MARKET
Market and Retail-rate Knowhow for the Energy Transition

Insights into Scaling Virtual Power Plants

Real-World Findings for Successful Deployment

January 2025

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Acknowledgments

We would like to thank Ted Light of Lighthouse Energy Consulting, Elizabeth Bye and Melissa Costello of Strategy by eb, and John Hall of Jhallx Design for their significant contributions to this report.

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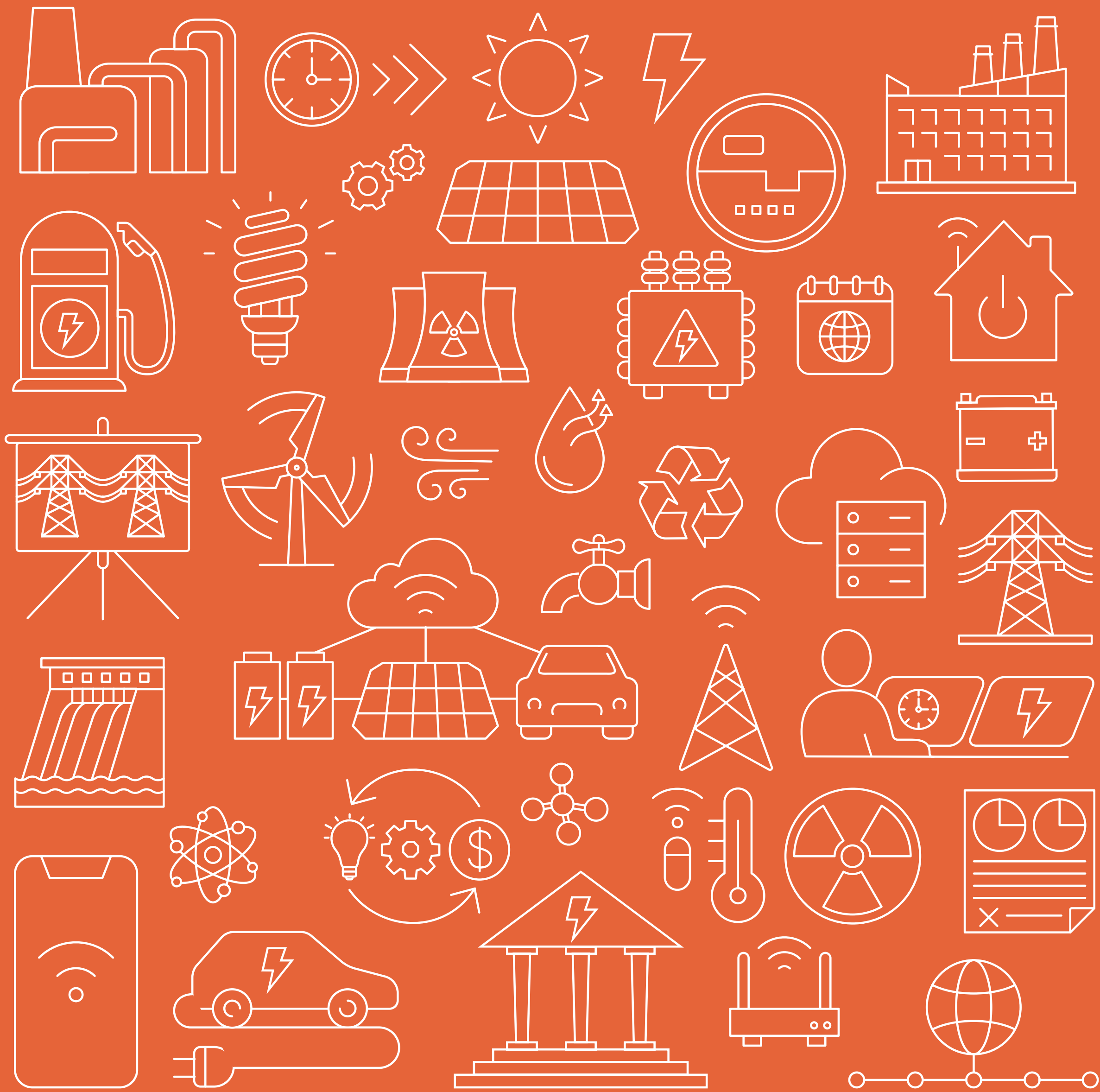
Insights into Scaling Virtual Power Plants



REAL-WORLD FINDINGS FOR SUCCESSFUL DEPLOYMENT

Executive Summary

Virtual Power Plants (VPPs) are a distributed, technology-neutral solution that effectively address critical grid and customer needs, such as reducing peak demand and lowering energy bills.[1] They can offer clean, flexible, low-cost resources as grid needs evolve—driven by increased adoption of distributed energy resources (DERs), building and vehicle electrification, policy goals and shifting consumer preferences. VPPs are poised for rapid growth, with the potential to expand by up to 160 GW by 2030—tripling their current scale and reducing grid costs for consumers.[2] However, a variety of challenges are slowing the rate at which VPPs are adopted and expanded.

The Role of Leadership in VPP Success Findings

Strong Leadership is Essential for VPP Success: Effective leadership from both utilities and regulators enables successful implementation and long-term sustainability of VPPs. A clear vision, and executive-level staff support help guide the integration of DERs and foster internal collaboration.

Clear Vision, Goals, and Terminology Drive VPP Effectiveness: Defining a tailored vision and clear, measurable goals for VPPs enables internal buy-in and helps to address the complexities of VPP implementation. Standardizing VPP terminology across utilities, regulators, and solution providers streamlines communication and can reduce confusion during program deployment.

Dedicated Staff and Cross-Functional Collaboration are Key to Implementation: Successful VPPs use dedicated teams, with a focus on consistency and collaboration across departments. These teams enable the successful integrated design, deployment, and ongoing operation of VPPs.

1 The United States (U.S.) Department of Energy (DOE) defines VPPs as "aggregations of DERs such as rooftop solar with behind-the-meter (BTM) batteries, electric vehicles (EVs) and electric water heaters, smart buildings and their controls, and flexible commercial and industrial (C&I) loads that can balance electricity demand and supply, as well as provide utility-scale and utility-grade grid services."
2 Downing, J. N. Johnson, M. McNicholas, et al. Sept. 2023. Pathways to Commercial Liftoff: Virtual Power Plants.

Grid and Technology Investments Findings

Investment in Software Solutions Support VPP Integration: Successful VPPs use software solutions, such as Distributed Energy Management Systems (DERMS) and Advanced Distribution Management Systems (ADMS), to seamlessly integrate DER deployment into grid operations. Investing in unified solutions that consolidate systems can improve operational efficiency, reduce costs, and allow for more sophisticated grid management capabilities, such as visibility, control and flexibility of DERs.

Clear DER Participation and Communication Protocols Support Effective VPP Operations: Establishing standardized participation guidelines and communication protocols to achieve interoperability across diverse OEMs and devices enables DER integration. Standards, such as Institute of Electrical and Electronics Engineers (IEEE) 1547-2018[3] for smart inverters, and the adoption of open communication protocols can help align DER performance with grid requirements, streamline integration, and reduce inefficiencies.

Standardized Technology and Integrated Solutions Are Critical for VPP Scalability: Clear technology standards and integrated enterprise solutions enable successful operation of VPPs. Standardized processes for measurement, data reporting and interoperability of Original Equipment Manufacturer (OEM) devices enable DERs to integrate into grid operations, providing reliable services. Additionally, integrating systems for managing customer eligibility, DER dispatch, and forecasting improve operational efficiency across multiple processes, facilitating smoother VPP deployment.

[3] IEEE Standards Association's IEEE 1547-2018 is the standard for interconnection and interoperability of DERs with associated electric power systems interfaces.

Program Planning and Design Findings

Collaboration Across Stakeholders Enhances VPP Design: Industry-wide collaboration, including between utilities, regulators, solution providers, and OEMs assists in overcoming challenges related to technology integration, data management, and program participation.

Customer-Centric Design and Clear Metrics Drive VPP Success: Programs designed with a focus on customer needs, flexibility, and clear performance metrics enhance participation, retention, and long-term value. Performance metrics and clear methodologies to measure performance can help demonstrate the value of VPPs in managing grid needs.

Pilots Help Uncover Early Challenges and Refine VPP Strategies: Pilot programs can provide valuable insights into technology performance and customer engagement, and allow for quick identification and resolution of program challenges. Well-structured pilots, with clear goals and endpoints, promote smooth transitions to full-scale operations and enhance program success.

Introduction

This project, **Scaling VPPs: Insights, Profiles and Inventory**, seeks to overcome several challenges of accelerating the deployment of VPPs through three research tasks. First, while conducting research and interviews for this report, we discovered a gap in guidance on using clear, consistent language to describe various types of VPPs, as well as a gap in information regarding current VPP trends. To address this, we developed a companion report titled, **Virtual Power Plant Profiles and Inventory**.

The goal of this report is to better understand the challenges and opportunities to scaling VPPs from the utility, solution provider and regulator perspective. This report presents an overview of findings from interviews with 24 subject matter experts and a literature review on successfully scaling VPPs, structured around three key themes: 1) the role of leadership in successful VPP designs, 2) grid and technology investments and 3) program planning and design. Each theme has subcategories with examples and insights gained from interviews. Often, the examples span more than one theme, and we have organized them to highlight the primary point of the remark, although they could be included in multiple categories. The report concludes with seven utility VPP case studies.

The appendices offer depth to the findings in this report. **Appendix A** discusses the methods used to guide the development of this report and the interviews. **Appendix B** lists the interview questions. **Appendix C** is a glossary of DERMS terms. **Appendix D** provides additional details from the interviews with high-level takeaways.

The report is primarily intended for regulators, utilities, and solution providers to use as they develop or improve existing VPPs. Strategies identified through interviews, such as improving program design, sharing insights with other utilities, and aligning grid signals to optimize existing resources can be used by all audiences to maximize VPP value and long-term benefits.


Swobbee
Bitte alle Türen schließen!
SCAN ME

The Role of Leadership in Successful VPP Designs

Our interviews found that leadership from a utility or regulators is important for the success of VPPs. In particular, effective leadership plays a crucial role in the success of VPPs, as it helps ensure alignment and successful implementation.

Our interviews revealed that successful VPP projects are often driven by strong leadership from both utilities and public utility commissions. Key themes identified across successful projects include the importance of a clear vision and goal, dedicated VPP staff, and consistent use of standardized terminology. These elements work together to overcome the complexities of integrating DERs into grid operations and help secure internal buy-in for VPPs. The following sections explore leadership components:

- Identifying a Clear Vision and Goal
- Establishing Strong Leadership Supporting VPPs
- Creating Dedicated VPP Staff
- Clearly Defining and Using VPP Terminology

These insights underscore the necessity of leadership at every stage of VPP development, from the initial planning stages to long-term implementation.

Identify A Clear Vision And Goal

Interviewees emphasized that a clear, tailored vision and goals are necessary for gaining internal approval and support for VPPs. Clear objectives help overcome ambiguity about the DERs that are included and the services provided, preventing challenges for utilities and regulators that could slow progress and complicate VPP implementation. When implementing a VPP, focusing on near-term goals ensures swift DER integration, while long-term considerations ensure sustained value for both customers and the grid. **Figure 1** highlights case study insights.

Figure 1. Identifying A Clear Vision and Goal—Examples of Interview Insights

REGULATOR PERSPECTIVE

Regulators can use formal or informal processes to collaboratively develop VPP goals that support state policies with utilities, solution providers and stakeholders.

HOLY CROSS ENERGY

HCE prioritizes customer satisfaction and simplicity in the design of their VPP program, which enhances grid resilience, particularly during extreme weather events. Data on customer enrollments show a significant spike following these events, indicating a strong customer interest in programs that support local resiliency.

PORTLAND GENERAL ELECTRIC

PGE focuses on balancing operational flexibility with customer satisfaction when developing their VPP goals.

SOLUTION PROVIDER PERSPECTIVE

While state DER goals vary, making VPP implementation challenging, having a clear vision and goal will ensure stakeholders are aligned on the scope and responsibilities of each party involved.

SOLUTION PROVIDER PERSPECTIVE

A clear vision for VPPs requires clearly defined data requirements across all stakeholders. By understanding data needs across various parties, solution providers can better design VPPs that respond to grid needs and align with state-level goals.

Establish Strong Leadership Supporting VPPs

Interviews revealed that strong internal leadership helped navigate challenges, foster collaboration, and drive decision-making, ensuring the VPP development process stayed on track. Leadership can direct the thoughtful design and integration of DERs into grid operations as well as the strategic deployment of them. This theme of a well-rounded approach was highlighted throughout our interviews. Strong leadership also helps build trust, secure resources, and help stakeholders embrace change, ultimately increasing the likelihood of successful VPP deployment and long-term sustainability. **Figure 2** highlights case study insights.

Figure 2. Establishing Strong Leadership Supporting VPPs—Examples of Interview Insights

SOLUTION PROVIDER PERSPECTIVE

Utilities need vision, policy support, and executive leadership to swiftly adapt integrated resource planning and other resource adequacy mechanisms for VPP operations.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD emphasizes the importance of cross-functional collaboration driven by leadership and a clear change management process to ensure DERs are coordinated effectively among teams.

PUGET SOUND ENERGY

PSE highlights the value of executive support in overcoming risks and establishing dedicated roles to manage VPPs, including integrating teams from various departments like IT, distribution operations, and energy management.

Create Dedicated VPP Staff

Interviews revealed that successful VPPs benefit from a dedicated role that ensures consistency and collaboration across the design and deployment process. Shifting from traditional grid operations to VPP operations demands constructive collaboration and innovation across teams that have historically been siloed. The role also provides staff with the necessary tools and resources, ensuring processes are standardized and success is embedded throughout the organization. **Figure 3** highlights case study insights.

Figure 3. Creating Dedicated VPP Staff—Examples of Interview Insights

REGULATOR PERSPECTIVE

VPPs and DERs need to be automated and standardized, all the way from infrastructure to people.

PUGET SOUND ENERGY

PSE expanded its workforce to include roles specifically for managing the VPP, involving teams from Customer Energy Management, Customer Energy Innovation, Electric Systems Operations, and IT.

PORTLAND GENERAL ELECTRIC

PGE established a specific director role to manage and oversee VPP initiatives, which includes integrating cross-functional teams to develop and operate VPPs. PGE underscores the role of a VPP director as a facilitator, ensuring alignment and clear communication across teams.

EVERSOURCE

Eversource focuses on the many moving parts of a VPP. Their teams are cross-functional and collaborative as they are required to conduct program forecasts, call events, perform DER operations, conduct evaluations, and ensure customer experience.

Clearly Define and Use VPP Terminology

Interviews found that there is a need for standard terminology in order to avoid confusion when planning and implementing VPPs. In our research, we identified over 30 definitions of VPPs, revealing various definitions influenced by audience, goals, region, perspectives, use cases, resource types and location, and utilization methods. Among the definitions of VPPs identified, four common themes emerged, as seen in **Figure 4**, which can provide guidance when defining VPPs.[4]

Figure 4. VPP Definition Themes

Theme 1

Goal & Objectives

- Allows for an understanding of its purpose
- Ensures flexibility and adaptability needed to evolve
- Example goals include decarbonization or customer satisfaction

Theme 2

Diverse Set of Aggregated DERs

- Highlights a combination of demand, generation and/or storage
- Examples include solar panels, batteries and devices like smart thermostats

Theme 3

Grid Services and Flexibility

- Ensures essential grid services such as balancing supply and demand, reducing peak demand and improving grid reliability
- For example, a VPP can be used as an alternative to traditional power plants and contribute to making grids more flexible and resilient

Theme 4

Control Systems and Software Integration

- Highlights the importance of remote control and software
- VPPs rely on these systems to remotely control and optimize the operation of various DERs, ensuring effective energy management

Utility program managers, grid operators and regulators can establish and use standardized language and terminology to enable streamlined communication and advance VPP deployment efforts. **Figure 5** highlights case study insights.

[4] **Appendix C** of our Virtual Power Plant Profiles and Inventory report contains a list of definitions we reviewed as part of our approach to developing Figure 4.

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Figure 5. Clearly Define and Use VPP Terminology—Examples of Interview Insights

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD uses the term VPP as an adjective to describe the collection of resources and grid services. This is because people frequently use the term VPP to describe the use case, benefits, or goals of how they want DERs to perform. As a result, the definition of a VPP can vary depending on the speaker's perspective.

For instance, program operators view a VPP as a customer program focused on recruiting customers and enrolling assets, involving data collection and customer communication. Conversely, distribution operations engineers see a VPP as a platform for grouping, controlling, and monitoring DERMS.

EVERSOURCE

Eversource highlights the importance of aligning industry language and terminology to enhance communication and understanding. Because there is no industry-wide standardization and clarity in VPP terminologies like DERMS and even VPPs, developing a common set of VPP models will help to categorize programs effectively. This will aid in overcoming challenges and variations in defining VPPs across different programs and utilities.[5]

PUGET SOUND ENERGY

PSE defines its VPP as a platform that allows for the forecasting, control, and dispatch of aggregated DERs. This software tool enables PSE to utilize diverse types of DERs at desired magnitudes meaningful for the Load Office, Market Dispatch, and System Operations.

PORTLAND GENERAL ELECTRIC

PGE defines their VPP as "the orchestration of DERs and Flexible Loads, through technology platforms, to provide grid and operations services."

REGULATOR PERSPECTIVE

The term VPP can be problematic. Because of this there is a need to clearly define the terms VPP and DERs. Some VPPs integrate both load and supply, and some do not need to operate like a power plant. A VPP does, however, need to provide specific services that the grid needs.

SOLUTION PROVIDER PERSPECTIVE

Utilities and regulators can use non-litigated proceedings and workshops to define VPPs and DERs. This will help eliminate ambiguity and ensure all stakeholders are aligned on the scope and responsibilities of each party involved. This can provide a strong foundation for the development of consistent policies and procedures.

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[5] Our companion report, Virtual Power Plant Profiles and Inventory developed a set of VPP profiles. We based these profiles on insights we heard from this report such as this one.

Grid and Technology Investments

Successful VPPs—whether they provide peak shaving or ancillary services—receive support from grid planning and operations due to their proven reliability and credibility as grid resources. Insights gathered from our interviews emphasize the pivotal role of technology capabilities and interoperability in ensuring VPPs effectively contribute to grid operations. The following sections explore key elements when considering grid and technology investments:

- Align Software Investment in VPP with Grid Needs
- Establishing DER Participation Guidelines
- Adopting Technology Standards
- Enabling Enterprise-Wide VPP Adoption with Integrated Solutions
- Considering the Need for Visibility, Monitoring and Control
- Developing Communication Protocols

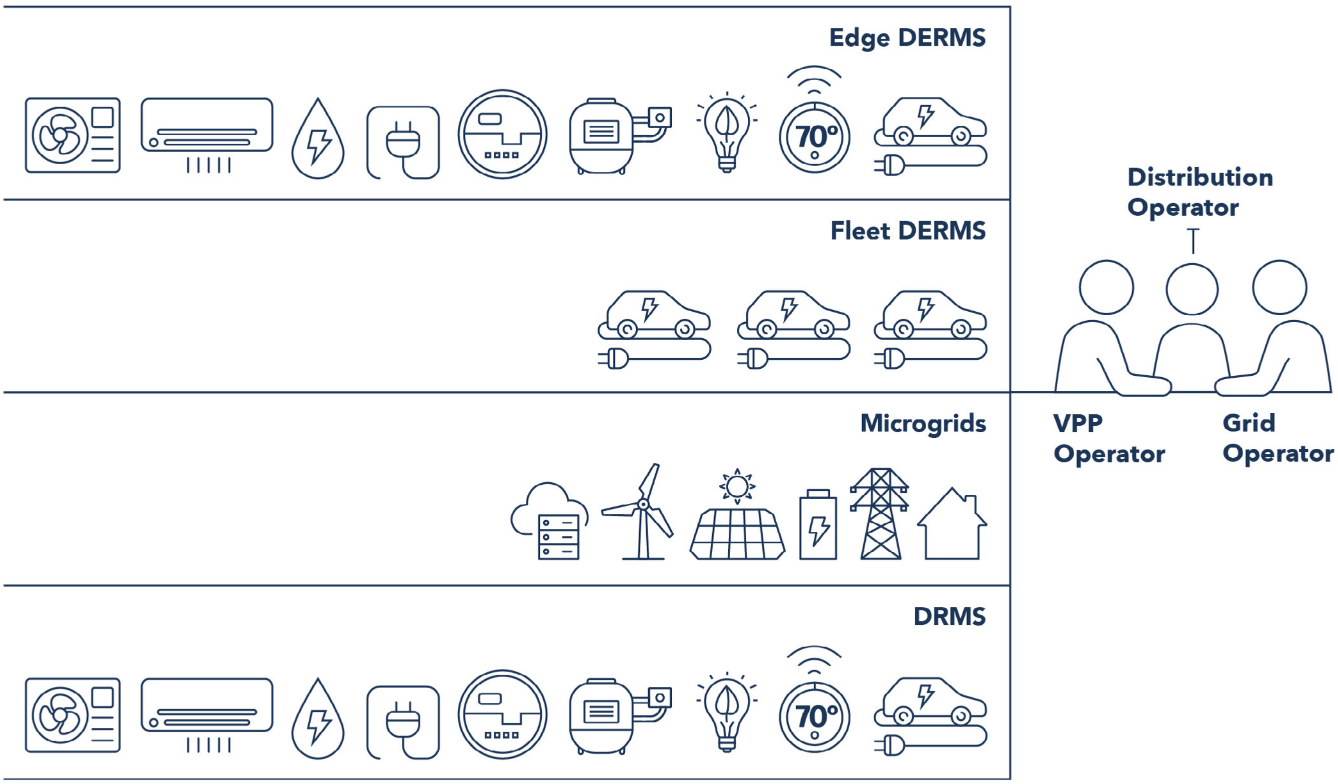
These insights highlight essential considerations for optimizing the role of VPPs in grid operations, driving efficiency, and ensuring their successful integration into energy systems.

Align Software Investment in VPP with Grid Needs

A variety of software tools, such as DERMS,[6] can be used to combine aggregate DERs into a unified resource that can provide grid benefits to the distribution and transmission system (e.g., deferral of new assets), and utility customers (e.g., bill reductions or compensation). **Figure 6** provides an example of how the software tools used to control a VPP may be composed of multiple DERs and DERMS, and be managed by a solution provider or grid operator, or a combination of the two.

[6] Definitions are provided in **Appendix C**.

Figure 6. Software Solution Examples



VPP software solutions can have a range of complexity and sophistication. For example, utilities can procure "off the shelf" software solutions such as an Edge DERMS through a solution provider, or invest in a solution with advanced functionalities (often referred to as a VPP platform), such as software integration (e.g., customer databases and Eaton's CYME modeling software), enhanced cybersecurity, and improved controllability. VPP software solutions may have enabling technologies (e.g., Supervisory Control and Data Acquisition (SCADA), Advanced Metering Infrastructure (AMI)) and integrate with other energy management systems (e.g., ADMS and centralized DERMS) or other enterprise-wide systems for grid optimization such as Geographic Information System (GIS), and outage management systems.

The evolution of VPP software solutions is similar to the shift from cable TV to streaming services like Netflix and Hulu. As DERs are integrated into grid operations and the understanding of how to fully utilize these resources matures, grid operators may need to manage multiple energy management systems each with their own sign-in protocols and subscription costs, versus a single operations platform. For example, a utility might have a commercial DR program that is managed by a solution provider via a demand resource management system (DRMS). That same utility may also have a residential DR program that is managed by an Edge DERMS. Having a single VPP platform solution allows operators to consolidate systems into one interface.

Insights from our interviews emphasized the importance of having seamless integration between DERs and grid operations. Our interviewees identified that successful VPPs make appropriate investments to achieve their VPP goals (near-term and long-term), and those with more advanced goals have robust software solutions (e.g., ADMS) to efficiently control, monitor and integrate DERs into grid operations and identified considerations for shaping centralized DERMS design (e.g., delivery of peak load electricity or load-following power generation on short notice, ancillary services including frequency regulation and providing operating reserve). **Figure 7** highlights case study insights.

Figure 7. Align Software Investments in VPP with Grid Needs—Examples of Interview Insights

HOLY CROSS ENERGY

Off the shelf software solutions are tailored to larger programs, more suited for larger utilities such as investor-owned utilities. For instance, OEMs and VPP solution providers often charge flat upfront setup fees, which are not scaled according to the utility's size.

PORTLAND GENERAL ELECTRIC

PGE's VPP platform is managed through its centralized DERMS and integrated into their ADMS. This enables DERs to be registered, visualized, grouped, and operated within ADMS parameters (providing locationality to their VPP).

PGE is enhancing operations at the grid edge for flexibility. This involves real-time computation and communication at the device level to manage customer usage patterns dynamically. DERs and flexible loads are viewed as integral tools for grid operators, capable of being dispatched like traditional resources when managed through a VPP platform.

PUGET SOUND ENERGY

PSE began with the belief that a VPP should be built by the teams most impacted by it and needs of the grid. This entails involving the teams responsible for initiating and dispatching events from the outset. This approach has helped facilitate strategic decision making and alignment with business objectives when designing and developing their VPP platform.

EVERSOURCE

Eversource emphasizes the importance of data collection and real-time visibility to justify the benefits of VPP participation. Eversource has a high focus on DERs as a grid resource. Their VPP operations are focused on achieving realtime visibility of devices and software, such as DERMS, needed to control devices.

Figure 7. Align Software Investments in VPP with Grid Needs—Examples of Interview Insights (continued)

SOLUTION PROVIDER PERSPECTIVE

The focus in the VPP sector is shifting from software development to enhancing access. This involves creating platforms that enable utilities to seamlessly aggregate DERs throughout their lifecycle. One significant development is the introduction of Edge DERMS, a foundational software solution designed to interface with centralized DERMS or ADMS. A key challenge is that many Edge DERMS are underutilized because grid operators lack trust in them.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD highlights that DERs require advanced centralized DERMS and ADMS for effective grid integration and coordination among internal teams, and are needed to operationalize DERs as a grid resource.

REGULATOR PERSPECTIVE

The development of custom-built systems and backends software is not always necessary, yet many utilities will custom build software and systems if clearly directed otherwise. Rather than building out new software solutions, utilities and solution providers can work together to ensure various APIs can be easily integrated into existing processes.

Establish DER Participation Guidelines

Although DER technology may be sufficiently mature for use in a VPP, a major challenge for DER adoption lies in ensuring the interoperability and integration of OEM technology within grid operations. Many device manufacturers and software providers offer their own apps and interfaces, which can create inefficiencies and increase costs to consumers and utilities. Standardized setups and interoperability standards, similar to how Bluetooth wireless technology connects a wide variety of devices, can accelerate scaling VPPs.[7]

Interviewees noted that variability among OEMs necessitates clear program requirements and standards to ensure DER compatibility with grid requirements. While utilities are working with OEMs to develop these standards in the absence of industry-wide guidelines, this approach can lead to confusion. **Figure 8** highlights case study insights.

[7] M. Gallucci. Mar. 2024. Four Ways Virtual Power Plants Can Help the US Grid Keep up With….

Figure 8. Establishing DER Participation Guidelines—Examples of Interview Insights

REGULATOR PERSPECTIVE

It would be helpful if industry specific communications and controls norms or standard approaches were developed for VPPs, which can be instituted by states. Additionally, guidance on what states can do to support such norms and standards through regulatory processes is needed.

EVERSOURCE

Eversource only has a few battery OEMs that are able to integrate with its Edge DERMS and can provide 15-minute interval data. For other OEMs, they must integrate data through a manual file transfer after each event.

PACIFICORP

PAC emphasizes that successful VPPs rely on clear expectations and standards from utilities, allowing OEMs to adapt their products to meet grid requirements and participate in VPP programs.

PAC has established guidelines for energy storage based on grid and customer needs, including data reporting, daily cycling, charge/ discharge requirements, and adherence to Underwriters Laboratory (UL) safety standards. This ensures VPP effectiveness by setting clear expectations for DER performance, including rapid response times (within 30 seconds for frequency response, 10 minutes for contingency reserves). These standards are crucial for OEMs to design compatible products that ensure DERs align with grid requirements.[8]

NATIONAL GRID

National Grid emphasizes the need for enhanced collaboration among solution providers and OEMs for streamlined program participation and cost-effectiveness.

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[8] Rocky Mountain Power. Participation for Battery Manufacturers. Accessed Oct. 2024.

Adopt Technology Standards

Adopting technology standards, such as IEEE, can help enable DERs to participate in VPP operations. In the absence of established standards, states, utilities, and solution providers are developing their own guidelines. For example, as seen in **Figure 8**, PacifiCorp established its own standards for energy storage based on the needs of their grid and customers. These standards include 30 second interval data reporting, minimum daily cycling, charge and discharge requirements, and adherence to UL or equivalent safety standards.

Our interviews highlighted the need for developing technology standards to ensure DERs operate cohesively within VPPs, integrate smoothly with grid operations, and function like traditional generators. Utilities are moving toward increased technology compatibility with grid operations through common standards, as demonstrated by initiatives like IEEE 1547-2018 and IEEE 2030.5.[9] **Figure 9** highlights case study insights.

[9] IEEE Standards Association's IEEE 2030.5-2018 is the standard for smart energy profile application protocol.

Figure 9. Adopting Technology Standards—Examples of Interview Insights

PACIFICORP

IEEE 2030.5 establishes a secure, scalable protocol for communication between energy devices, the smart grid, and consumers. It addresses aspects such as pricing, demand response, and energy usage, supporting the integration of smart thermostats and electric vehicles.

PAC uses this standard for its Utah Wattsmart solar and battery VPP operations by setting criteria for battery manufacturers, thus reducing the need for additional software such as an Edge DERMS.[10] These components create opportunities to improve existing DERs for VPPs, decentralize energy production, and enhance grid services.

PORTLAND GENERAL ELECTRIC

Technology standards are essential for facilitating communication between DERs and the grid. The IEEE 1547-2018 standard, for example, governs the interconnection and interoperability of smart inverters, which aids in the integration and control of distributed solar. PGE views this standard as best practice for distributed solar interconnection.

REGULATOR PERSPECTIVE

VPPs and DERs need to be automated and standardized, all the way from infrastructure to people.

REGULATOR PERSPECTIVE

Under Order No. 07-319, Oregon adopted new interconnection rules that require all interconnecting systems to use smart inverters in compliance with IEEE 1547-2018. This rule supports goals of increasing battery adoption, ramping solar, increasing EV adoption and increase storage in general.

10 Trabish, Herman. Tackling 3 Key Issues Can Help Scale Virtual Power Plants and Spur a Wave of Benefits, Analysts Say. Accessed Oct. 2024.

Enable Enterprise-Wide VPP Adoption with Integrated Solutions

Interviews found that many utilities needed to invest in multiple tools and ensure standard processes across all areas of their workforce. When developing VPP programs, utilities may consider the need for new enterprise-wide solutions, specifically tools that allow them to manage new processes related to integrating DERs into traditional utility planning. For example, while PSE had a need for a VPP platform, they also saw the need for other tools that integrate DERs into utility operations, such as customer eligibility, as illustrated in the PSE example below. Additionally, SMUD sees the need to ensure they can integrate DERs into distribution level planning processes like locational DER forecasting. **Figure 10** highlights case study insights.

Figure 10. Tools to Enable VPPs Enterprise-wide—Examples of Interview Insights

PUGET SOUND ENERGY

PSE developed custom back-end tools and standardized processes to automate fundamental VPP activities, allowing them to manage all aspects of the customer and DER lifecycle. This includes DER enrollment, customer eligibility, DER eligibility and dispatch, customer program design, and evaluation and reporting.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD sees effective management of multiple DER programs and tools as crucial. As SMUD integrates DERs into their VPP, they are working to ensure standardized processes such as enhanced forecasting and day-ahead models to improve the predictability and utility of these resources.

Consider the Need for Visibility, Monitoring and Control

We also found that the integration of DERs into grid operations remains complex, requiring interoperable platforms, industry standards, and advanced communication protocols. Standardized processes help improve interoperability, simplify testing, and accelerate VPP deployment, enabling better collaboration between utilities, OEMs, and DERs. However, many utilities said achieving this may require both regional and national efforts to help states establish VPP-specific standards.

Advanced software such as ADMS and technology such as distribution automation enables seamless real-time operations in VPPs. Interviewees identified that VPPs will drive changes in grid operations and require grid modernization due to the integration of DERs into the grid. Real-time data collection and enhanced visibility allow VPPs to demonstrate the operational and financial benefits of DER participation, underscoring their importance in advancing grid innovation.

Custom tools and automation play a role in streamlining VPP operations, including components that manage the customer and DER lifecycle. This enables VPP software solutions to function as enterprise-wide systems that integrate with customer management systems, thereby enhancing the customer experience while minimizing disruptions. **Figure 11** highlights case study insights.

Figure 11. Consider the Need for Visibility, Monitoring and Control—Examples of Interview Insights

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD finds that the value in VPPs in the near-term is in bulk system management rather than addressing complex distribution constraints. This is because bulk value is most readily available in today's operational and policy environment. While distribution constraints are important to address, doing so is more challenging and will take longer with existing tools and processes, due to the lack of mature solutions for targeting locational grid issues. Longer-term, they are working to improve their ability to solve distribution issues with DERs through visibility and control.

PORTLAND GENERAL ELECTRIC

Using DERs creates an intertwining of the customer experience with operational performance—the flywheel of value. Balancing reliable operation with customer choice and control is essential.

EVERSOURCE

Eversource works to ensure customer programs and backend system operations can find ways to communicate with grid operations. This will unlock the value of VPPs and help them grow exponentially.

PACIFICORP

PacifiCorp's VPP is integrated into grid operations, enabling DERs to rapidly respond and drop load within 30 seconds during frequency response events.

Develop Communication Protocols

Interviewees highlighted the need for investments in interoperable platforms, and advanced communication protocols as well as industry standards on how devices connect and interact with the grid. While DERs are mature consumer technologies, their integration as utility resources remains challenging. Utilities acknowledge the need to ensure compatibility across OEM technologies and software platforms for VPPs to function efficiently. **Figure 12** highlights case study insights.

Figure 12. Develop Communication Protocols—Examples of Interview Insights

SOLUTION PROVIDER PERSPECTIVE

Efforts have led to the successful integration of numerous manufacturers and various DER devices, including energy storage options, water heaters, and EV chargers. This integration facilitates control over these devices by utilities. One challenge is integrating Edge DERMS with OEM devices. This is addressed through non-disclosure agreements (NDAs) for software integration. An open API has been developed to allow OEMs to connect to any Edge DERMS at no cost, acting as a pass-through agent.

NATIONAL GRID

National Grid is expanding its programs and exploring the integration of new and emerging technologies such as batteries. The success of these efforts will depend on forming new partnerships, improving technological efficiency, and the realized addition of grid and customer benefits provided by these devices.

HOLY CROSS ENERGY

Integrating new OEMs proved time-intensive for HCE due to legal constraints and API complexities, so they chose a vendor that streamlined integration, enabling a quicker and cost-effective deployment. HCE also faced cost and compatibility issues when adding new OEMs and VPP solution providers. Their goal is to have VPP solutions that are compatible with multiple OEMs as well as offer streamlined packages. However, they found it challenging to scale VPP solutions because new OEMs and solution providers prefer larger utilities due to their program size and will charge higher upfront fees that are not scaled for smaller programs.

Figure 12. Develop Communication Protocols—Examples of Interview Insights (continued)

EVERSOURCE

Eversource highlights the importance of real-time data, which is often unavailable and impacts decision-making. This challenge became especially apparent during the process of working with battery manufacturers on integration strategies, resulting in the need for manual data transfers.

REGULATOR PERSPECTIVE

Regulators can advance development of communication protocols that are technology-agnostic through informal or formal processes.

REGULATOR PERSPECTIVE

Regulators can support the creation of standardized operational protocols to ensure VPP resources are controllable, operable, and measurable by grid operators. These protocols can specify all necessary communications and operational requirements. For example, regulators can explore opening a communications protocol docket or investigation to identify the minimum standards required for VPP participation in retail markets.


Living Room
IN 15 MIN
77
Inside Humidity
36%
45°
ECO
FAN
SCHEDULE
HISTORY

Program Planning and Design

Effective program planning and design are essential for the success of VPPs. Our interviews with industry leaders reveal that a structured approach to VPP development—focused on policy goals, cost considerations, customer-centric design, and innovation—can enhance program success and scalability. To ensure that VPPs achieve both technical and strategic objectives, it is important to integrate a range of considerations into the planning process. This includes meeting policy goals, conducting comprehensive cost-benefit analyses, and developing innovative cost recovery mechanisms. Moreover, aligning utility investments with VPPs, designing programs that prioritize customer needs, and establishing clear procurement processes are fundamental to long-term program success. The following sections explore key elements involved in the planning and design of VPPs:

- Supporting Industry-Wide Collaboration
- Establishing Measurable Performance to Achieve Goals
- Developing a VPP Procurement Process
- Enabling Robust VPP Valuation
- Designing Customer-Centric Programs
- Using Pilots to Learn Quickly

By addressing these areas, utilities and regulators can lay the groundwork for VPPs that are designed to deliver both grid reliability and long-term sustainability.

Support Industry-Wide Collaboration

Interviewees discussed the complexity of VPPs and the need for better collaboration. By applying insights from various parties that can be gained through collaboration, VPPs can be designed to effectively address challenges and ensure key elements are embedded into their design and operation such as technology integration and customer engagement. **Figure 13** highlights case study insights.

Figure 13. Support Industry-Wide Collaboration—Examples of Interview Insights

NATIONAL GRID

National Grid is learning from other utilities, such as ConEd, by leveraging insights from their targeted dispatch of DERs and exploring similar strategies in Massachusetts. They emphasize the need for streamlined collaboration among solution providers and OEMs to enhance program participation and cost-effectiveness. Looking forward, National Grid sees opportunities for VPP growth and scalability through new partnerships and innovative energy solutions.

PORTLAND GENERAL ELECTRIC

PGE is expanding its clean energy supply and integrating distributed resources to meet Oregon's emission reduction targets, demonstrating how collaboration among utilities, industry, and customers can ensure reliable, affordable, and decarbonized power while supporting regional economic development.

SOLUTION PROVIDER PERSPECTIVE

Strong partnership and collaboration between utilities, solution providers and OEMs can address technology challenges that are crossdisciplinary such as data integration issues, device interoperability constraints, and standardization needs.

SOLUTION PROVIDER PERSPECTIVE

Scaling VPPs requires extensive coordination among government entities, utilities, customers, and solution providers. This coordination is often complicated by conflicting business models, jurisdictional misalignment, and information asymmetries.

Establish Measurable Performance to Achieve Goals

Establishing baselines, evaluation methodologies and performance metrics can guide utilities and solution providers in their VPP development. Thoughtful development of performance metrics can also help regulators align the design of a VPP with achieving desired outcomes, including state energy goals, and demonstrate the value of VPPs in managing demand and optimizing grid performance.

Several utilities interviewed, including PGE, SMUD and PSE, have decarbonization and equity goals. These interviewees emphasized the importance of including the value of complying with these goals, specifically greenhouse gas emissions reductions, and the integration of DERs to expand access to clean energy, in their VPP design. Regulators also identified that using VPPs to meet policy goals or explicitly including VPP goals in policies, helped to advance adoption in their state. **Figure 14** highlights case study insights.

Figure 14. Establish Measurable Performance to Achieve Goals—Examples of Interview Insights

PORTLAND GENERAL ELECTRIC

PGE's VPP orchestration is matching generation and load. With the passage of Oregon's 2021 House Bill 2021, PGE demonstrated a path to 2030 decarbonization targets through its 2023 Clean Energy Plan (CEP) and Integrated Resource Plan (IRP). There was significant growth of DERs predicted in their 2023 CEP and IRP. Their IRP resource adequacy calculations and portfolio analysis assumed that all DER types can be integrated into PGE's system and deliver their full potential system value. However, extending this assumption to smaller and/or behind-the-meter resources requires advancement of technology to efficiently monitor, schedule and dispatch resources.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD emphasizes that decarbonization and the integration of DERs expand access to clean energy—objectives that go beyond conventional utility planning methods, which prioritize lowest-cost resource selection.

SMUD's board approved their 2021 Zero Carbon Plan, which aims for a carbon neutral power supply by 2030. This plan, with a VPP as a central resource component, is more ambitious than existing state mandates and positions the utility ahead of most others in the nation. SMUD's VPP delivers dual benefits: reducing reliance on natural gas and its associated emissions, while also enabling effective management of peak power demand. By promoting widespread adoption of customer-owned DERs, such as electric vehicles and rooftop solar, the company aims to ensure universal access to these resources, while also planning to add 360-1,300 MW to the grid by 2030. Additionally, they anticipate implementing 165 MW of flexible load programs by the same year.

PUGET SOUND ENERGY

PSEs initially lacked the typical VPP drivers, like load growth or peak management, needed to develop a VPP as a core business requirement. With the passage of Washington state's 2019 legislation, Clean Energy Transformation Act (CETA), the VPP was envisioned as the management and dispatch platform for a significant portion of this new DER capacity.

REGULATOR PERSPECTIVE

Regulators can set baselines and methodologies for assessing the impacts of VPPs early in the design process to ensure the VPPs are appropriately evaluated and contribute meaningfully to state policy goals.

Develop a VPP Procurement Process

Our interviews found that switching from traditional utility operations to VPP operations may require utilities to procure new energy management systems such as a VPP software solution.[11] Changes in procurement strategies are often driven by a combination of technological advancements, regulatory shifts, market dynamics, and evolving customer expectations. By adjusting procurement approaches, utilities and regulators can optimize costs, increase resilience, support sustainability, and ensure that they are effectively meeting current and future demands. **Figure 15** highlights case study insights.

Figure 15. Develop a VPP Procurement Process—Examples of Interview Insights

PUGET SOUND ENERGY

PSE's 2021 RFP for its VPP platform was designed to meet its clean energy targets while developing technical and operational requirements for the VPP platform. Industry insights helped refine PSE's VPP planning process by addressing challenges related to managing multiple resource systems. The emphasis was on developing a user-friendly interface with a complex backend to enable better data management and alignment with business goals.

REGULATOR PERSPECTIVE

Regulators can help support the procurement of VPPs through the establishment of a clear, consistent, and scalable procurement process. This includes developing a robust regulatory and contractual framework that ensures VPP resources are dispatchable, interconnected, and integrated into grid operations. Regulators can define grid services and operational protocols to ensure VPP resources are controllable and measurable, clarify ownership and accountability, and establish performance mechanisms to maintain reliability. Additionally, ensuring the delivery of VPP resources through third-party contracts with provisions for penalties or liquidated damages can help hold stakeholders accountable. By considering these factors, regulators can design policies and contracts that promote the effective integration and long-term value of VPPs for utilities, consumers, and the grid.

[11] Long, A., R. Long, N. Frick. Jan. 2025. Virtual Power Plant Profiles and Inventory.

Enable Robust VPP Valuation

Our interviews found that states and utilities often rely on traditional cost-benefit tests to evaluate the economic viability of VPPs. Despite their widespread use, traditional cost-benefit tests have limitations highlighted by many interviewees (e.g., they often do not quantify all grid benefits). **Figure 16** highlights case study insights, which includes considering a broader range of benefits to fully value VPPs.

Figure 16. Enable Robust VPP Valuation—Examples of Interview Insights

NATIONAL GRID

National Grid uses the TRC test to assess "all cost-effective energy efficiency and demand response programs." However, this approach often overlooks the broader range of benefits VPPs can provide, including societal benefits and frequency regulation. This narrow scope poses challenges for scaling VPPs, which deliver diverse grid benefits that traditional tests fail to capture, resulting in utilities unable to justify cost expenditures for such investments.

PORTLAND GENERAL ELECTRIC

PGE acknowledges that compensating customers based on the value of their resources is a mature aspect of VPP development. However, DER cost-effectiveness needs adapted to ensure fair and effective compensation of a VPP's value to the grid.

REGULATOR PERSPECTIVE

Regulators can support policies that allow utilities to rate-base and depreciate assets owned by consumers or solution providers.

REGULATOR PERSPECTIVE

The value proposition is absent for VPPs, but can be increased with improved load factor, avoided cost of distribution investments and ability to "actively" manage load.

SOLUTION PROVIDER PERSPECTIVE

There is a lack of a "regulatory" business case for VPPs. One utility is applying traditional cost-effectives to DERs, which minimizes the potential for VPPs and DERs. It does not include all of the potential DERs. Valuing VPPs could be considered more broadly. What evaluation and avoided costs should a regulator use to value a VPP?

SOLUTION PROVIDER PERSPECTIVE

Considerations need to be clearly articulated to policymakers on whether the valuation of VPPs is based on comparing their costs to those of legacy or new centralized baseload generation, evaluating their capacity to provide emergency support, or deferring distribution system expenses.

REGULATOR PERSPECTIVE

IOUs don't see load flexibility as a benefit.

REGULATOR PERSPECTIVE

There is a need to determine the locational value of VPPs.

Design Customer-Centric Programs

Our interviews stressed the importance of customer-centric program design that ensures the final implementation strategy is aligned with customer needs and expectations. Recent Berkeley Lab research on increasing VPP enrollment also found that customer-centric program design can enhance participation and retention.[12] For example, using flexible engagement strategies that address the needs of diverse customer groups can encourage participation and ensure long-term retention, ultimately sustaining program momentum and enabling large-scale customer engagement. Our interviews revealed that utilities that prioritize customer satisfaction also see added benefits such as resiliency and energy affordability. **Figure 17** highlights case study insights.

Figure 17. Design Customer-Centric Programs—Examples of Interview Insights

SOLUTION PROVIDER PERSPECTIVE

Striking a balance in the allocation of risks and benefits among all parties involved is crucial. This balance will be key to integrating VPPs into utilities' planning and operations, modernizing the grid, and ensuring substantial benefits for participating customers and all ratepayers.

PACIFICORP

PAC highlights the importance of designing with a "customer-centric" approach by continually improving their DER programs to align with grid and customer goals.

PORTLAND GENERAL ELECTRIC

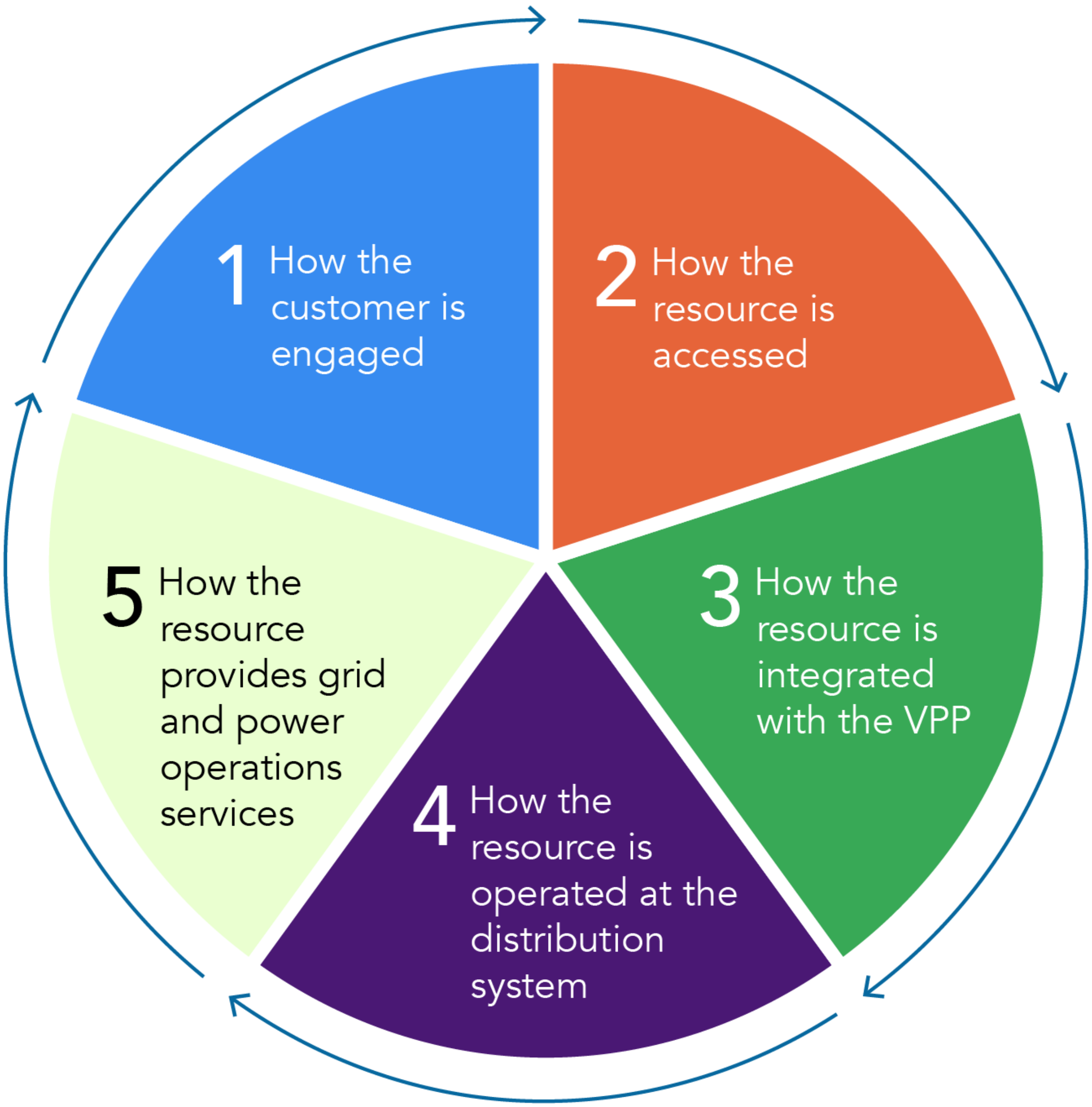
PGE uses a "lifecycle of DERs" approach (**Figure 18**). This approach develops effective VPP and DER operations by starting with how a customer is engaged in the VPP process to ensuring how DERs operations flow from end users to grid operations.

NATIONAL GRID

National Grid aims to enhance engagement with low- to middle-income communities through increased incentives for thermostat-based DR measures, and new offerings, including free batteries.[13]

[12] Hledik, R, A. Ramakrishnan, S. Patel, et al. Jan. 2025. Distributed Energy, Utility Scale: 30 Proven Strategies to Increase VPP Enrollment.
[13] U.S. Grid Deployment Office Grid Resiliency and Innovation Partnerships Program Fact Sheet. Oct. 2023. Grid Resilience and Innovation Partnerships (GRIP) Program.

Figure 18. PGE Design Process for a VPP



Use Pilots to Learn Quickly

Our interviews found that many utilities deploy pilots to refine program models and uncover challenges related to DERs. Piloting programs helps to gain insights and refine strategies to differentiate the value of various DERs and identify challenges early in implementation (e.g., testing different program models, refining customer engagement approaches, and uncovering technical issues such as DER integration). Our interviews found that pilots with a clear action plan allow for DER integration into full-scale grid operations. Also, many utilities used early learnings from pilots to determine if pilots should be discontinued if they fail to meet their objectives.

We also heard from interviewees that pilots without a clear endpoint or structure can negatively impact the customer experience, especially when they differ significantly from what the actual program will be. Switching the program design may require re-educating or re-enrolling customers, which can add unnecessary complications and hinder participation. Moreover, unnecessarily prolonging the pilot's testing and development cycle can prevent it from reaching the desired end-state. **Figure 19** highlights case study insights.

Figure 19. Use Pilots to Learn Quickly—Examples of Interview Insights

SOLUTION PROVIDER PERSPECTIVE

A shift is needed from conducting small-scale demonstrations and pilot projects to deploying comprehensive VPP programs with clear capacity targets that can substantially impact utility operations and power marketing.

SACRAMENTO MUNICIPAL UTILITY DISTRICT

SMUD recognizes the significant value of their battery pilot in providing grid benefits. However, battery programs can be complicated by the fact that current planning practices consider batteries new loads which may require system upgrades. Piloting these technologies allows SMUD to gain new insights on how to account for the costs and benefits of batteries to the grid and customers.

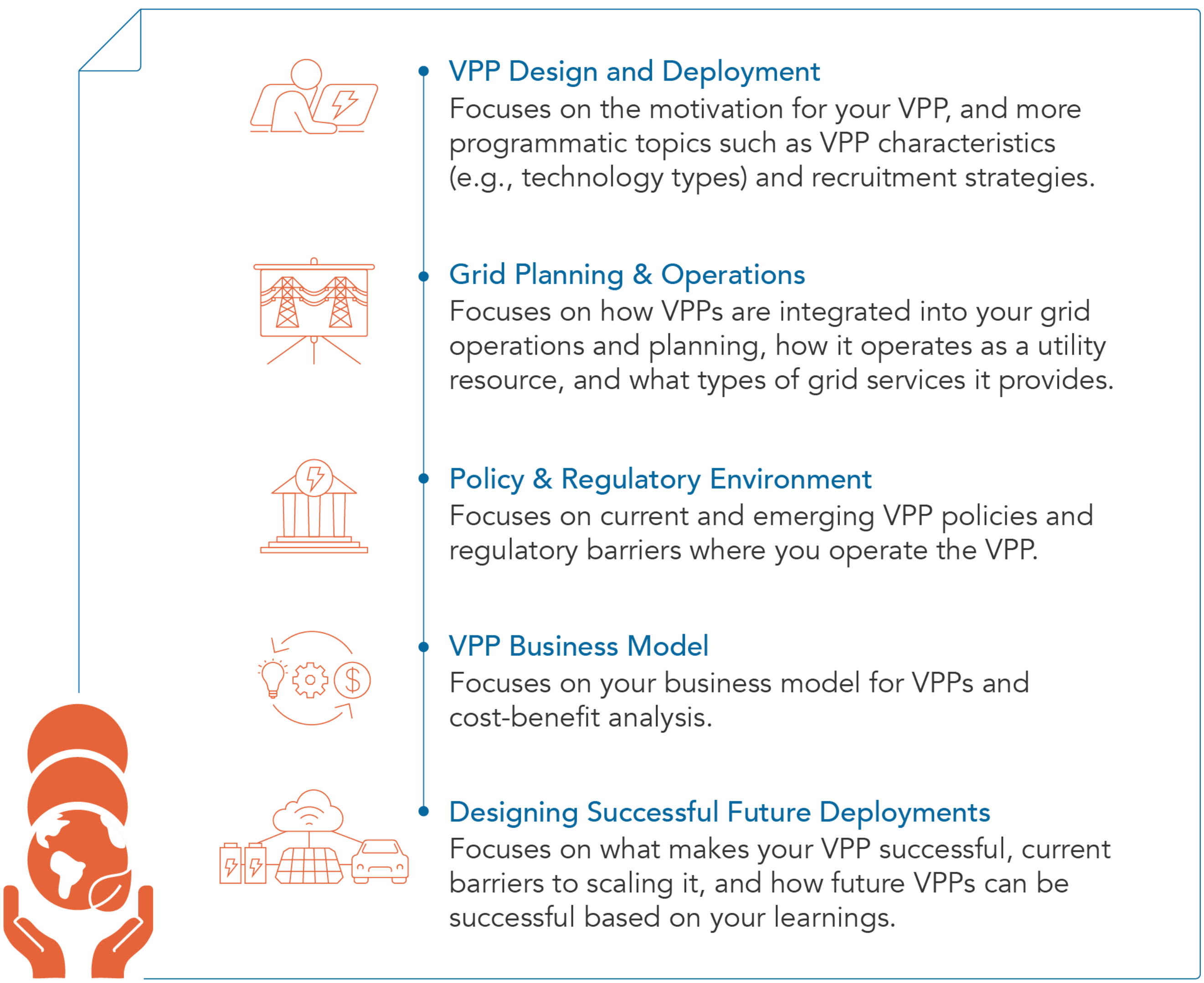
PACIFICORP

PAC's battery program successfully transitioned from pilot to full-scale deployment by validating software and DER performance. The pilot focused on ensuring the solution could meet grid needs while addressing customer expectations. Principal metrics, such as resource responsiveness and customer enrollment, were tracked to evaluate whether the program could scale and function as a reliable grid resource.

VPP Case Studies

This section presents seven case studies which explore how VPPs have been implemented by specific utilities. Interviews were conducted using the guide in **Appendix B**. In many cases, we interviewed multiple individuals within each utility (e.g., program manager, engineers, IT). Our primary objective was to identify the main factors enabling successful deployment of VPPs and to highlight the primary challenges that future VPP initiatives are likely to face. The case studies are organized around five themes as illustrated in **Figure 20**.

Figure 20. Case Study Interview Topics



Our interviews with participants discussed existing VPP program and project strategies, designs, customer participation, as well as insights gained in overcoming barriers to implementation. We also sought insights on how participants utilize VPPs for grid management and if utility grid operators deploy these resources when available. Finally, we sought to identify unique opportunities and challenges for DERs and VPPs in contrast to traditional utility resources. Below we highlight our interviews with utilities by providing a summary of their VPPs. We provide additional details from our interviews in **Appendix D**.

CASE STUDY EVERSOURCE

A diverse demand management portfolio focused on summer events

From residential to commercial and industrial, Eversource taps into curtailment strategies and demand response through thermostats, batteries and EVs.

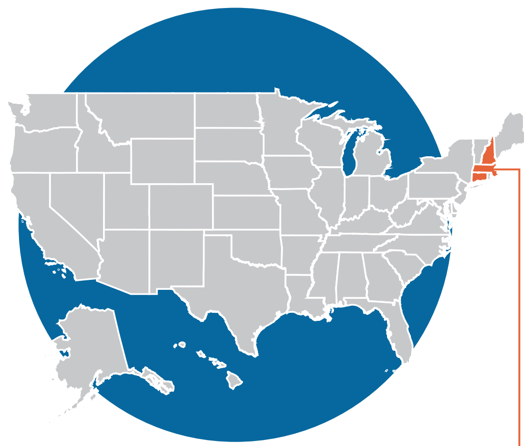
Eversource's approach to Virtual Power Plants (VPPs); addresses the challenges, complexities, and resulting success in managing and optimizing Distributed Energy Resources (DERs), especially regarding data management, real-time operations, and program effectiveness.

Eversource Interview Summary

Eversource's ConnectedSolutions program has been helping customers lower demand on the grid and reducing New England's carbon footprint since 2019. Under the ConnectedSolutions program, Eversource offers a residential Wi-fi thermostat direct load control program, targeting peak demand reduction by controlling residential air conditioning systems on specific summer days. In summer 2019, the program enrolled 16,000 thermostats, called 7 events lasting 3 hours each, and reported an average demand reduction of 7,653 kW per event.

Also, under the ConnectedSolutions program, Eversource offers a targeted C&I program, which is device agnostic and offers relief on highest peak days of the summer. In summer 2021, their targeted C&I program called 5 events, achieving a 146 MW demand reduction across 671 participating accounts with an enrolled capacity of 208 MW.

Eversource's Massachusetts ConnectedSolutions battery storage offering is a residential BYOD (bring-your-own-device) program aimed at reducing peak demand. During the summer 2023 program period, 29 residential battery storage events were called, between 2 to 3 hours each, with 2,449 customers enrolled and 6,760 unique devices providing an aggregate load reduction potential of 57 MW. The program achieved a 25 MW load reduction per event.



4.4 million

customers across Connecticut, Massachusetts, and New Hampshire

The residential bring-your-own-battery program, with 2,449 customers (and 6,760 devices), provides an aggregate load-reduction potential of 57 MW.

The 9,323 residential central air conditioning systems controlled by Eversource via customers' Wi-Fi thermostats resulted in an average demand reduction of 7,653 kW per event.

Current VPP Focus

ISO New England Focus: Primarily targets summer system peaks.

Residential Programs: Include 100,000 thermostats (41% of load shed), 6,000 batteries (6% of load shed), and 6,000 EV chargers and electric vehicles.

Commercial and Industrial: In MA, where fossil fuel generation is no longer an eligible participation measure, C&I thermostats contributes 41% and C&I batteries 11% to load shed.

Grid Operations: Eversource has a high focus on DERs as a grid resource. Their VPP is focused on achieving real-time visibility of devices and software such as DERMS needed to control devices.

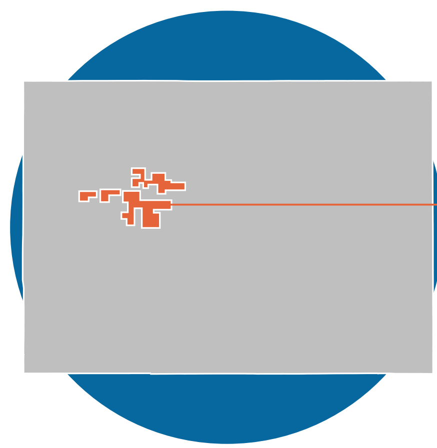
Emphasizing customer satisfaction and deployment simplicity

A multifaceted VPP strategy drives decisions on customer-focused VPP benefits, OEM partnerships, battery ownership, program management, and clean energy goals.

Holy Cross Energy (HCE) customers demonstrate a strong interest in resiliency, which their VPP provides. Enrollment in programs tends to spike after extreme weather events. Their utility-owned battery program allows for on-bill repayment, which helps customers afford the high cost of battery systems. HCE is exploring other models, such as Power+FLEX, which offers performance-based credits, allowing customers to decide how much power to make available to HCE.

Holy Cross Energy Interview Summary

HCE, established in 1939 as a cooperative to serve rural areas in Colorado, has grown from serving 175 homes to over 42,000 members with a peak demand of 261 MW by 2023, significantly expanding with the development of the Vail ski area in 1962. Committed to sustainability, HCE launched various initiatives starting in 2010, including energy efficiency programs, a feed-in tariff for wind energy, and community solar gardens. Their "Seventy70Thirty" plan, adopted in 2018, aims for 70% clean energy and a 70% reduction in greenhouse gas emissions by 2030, with goals of 100% clean energy and carbon neutrality by 2035. In 2023, HCE exceeded its goal of adding 4 MW of distributed energy resources (DERs) by reaching 4.24 MW and supported 176 home chargers, 305 rebates for e-bikes and e-lawn products, and 136 residential electrification rebates. Their Peak Time Payback program avoided 12 MW of peak demand, resulting in $109,549 in payments to participants. The High Mesa solar plus storage project in Parachute, Colorado, slated for completion in 2024, will include a 10 MW solar array and 20 MWh battery storage to serve up to 2,800 households.



42,000

members in rural Colorado

Current VPP Focus

Power+ Battery Program: Has over 200 customers enrolled; with 3.5 MWs of capacity. Features an on-bill repayment option with 0% financing for 10 years and a monthly bill credit.

Power+FLEX Program: A no opt-out program, performance-based credits.

High Mesa Project: HCE's High Mesa project integrates battery storage and renewables. Stores excess solar energy produced during the day for use during peak evening hours. Calls up to 10 events per month, with the goal to hit the coincident peak

Electric Vehicle (EV) charger pilot: Focuses on curtailing during the same hours that customers discharge their power+ batteries.

HCE has over 200 customers enrolled and 600 EV chargers; with 3.5 MWs of capacity.

The High Mesa solar plus storage project will include a 10 MW solar array and 20 MWh battery storage to serve up to 2,800 households.

CASE STUDY — NATIONAL GRID

Residential and Commercial programs offer significant energy savings

nationalgrid

By collaborating with multiple original equipment manufacturer (OEMs), National Grid can provide a variety of options for residential and commercial customers. Low- and middle-income communities are engaged with increased incentives and free equipment.

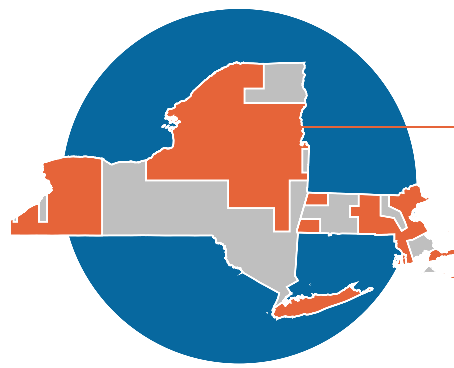
National Grid focuses on using demand response (DR) for peak shaving and offers a diverse distributed energy resource (DER) portfolio for residential and commercial customers. They addressed the challenges and costs associated with high-resolution metering and telemetry, efforts to standardize programs across their service territory, and their commitment to broadening the impact and reach of their programs.

National Grid Interview Summary

National Grid, one of the largest privately owned energy companies in the U.S., serves over 20 million residents and companies across New York and Massachusetts. In January 2024, the company presented its Electric Sector Modernization Plan to the Massachusetts Department of Public Utilities (MA DPU), detailing critical investments needed in the distribution system over the next five to ten years that will enhance the electric distribution grid's capacity, ensuring reliability, accelerating the integration of solar, storage, and electrified heating and transportation. Their ConnectedSolutions portfolio includes technology-agnostic programs aimed at optimizing energy use. The thermostat program, active for years, involves about 15 summer events, each lasting 3 hours. The battery program, launched in 2018/2019, holds around 50 summer events with durations of 2-3 hours. The company also introduced a Time-of-Use (TOU) program for electric vehicles (EVs).

A water heater program is planned for 2025, designed to operate like the smart thermostat program via EnergyHub's distributed energy resource management system (DERMS).

National Grid has two options for commercial customers: Targeted Dispatch which holds around 5 events per summer, and Daily Dispatch which holds about 50 events per summer. National Grid's commercial program incentivizes energy-intensive process reductions during events, with a multi-technology approach that accommodates diverse customer and device types, including HVAC, lighting controls, thermal storage, and vehicle-to-grid. The National Grid programs do not allow fossil fuel generators to participate, and incentives for customers using battery storage are capped relative to site load. Customers' incentives are based on the customers performance during events.



20 million

residents across New York and Massachusetts

VPP shaves peak, reducing peak demand by 10% with estimated long-term grid operational costs reduced by 40%.

The thermostat program holds 15 summer events, each lasting 3 hours, while the residential-scale battery program holds 50 summer events with durations of 2-3 hours.

Current VPP Focus

Demand Response Strategy: Currently uses DR primarily for peak shaving. They estimate that reducing peak demand by 10% could cut long-term grid operation costs by 40%. (Massachusetts State of Charge Report pages 5 and 6 Massachusetts Energy Storage Initiative).

Peak Shaving: The entire Connected Solutions portfolio can remove about 350 MW of load from the grid during peak times.

Equity: In partnership with Generac, has received a United States Department of Energy (US DOE) GRIP Grant to offer income eligible customers approximately 2,000 free battery storage system installs.

CASE STUDY PACIFICORP

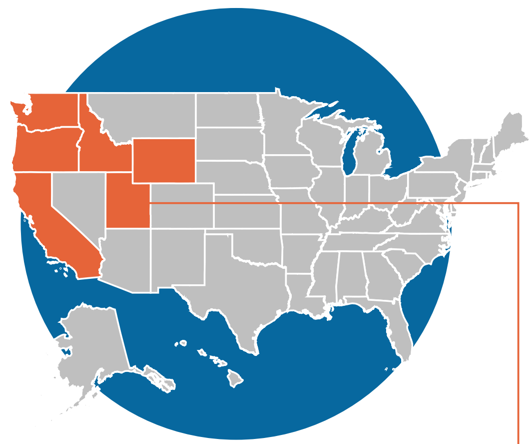
Balancing innovation and practicality

A VPP design that focuses on delivering value to customers and ensuring DERs meet performance standards akin to traditional resources.

PacifiCorp's approach to Virtual Power Plants (VPPs) addresses the technical and operational challenges of distributed energy resources (DERs), focusing on customer satisfaction and regulatory compliance, and fostering innovation and collaboration to enhance grid management and integration. And while traditional performance standards are prioritized, PacifiCorp believes traditional practices must be replaced with inventive approaches, calling on a unified vision and innovative mindset as critical for VPP success.

PacifiCorp Interview Summary

PacifiCorp has a strong legacy in DER programs, notably its long-running Cool Keeper demand response (DR) program totaling 300 MW, which curtails residential and commercial loads via central air conditioners. Cool Keeper, PacifiCorp's first DER-to-grid initiative, offers real-time dispatch capabilities for various smart grid applications, such as frequency response, contingency reserve and peak reduction. This success paved the way for projects like Soleil Lofts in Herriman, Utah, a net-zero, all-electric residential development featuring 630 Sonnen batteries, totaling 5 MW/12 MWh of storage. The Soleil Lofts project, launched in 2019, became the largest utility-managed network of residential solar-powered batteries in the United States (U.S.) and served as a proof of concept for expanding residential renewable power. PacifiCorp's Wattsmart Battery program offers incentives and grid services through aggregated batteries, contributing to grid reliability, demand response and resilience. Additionally, PacifiCorp is expanding all their demand response customer programs (batteries, commercial, industrial, electric vehicles, residential) to integrate within a VPP to provide real-time grid services and manage peak loads.



2.1 million

customers across Utah, Wyoming, Idaho, Oregon, Washington and California

PacifiCorp's VPP has up to 400 MWs and operates 24/7 year-round, and typically lasts 5-15 minutes; resulting in an extremely high customer satisfaction rate of ~90%.

Battery systems managed by PacifiCorp provide grid services such as frequency response, distribution voltage control, contingency reserve, peak load management and customer resiliency while ensuring a minimum reserve 20% state-of-charge for each battery. There are currently over 4,000 participating batteries.

Current VPP Focus

Grid Operations: Cloud-based software or platform-enabling grid operators, similar to conventional generation resources.

VPP Platform: Allow DERs to contribute additional grid benefits and reliably serve their customers.

Grid Services: Grid efficiency, affordably and reliably, by allowing autonomous operation of DERs.

DER Diversification: Multiple use cases and defining how those DERs react to grid conditions.

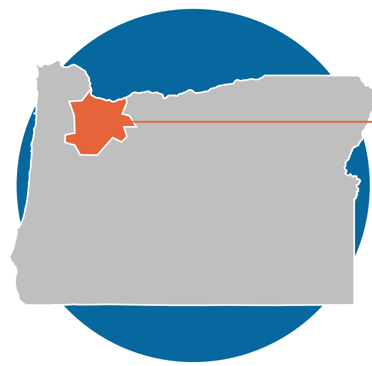
The role of team communication and change management in VPPs

A structured approach to deploying Virtual Power Plants (VPPs), led by a VPP director who serves as a facilitator or "translator," ensures effective integration of cross-functional teams from concept through deployment.

Portland General Electric (PGE) developed a strategic approach to integrating Flexible Load and distributed energy resources (DERs) through a VPP, focusing on technological integration, customer benefits, regulatory and policy enablers, and effective communication and management practices.

PGE Interview Summary

PGE, a vertically integrated, regulated energy company operating in Oregon for over 130 years, serves more than half the state's population across 51 cities, delivering over 20 GWh of energy annually. With an average load fluctuating between 2 GW and 3.5 GW and a peak of 4.5 GW, PGE defines its VPP as the orchestration of DER and Flexible Loads through technology platforms to provide grid services and respond to fluctuating locational prices. PGE is expanding its clean energy supply and integrating distributed resources to meet Oregon's emission reduction targets, demonstrating how collaboration among utilities, industry, and customers can ensure reliable, affordable, and decarbonized power while supporting regional economic development. PGE is committed to reliably and affordably reducing emissions by 80% by 2030 and achieving 100% by 2040. PGE continues to power the advancement of society, delivering increasingly clean electricity while transforming energy systems to meet evolving customer needs. PGE customers lead the nation with the number one voluntary renewable energy program.



900,000

meters serving 2 million customers in Oregon

PGE aims to incorporate 2,000 MW of VPP-enabled DERs by 2030 to deliver a 25% peak usage offset while serving 100% of customer energy demands.

The current VPP delivers 225 MW, with over 225,000 customers enrolled and 140+ events called.

Current VPP Focus

- **Valuation of DERs:** Providing grid benefits and enabling customer compensation.
- **Battery Storage:** PGE acquired 475 MW of battery storage, operational by mid-2025.
- **VPP Orchestration:** Aims to integrate 2,000 MW of VPP-enabled DERs by 2030.
- **"Flexible" Load and DERs:** Improved monitoring, scheduling, and dispatching. Flex Load and DER participation in regional markets are supported through DERMS integration.

A VPP that serves as a comprehensive business platform

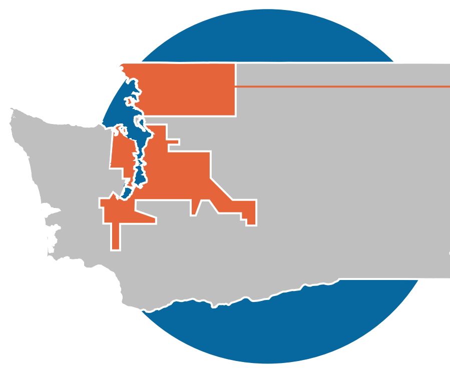
Integrating the VPP seamlessly with platforms like Systems, Applications, and Products (SAP), customer lifecycle management, and customer acquisition emphasizes customer impact and satisfaction, minimizing disruptions and enhancing user experience.

Puget Sound Energy (PSE) holds a strategic vision for their Virtual Power Plant (VPP) that aligns with regulatory goals, integration with business processes, and a focus on customer satisfaction and operational efficiency. This informs their approach to developing and implementing their VPP platform.

PSE Interview Summary

PSE, an investor-owned utility in Washington with over 150 years of history, serves 1.2 million electric and 900,000 natural gas customers across 6,000 square miles in Western Washington. PSE has long been committed to clean energy, becoming the largest producer of renewable energy in the Pacific Northwest in 2005. By 2022, PSE set ambitious goals to be coal-free by 2025, carbon neutral by 2030, and 100% clean by 2045. Following Washington's 2019 Clean Energy Transformation Act (CETA), PSE's 2021 Integrated Resource Plan (IRP) emphasized Distributed Energy Resources (DERs) as key to meeting these targets. In 2022, PSE selected a vendor for its VPP platform to manage DERs and Load Flexibility programs, with further development underway. By the end of the 2023-2024 winter demand response season, PSE had tested and dispatched eight events using over 30,000 customer devices, delivering up to 30 MW of curtailment.

PSE's initial VPP programs include automatic demand response (ADR) and behavioral demand response (BDR) for residential customers and businesses, with ADR providing incentives for thermostats, water heaters, electric vehicles (EVs), and electric vehicle supply equipment (EVSE) chargers. PSE is also working to integrate up to 5 MW of energy storage per site under VPP control.



1.2 million

electric and 900,000 natural gas customers in Western Washington

During the 2023-2024 winter demand response season, PSE tested and dispatched 8 events with 30,000+ customers, delivering up to 30 MW of curtailment.

Plans for 522 MW of distributed batteries, solar, and demand response by 2031.

Current VPP Focus

Decarbonization: Plans for 522 MW of distributed batteries, solar, and demand response by 2031.

Scalability: Underscores the importance of adaptability, regulatory alignment, and custom solutions, decarbonizations, non-wire solutions, and grid flexibility.

Customization: There is no single VPP vendor that can manage all aspects of the VPP lifecycle, particularly the custom back-end processes like meter swaps, customer relocations, and decommissioning.

VPP Operations: Assigned distribution system operators from the start, ensuring that load forecasts, dispatch threshold, and event scheduling align with broader business objectives.

CASE STUDY — SACRAMENTO MUNICIPAL UTILITY DISTRICT

A clean energy pioneer with an aggressive Zero Carbon Plan

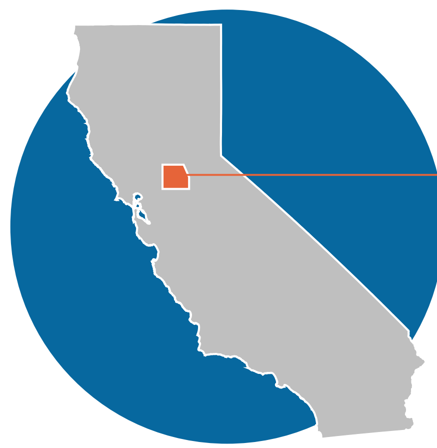
SMUD

The Sacramento Municipal Utility District (SMUD) developed a detailed playbook, clearly defining what a Virtual Power Plant (VPP) is for their organization.

SMUD focuses on collaborative planning, improving distributed energy resource (DER) control and predictability, and using incentives to expand their VPP programs. They aim to integrate various DERs effectively while aligning their efforts with broader decarbonization goals and enhancing operational coordination.

SMUD Interview Summary

SMUD is the sixth-largest community-owned nonprofit electric service provider in the U.S., serving over 1.5 million people across a 900-square-mile territory in Sacramento County for over 75 years. Committed to clean energy for more than 50 years, SMUD's Upper American River hydroelectric project, established in 1957, now provides 16% (688 MW) of its energy needs. In 2021, SMUD's board approved the Zero Carbon Plan, targeting a decarbonized power supply by 2030, surpassing state mandates. This plan emphasizes broad adoption of customer-owned DERs, such as EVs and rooftop solar, with a goal to add 360-1,300 MW flexible capacity to the grid to offset variability from renewable resources. SMUD launched a battery storage VPP program in 2023, planned to deliver 20 MWh and 10 MW of dispatchable clean energy, with the potential to expand to 54 MWh and 27 MW. Currently, SMUD has around 2,600 energy storage systems, installed at customer sites, with 900 more in progress, and plans to add thousands more on their way to a decarbonized grid.



660,000

customer accounts serving 1.5 million people in Sacramento County

Strives to ensure universal access to DER resources, while also planning to add 360-1,300 MW of flexible customer resources to the grid, including 500 MW of dispatchable VPP resources by 2030.

As of October 2024, SMUD had ~ 2,600 batteries installed at customer sites, with 900 more in progress.

Current VPP Focus

Decarbonization: SMUD's objective is to displace additional grid infrastructure with VPP resources, aiming to accumulate 500 MW of controllable load flexibility by 2030, representing 6% of their peak load.

DER Programs: SMUD has four key programs: My Energy Optimizer Partner (thermostat for peak shaving), Partner Plus (battery storage), and a new forthcoming multifamily pilot with a goal of 100 batteries and solar installations to enhance resource optimization and customer resilience. SMUD has an EV managed charging pilot program with over 1,100 participants. It is in the pilot phase and expected to be replaced by a production program to launch in 2025.

Enhanced Incentives: SMUD aims to increase the number of enrolled batteries and other resources to improve the effectiveness of their VPP. Their Partner Plus program offers up to $10,000 in up-front incentives for batteries, plus up to $1,200 in annual performance payments, intended to stimulate market transformation and customer participation.

Customer Enrollment: SMUD has over 27,000 customers enrolled in their thermostat "program" as of September 2024. HVAC cooling load is the largest contributor to their peak and these programs offer substantial relief during peak loads.

Appendices

Appendix A. Methods

We consulted with 24 subject matter experts to provide a deeper understanding of the current VPP landscape and the factors leading to success. Our interviewee pool represented a range of perspectives and expertise, including government representatives, utility staff, solutions providers, researchers, advocates, and an engineering firm representing building owners. **Figure 21** provides the key research questions.

Figure 21. Key Research Questions

VPP Design

- What are common characteristics of successful VPP programs and projects (e.g., implementation strategies and program designs, influencing factors for success, best practices)?
- What lessons can be drawn from case study examples to help drive replication of successful VPP programs?
- How are VPPs integrated into utility planning and operations?

VPP Deployment

- What methods are used for calculating benefits and costs?
- How are risks and uncertainties addressed?
- What strategies have worked for overcoming common barriers to project implementation?
- What are good strategies for deploying VPPs for low- and middle-income (LMI) communities?
- How do grid operators utilize VPPs as a grid resource (e.g., is the resource responsive to grid needs, can it provide grid services)?

VPP Policy and Regulatory Drivers

- What emerging policies and regulations are influencing VPP design and deployment?
- What are the current policy and regulatory barriers to success for VPPs?
- What policies and regulations are needed to overcome these barriers?

Research Summary

We focused on five key themes to guide our research and interviews, helping us navigate the complex topics surrounding VPPs (**Figure 22**). The factors influencing VPPs are diverse, driven by policy initiatives, utility requirements, and customer DER adoption. The use of broad themes enabled us to explore key factors that drive utilities to develop VPPs, their operational strategies, and plans to scale them.

Figure 22. Key Research Themes

VPP Design and Deployment

› Is your VPP made up of an individual DER technology or an aggregation of DERs?
› What are the DER types, sizes, and locations?
› What grid services are provided by the VPP?

Grid Planning and Operations

› What grid services are provided by the VPP?

Policy and Regulatory Environment

› What is the current policy and regulatory framework in the service territory or markets in which you operate?

VPP Business Model

› What analytical methods and approaches do you use to determine the costs and benefits of VPPs?
› Do you have regulatory requirements to report certain costs and benefits of VPPs?

Driving Success in Future Deployments

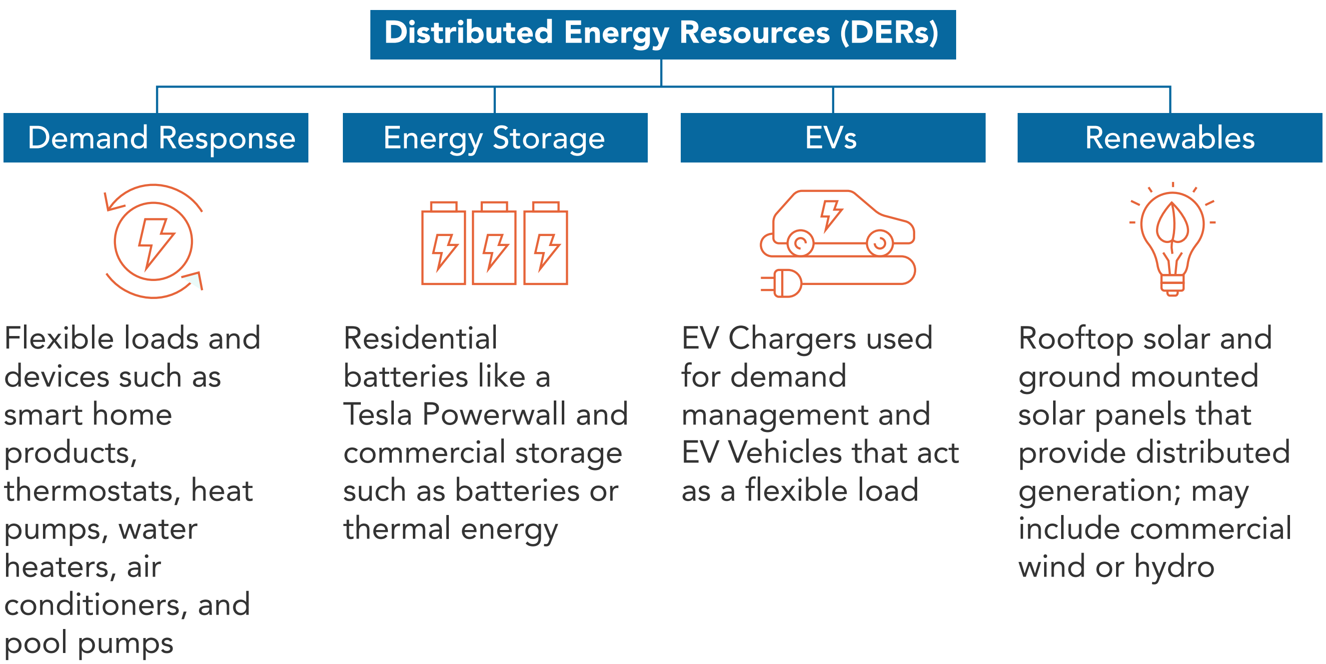
› How can VPPs increase PV/EV deployment and accelerate decarbonization?
› How can PV/EV deployment help or hinder VPP participation/operation/ benefits (to customers/VPP operators/utilities)?

Defining DERs

Within the definitions we reviewed, each included the broad term of "DER" or a sub-set of DERs. In general, the term "DER" covers a wide variety of resources. While many in the industry define VPPs as DER aggregations, the resources included in the description vary, complicating direct comparisons between VPP projects.

For example, some utilities designate a network of smart thermostats as a VPP, while others include a suite of behind-the-meter devices (such as battery storage, electric vehicle charging or smart water heaters). Meanwhile, other utilities refer to the VPP platform itself as constituting a VPP. This lack of a standardized definition may cause confusion among utilities, customers, and regulators, which could inhibit policy adoption or regulation. **Figure 23** illustrates how the umbrella term "DER" is being used to describe VPPs within the definitions we reviewed. When defining VPPs, it is important to consider which technologies are part of the VPP solution.

Figure 23. Defining DERs



Appendix B. Interview Guide

Lawrence Berkeley National Lab (Berkeley Lab) is researching and writing a report, funded by the U.S. Department of Energy (DOE) titled *Insights into Scaling Virtual Power Plant (VPP): Real-World Findings for Successful Deployment*. The report will use interviews and a case study approach to examine factors leading to successful VPP deployment. It will draw upon lessons learned, best practices, and insights from real life examples to inform states, utilities, regional grid operators, and DER aggregators of successful policies, programs, and projects. The case study approach will identify key characteristics, methods and strategies needed to successfully deploy a VPP.

The interviews aim to identify factors contributing to the success of your VPP and capture your insights to provide valuable lessons for future VPP deployments. Our questions are organized around five themes:

- VPP Design & Deployment: Focuses on the motivation for your VPP, and more programmatic topics such as VPP characteristics (e.g., technology types) and recruitment strategies.
- Grid Planning & Operations: Focuses on how VPPs are integrated into your grid operations and planning, how it operates as a utility resource, and what types of grid services it provides.
- Policy & Regulatory Environment: Focuses on current and emerging VPP policies and regulatory barriers where you operate the VPP.
- VPP Business Model: Focuses on your business model for VPPs and cost-benefit analysis.
- Driving Success in Future Deployments: Focuses on what makes your VPP successful, current barriers to scaling it, and how future VPPs can be successful based on your learnings.

In advance of the interview, please feel free to share with us any relevant materials regarding your VPP, such as links to regulatory filings, presentations and reports. We will use this material to tailor our interview to your specific VPP. Additionally, this will ensure we spend time during the interview capturing details of your VPP that are not already publicly available.

Questions we will seek to answer in advance of your interview include:

- Is your VPP made up of an individual DER technology or an aggregation of DERs? What are the DER types, sizes, and locations? What grid services are provided by the VPP?
- What is the current policy and regulatory framework in the service territory or markets in which you operate?
- What analytical methods and approaches do you use to determine the costs and benefits of VPPs? Do you have regulatory requirements to report certain costs and benefits of VPPs?
- How can VPPs increase PV/EV deployment and accelerate decarbonization? How can PV/EV deployment help or hinder VPP participation/operation/benefits (to customers/VPP operators/utilities)?

Interview Structure & Questions

Information from our interviews will be used to inform the report. We will not specifically attribute any comments to a person without their review and consent, and we will provide a draft report to the interviewee to review for accuracy prior to submitting it to the U.S. DOE. We plan to record the interviews and will use them as a reference during the report-writing process. We will not distribute the recording or share it with other organizations.

Introduction (5 minutes)

- Describe your role and responsibilities within the VPP project.

VPP Design & Deployment (10 minutes)

- How is the VPP designed and deployed?
- What are the main characteristics of the VPP design and deployment?
- What is/was the motivation for the VPP (e.g., policy, stakeholders, regulatory requirement, long-term planning, grid need)?
- Is your VPP in the pilot stage or is it a full-scale program? How long has the VPP been operating? Are there requirements or expectations that the pilot will inform a full-scale program or be replicated? If so, what are they?
- What does the customer recruitment process look like, including low to middle income recruitment if applicable?

Grid Planning & Operations (10 minutes)

- What are the planning requirements, considerations and needs of the VPP (e.g., how quickly the VPP needs to be available, how long it needs to operate, total MWs needed to be considered a utility resource)?
- How is the VPP incorporated into grid planning and managed within operations? What is the utilization rate of your VPP by utility grid operators?
- What are the challenges you face today regarding integrating VPPs into your operations? As VPPs scale, do you anticipate future challenges?

Policy & Regulatory Environment (10 minutes)

- What are the current policy and regulatory barriers to success for VPPs? What policies and regulations are needed to overcome these barriers?
- Are there new or evolving policies and regulations that are influencing the way you design and implement VPPs? Do they support VPP deployment and scaling?

VPP Business Model (10 minutes)

- What is the current business model for your VPP?
- What are the utility and participant incentive/ compensation models?
- How does the utility recover VPP costs, and is the process unique for VPPs?
- What type of cost-benefit analysis do you use to calculate whether a VPP is cost-effective or not? (e.g., TRC, least-risk, least-cost planning)?
- What costs, benefits or value streams do you include?
- Do you include harder to quantify benefits (e.g., equity, resiliency, flexibility)?

Designing for Success in Future Deployments (10 minutes)

- What factors are key to driving the successful deployment of VPPs?
- What have you identified as a best practice and/or lessons learned when designing a VPP?
- What are the major challenges, barriers, risks, and uncertainties you faced? What challenges will future projects need to overcome when scaling VPPs?

Appendix C. DERMS Glossary

DRMS

A Demand Response Management System directly connects to and manages customer resources, such as smart thermostats and home energy systems, to facilitate demand response capabilities like load shifting or curtailment. It aggregates various small, individual DERs and enables control over devices and data. Eversource's commercial customers predominantly use DRMS for DR, unlike residential programs which often use an Edge DERMs model. National Grid noted that commercial customers primarily rely on curtailment service providers (CSPs) for energy management, which typically utilize a DRMS, whereas residential programs often adopt an aggregator model.

Edge DERMS

Edge DERMS are technology agnostic and integrate various grid edge devices such as flexible loads and dispatchable solar. They enable DERs to serve as a utility-scale resource by dispatching technologies for grid needs or services. Typically, they do not have a direct connection to the utility and must interact with the centralized DERMS to perform grid services.

For example, National Grid manages its DER portfolio (residential batteries, thermostats, C&I sites and aggregators) through EnergyHub's edge DERMS, Mercury. This allows National Grid to monitor, dispatch, and optimize a suite of DERs for near real-time grid services and needs. Holy Cross Energy (HCE) recently transitioned to a new VPP solution provider, who can provide Edge DERMS. This will enhance their DER portfolio with the necessary communications, software, and hardware, improving their capability to manage DERs for grid operations.

Fleet DERMS

A Fleet DERMS manages OEM-specific technologies, such as a fleet of Ford electric vehicles. Much like an Edge DERMS, a Fleet DERMS enables OEMs to provide control, monitoring, and management of their devices in collaboration with third parties. For example, Ford's DERMS platform allows managers to oversee their fleet of electric vehicles. The primary goal of a Fleet DERMS is to provide consumer control rather than grid services. These systems do not connect directly to grid operations and must interface with centralized DERMS.

Microgrids

Microgrids act as an independent resource, which can island from the grid at a specific geographic location. This may differ from other VPP resources which may be tied to the grid and serve a broader geographic region. Both Microgrids and VPPs can generate distributed renewable energy and store this energy at the distribution level; however, microgrids rely more heavily on physical materials and innovations, while VPPs depend more heavily on smart metering and information technology.[14]

[14] *Microgrids and Virtual Power Plants Issue Brief*. National Caucus of Environmental Legislators.

Appendix D. Interview Findings Catalog

Table 1 provides the themes and findings from our case study interviews.

Table 1. Case Study Interview Themes

Utility	Theme	Category	Subcategory	Details
Eversource	1. Designing & Deploying VPPs	Deploying VPPs	AMI Deployment	Scaling VPPs requires the widespread deployment of AMI. Without advanced meters, VPPs may be restricted in their effectiveness to fully capture the value of behavioral demand response (DR) programs.
			Challenges with Device Control and Data	There are operational hurdles to deploying VPPs which include device control, program enrollment approvals, and access to customer data.
		Designing VPPs	Branding and Relationship Management	Determining the VPP purpose is important to branding considerations of VPPs. This is significant in managing relationships and expectations with aggregators and customers in utility programs.
			Alignment and Understanding	The importance of aligning industry language and terminology for better communication and understanding cannot be understated.

Utility	Theme	Category	Subcategory	Details
Eversource	1. Designing & Deploying VPPs	Designing VPPs	Cross-functional Program Management	Program management of a VPP is more of an art than a science. It takes a team that focuses on the many moving parts of a VPP. The team must be cross-functional and collaborative as they are required to conduct program forecasts, call events, perform DER operations, conduct evaluations, and provide customer service.
Holy Cross Energy	1. Designing & Deploying VPPs	Deployment of VPPs	Customer Satisfaction & Resilience	HCE prioritizes customer satisfaction and simplicity, emphasizing the increased resiliency provided by their VPP. Enrollment typically spikes after extreme weather events, indicating strong customer interest in resilience.
National Grid	1. Designing & Deploying VPPs	Customer Experience	Targeting Low- and Middle-Income Communities	National Grid plans to enhance engagement with low- to middle-income communities through increased incentives and new offerings, including free batteries through the Generac DOE Grip Grant and higher incentives for income eligible customers for the thermostat-based DR measure.

Utility	Theme	Category	Subcategory	Details
National Grid	1. Designing & Deploying VPPs	Deploying VPPs	Program Efficiency and Savings	Commercial programs offer significant energy savings, and National Grid strives to work with multiple OEMs to offer diverse options to customers.
			Various Program Designs	National Grid covers multiple states with their VPP. This allows them to achieve more with their programs and enables state specific strategies. For example, in Massachusetts, fossil-based generation is not eligible for DR programs, whereas in New York, fossil-based generation is allowed. Commercial-scale battery storage is allowed to participate in both Massachusetts and New York. However, in Massachusetts incentives for commercial-scale battery storage is limited to 150% of site load. Commercial customers have several options to participate with the number of events per summer varying between 5 to 50 events per summer depending on the option selected.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	1. Designing & Deploying VPPs	Building a VPP Team	Dedicated VPP Role and Integration	PGE has established a specific role to manage and oversee VPP initiatives, which includes integrating cross-functional teams to develop and operate VPPs effectively from concept through deployment.
			Role of a Facilitator	The role of the VPP director includes acting as a facilitator or "translator" among teams, ensuring clear and consistent communication and alignment on VPP goals and processes.
		Change Management	Team Communication and Change Management	Effective communication within teams involves understanding resistance to change and ensuring coherence in conveying concepts. Listening to concerns and addressing them is key to successful change management.
		Customer Experience	Customer Experience and Operational Flexibility	With DERs, the customer experience becomes intertwined with operational performance—the flywheel of value. Balancing reliable operation with customer choice and control is essential.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	1. Designing & Deploying VPPs	Building a VPP Team	Dedicated Roles	PSE has expanded its workforce to include roles specifically for managing the VPP, involving teams from Customer Energy Management, Customer Energy Innovation, Electric Systems Operations, and IT.
			Executive Support	Strong leadership support is crucial for overcoming risks and challenges associated with pioneering a new VPP approach.
		Designing VPPs	Design and Refinement	PSE's VPP design began with a vision and was refined through industry research and lessons from other utilities. These efforts revealed that many utilities had more than one VPP, which led to significant back-end complications. These experiences contributed to PSE's focus on creating a custom streamlined, user-friendly interface with a complex backend tailored to enhance customer and data lifecycle management, control, and alignment with business objectives.
			Vision and Strategic Planning	PSE began its VPP platform envisioning the VPP as central to managing and dispatching existing and new DER capacity, while providing scalability for it to operate DERs at the distribution level.

Utility	Theme	Category	Subcategory	Details
Rocky Mountain Power	1. Designing & Deploying VPPs	Customer Experience	Customer-Centric Approach	RMP's VPP design focuses on delivering value to customers and ensuring DERs meet performance standards akin to traditional resources.
		Designing VPPs	Innovation and Flexibility	RMP emphasizes the need for innovative approaches rather than sticking to traditional practices. A unified vision and innovative mindset are crucial for success.
			Pilot Programs	Rapid transition from pilot to full program is needed to scale VPPs. For example, RMP successfully scaled its battery program from pilot to full implementation, enrolling over 1,000 customer commitments within 9 months.
			Process Refinement	RMP continually improves its DER programs to align with grid goals, using programs like Cool Keeper as blueprints for new battery, EV, and commercial/industrial demand response (DR) programs.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	1. Designing & Deploying VPPs	Building a VPP Team	Change Management	Change management is required to realize the stacked value of the coordinated resources. Negotiation and communication between distribution system operators and customer program operators is needed to realize the full potential of DERs.
			Cross-Functional Collaboration	Successful VPP implementation requires coordination between various internal teams and effective change management. SMUD leadership and its zero-carbon goal drives this cross-functional collaboration, aiding the integration of DERs.
		Designing VPPs	Program Design	SMUD has found that their battery program design offers low supply costs (both capacity and energy) and high reliability for the grid and bill savings for customers. They also have air conditioning cycling and direct power disruption via load control switches. Customers have an option to opt out; however, it is not typical for customers to override the settings, so incentives are larger.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	1. Designing & Deploying VPPs	Designing VPPs	Load Flexibility	SMUD's internal goals for load flexibility are helping them meet their decarbonization goals, while also offering behavioral and VPP programs allowing their customers to participate in that clean energy transition. Having a clear goal of load flexibility allows them to build VPP programs and resources that meet their changing grid needs. Their behavioral programs provide access to resources that modify or shape load, while their VPP programs are able to provide dispatchable resources that behave similar to supply-side resources.
		Program Impementation	Vendor Challenges	In 2022, SMUD and Swell Energy launched a battery storage VPP program with the ability to provide 20 MWh and 10 MW of clean energy. In August of 2024, SMUD put the program on hold after Swell went out of business.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	1. Designing & Deploying VPPs	Standardization	VPP Definition	Definitions for VPPs are inconsistent; therefore, SMUD prefers to use the term "DERs" internally for clarity and uses the term "VPP" mainly for external communication. The term "VPP" is often used ambiguously to describe different aspects of DERs and their functions; creating confusion and hindering effective communication. Instead, SMUD refers to how they need DERs to perform for utility operations.
Eversource	2. Technology Maturity	Technology	Real-Time Data Limitations	Real-time data is often unavailable, affecting decision-making. Integration challenges or inconsistencies with battery manufacturers lead to manual data transfers.
			Resource Reliability and Event Savings	Batteries tend to more reliably participate in demand response events compared to thermostats due to less customer awareness of battery discharge.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	2. Technology Maturity	OEM	OEM Collaboration and Cost-Efficiency	HCE initially prioritized Tesla as an OEM in its Power+ program due to its cost-effectiveness and energy density. Now, with prices leveling, HCE is expanding partnerships to include other OEMs like Emporia, Flow and EnelX.
			OEM Integration Challenges	Incorporating new OEMs involves significant time and complexity due to legal constraints and API integration issues. HCE opted for a vendor that offers quick and cost-effective integration for their VPP platform.
		Standardization	Communication and Custom Solutions	VPP solution providers are creating custom solutions instead of using established DER communication standards (IEEE 2030.5), which are intended to streamline integrations. Communication standards will reduce costs for small utilities and increase the standardization of communications across multiple technologies.

Utility	Theme	Category	Subcategory	Details
National Grid	2. Technology Maturity	Technology	Emerging Technology	National Grid aims to expand programs and potentially incorporate new and emerging technologies. This will depend on new partnerships, enhanced technology efficiency and additional grid and customer benefits.
Puget Sound Energy	2. Technology Maturity	Standardization	Technology	It's the "wild west" out there when it comes to joining VPPs, DERs, and customer programs. The need for a vision is critical, but compromise and flexibility will be key when scaling VPP as technology matures.
Rocky Mountain Power	2. Technology Maturity	OEM	Vendor and OEM Relations	Effective VPPs require clear expectations and standards from utilities. OEMs should adapt their products to meet grid needs in order to participate in VPP programs.
		Standardization	OEM Compatibility	Clear program requirements and standards are essential for OEMs to design compatible products. Utilities must also test DERs to ensure alignment with grid needs.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	2. Technology Maturity	Technology	Technology Adoption	SMUD uses programs and incentives to drive the scale within their VPP operations. This will help grid operators utilize DERs as a VPP. If SMUD has a low number of enrolled batteries, grid operators will not be as interested in calling on them. This means that finding the right incentives structure is critical to scale VPPs. Utilities have an opportunity to scale VPPs with current state and federal funding, ultimately building up the resource base for their VPPs.
Eversource	3. Grid Planning & Operations	Emerging Technology	Data Collection and Real-time Visibility	Data collection and real-time visibility is important to justifying the benefits of VPP participation.
		Grid Services	VPP Operations	The utility needs to leverage assets like thermostats, batteries, and electric vehicle chargers for grid operations. There are challenges and considerations related to managing VPPs, such as load shifting, system peaks, and event calling. This will require the restructuring of VPPs to be more valuable and efficient by grouping assets at different levels like substation or feeder.

Utility	Theme	Category	Subcategory	Details
Eversource	3. Grid Planning & Operations	Software	DERMs	The utility works to ensure clarity on what types of energy management systems exist and how they are operated. For example, there are edge-DERMS, OEM-specific DERMS, and aggregator DERMS. The complexity of managing behind-the-meter assets and aggregating them into a megawatt form for grid response grows exponentially when you factor in all the different technologies and players in the VPP sector. For example, what is the role of an aggregator DERMS in pulling together edge DERMS and fleet DERMS into a VPP?
				There is ambiguity in how VPP software is defined today. There are varying definitions and functions of DERMS which can cause confusion. There's a need for clearer roles and better communication between grid and aggregator DERMS, something Eversource is championing.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	3. Grid Planning & Operations	Operations	VPP Platform	HCE's VPP solution partner provides an edge DERMS. This enhances their DER portfolio with the necessary communications, software, and hardware, improving their capability to manage DERs for grid operations.
National Grid	3. Grid Planning & Operations	Emerging Technology	Impact of Battery Integration	National Grid's early adoption of batteries to explore their various benefits has been a key factor in enhancing their resource capabilities, whereas other utilities were initially reluctant to use this resource.
		Grid Services	Grid Operations	Participating in an ISO has many advantages. It's also important to recognize that grid operators in New York play roles in calling events and forecasting peak grid times. This role is important to scaling VPPs and utilizing the resource for market participation and grid needs.
		Platform and Tools	Commercial vs. Residential Resource Management	Commercial customers predominantly use curtailment service providers (CSPs) for energy management, unlike residential programs which participate by the Company directly controlling customer-owned devices, such as thermostats, batteries, and water heaters.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	3. Grid Planning & Operations	Grid Services	Grid Edge Operations	Enhancing operations at the grid edge is critical for flexibility. This involves real-time computation and communication at the device level to manage customer usage patterns dynamically.
		Platform and Tools	DERs as a Grid Tool	DERs and flexible loads are viewed as integral tools for grid operators, capable of being dispatched like traditional resources when managed through a VPP platform.
		Utilization	Visibility and Confidence in Resource Availability	Real-time visibility and standardized protocols are crucial for reliable VPP operation. Ensuring customer engagement and resource performance requires centralized coordination and confidence in resource availability.
			Grid Services and Resource Efficiency	VPPs currently provide capacity and contingency reserve services. However, as PGE modernizes the grid and DERs advance, they intend to expand their VPPs to provide voltage control and economic dispatch. They will optimize DERs, reduce costs, and improve overall system efficiency.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	3. Grid Planning & Operations	Grid Operations	Single Platform Efficiency	PSE favors a unified VPP platform to simplify operations and enhance flexibility and value.
		Grid Services	Operational Approaches	PSE utilizes two main approaches for their VPP operation. They utilize their VPP to reduce grid demand through customer behavior and DERs, and plan to augment electric grid supply via VPP managed DERs (i.e., PSE owned, and non-PSE owned batteries) to enhance electric grid during specific time periods.
		Operations	VPP Forecast and Event Dispatch	VPP Forecast and Event Dispatch: PSE understood VPP dispatch would have operational impacts on the distribution system, because the VPP operational ownership was assigned to Distribution System Operations (DSO) from the outset. DSO is responsible for monitoring load forecasts, establishing dispatch thresholds and scheduling events. This approach has helped facilitate strategic decision-making and alignment with business objectives.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	3. Grid Planning & Operations	Platform and Tools	Business Platform Functionality	PSE considers the VPP platform to also function as a business platform which integrates into SAP, customer lifecycle management and customer acquisition capabilities. PSE emphasizes customer impact and satisfaction during VPP operations, aiming to minimize disruptions and enhance user experience.
			Custom Tools and Automation	PSE developed custom back-end tools and processes to automate key VPP activities managing all aspects of the customer and DER lifecycle. This includes DER enrollment, customer eligibility, DER eligibility, DER dispatch, customer program design, and evaluation and reporting.
			VPP Constraints	There are multiple layers of constraints to consider when developing a VPP. PSE says it is not just the VPP platform itself which has inherent constraints. While VPP platform interfaces will have constraints due to the various OEMs it's paired with, the OEMs have operational constraints which conflict with each other. On top of that, the tariffs which dictate your ability to execute different DER programs will have constraints that may conflict with VPP or OEM capabilities.

Utility	Theme	Category	Subcategory	Details
Rocky Mountain Power	3. Grid Planning & Operations	Grid Services	Single Button	"Single Button" Integration: RMP is working towards a streamlined VPP grid integration, which will take time to fully realize but is crucial for maximizing VPP value.
		Operations	Dashboard Integration	A user-friendly dashboard integrated with utility systems is necessary for efficient DER scheduling and automation.

Utility	Theme	Category	Subcategory	Details
Rocky Mountain Power	3. Grid Planning & Operations	Utilization	Capacity and Duration	RMP draws 250-300 MWs of DR during peak periods, with VPP events typically lasting 5-15 minutes. The program has a high customer satisfaction rate of approximately 90%.
			Contingency Reserve	During unscheduled DR events, RMP observed significant load drops and began using DR as a contingency reserve. The VPP can currently dispatch DERs for frequency response and contingency reserves within specific time frames.
			Frequency Regulation	Battery models vary in their response times to frequency events. Batteries in discharge mode respond quickly (6-7 seconds to ramp up), while those in standby or recharge mode have significant delays (45 seconds to ramp up and 60 seconds to reach target levels).
			Responsiveness	RMP's DERs are tested for instantaneous, autonomous response, meeting frequency response within 30 seconds and contingency reserves within 10 minutes.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	3. Grid Planning & Operations	Grid Services	Control and Predictability	Scaling VPPs is complicated by the lack of control over customer-owned DERs, which can be overridden, affecting their predictability and reliability. Current customer behavior models are insufficient for managing real-time grid needs.
		Operations	Bulk vs. Distribution System	SMUD finds the most value in VPPs is in bulk system management rather than addressing complex distribution constraints. This is because bulk value is most readily available in today's operational and policy environment. Distribution constraints have significant value to address, however, it is harder and will take longer with today's tools and processes due to the lack of mature solutions needed to target locational grid challenges. They are working to improve their ability to solve distribution issues with DERs through visibility and control.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	3. Grid Planning & Operations	Operations	Operational Management	Effective management of multiple DER programs and tools is crucial. SMUD sees the need for better forecasting and day-ahead models to improve the predictability and utility of DER resources.
		Software	Controllability	DERs require advanced enterprise DERMS and ADMS for effective grid integration and coordination among internal teams, needed to operate DERs as a grid resource.
Eversource	4. Policy & Regulatory	Achieving Alignment	Streamlined Processes	It's more than just saying 'we have these devices, so we can control them.' The utility actively manages the devices in partnership with their DERMS as well as the software of their party aggregator such as an edge-DERMS. Utilities need to identify and contact third party aggregators, gain regulatory approval for new programs or revise existing programs, as well as have access to customer data to justify the program offering.
		Adoption	Focus on Adoption	VPP programs should prioritize policy goals and DER adoption over immediate cost benefits.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	4. Policy & Regulatory	Adoption	Impact of Federal and State Incentives	The federal solar plus energy storage tax credit (30%) and Colorado's additional 10% incentive are significant drivers for expanding HCE's VPP resources.
National Grid	4. Policy & Regulatory	Achieving Alignment	Statewide Program Consistency	In Massachusetts, investor-owned utilities offer standardized programs under the "Mass Save" brand, providing uniform services across the state except for municipal light departments.
		Value and Cost	Cost Studies	The New England Avoided Energy Supply Cost Study provides a consistent, regional view of cost-effectiveness including utility-specific savings and is updated every 3 years.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	4. Policy & Regulatory	Adoption	Compensation Challenges	Compensating customers based on the value of their resources is a mature aspect of VPP development. However, DER cost-effectiveness needs adapted to ensure fair and effective compensation of a VPP's value to the grid.
		Value and Cost	Value Measurement and Evaluation	PGE evaluates VPP success through customer enrollments and the long-term value the resource is able to provide to the system. They are developing analysis to compare costs with and without VPP integration. The methodology needed to do this analysis is limited, but once developed, PGE will be able to assess the added value of a VPP to their system and customers.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	4. Policy & Regulatory	Achieving Alignment	Policy Drivers	PSE's initially lacked the typical VPP drivers like load growth or peak management, needed to develop a VPP as a core business requirement. With the passage of Washington state's 2019 legislation, Clean Energy Transformation Act (CETA), the VPP was envisioned as the management and dispatch platform for a significant portion of this new DER capacity.
			Transparency and Collaboration	PSE advocates for transparent dialogue with regulators and the development of national industry standards due to the various levels of knowledge and experience with DERs and load flexibility programs. Utilities should engage with regulators and legislators to establish how to account for, track and report the use of DERs within their market, along with ensuring an understanding of real-market feasibility of DER and load flexibility program capabilities.
		Value and Cost	Customer Benefit Indices	As part of their VPP, PSE has developed a cost-benefit analysis incorporating customer benefit indices to better assess the value of DERS, creating a value comparison, not just a dollar comparison.

Utility	Theme	Category	Subcategory	Details
Rocky Mountain Power	4. Policy & Regulatory	Funding and Support	State and Federal Funding	Strong relationships with regulators and access to state and federal funding are important for scaling VPPs. Utah's support and funding for innovative projects have been beneficial for RMP.
Sacramento Municipal Utility District	4. Policy & Regulatory	Funding and Support	Funding and Support	Leveraging state and federal funding is critical for scaling VPPs and building a robust resource base. SMUD sees this as a key factor in successfully deploying their VPP initiatives.

Utility	Theme	Category	Subcategory	Details
Eversource	5. VPP Models	Current VPP Focus	ISO New England	Primarily targets summer system peaks.
			Residential Programs	Includes 100,000 thermostats, 6,000 batteries, and 6,000 EV chargers and electric vehicles.
			Commercial and Industrial	Large C&I customer curtailment contributes 75%, thermostats 20%, and the remainder from batteries and EVs.
			Grid Operations	Eversource has a high focus on DERs as grid resources. Their VPP is focused on achieving real-time visibility of devices and software such as DERMS needed to control devices.
		Evolution	Improvement Efforts	Enhancing VPP operations and marketing strategies will allow for program scalability. Additionally, there is a need for continued and improved integration and coordination among different players in the VPP landscape.
		Value and Cost	Value and Compensation	Eversource uses the New England Avoided Energy Supply Cost Study to determine the grid service value of DERs. Eversource included the concept of a grid compensation fund in their Electric Sector Modernization Plan, which was proposed in 2024, that would allow compensation of VPPs.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	5. VPP Models	Current VPP Focus	Charge at Home	HCE has 600 EV chargers enrolled. Incentivizes Level 2 chargers that provide distribution flexibility. The pilot is beginning to use EV chargers to curtail load during the same hours that they discharge their Power+ batteries.
			Power+ Battery Program	HCE has the option to control member-sited batteries up to 10x per month for peak demand reduction and oversupply management. Member cannot opt out, in return for a high monthly incentive. Member pays for batteries with on bill financing, and the cost is offset by the bill credit for HCE control. Currently the program has approximately 200 participants and 3.5 MW.
			Power+Flex Program	HCE has the option to control member-owned batteries up to 10x per month for peak demand reduction and oversupply management. Member decides the battery capacity to enroll, and member is compensated based on performance during control events.

Utility	Theme	Category		Details
Holy Cross Energy	5. VPP Models	Current VPP Focus	High Mesa Project	HCE's distribution connected, multi-MW scale High Mesa project integrates battery storage and renewables. This project will store excess solar energy produced during the day for use during peak evening hours, addressing high demand periods.
			Peak Time Payback	Since 2019, HCE has called demand response events to support the grid. Today, HCE regularly calls events to lower its coincident peak and ensure reliability. Members who are enrolled in HCE's Peak Time Payback program and reduce their energy use during these events receive credits on their bill. Currently, HCE has access to about 2 MW of demand response resources through this program. HCE's system peak demand is 270 MW. HCE is also piloting their Green Up program to incentivize increases in usage during renewable oversupply events.
		Decarbonization	2030 Renewable Target	HCE aims to reach 100% renewable energy by increasing the renewable electricity they provide to members, and completely offsetting their greenhouse gas emissions to net-zero by 2035. To achieve this goal, they will need to partner with their members and communities to incorporate new, clean, dispatchable resources into their power supply mix.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	5. VPP Models	Decarbonization	Executive Support	HCE's Board values clean energy projects and supports the pursuit of their VPP. Strong leadership is key to deploying and scaling their VPP. Without this, their VPP likely would not exist or be as successful.
		Model Types	Utility vs. Customer Battery Ownership Models	HCE traditionally owned customer batteries but is testing a customer-owned model. Utility ownership of batteries is labor-intensive and costly. The ownership model's key benefit is offering on-bill repayment, enabling zero up-front costs for members purchasing a $60K battery system. HCE is exploring other models to reduce costs such as its Power+Flex program, which offers performance-based credits to customers. Customers can choose how much power they want to make available to HCE. HCE discharges Power+ and Power+FLEX battery programs the same way, up to 10 ten events per month to try to hit the one coincident peak hour.
			Reluctance to Replicate Model	HCE's VPP and DR programs are designed to be revenue neutral, returning benefits to the participants without shifting costs to non-participating members. While HCE has had success with their VPP and DR programs, other small utilities may be hesitant to adopt HCE's model due to the administrative complexities of these programs.

Utility	Theme	Category	Subcategory	Details
National Grid	5. VPP Models	Current VPP Focus	Demand Response Strategy	Currently uses DR primarily for peak shaving. They estimate that reducing peak demand by 10% could cut long-term grid operation costs by 40%.
			Peak Shaving	The entire Connected Solutions portfolio can remove about 350 MW of load from the grid during peak times.
			Connected-Solutions	A technology agnostic program, that recently launched a thermostat program; operating 15 events each summer, each lasting 3 hours. The battery program, launched in 2018-2019, includes ~50 events per summer, each lasting 2-3 hours. They also have an EV Time-of-Use incentive program. A water heater program is slated for 2025, designed to function similarly to the existing smart thermostat program through EnergyHub's DERMS.

Utility	Theme	Category	Subcategory	Details
National Grid	5. VPP Models	Current VPP Focus	Commercial Offerings	National Grid's commercial program incentivizes load reduction during events, with pay-for-performance incentives allowing flexible curtailment strategies and diverse DER technologies (e.g., HVAC, lighting controls, thermal storage, vehicle-to-grid).
			Equity	In partnership with Generac, has received a US DOE GRIP Grant to offer income eligible customers approximately 2,000 free battery storage system installs.
		Evolution	VPP Challenges	The regulatory framework and profit mechanisms for using DERs to solve local distribution system needs is still being developed in MA.

Utility	Theme	Category	Subcategory	Details
National Grid	5. VPP Models	Value and Cost	Cost-Effectiveness and Incentives	Massachusetts mandates utilities to offer all cost-effective energy efficiency and demand response programs. This provides a solid mandate for offering DR programs for benefits quantified in the Avoided Energy Supply Cost (AESC) study. However, some benefits that DERs can provide, such as improving power quality with inverters, or accelerating solar and battery interconnection by allowing utilities to control output at peak times, are not yet quantified in the AESC. A significant portion (90%) of the demand response program costs is allocated to customer incentives. National Grid sees the benefits of increased thermostat incentives as they have occasionally experimented with higher incentives to observe their impact on market behavior, resulting in increased thermostat enrollment.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	5. VPP Models	Current VPP Focus	Valuation of DERs	DERs are capable of full participation in the energy value chain when integrated with the technology necessary to operate them with confidence. By deploying them in concert with system conditions, resources within the distribution system provide grid benefits, which enables compensating customers for the value they contribute. With increased compensation tied to grid value, customers are incentivized to increase participation, which then provides more grid value. This creates a flywheel encouraging more participation that generates more value over time.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	5. VPP Models	Current VPP Focus	VPP Orchestration	VPP orchestration is the matching of generation and load. Significant growth of DERs is predicted in PGE's 2023 Clean Energy Plan (CEP) and Integrated Resource Plan (IRP). Their IRP resource adequacy calculations and portfolio analysis assume that all DER types can be integrated into PGE's system and deliver their full potential system value. However, extending this assumption to smaller and/or behind-the-meter resources requires advancement of technology to efficiently monitor, schedule and dispatch resources.
			DERMS	PGE manages DERs through their DERMS, which will provide real-time visibility and dispatch capability for generation, flexible loads, and batteries residing within the distribution network. DERMS implementation will provide data to support improved accuracy of DER and flexible load modeling in IRP analysis, as well as simplified integration and operation.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	5. VPP Models	Current VPP Focus	TestBed	PGE manages a Smart Grid TestBed (TestBed) to evaluate technologies that will be integrated to increase VPP capabilities. Their award-winning Strategic Innovation approach accelerates these technologies from concept to commercialization. PGE's Flexible Feeder tests new smart-grid control devices to allow bi-directional power exchange between PGE and program participants. As part of the TestBed, three neighborhoods were enrolled to evaluate different program models to reduce peak demand. The Flexible Feeder was composed of 525 residential storage batteries. Some households were offered $5,000 in rebates for battery systems plus incentives which were deducted from their monthly electric bill.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	5. VPP Models	Current VPP Focus	Peak Offset	PGE aims to incorporate 2,000 MW of VPP-enabled DERs by 2030 to deliver a 25% peak usage offset while serving 100% of customer energy demands. By increasing the utilization of existing resources, it is contributing to decarbonization goals, which is an essential component of the clean energy transition.
			Current VPP	PGE's VPP had approximately 225 MW capable of providing one or more grid services such as peak shaving by precooling homes before a heatwave or asking customers to wash laundry outside of the peak period. They have over 225,000 customers enrolled in its Flexible Load and Renewable Energy programs and have called over 140 events.
			Battery Storage	PGE recently acquired 475 MW of battery storage which will be operational in mid-2025. In addition to direct regional market participation, these batteries will be integrated with PGE's EMS and visible to PGE's DERMS to support the operation of DERs and flexible loads, offering services that couldn't be delivered in isolation.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	5. VPP Models	Model Types	Utility Business Model Adaptation	The regulated utility model is seen as well-suited for VPP deployment, as it can equitably serve all customers while managing infrastructure and reducing costs.
		Value and Cost	Collective Benefits and Inclusivity	A core tenant of PGE’s VPP is maximizing collective benefits from DERs and flexible loads and ensuring that clean energy advantages extend to all communities, not just those with financial means.
Puget Sound Energy	5. VPP Models	Current VPP Focus	Decarbonization	CETI mandates a shift to 100% clean energy by 2045. PSE's Integrated Resource Plan (IRP) updated in 2021 reflects this goal, with plans for 522 MW of distributed batteries, solar, and demand response by 2031.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	5. VPP Models	Current VPP Focus	Customization and Scalability	Because PSE is building their VPP internally with support of a third-party, they can manage the process from end-to-end. However, lack of standardization throughout the OEM ecosystems sometimes requires customization limiting the ability to rapidly and comprehensively design and deploy new VPP programs. PSE emphasizes the importance of assessing the ability of DERs to support system load reduction. This assessment considers factors such as weather forecasts, total number of outages, program constraints, DER availability, DER operations, and recent event calls for each of the specific programs. Finally, PSE says daily monitoring of the six-day system load forecast helps assess forecasted peak load and establish whether demand is expected to exceed defined dispatch thresholds.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	5. VPP Models	Evolution	VPP Challenges	Challenges may stem from the origins of VPP technology and customer programs stemming from traditional DER program implementation, which were created in deregulated markets and thus may not have factored in additional complexities, such as regulations and standards that utilities must consider when managing the grid. This has been a big hurdle in PSE's VPP development process.
			Custom Solutions	The unique needs of utilities mean that no single VPP solution fits all. PSE uses multiple vendors to manage different aspects of the VPP lifecycle, highlighting the need for tailored solutions.
			Customer Management	Utilities are best situated to manage the customer life-cycle management process. Currently, there isn't a single VPP vendor with the ability to manage custom back-end processes related to meter swaps, customer relocations, move outs, opt outs and decommissioning.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	5. VPP Models	Model Types	VPP as a Utility Resource	The business model for a VPP is to ensure it acts as a utility resource. This requires standardization.
Rocky Mountain Power	5. VPP Models	Value and Cost	Cost Evaluation	RMP evaluates the incremental cost to the utility rather than the cost of customer ownership when assessing the effectiveness of DERs and VPPs.
Sacramento Municipal Utility District	5. VPP Models	Value and Cost	Battery Costs vs. Benefit	According to current planning practices, batteries are considered new loads which may require system upgrades. A challenge SMUD faces is how to account for the fact that their battery pilot will help provide grid benefits but is also seen as a load addition. This requires new thinking on how to account for the costs and benefits of batteries to the grid and customers.

Utility	Theme	Category	Subcategory	Details
Eversource	6. Scaling Future VPPs	Workforce Development	Coordination and Communication	Having a clear understanding of how VPPs should operate, what is needed and what each parties' roles are is needed among the many various stakeholders in the VPP ecosystem.
		Solution Development	Programs for Distribution Constraints	Policies driving VPPs that are focused on traditional DER program implementation sometimes hinders a utility's ability to deploy a VPP for distribution system constraints. Eversource has three programs in addition to its ConnectedSolutions program, which are funded outside their energy efficiency portfolio, that have the ability to target distribution level constraints: New Hampshire Clean Energy Fund battery program, Connecticut Electric Vehicle Managed Charging program, and Energy Storage Solutions battery program in Connecticut.

Utility	Theme	Category	Subcategory	Details
Eversource	6. Scaling Future VPPs	Solution Development	Solution Provider Specialization	VPP solution providers are encouraged to focus on specific services to improve effectiveness of scaling VPPs. A one-size-fits-all approach may not be productive for identifying solutions that fit a utility's specific resource and grid needs.
			Visibility	During events, real-time visibility is key to see when customers are opting out—which opens up the opportunity to improve participation rates. For example, Eversource is managing peak load for all of New England yet does not have visibility into more localized system constraints, which could be addressed by VPP.
		Standardization	Standardization and Clarity	There is no industry-wide standardization and clarity in terminologies like DERMS and VPPs. This is needed to overcome challenges and variations in defining VPPs across different programs and utilities. Developing a common set of VPP models will help to categorize programs effectively.

Utility	Theme	Category	Subcategory	Details
Eversource	6. Scaling Future VPPs	Technology Advancements	Real-Time Data	Real-time data is not currently available, despite the advancements that VPP solution providers have made. OEMs will need to develop ways for more technologies to integrate into grid operations and provide at least 15-minute interval data. For example, Eversource only has a few battery OEMs that are integrated with its aggregator DERMs to provide 15-minute interval data. Eversource has to integrate data from the other OEMs through a manual file transfer after each event.
		Value and Cost	Value from VPPs	There is a tremendous opportunity to optimize VPPs by grouping resources at localized levels like substations or feeders and improving communication between customer programs and backend systems. The more customer programs and backend system operations can find ways to communicate, the value of VPPs will grow exponentially.

Utility	Theme	Category	Subcategory	Details
Holy Cross Energy	6. Scaling Future VPPs	Solution Development	Provider Challenges for Smaller Utilities	HCE is looking for VPP solutions that are compatible with multiple OEMs and offer streamlined packages. However, they are finding it challenging to scale VPPs because solution providers prefer larger utilities or will charge higher fees for smaller programs.
		Value and Cost	Future Value of VPP	HCE is exploring using batteries to address transformer overloads and other system operation needs in the future.
National Grid	6. Scaling Future VPPs	Solution Development	Future VPPs	National Grid sees opportunities for VPP growth and scalability through new partnerships and innovative energy sector solutions.

Utility	Theme	Category	Subcategory	Details
National Grid	6. Scaling Future VPPs	Solution Development	Learning from Other Utilities	National Grid is leveraging insights from ConEd's targeted dispatch of DERs and exploring similar strategies in Massachusetts.
			Streamlined Collaboration	National Grid emphasizes the need for enhanced collaboration among aggregators and OEMs for streamlined program participation and cost-effectiveness.
Portland General Electric	6. Scaling Future VPPs	Regulatory Adaptation	Compensation	Compensation for DERs is a critical aspect of VPP maturity. Adapting regulatory approaches and compensation models is essential for the successful implementation, scaling and operation of VPPs. This involves evolving traditional methods to better capture the dynamic and variable value that DERs provide in an increasingly complex and weather-dependent energy system.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	6. Scaling Future VPPs	Solution Development	Challenges with New Infrastructure	VPPs are positioned as a crucial tool for managing immediate energy demands and optimizing existing infrastructure, bridging the gap until new energy solutions come online. Growing demand necessitates new generation and transmission infrastructure, which is a time-consuming process. These new resources will take many years to develop and integrate into the grid. VPPs enhance the utilization of current DERs and infrastructure, making them more efficient and effective. They serve as a critical interim solution to address increasing customer needs while new, clean energy resources are being developed and integrated.
			Utility Business Model Adaptation	The regulated utility model is seen as well-suited for VPP deployment, as it can equitably serve all customers while managing infrastructure and reducing costs.

Utility	Theme	Category	Subcategory	Details
Portland General Electric	6. Scaling Future VPPs	Solution Development	VPP Design Considerations	A well-designed VPP requires new ways to forecast load and generation on the distribution system. It considers resource adequacy, resource diversity, and supply chain and labor market dynamics. Systems to see and manage system and resource conditions on both the transmission and distribution side must integrate to orchestrate the VPP.
		Technology Advancements	Advanced Technology Integration	PGE utilizes advanced enterprise energy management systems (ADMS and DERMS) for managing DERs, emphasizing the need for real-time technology and optimization at the grid edge level needed for effective, scalable VPP operations.
			Open-Source Technology	PGE supports open-source technology frameworks and uniform interconnection standards to accelerate integration of devices with VPPs. The availability of open-source code and uniform standards enables faster implementation and reduces the costs when integrating with multiple application programming interfaces (APIs).

Utility	Theme	Category	Subcategory	Details
Portland General Electric	6. Scaling Future VPPs	Value and Cost	Balancing Static and Dynamic Pricing	Addressing skepticism about the value of VPPs involves balancing static value assessments with real-time dynamic pricing. Also recognizing that VPPs are not a replacement to other resources, but a crucial complementary part of the energy transition.
Puget Sound Energy	6. Scaling Future VPPs	Solution Development	Platform Evolution	PSE believes that starting with one integrated VPP platform provides the most flexibility and value to an organization. A unified platform also enhances the user experience by simplifying and streamlining operations, making it more user-friendly and valuable. PSE's VPP is designed to evolve with system changes and is currently used for peak demand response. Future plans include expanding VPP capabilities and increasing resource engagement as the platform grows.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	6. Scaling Future VPPs	Solution Development	Regulated vs. Deregulated Models	PSE operates under a regulated model, requiring different strategies compared to deregulated markets, which are very different from regulated markets. FERC 2222 will help with leveling the playing field, but effective operation of DERs in regulated markets requires collaboration among the various entities.
			Scalability	PSE underscores the importance of adaptability, regulatory alignment, and the need for custom solutions in ensuring future VPP development and deployment. The largest opportunity for PSE's VPP to provide benefits and value is through decarbonization, non-wire solutions, and grid flexibility. PSE sees great potential benefit with DERs. PSE is currently working to add new resources such as residential and non-residential batteries, SMB Thermostats and expanded water heater programs. During this Winter Season, PSE was able to demonstrate that the VPP can be used to enable DER management and dispatch for System Peak Demand Response events while delivering grid benefits. They currently aim to establish 86 MW of capacity savings by end of 2025.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	6. Scaling Future VPPs	Standardization	OEM Standardization	In the VPP market, achieving OEM standardization is crucial. However, this can be challenging due to competition among various players attempting to establish direct connections with customers. This can lead to confusion among utilities, regulators, policy makers, OEMs, aggregators, and customers. This leads to complications when designing a program, enrolling customers, and identifying the optimal participation process. Things get even more challenging when OEMs want to be DER aggregators, a challenge PSE is trying to solve by implementing a holistic aggregation platform with their solution provider. This platform consolidates customer enrollment into a single point, but even this has challenges as some OEMs only enroll in programs through proprietary apps or other software that is incompatible with standardization efforts. PSE is utilizing this enrollment aggregation point in an attempt to ‘aggregate the aggregators,’ giving customers a single point of program enrollment, but some OEMs prohibit this.

Utility	Theme	Category	Subcategory	Details
Puget Sound Energy	6. Scaling Future VPPs	Standardization	Industry Standards	Creating industry-recognized methods is needed to ensure resources are dispatched, reliably delivered, and perform as expected for customers, while establishing clear measurement standards can help alleviate uncertainties.
Rocky Mountain Power	6. Scaling Future VPPs	Value and Cost	Resilience	The timing of power outages affects VPP performance. Outages during the day can be mitigated by solar power and battery recharging, while nighttime outages might deplete batteries faster. For example, summer solar production exceeds consumption, whereas winter production is less than consumption. The variation in daytime and night-time usage complicates efforts to develop a straight average calculation of back-up battery coverage hours, but the subtleties are important to consider so customers can implement a conservation strategy during a grid outage. This will ensure they have sufficient resiliency as batteries are not intended to provide complete home back up for an extended period of time.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	6. Scaling Future VPPs	Solution Development	Playbook	Develop processes needed to establish what a VPP is for your organization. This will avoid painful backend processes where there is no clear industry standard with definitions and terminology for VPPs.
			Streamlined Management	SMUD sees the need to effectively manage multiple vendors and software platforms in order to fully utilize DERs and ensure a range of offerings for all customers to participate in their programs. Their grid needs to use VPP resources for real-time operations, but today it is not large enough or predictable enough to displace other bulk system resources. This means that better forecasting and modeling are key; including day-ahead forecasting.

Utility	Theme	Category	Subcategory	Details
Sacramento Municipal Utility District	6. Scaling Future VPPs	Standardization	Terminology	VPP is most often used ambiguously as a noun. SMUD is learning to use it as an adjective to accompany more descriptive aspects of DER integration. This is because people frequently use "VPP" to describe the use case, benefits, or goals of how they want DERs to perform. As a result, the definition of a VPP can vary depending on the speaker's perspective. For instance, program operators view a VPP as a customer program focused on recruiting customers and enrolling assets, involving data collection and customer communication. Conversely, distribution operations engineers see a VPP as a platform for grouping, controlling, and monitoring DERMS.
				The term "aggregator" varies widely in the VPP space, complicating integration efforts. SMUD highlights the need for standardized definitions and platforms to streamline the integration of diverse assets and services.
		Technology Advancements	Scalability	The ability to scale VPPs is dependent on the specific assets within the VPP platform.