White Paper

How Modular Solutions Accelerate Worldwide Microgrid and VPP Opportunities

Building the Business Case for a Resilient, Sustainable, and Digital Energy Distribution System

Published 4Q 2020

Commissioned by ABB

Peter Asmus
Research Director

Roberto Rodriquez Labastida
Senior Research Analyst

Michael Kelly
Senior Research Analyst

Guidehouse INSIGHTS

Executive Summary

The world is changing fast, especially when it comes to the energy distribution system needs of today's economy and environment. Pressing challenges to business as usual such as unprecedented extreme weather events coupled with pandemics require new solutions. The good news is that rapid advances in digital technology provide advanced and smart solutions to the world's increased reliance upon electricity as the most fundamental driver of the world economy. Three key trends are driving innovation in the energy infrastructure space. They are as follows:

- **Resiliency:** The availability of 24/7 power is more important than ever as the COVID-19 pandemic encourages telecommuting and limits the ability of traditional business practices like in-person conferences and shared office spaces. Furthermore, the electrification of the transportation sector requires an even greater reliance on the electricity system. Extreme weather events and the ongoing threat of terrorist attacks necessitate an always on power systems.

Rapid advances in digital technology provide advanced and smart solutions to the world's increased reliance upon electricity.

- **Sustainability:** A shift from fossil fuels toward renewable energy systems is required to reach the greenhouse gas emission reductions necessary to stabilize the increasing burdens imposed by global climate change. It is estimated that greenhouse gas emissions will need to be reduced by 7.6% annually over the next decade to meet the 1.5°C global target for 2030. Consider the following: 1 MW of solar energy can save the equivalent of a half-kton of CO_2 annually in a manufacturing industrial plant. It can also supply clean electricity for 130 EVs over the same 1-year period.
- **Digitalization:** Technologies vital to achieving both resiliency and sustainability goals fall in the digital realm. While the world moves toward greater reliance upon distributed energy resources (DER), management of electrical distribution system through new advanced software-based platforms becomes necessary to achieve shared value for all energy ecosystem stakeholders. Thanks to these platforms, these DER assets can maximize their value to owners, integrators, utilities, and society at large.

The world is increasingly reliant on diverse DER, from rooftop solar PV to energy storage, EVs, and demand response. These diverse DER assets need to be aggregated and optimized into nimble systems capable of responding in real time to ever changing market conditions, goals Guidehouse defines as integrated DER. Two platforms that tap digitalization to create greater value are microgrids and virtual power plants (VPPs). The key to unlocking often hidden value embedded in DER assets is a modular approach to project development for digital platforms such as microgrids and VPPs.

This white paper articulates how one digital platform provider—ABB—is changing its business strategy to offer new solution blocks directly to engineering, procurement and construction companies and to integrators that interface directly with consumers. This new modular approach promises to reduce costs, speed up the development cycle, and increase the prospects for meeting society's resiliency and sustainability needs.

Digital Platforms: Microgrids and VPPs

In the past, platform solutions for managing distributed energy resource (DER) assets often were pitched directly to project hosts, utilities, or other asset owners. Yet new business models and efforts to streamline and standardize microgrids and VPPs to the greatest extent possible are transforming market conditions.

ABB defines a microgrid as “a group with clearly defined electrical boundaries of low voltage DER and loads that can be operated in a controlled, coordinated way either connected to the main power network or in islanded mode.” This definition mirrors that of the US Department of Energy and other US federal agencies and global institutions. Despite congruence on fundamental definitions, there is considerable debate over whether specific projects fully meet the definition of a microgrid. For the most part, these debates center around esoteric engineering details or may be shaped by vendors focusing on specific microgrid-enabling technologies or capabilities for seamless islanding.

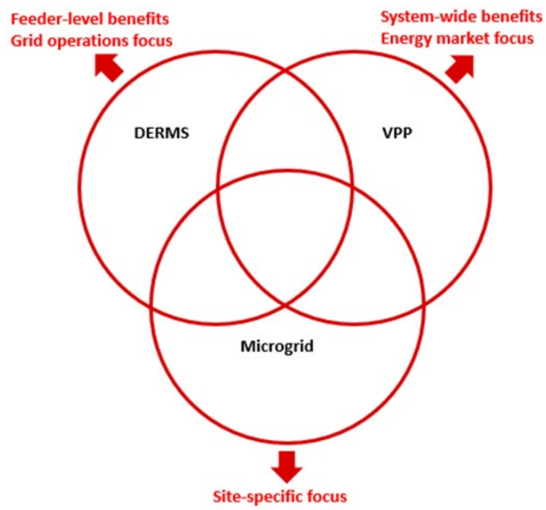
What then is a virtual power plant (VPP)? ABB defines the technology as “an aggregated system of energy assets remotely and automatically optimized by a software-based platform to dispatch services for distribution or wholesale market.”

VPPs can aggregate heterogeneous DER to make the services these resources provide resemble conventional and dispatchable centralized power plants. The term VPP flows from this comparison; it was devised to help utilities and other grid operators understand how advanced software systems incorporating AI algorithms could mimic the same essential services provided by a fossil or nuclear plant. VPPs deliver the same services (and more) as a traditional power plant without the liabilities associated with land use, air emissions, waste management, and stranded asset risk.

Once a microgrid sells a service to a load aggregator or utility, it becomes VPP-ready. Furthermore, if a utility develops a microgrid and deploys it to help mitigate voltage hotspots on a feeder (for example), it could be viewed as a form of distributed energy resource management systems (DERMS). Just as demand response providers are expanding software platforms to control generation along with load—and manage energy storage—microgrids are being optimized as VPPs and DERMSs by providing bidirectional value. VPPs provide economic value upstream while mitigating frequency challenges on the larger grid.

There is growing overlap and convergence with other digital platforms designed to manage, control, and optimize DER portfolios. There is a clear move away from siloed solutions by utilities and solution providers alike for classes of DER assets to broader platforms that can be adopted for specific use cases, such as microgrids. As Figure 1 depicts, ABB offers related aggregations and automated control schemes for microgrids, VPPs, and DERMS. DERMS is another digital platform designed to maximize value from DER assets, with a special focus on utilities’ need to balance grid resources to protect the integrity of the overall system.

Figure 1 Digital DER Platforms Are Converging



(Source: ABB)

Both microgrids and VPPs are enjoying exponential growth, with DERMS also slowly gaining traction. Yet engineering, regulatory, and financing challenges remain. Innovative solutions to these challenges offer end users a number of benefits.

Digital Platform Market Application Segments

Microgrids and VPPs represent two digital platforms that bring significant economic and environmental benefits to a variety of end users. Project developers and engineering, procurement and construction (EPC) companies seeking opportunity in this space would be wise to think through the top value propositions and solution sets needed to meet the needs of the following customer segments (also illustrated in Figure 2).

- **Commercial Buildings.** One of the most prominent ways for commercial buildings like shopping malls or offices to use digital platforms is to reduce demand for energy. By collecting real-time data monitoring power flows in the cloud, digital platforms can shrink peak demand by up to 20% with state-of-the-art controls. This goal is achievable with fast load shedding technologies responding to frequency shifts. Factor in predictive maintenance algorithms and ongoing operations costs can be cut by as much as 33%. In the event of a distribution grid fault, mission critical power loads at sites such as hospitals can be maintained via islanding. Furthermore, energy storage systems outfitted with advanced power conversion systems can act as virtual generator units. Digital platforms can also use uninterruptible power supply (UPS) systems and backup generators for resiliency.
- **Industrial Sites.** Wastewater and clean water treatment facilities, food and beverage stores, automotive operations, data centers, and mines and manufacturing facilities also benefit immensely from digital platforms. For example, they can institute creative load management programs to maximize self-consumption from any onsite generation sources. They can manage e-mobility charging to maximize renewable energy consumption if available locally or from the utility grid. Monitoring systems can help identify areas at the industrial site that could benefit from compensation switchboards or active filters. Industrial loads tend to be bigger than most

commercial operations, so they stand to gain the most economically from digital platforms on a direct monetary basis. These industrial loads can use a microgrid platform for resiliency and can provide ancillary services to the utility in the form of a VPP—whether acting as a demand response resource or providing other grid services.

- **Campuses and Institutions.** Campus institutions including universities, schools, and fire and police stations can shave peak demand by 20% and shrink operation costs by as much as 33% with state-of-the-art digital platforms. Along with these efficiency benefits comes the resiliency options outlined above for commercial buildings.
- **Communities and Utilities.** Smart communities and utility distribution networks will need to rely upon digital platforms to maximize the use of prosumer assets such as rooftop solar PV or community solar programs or centralized combined heat and power. Such customers may desire either slow- or fast-charging EV charging—or both. Prosumer assets can also be aggregated into DER portfolios that trade energy services via VPPs, provided market structures in a specific jurisdiction allow for the creation of these additional revenue streams.
- **AC and DC Marine Applications.** Ships ranging from large fishing vessels to cruise line ships, ferries, and military boats can also be considered microgrids. They must operate in 24/7 island mode while traveling to destinations and then can also interconnect to onshore power distribution grids by ship-to-grid technologies. With the help of digital platforms, these marine application segments can access SCADA systems for data on temperature, humidity, and vibrations to optimize predictive maintenance. When docked, the digital platform can coordinate among protection devices while also using dynamic positioning to save fuel. In some cases, digital platforms can manage direct current (DC) architectures, saving 30% of space due to a reduction in conversion equipment. In this case, there is no need for synchronization with the portside grid as there is with alternating current (AC) systems.

Figure 2 Microgrids and VPPs Can Support Multiple Customer Applications

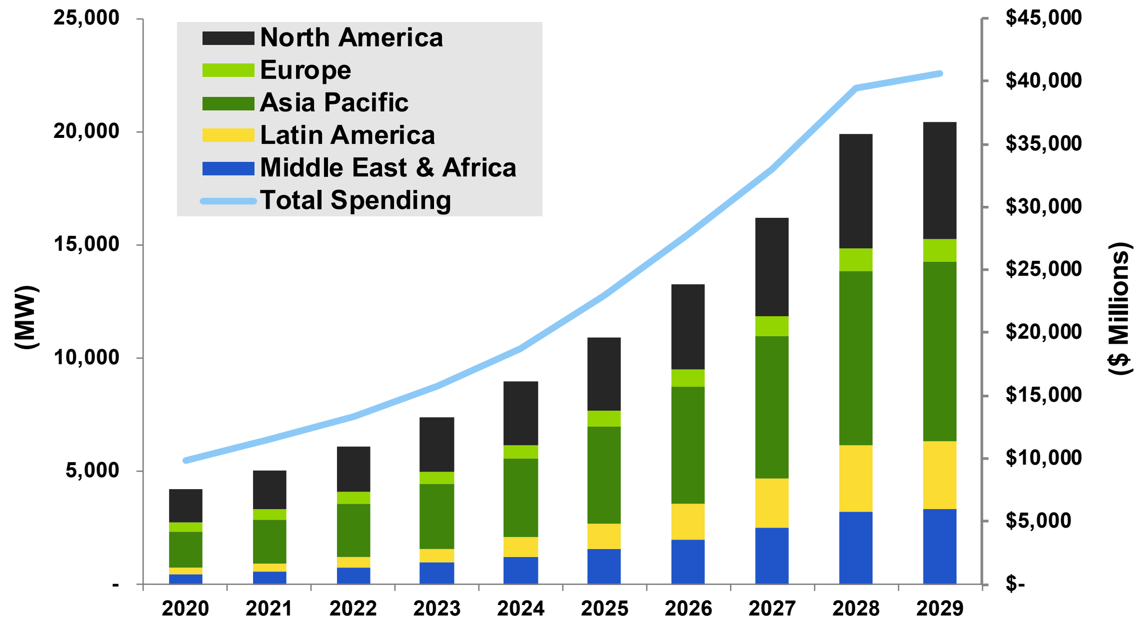
(Source: ABB)

Market Sizing the Digital Platform Opportunity

Microgrids come in many sizes, are installed at multiple customer application sites, and can feature diverse resource configurations including conventional and renewable energy supply, energy storage, demand response, and EV charging. What ties these DER assets together into intelligent aggregations are digital monitoring and control platforms. Without a premium monitoring and control platform, the full value of a microgrid cannot be realized. One of the industry's current focuses is on a platform that can be fine-tuned to meet the end customer's needs without excessive engineering and customized expense.

Since these end users may not understand the complexities and nuances of smart integration, a new approach is to offer modular solutions to those building microgrids that lack the capability to offer their own controls technology stack. One of the primary drivers for increased microgrid deployments globally are shifts in strategy among growing numbers of vendors. The focus is moving from hardware to software and more modular approaches to development are gaining traction. New business models to streamline financing are emerging. These factors explain why microgrids are expected to showcase double-digit annual growth and reach nearly $40 billion in implementation spending annually by the end of the next decade (See Chart 1).

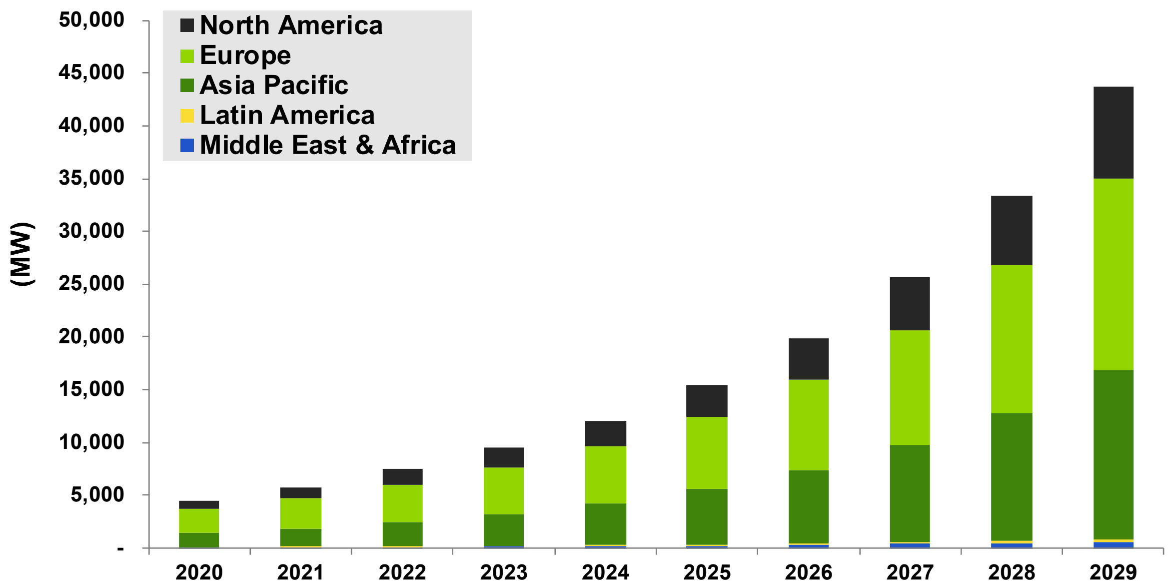
Chart 1 Annual Total Microgrid Power Capacity and Implementation Spending by Region, World Markets: 2020-2029



(Source: Guidehouse Insights)

VPP capacity displays exponential growth, reinforcing the increased importance of orchestrating DER assets. The key enabling technology for VPPs are also digital platforms, which help squeeze more grid value from prosumer assets across similar customers as microgrids.

Chart 2 VPP Capacity by Region, World Markets: 2020-2029



(Source: Guidehouse Insights)

Three Key Regional Markets Serve as Bellwethers for Digital Platforms

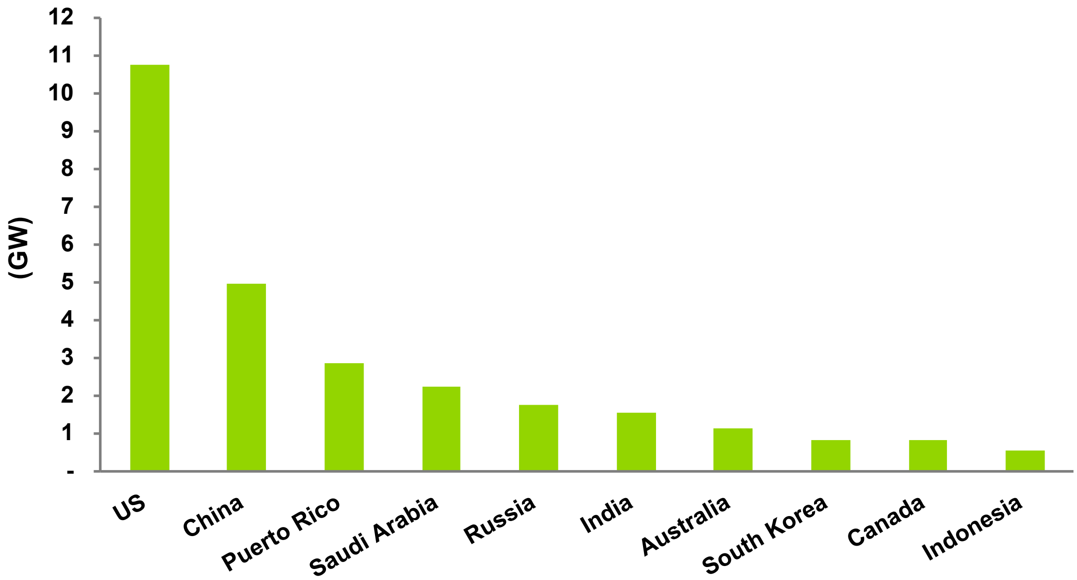
The market for digital platforms is truly global. However, regional policies, resources, and grid conditions shape near- and long-term market opportunities. This section focuses on three leading regional markets, highlighting a handful of specific countries that are particularly promising. A case study application is presented to illustrate how a modular and scalable digital platform solution solved a problem at specific customer sites.

Asia Pacific

Australia is a hotspot for microgrids and VPPs. The majority of the continent's microgrids are deployed by utilities such as Horizon Power. Located in Western Australia, the utility has the largest service territory in the world and the fewest customers per square meter, for customers are not interconnected to a traditional grid. Australia has long been a leader in hybrid microgrids, many of which were provided by vendors such as ABB. When it comes to VPP energy trading, Australia represents the new frontier. Recent power outages, high energy prices, and the highest penetrations of distributed solar PV in the world have made Australia a focal point of innovation. Australia's consumers also boast one of the highest per capita electricity consumption rates in the world, even greater than the US. These consumption levels translate into flexible load resources ideal for VPP manipulation, aggregation, and optimization.

If Australia is a hotspot for innovation, China is the top prize in terms of sheer magnitude of opportunity. According to Guidehouse Insights' *Microgrid Deployment Tracker*, China only lags the US in terms of total identified microgrid capacity. Five of the top microgrid markets are located in the Asia Pacific region.

Chart 3 Total Microgrid Capacity, World Markets: 1Q 2020



(Source: Guidehouse Insights)

Most microgrids installed in the Asia Pacific region serve remote clients not interconnected to a traditional grid. In cases such as India, the incumbent utility distribution network is so unreliable that microgrids and other forms of backup power are required for businesses and critical facilities to enjoy resilient and reliable electricity. China's market diverges a bit from these regional trends. Though many early microgrids did serve remote communities, the country has launched recent initiatives focused on distribution feeder retrofits. According to one veteran vendor active in China, 240,000 sites have been identified as microgrid candidates for weak feeder upgrades.

Recent policy reforms are creating new opportunities for outside vendors to offer digital platforms. In October 2017, the National Energy Administration (NEA) and the National Development and Reform Commission (NDRC) announced a joint initiative for market-oriented distributed power generation as a new part of the power sector reform in China. This new initiative has the most potential to transform the Chinese energy industry from the edge of the grid. The initiative calls for the creation of platforms that facilitate electricity trading between distributed generation projects and end users across a local electricity distribution network. The electricity market and distributed energy reforms introduced by NDRC and NEA jump-started an effort to create new business models based on DER solutions. These new business models are geared toward new investments in solar PV on local distribution networks and are financed and implemented by third parties or new, privately owned distribution companies, which could represent key new markets for microgrids. In 2019, State Grid Corporation of China announced a new initiative to build microgrids under the rationale of a non-wires alternative, given its stated mission of providing reliable electricity to all customers.

NEA recently released its annual national energy strategy, *Energy Sector Work Guiding Opinions for 2020*, which states that energy security is the most important task of the country's energy industry. The change signals Beijing's concerns over energy access and sufficiency, amid challenges raised by geopolitics and global market issues. Accordingly, the most critical R&D areas now are the applications of storage in auxiliary services, DER, and microgrids.

Case Study: Jibei Electric Power Co. Ltd.

Thanks to its new public policies, China is also exploring VPP platforms. The state grid company, Jibei Electric Power Co., Ltd., now controls diverse DER assets while also managing flexibility resources such as energy storage devices. This enables the company to provide the equivalent grid services as a conventional power plant but at less cost and environmental impact. In operation since December 2019, 11 types of DER assets have been aggregated and optimized, representing 26.5 MW. The second phase of the project leverages an Internet of Things (IoT) digital platform provided by ABB that will expand to incorporate another 226 MW of capacity. Once the second stage of the project is completed, the VPP will serve 12.4 million people in the cities of Zhangjiakou, Qinhuangdao, and Langfang.

This VPP is enabled through a combination of intelligent instrumentation and digital equipment, including state-of-the-art smart meters and switchgear for monitoring, protection, and control. Data on electrical and environmental parameters are all processed in real time to realize efficiency goals and to power peak shaving and creative load management. Distributed solar PV systems, air-source heat pumps, residential and industrial air conditioning units, and EV charging stations are all used to balance variable solar and wind generation.

This project serves as a demonstration use case to help articulate an International Electrotechnical Commission (IEC) VPP standard. Merging IoT and VPP digital management sets the stage for further innovation in enabling real-time optimization between renewable generation and flexible load management. For China, this represents a path forward as it modernizes its overall grid network and enables prosumers to contribute to grid stability and efficiency.

North America (US)

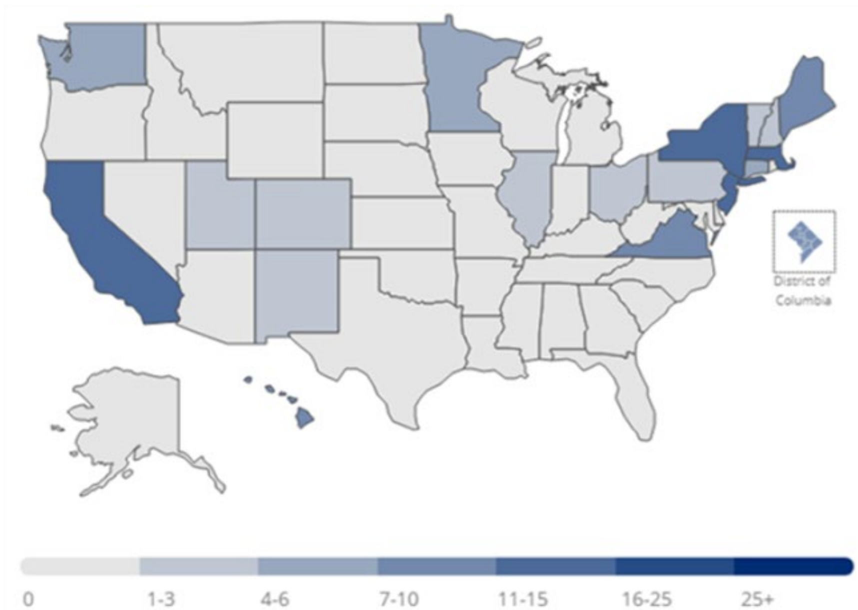
The US leads on global microgrid capacity and represents the vast majority of microgrid activity in North America. This largely is due to extreme weather events, including hurricanes and wildfires. It is also a reflection of aging grid infrastructure with power quality and reliability going down rather than up.

In response to aging grid infrastructure and extreme weather events leading to increased frequency of power outages, growing numbers of US states have approved microgrid support programs. All told, 112 bills have been proposed or enacted in 18 different states and in Washington, DC over the last 5 years (see Figure 1). Connecticut was the first state to pass a microgrid law in 2011. The northeast led the way initially, with the top three states ranked according to number of bills coming from that region: New York (15), Massachusetts (14), and New Jersey (13). The latest state from the northeast to join the microgrid ranks is Maine, which enacted L.D. 13 in 2020. L.D. 13 tackles many of the policy questions surrounding microgrids as utilities move more aggressively into this space.

In response to aging grid infrastructure and extreme weather events leading to increased frequency of power outages, growing numbers of US states have approved microgrid support programs.

On the other side of the country, Hawaii pioneered a microgrid services tariff released in March 2020. An important element of this tariff is that the onus is with microgrid operators to make the case for monetizing the societal and resiliency benefits of the technology. Microgrid tariffs are also being developed in California per state legislation SB 3119, largely due to the last 3 years of unplanned and planned power outages from major wildfires. The California Public Utilities Commission (CPUC) approved new microgrid directives in June 2020. As a result, a new Community Microgrid Enablement Program will move forward in Pacific Gas & Electric's service territory. This CPUC program will provide incentives in the form of credits to offset distribution upgrades to encourage the commercialization of microgrids in its service territory.

Figure 3 Microgrid Legislative Activity by US State: 2015-2020



(Source: Smart Electric Power Alliance)

The US is also a leader in VPPs. FERC Order 2222, approved in summer 2020, opens new revenue opportunities for mixed DER asset portfolios as small as 100 kW in scale to provide grid services for wholesale markets. This tighter integration between retail and wholesale markets is vital for digital platforms to grow market share. FERC Order 2222 also highlights how regulators are shifting to an agnostic approach to achieve desired policy outcomes. This approach allows for diverse DER assets including EVs and various forms of energy storage, generation, and demand response, which will be marshalled in support of improving grid reliability, reducing emissions, and boosting resiliency.

Case Study: Florida Air Force Base

US military facilities are leading candidates for microgrids given their need for premium, cyber secure, and resilient power. With bases located around the world, the US Army, Marines, Navy, and Air Force have been microgrid pioneers. Many of these facilities cannot be disclosed due to security concerns.

An Air Force base in Florida, for example, required insurance that it would always have power given the site's sensitive equipment and the security threats that result from power outages. ABB installed two transformers to provide redundant power supply options. If the primary transformer goes down, the other serves as a backup. Additional advanced distribution system upgrades were installed in a difficult to access mezzanine and other locations on the facility. The automatic transfer switches embedded in circuit breakers are key to maintaining this site's resilience. This reduces the need for components and wiring, allowing for a much smaller footprint. A human machine interface also allows for manual optimization remotely for distribution feeders.

Europe

Europe is often touted as a global leader moving toward a low carbon energy future; however, the tightly regulated EU markets have several features that historically limited the development of microgrids:

- Policymakers focused on large-scale renewable energy developments such as offshore wind, which requires massive investment in transmission infrastructure.
- DER deployments (such as rooftop solar PV) primarily based on feed-in tariffs (FITs), a business model that precludes the defining feature of a microgrid: the ability to seal off resources from the larger grid via islanding.

Until recently, the vast majority of microgrids deployed in Europe were on islands not interconnected to the mainland grid. According to Guidehouse Insights' *Microgrid Deployment Tracker*, Europe's cumulative global market share is the smallest of any major region analyzed.

The European VPP market historically has centered around renewable energy integration. The tightly connected countries in the European Union (and the UK) have advanced market integration that takes VPP platforms in a more sophisticated direction, stacking complex use cases. The continent is adapting VPP platforms to provide new, more sophisticated capabilities to maximize the value of flexibility. The use of advanced software platforms to enable smart energy trading is the distinguishing feature of Europe's VPP market.

Case Study: Bank in Rome, Italy

A major EU bank in Rome offset the need for additional fossil backup generators because of the functionality embedded in a smart circuit breaker from ABB. This has reduced costs and increased resiliency. The all-in-one circuit breaker can control, protect, and coordinate operations of a microgrid designed to provide 24/7 power services to support mission critical financial services processing needs. Banks historically have relied upon fleets of backup generators to maintain uptime in the event of a grid outage. Similar to data centers and military bases, several layers of redundancy are required so financial transactions can proceed around the clock. The very last resort is often UPS systems deployed at each critical load. Digital technologies like this circuit breaker provide advanced protection, programmable logic, full connectivity, and streamlined integration for microgrid energy management. Other vendors often require a host of different hardware and software technologies to achieve a similar result. The circuit breaker's digital software can deliver a load shedding strategy based on voltage and frequency. If the first line of defense fails and a generator trips off, the circuit breaker sheds loads so a second line of defense, a smaller generator, kicks on to maintain mission critical operations.

Digital technologies like this circuit breaker provide advanced protection, programmable logic, full connectivity and streamlined integration for microgrid energy management.

Modular Solution Blocks for EPCs and Aggregators

As microgrid and VPP markets mature, the industry's needs are evolving. Larger, more established EPC companies (e.g., AECOM, Worley, and Mortenson) are entering the fray, expanding their coverage across renewables, battery energy storage, gensets, and e-mobility. These historically nontraditional players see opportunity in capitalizing and creating new value streams as a function of these complex applications. There is a need for more standardization and a more nimble, distributed way to control DER assets. Industry and vendor focus is shifting from hardware to software, with more modular and scalable solutions gaining traction within the microgrid and VPP markets.

Solutions providers build modular solutions in various ways; one approach is the use of solution block modules sold directly to system installers and integrators. Since these end users may not understand the complexities and nuances of smart integration, this new approach offers modular solutions to those building microgrids who lack the capability to offer their own controls technology stack. This enables installers and integrators to streamline their deployments, reduce engineering and testing efforts, maximize use of state-of-the-art digital products, and allow for a new form of customization based on several fundamental building blocks for microgrids and VPPs.

Within this microgrid and VPP context, there are several functional areas that lend themselves well to this modular, solution block model. For example, the establishment of microgrid energy management systems can be broken up logically along the lines of several core capabilities, including:

- **Metering and Connectivity:** Measuring system used to define the installation load profile and collecting all energy to environmental data required for operation of the energy management system within a fully connected architecture based on interoperable communication protocols.
- **Power Quality:** Performance monitoring system that provides comparative analysis of consumption profiles and indicates trends and data for power quality analysis.
- **Energy Management:** Core management systems such as distributed control systems and energy management systems that enable customers to monitor, optimize, and control their plants and assets.
- **Asset Management:** Applications and tools to help customers detect, analyze, and predict the health and status of monitored devices leveraging predictive analytics.

Pooled under a common architecture, these modules create a functional microgrid energy management system. This provides end users with more financial flexibility and allows for more strategic deployments based on near-term and long-term business objectives. Along with the modularization of software management systems, there are also several foundational microgrid capabilities that can be enabled through this modular approach, including holistic islanding and synchronization:

Solution providers build modular solutions in various ways; one approach is the use of solution block modules sold directly to system installers and integrators.

- **Load Shedding:** Platform that enables load shedding to reduce microgrid stress during islanding events in synergy with resynchronization logistics
  - Basic load shedding is enabled by a simple logic that can detect the microgrid disconnection

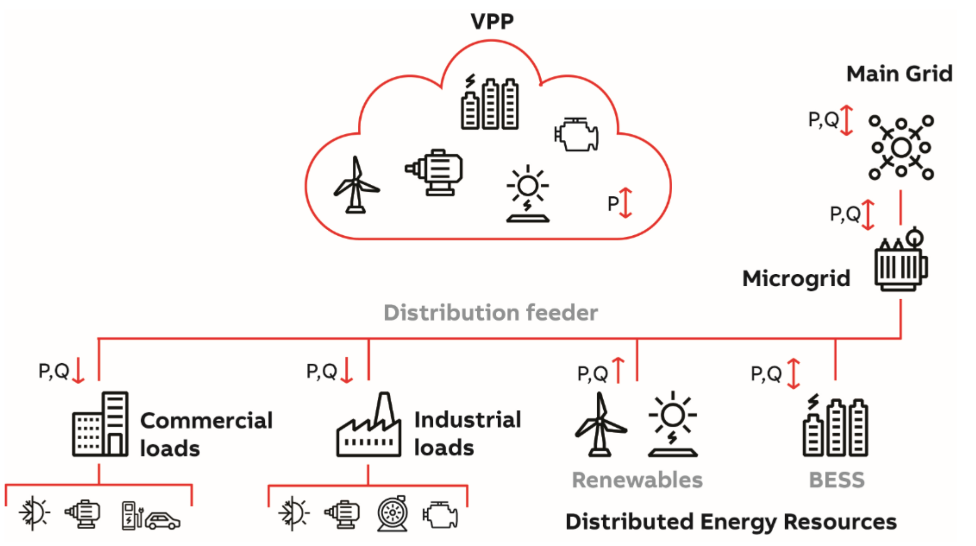
event and shed a group of nonpriority loads, enabling a fast response time and proper power balancing

- Adaptive load shedding uses advanced algorithms to shed nonpriority loads quickly according to the microgrid power consumption and frequency measurement

- **Peak Shaving:** Keeps the load profile under established thresholds to enable electricity bill savings and the achievement of demand response targets
- **Automatic Transfer Switching:** Enables instantaneous automatic switching between power sources
- **Interface Protections:** Interface devices that enable disconnection whenever the voltage and frequency values of the grid are out of the ranges prescribed by the local grid codes and standards
- **Adaptive Selectivity:** Protection strategy that adapts protection thresholds automatically according to microgrid scenarios for loads and generators

Modular approaches allow for a more incremental and longer-term customer journey. Similar to how electric utilities adopted advanced distribution management systems in a stepped fashion, end use customers may not have the requisite resources or knowledge to deploy a fully-fledged microgrid or VPP platform without delay. Vendors have responded by making their suites of systems highly interoperable and are increasingly adopting modular system architectures. This allows for logical investments to be made with a clear path forward as end users work to meet immediate needs and plan for future requirements and competitive pressures. Modular, microservices-based architectures allow end customers the flexibility to evolve their management system portfolios without the constraints of expensive and complex rip and replace projects down the line. Under this microgrid and VPP scenario, an end customer may begin with a battery management system, graduate into an intelligent energy management system, and then move into microgrid control and ultimately VPP platforms (see Figure 4).

Figure 4 Modular Digital Platforms for DER Optimization



(Source: ABB)

Not every project will require the complete set of solution blocks. That is the beauty of a modular approach. Under this pathway to market adoption, the goal is to simplify the value proposition across the entire ecosystem with a new focus on those experts bringing projects to life, on budget and on time.

Although the end user is still the ultimate customer, onsite power solutions are increasingly complex, coupled with emerging trading markets to create new revenue streams. This landscape means that underpinning technology to maximize value may be beyond end users understanding .

While the energy as a service trend considers the upfront capital costs barriers, modular solution blocks address implementation challenges in a new way. In short, digital control solution providers offer validated off-the-shelf solution sets in a menu that can then be customized during the installation process.

Conclusions and Key Takeaways

There are many competing products, technologies and platforms vying for increased market share in the DER management space. Superior and validated hardware and software products that stand behind new concepts such as VPPs and microgrids are necessary to bring these platforms fully into the mainstream. These digital platforms and products are foundational to the new energy distribution system. With the right approach to market adoption, these platforms can deliver end users and the larger grid the full value embedded in diverse DER portfolios (which increasingly include EVs and unprecedented forms of load management).

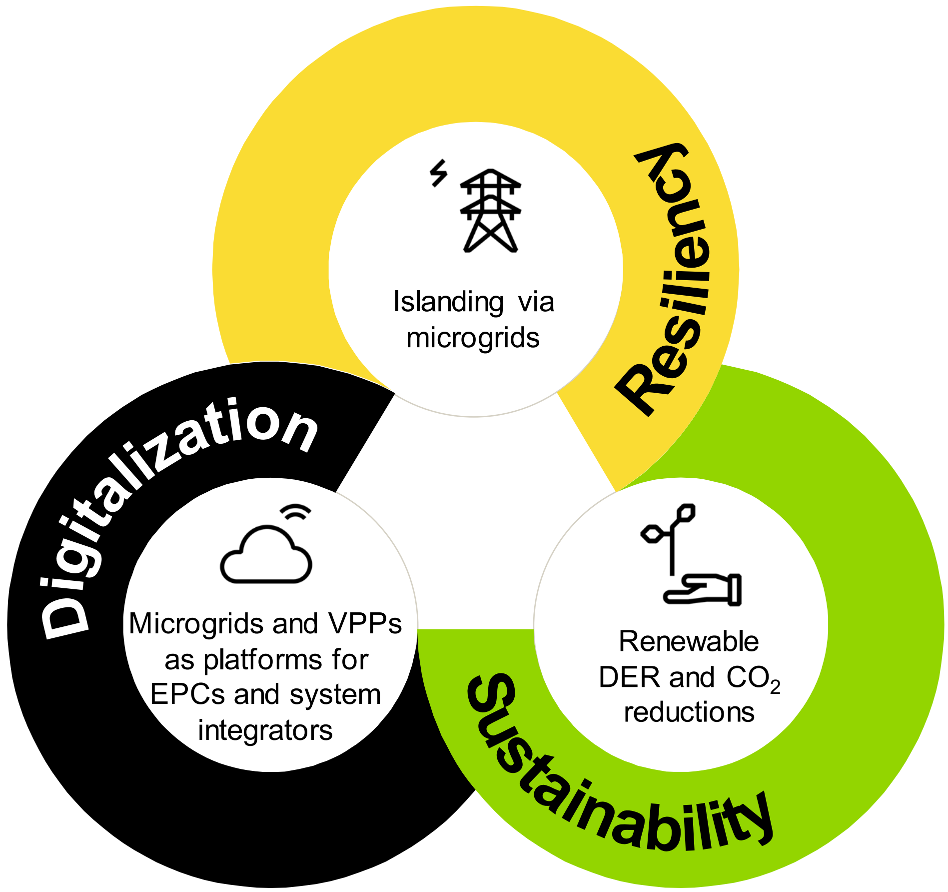
Here are three key takeaways from this white paper:

- **Digital platforms for DER optimization such as microgrids and VPPs are gaining traction across a broad array of customer applications.** The value of digital platforms continues to grow for utilities, C&I customers, small to midsize industrial operations (such as food and beverage sites), communities, and maritime vessels. These technologies offer resiliency and flexibility, lower energy costs and the ability to tap, support, or draw from the larger distribution and transmission network. The bidirectional exchange of value between host site and different layers of grid topologies has wider acceptance as digital products prove themselves in the marketplace.
- **The need for microgrids and VPPs is global, but key regions are fostering innovation today.** There is universal need for digital platforms that optimize DER assets. Yet the pace of adoption will vary immensely due to policy and regulation, available renewable resources, and end use customer profile differences. China, the US, and Italy feature examples of deployments ranging from microgrids to VPPs. Digital platforms will proliferate around the world, but today innovation is led in the Asia Pacific, North America, and Europe.
- **Modular solution blocks for EPCs, system integrators, and other installers is one of the better ways to build market momentum toward full-scale commercialization.** Most digital platform providers today sell their products and services directly to end users. Outside of utilities, many of these entities do not have the expertise to make informed decisions. Furthermore, they may not understand a better way to finance these solutions. Selling modular solution blocks to experts that design and install the systems is a better path forward and fully reflects the commercially viability of these technologies.

Resiliency, sustainability, and digitalization are the three pillars supporting growing investment in microgrid and VPP solutions.

Resiliency, sustainability, and digitalization are the three pillars supporting growing investment in microgrid and VPP solutions (see Figure 5). Digitalization enables resiliency and sustainability. Devices such as circuit breakers can provide mutual value for end users and utility grids, revolutionizing the way the world builds green distribution networks. These digital devices capture previously hidden value created by the rapid growth in DER assets and leverage the expertise of a growing pool of well-established companies that require digital products and services to deliver top value to their customers.

Figure 5 Modular Digital Platforms Vital to World's Resiliency and Sustainable Goals



(Source: Guidehouse Insights, ABB)

Acronym and Abbreviation List

AC .... Alternating Current

AI .... Artificial Intelligence

DC .... Direct Current

CPUC .... California Public Utilities Commission

EPC .... Engineering, Procurement and Construction

DER .... Distributed Energy Resources

DERMS .... Distributed Energy Resources Management System

EU .... European Union

EV .... Electric Vehicle

FERC .... Federal Energy Regulatory Commission

IoT .... Internet of Things

NEA .... National Energy Administration

NDRC .... National Development and Reform Commission

PV .... Photovoltaic

SCADA .... Supervisory Control and Data Acquisition

UPS .... Uninterruptible Power Supply

UK .... United Kingdom

US .... United States

VPP .... Virtual Power Plant

Table of Contents

Table of Charts and Figures

Scope of Study

Guidehouse Insights prepared this white paper, commissioned by ABB, to summarize how a new modular solution block approach to microgrids and VPP deployments can help accelerate market adoption. Rather than targeting these solution block offerings directly to project hosts, digital platforms should instead be sold to EPC firms, system integrators, and installers. These customers are more likely to recognize the proper solution and are knowledgeable about proper technology integration for microgrids and VPPs. Guidehouse Insights believes modular solutions are gaining market share, which reflects the rapid maturation of digital platform technologies around the world.

Sources and Methodology

Guidehouse Insights' industry analysts use a variety of research sources in preparing research reports and white papers. The key component of Guidehouse Insights' analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Guidehouse Insights' reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Guidehouse Insights is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Guidehouse Insights is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

Published 4Q 2020