NARUC

National Association of Regulatory Utility Commissioners

Regulators' Financial Toolbox: Virtual Power Plants

The National Association of Regulatory Utility Commissioners (NARUC) Center for Partnership and Innovation (CPI) Regulators' Financial Toolbox series explores the types of financial tools utility regulators can use to support integration of electricity system technologies that benefit the public interest. This brief was prepared by Jamie Scripps of Hunterston Consulting LLC and is based upon work supported[1] by the Department of Energy under Award Number DE-OE0000925. The speakers' presentations and recordings can be found at www.naruc.org/cpi-1/energy-distribution/valuation-and-ratemaking/.

On June 21, 2023, NARUC's Center for Partnerships & Innovation (CPI) and the NASEO-NARUC Grid-Interactive Efficient Buildings (GEB) Working Group co-hosted a Regulators' Financial Toolbox Webinar on the topic of virtual power plants (VPPs). The webinar featured opening remarks from moderator Commissioner Cecile Fraser of the Public Utilities Commission of Massachusetts and presentations from Ryan Hledik, Principal, The Brattle Group; Brenda Chew, Director of Product Management, Virtual Peaker; and Franco Albi, Director of Regional Integration, Portland General Electric.

The webinar and this accompanying brief address:

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What is a Virtual Power Plant (VPP)?

There is no standard definition of a virtual power plant (VPP). However, every VPP exhibits certain common characteristics and provides a similar set of benefits to customers and the grid. According to The Brattle Group, "a VPP is a portfolio of distributed energy resources (DERs) that are actively controlled to provide benefits to the power system, consumers, and the environment."[2] Portland General Electric defines a VPP as, "the orchestration of distributed energy resources and flexible load, through technology platforms, to provide grid and power operations services."[3] All VPPs feature an aggregation of DERs and/or flexible load that is controlled through technology. VPPs often work by controlling resources located on the customer's premises. As a result, a key feature of a VPP is automating or otherwise making it easy to communicate and engage customers in saving energy.[4]

In a VPP, various DERs are controlled and managed in a coordinated way by a utility or an aggregator using software. This is done to benefit all the following: the power system, the distribution system, the transmission system, and the bulk generation system.[5] By managing DERs in an orchestrated way, overall system costs and emissions can be reduced. Ultimately, those benefits are shared between the consumer, the utility, and the entity that is controlling the load, as well as non-participants.[6]

A VPP's portfolio can include a wide range of energy technologies and can serve an array of participants. According to the RMI report *Virtual Power Plants, Real Benefits*: "VPPs can include EVs and chargers; heat pumps; home appliances; heating, ventilating, and air conditioning (HVAC) equipment; batteries; plug loads; solar PV; or industrial mechanical equipment. Single-family homes, multifamily homes, offices, stores, factories, cars, trucks, and buses can all participate in a VPP."[7] Some VPP configurations rely solely on demand response or load shifting and do not include any power generating technologies. According to the report *Real Reliability: The Value of Virtual Power* from The Brattle Group: "[A] VPP does not even need to generate power. Dispatchable demand response (DR), enabled by technologies such as smart thermostats and electric vehicles (EVs), can provide many of the same benefits as distributed generation resources by reducing or shifting load."[8]

Interest in VPPs is on the rise, driven by several factors.

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[2] "Real Reliability: The Value of Virtual Power," NARUC CPI/NASEO-NARUC GEB Workgroup Regulators' Financial Toolbox Webinar on Virtual Power Plants, Presentation by Ryan Hledik, Principal, The Brattle Group, at slide 2 (June 21, 2023). Available at https://pubs.naruc.org/pub/20E2F9EB-9659-205E-1E81-8E40B370EACF.

[3] "Virtual Power Plant (VPP)," NARUC CPI/NASEO-NARUC GEB Workgroup Regulators' Financial Toolbox Webinar on Virtual Power Plants, Presentation by Franco Albi, Director of Regional Integration, Portland General Electric, at slide 7 (June 21, 2023). Available at https://pubs.naruc.org/pub/20E2F9EB-9659-205E-1E81-8E40B370EACF.

[4] "Virtual Power Plants: Financial Toolbox Webinar," NARUC CPI/NASEO-NARUC GEB Workgroup Regulators' Financial Toolbox Webinar on Virtual Power Plants, Presentation by Brenda Chew, Virtual Peaker, Director of Product Management, at slide 5 (June 21, 2023). Available at https://pubs.naruc.org/pub/20E2F9EB-9659-205E-1E81-8E40B370EACF.

[5] Hledik at slide 1.

[6] Ibid.

[7] Brehm, Kevin, Avery McEvoy, Connor Usry, and Mark Dyson, "Virtual Power Plants, Real Benefits," RMI report, at p. 8 (January 2023). Available at https://rmi.org/insight/virtual-power-plants-real-benefits/.

[8] Hledik, Ryan and Katie Peters, "Real Reliability: The Value of Virtual Power," The Brattle Group report, at p. 12 (May 2023). Available at https://www.brattle.com/real-reliability/

- Declining DER costs
- Technological advancement and availability to consumers
- Federal spending (*e.g.*, Inflation Reduction Act)
- FERC Order 2222
- The decarbonization imperative[9]

The costs of DERs have come down significantly and are forecasted to continue to decline in the future. Meanwhile, technology is advancing quickly in relation to the software that is needed to manage large numbers of DERs in a coordinated way.[10] According to RMI: "Although VPPs are not new, they are at an inflection point. Consumer adoption of flexible devices such as heat pumps, electric vehicles (EVs), and battery storage is accelerating just as the Infrastructure Investment and Jobs Act and Inflation Reduction Act will pump billions of dollars into the electric grid. At the same time, regulators and utilities are looking for short- and long-term solutions to reliability and affordability challenges."[11]

FERC Order 2222 is designed to remove barriers to various DERs participating in wholesale energy markets and has the potential to further spur VPP deployment and participation. According to RMI: "Federal Energy Regulatory Commission (FERC) Order 2222 (2020) requires regional transmission organizations (RTOs) and independent system operators (ISOs) to allow DERs to participate alongside traditional resources in the regional organized wholesale markets through aggregations. In theory, this decision allows the two-thirds of US businesses and households served by utilities and retail electricity providers within RTOs and ISOs to participate in VPPs."[12] Meanwhile, availability of electric vehicles, smart thermostats and other distributed energy technologies is growing quickly and is expected to continue to increase in the future.[13]

The decarbonization imperative is driving significant activity in the industry and is leading organizations to think more thoroughly about the potential role that DERs can play in helping us manage and reduce the cost of the energy transition.[14] Federal funding for clean energy and climate solutions also has the potential to increase the use of VPPs. The Inflation Reduction Act includes provisions that will reduce the cost of energy efficiency and electrification.[15] All of these factors will continue to encourage the use of VPPs as we move forward.

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[9] Hledik at slide 2.
[10] Ibid.
[11] RMI report at p. 7.
[12] Ibid at p. 18.
[13] Hledik at slide 2.
[14] Ibid.
[15] H.R. 5376 — 117th Congress: Inflation Reduction Act of 2022. Accessed July 5, 2023. Available at https://www.govtrack.us/congress/bills/117/hr537

Virtual Power Plant Business Models

According to RMI, there are two channels through which VPPs can provide value and be compensated.

- Market-participant VPPs provide services to and are compensated by wholesale electricity markets
- Retail VPPs provide services to and are compensated by utilities[16]

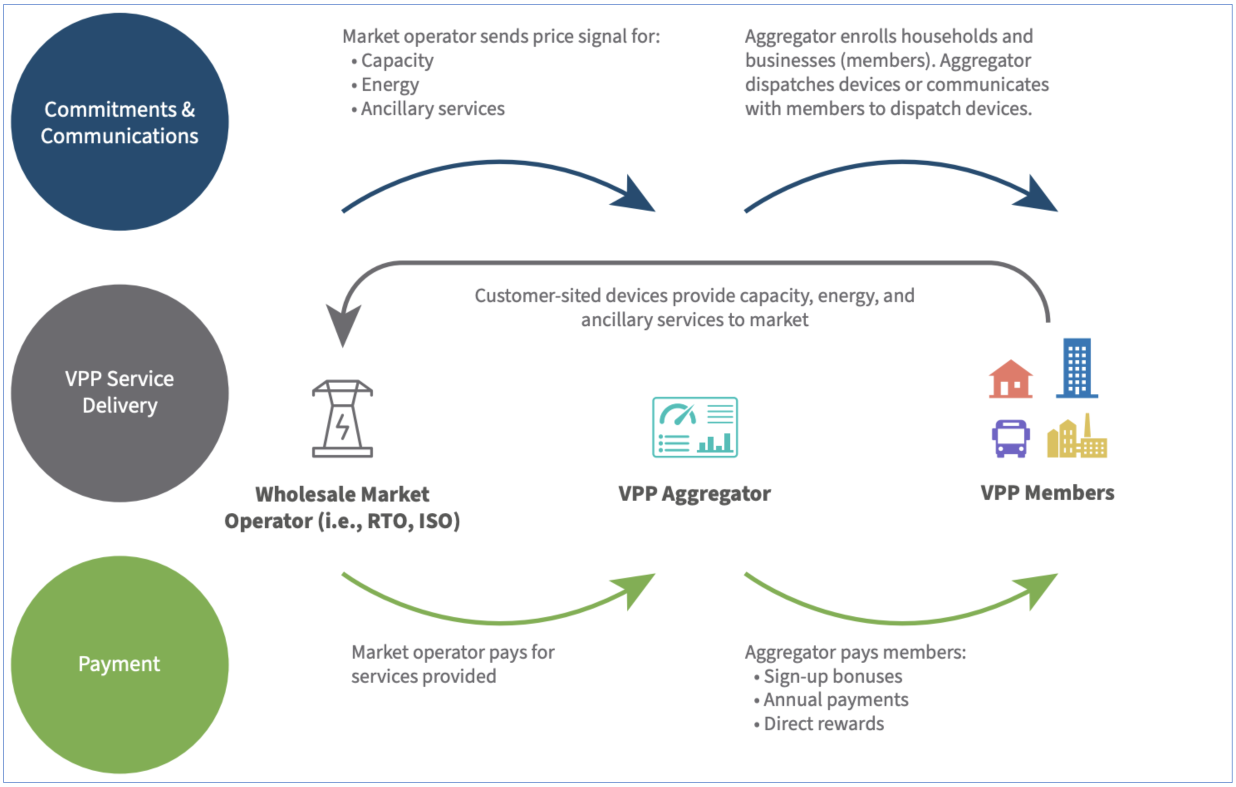

Figure 1:VPP Business Models, Market Participation. Source: Virtual Peaker.

Market Participant VPP

With a market participant VPP, a third-party aggregator provides benefits directly to the market in response to price signals for capacity, energy, and ancillary services.[17] The aggregator is responsible for getting the customers to sign up, engaging with them, aggregating customer devices, incentivizing and communicating with customers to ensure they are having a good experience, and reporting.[18] Figure 1 above is an illustration of a market participant VPP.

In the case of a market participant VPP, the wholesale market operator is paying the aggregator for these services. Overall, the market participant VPP is a third-party wholesale market business model.[19]

[16] RMI report at p. 9.
[17] Chew at slide 3.
[18] Ibid.
[19] Ibid.

Examples of market participant VPP third-party aggregators are OhmConnect,[20] Voltus,[21] and Octopus Energy.[22] According to RMI:

> During an extreme heat wave that lasted from August 31 to September 8, 2022, California's wholesale market operator, California Independent System Operator (CAISO), called on all available resources to match supply and demand. These resources included VPPs managed by OhmConnect, Tesla, Sunrun, Leap Voltus, AutoGrid, and others. Over the nine-day heat wave, OhmConnect's VPP automatically dispatched member devices 1.3 million times in response to real-time signals from CAISO. CAISO paid OhmConnect for services delivered. OhmConnect in turn paid $2.7 million in rewards to its members.[23]

Retail VPP

In a retail VPP, the program carries a utility brand. The value of the VPP is realized within the utility's operations and load-serving obligations. The utility enrolls the customers, dispatches the devices, and communicates with the customers. The utility may be using the VPP to meet different system needs, such as resource adequacy, deferring or avoiding T&D upgrades, and/or carbon emission targets.[24] The utility may also be seeking market benefits.[25]

Retail VPP programs play an especially important role in locations without ready access to electricity markets. According to RMI: "In areas not served by wholesale electricity markets, retail programs and retail rates are the only option for customers who want to be compensated for the services their devices can provide. Additionally, in areas served by wholesale markets, retail programs and rates will remain an important channel for VPPs."[26]

An early example of a retail VPP was that of Green Mountain Power,[27] which has been using Virtual Peaker's[28] platform since close to its inception. The utility continues to offer its VPP program to this day. Green Mountain Power has a Bring Your Own Device program, featuring devices such as batteries, EV

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[20] "Resi-Station: California's Largest Virtual Power Plant." Available at https://www.ohmconnect.com/about-us/news/resi-station.

[21] "Voltus Named a Leader in Wood Mackenzie Virtual Power Plant Market Report," March 2023. Available at https://www.voltus.co/press/voltus-named-leader-in-wood-mackenzie-virtual-power-plant-market-report.

[22] "Octopus Energy grows UK's largest virtual power plant." February 2023. Available at https://octopus.energy/press/octopus-energy-grows-uks-largest-virtual-power-plant/.

[23] Brehm, Kevin, Avery McEvoy, Connor Usry, and Mark Dyson, "Virtual Power Plants, Real Benefits," RMI report, at p. 10 (January 2023), citing inter alia "Join the Tesla Virtual Power Plant: 2022 Performance," Tesla, accessed October 24, 2022, https://www.tesla.com/support/energy/tesla-virtual-power-plant-pge-2022#2022-performance; and "East Bay Customers Support California's Grid During Extreme Heat Wave Through Innovative Program," Sunrun, September 20, 2022, https://investors.sunrun.com/news-events/press-releases/detail/271/east-bay-customers-support-californias-grid-during-extreme.

[24] Chew at slide 4.

[25] Ibid.

[26] RMI report at p. 19.

[27] "Green Mountain Power and Virtual Peaker Announce Partnership to Help Customers Save Money, Reduce Emissions," December 16, 2016. Available at https://virtual-peaker.com/news/media-1-2018-4-6-green-mountain-power-and-virtual-peaker-announce-partnership-to-help-customers-save-money-reduce-emissions/.

[28] Virtual Peaker. Available at https://virtual-peaker.com/.

chargers, water heaters, thermostats, and a range of DERs. Batteries are at the heart of Green Mountain Power's VPP program, through which the utility has been able to defer or retire diesel generators equivalent to nearly 5 MW of capacity. From a regulatory perspective, Green Mountain Power was permitted to rate base customer-sited assets.[29]

Another example of a retail VPP is National Grid's ConnectedSolutions program. According to RMI:

> In the ConnectedSolutions program, National Grid — an electric utility serving customers in New York and Massachusetts — pays customers both upfront and annual incentives to enroll their smart thermostats, home batteries, and EVs in the VPP program. National Grid dispatches these devices to balance summer peak demand. In 2020, the VPP helped reduce summer peak demand by 0.9%. This helps National Grid avoid costs it would otherwise need to spend on wholesale power costs, transmission and distribution infrastructure upgrades, fuel, and other expenditures.[30]

Figure 2 below is an illustration of a retail VPP.

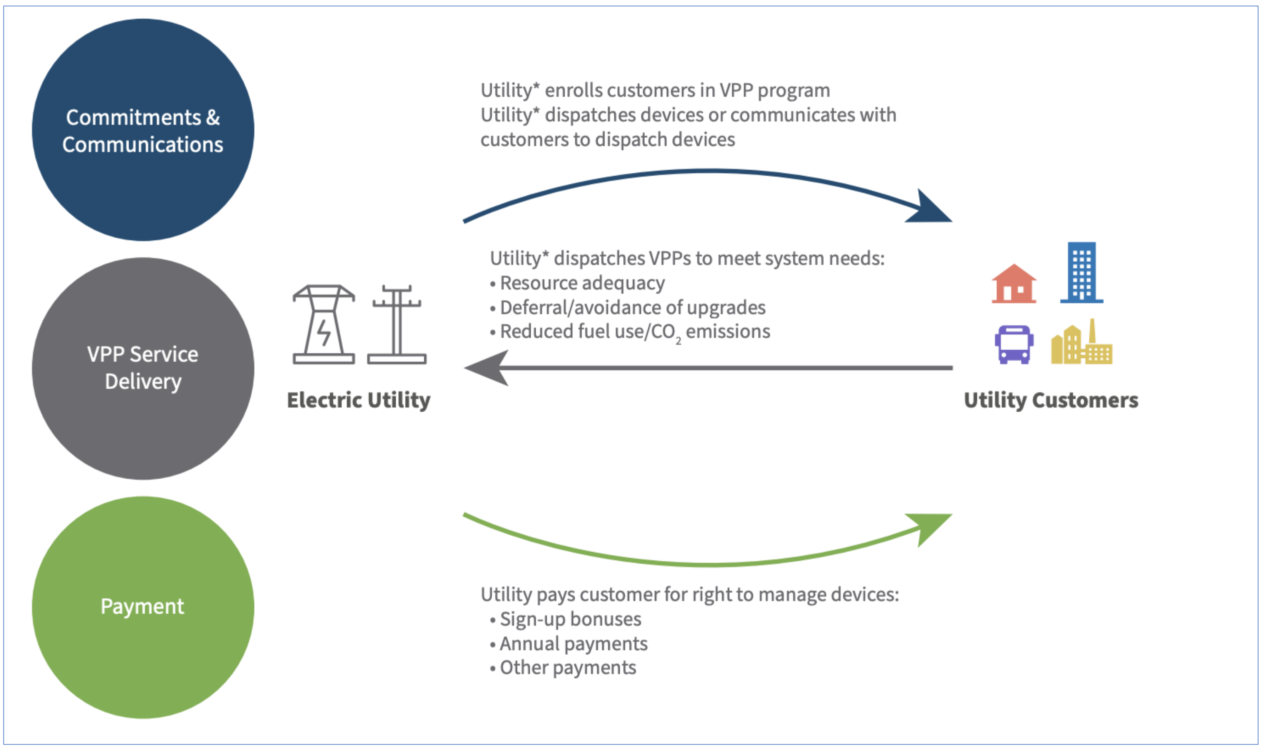

Figure 2: VPP Business Models, Retail VPP. Source: Virtual Peaker.

[29] Chew at slide 4.
[30] RMI report at p. 11.

Opportunities and Challenges of VPPs

Benefits of VPPs

Although VPPs are often implemented primarily as a resource adequacy solution, they offer many additional potential benefits, including increased renewables deployment, better power system integration of electrification, faster grid connection, flexible scaling, enhanced customer satisfaction, and improved behind-the-meter grid intelligence.[31]

The following section focuses on resource adequacy, with a look at highlights from the May 2023 report from The Brattle Group titled *Real Reliability: The Value of Virtual Power.*[32]

VPPs and Resource Adequacy

VPPs Provide Capacity to the System

There is an urgent need for electric transmission and distribution capacity across major portions of the country. According to The Brattle Group: "Electrification, coal retirements, and dependence on resources with limited capacity value (wind, solar) will continue to result in a persistent need to maintain sufficient system 'resource adequacy' by adding new dispatchable capacity."[33]

Many of the resources that could potentially address this resource adequacy need are stuck in interconnection queues, and there are delays associated with getting those resources connected to the distribution and transmission systems.[34] VPPs composed of existing assets and resources do not face these same constraints; essentially, you can build a virtual power plant from installed distributed energy resources and customer equipment about as quickly as you can enroll customers in these types of programs.[35] Overall, complex market dynamics and challenges in connecting clean energy resources to customers increase the importance of virtual power plants.[36]

Virtual power plants can be scaled. If needed, a VPP's capacity can be increased by, for example, increasing customer enrollment or by increasing the capacity per customer by increasing the duration of a demand response event.[37] If capacity needs moderate, the VPP can be scaled back through reductions in participation incentives, although this dynamic needs to be managed carefully so that customers are not experiencing "whiplash." Overall, VPPs offer flexibility and scale that basic investments in infrastructure cannot offer.[38]

The need for new capacity and resource adequacy is going to persist into the future, driven by several factors, including peak demand growth related to electrification initiatives and the retirement of coal

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[31] Hledik at slide 7.

[32] Hledik, Ryan and Katie Peters, "Real Reliability: The Value of Virtual Power," The Brattle Group report (May 2023). Available at https://www.brattle.com/real-reliability/

[33] The Brattle Group report at p. 7.

[34] Hledik at slide 3.

[35] Ibid.

[36] Albi at slide 7.

[37] Hledik at slide 3.

[38] Ibid.

plants. [39] Additionally, our growing dependence on renewable generation, while a great source of carbon free energy, increases the need to match demand to available supply in a more dynamic, flexible way.[40]

In the study *Reliability: The Value of Virtual Power*, The Brattle Group tried to answer whether virtual power plants can reliably and economically serve this resource adequacy need. The study looks at how VPPs compare economically with other conventional alternatives, namely natural gas peaker plants and utility-scale batteries. The study asks whether a VPP can provide the same resource adequacy benefits at a lower cost.[41] The study modeled four commercially available residential demand flexibility technologies for an illustrative utility composed of 1.7 million customers.[42] The modeled technologies included behind-the-meter battery storage; managed electric vehicle charging at the home; smart, grid-interactive, electric resistance water heaters; and smart thermostats. The study analyzed the availability of these resources on an hourly basis subject to specific constraints around customer willingness to have their load curtailed and assumptions around likely enrollment in these programs.[43] Overall, the modeled VPP could provide 400 MW of resource adequacy for a moderately-sized utility.[44]

The VPP both curtailed load in the evening and shifted load to lower-priced hours.[45] In order to provide the 400 MW of resource adequacy to the system, the VPP ended up reducing demand in both the summer and the winter, spanning seven different months of the year, reducing demand during 63 hours of the year.[46] On a peak day, the VPP was able to reduce demand for seven consecutive hours.[47] On the whole, the study showed that VPPs can reliably provide capacity to the system.[48]

VPPs Provide Economical Resource Adequacy

The VPP as modelled by The Brattle Group could be deployed to reduce peak demand, thereby reducing needed investment in both the transmission and the distribution systems.[49] The battery portion of the VPP also provides resilience benefits to enrolled customers by serving as a source of backup generation. Lastly, the VPP provides an overall emissions reduction, stemming primarily from the energy efficiency benefit associated with the smart thermostats.[50] Looking at cumulative benefits, including the societal emissions benefit associated with the VPP, the result is a net annual cost of only $2 million per year to provide 400 MW of resource adequacy.[51] This is compared to $29 million per year for utility-scale battery storage and $43 million per year for a gas peaker.[52]

Furthermore, particularly in markets that have higher cost of transmission and distribution, or higher costs associated with GHG emissions, the benefits of a VPP can outweigh its costs even before

[39] Hledik at slide 3.
[40] Ibid.
[41] Hledik at slide 4.
[42] Ibid.
[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] Ibid.
[49] Ibid.
[50] Ibid.
[51] Hledik at slide 5.
[52] Ibid.

accounting for the value of resource adequacy. As a result, it is possible to obtain resource adequacy from a VPP at a negative cost to society.[53]

VPPs and the Customer Experience

While a VPP involves participation by a utility or an aggregator and requires close coordination and interaction with the power system, a VPP is ultimately a system that starts and ends with the customer.[54] In considering VPP customer incentives, it is important to consider the marginal cost of VPP resources.[55] In engaging with the customer, it is important for the customer to know when they are participating in the VPP.[56]

Utility Example: Portland General Electric

Portland General Electric (PGE) serves as an example of how a VPP can help a utility successfully obtain reliable, economical resource adequacy while effectively engaging with its customers.[57]

PGE is a vertically integrated electric utility encompassing generation, transmission, and distribution. PGE serves approximately 926,000 retail customers within a service area of approximately 1.9 million residents. Roughly half of Oregon's population lives within the PGE service area, encompassing 51 incorporated cities entirely within the State of Oregon. Roughly two-thirds of Oregon's commercial and industrial activity occurs in the PGE service area.[58]

PGE's goals align with achieving 100% clean energy by 2040. The targets to reduce baseline GHG emissions from power served to Oregon retail customers are:

- 80% reduction in greenhouse gas emissions by 2030
- 90% reduction in greenhouse gas emissions by 2035
- 100% reduction in greenhouse gas emissions by 2040[59]

In pursuing these goals, PGE manages an integrated system for the 24/7 clean energy future, recognizing that increasing customer choice and control requires a bidirectional, automation-enhanced grid.[60] Figure 3 below provides an illustration of PGE's integrated system that enables its VPP.

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[53] Hledik at slide 6.
[54] Hledik at slide 6.
[55] Chew at slide 6.
[56] Ibid.
[57] Ibid.
[58] Albi at slide 7.
[59] Ibid.
[60] Ibid.

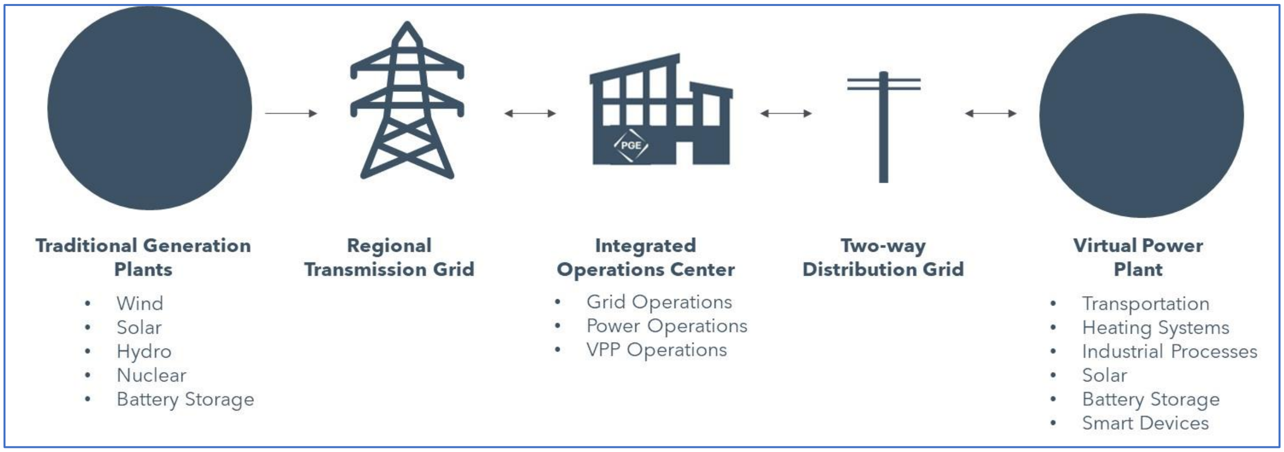

Figure 3: PGE Integrated System. Source: Portland General Electric.

PGE is scaling its VPP to meet 25% of peak load and provide grid services 24/7/365.[61] With PGE's VPP, the utility is focused on creating a clean energy ecosystem in which everybody can participate and thrive. The utility translates internal, utility-centric capabilities into experiences where customers have more choice and more control of the energy that powers their home, their work, their life, and their community.[62] The clean energy ecosystem that powers PGE's VPP consists of a variety of technologies, such as distributed solar generation, distributed thermal, and both distributed and utility-scale storage.[63] PGE also manages flexible load as part of its VPP.[64]

Meanwhile, PGE customers engage with the VPP through technology that is "in their pocket." To make it easy for customers to access the services of the VPP, the utility offers several customer programs, such as its Energy Partner program, Peak Time Rebates, Residential T-Stat, and Multi-Family Water Heater.[65] Residential customers can access the benefits of PGE's VPP through single/multi-family rooftop solar, distributed batteries, smart devices, vehicle charging, heat pumps, thermostats, and hot water appliances.[66] Municipality, school, university, and hospital customers can access the benefits of PGE's VPP through community-based renewables, microgrids, school bus V2G, and advanced heating/cooling. Commercial and industrial (C&I) customers can access the benefits of PGE's VPP through heating systems, building management systems, industrial processes, warehouse automation, chillers, data center, and back up batteries and generation.[67] Transportation electrification customers can access the benefits of PGE's VPP through transit and freight, fleet charging, public charging, rental properties, and OEM V2G and V2X.[68]

What this means for the VPP is that, on the inside, PGE manages the complexity of technology and infrastructure to provide reliable operation and deliver exceptional customer experience. On the

[61] Albi at slide 7.
[62] Ibid.
[63] Ibid.
[64] Ibid.
[65] Ibid.
[66] Albi at slide 9.
[67] Ibid.
[68] Ibid.

outside, PGE manages customer expectations for increasingly clean energy without compromising reliability while keeping costs as low as possible.[69]

PGE's Integrated Operations Center (IOC) is key to bringing all these resources together, providing uniform standards, open-source application programming interface (API), and plug-and-play connectivity. The IOC is a physical manifestation of PGE's virtual power plant.[70] The ability to integrate and operate those systems to provide valuable services is the reason for the integrated operations center.[71]

VPP Deployment – Ideal Conditions

When considering market design, technological innovation, policy support and regulatory frameworks, there are a few ideal conditions for the deployment of virtual power plants. Figure 4 below illustrates the ideal conditions for achieving maximized VPP value.

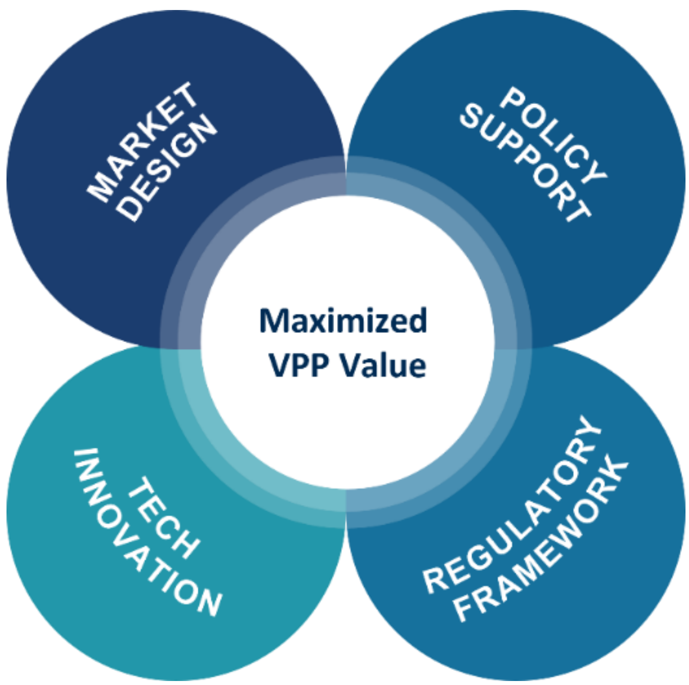

Figure 4: Maximized VPP Value. Source: The Brattle Group.

Regarding market design, wholesale markets should provide a level playing field for demand-side resources. FERC Order 2222 was issued with this in mind. Retail rates and programs should incentivize VPP participation in innovative, customer-centric ways.[72] In terms of technological innovation, DERs should be widely available and affordable, and should have the ability to communicate with each other

[69] Albi at slide 9.
[70] Ibid.
[71] Ibid.
[72] Hledik at slide 8.

and the system operator. Algorithms should effectively optimize DER use while maintaining customer comfort and convenience.[73]

Open-source technology frameworks and uniform interconnection standards are important for future deployment of VPPs. One important consideration is the creation of an open-source framework that can be readily deployed by anyone: utilities, aggregators, and technology vendors. The availability of that software code, and the uniform standards that go along with it, will likely enable faster implementation, and reduce costs, when integrating with multiple APIs.[74]

Concerning policy support, codes and standards should promote the deployment of flexible end-uses. Research and development funding should support removal of key technical barriers.[75] When considering regulatory frameworks, utility business models should incent the deployment of VPPs wherever cost-effective. Utility resource planning and evaluation should account for the full value of VPPs.[76]

Compensation and Rate Design

Rate design can play an important role in the success of a VPP. According to RMI:

> A specific, but important, category of retail VPP is a VPP in which aggregations of DERs respond, either actively or passively, to rate designs set by power providers — usually retail utilities or load-serving entities, but in some cases wholesale market operators. … [T]ariffs (rates) paid by electric customers can also induce DER build-out and demand flexibility. These include time-of-use pricing, real-time pricing, critical peak pricing, and participation incentives, which all can achieve some level of demand flexibility but differ in their level of responsiveness and ability to dynamically adjust incentives in real time.[77]

Overall, there is a need for retail rates and programs that incent participation in VPPs in innovative, customer-centric ways.[78] As an example of this, subscription pricing is designed to give customers access to the benefits of VPPs and attract customers to participating in VPP programs in a way that does not exist with more conventional ratemaking approaches.[79] The utility offers the customer a fixed monthly bill for a fixed term—typically 12 months—based on the customer's recent average annual usage. In return, the customer agrees to adopt a load flexibility or energy efficiency measure that could include participation in a VPP. The ability to manage the customer's usage and derive value from their resources generates value that can allow the utility to offer a fixed bill that is lower than the customer's average historic bill while also sharing in some of the cost savings.[80] With innovative rate design, subscription pricing can reflect both the cost savings and value of services offered by the VPP.

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[73] Hledik at slide 8.
[74] Albi at slide 9.
[75] Hledik at slide 8.
[76] Ibid.
[77] RMI report at p. 12.
[78] Hledik at slides 8-9.
[79] A subscription-based pricing model is a payment structure where customers pay for a service or product on a regular basis. *See* Hledik at slides 8-9.
[80] P. Fox-Penner, R. Hledik, A. Lubershane,"FixedBill+: Making Rate Design Innovation Work for Consumers, Electricity Providers, and the Environment," The Brattle Group working paper (June 2020). Available at https://www.brattle.com/wp-content/uploads/2021/05/19251_fixedbill_working_paper_brattle_june_2020.pdf.

Business models need to enable the recognition of the value created by the additional services that are unlocked by VPPs. The value of those grid services changes based on the conditions of the system. Often, the annual averages for long-term planning fixed prices do not reflect operational realities. Meanwhile, most customers do not want to be energy day traders. Utilities and aggregators need to strike a balance so that customers can make good choices and can choose where they set their VPP dial, with the ability to turn the dial based on their needs at the time.[81]

Today, most utility business models incentivize the deployment of infrastructure and capital investment because that is where utilities earn their return. Utilities do not have the same financial incentive to spend on operational expenses to deploy VPPs. Overcoming the misalignment between the utility's financial incentive and the deployment of VPPs is one of the most important areas for regulators innovation.[82] In addition, resource planning and cost effectiveness evaluation must evolve to account for the full value of VPPs, rather than capturing only a portion of the total "value stack."[83]

What's Next?

The Brattle Group suggests the following three low-risk actions utilities and regulators can take now:

- Conduct a **jurisdiction-specific VPP market potential study**, then establish VPP procurement targets.
    - A jurisdiction-specific VPP market potential study is important for understanding, for any given utility system or any state, where the low-hanging fruit is from a VPP procurement standpoint.[84]
- Establish a VPP pilot and test innovative utility financial incentive mechanisms.
    - In addition to serving as a screening exercise to help interested parties know where to dedicate their resources, a jurisdiction-specific VPP market potential study can lead to the establishment of a VPP pilot to help demonstrate that a VPP is a dependable resource.[85]
    - Not only can a pilot prove that the technology works, but it can test innovative ideas around improving the utility business model and aligning incentives with the deployment of VPPs.[86]
- Review and update existing policies to comprehensively account for VPP value.[87]

Overall, based on real-world experience with VPPs to this point, it will be important for the next generation of VPPs to:

- Bridge the gap between customer programs and operations/planning.
- Unlock more quantifiable value.
- Enable a culture of innovation in the industry.
- Ensure an equitable transition for all.[88]

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[81] Albi at slide 7.
[82] Hledik at slide 8.
[83] Ibid.
[84] Hledik at slide 9.
[85] Ibid.
[86] Ibid.
[87] Ibid.
[88] Chew at slide 7.

Resources for More Detailed Information

Brehm, K., McEvoy, A., Usry, C., & Dyson, M. (January 2023). *Virtual Power Plants, Real Benefits.* RMI. Retrieved from https://rmi.org/insight/virtual-power-plants-real-benefits/

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Summary of Webinar Q&A

Should VPPs include energy efficiency? Should VPPs also include behavioral forms of demand response that are induced through rate designs or other incentives?

Ryan Hledik, The Brattle Group: We should be as comprehensive as we can be when we think about our definition of virtual power plants and not exclude certain demand side resources, because the reality is from one market to the next, different elements or components of a virtual power plant are going to have more value depending on the specific conditions of that market.

If we only think about resources as a demand response resource, or only an energy efficiency resource, we are splitting the benefits of the thermostat into two service categories but still assigning the whole cost when evaluating either those services on their own. If we think about VPP more holistically, in terms of the benefits that it can provide to the system and include energy efficiency in that, then that's aligned with being comprehensive in our view of value. You might need capacity, or you might need energy; the baseload versus peaking issue. If you package energy efficiency, it can give you some of that baseload resource that you wouldn't be getting from something that's only going to give you peaking capacity. It's very jurisdiction specific; if you're a jurisdiction that has a greater need for energy than capacity, then a VPP that includes energy efficiency is going to be better aligned with your needs.

What should a regulator be looking for in a proposal for a VPP from a regulated utility? What questions should we be asking?

Franco Albi, Portland General Electric: How does the benefit flow to customers? And what service is being provided to those customers? How are you analyzing and assessing that? I think the other thing that keeps coming to my mind is flexibility. We very much come from a world of a static rate, but we're starting to move into time of use, so a little bit of differentiation there. The system is changing so fast. And the participation of customers is changing so fast. Flexibility in how those rate structures are applied is going to be really important going forward.

Ryan Hledik, The Brattle Group: Is the VPP being used in a way that maximizes its potential value to the system is an important question when it comes to making sure that value is then available to the consumers and participants.

Brenda Chew, Virtual Peaker: How could this program also allow more flexible ways to engage those customers for multiple services?

Ryan, your analysis assumed that the DERs in the VPP already are built, correct? Did the analysis factor in the possibility that a DER was already participating in a program like demand response? At what point would you need to assume investment in additional incremental DERs to support VPP?

Ryan Hledik, The Brattle Group: There is all of this investment that's already been made, in technology that's sitting on the customer side of the meter, that we aren't fully utilizing. Customers are buying smart thermostats because they look good, and they want to control them from their phone. Customers are buying electric vehicles because they're clean, the acceleration is awesome, reasons X, Y, and Z. And we now have the opportunity to unlock an additional feature of that investment that the customers have already made by participating in a VPP. From an accounting standpoint, it would be important to make sure that if we're assigning value to a VPP, we aren't double counting benefits that are already associated with a demand response program.

Brenda, how do you enable customers to opt out of providing a service? For example, are there penalties? And how do you manage that?

Brenda Chew, Virtual Peaker: For all of our control events we have varying logic, depending on the technology, and how folks may want to set up that program. The parameters will vary— you could allow customers to really have their own schedule set up or have certain preferences, where they would just automatically be opted out and not be asked to participate during certain circumstances. Or there could be more traditional examples where you're going to have an event, and then about an hour before the event or a day before, they'll get an email, a text message, they can click the link, they can choose to opt out actively as well.

Franco, you show the complexity of the system. How might AI capabilities impact the system? Can it help reduce costs or increase available capacity?

Franco Albi, Portland General Electric: I think AI technology in general is incredibly fascinating. And I think that the way that we're talking about managing the distribution system and managing the real time energy flows is not going to be a human-centered process. It is going to be algorithm driven. Those algorithms are going to have machine learning embedded in them. In addition, AI technology is in the ability to disaggregate loads. It's going to be core; it is already core to how we manage the system, and it's only going to get exponentially more complicated.

Brenda Chew, Virtual Peaker: I think AI has huge potential to help us really be intelligent and optimized so that folks will feel confident about what they can get. For our own work, we are very careful that security is first and foremost.

Can a utility customer, for example, a large energy user utilize a virtual power plant without their utility having a program to facilitate that?

Ryan Hledik, The Brattle Group: Yes. FERC Order 2222 opens wholesale markets up to demand side participation. This is designed in part so that customers have access to the market. A very large customer could participate directly in wholesale markets to bid their load in ways that would provide additional value. Or aggregators in wholesale markets are available to customers and give them that avenue for participating.

Franco Albi, Portland General Electric: Yes, I echo that. As the distribution system operator, we want to make sure that that customers are getting high power quality as affordably as possible, as much clean energy as possible. And we partner with others. Today, we partner with energy service suppliers, third parties to manage our participation in the wholesale markets to make sure that we're meeting demand every second of every day. Rather than build that up from scratch, we want to partner with the right entities to be able to bring their capabilities where customers feel is a seamless experience.

Brenda Chew, Virtual Peaker: There will always be opportunities for those folks to become more optimized and more self-sufficient. There are complexities around visibility and understanding of grid constraints. They could be getting clearer, localized market signals. Maybe that's a little bit further down the road, in a more transactive world, but less so today.