Using Virtual Power Plants to Provide Real Grid Services and Cost Savings

DOE/LBNL Technical Training

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Agenda

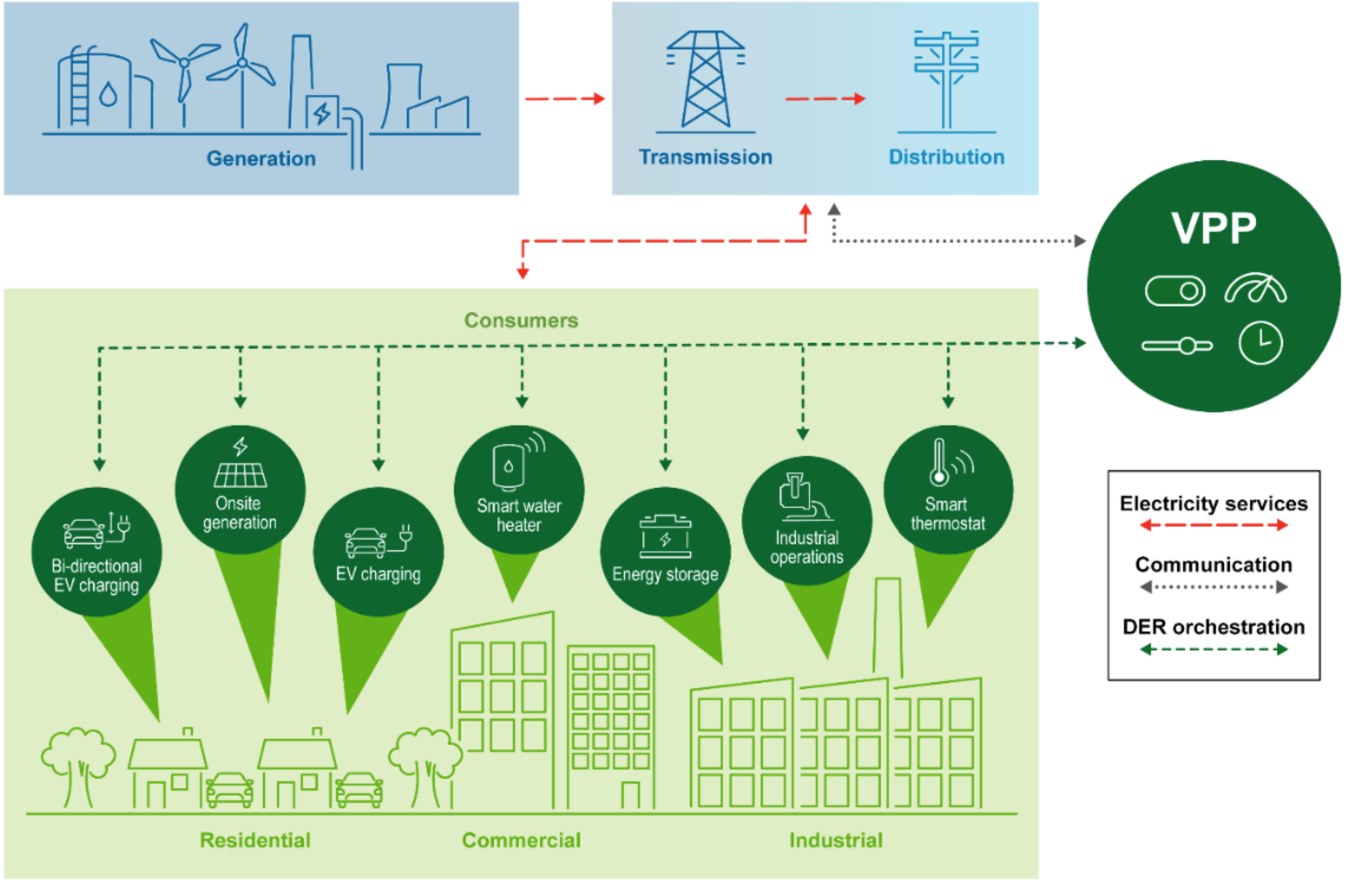
Background – What is a VPP?

Challenges, Opportunities and Examples of Scaling VPPs

- ◻ Establish clear goals and objectives
- ◻ Identify and implement how DERs can be integrated into different organizational silos
- ◻ Design programs for customers
- ◻ Ensure grid operators see VPPs as a credible, reliable resource
- ◻ Leverage existing DERs to more quickly create VPPs
- ◻ Understand what grid investments are needed, based on the sophistication of the VPP

Background

What is a virtual power plant (VPP)?

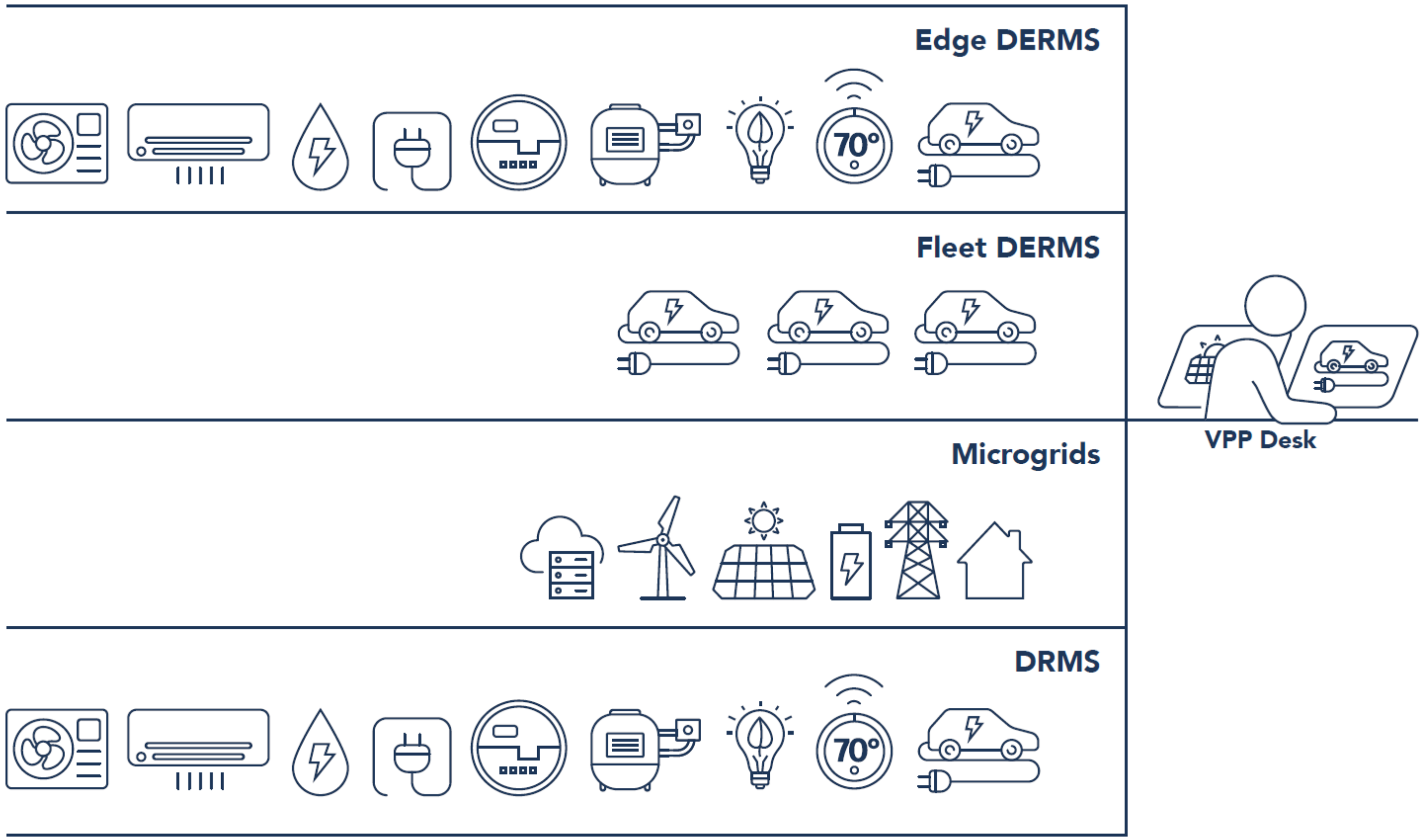


Source: DOE

VPPs are aggregations of distributed energy resources (DERs) such as smart appliances, rooftop solar with batteries, EVs and chargers, and commercial and industrial loads that can balance electricity demand and supply and provide grid services like a traditional power plant.

The grid edge is where buildings, industry, transportation, renewables, storage, and the electric grid come together. More specifically, it's the area where electricity distribution transitions between the energy utility and the end user (DOE).

VPPs can be composed of aggregated DERs from a variety of platforms

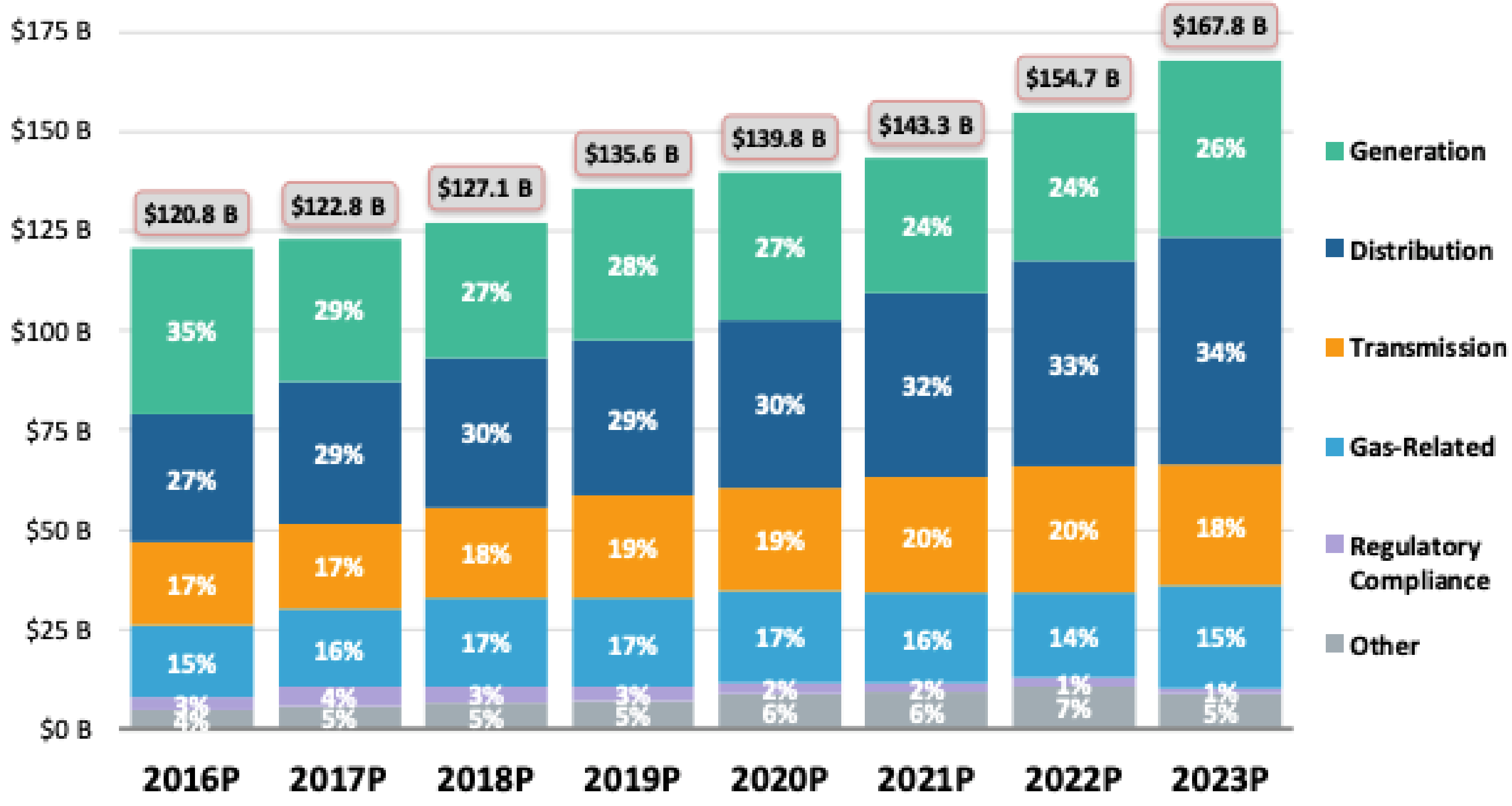


Distributed Energy Resource Management Systems (DERMS) are application platforms designed to manage DER device information, monitor and enable optimization and control of DER and demand response assets, and integrate aggregation and network information to the utility (SEPA).

DERMS are often classified by where they are located in the grid architecture (e.g., centralized, edge, fleet) (SEPA).

Demand Response Management Systems (DRMS) are similar to DERMS but have been traditionally used for a utility's day-ahead and bulk system needs, using behind-the-meter technologies.

VPPs can help achieve state energy goals as a least-cost resource



VPPs can be a least-cost resource to meet grid needs, achieve state energy goals, provide increased consumer choice and advance equity.

Source: EEI, 2023, Projected Electric Company Industry Capital Expenditures

VPP value proposition

Resource adequacy	Affordability	Reliability & resilience	Decarbonization & air pollution reduction	T & D infrastructure relief	Community empowerment	Versatility & flexibility
• Integrate distributed generation and storage capacity • Shift demand to follow supply	• Defer grid capex (generation, T & D) • Avoid fuel costs • Compensate consumers and businesses	• Integrate back-up power • Eliminate single-point-of -failure	• Add distributed renewable generation • Reduce curtailment of renewables • Reduce reliance on fossil fuels	• Increase efficiency by smoothing peaks • Alleviate congestion with local dispatch	• Enable consumers to optimize energy cost, use, and source • Retain and create good jobs	• Customize design to fit grid needs • Reconfigure as needs evolve

Source: DOE

VPPs can provide a variety of grid services

Demand side resources (efficency, demand response/flexibility)

- Energy
- Generation, transmission and distribution capacity
- Frequency response
- Grid edge resilience

Solar photovoltaic (PV) and fossil fuel generators

- Energy
- Generation, transmission and distribution capacity
- Frequency response
- Operating reserves
- Grid edge resilience

Batteries and electric vehicles (EVs)

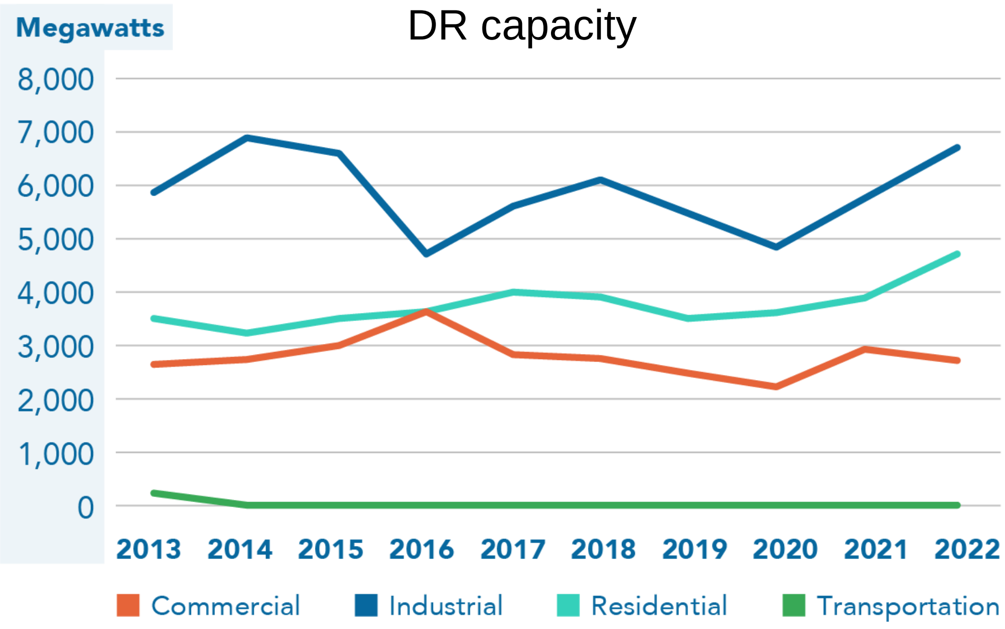
- Energy
- Generation, transmission and distribution capacity
- Frequency response
- Operating reserves
- Grid edge resilience

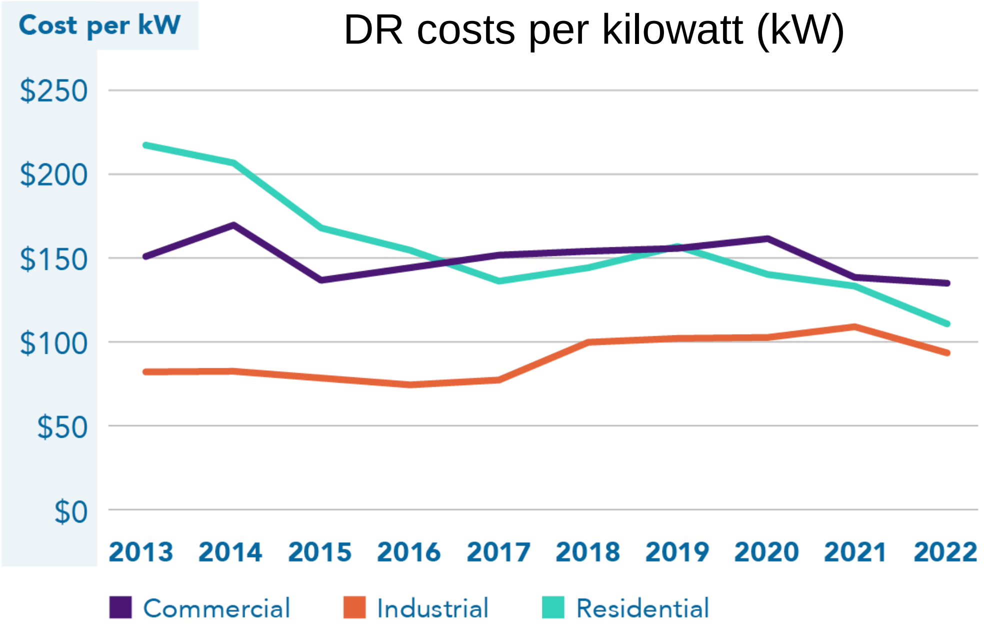
Today, most VPPs provide peak demand reductions

- Composed of DER aggregations that provide limited grid services due to lack of communications, visibility, and control.

- Predominently owned and operated by utilities.

- Demand response programs for peak load reduction include:
  - Smart thermostat programs
  - Bring your own battery programs

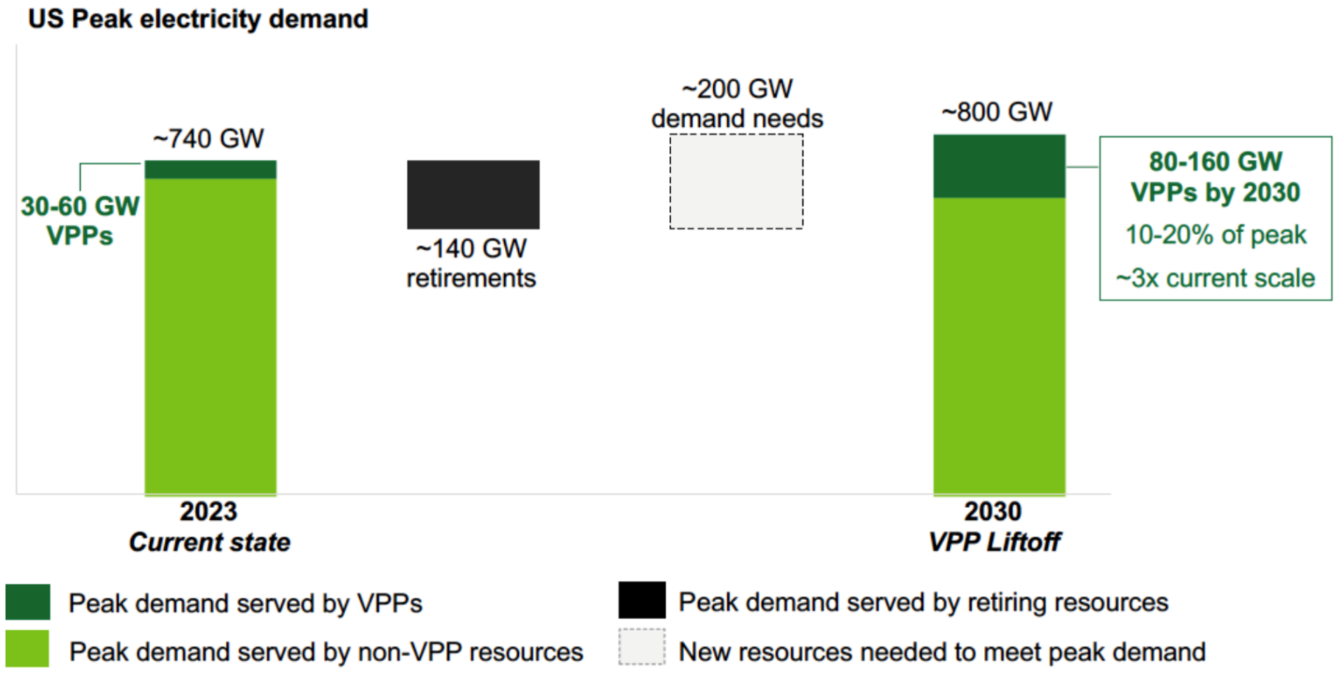




Challenges, Opportunities and Examples of Scaling VPPs

Opportunities to accelerate scaling VPPs

- Establish clear goals and objectives
- Identify and implement how DERs can be integrated into different organizational silos
- Design programs for customers
- Ensure grid operators see VPPs as a credible, reliable resource
- Leverage existing DERs to more quickly create VPPs
- Understand what cost-effective grid technologies and operational changes are needed



Source: DOE

Clear goals and objectives

There are many definitions of VPPs, which can create confusion when communicating between regulators, utilities, aggregators and other parties. To avoid this, successful VPPs establish specific goals and objectives, including:

- Desired grid services
- Eligible DERs
- Standards and protocols for DER participation
- Target customer type/class
- How often the VPP will be used
- Policy goals the VPP will contribute to achieving
- How cost-effectiveness (or if a VPP is a least-cost resource) is determined

Organizational change

- This transition from traditional grid operations to more complex VPP requires active participation from all levels of the organization, from operators to leadership.

- Implementing advanced VPPs will likely require a shift from conventional grid practices.

- Engaging all levels of the organization is an integral part of the process, from integrating DERs into grid operations to customer programs.

Source: Berkeley Lab

PGE's VPP is successful, in part, because they have a VPP director

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.

Flex Load and DERs: Improved monitoring, scheduling, and dispatching. Flex Load and DER participation in regional markets are supported through DERMS integration.

CASE STUDY — PORTLAND GENERAL ELECTRIC

PGE

The role of team communication and change management in VPPs

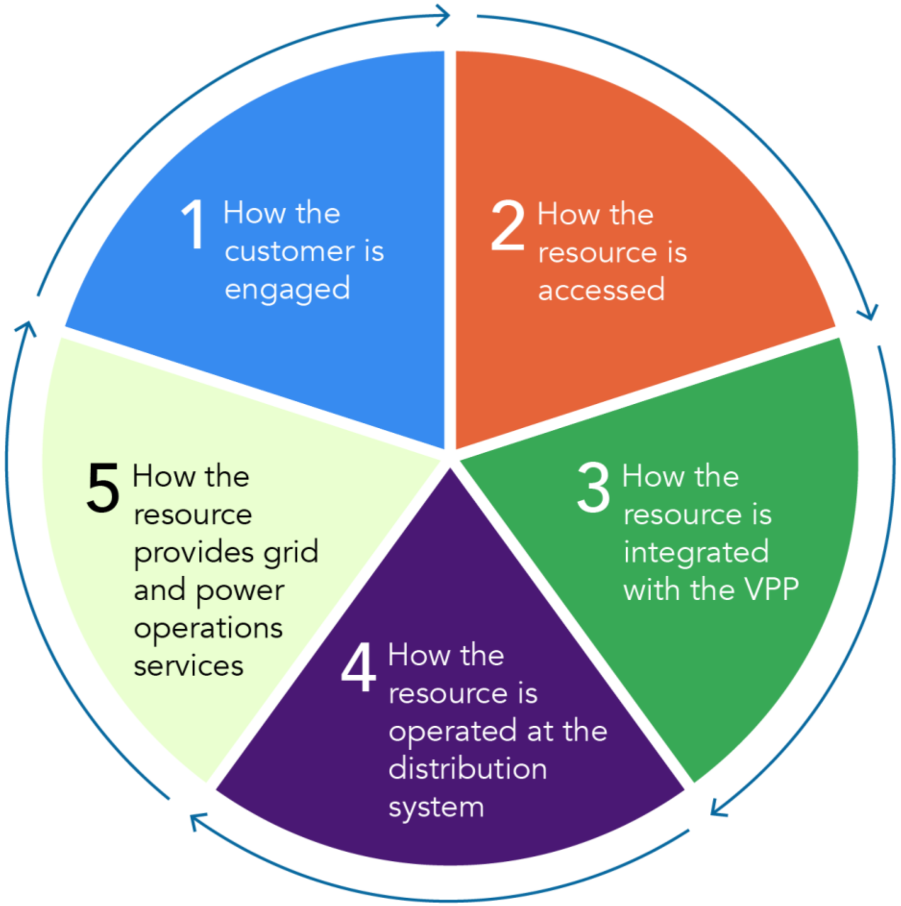
A structured approach to deploying VPPs, led by a VPP director who serves as a facilitator or "translator," ensures effective integration of cross-functional teams from concept through deployment.

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

Source: Berkeley Lab

Design VPPs for customers

- Focusing on customer needs in program design can improve VPP success and value
  - SMUD My Energy Optimizer Partner+ - Bring Your Own DER programs can provide additional value streams for customers for assets they already own
- Identify customer priorities (e.g., resilience, affordability) and focus program incentives to meet those needs
  - Portland General Electric offers higher incentives for energy efficiency and renewable energy in specific geographic locations, including a 1.4 MW Flex Load resource project targted at a historically underserved community.
- Design programs for multiple goals
  - Generac and Massachusetts utilities are offering grid-edge technologies to low-and moderate-income (LMI) customers, leveraging a federal resilience grant. Generac will manage the energy assets as a VPP.



Source: Berkeley Lab

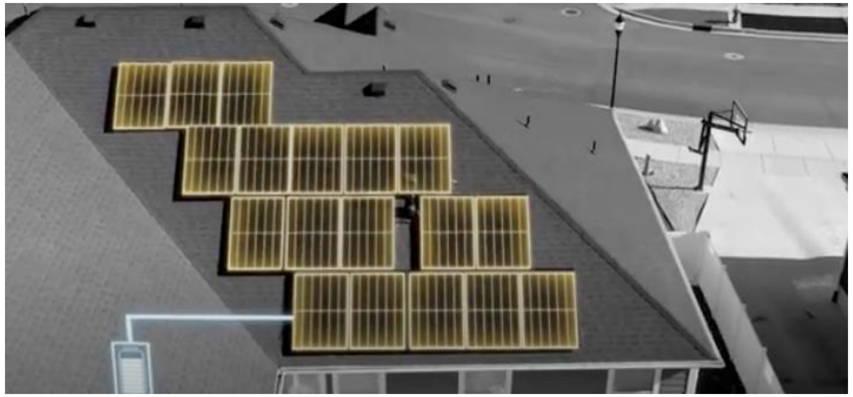
Grid planners and operators must see VPPs are credible, reliable resources

Source: Berkeley Lab

- Conduct pilots – Test resources; build operator confidence
- Utility ownership of assets – Low-cost equipment for customers; ability of utility to test resources
- Set technical standards for participation in VPP – Enable faster, better coordination between utility and aggregator/OEM
- Involve distribution system operator from planning to implementation – Ensures resources help the system and grid edge

Example: Moving from pilot to full scale program

The Wasatch Group



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

Source: Berkeley Lab

Source: PacifiCorp Soleil Lofts,
Pacificorp WattSmart program

Example: Utility ownership and ability to use DERs for multiple use cases

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 renewable. Stores excess solar energy produced during the day for use during peak evening hours. Calls up to 10 per month, with the goal to hit the coincident peak hour.

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

Source: Berkeley Lab

CASE STUDY HOLY CROSS ENERGY

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 tend 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.

Your backup power partner.

- ✔ **Inrease your home's energy resilience**
- ✔ **Help the co-op reduce our collective peak energy costs**
- ✔ **Receive a monthly bill credit to help pay off your system**

Example: Involve the distribution system operator from planning to implementation

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 | PUGET SOUND ENERGY

A VPP that serves as a comprehensive business platform

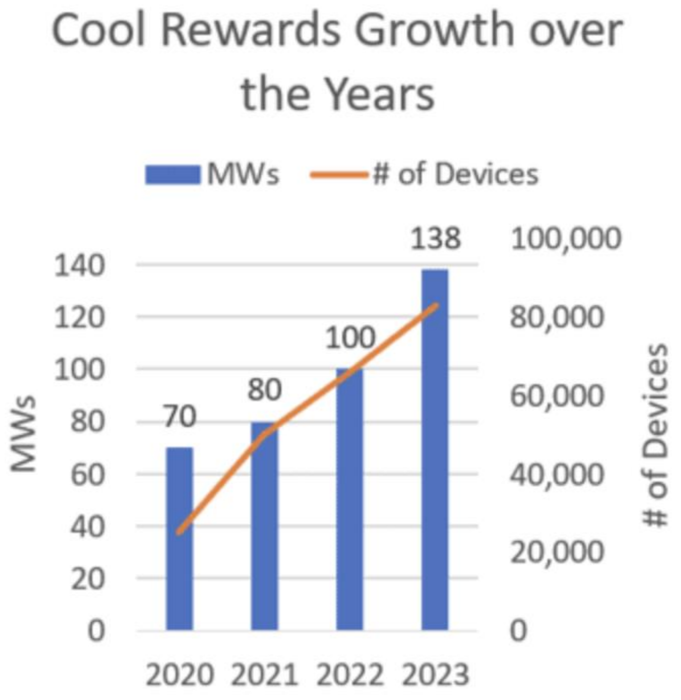
PSE PUGET SOUND ENERGY

Integrating the VPP seamlessly with systems like 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 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.

Source: Berkeley Lab

Existing DERs can be aggregated to quickly scale a VPP

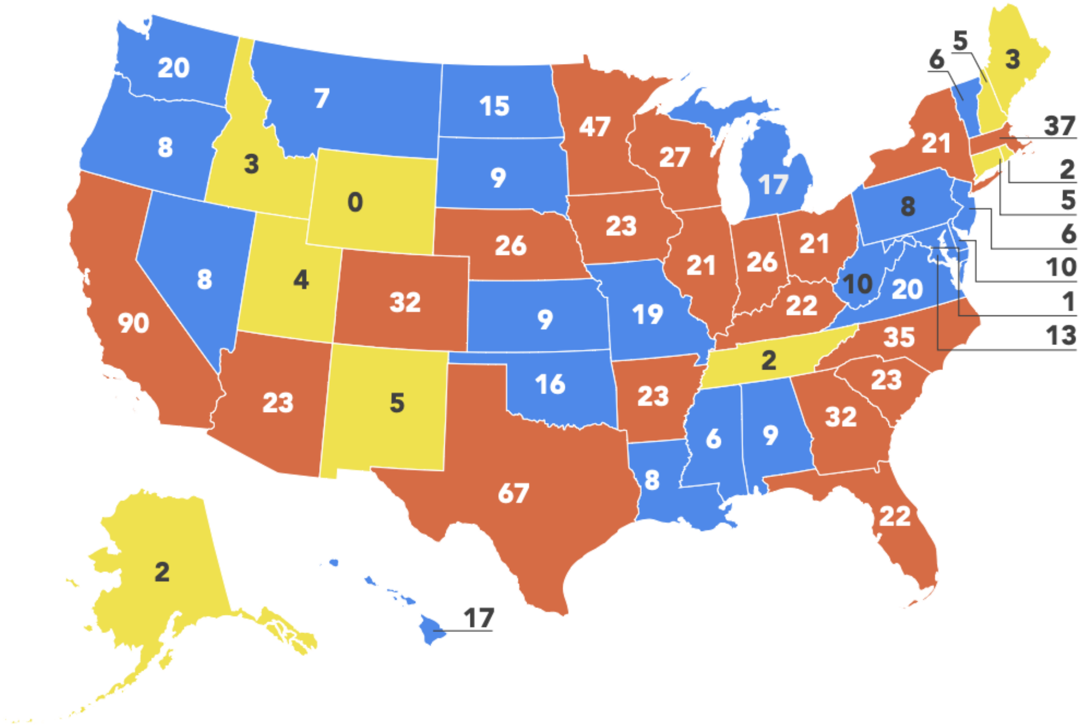


Source: APS

Manufacturer	Event Name	Event Notifications		Manufacturer Pre-Cooling Prior to Event		Event Start Time	Event Duration
		Mobile app	On-Device	Weekdays during off-peak hours	Weekends all day off-peak hours	Weekend start times may vary	
Nest	• APS DR Energy Rush Hour • Energy Rush Hour	✓	✓	Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours
Honeywell Home	• Savings Event • Energy Savings Event	✓	✓	Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours
ecobee	• Community Energy Savings • APS Cool Rewards Program • High Energy Demand	✓	✓	-	-	5 or 6 p.m.	2-3 hours
Sensi	• APS Active Savings Event	✓	✓	Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours
ADC/Vivint	• APS Cool Rewards	✓		Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours
Lux	• Demand Response Event	✓	✓	Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours
Amazon	• Energy Savings Event	✓	✓	Noon - 3 p.m. or 1-4 p.m. (depends on rate plan)	3 or 4 p.m.	5 or 6 p.m.	2-3 hours

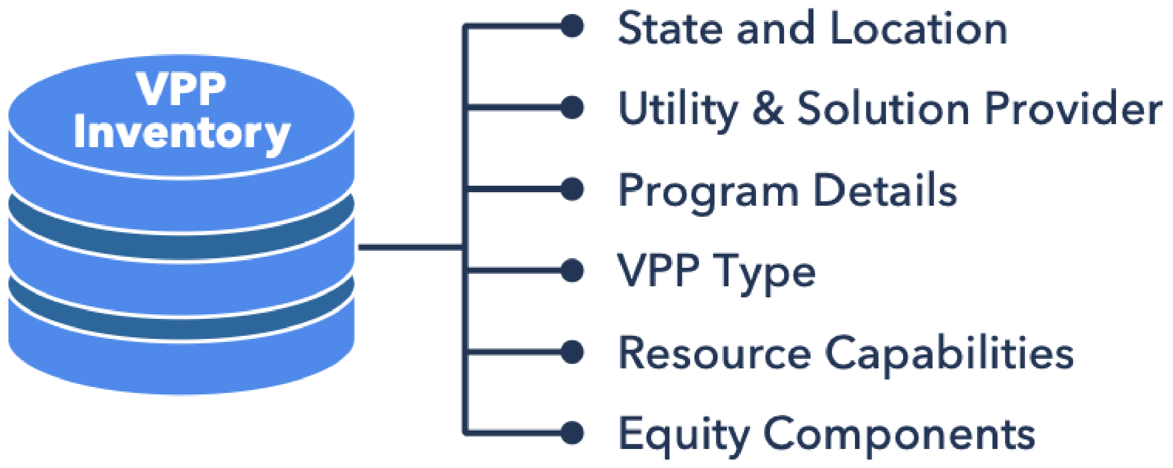
Source: APS

There are opportunities to aggregate existing DERs into VPPs



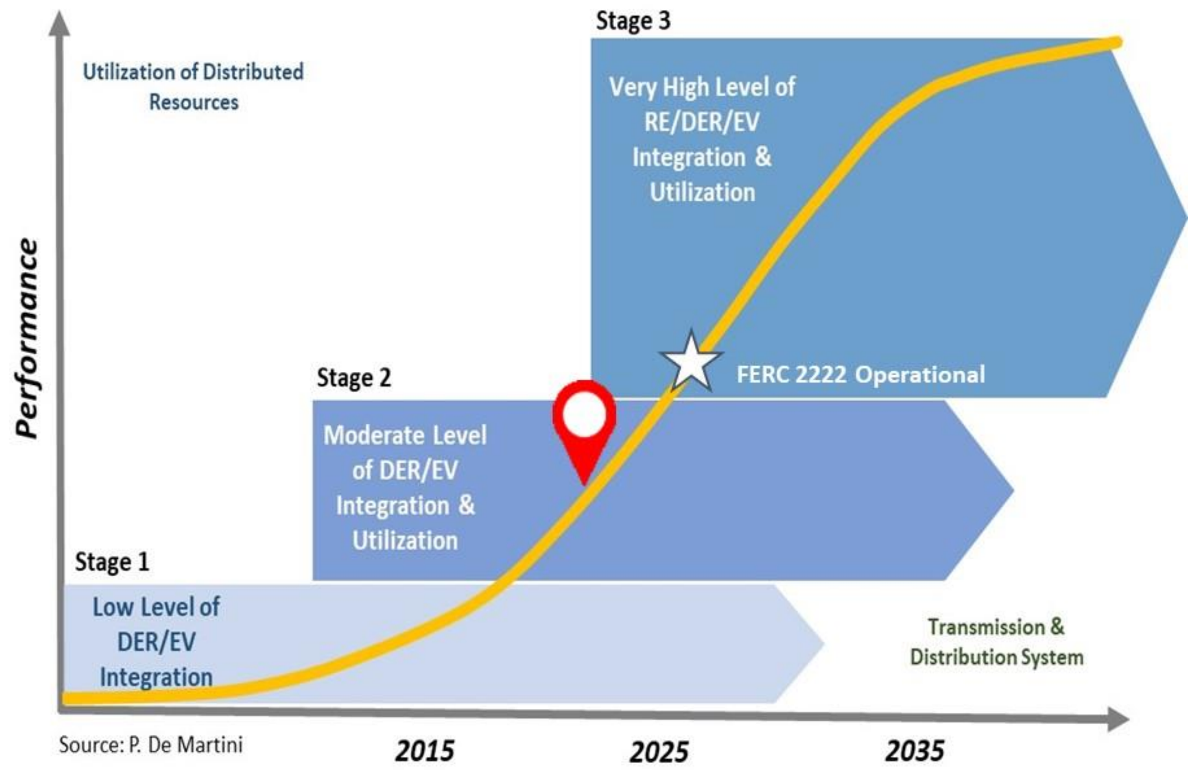
Count of existing and potential VPPs per state

5 or less | 6 – 20 | More than 20



Source: Brekeley Lab

Cost-effective grid modernization technologies and operational changes may be needed

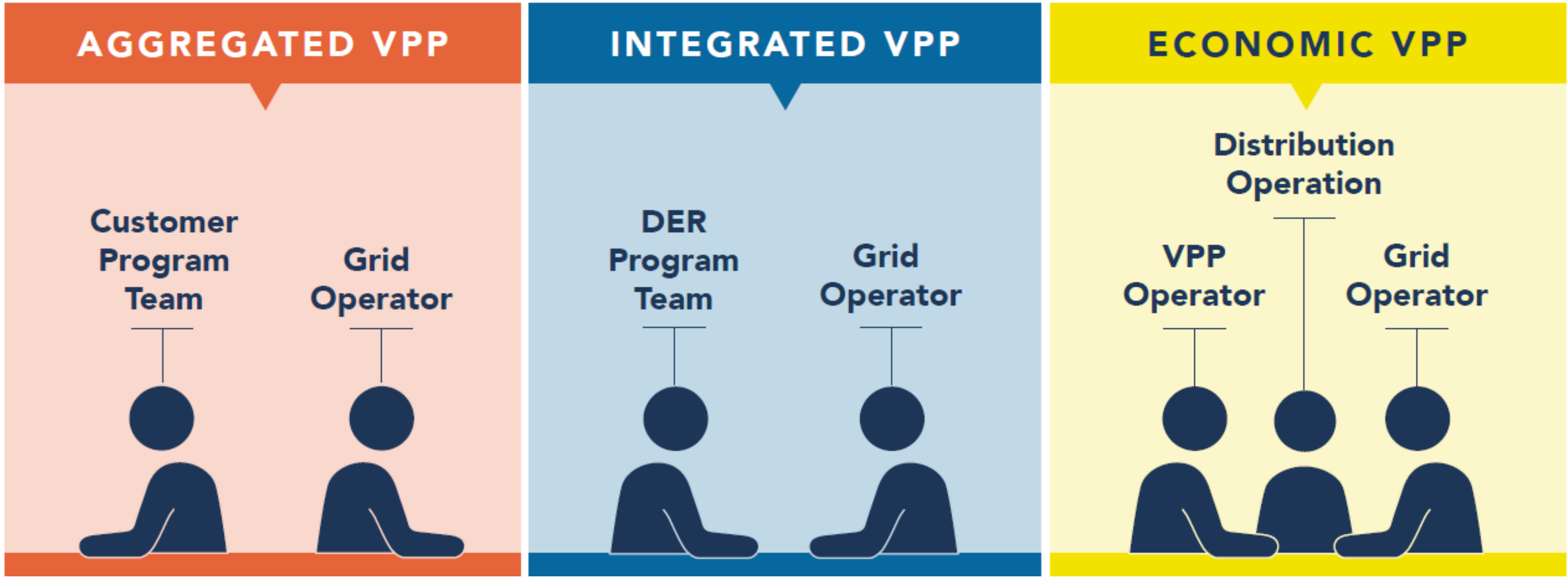


Source: Paul De Martini, Newport Consulting

	Technology	Grid Function	Deployed By
Digital Hardware	Advanced Meter Infrastructure	A series of technologies including a smart meter and its attendant supporting systems that allow for two-way communication between the customer point of service and the utility.	Distribution Utility
	Smart Inverters	Due Changes the direct current from solar panels to alternating current used by consumers and has communication and control capabilities to help manage power quality on the grid.	Distribution Utility
	DER Submetering	Due to the unique nature of DERs compared to typical consumer load, FERC Order 2222 requires separate metering for distributed generation and storage.	Distribution Utility
	Voltage Optimization	Manages voltages within service limits due to power injections from generator sets or solar photovoltaic generation (PV), withdrawals for charging of batteries and EVs, and sudden load switching such as some cases with demand response and EVs.	Distribution Utility
	Advanced Communication Networks	High speed, high bandwidth communications between grid devices is a foundational capability to allow for reporting and control between ISOs, substations, utilities, and aggregators and their grid devices.	Distribution Utility
Software-Based Grid Components	Distributed Energy Resource Management System (DERMS)	A platform to dispatch each individual DER.	Aggregator
	ADMS	Host applications that collect data and evaluate and mitigate DER impacts on power flows; and utilize DERs for distribution benefits.	Distribution Utility
	GIS	Aggregation requires GIS tracking to locate DERs on the network.	Distribution Utility
	VPP		Aggregator
	Analytics Platform	Optimizes the use of DERs for supplying distribution-level services.	Distribution Utility
	Advanced Retail Billing	In the case of customers with DERs, retail bills must be adjusted for net of wholesale market participation of aggregated DERs to avoid double rewarding.	Distribution Utility
Technology-Enabled Processes	Advanced Integrated Planning	Permits the distribution utility to evaluate the impact of DERs on distribution infrastructure planning.	Distribution Utility
	DER Load Forecasting	Provides the ability to avoiding double counting DERS.	Distribution Utility

Source: Grid Investments to Support FERC Order 2222

VPP hurestic typology



Source: Berkeley Lab

Aggregated

- Limited DER adoption
- Utility may be aggregator or work with vendor
- Example program: Bring Your Own Smart Thermostat program.
- Example grid service: System peak demand capacity

Integrated

- Higher DER penetration or working to integrated diverse DERs into grid operations
- Utility may be aggregator or work with vendor
- Example program: Bring Your Own Device program
- Example grid service: Daily peak demand capacity

Economic

- DERs transact and participate in economic dispatch (e.g., wholesale market or balancing authority)
- Aggregator can participate independently of utility; utility can also provide resources
- Example program: Texas ADER
- Example grid service: Frequency regulation

Actions states can take to advance VPPs

- Remove barriers to aggregating DERs (e.g., Missouri, Michigan)
- Require VPP pilots or programs (e.g., Colorado, Connecticut)
- Implement building codes and standards that ensure DERs support VPPs (e.g., California)
- Adopt policies to accelerate and remove barriers to interconnecting renewable energy and storage resources to the electricity grid.
- Consider innovative DER compensation and tariff design (e.g., Hawaii, California, Maryland)
- Encourage or require that utilities competitively procure energy resources including utility-scale renewable energy and distributed energy storage
- Encourage transparent distribution system planning and operation, and grid modernization (see LBNL's Integrated Distribution System Planning resources)

Select resources

- The Pathway to: VPP Commercial Liftoff , U.S. DOE
- Aggregated DER in 2024: The Fundamentals, National Association of Regulatory Utilities Commissioners (NARUC)
- Grid Investments to Support FERC 2222: Technologies that Enable Aggregated DER Participation in Wholesale Power Markets, Gridwise
- Research and Emerging Issues: Virtual Power Plants, Colorado Public Utilities Commission
- VPP Flipbook, Rocky Mountain Insitute
- VPP and Energy Justice, National Renewable Energy Laboratory
- Locational Value of Distributed Energy Resources, Lawrence Berkeley National Lab

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