Technology Brief: How EaaS Microgrids Optimized with VPP Software Accelerates The Energy Transition

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Executive summary

Energy-as-a-service (EaaS) solutions offer customers the unique opportunity to dramatically increase their energy resiliency while incurring no upfront capital costs and make a positive contribution in the fight against climate change. Schneider Electric and AutoGrid's integrated EaaS offering offers customers the ability to reduce electricity bills, achieve new levels of energy independence, and capture new revenue streams by selling surplus electricity to the grid via virtual power plant (VPP) resource aggregation. This industry-leading solution enables C&I customers to meet their financial and resilience objectives while accelerating the global energy transition.

Introduction

Alarming data presented in a recent United Nations assessment about climate change points to a crisis so severe that the only viable course of corrective action is for the global economy to accelerate its transition toward a net zero future. The consensus of the scientific community is that to avert climate catastrophe, a global "all of the above" effort is needed to shift to sustainable energy resources. And key to this shift is the emerging energy "prosumer", who when empowered with the right tools, can shift from simply consuming electricity to becoming catalysts in the energy transition. Working in microgrid-powered commercial and industrial (C&I) sites, these larger energy prosumers will be able to help stabilize the larger grid through bidirectional exchanges of electricity and other energy products and services. This prosumer future is possible thanks to major hardware and software advances currently being offered by sustainability leaders like Schneider Electric and AutoGrid.

According to the global consulting firm Guidehouse Insights, the amount of capacity being added to power grids worldwide from distributed energy resources (DER) -- everything from rooftop solar photovoltaic (PV) systems, electric vehicle (EV) charging and a variety of other loads being converted into demand response (DR) assets – has already surpassed the new capacity coming on-line from centralized power sources such as conventional coal, gas and nuclear plants. The gap between distributed and centralized energy capacity grows over time, highlighting the need for new grid infrastructure approaches that revolve around aggregating and optimizing the diverse new set of distributed assets in real time.

One clear market need that responds to this paradigm shift are go-to digital platforms to manage the increasing diversity of DER assets integrated into utility distribution grids – or which stand alone in remote power applications. Concepts such as microgrids and virtual power plants (VPPs) will be necessary to squeeze the most value out of these DER assets, while making the energy transition just, affordable and sustainable. This growth in DERs is creating a new and growing class of prosumers, formerly passive consumers now embracing on-site energy solutions such as rooftop solar photovoltaics (PV), batteries and smart thermostats. Thanks to the integration of digital technologies and electrical distribution products developed by both Schneider Electric and AutoGrid, a unique set of value propositions is now possible for customers large and small:

- Modular, standardized microgrids for medium-sized C&I enterprises that can be implemented within less than a year's time with no upfront capital investment or performance risk.
- Microgrids can reduce carbon and other pollutant emissions while keeping critical loads up and running during emergencies such as wildfires, hurricanes, and other extreme weather events.
- Microgrids also offer protection against cyber-attacks on grid infrastructure, an increasing threat to the integrity of our legacy power grids.
- Microgrids that can be designed purposely to create customer bill savings by leveraging artificial intelligence (AI) and machine learning powered analytics to optimize when to generate, buy or sell electricity from a microgrid that is interconnected to a balancing authority with viable market structures.
- With the help of AI and deep data on optimization opportunities in major markets, microgrids can also generate substantial bill savings with the right software platforms.
- In the future, combining microgrid aggregations with the concept of a VPP (which is defined in the next section of this report) is a compelling value proposition for management of DER assets. Under this scenario, fleets of microgrids

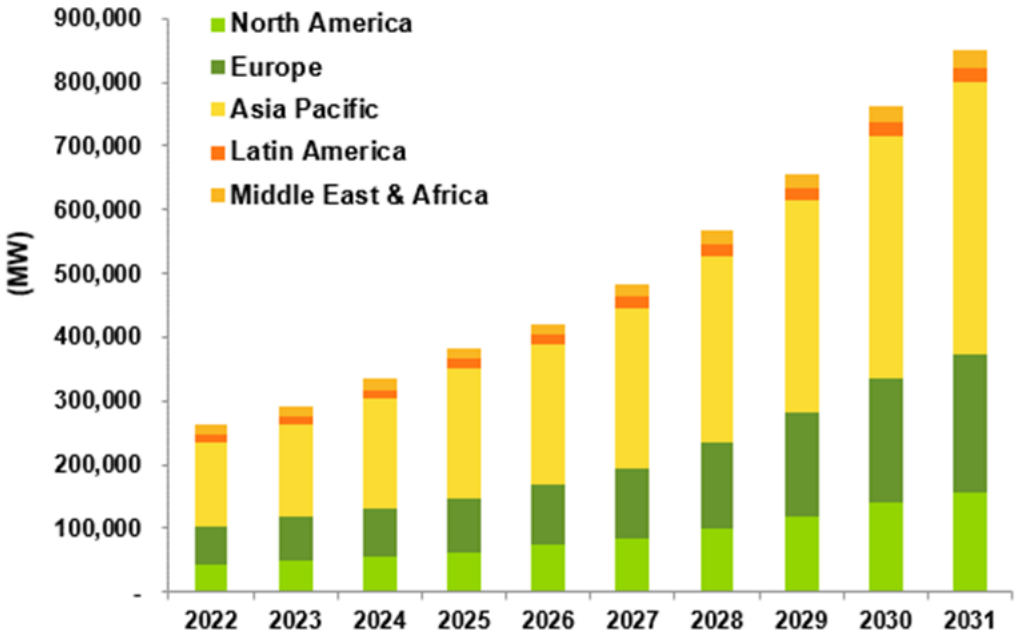
(themselves DER aggregations) can be organized into VPPs that can respond to the real-time grid service needs of retail and wholesale markets.

For grid operators and utilities, microgrids can help support the larger grid through provision of grid services which will only increase over time as transmission system operators comply with Federal Energy Regulatory Commission (FERC) Order 2222. This order's primary purpose is to create uniform opportunities for DER aggregations as small as 100 kW deployed at the distribution level of electricity service to play a role in balancing wholesale power supplies at the transmission level of electricity service. Now imagine a future where clusters of microgrids capable of operating independently as islands could also be aggregated into VPPs, enabling even more resiliency, peak load reductions and optimization of DER assets that have historically faced barriers to being fully utilized by the new energy landscape stakeholders.

Figure 1: Global DER Capacity by Region, World Markets: 2022-2031

Figure 1

It is estimated that more than 250,000 MW of DER capacity came on-line in 2022, with the Asia Pacific region in the lead, followed by Europe and North America respectively.



(Source: Guidehouse Insights)

DER Assets Are the Future

"The majority of new energy assets (generation, loads and energy storage) coming on-line globally will be DERs installed at the distribution level."

As noted at the outset, the majority of new energy assets (generation, loads and energy storage) coming on-line globally will be DERs installed at the distribution level and will not follow traditional pathways of ownership or management as has dominated the provision of electricity for well over a century. This trend away from monopoly one way power flows has been building for decades, with competition being introduced across the electricity supply chain in generation, transmission access, and retail distribution. Yet we are reaching a threshold point where prosumers large and small can clearly become the centerpiece of the energy transition. At least from a technology evolution point of view, this is the space that is clearly pushing the innovation envelope with new technologies, business models and market participants. The key to success will be how these DERs are financed and then managed intelligently to provide value both to microgrid customer hosts and to the larger grid network via VPPs.

The capabilities of Schneider Electric's products enable the islanding function that is the core to the microgrid value proposition: reliable and renewable energy resources during times of a larger grid outage. The company, ranked consistently as a global leader in social responsibility and sustainablility, can provide the assets that ground

any microgrid in the reality of meeting the most basic of customer needs while augmenting the resilience of any microgrid site in the event of a grid outage.

The capabilities of the AutoGrid Flex platform can layer on top of the fundamental functions of a microgrid, such as resiliency, by fine-tuning operations to reduce utility bills immeidiately while setting the stage for future revenue generation as markets continue to open up opportunities for compensation for grid services such as peak load reduction and frequency regulation. Before proceeding, let's define key terms.

Microgrids and VPPs: Definitions and Synergy

"Two concepts – microgrids and VPPs – have emerged as leading options for aggregation and optimization of DERs across the globe."

Two concepts – microgrids and VPPs – have emerged as leading options for aggrgeation and optimization of DERs across the globe. . What would happen if these two related, but distinct, solutions could be combined – and offered to customers with little or no upfront capital costs?

That's the value propostion presented in this white paper. This value proposition is made possible by integrating Schneider Electric hardware (switchgear and distribution infrastructure) and advanced software (microgrid controllers in the form of EcoStruxure Microgrid Advisor (EMA) and EcoStruxure Microgrid Operation (EMO) with AutoGrid's industry leading Flex platform, which focuses on how to optimize operations for bill savings and enables the capture of new revenue streams from wholesale market operations.

What is a microgrid? Here is the federal Department of Energy definition:

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in either grid-connected or island mode.

Microgrids are proliferating today, in large part, due to extreme weather events leading to increase power outages, especially in the United States. The need for resiliency and power availability without a sole reliance upon traditional back-up power solutions such as diesel or other fossil fuel-based generators that contribute to climate change is a key market driver.

What is a Virtual Power Plant? There is no official government definition of a VPP. Here is a definition being offered up by AutoGrid:

A Virtual Power Plant is an AI and machine-learning driven orchestration of distributed energy resources including solar, storage, EVs, and other C&I loads to deliver dispatch-grade flexibility that may be used as a cheaper, cleaner, and modular alternative to peaker plants.

VPPs enable prosumers to derive economic and resiliency benefits at the customer site while also supporting the larger grid by helping meet peaks in demand and balancing services, which are becoming increasingly important as variable renewables begin to dominate wholesale power supplies and extreme weather events become more frequent.

What is Energy-as-a-Service?
There is also no official definition of EaaS and if broadly defined, this financing method includes structures ranging from a Power Purchase Agreement (PPA) to pay-as-you-go programs for energy access in emerging economies. Here is the definition of EaaS put forward by Schneider Electric:

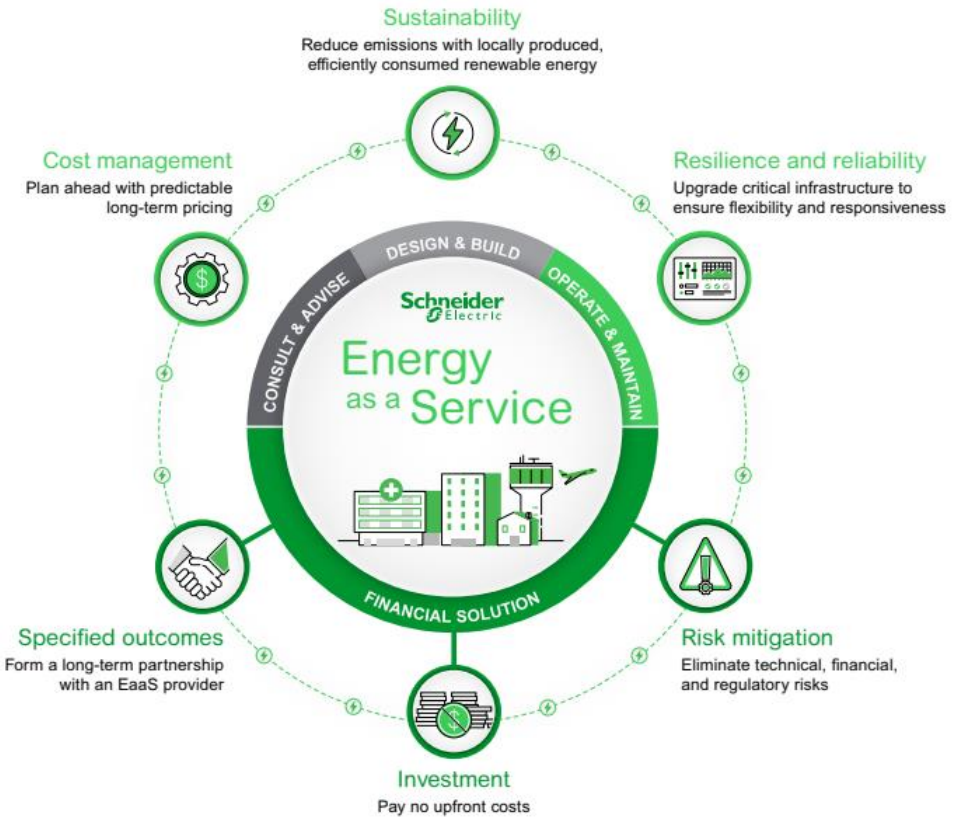
EaaS is a businjess model that lets customers benefit from microgrids without the cost and risk of capital investment. EaaS providers build, own and operate a microgrid at your site under a long-term, fixed price per kWh contract, helping to reduce your financial risk.

EaaS microgrid contracts take a more comprehensive scope beyond mere supply as is the case with a PPA. EaaS microgrid contracts can also incorporate energy effciency measures and specific technologies to enable islanding when the larger surrounding grid suffers a power outage. The trend toward EaaS is a reflection of the financial community recognizing the climate change threat and factoring climate risk into investment decisions. This recognition has resulted in a number of industry-leading joint ventures including AlphaStruxure (Schneider Electric and the Carlyle Group) and GreenStruxure (Schneider Electric and Huck Capital and ClearGen.) The Figure 2 below highlights the value streams an EaaS microgrid can provide:

Figure 2: EaaS Value Propositions

Figure 2

An EaaS microgrid can contain costs, reduce emissions, upgrade infrastructure, reduce risks and deliver on specific performance targets – without any upfront capital costs by the client.



"Bringing these three elements together – microgrid, VPP and EaaS – into an integrated package is unprecedented in the energy and power industry."

Bringing these three elements together – microgrid, VPP, and EaaS - into an integrated package is unprecedented in the energy and power industry. Synergies are created between hardware and software products and services. With little or no need for capital outlays but bill savings, the economics of microgrids, VPPs and EaaS solutions is inherently attractive. The ability to secure resiliency in addition to utility bill savings and supportive grid services validates the supposition that DER assets can be harnessed to benefit all new energy industry stakeholders. What makes the value proposition so compelling is that customers gain access to best-in-class technology with little to no risk, while setting the stage for new revenue opprtunities that will likely grow as DER market mechanisms mature all across the globe.

Next, let's discover recent trends within the microgrid market that make these DER aggregations more modular, scalable and repeatable. This section is focused on what Schneider Electric brings to the table. After that, we'll dive into how AutoGrid's software offers value to each individual microgrid site as well as creative future aggregations of microgrids into VPPs.

Modular, Scalable and Repeatable Microgrids

Microgrids are becoming an increasingly important tool for C&I enterprises. By generating and storing power on-site with microgrids, these businesses are becoming more efficient, resilient, and self-reliant – making them better able to withstand the impacts of volatile energy costs and frequent grid outages. In most cases, microgrid implementations also significantly reduces carbon emissions– making it one of the fastest ways a key component to progress toward net-zero emissions goals.

Until now, C&I microgrids have required so much time and investment that, in most cases, only large enterprises could deploy them. Every microgrid is a bespoke – unique solution. The systems are largely custom-engineered and incorporate different software, hardware, and interfaces to meet the unique specifications for each project build. This creates a complex setup that could require multiple contractors, up to two or even three years of engineering time, and a potentially lengthy utility interconnection process before it is energized. Creating a bespoke solution for each new microgrid project can impact the ROI projections over a significant period of the microgrid lifecycle.

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As microgrid markets mature, there is a new trend which seeks to streamline feasibility, design, build, installation, commisioning and operation of new microgrids. Increasingly, this level of standardization will also streamline the requirements for new "microgrid ready" constructions in the C&I market segment. The ability to reduce upfront costs and shorten the development cycle for microgrids is a key advancement needed to scale up deployments. In other words, microgrids need to be more modular, from the perspective of solution design including hardware equipment and software solutions. With the advancements in virtualization and software defined architectures, project customizations will increasingly be accomplished up in the cloud leveraging new advanced edge control platforms. This will allow for remote monitoring and trouble shooting, reducing operations and maintenance (O&M) costs while simplifying microgrids from the customer's perspective.

From needs assessment to installation, these modular microgrids shortens project rollout times from years to months, significantly reducing overall costs. The customer can engage with one contractor for the entire deployment, then use a standard set of software and services to operate it – with or without an on-site dedicated facilities manager.

As Schneider Electric offers the complete technology stack from electrical distribution to edge control and enterprise services for microgrids, it will continue to play key role across the value chain and the lifecycle of microgrid projects by bringing standardization to the fore both in the horizontal and vertical directions.

AutoGrid's Flex: Bill Savings and Flexibility Services

The hardware and software that Schneider Electric offers to the microgrid industry lays a firm foundation upon which AutoGrid's Flex can layer on top additional value-added services focused on customer bill savings and the capture of new revenue streams. The six primary services (and related value propositions) that Flex offers to the microgrid market are summed up in Figure 6 below.

Figure 3: AutoGrid Flex Microgrid Services

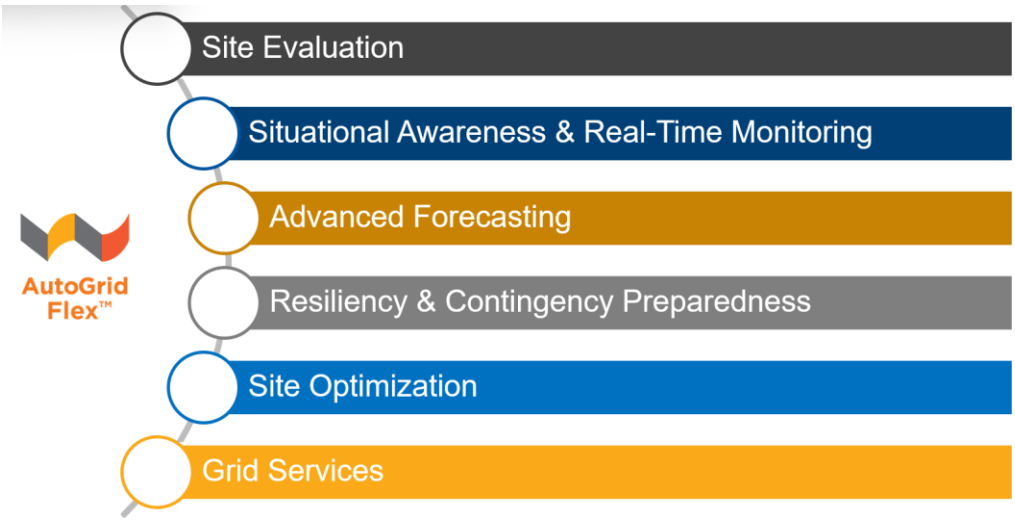


Figure 3

AutoGrid's Flex can provide value at the individual microgrid site, including initial site evaluation. Once the microgrid is installed, real-time monitoring and advanced forecasting optimize operations to prepare contingencies in the event of outage or supply shortage. Longer-term, Flex will allow microgrids to provide grid services individually and as aggregations, creating new VPP fleet configurations.

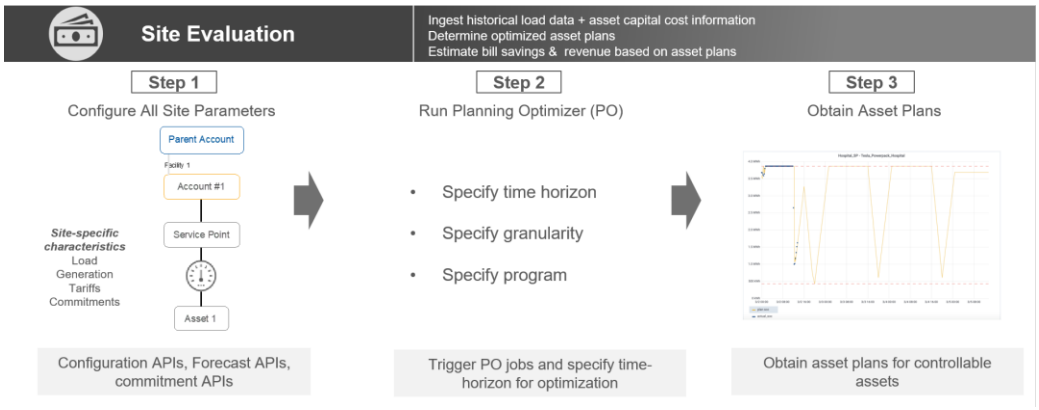
AutoGrid has maintained its industry leadership by diversifying the DER assets that it is capable of on-boarding, sensing and then controlling in real-time. The Flex digital platform keeps expanding as the DER assets coming on-line grows in diversity and volume. This DER growth naturally lends itself to inclusion in Virtual Power Plants, which have come to be seen as necessary innovations to accommodate growing reliance upon DERs as the primary assets being added to existing grid networks. Through these orchestrated aggregations of load, generation and energy storage, VPPs can provide the same essential electricity services as a traditional centralized power plant -- if the right market rules and conditions exist. VPPs are particularly valuable as displacements for fossil fuel-based peaker plants, often the most expensive and polluting of all possible electricity resources. These VPPs can balance energy markets seeking to decarbonize supply while also helping policy makers refocus energy systems to become more democratic as formerly passive consumers evolve to become proactive prosumers. Using a comprehensive hardware and software solution, microgrids creates an even more robust solution, enabling resiliency (microgrid islanding) with utility bill optimization benefits, and incremental value in VPP dispatching to support the larger grid when it is fully up and running.

One of the advantages of integrating the Schneider Electric and AutoGrid platforms is that the same software packages used to initially design and configure the site are then also used to operate the site. In the past, when designs were not implemented with the same software, performance would often not match up with design estimates. Though this white paper started with a description of the Schneider Electric hardware offerings – and software controls – the initial steps for a microgrid could also start with Flex in the initial site assessment process.

Figure 4

AutoGrid's Flex can get a microgrid started once the hardware components have been identified and sized by configuring the Application Programming Interfaces (APIs) of each DER asset deployed within the microgrid. Step 2 leverages a Planning Optimizer (PO) to fine-tune the orchestration of DERs based on time horizons, required granularity of data synced to specific programs that could shape microgrid operations. Step 3 is onboarding controllable DER assets into the system, allowing for future operations to match up with project performance goals and metrics.

Figure 4: A Three-Step Microgrid Site Evaluation Using Flex



By optimizing a site in advance and then using the same models and historical data for specific DER assets informed by AI allows for clients and solution providers to be working together with aligned purpose. This will lead to more predictable performance. This, in turn, leads to more realistic assumptions and a more compelling value proposition. Why? Performance targets – and results – will be based on real-world data and accommodate the nuances of regional public policies and regulations, including state mandates and incentives. In the end, the rules for wholesale market particpation can shape the size and selection of specific DER assets and supportive infrastructure.

AutoGrid's site evaluation engine can be used to ingest site-specific paramters, asset parameters, and utility or market opportunities for portfolio optimization to determine optimized asset plans and planned net load at size. This data can then we used to calculate financial benefits such as bill savings and market revenue to generate internal rates of return (IRR) for a range of scenarios.

Advanced site optimization is not an easy task. In fact, each site may have to factor in as many as 5,000 variables and 10,000 constraints that revolve around the following data points:

- Wholesale market prices
- Wholesale market rules
- Tariffs and DER asset export limits
- Specific site constraints
- Round trip efficiency of a specific battery chemistry
- Battery life (number of cycles charged and discharged)
- Leveraging of AI to develop solar PV and load forecasts
- Leveraging of AI for future wholesale price forecasts

When translating this to 10s, 100s, or 1000s of sites, the optimization engine needs to scale to deliver optimized asset plans for each site in the portfolio. In the end, Flex can fine-tune DER portfolio bids into wholesale markets, provide real-time monitoring of asset performance, develop DER asset deployment plans and then disaptch these DER assets in real-time.

As noted earlier, it is the Schneider Electric devices and software that play the primary role in providing resiliency through the process of islanding a microgrid during times of planned or unplanned outages. Yet AutoGrid's Flex can also offer value in this regard. For example, Flex can prepare assets such as batteries to charge up in

anticipation of an islanding event based on weather forecasts, or extreme peaks in demand in wholesale markets or other contingencies such as wildfires. Weather forecasts focused on future solar or wind resource availability can also help inform contingency plans.

The Art of the Possible: Microgrid Fleet Aggregations

"Perhaps the most exciting aspect of the Schneider Electric products and services being integrated with AutoGrid's Flex is the potential optimization of entire fleets of EaaS microgrids."

Perhaps the most exciting aspect of the Schneider Electric microgrid products and services being integrated with AutoGrid's Flex is the potential optimization of entire fleets of EaaS microgrids. Imagine the potential for microgrid fleet aggregation benefits with Flex:

- Simulated microgrid operations to deliver reliable cash flows under the EaaS solution model.
- Optimization of multi-asset microgrids consisting of solar PV, energy storage, combined heat & power (CHP) and generators to deliver time-of-use arbitrage savings as well as limit demand charges through timely self-consumption operations.
- Optimize the DER asset portfolio within each microgrid for incremental benefits derived from grid services and other forms of market participation.

Microgrids, whether deployed under an EaaS model or a more traditional capital expense model, will continue to proliferate as DER portfolios grow and as the impacts of climate change continue to accelerate. Modern society is only growing ever more dependent upon reliable, resilient and more sustainable energy systems. Combining the resiliency now possible with microgrids with the flexibility services offers a compelling hybrid opportunity for the future. As each microgrid becomes optimized for economics and resiliency, the sum of the parts (each individual microgrid) will clearly be greater as a whole portfolio. This solution, which includes grid services delivered at the portfolio level, also offers utility the benefit of engaging with a growing base of proactive prosumers who are otherwise reducing their dependence on the grid. The growth in DER assets and corresponding needs for both microgrids and VPPs can be self-sustaining with the right technologies – both hardware and software – and compelling business models such as EaaS.

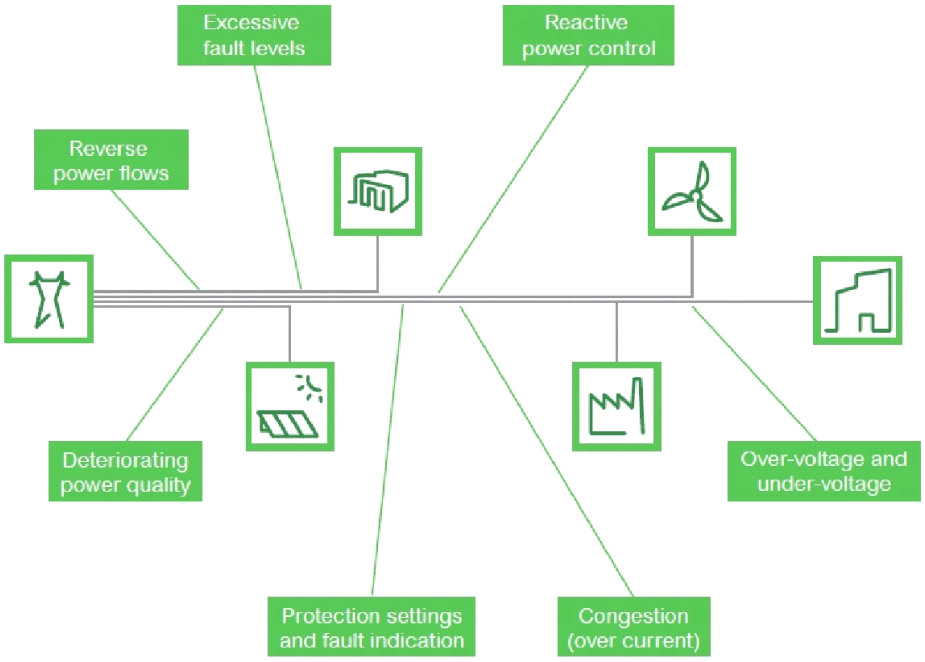
Orchestrating self-balancing microgrids into fleets that could be marshalled in support of grid integrity could spur acceptance of microgrids across the entire stakeholder spectrum, including incumbent utilities. As we electrify the economy, displacing fossil fuels for heating and transportation services, the need for resiliency becomes even more paramount. The solutions presented in this white paper can help accelerate the energy transition while meeting the needs of prosumers seeking to become part of the solution to global climate change.

Conclusion

To maximize the value from these assets under a VPP framework -- where price signals facilitate the provision of grid service trading -- a concurrent push for solutions occurred for resiliency through the microgrid platform. New market needs revolve around ensuring the overall integrity of the electricity distribution system. As DER assets increasingly provide value upstream to wholesale markets, digital controls and active power optimization is also needed to ensure overall grid reliability was not compromised by the sheer volume of transactions bridging what had been previously siloed retail and wholesale market transactions.

The complex challenges facing today's energy system is chronicled in Figure 5 and span the gamut of issues attached to increased DER asset deployments as well as greater reliance upon variable renewables even as utility grid infrastructure needs call for system upgrades.

Figure 5: Distribution Network is Facing a Host of Challenges



In the past, the burden for solving these issues would have fallen on the shoulders of utilities, often still operating within a monopoly setting. This would lead to costs for their customers for damaged equipment and process interruptions which can add up to thousands if not millions of dollars. Today, the combination of market reforms and advances in technology create the opportunity to address the plethora of challenges -- such as deteriorating power quality, reverse power flows and congestion and the like -- with new tools and platforms incorporated into microgrids and VPPs. The key to making this new energy paradigm work is finding a trusted energy service provider that can help empower prosumers to play an active role in tomorrow's energy solution ecosystem.

Figure 6

Electricity used to be viewed as a commodity provided by a utility in a one-way power flow to consumers. That formula no longer works in a world increasingly populated with new kinds of market players and increased reliance upon DER assets owned by prosumers. They key to making this new energy paradigm work is finding a trusted service provider team that can create new value by optimizing DER assets both at the site and for the larger grid that connects us all to a common purpose in the current energy transition.

Figure 6: From Commodity to Service Through Prosumer Optimization

About the authors

Peter Asmus is the Director of Strategic Marketing for AutoGrid. Previously, he was Research Director for Guidehouse Insights, a management consulting firm. There, he launched the microgrid and VPP research services over a decade ago, forecasting future trends and ranking leading solution providers. He has 34 years of experience in covering and analyzing and writing about emerging energy trends.

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