
What is a Virtual Power Plant?

A virtual power plant (VPP) is an aggregation of grid-integrated, distributed energy resources* (DERs) that can balance electrical loads and provide utility-scale and utility-grade grid services.

* Distributed energy resources include equipment located on or near the end-use site that can provide electricity demand flexibility, electricity generation, storage, or other energy services at a small scale (sub-utility scale) and are typically connected to the lower-voltage distribution grid.

The DER types featured in VPPs profiled in the flipbook include:

- Solar and/or battery storage
- Electric vehicles
- Smart thermostats
- Heat pumps
- Demand response (DR), which includes load flexibility, interruptible load, and behavioral load shaping for residential, commercial, and industrial loads and may involve the devices listed above as well as other devices.[1]



Sources: VPP and DER Definitions: Adapted from the *DOE Pathways to Commercial Liftoff: Virtual Power Plants*, 2023.
Individual resource type definitions can be found in the SEPA *Beyond the Meter Distributed Energy Resources Capability Guide*, 2016.
Infographic: *RMI Virtual Power Plants, Real Benefits*, 2023

Why Are Utilities Advancing VPPs?

VPPs are generating diverse benefits for utilities and customers.

Primary Drivers	Resource Adequacy	Reliability and Resilience	Transmission and Distribution Infrastructure Relief	Affordability for Ratepayers and the Utility	Decarbonization	Customer Empowerment	Versatility and Flexibility
Utility VPP Example	**Pacific Gas and Electric (PG&E)** PG&E's and Sunrun's Peak Power Rewards solar and battery storage program delivered a consistent average of 27 MW of power over two hours for 90 days during the 2023 summer.[2] *"Resource adequacy refers to the ability of the electric grid to satisfy the end-user power demand at any given time; it is an assessment of whether the current or projected resource mix is sufficient to meet capacity and energy needs for a particular grid." DOE Pathways to Commercial Liftoff Report*	**California's Emergency Load Reduction Program (ELRP) and Demand Side Grid Support (DSGS)** California's ELRP and DSGS emergency programs leveraged DERs for nine consecutive days to avoid rolling blackouts during a historic September 2022 heat wave.[3]	**National Grid Massachusetts** National Grid's ConnectedSolutions VPP has grown to include multiple DER types and allows value stacking with other programs as well as wholesale market participation. Based on the success of ConnectedSolutions, National Grid is looking beyond peak reduction, and considering how VPPs can provide non-wires alternatives to address local capacity constraints.[4]	**Green Mountain Power (GMP)** GMP's Energy Storage System lease program gives customers access to a home battery system for a fraction of the cost, affording more customers home resiliency in exchange for sharing stored energy with GMP during peak energy usage. By sharing energy and exporting back to the grid, the batteries reduce system costs for all GMP customers, benefiting both program participants and non-participants.[5]	**Sacramento Municipal Utility District (SMUD)** SMUD's solar & storage VPP was largely motivated by its Carbon Zero 2030 plan.[6] **Puget Sound Energy (PSE)** PSE's VPP portfolio has been primarily driven by Washington State policy that requires PSE to have 100% clean electricity by 2045, with 10% of historical peak load sourced through demand flexibility by 2027.[7]	**Arizona Public Service (APS)** APS has grown its Cool Rewards thermostat program from 42 MW in 2020 to 145 MW in 2023 by listening to and prioritizing customer needs.[8] *"VPPs empower consumers — all consumers — to play a more active role in shaping the way energy is used and consumed in society and within their homes and businesses." Virtual Power Plants, Real Benefits*	**Hawaiian Electric (HECO)** HECO's solar-powered battery VPP with Swell Energy, known as *Swell Energy Home Battery Rewards*, provides multiple grid services, specifically capacity and ancillary services.[9]

VPPs are a flexible and versatile solution that help utilities navigate the grid transformation being driven by fossil plant retirement, renewables build-out, load growth, and extreme weather.

This framework has been adapted from the *DOE Pathways to VPP Commercial Liftoff Report* and the RMI insight brief *Virtual Power Plants, Real Benefits*, 2023. The benefits listed are primary VPP benefits and the programs listed are representative examples, and not an exhaustive list. VPP programs span multiple benefits, which are further detailed in the VPP features section.

What's the Potential Impact of VPPs at Scale?

VPPs that deliver benefits for utilities and customers have the potential to become a cornerstone resource to the US power system. According to DOE, tripling VPP scale by 2030 could address 10%–20% of peak load while saving approximately $10 billion per year.

In this flipbook, we feature programs that provide over 1,500 MW of capacity from more than 3.9 million enrolled customers. Beyond the VPPs featured, at least 70 VPPs are located in 25 states and operate today (est. 30–60 GW nationally) with commercially available technology.[10]

Yet, VPP benefits will be even greater if more utilities follow suit.

DER adoption is accelerating and is expected to add hundreds of gigawatts and gigawatt-hours of potential capacity by 2030.

Each year from 2025 to 2030, customers are expected to add:[11]

- **EVs:** 20-90 GW of nameplate demand capacity from EV infrastructure, 300–540 GWh of nameplate storage capacity
- **Batteries:** 7-24 GWh of nameplate storage capacity
- **Flexible demand:** 5-6 GW from smart thermostats, water heaters, and non-residential DERs
- **Distributed solar and fuel-based generators:** 20-35 GW of nameplate generation capacity

This presents a critical opportunity to integrate these DERs into VPPs — ensuring they can provide benefits to customers and the grid.

VPPs have the potential to scale to 80–160 GW by 2030.[12] At this scale, VPPs can play a key role in helping to address national resource adequacy and reliability needs and save on the order of $10 billion in annual grid costs, while directing grid spending back to communities and electricity customers.

For additional details on definitions, see *DOE's Bulk Power, Distribution & Edge Services Definitions*.

How Do VPPs Provide Grid Services?

VPPs provide several utility-scale and utility-grade grid services that benefit the overall power system.

In this flipbook, we feature VPPs that primarily provide the following grid services:

Energy, the production or use of electric power by a device over a period of time, expressed in kilowatt-hours (kWh) or megawatt-hours (MWh)

Capacity, supply and/or a load-modifying service thats capable of reliably and consistently reducing net load system-wide or on specific infrastructure (expressed in kW or MW)*

Ancillary services, which includes frequency and voltage regulation

Resilience, the overall ability of the electricity system to prevent, mitigate, and recover from wide-area, long-duration outages[13]

For additional details on definitions, see *DOE's Bulk Power, Distribution & Edge Services Definitions*.

*Derived from DOE's definition of transmission and distribution capacity. This definition may vary from market-specific definitions for capacity and may be more closely aligned with the idea of peak management.

VPPs can be dispatched at multiple time scales and frequencies

- Ancillary Services
- Energy
- Capacity
- Resilience

VPPs can be dispatched to provide location-specific benefits

- Transmission
- Distribution
- Behind-the-meter

What Is the Utility's Role in a VPP?

Utilities may play a variety of roles within a VPP:

Resource Offtaker

- Responsible for determining the operating conditions of the VPP (i.e., calling the events) and settling the energy resources.
- Other actors who could play this role, beyond the utility: for wholesale market regions, resources can be dispatched (market-aware) or bid into the market (market-integrated)

Program Operator

- Responsible for coordinating devices and aggregations to perform when called upon by the resource offtaker.
- Operators may utilize a distributed energy resources management system (DERMS) to help manage multiple data inputs to optimize and automate operations and value stack across technologies.
- Other actors who could play this role, beyond the utility: third-party service provider

Customer Enrollment

- Responsible for enrolling and aggregating DERs
- Other actors who could play this role, beyond the utility: third-party aggregators, installers, and/or original equipment manufacturers (OEMs)

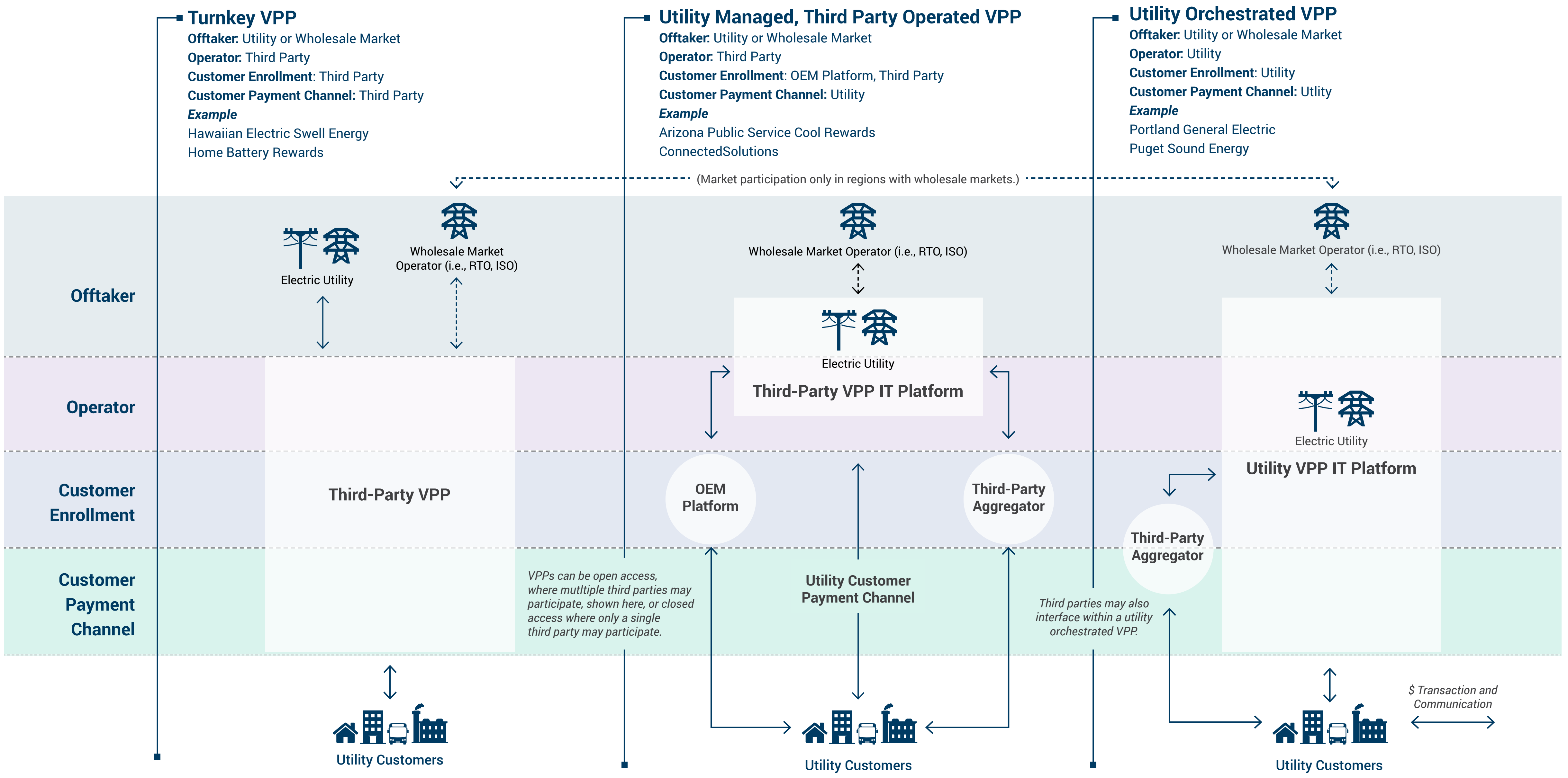
Customer Payment Channel

- Responsible for delivering customer payments or incentives.
- Other actors who could play this role, beyond the utility: third-party aggregators and/or OEMs. Can be the same or different as the party responsible for customer enrollment.

Utilities may procure many or all VPP services from third-party technology and service providers. Utilities and third parties often share in the responsibility of marketing and communicating programs to customers to maximize customer enrollment.

What Is the Utility's Role in a VPP?

Example VPP Utility Participation Models*



*The models and roles shown are representative and not exhaustive. Individual VPP features add more details to the structure and operations for each VPP. In addition to the models described above, some third parties have VPP programs that participate directly in wholesale markets. In this model, a utility may not hold any of the above roles, but may require visibility for management of distribution system impacts.
This framework has been adapted from the DOE Pathways to VPP Commercial Liftoff Report.

How Are Customers Engaged in a VPP?

There are various ways with different levels of involvement to engage customers in VPP decisions.

Who owns the device?

Customers may own their enrolled DER, or the DER could be customer-sited but financed or owned through a utility or a third party.

How often and for how long is the device dispatched?

Dispatch timing varies with respect to frequency, duration, and scheduling of the event.

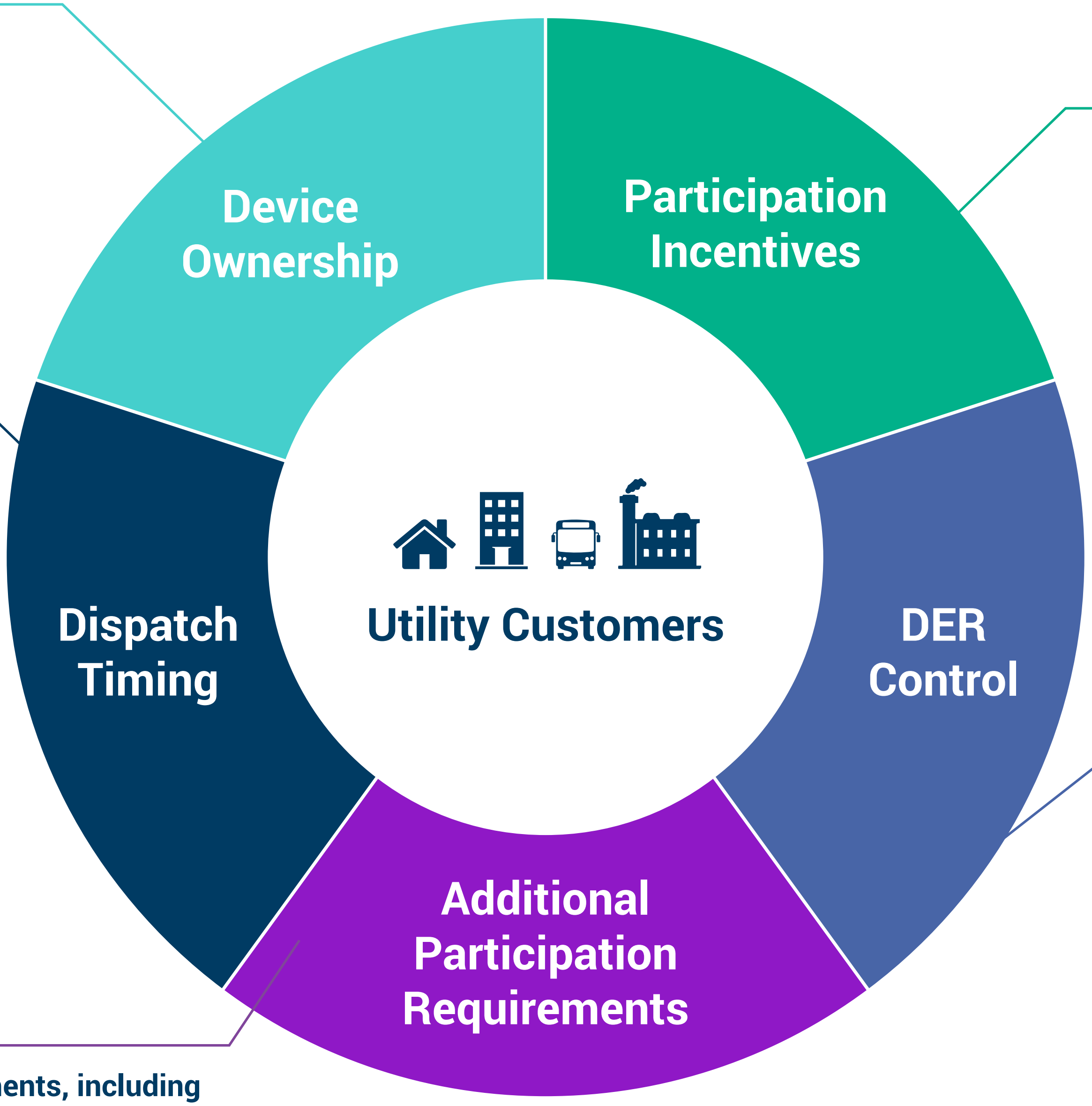
Frequency: DERs may be dispatched daily, seasonally, or solely for emergencies. Some VPPs may have a set minimum or maximum number of events per month or year.

Duration: Dispatch events may range from five minutes to up to more than four hours.

Scheduling: Events may be dynamically scheduled the day-of, day-ahead, or statically scheduled further in advance based on historic electricity patterns.

Who can participate and under what terms?

Some VPPs have additional participation requirements, including contract lengths and not participating in a conflicting program.



How are customers incentivized?

Customers may be compensated in several ways:

- Up-front and/or completion payments
- Performance payments based on kW or kWh delivered
- Monthly or annual bill credits or payments
- Bill reductions if customers are on time-of-use (TOU) rates and shift use away from high-cost times
- DER rebates to reduce the up-front costs of ownership and enable participation

Who controls DER dispatch?

Customers agree to participate in VPPs with various levels of device control, including:

- **Autonomously VPP-initiated with customer override:** device responds autonomously but customers can opt out of an event
- **Autonomously VPP-controlled without customer override:** device responds autonomously and customers can't opt out of an event
- **Customer-controlled:** customers control their devices in response to an event notification

What Are the Steps to Developing a VPP?

VPP design and initial implementation involves six main steps for utilities*

STEPS	1 Define objectives and priorities	2 Baseline resources and constraints	3 Initial draft program design	4 Engage stakeholders and solution providers	5 Updated design, procurement, implementation, and operation	6 Program assessment, iteration, and expansion
QUESTIONS TO CONSIDER	What is driving program development?** What does success look like in year 1? In year 5? What capabilities are required to meet future system needs? Which objectives are most important?	What are the current and projected levels of DERs? What are the software, staff, and policy enablers and constraints? What current programs or resources can be folded into a VPP program?	What form will the initial version of the program take? How can the program be designed to adapt to changing system needs? How will the VPP be funded and what's the budget? What third-party input is needed to inform final program design? What design components are specified by policy?	What software, hardware, and services can third parties provide? What recommendations do VPP companies have regarding program design to enable their participation, as needed?	What changes will be made to the program based on stakeholder input? How should the utility identify and partner with vendors to meet utility, customer, and vendor needs?	What is the plan for measurement and verification? What can be done to improve cost-effectiveness in the future? How will operating insights inform utility planning and the next iteration of this program?
KEYS TO SUCCESS	Consider both future and near-term grid needs.	Consider policy enablers including federal funding opportunities.	Prototype a program design using the metrics in this report.	Engage VPP companies before finalizing program design	Develop practices that support cross-functional teams within a utility and ongoing collaboration with third-party technology and service providers.	Ensure that insights from VPPs inform not only future programs, but also resource and distribution planning.

* The six steps are not strictly linear. Insights will be iteratively incorporated to refine design and inform implementation.
** VPPs may be developed in response to a policy mandate, planning need, or proactively to test and develop new capabilities. In all instances, the same six general steps will apply.

Utility VPP Features

Introduction to Features Included in the Flipbook

VPP Features Profiled in the Flipbook Represent a Variety of Program Archetypes and Technologies from Utilities across Geographies

VPPs encompass a wide range of programs that harness and compensate DERs to meet evolving grid needs. Despite the broad definition, VPP programs share common characteristics.

VPPs included in the flipbook satisfy the following criteria:

- **Provide grid services using DERs and/or demand response to address grid challenges**
- **Compensate customers for program participation**
- **Communicate directly between the VPP and the customer and/or customer device**
- **Utility plays a critical role in the VPP, as outlined on pages 12 and 13.**

The VPP features in the flipbook showcase a variety of technologies, utility participation models, compensation frameworks, and third-party support roles to demonstrate the versatility of existing VPPs.

Some features represent programs that are more mature than others.

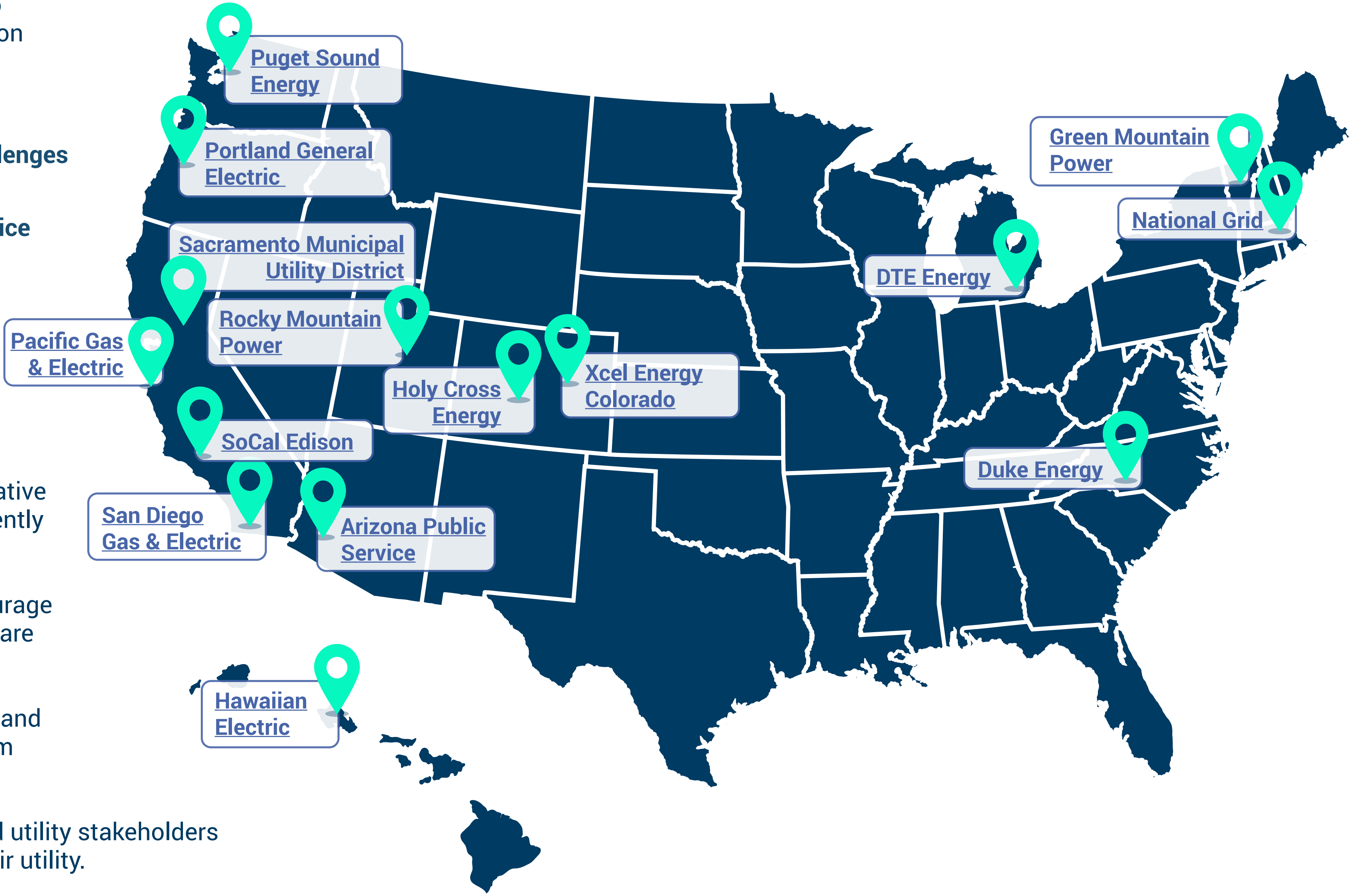
Pilot phase or recently launched VPPs are included as features to showcase innovative models, iterative approaches, and important VPP structural elements that are currently being deployed to demonstrate the value VPPs can provide. In some instances, the features showcase a specific subset of VPP program from a utility, and not the entire suite of offerings a utility may provide under the umbrella of VPPs. We encourage readers to visit specific utility websites to learn more about how individual utilities are describing and defining their VPPs.

Each profile includes background context, program design fundamentals, impacts, and takeaways for future VPP implementation. Additional information was sourced from conversations with utility program providers.

The list of VPPs is not comprehensive but provides key takeaways that utilities and utility stakeholders can leverage to design and implement efficient and impactful VPP programs at their utility.

Flipbook VPP features are based on research of publicly available information at the time of publication and input from utility reviewers. We look forward to expanding this resource as VPPs continue to evolve.

Use utility names below to link directly to corresponding feature:



Feature Summary Table

The Flipbook Includes VPP Features across more than 15 Utilities

Utility(s)	Programs	Primary Drivers	Grid Service(s)	Resource Type(s)	Page
Arizona Public Service	Cool Rewards Program	Customer Empowerment | Resource Adequacy | Decarbonization	Capacity	Smart Thermostat	20
California IOUs: PG&E, SCE, SDG&E	Emergency Load Response Program (ELRP)	Reliability & Resilience	Energy, Capacity, Resilience	Behavioral Load Shaping, Backup Generation, Batteries, EVs	23
California Utilities (Co-ops, Munis, Community Choice Aggregators (CCAs), POUs, IOUs)	Demand Side Grid Support (DSGS)	Reliability & Resilience	Energy, Capacity, Resilience	Behavioral Load Shaping, Backup Generation, Batteries, EVs	23
DTE Energy	DTE Smart Charge	Resource Adequacy | Decarbonization | T&D Infrastructure Relief	Capacity	EVs	26
Duke Energy	EV Complete Home Charging Plan	Affordability | Resource Adequacy | T&D Infrastructure Relief	Capacity	EVs	29
Green Mountain Power	Bring-Your-Own-Device	Resource Adequacy | Reliability & Resilience | Customer Empowerment	Ancillary Services, Capacity, Resilience	Batteries	32
	Energy Storage System (ESS) Lease	Resource Adequacy | Reliability & Resilience | Affordability	Ancillary Services, Capacity, Resilience	Batteries	32
Hawaiian Electric	Swell Energy Home Battery Rewards	Resource Adequacy | Versatility & Flexibility | Decarbonization	Ancillary Services, Capacity	Batteries	35
	Battery Bonus Program	Resource Adequacy | Decarbonization	Capacity	Solar + Batteries	35
Holy Cross Energy	Power+	Decarbonization | Affordability | Customer Empowerment	Energy, Capacity	Solar + Batteries, EVs, Heat Pumps	38
National Grid	ConnectedSolutions	Resource Adequacy | Versatility & Flexibility | T&D Infrastructure Relief	Capacity	Smart Thermostats, Batteries, Technology Agnostic Demand Response	41
Pacific Gas and Electric	Peak Power Rewards	Resource Adequacy | Versatility & Flexibility | T&D Infrastructure Relief	Energy, Capacity, Resilience	Solar + Batteries	44
Portland General Electric	VPP Portfolio	Decarbonization | Versatility & Flexibility | Reliability & Resilience	Ancillary Services, Capacity	Behavioral Load Shaping, Interruptible Load, EVs, Batteries, Thermostats, Water Heaters	47
Puget Sound Energy	VPP Portfolio	Decarbonization | Customer Empowerment	Capacity	Behavioral Load Shaping, Interruptible Load, EVs, Smart Thermostats, Water Heaters	51
Rocky Mountain Power	WattSmart Battery	Resource Adequacy | Reliability & Resilience | T&D infrastructure Relief | Customer Empowerment | Affordability | Decarbonization | Versatility & Flexibility	Ancillary Services, Energy, Capacity, Resilience	Solar + Batteries	54
Sacramento Municipal Utility District	Partner+	Decarbonization | Community Empowerment / Affordability	Capacity	Batteries	57
Xcel Energy	Charging Perks	Resource Adequacy | T&D Infrastructure Relief | Decarbonization	Capacity	EVs	60

GRID SERVICES ICON KEY: Ancillary Services Energy Capacity Resilience

Program Design Table Glossary

Each Feature Has a Program Design Table with the Following Metrics to Enable Comparison Across VPPs

	Metric	Definition	Category Options and Definitions
Overview	Primary Drivers	Primary motivations for establishing the VPP	Resource adequacy, reliability & resilience, T&D infrastructure relief, affordability, decarbonization, costumer empowerment, versatility & flexibility
	Grid Services	Primary grid services provided by the VPP	Ancillary services, energy, resilience, capacity
	Resource Type	VPP resource type(s) included	DER: Batteries, solar + batteries, EVs, smart thermostat, heat pumps DR: Interruptible load and behavioral load shaping
	Customer Market Segment	Participating customer segments in the VPP	Residential, commercial, and/or industrial
	Participating OEMs	OEMs who may participate in the VPP	Could be multiple OEMs or a single OEM depending on the program
	MW Enrolled	How many MW enrolled in the VPP	Numerical value (MW)
	Customers Enrolled	How many customers enrolled in the VPP	Numerical value (customers)
VPP Roles and Responsibilities	Resource Offtaker	Party responsible for determining the operating conditions (i.e., calling the events) and settling the energy resources.	**Utility** — Utility is calling the events and settling the resources, **Market Integrated** — resources are bid into the market, **Market Aware** —resources are dispatched by market operators
	Program Operator	Party responsible for coordinating devices and aggregations to perform when called upon by the resource offtaker.	Utility or a third-party service provider
	Customer Enrollment	Responsible for enrolling and aggregating DERs	Utility, third-party aggregators, installers, and/or OEMs
	Customer Payment Channel	Party responsible for delivering customer payments	Utility, third-party aggregators, and/or OEMs. Can be the same or different as the party responsible for customer enrollment.
Customer Experience	Device Owner	Owner of the enrolled DER device	Customers may own their enrolled DER, or DER could be customer-sited but financed or owned through a utility or third party
	Participation Incentives	Payment structure and value for participating customers	Numerical value and compensation structure (up-front, completion, pay-for-performance, monthly or annual flat-rate bill-credits, DER rebates, etc.)
	Participation Requirements	Any additional requirements for customer participation	Potential requirements could include contract lengths, not participating in a conflicting program, and/or minimum connected capacity
	DER Control	The level of DER control the VPP and customer has during the program	**Autonomously VPP-initiated with customer override:** device responds autonomously but customers can opt out of an event **Autonomously VPP-controlled without customer override:** device responds autonomously and customers can't opt out of an event, **Customer-controlled:** customers control their devices in response to an event notification
	Dispatch Timing	Description of VPP dispatch events	**Frequency:** DERs may be dispatched daily, seasonally, or solely for emergencies. Some VPPs may have a set minimum or maximum events per month or year. **Duration:** Dispatch events may range from 5 minutes to up to 4+ hours **Scheduling:** Events may be dynamically scheduled the day-of, day-ahead, or statically scheduled further in advance based on historic electricity patterns

Arizona Public Service

Cool Rewards for Summer Peak Reduction

Arizona Public Service: Cool Rewards for Summer Peak Reduction

Context and Background

Cool Rewards was launched in 2018 as a response to the 2017 Arizona Corporation Commission decision that authorized Arizona Public Service (APS) to implement demand response and load management programs.[14]

As one of the largest direct load control thermostat programs in the country, Cool Rewards provides peak load reduction when energy use is the highest during hot summer days.

Participating thermostats are set to pre-cool before 3 p.m. or 4 p.m. depending on the customer's rate plan to take advantage of clean energy and cool the residence prior to the event. Then, during the two to three hour event, the thermostat is raised a few degrees. After the event, the thermostat is returned to the original setting.


Smart thermostats are helping Arizona's grid ride out brutal heat

Amid soaring temperatures, Arizona has seen success with utility programs that incentivize people to turn down the AC when the power grid is stressed.

By **Jeff St. John**
14 September 2023

Source: Canary Media (above), EnergyHub (right)

Impact to Date

As of 2023, Cool Rewards has enrolled **83,000+ thermostats and 145 MW** of load-shedding capacity, up from 42 MW in 2020, and continues to grow. Eight Cool Rewards events were called during the summer of 2023 which resulted in a weighted average of 1.0 kW at meter load reduction per thermostat per event.[15]

DERs are becoming an increasingly important part of APS's carbon-free energy goals. According to their 2023 IRP, APS forecasts they will install nearly 5,000 MW of additional demand-side resources (including energy efficiency, distributed resources, and demand response) over the next 15 years that will contribute to 17% of the annual 2038 energy mix and 19% of coincident peak demand.[16]

Cool Rewards has been recognized nationally with Partner of the Year Awards by SEPA in 2019 and ENERGY STAR from 2021–2023.

Key Takeaways

Listen to customer needs to maximize participation. The "set and forget" format minimizes required customer action and customers can opt out of events without penalty. Additionally, APS increased incentives from $25 to $35 in 2022, responding to customer survey data, and saw a resulting increase in enrollment.[17]

Provide free or discounted smart thermostats to catalyze customer adoption. APS offers low- to no-cost thermostats, with rebates over $100 available, through their marketplace for customers who agree to have their thermostat pre-enrolled to participate in Cool Rewards.[18] In 2023, 7,900 Cool Rewards pre-enrollments were processed through APS Marketplace.[19]

Integrate VPP program implementation across utility teams. APS coordinates their customer-to-grid solutions teams with the operations team for holistic, up-front planning.

Arizona Public Service: Cool Rewards for Summer Peak Reduction

	Metric	Cool Rewards[21]
Overview	Primary Drivers	Customer Empowerment, Resource Adequacy, Decarbonization
	Grid Services	Capacity
	Resource Type	Smart Thermostat
	Customer Market Segment	Residential
	Participating OEMs	Nest, Honeywell Home, ecobee, Seni, ADC/Vivint, Lux, Amazon, Alarm.com
	MW Enrolled	145 MW
	Customers Enrolled	83,000+ Thermostats
VPP Roles and Responsibilities	Resource Offtaker	APS
	Program Operator	EnergyHub
	Customer Enrollment	Individual OEMs / APS Marketplace
	Customer Payment Channel	APS – Bill Credits
Customer Experience	Device Owner	Customer
	Participation Incentives	$50 one-time enrollment credit, $35 annual participation credit
	DER Control	Autonomously VPP-initiated with customer override
	Dispatch Timing	Frequency: Up to 20 events per summer Duration: 2–3 hours, home is pre-cooled prior to the event Scheduling: Dynamic responses

"My team is integrated with our operations team. We attend the weekly planning meetings — what the energy market looks like, what the weather is going to look like, any changes in the fleet that we need to prepare for."

— Kerri Carnes, APS' Director of Customer-to-Grid Solutions.[20]

More information: Cool Rewards website

California’s Emergency Load Reduction Program (ELRP) and Demand Side Grid Support (DSGS)

Statewide Participation to Keep the Lights On

California's Emergency Load Reduction Program (ELRP) and Demand Side Grid Support (DSGS): Statewide Participation to Keep the Lights On

Context and Background

Together, the ELRP and DSGS programs give customers across California a chance to earn incentives for their efforts to support the grid during times of grid stress and emergencies from May–October.

Unprecedented 2020 rolling outages led to quick action in California. The California Public Utilities Commission (CPUC) ordered a rule-making to identify and execute emergency reliability in response to a directive from Governor Newsom in November 2020.[22]

The CPUC then formally ordered ELRP on March 25, 2021.[23] ELRP launched in May 2021 as a 5-year pilot with five participation options for residential customers, non-residential customers, and third-party aggregators. It has since been extended through 2027 with expanded options, including residential DR, battery VPP, and vehicle-grid integration (VGI).[24]

DSGS complements ELRP, allowing more energy customers (including non-IOU customers) to participate in emergency reliability programs.

The California Energy Commission launched DSGS in August 2022 and had 142 MW of committed capacity by the 2023 program season.

DSGS expanded in July 2023 to include market-integrated aggregations of demand response as well as market-aware battery VPPs.

The Great California Electricity Blackout that Wasn't

Source: *Natural Resources Defense Council*

Impact to Date

Summer 2021: ELRP launch[25]

- 200 MW from non-residential customers.
- Called four times, $1million incentives.

Summer 2022: Rotating outages avoided

- ELRP added residential customers and VGI aggregators and DSGS launched.
- Called 9 days in a row, 10 days total.[26]
- DSGS: Over 315 MW enrolled under emergency conditions.

Summer 2023: Market-aware VPPs and market-integrated aggregations become part of DSGS[27]

- ELRP: 790+ MW enrolled.
- DSGS: 142.5 MW enrolled.

The open-access structure of DSGS and ELRP allows third-party aggregators to participate alongside utilities and/or use the CEC direct enrollment option.

DSGS and ELRP compensate exports from storage systems back to the grid, enabling better value streams for batteries.

ELRP subgroup A.6, the residential subgroup known as Power Saver Rewards, is ordered to sunset December 21, 2025, primarily due to lack of cost-effectiveness.[28] The baseline methodology for customer incentives has an inherent tendency to potentially overstate how much a customer reduced and therefore earned.[29]

Key Takeaways

Launch quickly and iterate on program design. Each year that ELRP and DSGS have been offered, program design rules have been adapted based on lessons from the previous year, such as expanding participation options and updating performance methodologies to measure and compensate for load reduction more accurately.

Make participation voluntary with performance-based incentives to unlock resources that aren't able to participate under penalty structures for non-performance.

Account for a difference between capacity estimates and performance for more accurate forecasting. To plan for participation fluctuations of a voluntary program, derate capacity estimates, request a capacity range, and/or base estimates off past performance data.

Implement a dispatch load order with preset prioritization metrics. Dispatch resources based on different triggers, such as cost or emissions, prioritizing VPPs and saving backup combustion as a last resort. For example, DSGS dispatches market-aware VPPs based on high day-ahead market prices and ELRP dispatches the residential program based on Flex Alerts to avoid more severe events. Backup combustion is reserved only for a Governor's Executive Order.

Add a same-day adjustment to improve the baseline accuracy results across a wide range of weather conditions. The Statewide Residential Emergency Load Reduction Program Baseline Evaluation found that a same-day adjustment improves the accuracy of baselines on hot days. The evaluation found a 40% adjustment cap helps balance the baseline accuracy, quantifying load reductions with settlement accuracy, paying customers for real reductions, on all but most extreme days.[30]

More Information: ELRP website and DSGS website

Acronyms:
POU: Publicly Owned Utility | VGI: Vehicle to Grid
CCA: Community Choice Aggregator
FPMA: Federal Power Marketing Administration

California's Emergency Load Reduction Program (ELRP) and Demand Side Grid Support (DSGS): Statewide Participation to Keep the Lights On

	Metric	ELRP[32]	DSGS[33]
Overview	Primary Drivers	Reliability & Resilience	Reliability & Resilience
	Grid Services	Capacity | Energy | Resilience	Capacity | Energy | Resilience
	Resource Type	Behavioral Load Shaping, Backup Generation, Batteries, EVs	Behavioral Load Shaping, Backup Generation, Batteries, EVs
	Customer Market Segment	Residential, Small, and Medium Business, Commercial & Industrial	
	Participating OEMs	OEM Agnostic	
	MW Enrolled	790+ MW	142 MW
	Customers Enrolled	3.7 million	1,300
VPP Roles and Responsibilities	Resource Offtaker	System-Aware | Market-Integrated	System-Aware | Market-Aware | Market-Integrated
	Program Operator	Olivine	
	Customer Enrollment	PG&E, SCE, SDG&E Third-Party Aggregators	California Energy Commission (CEC), Retail Providers, FPMA, and Third-Party Aggregators
	Customer Payment Channel		
Customer Experience	Device Owner	Customer	
	Participation Incentives	$2/kWh energy payment per event (residential customer incentive decreased to $1/kWh in 2024)	Three performance-based structures:* 1. $2/kWh energy payment per event, with standby ($0.25/kWh) 2. Market-Integrated DR — Capacity Payment 3. Market-Aware BTM Storage Pilot — Capacity Payment
	Participation Requirements *(ELRP OR DSGS)*	• IOU customers not in conflicting program • Complementary third-party aggregators • Select residential customers automatically enrolled in DR (thru 2023) and opt-in option (thru 2025)	• POU and FMPA customers not in conflicting programs • CCA, energy service provider, or electrical corporation customers (additional req. apply) • Third-party aggregators
	DER Control	Customer-control, or aggregator-control in which the DER would be VPP initiated with or without customer override, depending on the aggregator	Customer-control or aggregator-control in which the DER would be VPP initiated with or without customer override, depending on the aggregator
	Dispatch Timing	Frequency: Summer emergencies, (up to) daily Duration: Varies Scheduling: Dynamic responses to day-ahead or day-of signals (including immediate onset events)	Frequency: Summer emergencies, (up to) daily Duration: Varies Scheduling: Dynamic responses to day-ahead or day-of signals (including immediate onset, depending on participation option)

"ELRP and DSGS are both programs created to provide critically needed resources during extreme grid conditions. ELRP is ratepayer funded through the CPUC and DSGS is taxpayer funded through the CEC. That said, neither program is subject to the cost-effectiveness standards or measurement and evaluation requirements that the other IOU DR programs are held to. These programs highlight the importance of coordination and collaboration between state agencies in developing solutions to avoid unintentional competition for the same customers and to ensure the efficient use of resources."

— Wendy Brummer, Program Manager, Principal, Pacific Gas and Electric Company[31]

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

*More information about specific DSGS incentive structures on the DSGS website.

DTE Energy

Smart EV Charging for a Cleaner, Better Optimized Grid

DTE Energy: Smart EV Charging for a Cleaner, Better Optimized Grid

Context and Background

DTE Energy launched Smart Charge to understand how to effectively manage the load growth from EV charging for a cleaner, better optimized grid.

The current pilot launched in July 2023 and runs through December 2024. It is an expansion of a 2019–2022 EV Smart Charge pilot.

DTE Smart Charge helps EV drivers charge during periods that are cheapest for the consumer and helps the grid operate more efficiently. Customers input their desired charging preferences into their OEM's (for Ford, GM, and BMW) or evPulse (for Tesla) app to optimize the customer's EV charging to work with their current time-of-use rate structure, ensuring charge begins only during each customer's off-peak time-period.

Smart Charge also has the option to call up to five DR events in the summer months, June through September. DTE signals these DR events during periods of high grid stress. Automakers (or evPulse for Tesla drivers) then notify customers and pause charging automatically during the two-hour event. Customers can opt out, if needed.

Ford, GM, and BMW manage enrollment and the exchange of EV data using the Open Vehicle Integration Platform (OVGIP). The OVGIP enables the utility to access multiple OEM brands through a single interface as well as exchange grid event data with the OEMs.

In addition to the Smart Charge Program, DTE offers a $500 EV rebate or a $1,500 EV rebate for low-middle-income customers when they buy or lease an electric vehicle, enroll in an eligible electric rate that saves money on overnight and weekend charging, and install a Level 2 charger to support EV adoption.[34]

Impact to Date

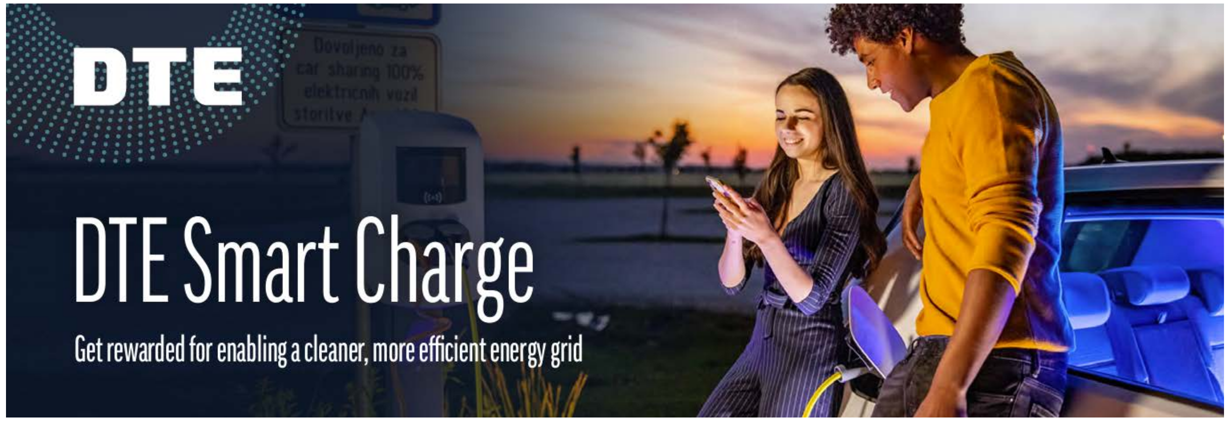
The 2022–2023 pilot saw a reduction of 14 MWh between 44 events from 663 participants, enough to power an average Michigan home for over 1.5 years.[35]

The pilot is ongoing and will transition to a program in 2025.

Key Takeaways

Implement the "set and forget" model to seamlessly integrate into the customer's existing driving schedule. Asking for customer input on driving schedules can help minimize disruptions from autonomous dispatch. Customers simply input their desired charging preferences (e.g., departure time, target state of charge, etc.) into an app. DTE and OEM optimization does the rest to shift charging away from on-peak hours or initiate a DR event.

Consider providing incentives at the end of a program to encourage participation throughout. Rewards upon Smart Charge completion incentivize customers to participate for the duration of the annual program.



Source: DTE Energy

DTE Energy: Smart EV Charging for a Cleaner, Better Optimized Grid

	Metric	DTE Smart Charge[37]
Overview	Primary Drivers	Resource Adequacy, Decarbonization, T&D Infrastructure Relief
	Grid Services	Capacity
	Resource Type	Electric Vehicles
	Customer Market Segment	Residential
	Participating OEMs	General Motors, Ford Motor Company, BMW of North America, Tesla
	Vehicles Enrolled*	1,575 vehicles enrolled, with a target and cap of 2,000 by December 31, 2024
VPP Roles and Responsibilities	Resource Offtaker	DTE Energy
	Program Operator	
	Customer Enrollment: OEM Dependent	GM, Ford, BMW: OEMs (coordinated using OVGIP), Tesla: evPulse
	Customer Payment Channel	DTE Energy
Customer Experience	Device Owner	Customer
	Participation Incentives	$50 enrollment gift card, $50 gift card upon program completion
	DER Control	Autonomously VPP-initiated with customer override
	Dispatch Timing	Frequency: Annual program, up to 5 DR interruption events during the summer Duration: DR events are up to 2 hours long Scheduling: EV charging is managed based on the customer's driving preferences and their static time-of-use peak and off-peak hours

"DTE is excited to offer more services to our EV driver customers with OVGIP and WeaveGrid joining our Smart Charge program. This will not only expand access to innovative smart charging solutions but allow us to learn more about EV adoption in our service territory to make strategic decisions for grid planning and EV growth."

— Ryan DeKimpe, Program Manager, Demand Response, DTE Energy[36]

More information:
DTE Electric Vehicle Resources and 2023 Smart Charge Brochure

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

* Vehicles enrolled because some households have multiple participating EVs.

Duke Energy

Managed EV Charging with Customer Cost Certainty

Duke Energy: Managed EV Charging with Customer Cost Certainty

Context and Background

Duke launched the EV Complete Home Charging Plan pilot in September 2023 to better understand how to best limit the increasing demand caused by the growing number of EVs on the road.

Shifting EV charging to off-peak times can also help Duke and North Carolina reach their carbon emissions reduction goals. Additionally, North Carolina has a goal to have zero-emissions vehicles account for 50% of in-state auto sales by 2030.[38]

The EV Complete Home Charging Plan provides home EV charging at a fixed monthly price ($19.99 or $24.99) with an 800 kWh per month limit, which is double the monthly consumption for the average driver.[39]

Customers input their desired charging preferences (e.g., departure time, target state of charge, etc). OEM optimization shifts charging away from peak hours.

Ford, GM, and BMW manage enrollment and the exchange of EV data using the Open Vehicle Integration Platform (OVGIP). The OVGIP enables the utility to access multiple OEM brands through a single interface as well as exchange grid event data with the OEMs.

In addition to the EV Complete Home Charging Pilot, Duke offers an EV Charger Prep Credit: a one-time rebate up to $1,133 to support Level 2 or higher charger electrical upgrades.[40]

Impact to Date

Pilot is ongoing

Key Takeaways

Prioritize customer preferences in program design. The EV Complete Home Charging Plan provides a fixed monthly rate for EV charging lower than the typical, volatile charging costs, providing customers with predictable savings.

Enroll customers through automakers for simplified customer and utility experience. Using OVGIP, automakers are the single point of contact for customers. Managing enrollment through the automaker streamlines the customer experience while decreasing the administrative responsibilities for the utility. OVGIP also enables Duke Energy to measure customer data directly from the enrolled vehicles, without installing a second meter.

DIVE BRIEF

Duke Energy unveils EV charging subscription service, partnering with BMW, Ford and GM

The pilot program in North Carolina will allow Duke to call up to three demand response events per month and utilizes vehicle telematics to avoid the need for a second meter at the customer's home.

Published Aug. 30, 2023

Source: Utility Dive

Duke Energy: Managed EV Charging with Customer Cost Certainty

	Metric	EV Complete Home Charging Plan[42]
Overview	Primary Drivers	Affordability, Resource Adequacy, T&D Infrastructure Relief
	Grid Services	Capacity
	Resource Type	Electric Vehicles
	Customer Market Segment	Residential
	Participating OEMs	General Motors, Ford Motor Company, BMW of North America
	Customers Enrolled	184[43]
VPP Roles and Responsibilities	Resource Offtaker	Duke Energy
	Program Operator	Individual OEMs (coordinated using OVGIP)
	Customer Enrollment	Duke Energy
	Customer Payment Channel	
	Device Owner	Customer
Customer Experience	Participation Incentives	Fixed monthly charging fee of $19.99 or $24.99
	DER Control	Autonomously VPP-initiated with customer override*
	Dispatch Timing	Frequency: Annual, three DR interruption events per month Duration: Up to 4 hours Scheduling: EV charging is managed based on the customer's driving preferences and static time-of-use peak and off-peak hours

"EV charging has the added benefit of flexibility, meaning charging can be managed — such as shifting charging to off-peak hours — which is important in limiting cost increases and mitigating peak demands."

— Harry Sideris, Executive Vice President of Customer Experience at Duke Energy.[41]

More Information: 2023 Duke Energy Press Release

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

* Customers can opt out of four DR interruption events total.

Green Mountain Power

Resiliency through Utility-Managed Residential Batteries

Green Mountain Power: Resiliency through Utility-Managed Residential Batteries

Context and Background

Green Mountain Power (GMP) administers two Battery VPP programs: a Bring Your Own Device (BYOD) program, where customers own their battery, or an Energy Storage System lease program (ESS) which currently uses the Tesla Powerwall. The battery programs are designed to keep customers powered up during severe weather and provide capacity by reducing expensive, carbon-intensive energy peaks that directly save all customers money.

The two programs began as pilots in 2015 through the Innovative Pilot provision in GMP's regulation plan with the objective of proving GMP could manage customer-sited batteries for the benefit of all customers. The pilots were approved as full programs in 2020 and could each enroll 500 customers, or 5 MW, annually. The VT PUC lifted the cap in August 2023, citing the growing demand for home batteries had outpaced the annual capacity limits, the likelihood of extreme storm events in the future, and that the expansion of home battery programs benefit all GMP customers.

The batteries are responsive to real-time loading signals from the Vermont and New England systems. In addition, the programs lower GMP's capacity obligation in the forward-capacity auction, administered three years in advance of the operating period by ISO New England (ISO-NE), through reducing GMP's load during the peak hour. Lastly, in 2021 GMP started a new pilot using a portion of these batteries in the ISO-NE regulation market, providing ancillary services such as frequency regulation to the wholesale market therefore creating an additional value stream for the batteries.

What's next? Giving customers batteries or other energy storage solutions for cost-effective, decarbonized outage resiliency. In October 2023, GMP asked the VT PUC to authorize $280 million to strengthen the grid (underground lines and storm harden above-ground lines) and deliver batteries—stating customer-sited batteries ensure safety and resiliency in the face of climate change. In 2023, storms cost GMP and customers roughly $55 million, up from an average of less than $10 million annually from 2015–2022. Additionally, when the batteries are not needed for resiliency, they provide several other benefits that are shared with all customers—such as participation in ISO-NE markets to reduce system costs for all GMP customers.

Impact to Date

Collectively, the programs have over 3,000 participants, providing over 30 MW in capacity reductions and power supply cost savings up to $3 million per year for the past three years.[50]

The battery programs reduce GMP's capacity obligation, which in turn reduces how much GMP customers pay for capacity. It also reduces transmission charges for the GMP service territory through reducing demand during peak hours.[51] All of these savings are delivered to customers, cutting costs and carbon.


DIVE BRIEF

Green Mountain Power proposes energy storage for all Vermonters

The utility has proposed spending $280M to harden the grid and provide customers with storage, after spending $45 million restoring its system following major storms last winter.

Published Oct. 10, 2023


The New York Times

Vermont Utility Plans to End Outages by Giving Customers Batteries

Green Mountain Power is asking state regulators to let it buy batteries it will install at customers' homes, saying doing so will be cheaper than putting up more power lines.


CleanTechnica

Green Mountain Power Takes A Bold Step Toward Energy Resiliency

Green Mountain Power in Vermont has a plan to add a residential storage battery in the homes of all 270,000 of its customers by 2030.

Source: (from top) Utility Dive, *The New York Times*, Clean Technica

Key Takeaways

Share lessons learned with other utilities. GMP designed and implemented the first storage program of its kind in 2015 and has helped other utilities follow suit like in New Hampshire with Liberty Utilities.[52] Collaboration between utilities can help ensure programs are customer focused and build off prior successes and lessons learned.

Evaluate DERs using forward-looking cost-curves and climate change costs. GMP concluded that installing customer-sited batteries is the way forward with resiliency in the face of climate change. This is in part due to growing climate change-fueled storm recovery costs; 2023 storm recovery costs were over 5.5x higher than the 2015–2022 average.[53]

Meet and exceed customer expectations of resiliency in the face of climate change. Customers expect a reliable power system. Interest in clean, seamless battery backup is growing. Three hundred customers joined the ESS program's wait list after historic state flooding in 2023, bringing the wait list to 1,200 prior to the program expansion.[54]

Reduce customer costs and increase DER adoption through flexible ownership models and utility DER financing. GMP's ESS Lease Program gives customers access to the benefits of a home battery system for a fraction of the cost, affording more customers home resiliency. Utility battery ownership was a point of contention when first designing the ESS Lease Program because utilities traditionally do not own behind the meter assets. However, GMP noted that because Vermont is a small state, it would likely not attract a large market for third-party aggregators and the utility could provide immediate benefits to its customers instead of waiting for the aggregator market to grow.[55] Furthermore, local installers support the installation and maintenance of the battery systems, benefiting local businesses.

Design incentives to provide benefits for program participants and non-participants. GMP designed incentive values by allocating approximately 80% of benefits to participants and 20% of benefits to non-participants, to ensure all electric customers in their territory, participating or not, are able to realize program benefits.[56]

Green Mountain Power: Resiliency through Utility-Managed Residential Batteries

	Metric	Bring-Your-Own-Device (BYOD)	Energy Storage System (ESS) Lease
Overview	Primary Drivers	Resource Adequacy | Reliability & Resilience | Customer Empowerment	Resource Adequacy | Reliability & Resilience | Affordability
	Grid Services	Capacity | Resilience | Ancillary Services	
	Resource Type	Batteries	
	Customer Market Segment	Residential	
	Participating OEMs	Emporia, Enphase, Generac, SolarEdge, Sonnen Battery, Tesla	Tesla
	MW Enrolled	2.52 MW	27.7 MW
	Customers Enrolled	373	3,076[58]
VPP Roles and Responsibilities	Resource Offtaker	Green Mountain Power	Tesla
	Program Operator	Virtual Peaker	Tesla
	Customer Enrollment	Green Mountain Power	
	Customer Payment Channel		
Customer Experience	Device Owner	Customer	Green Mountain Power
	Participation Requirements	10-year enrollment contract	10-year lease with option to extend an additional 5 years at no cost if batteries are in good condition
	Participation Incentives	Up-front: $850/kW for three-hour discharge, $950/kW for four-hour discharge | Up to $10,500	Two Powerwall batteries for $55/month or one $5,500 payment
	DER Control	Autonomously VPP-controlled without customer override	
	Dispatch Timing	Frequency: Annual, 5–8 events per month Duration: 3–6 hours on average Scheduling: Dynamic responses to the near real-time signal from Vermont and New England system loading, as well as the ISO-NE frequency regulation market	Frequency: Annual, up to daily Duration: Up-to several hours Scheduling: Dynamic responses to the near real-time signal from Vermont and New England system loading, as well as the ISO-NE frequency regulation market

"We all see the severe impacts from storms, we know the impact outages have on customers' lives, and the status quo is no longer enough. We are motivated to do all we can to combat climate change and create a Vermont that is sustainable and affordable, but we must move faster. Together with our customers, regulators, our communities, and that Vermont spirit that manages to innovate despite all odds, we have all we need to revolutionize the energy system and ensure a stronger, more affordable Vermont."

— Mari McClure, GMP president and CEO[57]

More information:
BYOD website and Energy Storage System Lease website

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

Hawaiian Electric

Two Battery Storage Approaches to Phase Out Fossil Fuel

Hawaiian Electric: Two Battery Storage Approaches to Phase Out Fossil Fuel

Context and Background

Hawaiian Electric (HECO) implemented a competitively bid Grid Services Purchase Agreement (GSPA) procurement program to serve capacity and ancillary resource needs with DERs. Sought-after grid services included fast frequency response (an ancillary service) and capacity.[59]

Swell Energy was one of the awardees of the GSPA, and received an 80 MW, PUC-approved contract in January 2021 known as Swell Energy's Home Battery Rewards Program. The program commenced operations in January 2022.[60] Swell Energy manages customer enrollment, installer relationships, resource aggregation, and operation. Swell Energy is also responsible for performance through capacity commitments and non-performance penalties. And Swell Energy offers $0-down financing or a low, fixed monthly payment structure for solar and storage systems.

The Hawaii Public Utility Commission emergency launched a separate program, the Scheduled Dispatch Program, commonly referred to as the Battery Bonus Program, in July 2021. The commission fast-tracked this program as an incentive to increase battery adoption to support fossil-fuel generation retirement and operate on a fixed schedule.[61] The Battery Bonus Program lacks the data sophistication from the GSPA proceedings in part because local industry stakeholders sought a simplified, universal approach to incentivized operation that did not require aggregators or performance data exchanges to serve the emergency capacity needs.

A successor to the Battery Bonus Program, titled Bring Your Own Device (BYOD), launched in April 2024, will offer lower incentives to participants.[62]

Impact to Date

Swell Energy's Home Battery Rewards VPP is contracted to deliver **80 MW** from **~6,000 customer systems**. The program is actively enrolling through 2024.

As of April 1, 2024, Battery Bonus has enrolled **46.8 MW out of the allotted 40 MW** of storage in Oahu and **8 MW** out of the allotted 15 MW for Maui.[63]

Battery Bonus participants are **lowering Oahu's grid demand daily by approximately 22 MW** from 6:00–8:30 p.m., accounting for 1% of Oahu's firm installed capacity. This value is expected to increase as more of the enrolled MW comes online.[64]

Key Takeaways

Manage the potential trade off between more complex grid services and program implementation speed. These two programs illustrate the benefits and drawbacks between a complex VPP that provides more services but takes longer to implement, and a simpler VPP that is faster to implement, but provides less services and data visibility.

- The robust GSPA procurement process was designed via regulatory proceeding and requires time to solicit, contract, and receive regulatory approvals for each supplier. Although a lengthier process, more is required from GSPA suppliers regarding forecasting and device performance data, grid services, cybersecurity, demonstrating cost-effectiveness, resource availability, and settlement as compared to non-GSPA procured programs.[65]

- In contrast, the Battery Bonus program was designed and fast-tracked to eliminate the need for a specific supplier and procurement process, and therefore was simpler in design and operational requirements.[66] Although quicker to implement, the simplicity requires HECO to incur more of the burden administering the program and managing customer enrollments and payments as compared with GSPA-solicited programs.

Partner with third parties to reduce the operational burden on the utility. OpenADR and Swell's GridAmp DERMS platform securely integrates with HECO systems, giving HECO program visibility and performance assurances while Swell operates the program.

Invest in DER data forecasting and visibility for long-term VPP program cost-effectiveness. Better data visibility can help manage devices, increase impact valuation, troubleshoot operations, and establish transparent performance settlement mechanisms. Aggregator services associated with forecasting and device performance can provide a cost-effective solution for resource management and real-time visibility.[67] HECO does not have visibility into Battery Bonus device performance or resource forecasting but will have access to historical device performance data in the successor BYOD program via 2030.5 requirements.[68]

Avoid designing and launching programs that compete for the same customers with similar resource types and services. The launch of the Battery Bonus program overlapped with the existing Swell Energy Home Battery Rewards VPP, which created market confusion and slowed the implementation of the competitively bid GSPA program.[69]

Hawaiian Electric Company: Two Battery Storage Approaches to Phase Out Fossil Fuel

	Metric	Swell Energy Home Battery Rewards[71]	Battery Bonus Program[72]
Overview	Primary Drivers	Resource Adequacy | Versatility & Flexibility | Decarbonization	Resource Adequacy | Decarbonization
	Grid Services	Ancillary Services | Capacity (Build/Reduction)	Capacity (Reduction)
	Resource Type	Existing and New Battery Storage	New Battery Storage w/Solar
	Customer Market Segment	Oahu, Maui, Hawaii Island Residential	Oahu Residential & Commercial, Maui Residential & Commercial
	Participating OEMs	Currently Tesla Battery	OEM Agnostic Battery
	MW Enrolled	80 MW Target (Oahu, Maui, Hawaii Island)	Oahu: 46.8 MW | Maui: 8 MW
	Customers Enrollements[73]	~2,000–6,000	~4,000
VPP Roles and Responsibilities	Resource Offtaker	Hawaiian Electric	
	Program Operator	Swell Energy	Hawaiian Electric
	Customer Enrollment		
	Customer Payment Channel		
Customer Experience	Device Owner	Customer or Third-Party	
	Participation Incentives	Monthly Performance Credits:* $3/kW for capacity build $5/kW for capacity reduction and fast frequency response	Up-front: $850/kW Monthly Flat Rate Credit: $5/kW of committed peak capacity Monthly Export Credit (available for non-net energy metering customers)
	Participation Requirements	Non-optional dispatch, flexible enrollment	Non-optional dispatch, required 10-year enrollment contract
	DER Control	Swell Energy autonomously VPP-controlled without customer override	OEM autonomously device-controlled dispatch without customer override
	Dispatch Timing	Frequency: Annual, 144 max events per year Duration: 4 hours Scheduling: Dynamic responses to dispatch signals (day-ahead up to 10 minutes ahead) to match grid needs	Frequency: Annual, daily 6–8:30 p.m. Duration: 2 hours Scheduling: Fixed 2-hour schedule established by HECO

"As we move forward with BYOD, customers can continue to receive incentives for providing grid services while playing a key role in Hawaii's clean energy transition."

— Lani Shinsato, Hawaiian Electric Customer Energy Resources co-director[70]

More Information: HECO Customer Incentive Programs

Program Design Metrics adapted from the DOE Pathways to Commercial Liftoff: Virtual Power Plants, 2023

* The specific grid services tied to performance credits for the Swell Energy Program are defined here.

Holy Cross Energy

Integrating VPPs into Communities

Holy Cross Energy: Integrating VPPs into Communities

Context and Background

Holy Cross Energy (HCE) forecasts that DERs will account for 10% of its 2030 carbon-free power generation.[74]

HCE has implemented a variety of VPP programs to leverage customer DERs to meet sustainability goals including an on-bill-repayment residential BTM storage program (Power+), a $549 up-front rebate for level-2 EV chargers when members enroll in managed HCE's charging program, a whole building integration program study, and a variety of customer rate options and rebates to make DERs more accessible.[75]

This feature focuses on the Power+ program, which optimizes energy use through Tesla's Powerwall 2 battery storage system to offer HCE members the combined benefit of extreme weather resilience with wholesale energy cost reduction for the entire HCE membership. The program was piloted in 2020 and launched as a program in the spring of 2021.[76]

To minimize up-front costs for HCE members, HCE pays for the battery and installation. Then, the participating customer repays HCE through a monthly bill charge, which is partially offset by bill credits from HCE's control of the battery as a grid resource.[77]

In addition to the Power+ Battery program, HCE has evaluated how to orchestrate different DER device types together to maximize grid and customer benefits. In 2020, HCE partnered with local housing community Basalt Vista, NREL, and others to implement a whole building integration program through outfitting four homes with utility-controllable DERs.[78]

Through this study, HCE learned how DER orchestration can provide value to the consumer and the grid by minimizing peak loads. By using interoperable standards and commercially available technology, Basalt Vista was designed so that DER orchestration learnings could scale to other utilities.[79]

Impact to Date

The initial installation at HCE headquarters avoided 12 interruptions/290 outage minutes in Q4 of 2020.[80]

As of May 2024, 174 residential locations had enrolled 3 MW of battery storage in the Power+ Battery program.[81]

The project is ongoing.

Key Takeaways

Maintain a minimum state of charge when managing customer batteries. HCE always leaves at least 20% of the battery charged to allow customers to maintain resilience in the event of an outage after a peak load event.

Reduce up-front costs to remove barriers to DER adoption. Through HCE's on-bill-repayment structure, HCE customers avoid prohibiting up-front battery costs and can reap the benefits of energy storage for a manageable monthly charge.

Educate customers about the incentives available so they can make an informed decision on their energy future. In addition to the 10-year on-bill repayment, HCE clearly lays out the available federal and state tax credits (40% and 10%, respectively) for customers if the battery system is fully paid off within the same year as installation. This enables customers to compare and contrast the benefits of leveraging tax credits with a large up-front payment, or leveraging HCE's repayment option with no up-front costs.[82]

Make device adjustments unnoticeable to customers for seamless customer experience. HCE operates the battery autonomously with no customer action required. The customer is unaware the DER management is taking place.

Holy Cross Energy: Integrating VPPs into Communities

	Metric	Power+ [84]
Overview	Primary Drivers	Decarbonization | Affordability | Customer Empowerment
	Grid Services	Capacity | Energy
	Resource Type	Batteries
	Customer Market Segment	Residential
	Participating OEMs	Tesla Powerwall 2
	MW Enrolled	3 MW
	Customers Enrolled	174
VPP Roles and Responsibilities	Resource Offtaker	Holy Cross Energy
	Program Operator	Virtual Peaker (DERMS for dispatch and operation)
	Customer Enrollment	Holy Cross Energy
	Customer Payment Channel	Holy Cross Energy
Customer Experience	Device Owner	Customer
	Participation Incentives	No up-front costs: the battery and installation paid for by HCE. The customer repays HCE over ten years at 0% interest through the Power+ monthly charge, which is offset by energy credits the customer receives for allowing HCE to control and optimize the battery usage. The energy credits can continue beyond 10 years if the member wishes to remain in the program.
	Participation Requirements	Customers must have had service with HCE for 12 months and have no delinquent payments in 12 months
	DER Control	Autonomously VPP-controlled without customer override
	Dispatch Timing	Frequency: Annual, no more than 10 times per month Duration: Varies, typically between 4 p.m. and 9 p.m. for 2–3 hours Scheduling: Dynamic responses to day-ahead signals

"For us, a co-op, 90 percent renewable energy capacity is feasible with existing and new solar energy projects. However, the trick is getting that last 10 percent, without needing the baseload capacity that fossil-power plants provide. To get to that goal, we need to deploy distributed battery storage technology throughout our service territory to firm up the grid and provide ancillary and baseload services. Power+ is a key program to help us get to 100 percent renewable energy."

— Lisa Reed, Holy Cross Energy's Energy Programs Manger[83]

More Information: Power+ website

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

National Grid ConnectedSolutions

Streamlined Multi-State and Multi-Technology VPP

National Grid ConnectedSolutions: Streamlined Multi-State and Multi-Technology VPP

Context and Background

ConnectedSolutions is a Northeast regional open-access VPP program that allows multiple OEMs and third-party aggregators to participate. ConnectedSolutions was initially developed in Massachusetts, and a version of the program has since been developed in several states in the Northeast, including Connecticut, Rhode Island, and New York.

The *Massachusetts Green Communities Act* (GSA) of 2008 requires that MA IOUs administer three-year energy efficiency plans that pursue all cost-effective efficiency and demand reduction measures. The 2016 *State of Charge* Report later reinforced the importance of peak demand management to lower energy costs, finding that 40% of each year's electric expenditures in MA are devoted to the 10% of hours with the highest demand. ConnectedSolutions is designed to minimize summer peak demand, reduce generation needed, and lower energy costs through leveraging customer resources.[87]

Two of Massachusetts IOUs (NationalGrid and Eversource) along with the Cape Light Compact, an energy efficiency program administrator, piloted ConnectedSolutions in 2016 and officially launched it as a program in 2019.[88]

National Grid's ConnectedSolutions currently has three parts: residential thermostats, residential batteries, and commercial and industrial demand response. For the residential battery program, customers can choose to have their incentives paid to their installer, device manufacturer, or power purchase agreement provider – allowing these providers to offer different incentive structures to customers.[89]

Impact to Date

2023 installed capacity across all Massachusetts participants totaled **227 MW from 95,766 customers**.[90]

Inspired by ConnectedSolutions, all six New England states have adopted a performance-based battery program.[91]

Based on the success of ConnectedSolutions, National Grid is looking beyond peak reduction and considering how VPPs can provide non-wires alternatives and "bridge to wires" solutions to address local capacity constraints, as well as calling on customer-owned DERs to reduce loads on the grid when the GHG marginal emission rates are high.[92]

Key Takeaways

Offer performance-based payments to drive consumer participation. ConnectedSolutions incentives are predictable and attractive enough to drive consumer performance, rather than penalize lack of performance. For example, the residential battery pilot survey showed 97% of customers would likely continue with the program.[93]

Enable value stacking across programs. Participation in ConnectedSolutions does not preclude costumers from value stacking with other programs, such as the New England capacity market.[94]

Incorporate multiple technologies for a streamlined customer experience. Residential customers can enroll both smart thermostats and battery storage in ConnectedSolutions and the program is designed to incorporate more devices in the future.

Implement an open access structure to empower multiple OEMs and service providers. Both customers and aggregators can enroll in the program. Customers can choose the device and provider that works best for them.

Standardize program design for efficiency. By aligning program designs across utilities and states, ConnectedSolutions mitigates program costs associated with customer acquisition and operations.

National Grid ConnectedSolutions: Streamlined Multi-State and Multi-Technology VPP

	Metric	Residential Thermostats[95]	Residential Batteries[96]	C&I Demand Response[97]
Overview	Primary Drivers	Resource Adequacy | Flexibility & Versatility | T&D Infrastructure Relief		
	Grid Services	Capacity		
	Resource Type	Smart Thermostats	Batteries	Demand Response (Technology agnostic but precludes fossil-fuel powered generators)
	Customer Market Segment	Residential		Commercial & Industrial
	Participating OEMs	Alarm.com, Building 36, ecobee, Emerson, Honeywell Home, Lux, Nest, Radio Thermostat, Sensi, vivint.SmartHome	Enphase, Generac, Outback, Sol-Ark, SolarEdge, SunPower, Tesla	Curtailment Providers: CPOWER, Enel-X, IPKeys, Voltus, NRG, Leap, IceTec, etc.[98]
	MW Enrolled**	55.38 MW	21.23 MW	Daily: 21.5 MW | Targeted: 128.65 MW
	Customers Enrolled**	91,700	3,096	Daily Dispatch: 84 | Target Dispatch: 886
VPP Roles and Responsibilities	Resource Offtaker	Market-Aware	Market-Aware	Market-Aware
	Program Operator	EnergyHub	EnergyHub	EnergyHub
	Customer Enrollment	Individual OEMs	Individual OEMs or Third-Party Service Providers	Third-Party Curtailment Providers
	Customer Payment Channel	Utility	Utility or Third-Party Aggregator	Third-Party Curtailment Providers
Customer Experience	Device Owner	Customer		
	Participation Incentives	$50 enrollment e-gift card $20 annual e-gift card	$275 per kW performed per summer*** ~$1,500 per year, system dependent	Daily Dispatch: $200/kW per summer Targeted Dispatch: $35/kW per summer
	DER Control	Autonomously VPP-Initiated with customer override		
	Dispatch Timing	Frequency: Seasonal, typically 15 events per summer Duration: 3 hours Scheduling: Dynamic responses to day-of signals	Frequency: Seasonal, up to 60 events per summer Duration: up to 3 hours Scheduling: Dynamic responses to day-ahead signals	Frequency: Seasonal, Summer • Daily: 30–60 events per summer • Targeted: 2–8 events per summer Duration: • Daily: 2–3 hours • Targeted: 3 hours Scheduling: Dynamic responses to day-ahead signals

National Grid's ConnectedSolutions was awarded the Energy Storage North America 2019 innovation award for behind-the-meter storage.[100]

More information:
ConnectedSolutions website, National Grid

Program design for National Grid (MA)

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

** Customer and MW enrollment numbers represent Summer 2023 performance and include all Massachusetts ConnectedSolutions participants, not just National Grid participants.

*** Performance varies based on size, configuration, internet, and other factors. Performance calculation information can be found here.

Pacific Gas and Electric

Leveraging Existing Customer Batteries for Quick Implementation

Pacific Gas and Electric: Leveraging Existing Customer Batteries for Quick Implementation

Context and Background

In 2023, Peak Power Rewards, a partnership between Sunrun and Pacific Gas and Electric (PG&E), provided flexible energy during August–October evening peaks to alleviate peak demand strain on the grid.

The three-month solar and battery storage program was authorized by the CPUC in early 2023 for $10.5 million in funding and was operational within six months, without the need to build costly new infrastructure.[101]

Sunrun operated and managed the program to provide power and performance data to PG&E. Specifically, Sunrun managed customer relationships, dispatch, incentives, measurement and verification, and aggregation risk. There was no software interaction or customer data shared between Sunrun and PG&E. No utility hardware (for example, a smart meter) or utility DERMS was involved.

Additionally, Sunrun automatically enrolled eligible customers because Sunrun was already optimizing customer batteries and had the correct customer contract.

Peak Power Rewards layered on top of existing tariffs to seamlessly integrate within PG&E's existing time-of-use rate structures, meaning Peak Power Rewards' daily evening dispatches occurred during on-peak pricing.[102] Eligible customers did not have to unenroll from existing programs.[103]


Green | Cleaner Tech

PG&E Will Pay Sunrun Battery Owners for Power to Avoid Blackouts

PG&E and Sunrun announce partnership to enlist home solar and battery systems that can shore up grid when demand spikes during hot weather.

Source: Bloomberg

Impact to Date

Delivered a consistent average of 27 MW over two hours for 90 days and frequently supplied the grid with up to 30 MW, which could power more than 20,000 homes.[104]

Peaked at nearly 32 MW from the enrolled 8,500 customers.

Expanded enrollment from an initial 30 MW and 7,500 customers due to strong interest.

Provided lessons learned about battery response rates to improve future VPP program design for both PG&E and Sunrun. For example, Sunrun is offering a similar program to California community choice aggregators to harness Sunrun's fleet to help manage peak demand and daily load curve.

Key Takeaways

Incorporate existing customer-sited DERs to expedite the program implementation process. Regulatory approval to dispatch was less than six months in part due to the magnitude of existing customer batteries and the third-party ownership aggregator model.

Simplify customer processes to maximize engagement. Peak Power Rewards had high customer participation because of automatic customer enrollment, meaning there was no customer action required for sign-up, and the program integrated into existing rate structures. Program opt-out rates were very low.

Leverage customer performance data in program analysis. Sunrun provided PG&E performance data that enabled PG&E to precisely analyze the benefits the program provided.

Offer incentives that adequately compensate customers for strong enrollment while maintaining program cost-effectiveness. Peak Power Rewards offered generous incentives that contributed to strong customer participation but hindered overall program cost-effectiveness. An updated model of this program should be refined to better balance customer compensation and program cost-effectiveness.

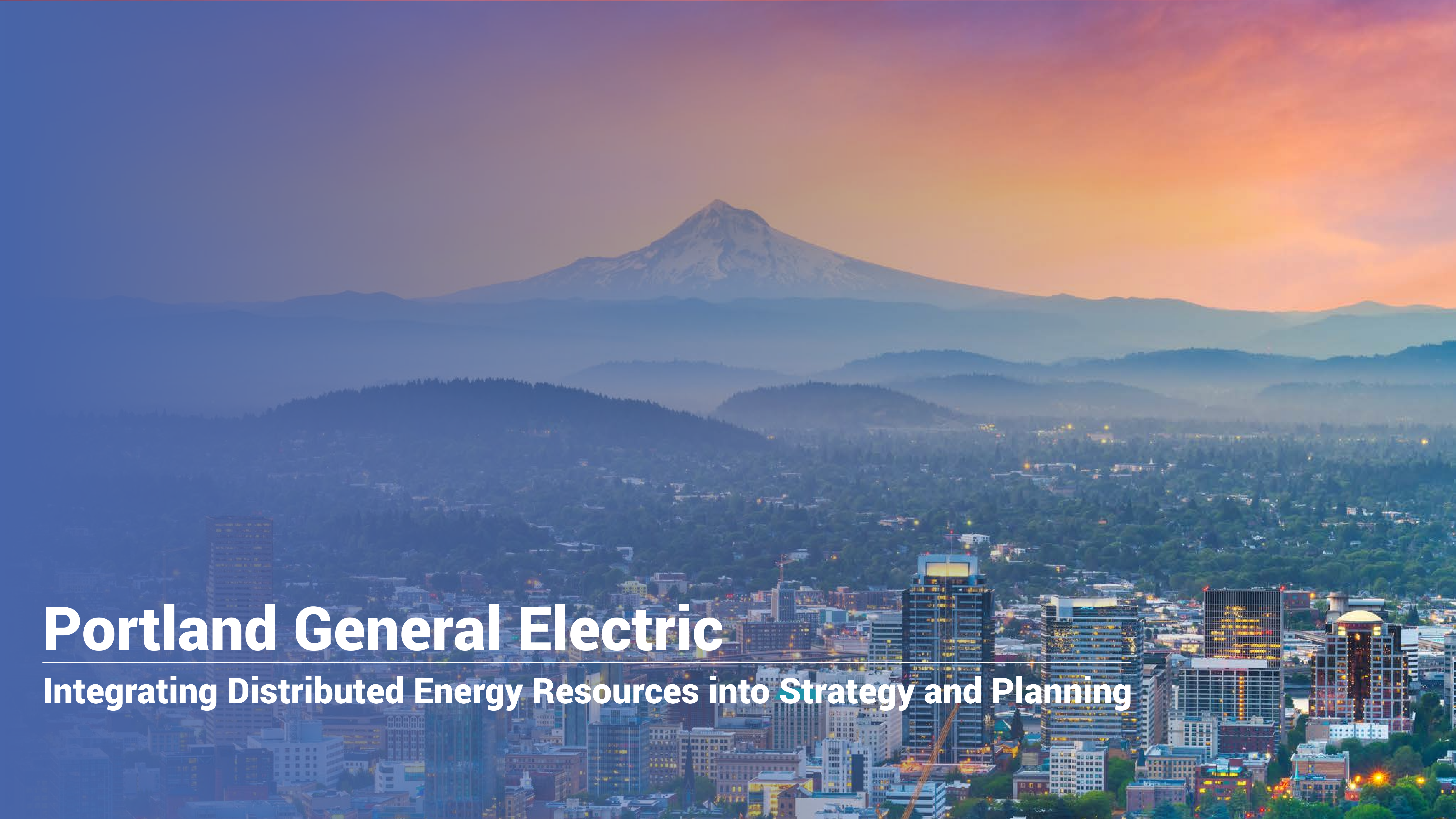
Pacific Gas and Electric: Leveraging Existing Customer Batteries for Quick Implementation

	Metric	Peak Power Rewards
Overview	Primary Drivers	Resource Adequacy | Flexibility & Versatility | T&D Infrastructure Relief
	Grid Services	Capacity | Energy | Resilience
	Resource Type	Solar + Batteries
	Customer Market Segment	Residential
	Participating OEMs	LG, SolarEdge, Tesla
	MW Enrolled	32 MW
	Customers Enrolled	8,500 Vehicles
VPP Roles and Responsibilities	Resource Offtaker	Pacific Gas & Electric
	Program Operator	Sunrun
	Participant Facing-Entity	
	Customer Payment Channel	
Customer Experience	Device Owner	Customer
	Participation Incentives	Customers receive a $750 Visa gift card and a free Nest thermostat (valued at $117)
	Participation Requirements	Sunrun solar and battery customers in single-family homes with an interconnection agreement with PG&E
	DER Control	Aggregator autonomously optimized and dispatched by the third-party fleet owner, with some customer override
	Dispatch Timing	Frequency: Seasonal, daily during summer months Duration: 2 hours, 7–9 p.m. Scheduling: Scheduled based on historic electrical patterns

"Working together with partners like Sunrun is a win-win-win for our customers, the electric grid, and California as a whole. Solar-plus-storage plays a significant role in California's clean energy future and we're proud of our customers who are leading the charge with their clean energy adoption. Every day, we're looking at new and better ways to deliver for our hometowns while ensuring safety, reliability, and resiliency for our customers."

— Patti Poppe, CEO of PG&E Corporation[105]

More information: PG&E 2024 Article



Portland General Electric

Integrating Distributed Energy Resources into Strategy and Planning

Portland General Electric: Integrating Distributed Energy Resources into Strategy and Planning

Context and Background

PGE is focusing on three key areas as it pursues its commitment to deliver clean, reliable energy to Oregonians.

1. Rapid Load Growth: PGE is experiencing rapid customer growth in the industrial segment in the near term and sustained load growth from accelerating electrification in all customer segments in the long term. From 2022 to 2023, demand from industrial loads and data centers grew 10.6%.[106] Looking ahead, PGE projects continued annual energy growth of 1.6% through 2042, driven by industrial load growth at 3.9%.[107]
2. Extreme and Uncertain Weather. Climate change is contributing to increasingly extreme and uncertain weather across PGE's service territory.[108] Heat waves, including record-breaking heat in June 2021 and August 2023, have led to record energy demand across PGE's system.[109]
3. Rapid Decarbonization: Oregon's *Clean Energy Targets Bill* of 2021 set ambitious targets to reduce greenhouse gas emissions from electricity. Specifically, PGE and other utilities are required to reduce emissions 80% below a 2010–2012 baseline by 2030 and achieve 100% carbon-free emissions by 2040.[110]

To meet these three challenges, PGE is advancing an integrated approach that relies not only on central assets, but also on customer partnerships and distributed energy resources. PGE estimates that by 2030, 25% of peak demand will be orchestrated through DERs and demand flexibility.[111] PGE's integrated resource plan articulates the utility's vision to manage and leverage these resources as part of a virtual power plant.[112]

At the core of PGE's approach is a two-way grid architecture. This two-way grid architecture is enabled by PGE investment in and implementation of third-party developed advanced distribution management system (ADMS) and distributed energy resource management system (DERMs) software.[113] As a result of these investments, PGE is able to integrate and manage two-way power flow driven by distributed energy resources as part of utility operations.

PGE's integrated strategy is deployed through a coordinated portfolio of programs. These include, but are not limited to:[114]

1: Residential Smart Thermostat
2: Peak Time Rebates
3: Multifamily Water Heater
4: Energy Partner (business) programs, including smart thermostats and load flexibility
5: EV Smart Charging[115]

PGE has advanced implementation-focused research to advance its vision. Notably, PGE launched the Smart Grid Test Bed in 2019. The Smart Grid Test Bed allows PGE to test a variety of approaches including approaches that leverage AI to collect data and integrate DERs.[116] In 2021, PGE received a US DOE grant of more than $6 million to expand its projects.[117]

Impact to Date

Participants in PGE's Peak Time Rebates and Smart Thermostat programs shifted enough energy during a typical peak event to power 5,450 homes during winter or 18,500 homes during summer.[119]

During record heat and record demand events on August 14 and August 15, 2023, customer actions reduced load by over 90 MW (~2% of overall peak demand) at the hottest time of day. This action helped alleviate stress on the grid and avoid potential outages.[120] This is illustrated in the graphs shown on page 50.

Key Takeaways

Implement an open software approach to improve program operation.
Software that allows PGE to monitor, communicate with, and manage a range of DERs is core to PGE's two-way grid architecture.

Incorporate DERs into long-term resource and distribution planning. PGE integrates DERs into all utility processes, including distribution and resource planning. This allows PGE to include VPPs in their resource mix.

Allow for iterative program design. PGE's Smart Grid Test Bed approach enables PGE to learn from existing studies and iterate for consistent program improvement and expansion.

Integrate VPPs as a core solution to evolving grid needs. VPPs are central to PGE's approach to customer engagement, planning, and grid operation. This approach involves multiple shifts:

From	To
Passive customer	Active customer
One-way flow	Omni-flow
Centralized control	Centralized coordination
Peak demand	Optimized utilization
Generation to match load	Flexible generation, load, and system
VPP is cool	VPP is core[121]

Portland General Electric: Integrating Distributed Energy Resources into Strategy and Planning

	Metric	Peak Time Rebates[122*]	Multifamily Water Heater[123*]	Energy Partner on Demand*
Overview	Primary Drivers	Decarbonization | Versatility & Flexibility | Reliability & Resilience		
	Grid Services	Capacity, Ancillary Services (Frequency Response, Contingency Response)		
	Resource Type	Demand Response: Behavioral Load Shaping	Water Heaters	Demand Response: Interruptible Load | Batteries
	Customer Market Segment	Residential	Commercial: Property Managers	Commercial and Industrial
	Participating OEMs	OEM Agnostic	OEM Agnostic	OEM Agnostic
	MW Enrolled (2023 summer capacity)[124]	14.5 MW	2.0 MW	36.4 MW
VPP Roles and Responsibilities	Resource Offtaker	Portland General Electric		
	Program Operator			
	Customer Enrollment			
	Customer Payment Channel			
Customer Experience	Device Owner	Customer	Customer	Customer
	Participation Incentives	Peak Time Rebates are $1/kWh reduced below baseline, which is a customer's average energy use over the past 10 similar days to the event.	Property owners earn $20 per participating water heater annually. PGE pays for necessary switch and communications equipment and installation.	Participation is voluntary and is customized for each business. PGE helps identify ways each business can best shift energy during peaks. Up-front incentives are also available to support battery purchase and installation.
	Participation Requirements	Unable to jointly participate with the smart thermostat program because joint participation would reward shifting energy during the same peak event.	Qualifying properties should have at least 50 apartments with water heaters that are 38 gallons or larger each. Residents receive rewards, such as coupons, as a recognition for being a part of the program	Flexible. No minimum or maximum participation requirement. For larger operations (>250 kW of nominated capacity) additional program offerings are available.
	DER Control	Customer-controlled	Autonomously VPP-initiated with customer override.	Customer-controlled
	Dispatch Timing	Frequency: Summer: June 1–Sept 30, Winter: Nov 1–Feb 28. Often on weekdays in the late afternoons or evenings, or on cold winter mornings. On average, 4–7 events in summer, 1–4 events in winter. Duration: Typically 3–4 hours Scheduling: Day-ahead dynamic dispatch	Frequency: Up to daily Duration: Typically 3–4 hours Scheduling: Dynamic dispatch, water tanks are heated when energy demand is low except when no extra hot water is available	Frequency: Summer: June 1–Sept 30, Winter: Nov. 1–Feb 28. Often on weekdays in the late afternoons or evenings, or on cold winter mornings. On average, 4–7 events in summer, 1–4 events in winter. Duration: Typically 3–4 hours Scheduling: Day-ahead dynamic dispatch

"We are in the midst of a transformation that is creating a fundamentally new relationship with our customers. From seeing them as passive receivers of electrons to being active participants in the clean energy future. This work is core in enabling that relationship to develop in ways that accelerate the clean energy future."

— Franco Albi, PGE's Director of Regional Integration

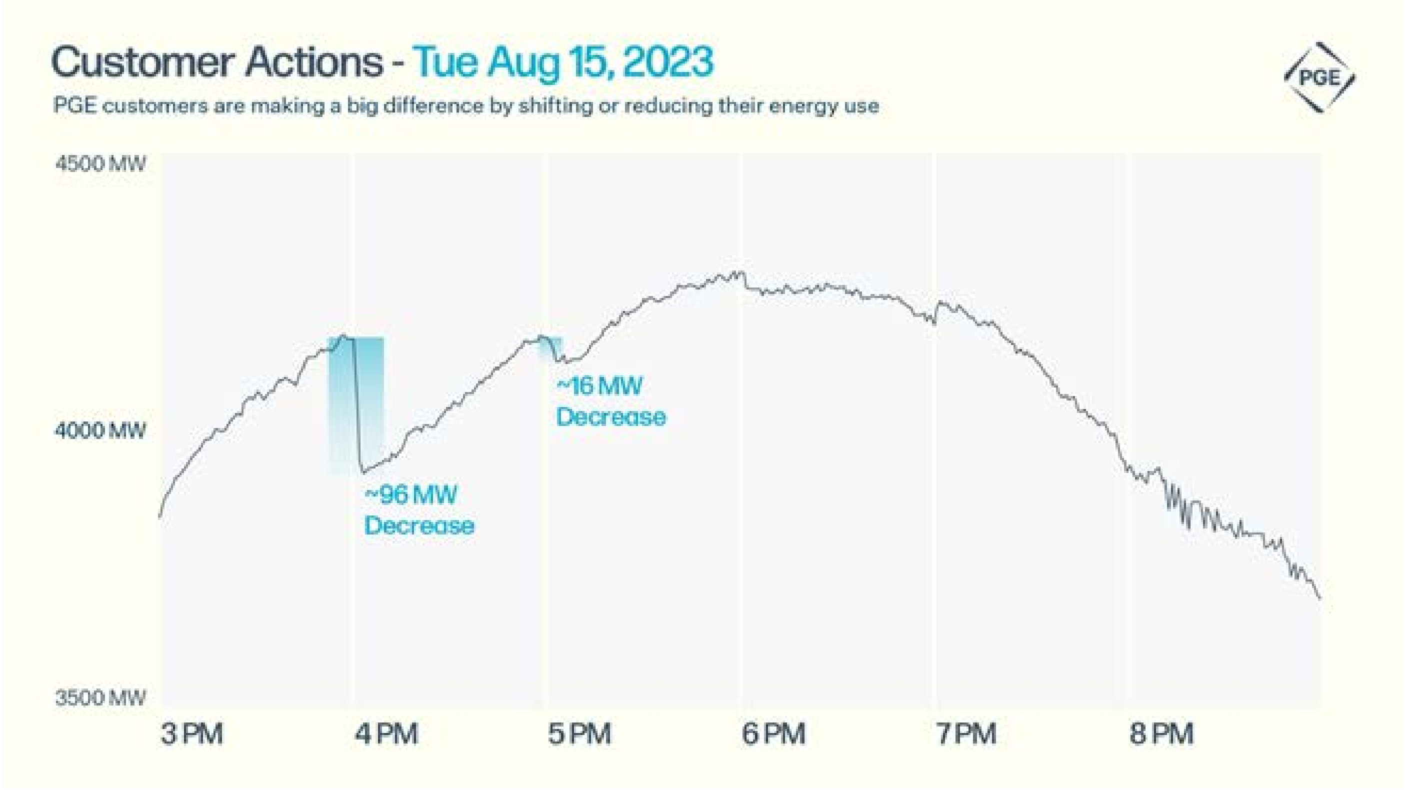
More information:
PGE Energy Shifting website and Multifamily Water Heater website

Program Design Metrics adapted from the DOE *Pathways to Commercial Liftoff: Virtual Power Plants*, 2023

*The subset of programs included in the table are a subset of PGE's VPP portfolio. For more information on all of PGE's energy-shifting programs, learn more on PGE's website.

** PGE owns and operates front-of-meter battery storage to support integrating more clean energy into its portfolio. In April 2023, PGE announced the procurement of 400 MW of new battery storage projects.[128]

Portland General Electric: Integrating Distributed Energy Resources into Strategy and Planning



Source: Portland General Electric

Puget Sound Energy

VPP for DER Enablement and Long-Term Benefit

Puget Sound Energy: VPP for DER Enablement and Long-Term Benefit

Context and Background

Driven by clean energy objectives and Washington state policy, PSE and Uplight (formerly AutoGrid) began developing a VPP in 2021 to provide a centralized application for enrolling, dispatching, and assessing the performance of individual and combined DER programs across PSE's portfolio.[129]

In late 2023, PSE and Uplight announced an expansion of their VPP to dispatch sufficient electric capacity to mitigate summer and winter system peaks. The expanded VPP will provide aggregation monitoring, reporting, and customer management for all participating VPP-related programs, including energy efficiency, residential and commercial demand response, energy storage, and electric vehicles that will be aggregated as a single resource.[130]

Initially, PSE is using a rewards program, PSE Flex, and supporting sub-programs to sign up residential smart thermostats, heat pump water heaters, and EVs for the VPP to use to alleviate grid stress, especially on hot or cold days. The VPP is expected to scale and include battery storage and other resources through PSE's service territory, which includes 1.2 million customers.

In March 2024, Washington passed HB 1589, requiring 80% non-emitting resources by 2030 and 100% by 2045.[131] The result of this house bill is that PSE will pursue a meaningful increase in flexible electric demand with the goal of sourcing 10% of the winter and summer peak electric load through demand flexibility by 2027 (approximately 500MW for PSE).[132]

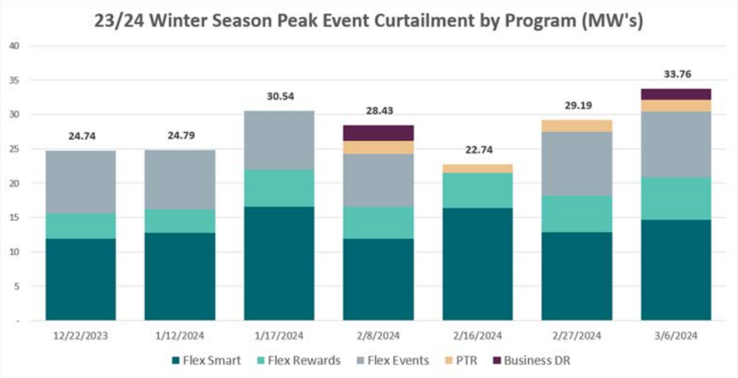
The PSE and Uplight VPP has a goal to grow to 100 MW by 2025 and is expected to scale over time as part of the 3,660 MW of demand-side and distributed resources that PSE plans to add to its system by 2045.[133]

Impact to Date

The 2023/2024 season called seven flex events encompassing multiple programs. The events had a three-hour duration average, 25.38 MW event average, and 27.74 MW event peak.[134]

The largest of the seven events occurred on March 6th, 2024, lasted three hours, had an event average of 31.99 MW, and peaked at 33.76 MW.[135]

As of April 2024, 40,317 customers were enrolled as part of Flex Smart, Flex EV, Flex Rewards, and Peak Time Rebates and the programs continue to grow; 2,321 customers were enrolled in March 2024.[136]



Source: Puget Sound Energy

Key Takeaways

Execute long-term (5+ years) VPP programs. Uplight delivers capacity to PSE under a contract that runs at least five years. This provides Uplight the certainty to front load financial incentives for customers to buy DERs that can become part of the VPP.

Plan for VPPs to provide multiple grid services. At the outset of the VPP, multiple grid services were considered. PSE hopes to leverage the VPP capability to bring additional value such as support to the wholesale market, energy arbitrage, local grid system capacity relief, and ancillary services.[137]

Tap into a broad portfolio of customers and devices. To ensure load reliability, PSE's VPP program brings together resources from both residential and C&I customers and draws on a wide range of asset types to provide the greatest flexibility.[138]

Leverage customer data to create a cohesive and effortless experience to maximize participation. Uplight operates behind a PSE-branded web portal to ensure utility touchpoints are consistent. Data is essential for a seamless customer experience. Data enables personalized messages through existing utility touchpoints like ebills, newsletters, and websites where customers are already used to hearing from the utility. These data-driven experiences operate as a positive feedback loop to encourage customer participation and increase enrollment for ultimately a greater grid-scale impact.

Avoid burying or conflating similar but distinctly different programs. PSE's Flex programs clearly state requirements and explain which programs allow multi-enrollment so customers can understand their options, avoid confusion, and feel in control of their comfort.

Puget Sound Energy: VPP for DER Enablement and Long-Term Benefit

	Metric	PSE Flex Portfolio[140]			Business Demand Response[141]
		Flex Rewards	Flex Smart	Flex EV	
Overview	Primary Drivers	Decarbonization | Customer Empowerment			
	Grid Services	Capacity			
	Resource Type	Demand Response: Behavioral Load Shaping	Smart Thermostats, Water Heaters	Electric Vehicles	Demand Response: Interruptible Load
	Customer Market Segment	Residential	Residential	Residential	Commercial & Industrial
	Participating OEMs	OEM Agnostic	Google Nest, ecobee, Honeywell Home, Sensi, Amazon, Mysa, Sinope	BMW, Ford, Hyundai, Jaguar, Kia, Land Rover, Lexus, Nissan, Tesla, Toyota, VW	OEM Agnostic
	MW Enrolled*	6.2 MW	14.6 MW	Not Available	2.6 MW
	Customers Enrolled	10,508	18,780	704	24
VPP Roles and Responsibilities	Resource Offtaker	Puget Sound Energy			
	Program Operator	Uplight			
	Customer Enrollment				
	Customer Payment Channel				
Customer Experience	Device Owner	Customer			
	Participation Incentives**	$25 for enrolling $/kWh saved during Flex events $15/year a customer stays enrolled	Up to $50/device for enrolling Up-to $40/year a customer stays enrolled	$100 for enrolling $0.50/kWh saved during Flex events	Businesses receive payment for being on standby and for what they are able to achieve during an event.
	Participation Requirements	PSE residential customers who have an AMI meter and whose home heating and/or cooling is provided by PSE electricity. Customers cannot enroll in Flex Rewards and Flex Smart simultaneously but can enroll in Flex Smart and Flex EV simultaneously.		Customers can participate through vehicle's onboard telematics or through connected Level 2 charger if they have an AMI meter. Customers can participate in Flex Smart and Flex EV simultaneously, but not Flex EV and Flex Rewards simultaneously.	Businesses must be a current PSE electric customer within PSE's electric service area. Participating businesses receive support from PSE, at no cost, to create an energy-reduction plan, with a strategy to deliver maximum value with minimum operations impact. The plan identifies how much energy a business can curtail during an event.
	DER Control	Customer-controlled	Autonomously VPP-initiated with customer override		Customer-controlled
	Dispatch Timing	Frequency: Winter (Nov 1–March 31) and Summer (May 1–Sept 30.), up to daily; Not dispatched on holidays; 15 events per season Duration: 2–4 hours, between 7 a.m. and 10 p.m. Scheduling: Dynamically scheduled day-ahead			Frequency: 12 events annually, not dispatched on holidays Duration: 2–4 hours, between 6 a.m. and 10 p.m. Scheduling: Dynamically scheduled day-ahead

"How we're thinking about it at Puget is 'energy orchestration' … where you've got decentralized systems that if you can create the right engagement mechanism with customers, you can literally transform when and how customers use energy."

— Aaron August, PSE Senior Vice President, Chief Customer and Transformation Officer[139]

More information:
PSE Flex Portfolio website and
Business Demand Response website

*Nameplate capacities and enrollments are current as of 3/06/24.[142]

**In addition to the Flex Programs, PSE has a TOU rate with peak time rebates that provides monthly bill credits for voluntarily participating in a peak time rebate event. Customers enrolled in a TOU rate plan with peak time rebates are not eligible to participate in Flex Programs. However, customers enrolled in a standalone TOU rate plan are eligible to simultaneously enroll in a Flex Program. For enrolling in a Flex Program, customers are automatically entered to win one of two $250 gift cards each month (except October and April).

Rocky Mountain Power

Cost-Effective Customer-Owned, Utility-Managed Battery Storage

Rocky Mountain Power: Cost-Effective Customer-Owned, Utility-Managed Battery Storage

Context and Background

WattSmart Battery was launched in December 2020 to help address current grid challenges and prepare for the needs of the future grid. A specific goal of the program was to influence the type of batteries coming into the market to ensure that batteries would be a benefit to the grid and could be utilized by the utility to effectively manage the grid.

In the WattSmart Battery program, customer-owned batteries from eligible manufacturers are actively managed by the utility to provide for multiple grid services including frequency response, peak reduction, contingency reserve, and backup power.

Residential and commercial customers of Rocky Mountain Power (RMP) (a business unit of PacifiCorp) with on-site solar in Utah, Idaho, and Wyoming (starting in 2025) are eligible to participate in the program. Enrollment in the program is the responsibility of the customer who may be assisted by solar installers or battery OEMs.

Using PacifiCorp's Energy Management System, RMP dispatches batteries daily, while ensuring that sufficient battery energy is available to customers with resilient back-up power.

The foundations of the WattSmart Battery program were developed through the Soleil Lofts project, a 600-unit all-electric apartment complex which features 5 MW of solar and 12.6 MWh of battery storage. Residents began moving into Soleil Lofts in September 2019, and the project was completed the following year.[144]

WattSmart Battery is just one of Rocky Mountain Power's VPP programs. Rocky Mountain Power also has a demand response program that PacifiCorp has been using as a VPP for more than 5 years, which is capable of delivering hundreds of megawatts.

•The Utah Public Service Commission has determined that the WattSmart Battery Program is cost-effective when considering benefits accrued over the program's 4-year contract commitment.[145]

Impact to Date

The WattSmart Battery program is growing quickly. As of 2023, impacts included:

- 61 frequency response events lasting five minutes each were called in 2023 for a total of 5 hours and 5 minutes.
- Batteries are autonomously integrated with PacifiCorp's Energy Management system to respond to real-time grid events.
- Enrollment of over 3,200 customer batteries with approximately 20 MW of load is available for real-time dispatch. An additional 2,000 batteries with 10 MW of capacity is expected to be enrolled during 2024.
- Batteries are actively used daily by Rocky Mountain Power to reduce overall system demand.

Key Takeaways

Dispatch batteries daily to provide multiple grid services. WattSmart batteries are integrated into utility operations and dispatched daily and dynamically to provide multiple grid services including frequency support, capacity, and to support solar integration.

Design VPP to support collaboration between solar installers, battery OEMs, and the utility.[146] While WattSmart batteries are managed by the utility, RMP relies on installer networks and trade allies to educate and sign up customers to participate. Any battery manufacturer capable of meeting the program requirements is able to participate in the program.

Consider program lifetime when conducting cost benefit tests. The WattSmart Battery program passed Utah's cost benefit tests given the assumption that there will be less than 1%–6% customer attrition throughout the four-year customer contract. While most of the costs of the program are up-front incentives, benefits to participating and non-participating RMP customers will accrue over time as the battery is operated.

Rocky Mountain Power: Cost-Effective Customer-Owned, Utility-Managed Battery Storage

	Metric	WattSmart Batter
Overview	Primary Drivers	Resource Adequacy | Reliability & Resilience | T&D Infrastructure Relief Customer Empowerment | Affordability | Decarbonization | Versatility & Flexibility
	Grid Services	Resilience | Energy | Capacity | Ancillary Services
	Resource Type	Solar + Batteries
	Customer Market Segment	Residential, Commercial
	Participating OEMs	Sonnen, SolarEdge, Fortress Power, Torus
	MW Enrolled	20 MW[150]
	Customers Enrolled	3,200
VPP Roles and Responsibilities	Resource Offtaker	Rocky Mountain Power (PacifiCorp)
	Program Operator	Rocky Mountain Power (PacifiCorp)
	Customer Enrollment	Installers/OEMs
	Customer Payment Channel	Up-front incentive through installer; Ongoing on-bill incentive (year 2)
Customer Experience	Device Owner	Customer
	Participation Incentives	$400 to 600/kW up-front payment Annual bill credit of $15/kW (starting in year 2)
	DER Control	Autonomously VPP-controlled without customer override
	Dispatch Timing	Frequency: Annual. DERs may be dispatched daily, seasonally, or solely for emergencies. Duration: Active dispatches are <5 minutes and generally impact state of charge by 2%–4%, allowing customers a sufficient reserve for backup power. Scheduling: Dynamic, autonomously

"This innovative program is intended to help solve some of today's challenges while also setting the foundation to evolve with technology and customer needs as we transition to a more renewable energy future."

— Rocky Mountain Power Promotional Video[147]

You can't necessarily wait. Sometimes you have to lead out and be very clear about what is needed."

— William Comeau, VP of Experience and Innovation, Rocky Mountain Power[148]

More information: WattSmart Battery website

Sacramento Municipal Utility District

Complementary Incentives for Customer Compensation

Sacramento Municipal Utility District: Complementary Incentives for Customer Compensation

Context and Background

Launched in 2023, Partner+ is, initially, a 20 MWh and 10 MW solar and storage VPP that supports Sacramento Municipal Utility District's (SMUD's) 2030 Zero Carbon Plan under the umbrella of SMUD's My Energy Optimizer Program.[151]

Partner+ has the opportunity to scale to 54 MWh and 27 MW over the course of the 6–12-year program.[152]

Swell Energy operates the Partner+ program by enrolling customers, conducting market outreach to local installers, aggregating and operating the fleet of systems, and paying customer incentives. SMUD maintains visibility and integrates the program into the greater SMUD operating system, including sending dispatch notifications to Swell Energy.

Swell Energy and SMUD are collaborating to ensure program success by co-marketing, maintaining flexible expansion potential, and iteratively improving customer incentive strategies to encourage enrollments.

For Partner+, up-front and ongoing incentives are set to decline annually toward a cost-effective resource range. Customers "lock-in" their performance incentive rates based on the year they enroll. All customers are guaranteed at least three years of performance payments.

Impact to Date

SMUD's Partner+ is expected to deliver approximately 10 MW of capacity from approximately 1,500 customer systems by the end of the first enrollment term (2025). The program is actively enrolling.[153]

Key Takeaways

Leverage incentives to motivate customer participation. Higher incentives for the Partner+ program are intended to fairly compensate customers for requiring participation in the solar and storage rate and the more frequent use of their systems year-round. The up-front incentive is intended to drive adoption of battery storage in SMUD's territory.

Provide customers with participation options and clearly communicate their differences. SMUD's umbrella program, My Energy Optimizer, enables subset programs between batteries and thermostats and allows SMUD to provide an incentive approach that allows customers to choose the participation commitment right for them.

Design programs to work together. Partner+ was built with complementary incentive structures and discrete customer requirements relative to other SMUD program offerings. The Partner+ program provides SMUD with the performance data necessary to optimize resource planning and operationally optimize dispatch over the entire year.

Partner with third parties to manage DER operations, customer enrollments, and incentive payments. SMUD can focus on how and when they dispatch the resource by sending day-ahead dispatch signals to the Partner+ aggregator, streamlining the integration process of the battery programs into the centralized SMUD operating platform.

Sacramento Municipal Utility District: Complementary Incentives for Customer Compensation

	Metric	Partner + — Aggregator Managed Dispatch[154]
Overview	Primary Drivers	Decarbonization | Consumer Empowerment | Affordability/Equity
	Grid Services	Capacity
	Resource Type	Batteries
	Customer Market Segment	Residential
	Participating OEMs	Tesla, soon to be open to more OEMs
	MW Target (2025)	10 MW
	Customer Enrollment Target (2025)	1,500[155]
VPP Roles and Responsibilities	Resource Offtaker	Sacramento Municipal Utility District
	Program Operator	Swell Energy in collaboration with Sacramento Municipal Utility District
	Customer Enrollment	
	Customer Payment Channel	
Customer Experience	Device Owner	Customer or Third Party
	Participation Incentives	Up-front: $250/kWh up to $2,500 Ongoing: Quarterly performance payments based on system size and year of enrollment
	Customer Participation Requirements	1-year minimum participation for up-front incentives, must enroll in the solar and storage rate and time-of-day rates
	DER Control	Swell Energy autonomously VPP-controlled without customer override
	Dispatch Timing	Frequency: Annual, 1 event per day, up to 240 events per year Duration: Up to 4 hours per day Scheduling: Dynamic responses to day-ahead signals

More information:
SMUD Residential Battery Storage website

Xcel Energy

Dynamic EV Charging to Real-Time Signals for Real-Time Grid Benefits

Xcel Energy: Dynamic EV Charging to Real-Time Signals for Real-Time Grid Benefits

Context and Background

Xcel Energy launched the Charging Perks pilot in June 2021 with a goal to make it easier for EV customers to charge vehicles at times when renewable energy production is high and when customer demand on the energy grid is low.

Xcel Energy sends a day-ahead hourly pricing signal, which varies daily depending on energy costs and renewable capacity, to the OEMs leveraging OVGIP (Ford, GM, and BMW) and to the third-party evPulse for other manufacturers such as Tesla and Wallbox. Then, the OEMs and evPulse create an optimized charging schedule for enrolled customers, taking into account their desired departure time and electrical rate (e.g., time-of-use). The customer can always override the schedule if needed.

The pilot cap was originally 600 electric vehicles. The cap was extended to 1,000 vehicles in January 2023. The cap was lifted in fall 2023.

Impact to Date

The pilot has been successful at shifting load to optimal times for the grid. Impacts varied among participants and across seasonal times of year, with the highest impact from battery electric vehicles using a Level 2 charger during the summer months as opposed to plug-in hybrid electric vehicles or Level 1 chargers.

During the 2022–2023 pilot cycle, the average EV reduced 0.4 kW during some on-peak hours, saved 0.20 kg of CO_2 for scheduled charging, and increased 0.41 kW of renewable energy consumption during some off-peak hours.[156]

Given this success, Xcel Energy submitted a filing to the PUC to expand the pilot into a full program. This was approved by the PUC in March 2024. As part of the approval, the PUC directed Xcel to increase annual payments to incentivize dynamic charging.[157]

Xcel Energy intends to include demand response use cases in the PUC-approved full program (in addition to the day-ahead pricing), illustrating the need for "on-demand" load shaving, which is the ability to pause EV charging for one to two hours during demand response events.

Key Takeaways

Educate customers about their EV charge scheduling during peak hours to avoid confusion. With a dynamic, day ahead pricing program, coupled with TOU inputs, EV charging is usually aligned with the off-peak periods of a customer's TOU rate. Sometimes the real-time conditions of the grid are misaligned with a customer's static TOU rate, but these misalignments are countered with the day-ahead price signal to discourage charging during mid-peak and/or on-peak periods.

Automate program processes for efficiency. Xcel Energy has created an automated process to send the hourly price signal to OEMs 24 hours in advance for the next day, decreasing the administration burden. Then, the OEMs (or evPulse) coordinate the managed charging automatically with no action from the customer for a streamlined process and customer experience.

CHARGING PERKS IMPACT FOR 2022-2023

0.40 kW	0.20 kg	0.41 kW
Average capacity reduction per EV (for some on-peak hours)	CO_2 emissions savings per EV (for scheduled charging)	Increased renewable consumption per EV (for some off-peak hours)

Source: Xcel Energy

Xcel Energy: Dynamic EV Charging to Real-Time Signals for Real-Time Grid Benefits

	Metric	Charging Perks Pilot[159]
Overview	Primary Drivers	Resource Adequacy | Decarbonization | T&D Infrastructure Relief
	Grid Services	Capacity
	Resource Type	Electric Vehicles
	Customer Market Segment	Residential
	Participating OEMs	General Motors, Ford Motor Company, BMW of North America, Tesla, Wallbox Charger
	MWh Enrolled	70.8 MWh based on battery size
	Customers Enrolled	1,200 Vehicles
VPP Roles and Responsibilities	Resource Offtaker	Xcel Energy
	Program Operator	
	Customer Enrollment	GM, Ford, BMW: OEMs (coordinated using OVGIP), Tesla, Wallbox Charger: evPulse
	Customer Payment Channel	Xcel Energy
Customer Experience	Device Owner	Customer
	Participation Incentives	Enrollment incentive: $100 e-gift card, year-end annual participation incentive: $50 e-gift card for Level 1 and $100 e-gift card for Level 2 charging; These incentives are set to change for 2024
	DER Control	Autonomously VPP-initiated with customer override
	Dispatch Timing	Frequency: Daily Duration: No DR event, ongoing managed charging Scheduling: Dynamic responses to day-ahead hourly signals

"Managed charging with a dynamic price signal has benefited our grid throughout the pilot. The EVs in our Smart Charging pilot not only charge more during off-peak hours but also charge with more renewable energy. The technology is helping customers further reduce their carbon footprint. We are excited to scale dynamic charging in the future."

— Carlos Hill, Senior Product Portfolio Manager, Xcel Energy[158]

More information: Charging Perks Pilot website

Takeaways for VPP Implementation

Successful VPP Implementation Requires Not Only Effective Program Design, But Also Reimagined Utility Practices

Leading Practice for VPP Design and Implementation

Effective Program Design

1.1 Open access in a VPP to integrate multiple technologies, vendors, and programs.

1.2 Develop partnerships that leverage third-party capacity and complementary capabilities.

1.3 Streamline customer experience during enrollment and participation.

1.4 Execute long-term programs (5+ years) with enrollment and operating terms to improve cost-effectiveness.

1.5 Incentivize DERs to enable additional customer participation.

Reimagined Utility Practices

2.1 Incorporate VPPs into planning of generation and distribution.

- Iteratively integrate DERs into planning processes.
- Evaluate VPPs transparently with defined metrics.

2.2 Proactively engage policymakers, including regulators, around effective VPP policy.

- Work with regulators to ensure policies allow for innovative and iterative approaches to DERs.
- Consider whether components of performance-based regulation can support VPP deployment.

2.3 Transform business practices.

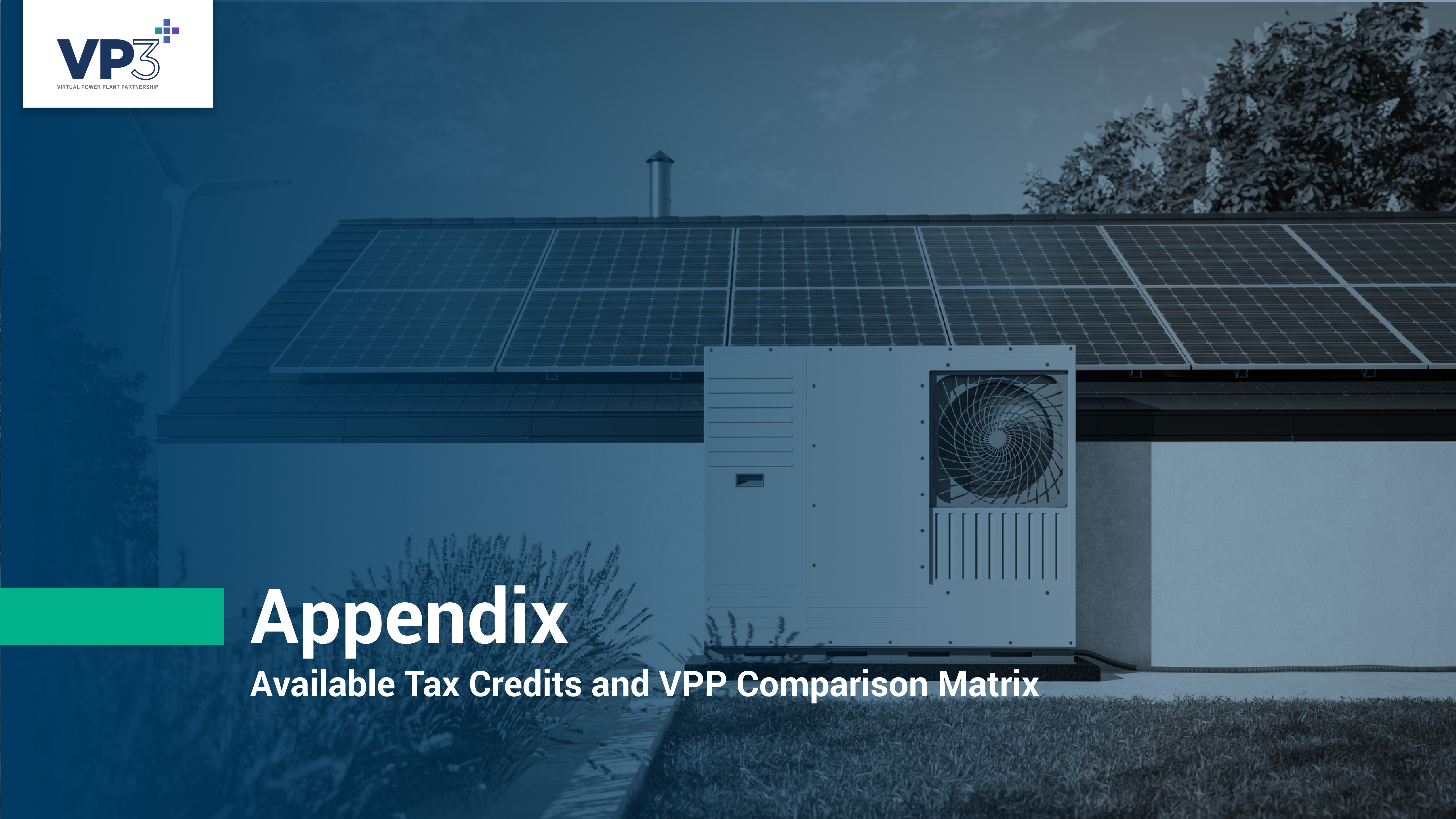
- Implement cross-functional teams including customer programs, operations, distribution, and planning teams.
- Automate VPP administrative and operational processes.

Effective Program Design Addresses Common Barriers to VPP Deployment

Common Challenge	Leading Practice: VPP Program Design		Utility Examples
Technology-specific programs lead to fragmented customer experience and increased management burden	**1.1 Open access in a VPP to integrate multiple technologies, vendors and programs**	Empower customers to use the device and VPP provider of their choice, and be able to participate with multiple DER types (e.g., thermostats and batteries). Allow stacking where possible to increase value for both the utility and the customer by leveraging the array of grid services and values that different DER types provide. A DERMS can help manage multiple data inputs to optimize and automate operations and value stack across technologies.	**National Grid** **Portland General Electric**
Limited staff capacity or experience with VPPs	**1.2 Develop partnerships that leverage third-party capacity and complementary capabilities.**	Partner with third parties to: • Manage enrollment, capacity commitments, incentives, optimization, and more. • Alleviate staffing constraints and integrate teams across the utility supporting VPP deployment. • Auto-enroll existing customers, pending regulator and utility approval, to expedite new programs.	**Pacific Gas & Electric** **Duke Energy**
Complicated customer experience limits enrollment or participation	**1.3 Streamline customer experience during enrollment and participation**	Minimize required customer action, simplify enrollment/unenrollment processes, offer adequate incentives without penalties, and maintain customer device preferences. Implement programs, rates, and incentives that are complementary and not competitive, and offer a variety of customer participation options: some customers want to manage their devices and others want to set the device and forget. Educate customers to facilitate enrollment through both the utility and any third-party partners.	**Sacramento Municipal Utility District** **Arizona Public Service**
Unclear payback for customers and aggregators limits interest	**1.4 Execute long-term programs (5+ years) with enrollment and operating terms to improve cost-effectiveness**	Execute long-term (5+ year) VPP contracts to: • Improve cost-effectiveness; program term influences VPP value. • Enable momentum, marketing, education, and the ability to iterate on lessons learned from previous years. • Provide runway for implementers to invest resources for long-term success, such as front-loading incentives for customers to buy DERs that will become part of the VPP.	**Hawaiian Electric** **Puget Sound Energy**
Up-front cost barriers to DER adoption prevent equitable adoption	**1.5 Incentivize DERs to enable additional customer participation**	Utility DER and/or third-party financing may include on-bill-financing, a lease, DER rebates, or full up-front payments. Fairly compensate customers for VPP participation. Customer incentives typically include one or a combination of enrollment credits, flat annual/seasonal credits, performance-based credits, and/or bill savings, which are greater for high-load customers. Up-front payments are useful to incentivize DER purchases, while performance payments help ensure customers maintain program participation.	**Green Mountain Power** **Holy Cross Energy**

Reimagined Utility Practices Use a Set of Common Approaches to Deploy VPPs

Leading Practice: Utility Practices		Examples
2.1 Incorporate DERs into generation and distribution planning	**Iteratively integrate DERs into planning processes:** • **Consider the full value of VPPs** such as capacity, ancillary services, energy, resilience, and social and other VPP benefits in cost-benefit analyses. • **Implement an iterative evaluation approach** to systematically re-evaluate evolving technology with forward DER cost curves. • **Use all-source procurement that is inclusive of both** VPPs and utility-scale resources.	**VPP Approach and Assumptions**: Brattle Real Reliability provides a template for modeling VPP value stacking. **Iterative DER Integration Evaluation**: WPD (UK) executes distribution assessment every six months (pg 13). **RMI Report**: *How to Build Clean Energy Portfolios*
	Evaluate VPPs transparently in planning with defined metrics • Establish **clear criteria** for VPP and integrated distribution solution evaluation. • Make **evaluation results** transparent. • Publish **network capacity maps** along with the data behind them, in a common format.	**VPP Evaluation Criteria**: HECO metrics include timing, economics, and performance (pg 16). **Network Capacity Maps**: NGED (UK) has a flexibility map tool and individual regional plans *RMI's Non-Wires Solutions Playbook*
2.2 Proactively engage regulators and policymakers around effective VPP policy	Work with regulators to structure VPP programs and pilots as an opportunity to test new regulations, such as through a regulatory sandbox, in addition to understanding the technology. Consider how components of **performance-based regulation** can support VPP deployment, including: • Evaluating whether a performance incentive mechanism could support VPP deployment and utilization • Exploring how mechanisms to equalize utility capex and opex incentives could support VPP adoption	VP3 Policy Principles RMI Performance Incentive Mechanism Database **Connecticut regulatory sandbox** – Innovative Energy Solutions Program
2.3 Transform business practices	**Implement cross-functional teams:** • **Eliminate silos**: VPPs require utility staff to understand multiple areas of the business (e.g., power supply, engineering, operations, customer services) that have been potentially separate in the past. Consider a change management agent who will work across all utility teams. • **Anticipate and build in time to learn** new software and operational processes.	**PGE** integrates DERs into its distribution planning and anticipates impacts and synergies with existing utility practice (pg 107). **APS** coordinates its customer-to-grid solutions teams with the operations team for wholistic, up-front planning.
	Automate VPP administrative and operational processes: • **Automate VPP processes** to enable scale and decrease administrative burden (e.g. customer enrollments, payments, measurement and verification, dispatch, and more). • **Align and integrate DER, system, and operator capabilities** so DERs are visible and have the ability to be orchestrated in coordination with the balance of the overall power system.	**California's ELRP** automatically enrolls residential customers in the demand response program. **Xcel Energy** has created an automated process to send the hourly dynamic rate schedule to OEMs 24 hours in advance.



VP3 VIRTUAL POWER PLANT PARTNERSHIP

Appendix

Available Tax Credits and VPP Comparison Matrix

Leverage Inflation Reduction Act (IRA) incentives to support customer DER adoption and to integrate DERs into utility integrated resource planning.

For more information, refer to page 77 of RMI's Planning to Harness the Inflation Reduction Act.

DER Technology	**Clean Vehicles**	**Vehicle Refueling and Charging**	**Rooftop Solar**	**Battery Storage**	**Heat pumps, Water Heaters, and Geothermal Heat Pumps**	**Additional Opportunities for IRA funding to support VPP deployment**
Customer Tax Credits Available	**Residential, commercial, and industrial customers:** Commercial Clean Vehicle Credit 45W and Clean Vehicle Credit 30D	**Residential, commercial, and industrial customers:** Alternative Vehicle Refueling Credit 30C	**Residential customers:** Residential Energy Tax Credit 25D **Commercial and industrial customers:** Production Tax Credit 45 or Investment Tax Credit 48	**Residential customers:** Residential Energy Tax Credit 25D **Commercial and industrial customers:** Investment Tax Credit 48	**Residential customers:** Energy Efficiency Tax Credit 25C or Residential Energy Tax Credit 25D	**Tax-exempt entities like electric cooperatives are also** eligible for additional elective pay tax credit incentives. **DOE LPO Title 17 Clean Energy Financing Program:** Innovative Energy and Innovative Supply Chain • Flyer mentions VPPs under the Innovative Energy category.

Utility VPP Comparison Matrix (1 of 3)

Utility Information		Overview						VPP Roles and Responsibilities			Customer Experience			
Utility Name State | Utility	**Program**	**Primary Drivers**	**Grid Services**	**Resource Type**	**Customer Segment**	**MW Enrolled**	**Cust. Enrolled**	**Program Operator**	**Customer Enrollment**	**Payment Channel**	**Compensation Structure**	**DER Control**	**Annual or Seasonal**	**Scheduling**
Arizona Public Service AZ | IOU	Cool Rewards										Up-front payment Annual flat rate			Dynamic
California IOUs: PG&E, SCE, SDG&E CA | IOU	Emergency Load Response Program (ELRP)										Pay-for-performance			Dynamic, day ahead or day of
California Utilities CA | POU, Muni, Co-op, CCA, FPMA, IOU	Demand Side Grid Support (DSGS)										Pay-for-performance			Dynamic, day ahead or day of
DTE Energy MI | IOU	DTE Smart Charge					Not Available					Up-front payment Completion payment			Dynamic (DR events)
Duke Energy NC | IOU	EV Complete Home Charging Plan										Fixed monthly-rate			Dynamic (DR events)
Green Mountain Power VT | IOU	Bring-Your-Own-Device										Up-front payment			Dynamic, near real time
Green Mountain Power VT | IOU	Energy Storage System (ESS) Lease										Lease: On-bill monthly payment or up-front payment			Dynamic, near real time

Icon Key

Primary Drivers
- Resource Adequacy
- Reliability & Resilience
- T&D Infrastructure Relief
- Affordability
- Decarbonization
- Customer Empowerment
- Versatility & Flexibility

Grid Services
- Ancillary Services
- Energy
- Resilience
- Capacity

Resource Type
- Batteries
- Solar + Batteries
- EVs
- Smart Thermostat
- Heat Pumps
- Interruptible Load
- Behavioral Load Shaping
- Water Heater
- Demand Response
- Backup Generation

Customers/MW Enrolled
- Low <500
- Medium 500-5000
- High >5000
- Low <10 MW
- Medium 10-100 MW
- High >100 MW

Operator/Payment Channel
- Utility
- Third-Party Service Provider
- OEMs

Customer Market Segment
- Residential
- Commercial
- Industrial

DER Control
- Autonomously VPP-initiated with customer override
- Autonomously VPP-controlled without customer override
- Customer-controlled

Annual/Seasonal
- Seasonal
- Annual

Utility VPP Comparison Matrix (2 of 3)

Utility Information		Overview						VPP Roles and Responsibilities			Customer Experience			
Utility Name State | Utility	Program	Primary Drivers	Grid Services	Resource Type	Customer Segment	MW Enrolled	Cust. Enrolled	Program Operator	Customer Enrollment	Payment Channel	Compensation Structure	DER Control	Annual or Seasonal	Scheduling
Hawaiian Electric HI | IOU	Swell Energy Home Battery Rewards										Pay-for-performance			Dynamic, day-ahead up to 10 minutes ahead
	Battery Bonus Program										Up-front payment, Monthly flat rate			Static, fixed daily schedule
Holy Cross Energy CO | Co-Op	Power+										On-bill financed			Dynamic, day-ahead
National Grid MA | IOU	Connected-Solutions										Up-front payment, Pay-for-performance			Dynamic, day-ahead
Pacific Gas and Electric CA | IOU	Peak Power Rewards										Up-front payment, Free smart thermostat			Static, fixed daily schedule
Portland General Electric OR | IOU	Peak Time Rebates						Not Available				Tariff			Dynamic, day-ahead
	Multi-Family Water Heater						Not Available				Annual flat rate			Dynamic
	Energy Partner on Demand						Not Available				Customized for each business, Up-front payment (for battery installation only)			Dynamic, day-ahead

Icon Key

Primary Drivers
- Resource Adequacy
- Reliability & Resilience
- T&D Infrastructure Relief
- Affordability
- Decarbonization
- Customer Empowerment
- Versatility & Flexibility

Grid Services
- Ancillary Services
- Energy
- Resilience
- Capacity

Resource Type
- Batteries
- Solar + Batteries
- EVs
- Smart Thermostat
- Heat Pumps
- Interruptible Load
- Behavioral Load Shaping
- Water Heater
- Demand Response
- Backup Generation

Customers/MW Enrolled
- Low <500
- Medium 500-5000
- High >5000
- Low <10 MW
- Medium 10-100 MW
- High >100 MW

Operator/Payment Channel
- Utility
- Third-Party Service Provider
- OEMs

Customer Market Segment
- Residential
- Commercial
- Industrial

DER Control
- Autonomously VPP-initiated with customer override
- Autonomously VPP-controlled without customer override
- Customer-controlled

Annual/Seasonal
- Seasonal
- Annual

Utility VPP Comparison Matrix (3 of 3)

Utility Information		Overview						VPP Roles and Responsibilities			Customer Experience			
Utility Name State | Utility	Program	Primary Drivers	Grid Services	Resource Type	Customer Segment	MW Enrolled	Cust. Enrolled	Program Operator	Customer Enrollment	Payment Channel	Compensation Structure	DER Control	Annual or Seasonal	Scheduling
Puget Sound Energy WA | IOU	Flex Rewards										Up-front payment, Pay-for-performance, Annual flat rate			Dynamic, day-ahead
	Flex Smart										Up-front payment, Annual flat rate			Dynamic, day-ahead
	Flex EV					Not Available					Up-front payment, Pay-for-performance			Dynamic, day-ahead
	Business Demand Response										Pay-for-performance			Dynamic, day-ahead
Rocky Mountain Power UT | POU	WattSmart Battery										Up-front payment, Annual flat rate			Dynamic
Sacramento Municipal Utility District CA | Muni	Partner+										Up-front payment, Pay-for-performance			Dynamic, day-ahead
Xcel Energy	Charging Perks										Up-front payment, Annual flat rate			Dynamic, day-ahead hourly signals

Icon Key

Primary Drivers
- Resource Adequacy
- Reliability & Resilience
- T&D Infrastructure Relief
- Affordability
- Decarbonization
- Customer Empowerment
- Versatility & Flexibility

Grid Services
- Ancillary Services
- Energy
- Resilience
- Capacity

Resource Type
- Batteries
- Solar + Batteries
- EVs
- Smart Thermostat
- Heat Pumps
- Interruptible Load
- Behavioral Load Shaping
- Water Heater
- Demand Response
- Backup Generation

Customers/MW Enrolled
- Low <500
- Medium 500-5000
- High >5000
- Low <10 MW
- Medium 10-100 MW
- High >100 MW

Operator/Payment Channel
- Utility
- Third-Party Service Provider
- OEMs

Customer Market Segment
- Residential
- Commercial
- Industrial

DER Control
- Autonomously VPP-initiated with customer override
- Autonomously VPP-controlled without customer override
- Customer-controlled

Annual/Seasonal
- Seasonal
- Annual

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