PikeResearch
A PART OF NAVIGANT

WHITE PAPER

Digital Energy Networks

Mission Critical Power Meets ROI

Commissioned by Blue Pillar, Inc.

Published 4Q 2012

Peter Asmus

Senior Research Analyst

Clint Wheelock

Managing Director

Section 1
EXECUTIVE SUMMARY

1.1 A Customer-centric Approach to Power Reliability, Security, and Revenue

The growing complexity of distributed energy resources (DER) being installed directly at commercial customer sites presents both a challenge and an opportunity. The challenge rests with monitoring and optimizing such a wide array of resources into a single smart “digital energy network” that serves both the asset owner and the host distribution utility. The opportunity lies within the ability to solve grid reliability and peak demand contingencies at the local distribution grid node level. Such ability would boost system efficiency, maximize the return on investment (ROI) in customer-owned generation and other DER assets, and ultimately, ensure the highest level of business operational uptime.

An increasing number of both large and small companies are tackling these issues with some success by deploying narrowly focused smart grid solutions, but few have been able to separate themselves from the pack. As smart grid platforms such as microgrids, demand response (DR), and virtual power plants (VPPs) evolve, enterprisewide management of these networks will become a key differentiator. Also key will be reducing the extensive custom engineering of control solutions.

The healthcare industry is a leading segment among the campus environment microgrids that have helped propel North America into the world’s top market for smart grid networks. There are plenty of competitors seeking to capture new business when it comes to designing communications and controls for the increasing diversity of DER installed at the facility premises. Each company – and each technology approach – has its relative strengths and weaknesses.

In light of this increasingly crowded market, why would a Fortune 1000 company want to move forward with a digital energy network today?

- Improve performance of critical DER assets that support business operational uptime
- Combat high and uncontrolled energy costs
- Move away from manual management of DER assets with limited or no automation
- Boost reliability of service from local distribution utilities
- Minimize expansive cyber security attack surface
- Realize significant DR potential
- Lessen high cost of maintaining critical DER assets
- Enhance centralized command and control of on-site DER
- Support 0.9999 reliability requirements for increasingly data-based electric loads
- Resolve generation capacity-customer load mismatch

This white paper outlines key opportunities and challenges afforded by the evolving smart grid landscape and competing DER control approaches – including the digital energy network. It also presents Pike Research’s market capacity and revenue forecasts for microgrids, DR, and VPPs.

Section 2
PROBLEM STATEMENT

2.1 Today's Power Grid Is under Attack

Just a few highly trained terrorists could cripple large segments of the centralized radial electrical grid today. This is why the U.S. Department of Defense (DOD) is so focused on near-term deployments of microgrids, a smart grid platform that aggregates and optimizes DER. Microgrids are also designed to separate from the larger utility grid and operate in "island" mode in the event of a power disruption. They represent just one tool within the smart grid toolbox that can be deployed by sophisticated Fortune 1000 companies as well as utilities looking to integrate higher levels of reliability and security than offered by legacy power grids.

Connecticut is the first state in the United States to move forward with a policy program to promote microgrids. The state's push for microgrids is in response to Tropical Storm Irene in August 2011 and a rare blizzard in October 2011, both of which led to massive power outages. While the focus of this effort is to identify 150 viable microgrid sites, it is currently limited to a one-time $15 million grant and loan program covering the interconnection costs of microgrids for police and hospital facilities. Clearly, private sector technological and financial innovation will be necessary to create viable business models for this microgrid solution set to take root.

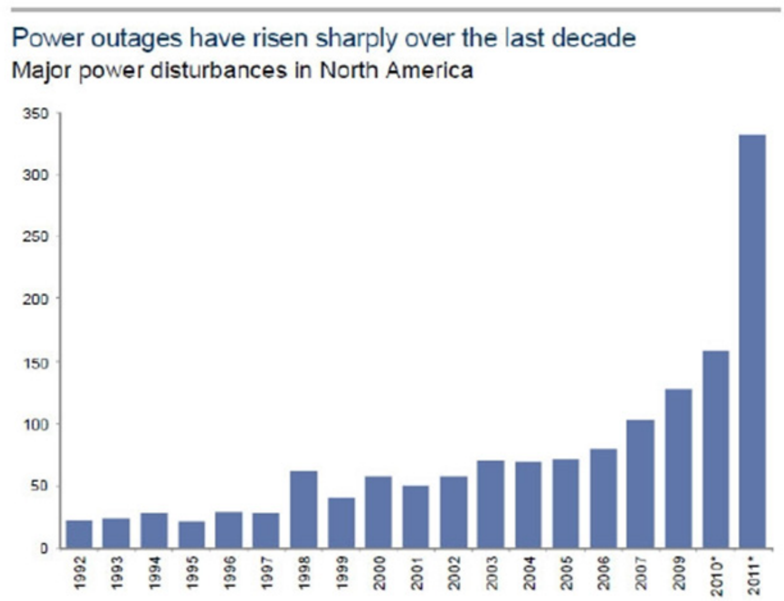
Recent evidence corroborates more severe weather is now business-as-usual. According to the Center for Research on the Epidemiology of Disasters, 100 million to 200 million people were affected by weather-related disasters between 1980 and 2009, with economic losses ranging from $50 billion to $100 billion annually. The magnitude 9.0 earthquake in Japan (and corresponding tsunami) was just one obvious example during 2011. (The Sendai 1 MW microgrid at Tohoku Fukushi University operated for 2 days in island mode while the surrounding region was without power.) Such natural disasters underscore the need for resilient infrastructure for vital electricity services.

Microgrids represent the most cost-effective business model to provide physical and cyber security and uninterrupted power. Note, though, that aggregating and optimizing DER can also create a virtual power plant, or VPP. This term refers to the ability of these grid subsystems to provide valuable ancillary services to distribution utilities or transmission grid operators, often on a temporary basis, and leverage utility smart meter and automated metering infrastructure (AMI). Whether reducing demand on the grid through a DR program or providing frequency or voltage support to firm up variable renewable energy resources, VPPs represent a new energy paradigm that resolves power supply challenges in the most efficient manner at each customer's site, surgically matching local load with local capacity.

2.2 Challenges Are Also Arising from Within the Power Grid

The U.S. utility grid was graded a lowly D+ by the American Council of Civil Engineers in 2009. Lawrence Berkeley National Laboratory (LBNL) statistics show that 80% to 90% of all grid failures begin at the distribution level of electricity service. Advocates for increased reliance upon DER argue that power quality and reliability can be dramatically improved at the local distribution level. It has become quite clear that the modern, digital economy requires a more advanced, robust, and responsive power grid framework than what is available today.

Figure 2.1 Power Outages in North America: 1992–2011



(Source: North American Electric Reliability Corporation; Eaton)

The fundamental architecture of today's electricity grid, which is based on the idea of a top-down radial transmission system predicated on unidirectional energy flows from large centralized power plants, is obsolete. If the electricity grid begins to resemble the Internet due to the proliferation of DER, then advanced aggregation platforms such as the microgrid will become vital. Consider the following trends highlighting the declining performance (and value) of today's U.S. utility grid power:

» **The U.S. average outage duration is 120 minutes and getting worse ...** while the rest of the industrialized world is less than 10 minutes and getting better

» **The traditional "just build more of the same" mentality has yielded less than or equal to 45% capital asset utilization (generation, transmission, and distribution) and also getting worse ...** and meanwhile, outage duration and frequency is increasing

» **The top-down electric power system is not meeting the challenge ...** so businesses are embracing DER such as distributed generation and participation in peak demand reduction programs is climbing exponentially

Perhaps the most damning statistic gleaned from the Energy Information Administration (EIA) is this: for every 1 MW of power consumed by commercial and residential customers, ratepayers are paying for 2.2 MW of generation and transmission capacity. Although DER can clearly make the energy delivery system more energy- and capital-efficient, the growing complexity of this largely customer-owned resource base also poses new challenges for utilities and grid operators.

In terms of efficiency, less is more when it comes to DER. However, what then remains is the daunting task of orchestrating such a diversity of resources residing within the power grid into systems that deliver real economic value through sophisticated management upgrades, rather than creating voltage, frequency, or power quality issues. Consider the following dizzying array of DER that will require smart grid solutions:

» A diverse base of vintage fossil generation from a long line of different manufacturers

» Real-time smart grid-enabled DR resources

» Variable distributed renewables such as rooftop solar PV systems within the commercial and residential sectors

» Energy storage devices that rely upon different battery chemistries and provide over 20 different types of grid ancillary services

» Plug-in electric vehicles (PEVs) that increase variability for power grids on the load side while also offering potential distributed storage solutions – if managed intelligently

Along with the challenges attached to managing this complexity of DER are other more ordinary on-site power infrastructure concerns. Examples include:

» Aging DER portfolios

» Rusted switchgear and other grid equipment breakage

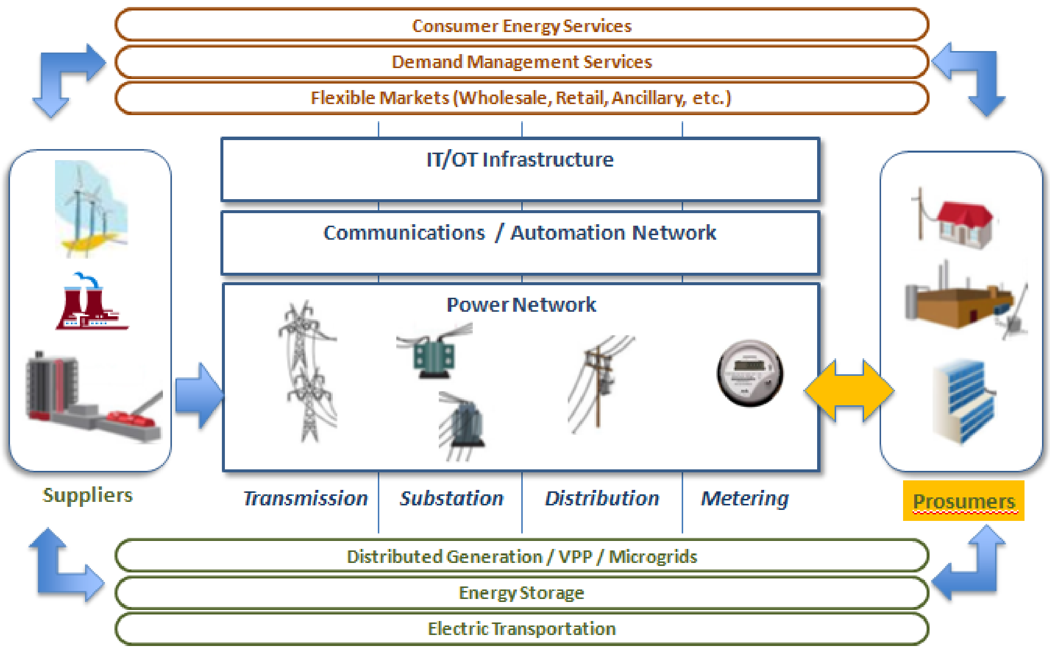
» Fuel supply bottlenecks

» The distance and cost of rolling maintenance trucks

» The latency of effective manual management

These sorts of concerns keep the CFOs of large Fortune 1000 companies awake at night, much more than terrorism or even recent examples of extreme weather compromising the reliability of the power grid. The large businesses – especially those that have multi-site operations – have deployed a massive number of disparate technologies to serve diverse loads at their facilities provided by a literal alphabet soup of different vendors. Most of this equipment is quite dumb; they operate in silos and have little to no on-board automation. Also note that although these diverse DER have not been linked together into any sort of network, they are somehow expected to work in unison to support core operations.

Figure 2.2 Today's Bi-directional and Increasingly Complex Power System



(Source: Pike Research)

Because the capital budgets at these Fortune 1000 companies have shrunk, been frozen, or been eliminated altogether, concepts such as a digital energy network – which touches microgrids, DR, and VPPs – can pay for themselves within a single year of operation. Indeed, due to the constant breakdowns of aging, vital equipment, these "systems of systems" can pay off. This is especially the case when the integration of DER is pushed down to the application enterprise software server located at the customer site, with instructions then passed down to each asset located at the circuit level. Such a basic approach eliminates the need for hard coding at nodal endpoints; hence, the term digital energy network.

Section 3

SUITE OF SOLUTIONS

3.1 Microgrids

Historically, the fundamental structure of utilities has prevented intentional islanding. Despite opposition from utilities, though, new technology advances are enabling microgrids to move beyond "an exception to the rule" to accepted practice among growing numbers of electrical engineers.

The cultural bias against islanding by utilities was most clearly expressed in the Institute of Electrical and Electronics Engineers (IEEE) 1547 standards, which historically required an automatic and rapid disconnection of all distributed generation (DG) during grid outages. For well over 5 years, the IEEE worked on developing an alternative approach: a guide on islanding to bring these standards up to date with the capabilities of new technology. This guide (1547.4), which went into effect in July 2011, is a major step forward. Not only does it spell out safe utility protocols for islanding, but it also puts standards for reactive power into place. These new 1547 standards will allow microgrids to sell ancillary services to distribution utilities, much in the same way that DR providers like PJM Interconnection currently do in well-developed markets. Although 1547.4 may not become a binding standard for utility operators for another 5 to 10 years, it is a major milestone for this emerging industry. (Also approved in 2011 was the 1547.6 standard, which addresses recommended practice for interconnecting microgrids with electric power supply distribution secondary networks.)

One reason for the growing support within the engineering community for islanding is the growing evidence that microgrids can help distribution utilities reduce costs and improve service. According to Horizon Energy Group, which is developing a 11 MW combined heat and power (CHP) microgrid in Connecticut, a portfolio of 500 MW of microgrids operating within the service territory of Consolidated Edison in New York would offer a wide range of benefits for consumers, the environment, and the utility itself (see Table 3.1). The data points below show how customer-owned microgrids can provide system benefits for a utility.

Table 3.1 Potential Benefits of Customer-owned Microgrids for Consolidated Edison

Compare 500 MW over 20 years	ConEd BAU	ConEd Microgrid
Amount of Microgrids	--	500 MW
Reliability (average customer outage minutes/year)	120	12
Power Plant Capacity Factor	45.3%	83.2%
Emissions (NO_X, SO_X, CO_2)	--	532,727 tons less
Consumer Savings	--	$2 Billion
Distribution Marginal Cost	$600/kW-year	<$250/kW-year

(Source: Horizon Energy Group)

3.2 Demand Response

Once seen as threats, many utilities now view microgrids as potential DR resources. Whether aggregated and optimized through microgrids, disparate DER can be plugged into grid networks and can capture new lucrative revenue streams recently enhanced by policy incentives. A series of the Federal Energy Regulatory Commission's (FERC) recent Orders – 719, 745, and 1000 – all take steps toward harmonizing innovation occurring independently at the wholesale and retail market levels of power grid service. DR is seen as a stop-gap resource whose role will expand in markets characterized by volatility, high demand peaks, and lack of new transmission-level generation capacity. And in some circles, microgrids are now being viewed as the ultimately reliable DR resource, since islanding securely takes load off of the utility grid.

How do DR resources actually work? Load reductions aggregated from grid-tied microgrids can be sold into power markets as three distinct products:

» **Peak capacity products** that help maintain a utility's typical 15% supply reserve margin

» **Economic energy** that can be sold on an hour-by-hour basis

» **Grid regulation services** that can last for a matter of minutes

The duration of each of these DR products has historically been surprisingly small. A typical capacity DR product may be activated once wholesale prices reach $150 per MWh and averages 20 hours of operation per year. An economic energy DR product – sometimes called price response – has a lifespan of 90 hours per year. Ancillary service DR products may be called upon once a week, but the duration time averages only 23 minutes for commercial and industrial (C&I) customers. The FERC's recent rulings now allow higher compensation for DR providing energy. As such, Pike Research anticipates the DR market will grow, especially as microgrids comprise a larger share of the overall DR market and are then optimized into VPPs that can be scheduled like traditional supply.

3.3 Virtual Power Plants

VPPs, a term sometimes used interchangeably with microgrids, rely upon smart grid software systems to dispatch and optimize generation or demand-side or storage resources remotely and automatically in a single, secure IT communications system. In short, VPPs represent an Internet of Energy. They tap existing grid networks to tailor electricity supply and demand services for a customer (or customers), maximizing value for both the end user and distribution utility through software innovations and robust IT such as digital energy networks.

VPPs and microgrids share some critical features, such as the ability to aggregate DR, DG, and energy storage at the distribution level. Some market participants estimate an 80% commonality between these two business platforms in terms of hardware components. VPPs are typically voluntary and participants are motivated by the prospect of enhancing revenue (or lowering energy costs). This emerging VPP model is highly dependent on market structures and the specific technology paths deployed. It is also dependent on the structure of the host utility markets – whether vertically integrated, fully deregulated down to the retail level, or owned by a municipality, rural cooperative, or another government entity, including national governments.

3.4 Competing DER Control Approaches

Among the key selling points of any grid-tied microgrid is the capacity to ride through utility grid failures. By rapidly disconnecting from a faulting grid system and then adjusting local generation while shedding non-priority loads, particularly high levels of reliability can be guaranteed for priority resources residing on the microgrid at less cost than a UPS system. Yet, today, no consensus has been reached as to the best way to manage a transition from distribution grid-connect to grid-disconnect mode.

The mechanics of how to designate priority loads within a microgrid are also far from clear-cut. The simplest approach is a prioritized list of critical and non-critical loads. Such an approach runs the risk of needing to shed more loads than necessary. An alternative approach integrates artificial intelligence techniques with dynamic decision-making that is influenced by current system conditions, generator outputs, and current load properties. Among the current options are centralized management systems requiring high-bandwidth links between the inverters and central controller. Other prototype microgrids rely on distributed on-board control, which reduces the bandwidth needed, but at the cost of synchronization difficulties. Some systems try to incorporate both seemingly contradictory approaches. Lockheed Martin, for example, deploys a hybrid system that features both centralized and distributed controls, as well as the capacity for enterprisewide management.

The following four sections outline several competing technology approaches to managing and optimizing microgrids, DR and VPPs, concluding with the new concept of a digital energy network.

3.4.1 Adapting Industrial Automation Systems

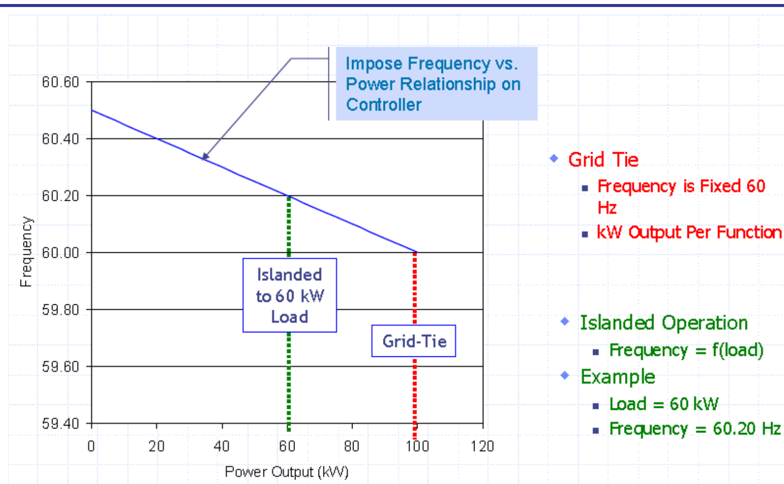
The favored approach of legacy technology vendors such as General Electric, ABB, Siemens, and Eaton is to adapt their existing industrial automation systems often deployed at the transmission level of grid service down to the distribution level. These structures then hook into the supervisory control and data acquisition (SCADA) systems that have become so integral to power grid management. Rather than a vertical control approach, these vendors are attempting to expand horizontally to reach out and control new devices – including legacy fossil DG, thermal energy systems, distributed renewables, and different forms of energy storage. This is primarily a hardware-based solution, though software is also integral to controls. Typically, the proprietary “black box” portion of these solutions is the algorithms software, a form of artificial intelligence that looks for patterns and then develops probabilistic models to guide automated technology responses.

The downside to this industrial automation approach is that every system is a customized solution often dependent upon large amounts of implementation-specific software development. Every time a new DER is added to the network, an engineer must add additional custom software code to the system. The primary goal of these industrial automation vendors is not the microgrid controls piece, but rather, the more lucrative equipment sales associated with hardware components such as renewable DG, switchgear, energy storage, etc. Generally speaking, microgrid controls software represents no more than 15% of the total capital cost of a microgrid. The biggest piece of the microgrid revenue pie is DG. These larger technology players therefore often understandably focus on selling hardware equipment that also includes advanced energy storage, distribution automation, smart meters, and smart switches. Some companies, such as Encorp of Fort Collins, Colorado, do not carry this baggage. Encorp sees itself as a hardware company that does the "nuts and bolts" of microgrids, including some level of customized engineering and controls – but is not focused on economic optimization.

3.4.2 Inverter-based Droop Frequency

Perhaps the very antithesis of the industrial automation approach is droop frequency. Much of the early literature about modern microgrid control approaches revolved around the Consortium for Energy Reliability Technology Solutions (CERTS) software, largely because it involved public institutions such as LBNL and the University of Wisconsin, as well as a utility, American Electric Power. Furthermore, the software was embedded in the Tecogen CHP unit, so it was more or less a microgrid control system that had no defined premium cost attached to it. However, a large number of engineers questioned the sole reliance upon droop frequency for running a microgrid, especially if the microgrid contained sensitive loads or generation sources that had little tolerance for deviations in frequency. Additionally, the CERTS system was a reliability-focused controller. More recently, the microgrid market has evolved and now economic optimization through sales of ancillary services back to the grid is of equal, if not more, importance for some microgrid owners/managers.

Figure 3.1 CERTS "Droop Frequency Control" Program



(Source: Tecogen)

The CERTS software has been subsidized by government; thus, it is the default lowest-cost alternative. Each generation, storage, or load component must be embedded with CERTS controls. Companies that provide CERTS-compatible equipment include Tecogen, S&C Electric, and The Switch. If any additional islanding communications and controls costs exist for CERTS, they are hidden in the equipment manufacturer's pricing.

Primarily designed for remote power systems looking to integrate variable solar or wind resources, other inverter-based controls often also mimic the CERTS droop frequency approach, but without the benefit of synchronous generators setting frequency. These systems are also not privy to the larger power grid offering a buffer or source of revenue streams attached to the provision of ancillary services. Companies deploying such inverter-based controls include Sustainable Power Systems, LLC of Boulder, Colorado, Younicos of Berlin, Germany, and Powercorp of Darwin, Australia, the latter of which was purchased by ABB in November 2011. ABB is in the process of integrating Powercorp's distributed controls approach into its grid-tied offerings. This is a clear sign that ABB sees the future and is shifting away from a pure industrial automation approach.

3.4.3 Pure Software Optimization Companies

A growing list of companies offer software packages that can optimize microgrids to sync up with market opportunities for ancillary services; some also promise open architectures that reduce the need for customized engineering. Often, these software systems can be layered on top of either an industrial automation hardware foundation or a droop frequency system to enable these microgrids to access revenue streams offered by utilities or grid operators.

It is in this smart grid space where the greatest activity has occurred recently. For example, Power Analytics and Viridity Energy are collaborating to optimize the 42 MW University of California-San Diego microgrid. Power Analytics manages the controls through a sophisticated models-based software rich in data. Meanwhile, Viridity Energy's software links into the intricacies of market structures in order to enable DER to respond to signals from grid operators for ancillary services.

Taking a slightly different approach is Green Energy Corp. of Denver, Colorado. The company is attempting to make its mark with its GreenBus, a next-generation automation middleware offering based on open source software intended to allow interoperability among disparate data and remote sensing devices from multiple vendors. The company is focused on substation and below communications protocols. Perhaps the most unusual aspect of Green Energy's business model is that anyone can use the open licensed projects of GreenBus at no charge. The firm generates revenue by charging a subscription fee for the enterprise package of Green Energy's future-proof platform.

3.4.4 Enterprise Digital Energy Networks

The companies that can manage multiple microgrids across an enterprise and tap DR revenue streams by selling ancillary services back to the grid have an immediate advantage in today's fragmented smart grid solutions environment. The capability to tap a rich diversity of DER and thereby transform these distributed resources into a VPP to provide value to both asset owners and the distribution and transmission grid systems drives near-term and substantial ROI for hospitals, military bases, and data centers. The resulting network acts as a "glue" between on-site assets and the power markets.

A growing number of firms are developing such networks today, each focused on different customer bases and each possessing their relative strengths and weaknesses. For example, Lockheed Martin has the ability to manage enterprisewide controls. However, since it has been largely focused on the military, it has yet to deploy significant microgrid capacity as DR resources. Power Assure of Santa Clara, California can also manage enterprise controls, but has been focused on global data center operations that can shift loads to low-cost regions of the world in order to capture DR resources. The company is developing data center microgrids as large as 15 MW in Europe, but has yet to deploy its envisioned global VPP network.

The company that has gained the most traction with the concept of a digital energy network is Blue Pillar of Indianapolis, Indiana. Blue Pillar has applied its new technology on 50 sites encompassing over 1050 endpoints. These represent over 150 MW of online capacity in leading U.S. DR markets such as the Carolinas, Florida, and most recently, California – many of the regions plagued by extreme weather events referenced earlier in this white paper. In Texas, the combination of severe weather and limited wholesale power generation has helped create some of the nation's most compelling DR programs. This, in turn, has proved to be a fertile environment in which to improve the economics of the microgrids developed by Blue Pillar as it sells DR services – the cheapest, fastest, and cleanest way to meet energy demand.

The company is focused first on mission-critical healthcare campus infrastructure to capture greater value from existing on-site generation by selling DR services to grid operators and utilities. This market can show immediate ROI. The next section of this white paper provides a deeper profile of how a digital energy network actually works.

Section 4
THE DIGITAL ENERGY NETWORK VALUE PROPOSITION

4.1 Digital Energy Networks: Enhancing ROI across the Enterprise

Digital energy networks eliminate the two primary hurdles for commercial microgrid enablement: customized code and logic-driven controls that perform, rather than simply recommend, asset dispatch in a microgrid setting. A digital energy network consists of enterprise software that runs on a central server and secure asset interface microservers (AIMs) that are connected to all of the energy assets, including generators, switchgear, fuel systems, cogeneration, chillers, etc. The AIMs add both a layer of intelligence and firewall protection, in addition to effectively providing a way to monetize any asset regardless of its age or sophistication. Facilities managers then monitor and manage the entire network of assets through an intuitive energy dashboard, which provides a holistic view with real-time situational awareness all the way down to the circuit level.

As a packaged system of systems, the digital energy network allows for rapid, turnkey implementation. Under this controls approach, a large library of standardized interfaces for virtually every vintage and vendor of fossil fuel generator, automatic transfer switches, and a growing list of other equipment is created. This enables the digital energy network to provide a complete set of detailed AIM wiring diagrams and work instructions for the entire inventory of an organization's energy assets after conducting a brief, tablet-based site survey. The resulting plug-and-play digital energy network provides a more comprehensive and, in most circumstances, cost-effective alternative to custom SCADA-based control systems.

With parallels in telecom networking and functionality, the practice of creating digital energy networks could revolutionize the way distributed power can solve problems at the customer site, instead of allowing issues of frequency, voltage, and power quality to cascade up to utilities and grid operators. By digitizing the world's map of DER – and allowing a centralized control room to manage multiple sites across an entire enterprise – this new way of managing energy assets enables islanding microgrids and VPPs to extract the most value from each asset.

4.2 Which Customers Need Command-and-Control of DER Complexity Today?

The growth of reliance upon DER solutions is increasing across the entire electricity value chain. However, there are distinct market segments that have a higher stake in the performance of the power grid, with losses of power equating to millions of dollars in lost revenue and/or dire consequences for national security. At present, Pike Research considers the following as leading-edge customers seeking smart grid networking solutions that can provide immediate value:

- **Medical industry:** Hospitals cannot afford to lose power since such outages endanger the lives of their patients. The status quo solution has been highly inefficient, expensive, and (often) polluting backup UPS systems that can still fail.

- **Mission-critical military establishments:** Whether addressing national security challenges such as armed conflict or emergencies related to natural disasters, the U.S. DOD needs reliable and secure 24/7 power. The only way for the DOD to meet both its net zero energy and renewable energy targets (25% by 2025) is by developing microgrids. In order to fund these upgrades, the DOD is also turning to DR revenue streams.
- **Industrial enterprises:** Many industries can afford some small disruptions in power supply. But growing numbers of cutting-edge companies active within the digital economy cannot and are seeking cleaner, more efficient solutions. The classic UPS system for data centers is too expensive and inefficient, and is often still vulnerable due to manual operations and controls.

Without greater intelligence and organized markets offering market-based prices for services, increased reliance upon DER could retard rather than enhance power quality and reliability. Perhaps the best way to grasp the challenge at hand is to drill down to take a look at a case study, this one focused on healthcare facilities.

4.3 Digital Energy Network Case Study: Tenet Healthcare

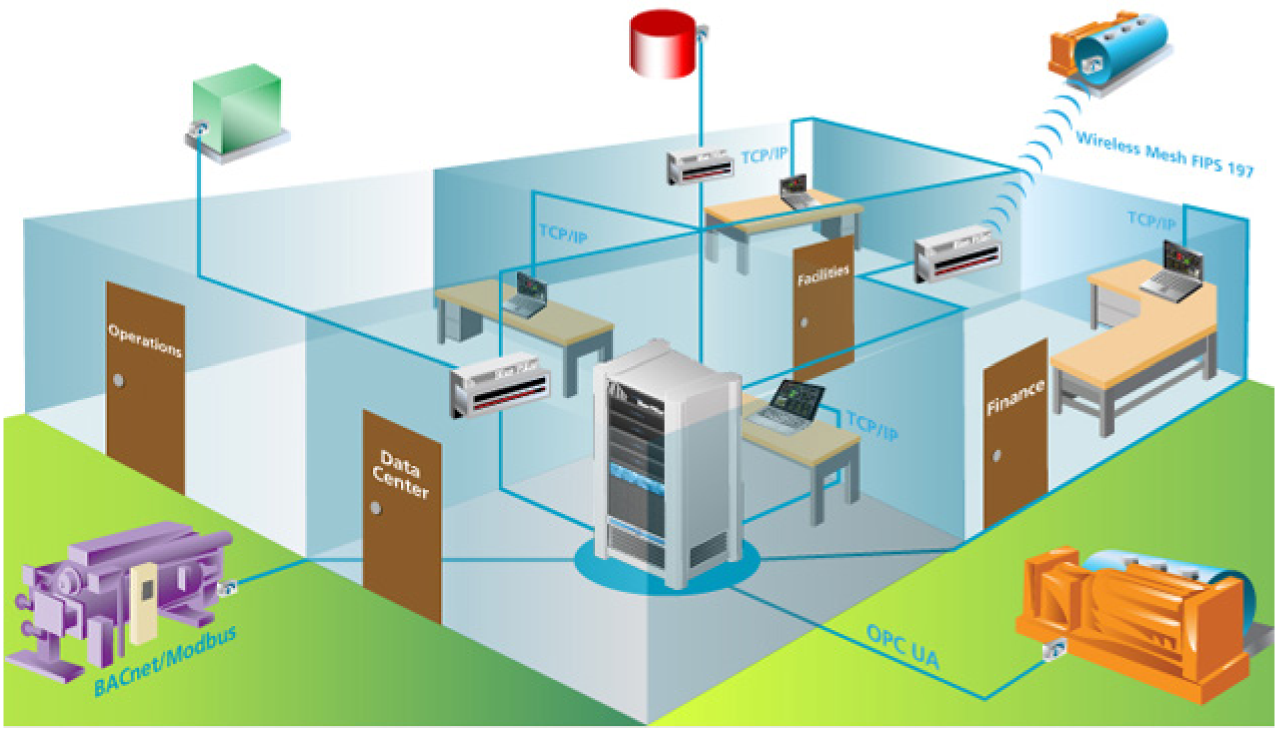
Depending on the size and configuration of any healthcare campus, there may be several emergency power supply systems (typically composed of a plethora of diesel generators and electrical distribution equipment) that are spread over many acres. Because hospitals expand and add new services on a continuing basis, the components of these backup power systems vary in age and come from a variety of manufacturers.

To date, with rare exceptions, the inspection and management of each emergency power supply system (EPSS) is performed individually and manually, increasing cost and reducing reliability. In the case of an extended power outage, hospital assets – ranging from the equipment to protect patient safety to revenue streams revolving around the IT network and data center – are put at risk. Facilities personnel have no way of knowing the status of isolated EPSS or UPS systems and other important factors (such as how much fuel is on hand to power them) without physically inspecting each and every system individually.

While relatively rare events, power outages have struck hospitals and university laboratories all across the country. At Ohio State University, for example, more than 2 years' worth of research and 700 research animals recently died due to a power failure when emergency generators failed to keep up with demand during a heat wave.

One healthcare company that decided to take a new approach is Tenet Healthcare Corp. The company's facility portfolio spans across 10 different states, making it one of the nation's largest healthcare holding companies. Inherent in this diversity, however, is the challenge to secure and manage power infrastructure in a standard way that delivers "always on" power while reducing energy cost and managing a fleet of hundreds of on-site assets. For Tenet, exposure included aging, manually maintained infrastructure with limited intelligence; lack of a common platform to test, monitor, and optimize assets for safety and readiness; and the inability to participate in energy market programs like demand response. Following successful deployments across Tenet's Texas and Florida medical facilities and campuses, the company will use the digital energy network concept and technology to enable its on-site energy equipment assets in California, Pennsylvania, and the Carolinas to become more cyber-secure, automate testing, and provide real-time dispatch of any EPSS during periods of utility grid instability or emergency. The impacts to operations and energy management have been immediate. Tenet now has instant visibility into asset health, readiness, and circuit-level load, coupled with the ability to deploy on-site generation against load as grid instability or secure, economic opportunity allows.

Figure 4.1 Physical Architecture of a Digital Energy Network



(Source: Blue Pillar)

The concept and real-world implementation of real-time digital energy networks is a potential game-changer. Digital energy networks represent a platform that allows enterprise-level controls of the complete array of potential resources on a smart grid to extract maximum value while delivering near-term ROI for price-sensitive customers seeking premium power quality and security. At the same time, these customer-owned microgrids can capture immense value for distribution utilities looking to leverage private sector investments into upgrading the power reliability of their grids while reducing the overall marginal cost of the system.

Section 5

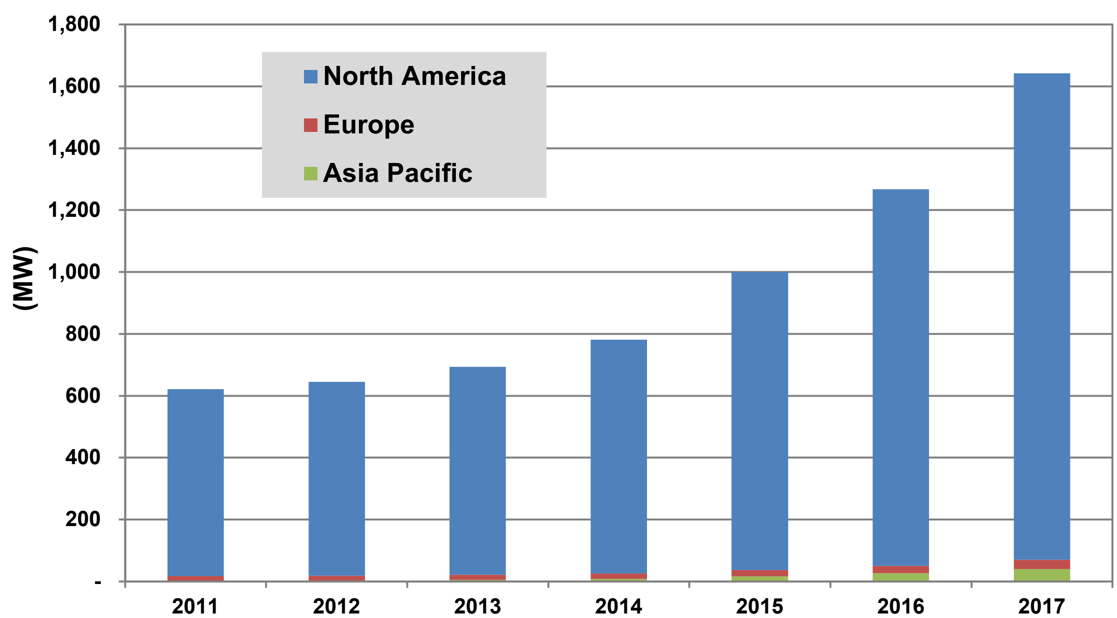
PIKE RESEARCH MARKET FORECASTS AND CONCLUSIONS

5.1 Market Overview

Whether talking about microgrids, DR, or VPPs, the future is bright for smart grid aggregation and optimization structures and programs. Three of the most relevant Pike Research capacity and revenue charts are included here in order to better frame and quantify the opportunity for offerings such as digital energy networks, which can bridge all three of these market segments (and where significant overlap exists). Due to regulatory barriers for C&I customers not operating within a campus environment, microgrids deployed by institutions such as hospitals, universities, and corporations (within a single campus setting) represent the most prominent market today.

Geographically, North America leads this microgrid market segment, largely due to the relatively poor reliability of the incumbent utility power grid. As utilities continue to resist changing long-standing rules and regulations on sharing power with more than two meters or sending electricity across a public right-of-way, sophisticated campus operations that already have significant on-site generation and some level of load controls represent the most attractive near-term microgrid market.

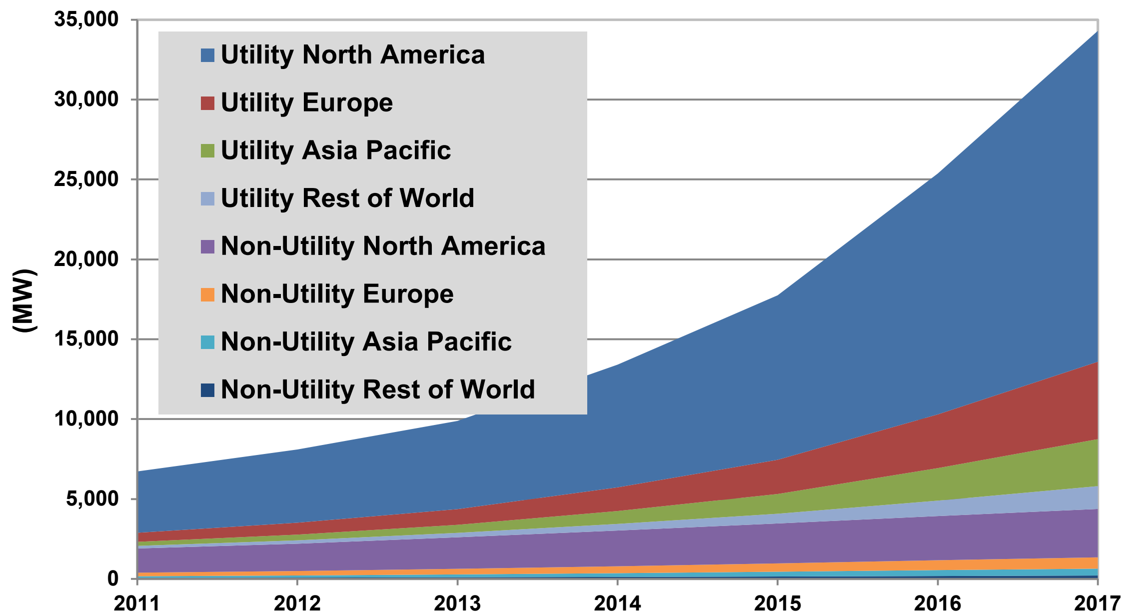
Chart 5.1 Planned Campus Microgrid Capacity by Region, Average Scenario, World Markets: 2011–2017



(Source: Pike Research)

Clearly, North America – and specifically the United States – is the global leader on campus environment and institutional microgrids. The same geography also holds a commanding global lead on DR, including the dynamic pricing market that serves as the basis for VPP aggregations, whether these aggregations are managed by the utility (and its end-use customers) or third-party companies such as EnerNOC.

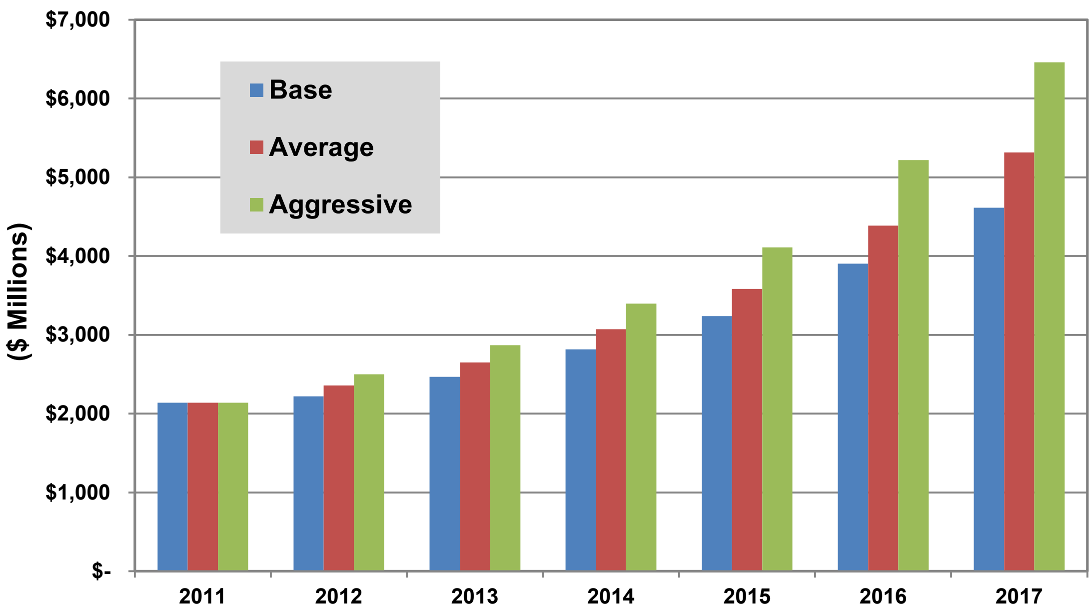
Chart 5.2 DR Capacity by Region, Dynamic Pricing, World Markets: 2011–2017



(Source: Pike Research)

Pike Research has divided the broad VPP market into three segments. DR programs are the main sources of revenue streams for the total VPP market in North America, as supply-side and mixed asset VPPs are concentrated in Europe. These two latter categories have consisted of R&D projects designed to aggregate and optimize distributed and wholesale renewables, with Denmark and Germany current hot spots.

Chart 5.3 Total VPP Revenue (DR, Supply-side, Mixed Asset), All Scenarios, World Markets: 2011–2017



(Source: Pike Research)

5.2 Conclusion

Interest in DER aggregation and optimization solutions is clearly on the rise. Whether these smart grid solutions take the form of a microgrid, DR, or VPP – or all three combined – does not really matter. A digital energy network takes an extremely focused approach to the problem of grid reliability, aging, and uncoordinated on-site energy assets and the need for near immediate ROI in today's challenging energy economy. Whether this circuit-level command-and-control approach to DER can broaden its repertoire to also seamlessly integrate distributed renewables, energy storage, and PEVs into digital energy networks remains to be seen. Regardless, the value proposition for a digital energy network focused on optimizing existing fossil, thermal energy, and meter/switch technologies can offer immediate paybacks while setting the stage for future upgrades. The end goal is to boost value for both end-use customers owning on-site energy assets and the host distribution utility and transmission grid operators.

Section 6

ACRONYM AND ABBREVIATION LIST

Asset Interface Microserver .... AIM

Automated Metering Infrastructure .... AMI

Business as Usual .... BAU

Carbon Dioxide .... CO_2

Chief Financial Officer .... CFO

Combined Heat and Power .... CHP

Commercial and Industrial .... C&I

Consolidated Edison .... ConEd

Consortium for Energy Reliability Technology Solutions .... CERTS

Demand Response .... DR

Distributed Energy Resources .... DER

Distributed Generation .... DG

Emergency Power Supply System .... EPSS

Energy Information Administration .... EIA

Federal Energy Regulatory Commission .... FERC

Information Technology .... IT

Institute of Electrical and Electronics Engineers .... IEEE

Kilowatt .... kW

Lawrence Berkeley National Laboratory .... LBNL

Megawatt .... MW

Megawatt-hour .... MWh

Nitrogen Oxide .... NO_X

Photovoltaic .... PV

Plug-in Electric Vehicle .... PEV

Research and Development .... R&D

Return on Investment .... ROI

Sulfur Oxide .... SO_X

Supervisory Control and Data Acquisition .... SCADA

U.S. Department of Defense .... DOD

Uninterruptible Power Supply .... UPS

United States .... U.S.

Virtual Power Plant .... VPP

Section 7

TABLE OF CONTENTS

Section 8

TABLE OF CHARTS AND FIGURES

Section 9
SCOPE OF STUDY

This white paper was developed based on previous reports by Pike Research covering emerging markets for microgrids, demand response (DR), and virtual power plants (VPPs). Interviews with Blue Pillar and other market participants were also incorporated, as were fresh original and secondary research.

Note that this white paper is not an endorsement of any company. Rather, it attempts to place the concept of the digital energy network within the context of evolving smart grid solutions for managing distributed energy resources in today's challenging economic environment.

SOURCES AND METHODOLOGY

Pike Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Pike Research's 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 Pike Research's 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 Pike Research's 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.

Pike Research, a part of the Navigant Consulting, Inc. Energy Practice, is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Pike Research 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 2012

1320 Pearl Street, Suite 300
Boulder, CO 80302 USA
Tel: +1.303.997.7609
http://www.navigant.com/pikeresearch