VIRTUAL POWER PLANTS:
Coming Soon to a Grid Near You
To meet these challenges, some utilities and system operators are turning to virtual power plants (VPPs) to help balance the supply and demand of renewable energy on the grid. VPPs are essentially digital platforms that aggregate renewable energy resources and manage their output to meet grid needs. They can be used to integrate new renewable energy sources, such as solar and wind, and help manage the intermittency of these resources.

The U.S. Energy Information Administration (EIA) notes that the cost of building a new coal-fired power plant ranges from $2,934 to $6,599 per kW, depending on the technology. And while natural gas-fired plants construction costs are less at $676 to $2,095 per kW, both options carry considerable environmental and stranded investment risks. Virtual power plants, on the other hand, pose a very different future to provide financial and environment benefits for distributed energy asset owners, while also maintaining a reliable supply and demand balance of the electric grid, at a cost of approximately $80 per kW.

Before recent elections in the Philippines, officials worried about the potential for blackouts due to problems integrating solar energy into the grid. Oversupply had been triggering outages, and the system needed ancillary services – especially frequency regulation – to keep electricity flowing, according to an article in the Manila Bulletin.
Providing Power – Without the Plant

Navigant Research defines a VPP as “a system that relies upon software and a smart grid to remotely and automatically dispatch and optimize DERs via an aggregation and optimization platform linking retail to wholesale markets.”

VPPs can be cloud-based, central or distributed platforms that aggregate, optimize and control varied and heterogeneous DERs to behave as conventional dispatchable power plants. They deliver power without the physical plant. As such, VPPs can replace conventional power plants while also providing higher efficiency, greater flexibility and increased grid reliability. In orchestrating distributed generation, PV, microgrids, storage systems, controllable and flexible loads, along with other DERs, VPPs provide critical and fast-ramping ancillary services.

Designed to provide flexible grid services that are not highly dependent on the specific locations of the DER assets, VPPs are ideal for applications such as frequency regulation — what was needed in the Philippines example — along with advanced demand response, peak demand management and operational reserves (secondary and tertiary reserves in Europe). They also enable energy trading in wholesale markets on behalf of DER owners who would otherwise not be able to participate on their own. VPPs can act as an arbitrageur between DERs and diverse energy trading floors.

It is important to note that this is in contrast to the location-specific (e.g., tied to locations of specific assets such as feeders), primarily distribution system-focused grid services enabled by distributed energy resource management systems, or DERMS.

Frequency Regulation/Secondary Reserves: Addressing the Renewable Energy Integration Problem

Since renewable power sources such as wind and solar are notoriously variable and therefore difficult to predict, new scheduling, control and management systems are needed to ensure a continuously balanced supply/demand mix on a second-to-second basis. This removes the uncertainty that renewables introduce to the energy balancing equation.

If you are a wires operator and get high concentrations of PV on the grid, like in Germany or California, and you have massive changes in demand from when the sun shines to when it is not shining, the entire distribution system has to pick up spikes in load. The system wasn’t designed to do that.

The same challenges arise with wind power. Variability factors have led to significant price increases in ancillary services such as the spinning reserves needed to stabilize the grid with traditional generation.

Today’s VPPs offer an ideal optimization platform for providing the supply and demand flexibility needed to accommodate the fast ramping needs of renewables, to balance wind and solar intermittency and to address corresponding supply forecast errors. For example, if one wind power source generates more energy than predicted and another generates less, a VPP will balance the two, resulting in a more accurate forecast. In addition, the wind power becomes a more reliable source of capacity in the market.

Often, utilities fire up large and less efficient power plants to grapple with small gaps in demand. They may deploy a 600-MW gas plant when only 5 MW is needed. With a virtual power plant, when the operator asks for 5 MW, the virtual plant will do two things. It will look for places to reduce load, so the system may not need all of the 5 MW. It will also look for places where it can self-generate electricity by discharging batteries, or dispatching hydropower, wind or solar facilities.

Moving Beyond Traditional Demand Response Programs

When the wind stops blowing or clouds shade sunlight destined for PV panels, system operators need flexible and reliable resources that can come on line immediately. The need to handle shifting loads and over-generation requires more than just meeting...
demand peaks. Traditional demand response (DR) programs — with alerts that go out a day or several hours ahead — are simply unable to support the rapid response times needed to keep today’s evolving grid stable and balanced. But VPPs can perform this critical function.

Unlike typical demand response programs, virtual power plants incorporate short-term load, distributed generation forecasting and aggregation capabilities. They perform near real-time shifting of commercial and residential net loads to provide the services needed by the grid. Under the control of a virtual power plant, demand on the system can be optimized and tweaked automatically, making day-ahead call-outs a thing of the past.

Furthermore, VPPs do this without the need for triggering by the utility or grid operator. VPPs can respond automatically based on grid signals or price signals. They achieve this without impacting or even being noticed by the customers from which DERs are being aggregated.

Virtual power plants use flexible capacity to move demand to another time, reducing the difference between base and peak load.

VPPs have the ability to go way beyond simple load curtailment and to leverage continuous communications and bi-directional control to deliver dispatchable grid support. As a result, aggregated DERs — orchestrated by VPPs with sub-second response speeds — are becoming the new demand response.

Virtual power plants can coordinate and control more efficient and clean sources of distributed energy so there’s no need to overbuild or fire up wasteful fossil-fuel plants to balance electric demand and supply.

A virtual power plant can automatically detect that capacity is needed on the grid. Or it may be fed an automatic generation control signal that indicates the utility needs a certain amount of capacity at a certain point in time. The system can then go get that capacity within the bounds of what is currently available, at a specified confidence range, such as 2 MW with 95% confidence or 3 MW at 70% confidence.

The capacity available to the virtual power plant is based on a variety of factors such as the assets that are under the system’s control, the time of day, and the historical usage of those assets at that time of day. Advanced learning algorithms, which search for regularities in great masses of data, can create a predictive model of grid electricity usage by consumers and businesses. This allows the virtual power plant to better allocate resources and more accurately anticipate electric demand.

Mitigating the Operational Reserve Challenges

The high reliability of the power grid is based on maintaining sufficient operational reserves. Historically, these reserves have been almost exclusively maintained in the form of traditional generation. Much like the peak demand scenario, this leads to the construction
of costly, carbon-emitting plants that are rarely or perhaps never used. VPPs provide a mechanism for changing this paradigm.

A VPP can be called upon to quickly ramp when more costly spinning reserves are tapped to maintain balance. This reduces the quantity and duration of spinning assets required. The fast-acting, non-impactful response provided by a VPP gives system operator(s) the confidence they need to depend on unconventional operational reserves. VPPs can simultaneously prevent participation fatigue that is all too common with existing DR programs. This is a key point of differentiation between VPPs and DR programs. VPPs operationalize the use of DERs for direct support of the grid, as determined by the system operator. DR participants drop out at a fairly predictable, and quite measurable, rate as the calls become more frequent. On the other hand, a VPP uses the flexibility of the entire fleet to modulate participation in a way that does not impact process or comfort, making it “always on.”

DERs aggregated and controlled by a VPP can provide operational reserves when they are needed, while also enabling much greater customer participation in ancillary grid services markets. By linking DERs to markets, VPPs provide real-time operational reserves that can be bid into ancillary markets. This provides an economic return for the participant, along with the ability, based on situational awareness, to instantly adapt to changing grid situations.

**Energy Arbitrage Market Bidding**

As alluded in the previous section, VPPs have both operational benefits and energy market benefits. Acting as an intermediary between DERs and the market, the VPP aggregates DERs, with the purpose of trading energy on behalf of DER owners who would otherwise not be able to participate in energy markets on their own. As a result, VPPs have the added value of meeting their end-customers’ demand for services that help monetize the capacity of DERs.

In other words, the virtual power plant acts as an arbitrageur by exercising arbitrage between diverse energy trading floors. The VPP can potentially remove the need for additional physical power plants by making a whole energy system more efficient, especially in competitive power markets. This creates a positive impact for every ratepayer served by the system that employs a VPP because the VPP reduces the delta between base and peak loads. The higher confidence that grid planners and operators have in shrinking this gap — and increasing the system’s capacity factor — the greater capital efficiency that can be achieved. Rather than throwing money at the problem, VPP software takes advantage of the unique characteristic of each asset to provide services that were incomprehensible just five years ago and does so in near real time.

With a VPP, the customer stays in control. The flexibility and ease of program participation make most customers highly amenable and loyal to the program. More than a give-and-take exchange, the VPP is a partnership between power suppliers and the consumers they serve. Because local demand adjustments are rarely, if ever, felt locally, participants commonly approach the VPP operator to inquire how they can offer even greater flexibility and contribution to the service. The premise of being present but not felt is core to a VPP’s success, given that it may be called upon often, without notice, any time of the year.

**Conclusion**

What if, instead of building new peaker plants, the industry could meet our energy needs by making hundreds or thousands of DERs work together to create virtual power plants? What if we could create a VPP-driven “Internet of Energy” — a web of interconnected solar panels, battery storage, wind farms, combined heat and power units, flexible process loads, fly wheels and other energy resources that can be flexibly and reliably dispatched as needed?

This is the future when it comes to making the most of DERs and keeping the world’s power grids in balance. This is the reason Navigant predicts that VPP spending will reach $2.1 billion a year by 2025. VPPs — coming soon to a utility near you.