Digital Electricity

Introduction

Connectivity is rapidly changing the world of energy, and the traditional electric grid cannot keep up. Pressure created by an array of factors, like aging grid infrastructure and a disruptive energy marketplace, are pushing utilities to go digital and guarantee their place in a connected world.

When it comes to planning a modern grid, most utilities seek greater reliability and efficiency in a secure environment. With this focus, utilities are deploying smart technologies on the distribution system to improve grid components and functions that render higher optimization, like remote monitoring, decision-making insight, and voltage and outage management. Even more, these functions create exciting new avenues for utilities and customers to work together to advance smart energy and co-design expanded grid services.

Though still early, some utilities are already leveraging digital technology with strong results, which is inspiring others to flip the switch on a digital grid. To get started, Black & Veatch advises an integrated planning process that is centered on six essential grid elements. A holistic planning approach will kickstart digital electricity and guide utilities through the most transformational shift in the history of the grid.

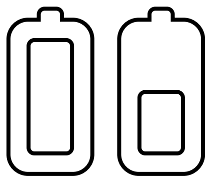
What's Driving Digital Electricity?

As connected devices scale from millions to billions, many elements of day-to-day life can be controlled by a handheld device. With a click, consumers are no longer isolated spectators in complex systems like transportation, energy, and public safety. They are part of a growing base of edge-located contributors who are challenging traditional business models and influencing the pace of innovation. In dramatic fashion, connectivity is changing everything.

Change is happening across industries, but the electric grid is undergoing its most transformational shift in history. Utilities are replacing conventional generation with flexible energy resources. This requires a dynamic, reactive network to respond to fluctuating power requirements in real-time, while ensuring reliability, efficiency, and security. To keep pace, utilities are modernizing their grids with digital technologies and investing in Network Operation Centers (NOC) to manage the two-way power and data flow. By going digital, utilities will be able to withstand market pressures and guarantee their place in a connected world.

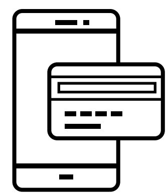
These Top 5 Electricity Market Pressures are pushing utilities to rethink their operations.

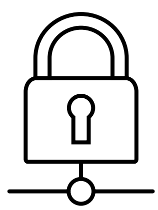
Aging Infrastructure: At an average age of 60 years, 45% of distribution infrastructure is near or at end of life, leading to higher failure rates. Today's system cannot support future energy demands, distributed energy resources (DERs), or digital technologies, and can fail in extreme weather.



Disruptive Marketplace: DERs like solar, wind, electric vehicles (EVs), battery storage, and microgrids are variable electricity sources that decentralize the grid and affect reliability. New market entrants, like energy aggregators, are impacting traditional energy generation, supply, and demand management.

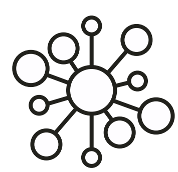
Consumer Demands: Through decentralization, customers are becoming more engaged in energy choices, generation, and management, which requires utilities to monitor load and understand what is happening at the edge of their grid.





Cybersecurity Threats: As the grid becomes decentralized, the potential for cyberattacks increase. Digital platforms establish long-term cybersecurity protections and standards across the enterprise.

Legacy Networks: Legacy networks, like analog technology, are becoming obsolete as providers migrate to digital platforms. A modernized IP network offers a reliable and scalable architecture to host automation, smart sensors, and emerging technologies like synchrophasors that advance real-time monitoring and control. By going digital, utilities take a technological step towards accurately understanding grid conditions and gaining better insight into reliability.



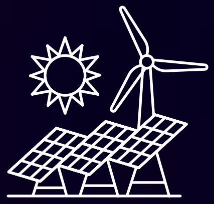
Flip the Switch: Go Digital

Utilities are going digital to lessen the impact of market pressures. Through digital architecture, utilities capture data from consumers, DERs, and the grid itself to remotely and automatically monitor power flow and adjust operations to prevent outages, enhance grid performance, and meet customer expectations. But a digital grid is more than just a remedy for today's complex market conditions—it provides a means to achieve a sustainable future regardless of how the world of energy changes year to year. Unavoidably, going digital increases cybersecurity importance.

To minimize risks, utilities should embed security within applications and interconnected devices to protect data as it is transferred across a modern grid.

The utility is not the only victor of grid innovation. The U.S. Department of Energy looked at the benefits of smart grids at the national level. They estimated that if every utility had a smart grid by 2030, then the U.S. could see an 18% reduction in carbon emissions, either directly through use of smart grid technologies that impact carbon emissions or indirectly by supporting greater participation in renewables and energy efficiency programs[1]. The impact of an 18% emissions reduction is equivalent to eliminating nearly 139 million U.S. homes or 229 coal-fired power plants from the grid for one year[2].

Signs it's Time to Go Digital



Regulators are mandating efficiency, renewable portfolios, or emissions reduction.

The grid and/or communications infrastructure cannot adapt to emerging demands.

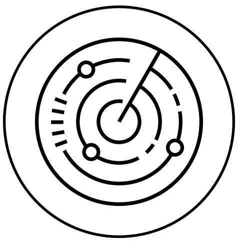
Customers are demanding more service options.

[1] U.S. Department of Energy. Quadrennial Energy Review. Transforming the Nation's Electricity System: The Second Installment of the QER. P.3-25, 2017.

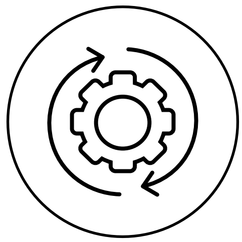
[2] Calculation using information from: USEIA. 2018. U.S. Energy-related CO2 Emissions Fell Slightly in 2017. 18% of 5.14 billion metric tons = 925,200,000. USEPA. Energy and the Environment. Greenhouse Gas Equivalencies Calculator. 2018.

DIGITAL GRID DISTINCTIONS

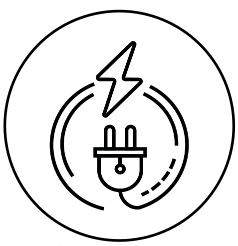
Utilities that modernize see electricity in a whole new light. A digital grid is:



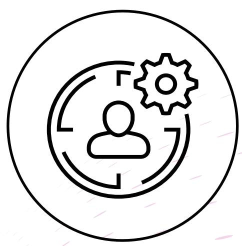
Visible: Utilities know what's happening across the electric continuum. Digital tech identifies and resolves issues earlier, reducing outages and optimizing operations.



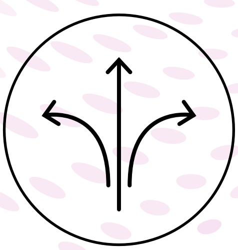
Optimized: Utilities use monitoring, control, and automation technologies to unlock the full potential of grid assets for greater reliability, efficiency, and security.



Whole-Systems: The grid operates as an integrated system of systems connected by an advanced communications network.



Customer-Centric: Utilities know how their customers generate and use energy and develop programs that align with their habits. Service is personalized.



Flexible: Utilities can adapt to a disruptive marketplace and integrate DERs beneficially.

Efficient: Utilities capture 20-30% profitability boost when they digitize their systems[3].

[3] U.S. Department of Energy. Quadrennial Energy Review. Transforming the Nation's Electricity System: The Second Installment of the QER. P.1-14, 2017.

Make Distribution the Digital Hub

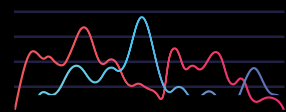
In their 2018 Strategic Directions: *Smart Cities and Utilities Report*, Black & Veatch found that 76% of surveyed utilities were busy developing grid modernization plans and strategies, with 66% zeroing in on the distribution system[4]. It's no secret that most utilities are planning digital upgrades, but why are they concentrating on the distribution system instead of the bulk power system (BPS)? The answer is this: because optimizing the distribution system delivers reliability and value across the grid.

Utilities have less control over the grid in a disruptive market because energy consumers can also be producers, DERs make energy supply and demand highly variable, and energy aggregators are creating competition. But utilities can regain control by centering grid modernization on the distribution system.

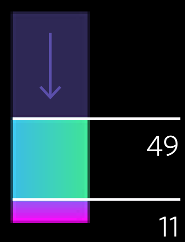
By focusing on the distribution system, utilities create the best opportunity to improve grid components and functions that render higher reliability, like forecasting analyses, remote monitoring, decision-making insight, voltage management, and capacity management. In turn, the entire grid is supported because these distribution functions are oriented to reliably interface with the BPS [5]. As the energy landscape continues to change, utilities will need advanced distribution circuits and substations to support two-way power and data flow, as well as digital technologies that support greater flexibility, control, and reliability. The takeaway: utilities need to make the distribution system the hub of digital upgrades. And they can do this by focusing on six essential elements.

5 Reasons to Upgrade the Distribution System

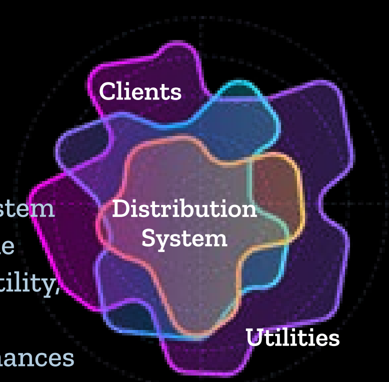
45%
of distribution infrastructure is near or at end of life[6]



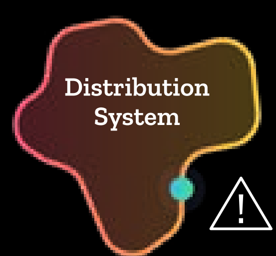
Digitizing distribution supports a rapidly changing energy portfolio and customers' need for on-demand service and control



11-49%
reduction in outage frequency (SAIFI) with distribution automation[7]



The distribution system directly connects the customer and the utility, and is a hotspot for technology that enhances customer experience



90% of electric power interruptions stem from disruption on the distribution system[8]

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[4] Black & Veatch. 2018 Strategic Directions Report: Smart Cities and Utilities Report. P. 27 & 28. 2018.

[5] U.S. Department of Energy. Quadrennial Energy Review. Transforming the Nation's Electricity System: The Second Installment of the QER. P.4-21, 2017.

[6] Harris Williams & Company. Transmission and Distribution Infrastructure. P.5, 2014.

[7] U.S. Department of Energy. Reliability Improvements from the Application of Distribution Automation Technologies – Initial Results. 2012.

[8] U.S. Department of Energy. Quadrennial Energy Review. Transforming the Nation's Electricity System: The Second Installment of the QER. P.4-2, 2017.

6 Essential Elements of a Digital Grid

How do utilities make the leap from a traditional system to a flexible, optimized system that is managed as a whole system for better visibility, reliability, and efficiency? The path toward digital electricity varies utility to utility, but Black & Veatch advises utilities large and small consider these six essential elements to take confident steps towards a successful digital transformation. Utilities will create a truly optimized grid if they look at these distinct initiatives and their supporting applications through integrated system planning and deployment. A holistic planning approach to digital electricity will get each of these elements humming in sync.

1. Communication Networks

2. Customer Expectations

3. Distributed Generation

4. Distribution Automation

5. Data Science

6. Operations

1. Communication Networks

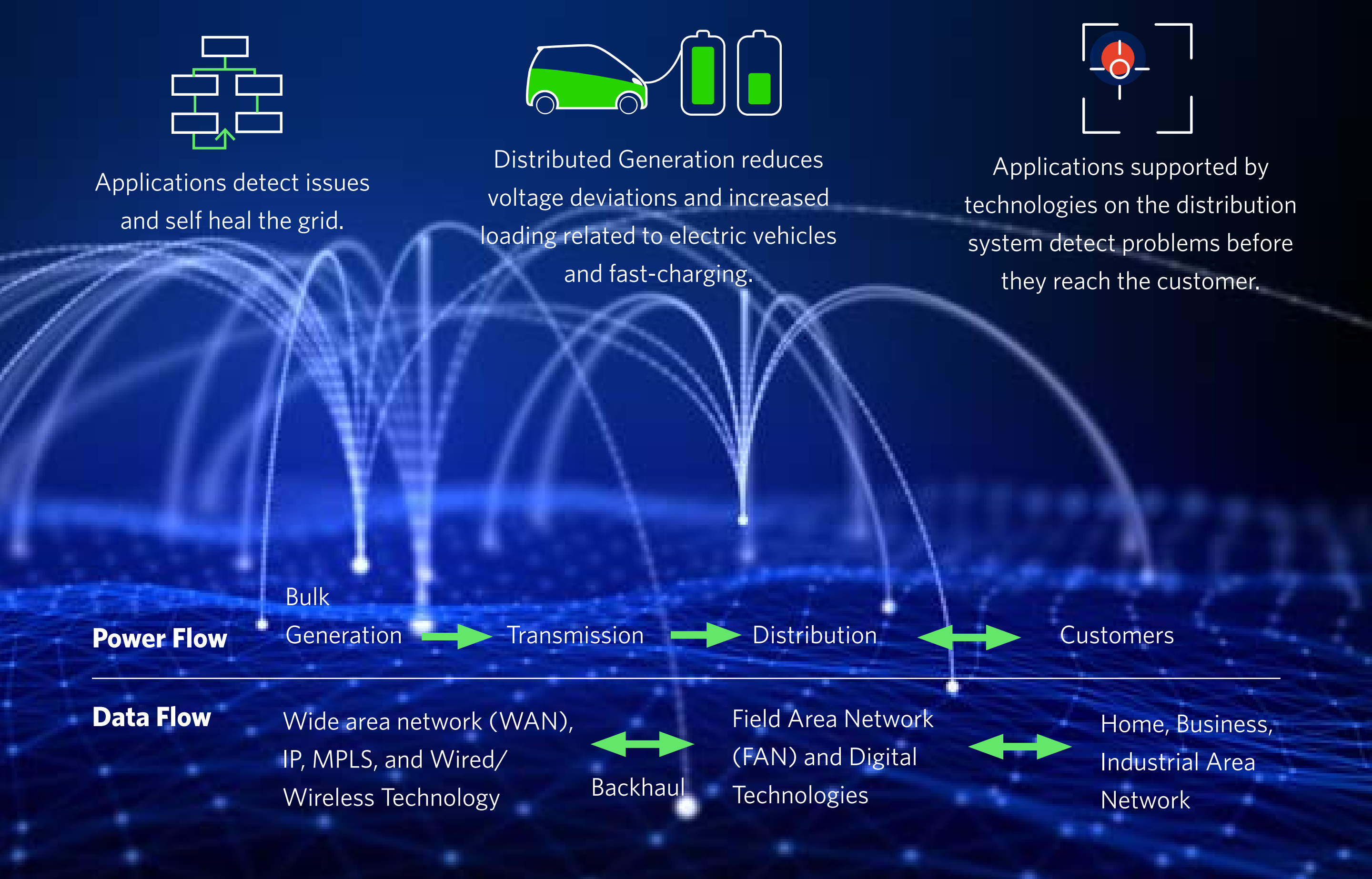
A digital utility is founded on communications that extend to the edge. Converged networks that use internet protocol (IP), multi-protocol label switching (MPLS), and an advanced field area network (FAN) are more efficient. This type of network architecture reduces network congestion, giving utilities speed, visibility, and control deeper into the distribution system where it's most needed. As Black & Veatch recently found in their 2018 report, most surveyed utilities think their communications system is inadequate, and are deploying private fiber in the next three years as their communications solution to support distribution automation.

When it comes to selecting digital technologies, utilities need to dig into the network requirements of each application, carefully assessing latency, bandwidth, coverage, and security requirements. This information helps pinpoint whether existing infrastructure can support long-term requirements or need network upgrades.

When designing the FAN, utilities need to check the availability of wireless spectrum and whether there is existing infrastructure that can be leveraged. Above all, the FAN needs to be flexible and scalable to evolve alongside the utility.

Digital Grid Communications

Advanced communications enable two-way power and data flows, moving grid operations into the 21st century.



2. Customer Expectations

Preserving the customer relationship is critical to any utility. To meet the changing needs of customers, utilities use programs like demand response (DR), customer information systems and smart meters. But customer expectations keep rising, so it's important utilities provide customers with sought-after services like personalized billing options and energy usage profiles. Of course, steady power supply tops the list of customer expectations.

3. Distributed Generation

Trying to keep up with the influx of DERs can be discouraging. But, utilities can change this by effectively integrating DERs into a digital platform, like Distributed Energy Resource Management Systems (DERMS), as part of the ADMS. This integration optimizes DER operation and balances the intermittent nature of renewable power and electric vehicle use. By enabling real-time visibility into DERs, this system provides heightened control and flexibility by forecasting DER capability and visualizing their impacts on the grid. With full integration, a DERMS facilitates use of a utility's DR programs and aggregated DER to manage the distribution grid. In addition, DER integration prompts utilities to find new ways to manage power quality on the grid. To this end, synchrophasor applications enable the utility to measure instantaneous voltage, current, and frequency at specific locations. This insight helps utilities avoid outages and achieve greater reliability on the distribution system.

As transportation heads towards mass electric vehicle adoption, electric utilities that prepare now have much to gain. For the full story, read Who's Driving Electric Vehicle Charging?

A Digital Grid Gives Customers What they Want...

Over 50% are interested in rooftop solar and programmable thermostats.

Nearly 75% are interested in energy storage.

Most customers support clean energy programs and over 70% are willing to pay for them at their utility.

The topmost benefits of a digital grid according to customers: energy efficiency savings, reduced GHG emissions, and reduced outages[9].

...and Utilities What they Need.

The top 4 challenges that utilities face are reliability, DER integrations, analytics, and efficiency—all vastly enhanced by a digital grid[10].

[9] Greentech Media. Survey: What Electricity Customers Really Want. June 2017.

[10] Black & Veatch 2018 Strategic Directions Report: Smart Cities and Utilities Report. P 47, 2018.

4. Distribution Automation

Digital technologies like sensors, automated line switches, reclosers, and regulators, plus advanced remote monitoring give utilities more control and faster response to power flow issues. Applications like FLISR can be used to automatically detect, locate, and isolate faults to improve restoration and overall reliability. Energy efficiency programs—like Volt/VAR optimization, CVR and IVVC—dynamically and autonomously optimize voltage and reactive power to help utilities reduce peak demands and improve power quality and stability. When distribution automation and analytic software are combined, smart capabilities expand further.

The Wow Factors of Distributed Automation Technologies and Systems[11]

Faster detection of faults and service restoration, lowering outage costs and meeting customer expectations.

Improved DER integration

Better resilience against extreme weather and faster repair of damaged equipment.

Better equipment monitoring and maintenance, reducing asset failures and enabling better use of assets.

More efficient use of repair crews and truck rolls, reducing operating costs.

[11] USDOE. Distribution Automation: Results from the SGIG Program. P, 4 & 5. 2016.

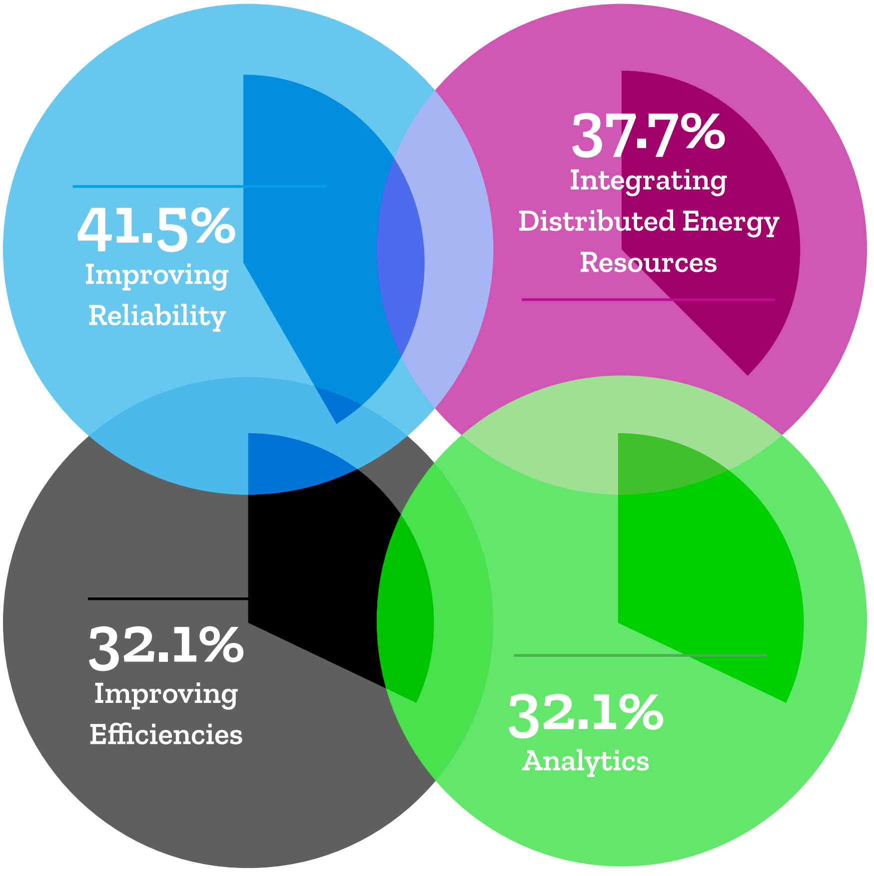
5. Data Science

Digital technologies produce a lot of data. Utilities with digital systems admit that managing the large amount of data generated has been challenging for data transmission, data processing, error checking, and integration[12]. To keep from being overwhelmed, utilities need to consider big data architecture alongside communications to organize data sources, ensure systems work together, and sync with an analytic process to get the biggest bang from their data. Utilities need to consider how to:

- Manage and govern data as a core component of automation and operational systems
- Prioritize data integration and include technologies in system designs
- Evaluate technologies, systems, and applications for standards compliance to make data sharing and analytics easier
- Use data lakes to clean, organize, and integrate data warehouses and historians across the enterprise.
- Use a project management tool to collect, organize, and manage grid endpoints during deployment. For example, Atonix Digital™ *Program Management, powered by ASSET360®*, a cloud-based data analytics platform, performs life-cycle optimization and data-driven decision-making.

Utilities are Daunted by Data Science and Analytics, Declaring It a Topmost Challenge.

What are the TOP THREE major challenges your team is facing with your current electric distribution system? (select top three choices[13].)



[12] U.S. Department of Energy. Distribution Automation. Results from the Smart Grid Program. P. 83, 2016.

[13] Black & Veatch. 2018 Strategic Directions Report: Smart Cities and Utilities Report. P. 48, 2018

6. Operations

Utility systems are becoming more distributed than ever and utilities must learn to operate among several stakeholders and systems, like transmission and distribution operators, third-party providers, energy aggregators, and customer systems. With a decentralized environment, utilities will benefit from managing DERs and other assets through the NOC, which is a centralized control hub. The NOC helps utilities monitor the grid and detect problems quickly to maintain high network performance.

A utility can integrate smart meters with Advanced Distribution Management Systems (ADMS) and link to critical subsystems such as Outage Management Systems (OMS) to quickly identify and restore outages. A standout function of the ADMS is its ability to integrate operations, which is critical to fully implement distributed automation.

ADMS collects and analyzes data from multiple systems and technologies—like OMS, SCADA, FLISR, GIS, EMS, CIS, MDMS, and analytics software—to continually model the distribution system in near-real-time. As a master hub, the ADMS alerts the utility when changes to load, outage, or maintenance occurs, increasing distribution efficiency and optimizing power flows. A utility can choose the level of ADMS sophistication —from data collection and monitoring to managing the operation of the entire distribution system—and add smart distribution technologies over time.

The Digital Grid is a layered network of communications, physical infrastructure, and smart applications. Here's a quick look at how the technologies and applications discussed in the eBook all come together.

CYBER SECURITY

DATA ANALYTICS | *Software that makes sense of digital data*

Project analytics
Meter analytics
DER analytics

- *Program Management, powered by ASSET360®*
- Intelligent project management
- Distributed asset management
- Performance analysis
- Informed Planning
- Risk assessment

APPLICATIONS | *Systems that put the "smart" in "smart grid"*

Network Operations Center – Utility Operations

- ADMS
- SCADA
- GIS
- OMS
- DERMS
- MDMS
- EMS
- CIS
- Demand Response (DR)

COMMUNICATIONS AND CONTROL | *Integrated systems start here*

Communications

- Private/Public LTE
- Microwave backhaul
- Fiber backhaul
- Fiber core
- IP/MPLS to the edge

Control

- Sensors
- CVR
- IVVC
- FLISR
- Syncrophasers

DISTRIBUTION | *The Edge — What to connect*

Wind
Solar
Storage
Microgrids

Distribution Poles & Wires

Electric Vehicles

Smart Meters

Volt/VAR: Volt/Volt Ampere Reactive
CVR: Conservative Voltage Reduction
IVVC: Integrated Volt/Var Control
FAN: Field Area Network
IP: Internet-Protocol
NOC: Network Operations Center

SCADA: Supervisory Control and Data Acquisition
FLISR: Fault Location Isolation Service Restoration
OMS:Outage Management System
MPLS: Multi-Protocol Label Switching
WAN: Wide Area Network
VPP: Virtual Power Plant
DR: Demand Response

DER: Distributed Energy Resources
GIS: Geographic Information System
ADMS: Advanced Distribution Management System
MDMS: Meter Data Management System
EMS: Energy Management System
CIS: Customer Information System

Make Digital Electricity Mean Something to You

Wide-spread connectivity, customer demands, and a competitive energy market are among the forces pushing transformational grid change. This shift creates exciting new avenues for utilities and customers to work together to advance smart energy and diversify the range of assets that can provide energy and grid services. Utilities that provide digital electricity are achieving dramatic improvements in individual system performance. They are managing and coordinating actions across very distributed and complex energy environments with strong results.

For utilities, digital electricity means security in a rapidly changing energy environment and reliable, optimized operations. For citizens, it means greater value through energy efficiency and clean energy programs. For technology integrators like Black & Veatch, we see digital electricity as an opportunity to reinvent energy systems that continuously evolve with the utility.

Regardless of the viewpoint, we all benefit from digital electricity. And that means optimized energy supply and demand, and cleaner, more efficient, economically sound energy options for everyone.

Information ahead of innovation.

Digital infrastructure deployment is accelerating. Our eBook series fast-tracks industry transformation. Read on.

Learn more at bv.com

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