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Virtual Power Plants (VPP): Insights, Profiles and Inventory

2025 Spring Technical Workshop

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Contributors
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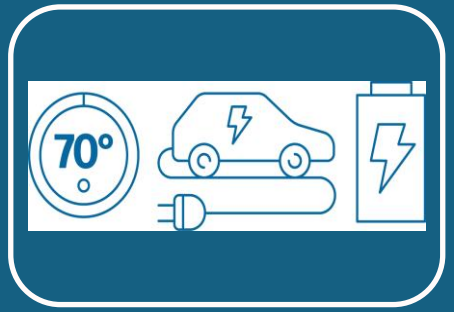
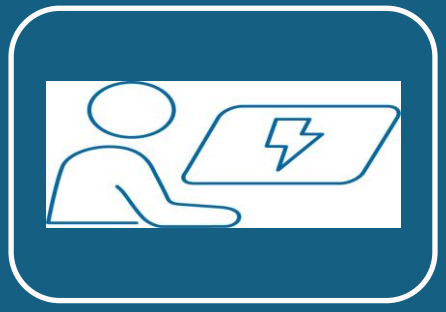
Scaling VPPs: Insights, Profiles, and Inventory Project

New research supports regulators, utilities, and solution providers in optimizing virtual power plants (VPP) strategies to enhance grid resilience, reduce peak demand, and integrate distributed energy resources (DERs) efficiently. It aimed to overcome challenges in accelerating VPP deployment through three research tasks:



Insights into Scaling VPPs



VPP Profiles

VPP Inventory

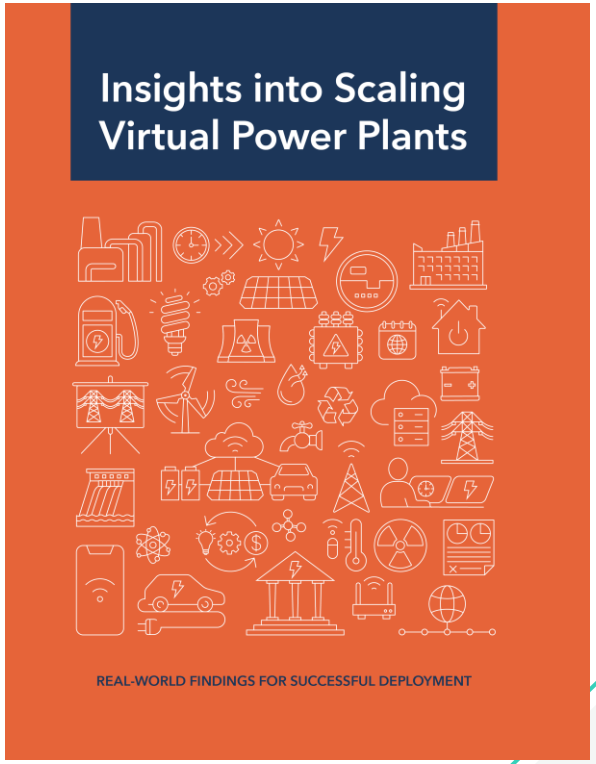
Interview Approach

- **Conducted 24 expert interviews** and a literature review to identify key challenges and opportunities in scaling VPPs.
- In many cases, interviews were conducted with multiple individuals within each utility to identify key factors for successful deployment and highlight the primary challenges that future VPP initiatives may encounter.
- The interviews were organized around five themes:
  - VPP Design & Deployment
  - Grid Planning & Operations
  - Policy & Regulatory Environment
  - VPP Business Models
  - Designing Successful Future Deployments

Interviews & Case Studies

- The findings from the interviews were organized into three high-level themes from our Insights into Scaling VPPs report:
  - The Role of Leadership in Successful VPP Designs
  - Grid and Technology Investments
  - Program Planning and Design

- Additionally, we conducted 7 utility-specific case studies on VPP implementation.
  - Holy Cross
  - PacifiCorp
  - Portland General Electric
  - Puget Sound Energy
  - SMUD
  - National Grid
  - Eversource



Overall Interview Findings

The Role of Leadership in VPP Success Findings

- Strong leadership is essential for VPP success
- Clear vision, goals, and terminology drive VPP effectiveness
- Dedicated staff and cross-functional collaboration are key to implementation

Grid and Technology Investments Findings

- Investment in software solutions supports VPP integration
- Clear DER participation and communication protocols support effective VPP operations
- Standardized technology and integrated solutions are critical for VPP scalability

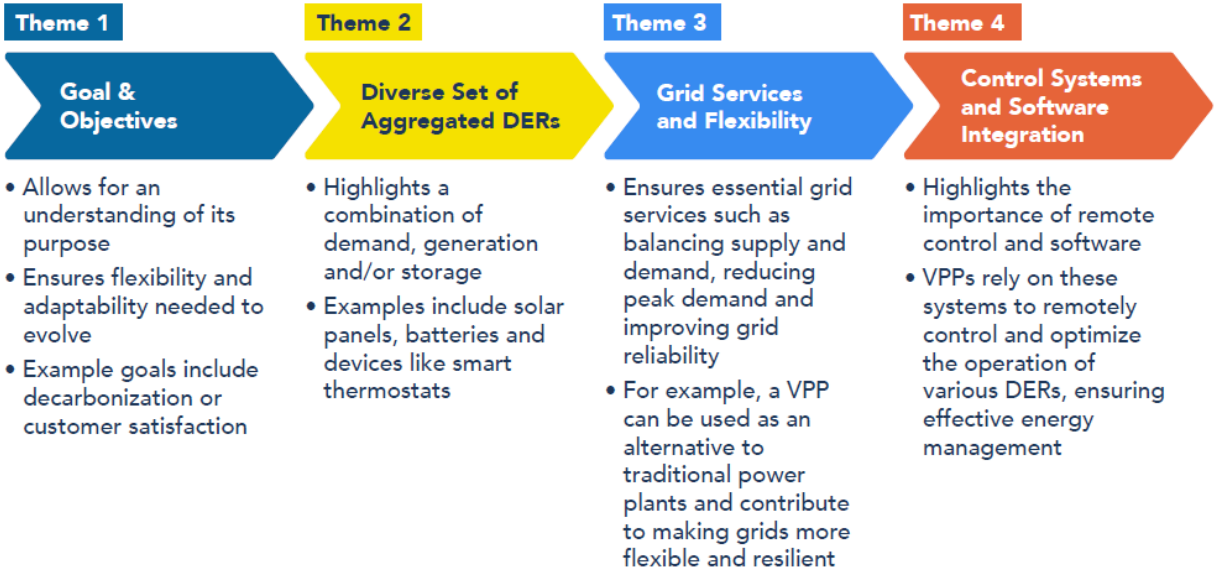
Program Planning and Design Findings

- Collaboration across stakeholders enhances VPP design
- Customer-centric design and clear metrics drive VPP success
- Pilots help uncover early challenges and refine VPP strategies

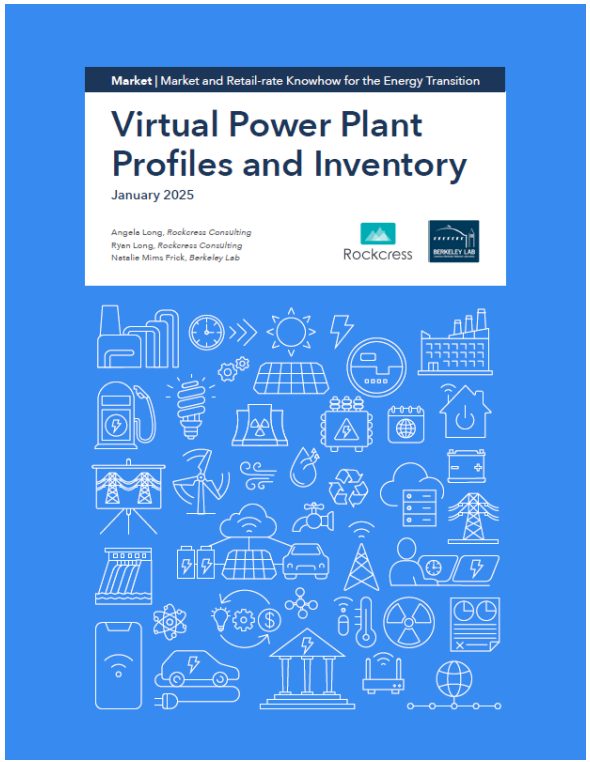
Clearly Defining VPPs

Our research 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.



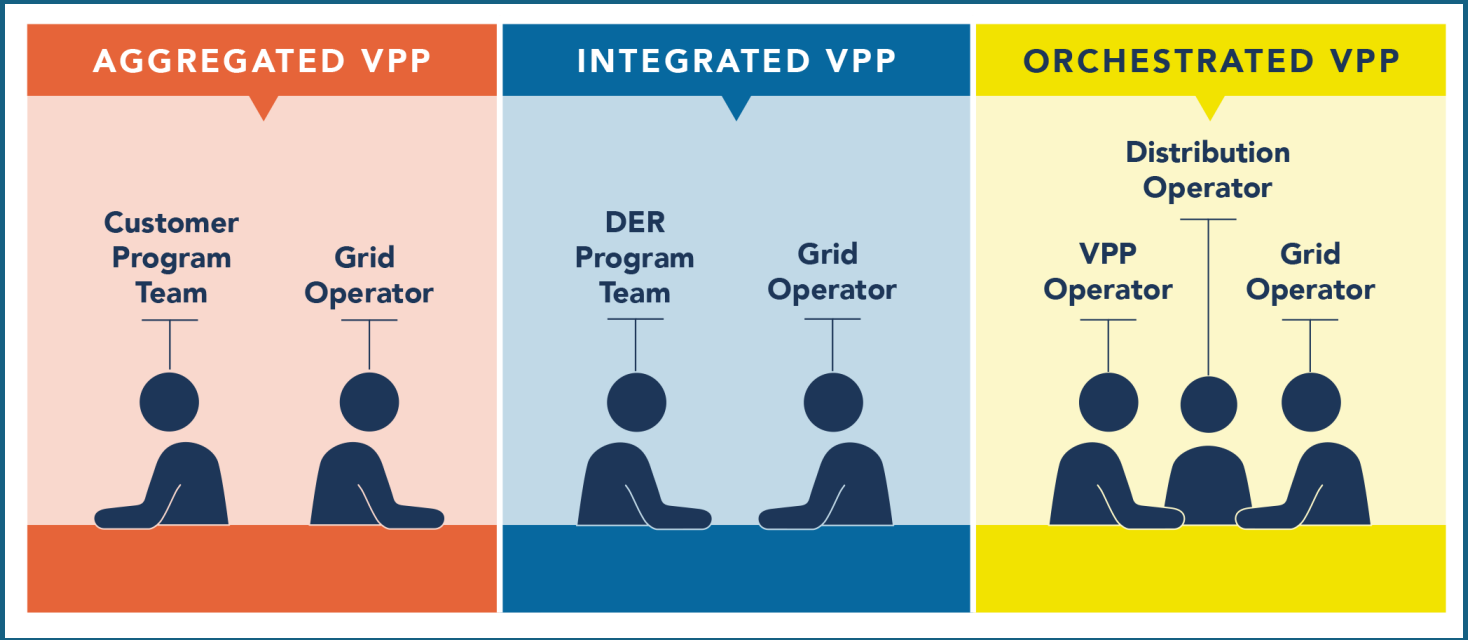
VPP Profiles and Inventory Approach



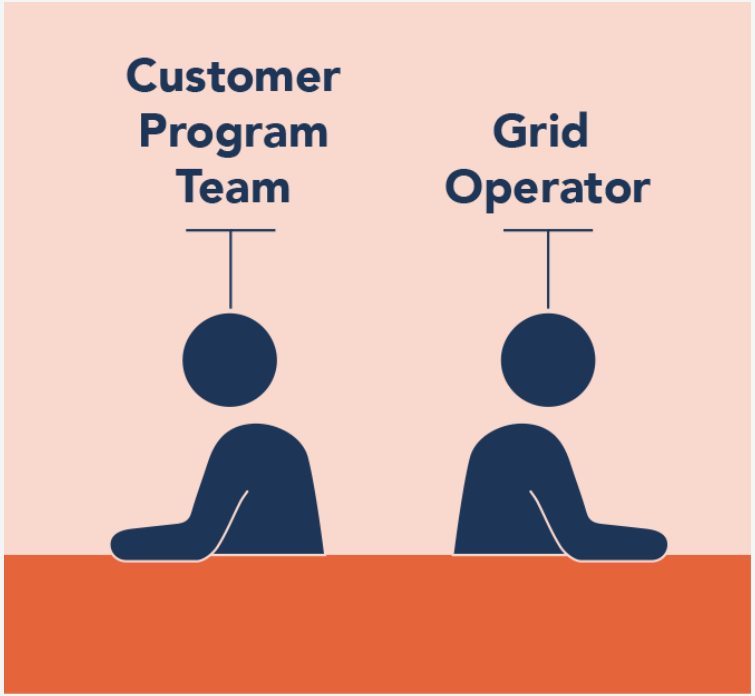
- **VPP Profiles**
  - Utilized interviews and over **30 definitions of VPPs**, influenced by audience, goals, region, perspectives, use cases, resource types, and location to develop **VPP Profiles**.
  - Developed three conceptual VPP models to standardize terminology and facilitate clearer discussions among stakeholders.
- **VPP Inventory**
  - Created a publicly available database categorizing VPP characteristics using datasets from independent research and U.S. EIA to track trends, equity considerations, and implementation strategies.
  - Documents key characteristics of VPPs and allows users to sort or filter for specific VPP data points (e.g., size, location).
  - Inventory data used to analyze four aspects of the VPP characteristics — implementer, VPP profile, ADER type and equity — to better understand current VPP trends.

VPP PROFILES

Developed three conceptual VPP models to standardize terminology and facilitate clearer discussions among stakeholders



AGGREGATED VPP



Aggregated VPPs represent the simplest and most basic type of VPP.

Simple to implement, with basic load-shifting capabilities.

Typically utilize demand-side resources like DR or flexible loads to shape and shift load.

Have minimal DER coordination, mainly manually dispatching DERs.

Primarily for energy and capacity services at the bulk system.

Integrated VPP

An Integrated VPP offers greater control, visibility, enabling better coordination and resource management.

Dedicated DER program team within the utility

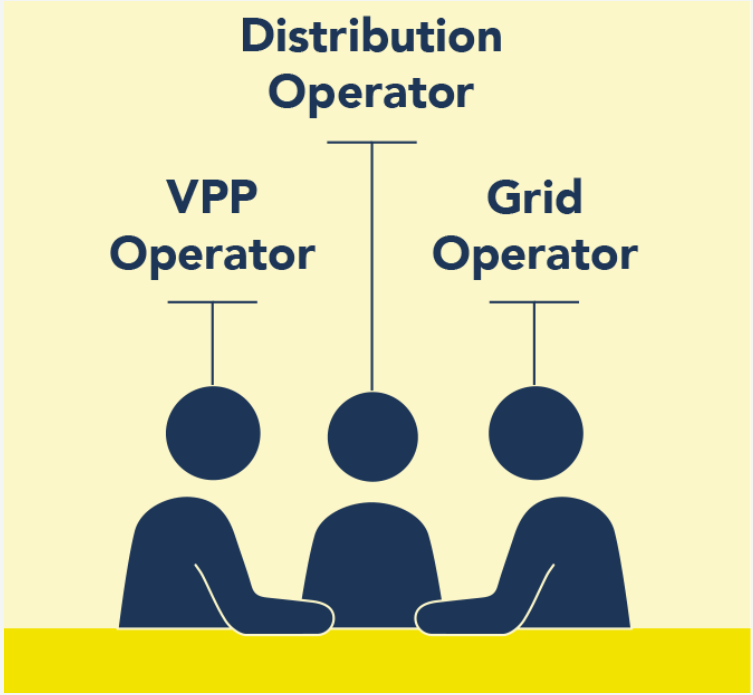
Combine homogenous and heterogeneous DERs, with the ability to utilize increasingly larger DERs such as microgrids.

Typically shape, shift and shed load.

Provide bulk system energy, capacity and reliability services while offering more dynamic control and near real-time responsiveness.

Involve closer integration between DER program teams, grid operators and solution providers.

Orchestrated VPP



Orchestrated VPPs leverage an ADMS to seamlessly integrate the VPP platform into centralized grid operations.

Integrates the ADMS into a centralized distributed energy resource management system (DERMS), aka grid DERMS or an enterprise DERMS.

Enables system actors— such as ISOs, utilities, solution providers, producers, and customers—to interact at the distribution-level. Sophisticated, continuously operating VPPs with real-time, locational dispatch.

Typically shapes, sheds, shifts and shimmies load.

Manages and operates high levels of DER integration, with the ability to leverage diverse interconnected DERs and third-party resources.

Provides local resilience and integrates with both bulk power and distribution systems.

Inventory Categories

The Inventory has six high-level categories, encompassing multiple characteristics.

The Inventory serves as a starting point, and further efforts are needed to refine and expand the database into a more comprehensive resource.

The six categories of the Inventory are summarized as follows. A full description of all data points can be found within the Inventory.

Location

Provides information on the location of the Inventory entry.

Implementor

Categorizes Inventory entries based on implementor type. We utilized four categories: utilities (such as IOUs, municipalities, public power, cooperatives and retail providers), soluti on providers (aggregators, which can include utilities, and Original Equipment Manufacturers), local (community choice aggregators, cities or communities), and state or national (state or national-led initiatives such as California's Demand Side Grid Support Program)

Entry details

Provides multiple high-level data points such as sector, DER(s), capacity, energy, incentive, customer count, dispatch time and months.

VPP Profile

Categorizes Inventory entries as Aggregated, Integrated or Orchestrated, based on the VPP Profiles. Specifically, EIA DER Dataset entries were classified as Aggregated VPPs (see Leveraging the EIA DER Dataset section). The Research Dataset entries were classified as an Integrated VPP unless it was specifically noted that the VPP was used for wholesale market participation, in which case they were classified as an Orchestrated VPP.

DER type

Provides the composition of Aggregated DERs (ADERs) in the Inventory entry and categorizes the entry as Demand, Generation or Storage DERs (**Figure 5**).[11]

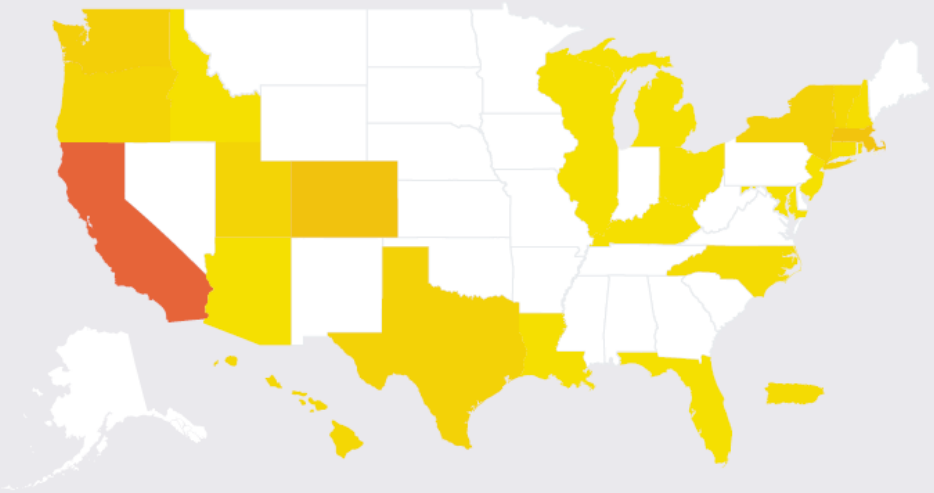
Equity attribute

Identifies if the VPP program has an equity attribute.

Research Dataset

Developed using publicly available data including utility filings, industry reports, news articles and press releases.

Serves as a novel, publicly available dataset of VPPs across the US, enabling stakeholders understand the current landscape of VPPs.



Count of VPPs Researched 1 62

Arizona	1	Illinois	1	New Jersey	1	Texas	8
California	62	Kentucky	2	New York	8	Utah	7
Colorado	16	Louisiana	2	North Carolina	4	Vermont	5
Connecticut	3	Maryland	1	Ohio	2	Washington	9
Florida	1	Massachusetts	15	Oregon	7	Wisconsin	1
Hawaii	6	Michigan	1	Puerto Rico	4		
Idaho	1	New Hampshire	3	Rhode Island	3		

The Research Dataset includes approximately

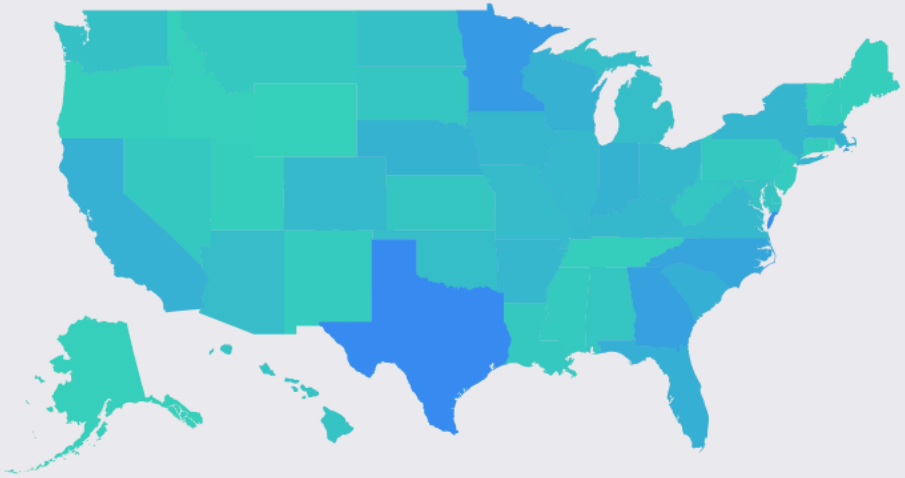
180 VPP programs with a potential VPP capacity of

19 GWs

EIA DER Dataset

Includes data on existing DR programs and NEM resources from 2023 EIA- 861 data.

To prevent duplicate entries, the datasets were cleaned after being merged. Entries appearing in both the Research and EIA DER Datasets were removed.



Count of EIA DERs 1 60

Alabama	9	Georgia	41	Massachusetts	26	New York	24	Texas	60
Alaska	2	Hawaii	12	Michigan	16	North Carolina	37	Utah	2
Arizona	17	Idaho	2	Minnesota	47	North Dakota	15	Vermont	1
Arkansas	23	Illinois	20	Mississippi	6	Ohio	21	Virginia	20
California	28	Indiana	26	Missouri	19	Oklahoma	16	Washington	14
Colorado	20	Iowa	23	Montana	7	Oregon	3	West Virginia	10
Connecticut	4	Kansas	9	Nebraska	26	Pennsylvania	8	Wisconsin	27
Delaware	10	Kentucky	21	Nevada	8	Rhode Island	1	Wyoming	1
District of Columbia	1	Louisiana	7	New Hampshire	4	South Carolina	29		
Florida	29	Maine	3	New Jersey	5	South Dakota	9		
		Maryland	12	New Mexico	5	Tennessee	2		

The EIA DER Dataset includes approximately

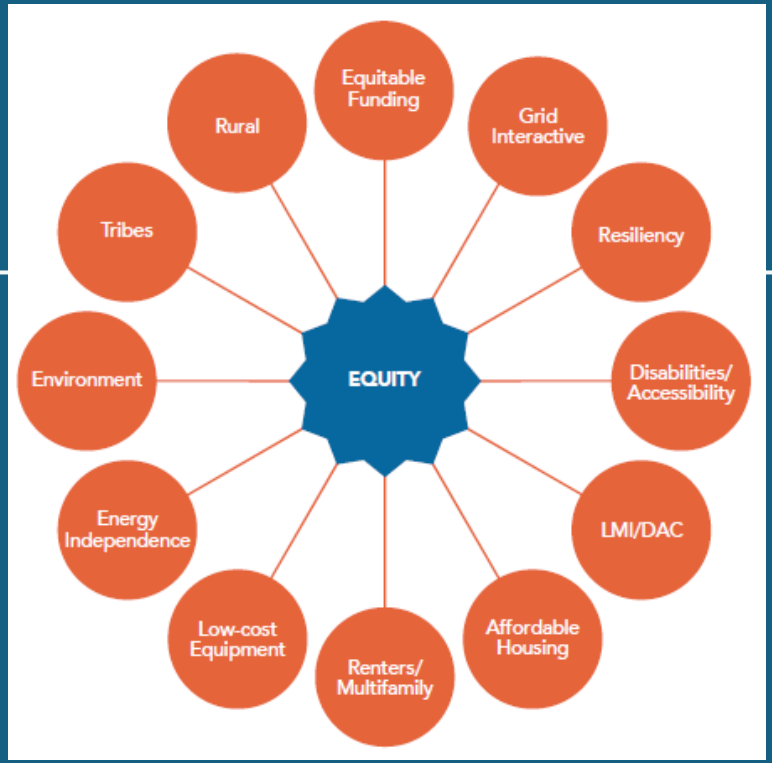
790

existing DR programs and NEM resources with a capacity of

27 GWs

Inventory Equity Attributes

Identifies over 40 VPP programs with equity attributes, representing a collective goal of 8 GWs of potential VPP capacity.



Five high-level types of equity-focused VPPs:

- Low-to-moderate income and disadvantaged communities
- Place-based
- Resilience
- Finance and Funding
- Tribal

VPP Inventory Findings

IOUs are currently the primary implementors of VPPs, though equity-focused VPPs often involve a more diverse group of implementors

VPPs primarily focus on DR or flexible load management strategies

10 largest VPP programs in the U.S. aim for more than 15 GW of potential VPP capacity

Majority of entries in the Research Dataset are classified as Integrated VPPs

Most entries rely on demand DERs, with equity-focused VPPs showcasing more diversity by incorporating a mix of demand, generation, and storage DERs

Over 40 VPPs, representing 8 GW of potential VPP capacity, include equity components. These include five high-level types of equity-focused VPPs: finance and funding, low-to-moderate income and disadvantaged communities, place-based, resilience, and tribal

Over 27 GW of existing DR programs and NEM resources, with 10 states making up the majority of capacity. These programs serve as a foundation for the design and deployment of future VPPs

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Reports and Inventory available at:
https://emp.lbl.gov/publications/virtual-power-plants-insights