The Promise of Virtual Power Plants

How VPPs Contribute to Grid Stability While Improving Your Bottom Line

enel

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Intro: Why Virtual Power Plants Should Matter to Your Organization

In this eBook, we explain virtual power plants (VPPs) in simple terms. Our goal is for potential VPP participants to better understand this simple but revolutionary concept.

Why *should* VPPs matter to you and your organization?

At the most basic economic level: organizations that participate in VPPs through partners like Enel can decrease energy spend and earn new revenues. They are compensated for contributing much needed energy flexibility to an energy grid that is increasingly pushed to its limit.

But the value of VPPs goes further: VPPs are a growing contributor to local energy stability as the Energy Transition progresses. Participants are helping to keep energy reliable in their communities.

We believe that by understanding how VPPs work, why they create value, and how they're evolving, organizations can better appreciate the important contribution they make to the Energy Transition by participating.

If you are interested in learning more about what a VPP can do for you, please do not hesitate to contact us.

> "Virtual power plants can catalyze DER deployment at scale and help make affordable, resilient, and clean energy accessible to all Americans."
>
> —Jigar Shah, Director of the Loan Programs Office for the US Department of Energy

The Growing Demand for Renewable Energy and Power Purchase Agreements

When the University of Massachusetts at Boston crafted a 25-year master plan to become more environmentally friendly, it opted to build an on-site 1-megawatt solar photovoltaic system paired with battery storage to reduce its electric consumption from the more emissions-intensive grid.

It also built a number of electric vehicle charging stations on its 120-acre campus. Those on-site solar, storage and EV charging assets are commonly known as distributed energy resources (DERs). DERs are increasingly popular as solutions to meet corporate net-zero commitments, with new financing models emerging to reduce upfront costs to customers. DERs will directly make the UMass campus greener and more energy efficient.

But these DERs are not only helpful in reducing emissions on the campus – they can have broader positive effects on the overall stability and sustainability of the grid. DERs often have this wider impact on the energy grid when aggregated and operated as part of "virtual power plants," or VPPs. VPPs orchestrate multiple distributed assets and can be bid into electricity markets to provide grid services. While most DERs are currently managed to optimize for a specific customer's needs, the promise of VPPs is the orchestration of multiple DERs to instantaneously balance supply and demand on the electric grid.

What Is a Virtual Power Plant?

A virtual power plant is a decentralized portfolio of DERs and other assets that can be aggregated and operated as a larger scale asset in response to market signals. VPPs can be helpful in addressing supply shortages during peak demand by using flexible capacity to help reduce demand during system peak hours. They can also improve the real-time balancing of supply and demand on the grid by providing energy flexibility and ancillary services.

For practical purposes, virtual power plants act like and have the same effect as a traditional, centralized large power plant. Their ultimate aims are the same: ensuring that energy demand on the grid is met instantaneously by the available energy supply and that the grid remains stable. But they achieve this in significantly different ways.

Traditional power plants operate out of one physical location and work only on the supply side of the grid equation – as demand increases, the centralized physical power plants are ramped up to supply more energy.

A virtual power plant, by contrast, uses its many decentralized assets in different ways to help supply meet demand. Current VPPs largely (but not exclusively) operate on the demand side of the equation by creating flexible demand, typically shifting demand away from times of peak energy use. Decreasing demand has the same effect as a traditional power plant increasing supply – ensuring that supply and demand stay balanced. But this is not all that VPPs can do. Some of the DERs in a VPP can also, in certain cases, supply energy to the grid (e.g., on-site generators, storage technologies), a trend that we see increasing in the future.

What do VPPs consist of? A wide variety of different energy assets can be aggregated into a VPP. Some examples of assets in VPPs include:

- **Flexible load:** The load of a facility can be bundled into a VPP by pledging to be flexible. The most common form of demand flexibility comes in the form of load curtailment, incentivized through many utility and market operators' demand response programs. In such a program, large energy users are paid to curtail their load during a system's peak hours.
- **Energy storage:** Battery energy storage systems can enable end users to stop drawing energy from the grid and instead use energy stored in their batteries. In some states and some circumstances, batteries can contribute stored energy directly to the grid as part of a VPP.
- **On-site solar:** On-site solar can help reduce the facility's consumption from the grid. In some states and under specific circumstances, excess solar can be exported back to the grid under a net metering scheme.
- **Electric vehicles:** Much like a battery, smart EV charging can respond to grid signals and allow EV owners to shift their charging time to a period where the price (typically correlated with system demand) is lower.

VPPs are growing in importance because they leverage existing assets to provide grid services. Enabling more supply- and demand-side flexibility means less need for peaker plants that are only used during times of peak demand. This reduces investment costs for new low-utilization infrastructure and local emissions (as peaker plants tend to be carbon-intensive). In addition, DERs sometimes allow utilities to defer investments in capital-intensive projects like transmission and distribution upgrades, by providing local reliability services. In this way, VPPs are really a no-brainer for unlocking the energy transition.

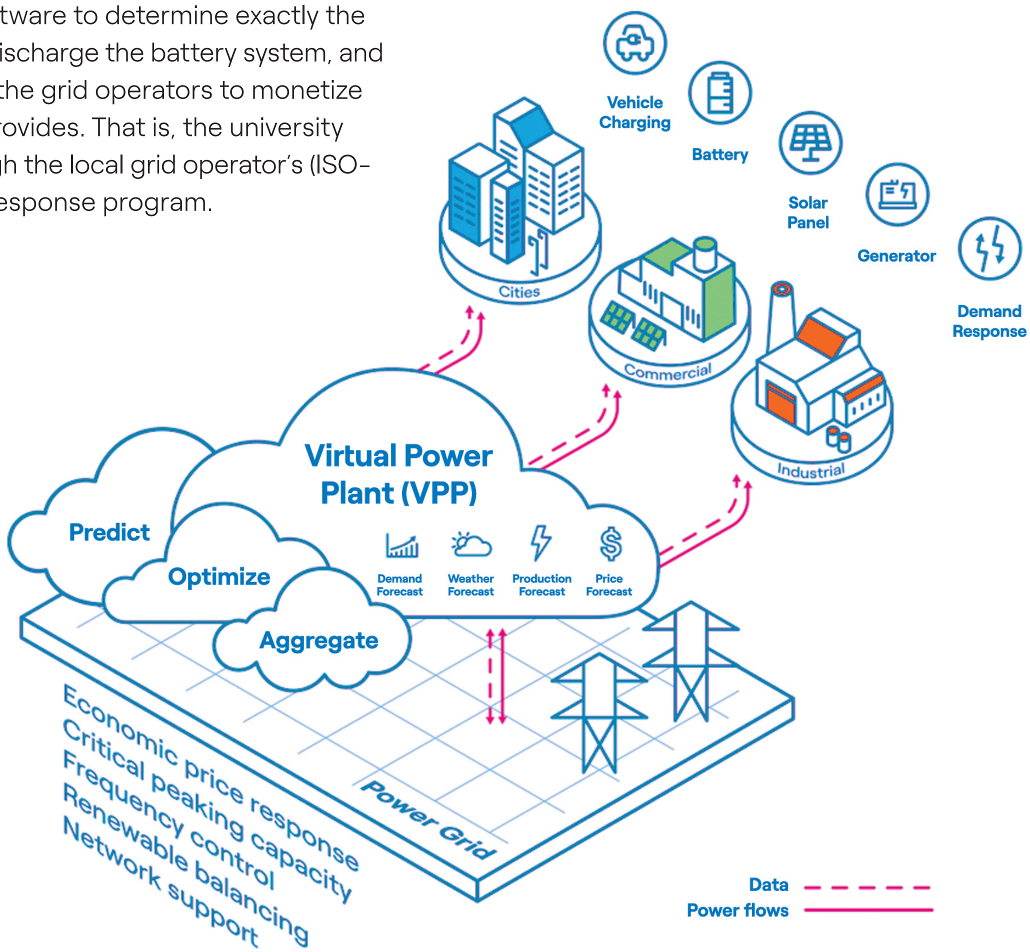
How Does a VPP Work?

The goal of a VPP is to manage a portfolio of DERs to provide real-time and stand-by capacities to the grid. But to do all of this, someone must aggregate and manage the DER assets to ensure they are made available to those who manage the grid. Because this requires both the sophisticated controls and the commercial structures that would enable a third party to operate assets on the customer's behalf, we have not seen large-scale deployment of VPPs yet. For now, aggregators are working to optimize site-specific DERs and bidding their bundled capacities into the marketplace.

At UMass, Enel operates the DERs as a VPP. In addition to designing and coordinating the construction of the on-site assets (including a power generator, battery storage and electric charging stations), Enel uses an advanced analytics optimization software to determine exactly the right time to charge and discharge the battery system, and it connects the assets to the grid operators to monetize the flexibility services it provides. That is, the university can earn payments through the local grid operator's (ISO-New England's) demand response program.

In a demand response program, the grid operator will signal the VPP operator (Enel) that it needs a certain amount of power within a specific window of time, and from there Enel coordinates with asset owners or uses automated software to shift energy usage away from the window (curtailing load during that time).

"We can take any flexible asset anywhere at any time and bid it into wholesale markets," says Greg Geller, who leads the regulatory efforts for Enel North America. "We have the know-how and the expertise to monetize that flexibility, whether as part of a utility program or an Independent System Operator market. We are the interface between customers and those utilities and grid operators."



The Evolution of the Energy Grid and VPPs

The electricity grid is rapidly evolving. What was once considered a moonshot has become commonplace – renewable resources becoming cost-competitive with the fossil-based dispatchable generation, while smart appliances and vehicles can quickly respond to price signals.

But these changes have also made the operation of the grid more complex, where supply must always balance with demand. For example, wind and solar power are intermittent resources (meaning there's no power if there's no sun or wind) – their growing penetration only serve to highlight the ramping (or flexibility) challenges and capacities needed to bridge between high and low intermittent generation (e.g., the Duck Curve in California).

Enter VPPs, decentralized power plants that can leverage existing assets to make the whole grid more reliable. The idea behind VPPs started two decades ago with demand response, which meant large energy users manually shifted their energy usage during peak hours to lessen stress on the grid. In return, these energy users were rewarded for their flexibility with demand response payments. Demand response aggregators (of which Enel was a key first-mover) signed up a lot of businesses willing to cut their use during peak times. The aggregators would bundle that package and sell it into energy markets.

Today, what was once manual load curtailment can be a VPP, where demand curtailment is bundled with on-site DERs – like solar PV, battery storage and electric vehicles. There are encouraging trends towards more DER capacity, greater revenue per capacity (through market participation), and reduced barriers to entry (more understanding of what the model entails).

"The goal is to have multiple assets – to mix and match assets to honor our commitment to the grid," says James Lombardi, solution and enterprise architect for demand response at Enel. "We are managing their assets on their behalf because we have incentivized those organizations. Our responsibility is to make sure they will participate when they say they will. We are confident we can deliver."

How VPPs Reduce Your Energy Spend

To understand why it's important to let operators tap into the flexibility of DERs, you need to first understand the time-varying costs of delivering electricity. Imagine that you run a factory. One day, you have an extra-large order and have to use more energy – something that could cause your load to spike by 25%. Your bill could spike by much more than 25% if you use that energy on the wrong day or at the wrong time (coinciding with system peak events).

In New York, for instance, the grid operator penalizes energy users that contribute to system peaks or use more energy during peak times of day (typically, late afternoon) or peak times of year (typically, extremely hot or extremely cold days). If you run the new process at the wrong time, not only will it cause your electricity bill to rise by thousands of dollars, but it can also cause operational challenges for the grid operators.

This is why unlocking the value of VPPs can be a win-win scenario, for both the customers who earn money for their assets (e.g., grid services, on-bill savings) and utilities and grid operators who can lower their infrastructure investment costs for large-scale power plants or transmission and distribution upgrades.

To realize the importance of VPPs in deferring infrastructure investments, consider ConEd, which was facing load growth in its service territory – in part due to the construction of high-rise buildings in Brooklyn. The utility could build new infrastructure to handle the expected energy demand – to the tune of $1.2 billion – or it could come up with lower-cost (non-wire) alternatives that include leveraging the combined capacity of DERs during peak hours. Specifically, the utility was concerned about 50 hours of the year when the load was expected to exceed its supply capacity – something that a VPP could solve.

Enel contracted with ConEd and the Related Companies to install a 4.8 MW battery storage project in a parking lot at the Gateway Shopping Center to alleviate the grid stress. In this solution, during peak hours, ConEd signals Enel when to dispatch their distributed assets, enabling the utility to forego an expensive capital grid upgrade project. In total, the cost of the DERs was hundreds of millions of dollars less than the new infrastructure project.

The Increasing Opportunities for VPPs

According to Wood Mackenzie's 2021 DER Outlook, 175 GW of DER capacity and demand flexibility will be added in the United States in the next five years (2022-2026). This represents 41% of total new capacities in the same time period, making DERs almost on par with centralized, utility-scale generation and storage. The Outlook also highlights tremendous cumulative capacity growth for all types of DERs by the end of 2026: an increase of over 615% in capacity for battery storage, a 530% increase for EV infrastructure, a 45% increase for solar, and a 165% increase for demand flexibility.

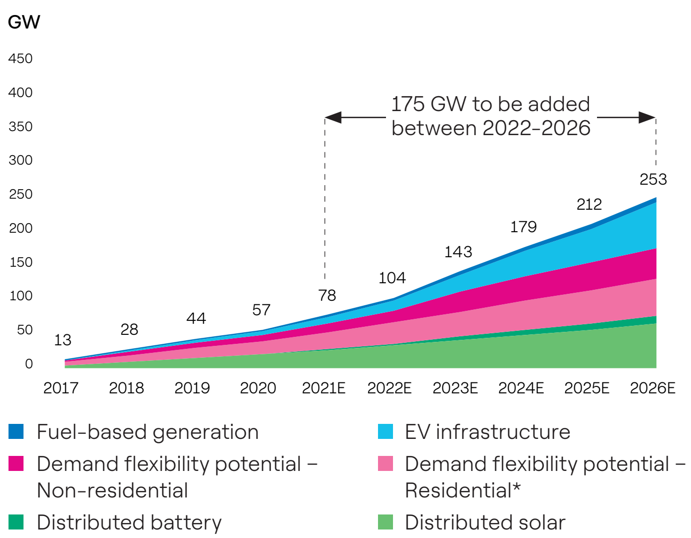
DER growth is bolstered not only by greater need for energy resilience, but also by the availability of federal and state funding. State incentive programs such as California's SGIP, Massachusetts' SMART, Connecticut's Energy Storage Solutions and New York's Charge Ready are critical to project economics today. Federal funding through tax credits, which have helped to advance the solar industry, is also expected in the form of the passage of a standalone storage ITC and the extension of the solar and wind ITCs. On the mobility side, the bipartisan Infrastructure Investment and Jobs Act will make $7.5 billion available to EV infrastructure – distributed assets that can be aggregated and operated as a VPP.

"More distributed energy is coming online this year than central generation," says Peter Asmus, research director for Guidehouse Insights. "We will need more virtual power plants – things that can orchestrate those assets. It is viable, and it is happening."

The impacts could be significant. To put things in perspective, Enel has sold 50,000 electric chargers in California. EV drivers could agree to sell the electricity in their car batteries to aggregators. Once the aggregator can get enough owners to agree to this arrangement, it can bid that collective load into electricity markets. Even if some individual customers are not able to respond, a significant portion of customers will – hence the benefits of the portfolio approach.

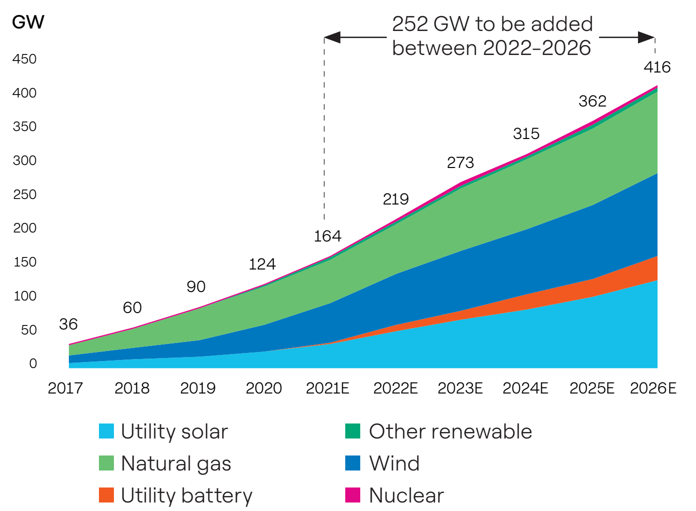
DER and demand flexibility, cumulative capacity additions since 2017 (GW)

(2017-2026E)



Bulk generation and storage, cumulative capacity additions since 2017 (GW)

(2017-2026E)



* Non-residential flexible capacity potential refers to the flexible capacity of new and expanded facilities, including those that are not yet commissioned for market participation.
Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, U.S. Distributed Solar Service, and North American Power Service

Why VPPs Will Continue to Grow

Most organizations will not have a facilities manager on staff with the bandwidth to focus on DERs. An aggregator with innovative software solutions automates the management of these DERs to help them achieve their goals: reducing energy expenses, earning new revenue and remaining resilient without adding operational costs.

DERs are valuable assets – not just to their owners but also to utilities and grid operators. They have increased grid efficiency, allowing for the growth of the green energy movement, while helping earn revenue for their owners. And there is hope they may play a bigger part in the future, in the wake of the Federal Energy Regulatory Commission's Order No. 2222 in September of 2020, which aimed to remove lingering barriers to DER participation in wholesale markets. Independent System Operators are in the process of submitting their compliance filings to FERC and will implement new participation options in the next three to four years, and the influence of VPPs could increase as decarbonization becomes an increasing priority of most grid operators.

"Being able to use distributed energy resources to support the grid will be an increasing trend," says Marco Artina, head of demand response product management globally for Enel. "CO_2 emission reduction goals imply an increase of electrification and an increase of our dependency on renewable energy sources that are hard to predict. Distributed energy resources will become the key, but they need an entity to aggregate and manage them. To keep the grid in balance, this will require more investments in virtual power plants."