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LightsOn

Virtual Power Plants:

Making Distributed Energy Resources Actionable in Smart Grid Commercial Operations

The vast complexity of resources that must be managed and integrated in advanced Smart Grid deployments can seem intimidating for almost any utility. For large commercial operations with hundreds of thousands – or even millions – of customers, it can seem like an impossibility. In this article, Smart Grid solutions expert Carlos Romero unveils a new mechanism for aggregating distributed energy resources and making them actionable in Smart Grid commercial operations as *Virtual Power Plants*.

In a recent survey, executives at leading global utilities indicated that a growing number of them have embraced Smart Grid strategy. No surprise there. But, what is new is the desire to drive the strategy not just in discrete areas like smart metering, load management and distributed generation, but "as a platform for fundamental business process transformation initiatives that span the entire energy value chain across generation, T&D, and customer service operations."[1]

The executives interviewed for the study see this strategy as an opportunity to fundamentally realign the relationship between supply, demand, economic efficiency, and environmental objectives to create new operating models that support intelligent utility enterprises. And, they see it as an opportunity that comes with many potential benefits; namely the facilitation of energy efficiency and customer choice for demand response (DR) programs, as well as maximizing the benefits of renewable resources and distributed generation (DG) as part of the complete utility's portfolio.

As a whole, the respondents viewed facilitating DR and seamlessly integrating distributed energy resources (DER) such as DG and renewable resources of strategic near-term importance. However, most perceived their readiness to implement DR and DER to be low. As a result, while many utilities are beginning to implement standalone programs, few are actually connecting the customer to the wholesale side of the utility (i.e., commercial operations).

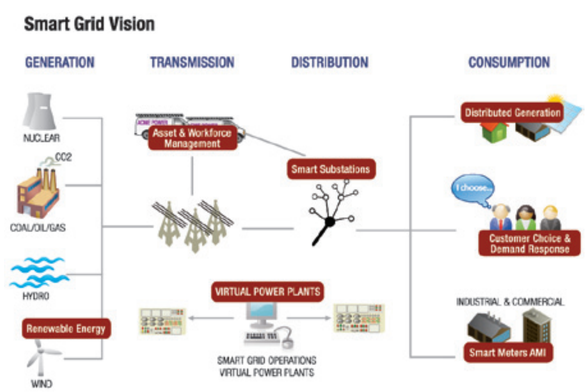
[1] Transforming the Energy Value Chain: Smart Grid Strategy of Leading Global Utilities," January 2009; The McDonnell Group.

Providing this link would represent a major step in implementing a true Smart Grid. It would enable customers to receive price or environmental signals, understand their energy consumption and even predict what their bill is going to look like. It could even enable customers to understand and affect their carbon footprint by adjusting their energy usage without diminishing their quality of life. Furthermore, it could help utilities make better use of existing infrastructure – even defer investments in new infrastructure for fuels, transmission, distribution, transformation, and generation.

If so many utilities understand the benefits of DR and DER as part of a comprehensive Smart Grid initiative, why are they not making more progress in implementation? Because they also understand the many challenges inherent in implementing effective Smart Grid programs and because the wholesale market and local tariff structures that support these approaches are just now emerging into the mainstream.

A Complicated Future

As complex and unwieldy as the electric network can be today, just imagine how complex it will be in the future, as we continue the growth of DG; as renewable resources such as wind generation – with intermittent availability – are integrated into the grid; as customers begin to plug in their electric vehicles, frequently connecting and disconnecting them from the network; and as smart appliances in homes begin responding to price and environmental signals. Imagine all your customers with different kinds of DR and DG programs, different types of resources and constraints on the utilization of these resources, and energy storage in their garage and/or at their business and how this storage will impact the distribution network.



The system gets even more complex as DR programs continue to evolve to provide more advanced controls based on time of use and real-time and dynamic pricing with the advent of smart meters. In some cases, customers can get information regarding prices (day-ahead or even real-time) and make decisions, or let intelligent devices make decisions, about their consumption based on that information.

DR programs will present even greater complexity as they begin to incorporate price-sensitivity. Utilities and service providers will have to understand and manage whatever kind of pricing structure is used for customer billing, how to calculate that price, and how fast those prices can be accurately calculated and communicated to the various control devices so that they can act/react in real time. And, how dynamic is the price to which they are expected to respond?

We must also take into account the reality that consumers can be price-sensitive, not only when the prices are high, but also when the prices are low. If large percentages of the market respond to prices on the demand side, the prices are going to come down rather than having demand resources function as a stop-gap reliability measure or critical peak resource, as they typically do today. Likewise people will connect because prices have come down, and a price-elastic market cycling process will ensue. Demand response is not only about shedding load; it is also about how the load is going to react, depending on where prices are headed at any given time.

DR programs need to be scalable and adaptable to manage these new complexities. For example, we expect customers to eventually react not only to pricing signals, but also environmental signals, as more renewable generation sources are integrated into the mix.

As all these changes come online, we will see a major impact on how utilities manage their electric networks. For many utilities there will be a major impact around the commercial operations of the Smart Grid. Traditionally, many components of the grid have been exclusively consumers of energy, such as the components on the right side of **Figure 1**. But now, not only can they contribute negative consumption by disconnecting from the network;

they can also contribute power to the network with distributed generation, electric vehicles and other kinds of devices such as storage devices and smart appliances in their homes.

Once all of these things are in place, one can only imagine the complexity of managing all of that data and managing the interactions between the various devices. But, even more importantly, managing the optimal economic interactions between these devices and the different agents of the energy markets presents even greater chal lenges. How can a utility overcome the numerous hurdles and get through to the wealth of benefits? That's where "Virtual Power Plants" come in…

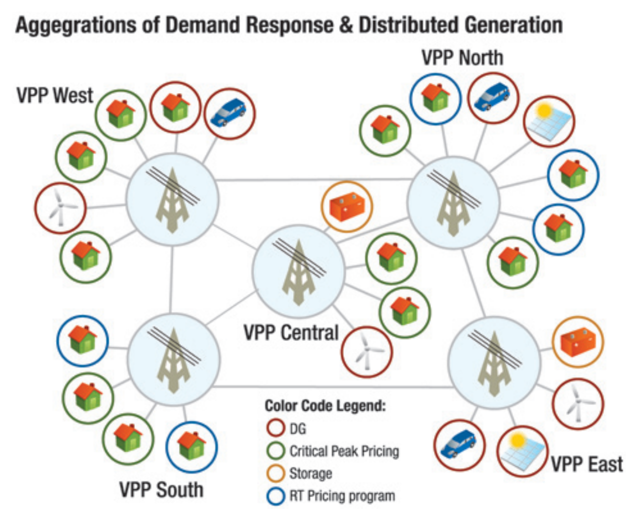
Virtual Power Plants: Doing More with Fewer Customers

So, how does a utility manage the complex systems associated with DR and DER to achieve their vision of a true Smart Grid? The first thing to realize is that we need better optimization of the various interactions along the energy value chain in order to manage this complex array of devices. We not only have a large number of them, but also a vast diversity of types of devices across the distribution network.

Households with smart appliances; electric vehicles plugged in at the home and/or the office, alternatively consuming and contributing energy; wind generation, distributed generation and other types of distributed resources must all be accommodated. Trying to manage all of these individual points would be very difficult and practically meaningless in terms of the actual kilowatts that can be extracted from each customer.

But, what if we aggregate large numbers of points on the network, in a meaningful way, as a single entity? That would certainly make things less complicated.

Say, for example, you have 300,000 customers consuming 1.5 kW each. And, you have to take into account the various DG and DR programs outlined above. At first this might seem like a nightmare, but what if you could group or otherwise aggregate these customers by program type and/or location on the distribution network? Then, instead of 300,000 customers consuming 1.5 KW each, you need only manage 15 customers each representing 30 MW. In the end, you not only have fewer customer programs to handle, but you have more capability and portfolio-level agility under each one of these programs. And, you don't lose the geographic location element of the groups (see **Figure 2**), which allows for managing the flows and constraints in the distribution topology. This is precisely what Virtual Power Plants are intended to do.



Basically, a Virtual Power Plant (VPP) is an aggregation of DR and DER programs (i.e., residential, commercial, or industrial) that enables the operator to model them as generation-quality resources. VPPs allow utilities to aggregate these programs by program type and by location in the distribution topology. This means that the utility can manage a meaningful number of customers in large volumes to affect their portfolio of options for commercial operations. In this way, using Virtual Power Plants provides a much tighter link between what is happening in the wholesale market with what is happening on the retail side with management of the transmission system and the distribution system. So, there is a complete, bidirectional flow of electrons (and money) that provides the tightly integrated optimization system that is needed to more efficiently manage the complexity of the Smart Grid.

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Why "Virtual Power Plants?"

At first, Virtual Power Plants might seem a strange name, but it actually makes a lot of sense. Indeed, the characteristics of DR programs can actually mimic what traditional generation looks like, as depicted in **Figure 3**, below.

Virual Power Plants Characteristics

VIRTUAL POWER PLANT	TRADITIONAL GENERATION ASSET
DR Capacity Forecast	Operating Limits
Number of Execution	Start Constraints
Event Durations	Total Energy Constraints
Time Between Event	Chronological Constraints
Customer Payments	Fuel and O&M Costs
Opt-Outs	Maintenance

For instance, a customer on a DR program might stipulate that the utility cannot shed his/her air conditioning unit more than once a day.

Otherwise, more frequent interruptions may cause customers to opt out of such programs altogether. Collectively these constraints mimic the startup constraints placed on a power plant unit. Alternatively, a customer might want to limit the minimum time between events.

For example, the customer might only allow the utility to call the dishwasher every two hours. Once again, that limitation mimics minimum downtime on a generation unit. Thus, we can readily see that many characteristics of a DR program can mimic how a conventional power plant operates. That is why we can make Virtual Power Plant programs a meaningful and tangible part of commercial operations. We can use them to incorporate an asset – or a group of assets – that can be dispatched based on pricing or environmental constraints to be part of the utility's entire generation portfolio.

In that respect, Virtual Power Plants represent the next generation of DR as integrated strategic resources for a utility company. As these programs have evolved from manual demand response for industrial loads to direct load control for A/C and heating units to advanced load management with dynamic pricing, the customer's demands have become more tightly linked with the utility's ability to meet them in real time. Now, Virtual Power Plants can help to create an even tighter link between the customer and commercial operations so that there is a two-way sharing of information, and the customers and all utility stakeholders can see tangible benefits from their participation in these programs.

This tighter link between the wholesale and retail sides of utility commercial operations is critical. At the end of the day, you don't manage two different utilities—a retail utility and a wholesale utility. If you are just a retailer and you don't have generation, you have to buy contracts, and you need to be able to optimize that as well. If you are an integrated utility, you have all of these businesses as part of a single company. They are not islands; everything is part of a single initiative and for many utilities the days of outsourcing this function to aggregators will give way to a reclaiming of these opportunities into the integrated portfolio. Using the Virtual Power Plant model, they can be more easily managed as a single initiative.

Additionally, there is enormous value that can be extracted from other resources such as renewable generation. Their intermittency and operational complexities can be minimized when these resources are optimized together with DR, storage and traditional generating resources.

Case Study: Xcel Energy's SmartGridCity

As a founding partner in Xcel Energy's Smart Grid Consortium, Ventyx has tested its Virtual Power Plant model as part of the utility's SmartGridCity™ initiative in Boulder, CO. Working with the initiative's various partners, Ventyx is providing – among other capabilities – the generation portfolio optimization and scheduling and customer program management solutions required to deploy and manage the Boulder-area Smart Grid.

By aggregating customer-level DR and DER into commercially actionable Virtual Power Plants, Ventyx solutions are helping Xcel Energy manage:

- Customer DR enrollments and device tracking
- More economic and environmental generation operations through the incorporated planning and dispatch of DR and DER
- Calculation and communication of real-time price and environmental signals
- Reporting of realized program and customer-level economic and environmental benefits

As a result, Xcel Energy's SmartGridCity is using Ventyx solutions to transform diverse data from the Smart Grid into more accurate price and load forecasts and connect customer actions to Xcel's trading portfolio operations and investment decisions via Virtual Power Plants. The resulting programs are giving SmartGridCity customers greater insight and control over their energy use, environmental footprint, and overall energy economics.

Summary

Virtual Power Plants are a key mechanism for making distributed energy resources actionable in commercial operations. The VPP model can enable complete portfolio optimization, helping to maximize the benefits of renewable resources, such as wind and solar generation, and acting as a local peaking resource to augment resource adequacy in real time.

And, there are many additional benefits to implementing this model, not the least of which is improved customer satisfaction. As customers have more information regarding energy prices and their own consumption, they will feel more in control of their budget and their impact on the environment. And, the Virtual Power Plant model provides real economic benefits beyond responding to emergency reliability issues, including the deferment of new investment in infrastructure.

Based on the aforementioned utility survey, leading global utility executives are beginning to recognize the opportunities as well. This is perhaps best captured by the author of the report, who concluded:

"As utilities begin to consider the potentially new business operating models presented by two-way connectivity with customers, the potential for entirely new operating models has emerged according to the interviews. While AMI is seen by those interviewed as the foundation for the Smart Grid of the future, the panel discussed a range of new business model opportunities including the ability to deploy increasing levels of distributed resources through significant expansions of energy efficiency and demand response. The potential to physically and financially optimize both planning and day-to-day utility operations for distributed generation and renewable resources, expanding custom choice, and integrating utility commercial operations with demand response programs were also cited as high priorities."

Of course, there will be challenges associated with implementing these new operating models (e.g., obtaining rate recovery for investments, change management and system integration issues, consumer economic stress, etc.). However, if utilities can overcome these challenges, the payoff can be enormous.

About the Author

Carlos Romero, Industry Solutions Executive at Ventyx, has 15 years experience in the energy industry providing expertise in consulting, design and implementation of information technology products and solutions for business strategies surrounding resource planning, portfolio optimization, generation operations, load and price forecasting, ISO/RTO bidding and settlements. Carlos has worked with more than 30 utilities and generation companies around the world helping them implement best practices for short-term operations management.