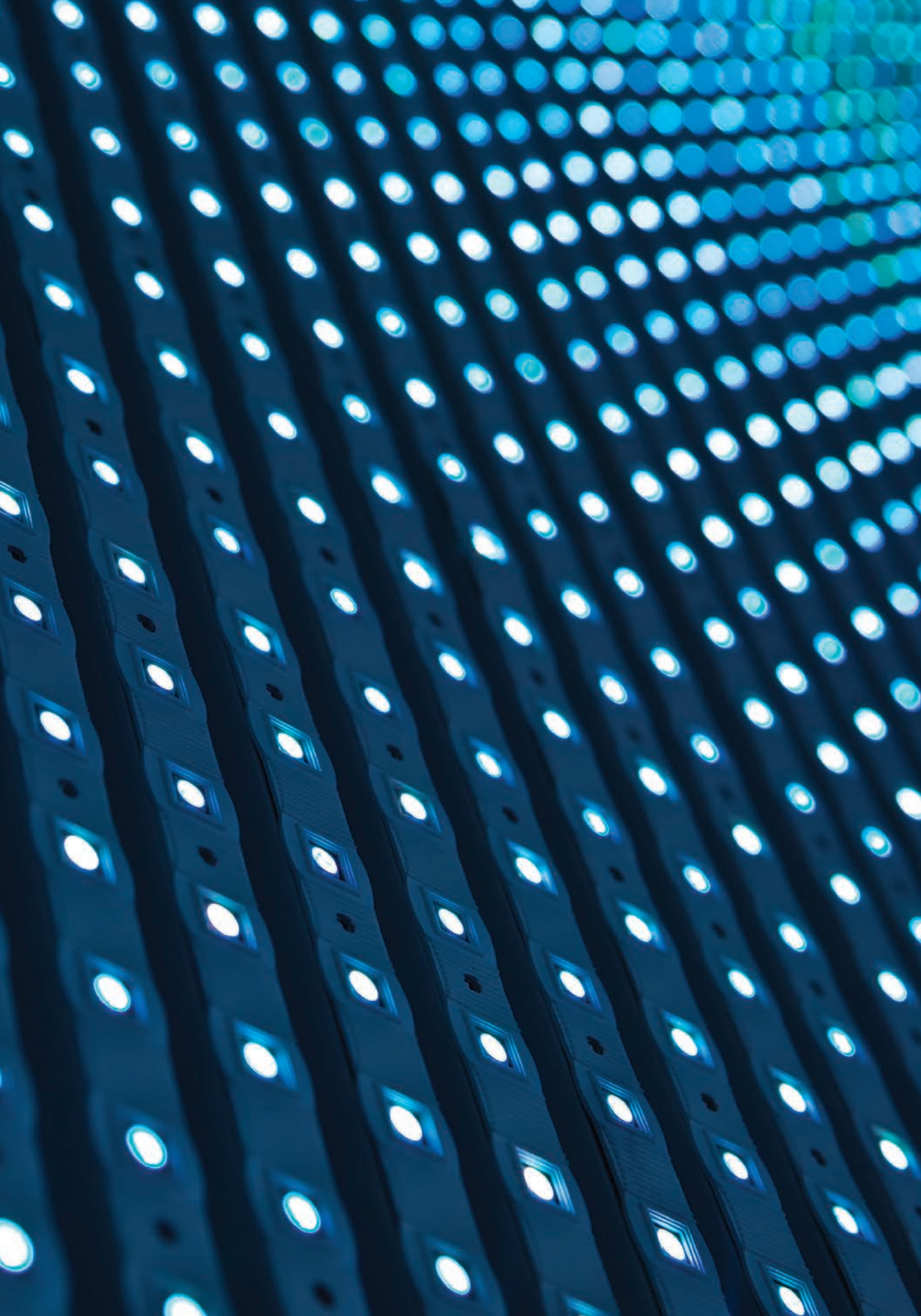
THOUGHT LEADERS SPEAK OUT:

Key Trends Driving Change in the Electric Power Industry

VOLUME III

The Edison Foundation
INSTITUTE for ELECTRIC INNOVATION



THOUGHT LEADERS SPEAK OUT:

Key Trends Driving Change in the Electric Power Industry

VOLUME III

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"Much of what was wishful thinking just a few years ago is being realized today."

–LISA WOOD

Introduction

LISA WOOD
Vice President, The Edison Foundation and
Executive Director, Institute for Electric Innovation

All of us in the electric power industry are well aware of the profound transformation that's underway. New technologies, public policies, and changing customer expectations are playing a role in this transformation, but technology continues to be the key driver. That's because technology changes what we can do, how we can do it, and what it costs to do it. In fact, as a result of the industry's investment in the digitization of the energy grid and the number of devices and technologies connected to the grid today, we are collecting far more data than ever—and we are using that data to manage the energy grid in real time; to create operating flexibility on the grid; and to provide new services to customers. Much of what was wishful thinking just a few years ago is being realized today.

In this third and final volume of essays, *Key Trends Driving Change in the Electric Power Industry*, we examine three issues that loom large at the end of 2016:

- Rate and Regulatory Reform;
- Data Analytics; and
- Grid Modernization.

The essays in the first chapter address our industry's greatest challenge—rate and regulatory reform—and focus on the challenges of moving from today's often inflexible regulatory process to a more flexible future. As is well known, technology, coupled with the right policies and regulatory support, can provide the essential ingredients for moving this transformation forward. In fact, regulators today have an unprecedented opportunity in defining the ways forward as we continue to build smarter energy infrastructure.

The second chapter essays focus on what's actually happening today with the application of data analytics and what it means for operational efficiencies and for customers. One author highlights how electric companies already are realizing value from data analytics but need to stay flexible in order to take advantage of opportunities to create additional value. In addition to highlighting the early gains, the essays describe what's next for energy grid management, for distributed energy resources, and for improved customer solutions and communications.

The essays in the final chapter focus on grid modernization. Driven by changing customer needs, environmental goals, the growth in distributed energy resources (DERs), and new technologies, electric companies in the past year have made tremendous progress in moving forward to build smarter energy infrastructure. The essays highlight how customers experience the benefits of a plug-and-play energy grid and what it means for the environment and for electric companies.

* * * * *

As this industry transition unfolds, it is a balancing act—the need to balance safe, reliable, affordable, and clean energy for the customers we serve 24/7. Ultimately, the balancing falls on the shoulders of regulators and other policy makers. As this volume makes clear, we have made great progress in deploying smart energy infrastructure and modernizing the energy grid. We also have put data analytics to work, moved beyond the hype, and are realizing true value. But, we have yet to make the necessary progress in rate and regulatory reform. That remains our biggest challenge today!

The authors of the essays that follow provide their unique views on these three key areas. As with earlier volumes, these essays are an important addition to the continuing conversation about the transformation of the electric power industry.

Regulatory Reform: Challenges

Data Analytics: Early Gains

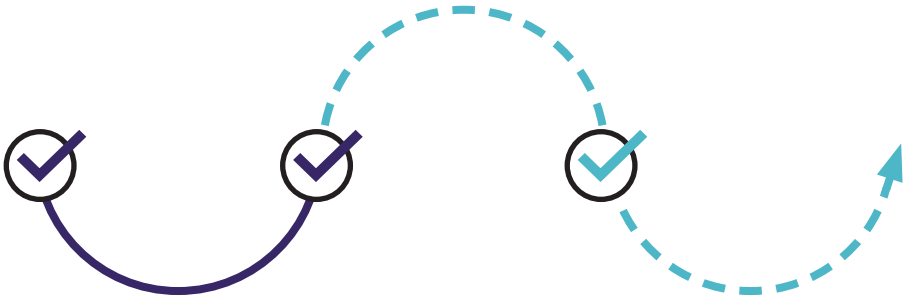
Grid Modernization: Drivers

At A Glance: Rate & Regulatory Reform

CHALLENGES

1. Rapid Technology Change
2. Changing Customer Expectations
3. Slow & Inflexible Process
4. One Size Does Not Fit All

WAYS FORWARD



1. Informal Collaboration
2. Performance-Based Ratemaking
3. Flexible Rate Structures
4. Transparent Pricing for Grid & Energy

CHAPTER 1

RATE & REGULATORY REFORM

The U.S. electric power industry is undergoing a profound transformation. But, given the rapid pace of technological change, and evolving customer needs and expectations, many stakeholders—on all sides—agree that today's regulatory process is too slow and inflexible to respond to the changes that are needed. The litigious, glacial pace of contested regulatory rate reviews is a barrier to technology and business innovation and, ultimately, harms customers. Several jurisdictions are tackling the problem and finding that informal collaboration can often show the way.

As a result of significant new technology and infrastructure investments, electric companies today have the ability to provide services well beyond commodity electricity—services that customers are demanding. And, distributed energy resources (DERs) are growing and presenting new challenges to the energy grid. Regulation is not keeping pace with the need to address these changes.

What can be done to meet customer needs, to allow for new entrants and new technology, and to continue to provide "plain vanilla" electricity to those who want it—safely, reliably, and affordably? Actually, quite a bit.

Regulators have several possible tools available today. They can implement time-varying rates; ensure that all customers who use the energy grid continue to share equitably in the costs of the grid; develop formula- or performance-based rate structures; or allow incumbents, as well as new entrants, to compete in providing some of the desired services. Although all of these tools are in use today to varying degrees in different regions, there is no general agreement on next steps forward.

Electric companies provide the essential infrastructure—the energy grid and grid services. A key next step would be recognition of these services and willingness to be transparent with customers about the energy and grid services they receive.

Any rate and regulatory reform must balance the need for safe, affordable, reliable, and increasingly clean energy with the ability to provide customized services to those customers who want them—and basic commodity service to those who do not. While we do not expect a one-size-fits-all regulatory solution, there is an urgent need for regulation to change now.

"Fundamentally, the goal in all states should be long-term alignment of customer expectations, public policy goals, and regulatory processes."

–BOB ROWE

Breaking the Logjam: Collaborative Processes Sometimes Can Help

BOB ROWE
President and CEO, NorthWestern Energy

The essential infrastructure and service that electric companies provide is safer, more reliable, more affordable, cleaner, and more ubiquitous than ever before. Regulation has guided the industry along an exciting and innovation-filled journey for a century, with significant course adjustments, detours, and even a few dead ends along the way. Now, with more aggressive environmental and other policy goals, new technologies on both sides of the meter, diverse market structures, and—especially—increasing and increasingly complex customer expectations, the regulatory model is proving too slow and too inflexible to meet all needs. Another evolutionary cycle is underway. While adjudicatory decisions remain an important tool, the costs and delays inherent in long and complex contested cases seem to many an ineffective means for reaching every decision. It's been said by some that "Utility 2.0 needs Regulation 2.0."

New York and California have launched important initiatives that seek to optimize cost, system efficiency, and environmental goals. We hope to learn from their experience. But, those states have large regulatory staffs (nearly 470 people in New York and 950 in California); complex economies and ambitious policy agendas; and electricity prices that are substantially above national averages.[1] Some of their solutions might not work well in other jurisdictions.

Between the coasts (and in Hawaii too), there's much innovation taking place. Here are some goals that various states are seeking to achieve:

- Increase system reliability and resiliency;
- Replace aging infrastructure;
- Modernize the energy grid to accommodate changing uses;
- Enhance cyber and physical security;

- Achieve environmental goals, including reducing greenhouse gas emissions;
- Ensure public safety, resource adequacy, and diversity;
- Promote long-term price stability while achieving the other objectives.

One infrastructure-focused initiative that appears to be succeeding is the Illinois Energy Infrastructure Modernization Act, passed in 2011 and extended until 2019. The legislation, implemented by the Illinois Commerce Commission (staff approximately 200), includes an annual formula rate-setting process, four performance-related standards, and one diversity-related standard. Litigation costs and hearing lengths have decreased, and critical grid investment by Ameren and ComEd has increased.[2] According to Commissioner Ann McCabe, "The use of formula rates in Illinois has spurred improvements in the grid and implementation of advanced meters."[3]

South Dakota has adopted a set of coordinated mechanisms to promote cost-effective investments in critical infrastructure, including environmental and transmission investments. A centerpiece is the Phase-In Rate Plan for Plant Additions. Based on initial success, the mechanism was expanded over the years from generation additions to include transmission and distribution assets as well. PUC Chairman Chris Nelson observes that, "The South Dakota PUC supports statutory mechanisms, which provide an efficient pathway for utility capital investments to be effectively reviewed by the Commission without having to resort to a full blown rate case. These mechanisms save time and money for the PUC, the utility, and for utility consumers."[4]

In Minnesota, the Great Plains Institute and the Center for Energy & Environment convened a multi-year stakeholder process called the e21 Initiative, with active participation by electric companies, public agencies, nonprofits, customers, and other key stakeholders. The project aims to address the increasingly complex policy goals of utility regulation; to integrate supply-side and demand-side resources better into planning; to make the regulatory process more collaborative in advance of formal filings; and to demonstrate "how a new customer-centric, performance-based regulatory approach and utility business model can enable both economically viable utilities and achievement of public policy goals."[5] Recommendations from the process soon will be presented to the Minnesota Public Utilities Commission (staff approximately 42).

According to Rolf Nordstrom, President and CEO of the Great Plains Institute, "e21's real strength is that it created a space for utilities, regulators, and other key interests to prepare for the future electric system in advance of

any particular crisis or controversy. As a result, Minnesota now has a good blueprint to evolve the regulatory framework and utility business model to keep pace with changing consumer expectations, more ambitious policy goals, and a fast-changing technology landscape."[6]

While serving as NARUC President, Montana Commissioner Travis Kavulla led the effort to write the NARUC Manual on Distributed Energy Resources Compensation.[7] The project and the process suggest ways for states and stakeholders to address other subjects. According to Commissioner Kavulla, "One of the primary benefits of the diversity of regulation is that these proverbial 'laboratories of democracy' will, through their experimentation, eventually surface winning approaches to novel problems. NARUC's tradition of writing manuals is really a practical exercise in sharing that state experience with commission staffs."[8]

Our customers and the communities we serve expect much more of us today. Our responsibilities include *infrastructure*, *service*, and *solutions*: Building, maintaining, and operating critical energy infrastructure; providing energy services for customers, including efficiency; and, working with our customers and communities to provide solutions that best meet their needs. This rich set of responsibilities is not always well-served by a system that looks primarily backward and mostly rewards spinning meters.

Fundamentally, the goal in all states should be long-term alignment of customer expectations, public policy goals, and regulatory processes. States across the country, working with electric companies, customers, and others, are mapping journeys to destinations of their own choosing, maintaining flexibility in the paths they take.

Alfred Kahn famously observed that, "All regulation is incentive regulation." It's better—more productive, more effective, and a lot more fun—to work through difficult subjects in collaborative processes like the one in Minnesota than to continue trying to make an expensive, complex, and inefficient regulatory process fit the needs of a changing world that presents new challenges.

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1. Estimates are from the National Association of Regulatory Utility Commissioners at http://www.naruc.org/about-naruc/regulatory-commissions.
2. Hon. Ann McCabe, with Orijit Ghoshal and Bill Peters, "A Formula for Grid Modernization?", Public Utilities Fortnightly, May 2016. https://www.fortnightly.com/fortnightly/2016/05/formula-grid-modernization.
3. Interview, October 17, 2016.
4. Interview, October 18, 2016.
5. The report is available at http://www.betterenergy.org/projects/e21-initiative.
6. Interview, October 19, 2016.
7. Available at http://www.naruc.org/about-naruc/press-releases/pr-111016.
8. Interview, October 16, 2016. (The Montana Public Service Commission has a staff of approximately 39.)

"The fact of the technology revolution in energy is a given; however, its impact on customers is subject to the shape and direction of policy design. Policy can speed or slow change."

–ANNE PRAMAGGIORE & VAL JENSEN

Policy: The Wildcard in Today's Energy Revolution

ANNE PRAMAGGIORE
President and CEO, Commonwealth Edison

VAL JENSEN
Senior Vice President, Customer Operations, Commonwealth Edison

Each day, across every commercial sector—communications, utilities, transportation, industrial production, eCommerce, and more—we are all seeing that a technology revolution is underway and is accelerating at lightning speed.

Technology is getting faster, better, cheaper, smarter, and smaller. It's also becoming ever more interconnected and throwing off more and more data that further fuels the technology innovation cycle and increases individual control, convenience, and, importantly, choice.

For the electric power industry as well, there is no doubt that a technology revolution is underway. As a result, the customer value is poised to expand through a power system featuring technology advancements—including widespread digitization and clean resource technology, cultivating an explosion in energy choices.

The fact of the technology revolution in energy is a given; however, its impact on customers is subject to the shape and direction of policy design. Policy can speed or slow change—and determine whether advancements are piecemeal and uncoordinated, or planned and collaboratively designed to maximize benefits across the board. Cell phone technology was available in the late 1970s, but didn't become commercially available until spectrum policy was redesigned in the late 1980s. Similarly, in our energy revolution, smart energy infrastructure must be matched by smart policy. Technology leads, but policy rules.

In the case of ComEd and Illinois, progress is underway. Smart regulations and policies have been integral to cascading forward motion, already helping to dramatically modernize the energy grid. In 2011, the Illinois General Assembly passed the Smart Grid Act, a $2.6 billion investment program for both refurbishing traditional infrastructure and adding digital technology such as smart meters, distribution automation, and intelligent substations.

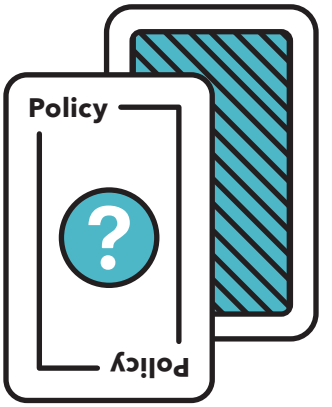
ComEd is now four years into the grid modernization plan. In that time, ComEd has replaced 3,600 miles of cable, installed 2,500 smart switches, rebuilt 26,000 manholes, built eight intelligent substations, and, in one of our most impactful programs, we have installed more than 2.9 million smart meters.

This work has allowed ComEd to lay the foundation for the 21st century network, improve reliability, and deliver the means to more affordable power. Customers are experiencing fewer and shorter outages—43 percent fewer and 49 percent shorter—with the best grid reliability in our company's history. The work has resulted in 5.9 million avoided outages and has produced $1.1 billion in societal savings, while supporting 4,600 new jobs. Modernizing the energy grid is the first layer of transformation. Smart policy is also in the driver's seat to set the pace for the next wave of progress.

The real significance of these numbers is that they represent a promise kept to policy makers on behalf of our customers, which is the currency of a productive and maturing policy dialogue.

Just as Illinois' 2011 policy decisions shaped the grid work currently underway, the next set of policy and regulatory decisions will have that same type of catalytic effect in the realm of clean energy.

Policy Is the Wildcard



Key provisions of the Future Energy Jobs bill, passed by the Illinois General Assembly on December 1, 2016, show how smart policy can have a dramatic effect on alternative power sources, support reduced usage, and enhance choice. The legislation reflects a pivot by the state to a policy supporting clean resources and an enhancement of its decades-long focus on customer choice. The bill expands Illinois'

Renewable Portfolio Standard by providing new funding for solar development; creates a specific fund for low-income community solar; offers new solar rebates for customers; and nearly doubles energy efficiency. Rate design provisions also lend security to the financial foundation of the electric companies. Like telecom, solar and clean technologies have been in place for some time, but it is the new Illinois policy that will set the clean energy sector in motion for the state.

* * * * *

This ability to set the pace for change—and to ensure the benefits of the changing world are shared widely and the costs borne fairly—is why regulation and policy decisions are the engines in our new energy future. Solar technology would continue to advance without smart policy decisions—and so, too, would the interconnectedness of digital energy technologies and the evolution of customer preferences and our own business model. But none of these changes would happen as fast. They would not be coordinated. And the chance of the sum becoming greater than its parts would be diminished greatly. The foundational tenet of electricity policy is to ensure the greatest benefits for the broadest range of customers. This is what smart policy is built upon.

When technology and policy work in lockstep, an innovation cycle results where each reinforces the other, fueling further innovation and social benefit. The result is a power system that is designed to do what power systems do: fuel the economy and provide the foundation of safety and security for all customers at the most affordable price.

"With the right policies and technologies, we can provide our customers the new energy services they want at a price they can afford."

–FRANK PRAGER & DOUG BENEVENTO

We Can Do It Better With the Right Policy and Technology

FRANK PRAGER
Vice President, Policy and Federal Affairs, Xcel Energy

DOUG BENEVENTO
Director, Energy Policy, Xcel Energy

The father of our industry, Thomas Edison, once said, "There's a way to do it better–find it!" At Xcel Energy, we are always looking for ways to "do it better."

Doing it better means meeting our customers' changing energy needs and competing in the new energy marketplace. Xcel Energy is focused on three initiatives that will create more flexible regulatory policies and allow us to provide customers with new energy products at the right price.

First. We are working on new ways to price our energy services.

Energy pricing is the key to effective regulatory policy, and we are pursuing energy pricing policies that reflect the value of the service provided. Unfortunately, like other energy companies, our regulatory structure was designed many decades ago, before the dramatic changes we see in the electric power industry today.

We need 21st century pricing models that provide customers better and more efficient access to the new energy marketplace. Today, many pricing structures are antiquated and no longer match cost with causation. At Xcel Energy, we're working with policymakers and stakeholders to design new and better pricing models.

We have proposed or are implementing multi-year rate plans in Minnesota and Colorado. These plans establish operational budgets for our system and set broad goals that incentivize system efficiency and cost reduction.

In Colorado, we recently reached an agreement with stakeholders that establishes a more transparent pricing

system, which will help to pay for a smarter and more efficient energy infrastructure. This pilot program will benefit customers who are installing private or rooftop solar or are charging electric vehicles, while protecting other customers from hidden subsidies.

Second. We are working to compete in the new energy marketplace.

We are committed to expanding the use of distributed generation and renewable energy in the most economical way for customers. For the past 12 years, our company has been the nation's top electric utility wind provider, and we offer customers in select states options for accessing solar and other distributed energy options. We are dedicated to working with policymakers and stakeholders to ensure that we can continue to respond to customer demand for new clean energy products.

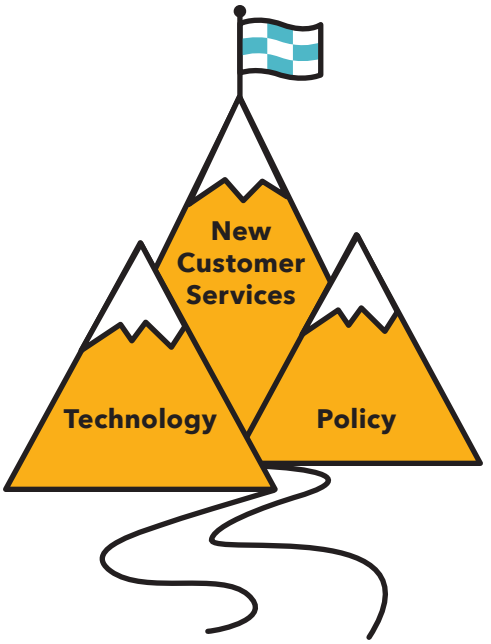
For example, we are seeking approval of our proposed Renewable*Connect℠ programs that will offer customers easier, more affordable access to clean energy through universal, large-scale renewables. Universal wind and solar projects are, by far, the most cost-effective renewable energy options; a study of our Colorado system showed that the cost of universal solar is less than half that of private solar.

The marketplace is changing because customers expect more choices from their electric company. Xcel Energy is eager to deliver those choices, but we must have a regulatory process that encourages our ability to respond to customer demand quickly. A more nimble regulatory process would help us to meet our customers' growing desire for more control and more energy options.

More and more, customers also are asking that electric companies provide a broad array of energy consulting and management services. Customers are seeking the support and expertise that an electric company can provide. Does a customer want renewables? We can tell if his or her home or business is well-suited for private solar (even if provided by a third party) and can provide the customer with other options, such as our Renewable*Connect product. We also can work with customers to maximize the value of their private solar by integrating it better with system resources, such as the advanced grid or battery storage. Because our customers know we're anchored in their communities, they want our advice on how to improve their energy usage.

We know competition is part of the future, even in traditionally regulated states, and we welcome it. But we should also be allowed to compete. Our customers win when we are in the market.

Third. We are exploring emerging technologies today so that we can use them for the benefit of our customers tomorrow.



Together with public policy, technology is the key driver transforming our industry. We are working hard to understand new technologies and are applying them in the real world. For example, Xcel Energy is a founding member of SolarTAC, an integrated, world-class solar research facility. We also are working on pilot programs to test the value of battery storage, both behind the meter and on our system.

In Colorado, our innovative technology project with Panasonic and Denver International Airport–two of our larger customers–will test battery storage, solar, and microgrid technologies in real-world conditions. The project could serve as the model for future efforts that integrate these technologies into an advanced electric distribution system for other interested customers.

Edison was right: We can do it better. With the right policies and technologies, we can provide our customers the new energy services they want at a price they can afford.

"Regulation must change with the times and reflect advances in technologies and public policy goals. State regulators hold the key to this."

–TOM WERNER

The Regulators' Opportunity

TOM WERNER
President and CEO, SunPower Corporation

What if I told you that one of the final challenges standing in the way of our clean energy future isn't the marketplace or the technology, but the decisions of regulatory agencies tasked with overseeing it?

As the world increasingly shifts to solar, wind, and other low-carbon energy sources, utility regulators now face the challenge of overseeing a transition that's already well underway. That transition—from a largely unidirectional central station dispatch system to one that includes growing numbers of distributed energy resources (DERs), includes meeting consumers' growing desire to control their own energy supply and use in their homes and businesses.

Regulatory decisions that support the adoption and deployment of new DER technologies—including distributed rooftop and community solar, electric vehicles, battery storage, and other options that empower consumers—are crucial to this transition. With a well-designed regulatory framework, these technologies offer a winning proposition for everyone involved.

Consider the following: For nearly a half-century, regulated electric utilities operated in a largely stable environment under government-granted, exclusive franchises. Utilities owned all the assets that were part of the grid, from power plants to electric meters. And, they earned a "regulated rate of return" for the money they spent on grid infrastructure. That model changed dramatically in 1978 with the passage of the Public Utility Regulatory Policies Act. PURPA encouraged private, non-utility investment in more efficient and environmentally-friendly generation, including solar, wind, and co-generation projects. Later, utilities lost partial control over the transmission system in some areas of the country when operations were granted to regional transmission organizations (RTOs). However, utilities retained

their exclusive authority to operate and maintain the distribution system, and to deliver retail electricity to their customers.

In time, many electric companies embraced these changes. In fact, today, electric utilities and their non-utility affiliates are the largest investors in both large-scale wind and solar energy in the U.S. Now, however, utilities face a different kind of competition, from consumer adoption of technology and DERs that reduce their need for energy from the grid.

THE TRANSFORMING ENERGY LANDSCAPE

In today's world, consumers can increasingly meet part or all their own electricity needs through alternatives like efficient appliances and solar power that appeal to them for economic, environmental, and/or self-sufficiency reasons. These alternatives have been widely embraced in places like Hawaii and California—where sunlight is abundant and electricity is more expensive than the national average. And, as costs come down, we are seeing increased adoption in more states.

Regulators and grid operators are adjusting to these changes by adopting new rules and rates to accommodate these technologies, but issues exist. Some regulators see their role as supporting consumer deployment of new efficient and renewable technologies. Others are concerned with the disruptive effect of these changes on electric utilities and the energy grid—on which virtually all consumers depend.

An area of particular concern to the solar industry is that regulators may adopt rate designs, interconnection requirements, and other regulatory measures that discourage either legitimate competition or customer adoption of solar and related technologies. For instance, many regulators have been considering new rate designs that increase fixed monthly charges and decrease volumetric charges (per kWh of electricity consumed). Since a consumer's economic incentive to invest in energy-efficient appliances, LED bulbs, or solar power systems is measured against the kWh price of electric energy from the utility, such a shift can radically reduce the motivation of some consumers to choose a clean energy alternative.

Rate design issues are being hotly debated today. Given the importance of solar in our clean energy future, we believe collaborative processes offer a way forward.

Win-Win Solutions

RISING TO THE CHALLENGE

Those of us in the solar industry recognize concerns about fairly allocating the electric utility's cost of serving its customers and the need to be paid for services that maintain the safety, reliability, and affordability of the grid for everyone. We recognize the difficult task regulators face in finding solutions that support the extraordinarily important role electric utilities play while also enabling consumers to embrace new technologies to manage their energy needs.

To move to a clean energy future, we need to support options for consumers. State regulators hold the key to this through their ability to design, adopt, and implement solutions that recognize consumer interests, while also accommodating the needs of utilities and other stakeholders. Regulation must change with the times and reflect advances in technologies and public policy goals, just as regulation changed following enactment of PURPA and FERC-led initiatives toward open access transmission and non-discriminatory transmission services.

I am confident that, as they have done before, state regulators will rise to the challenge of appropriately balancing these multiple goals to ensure that electric utilities, solar providers, other new entrants—and, above all, consumers—are well served as we transition to a 21st century energy grid.

At A Glance: Data Analytics

EARLY GAINS

1. Enhanced Visibility Into Energy Grid
2. Predictive Energy Grid Maintenance
3. Rapid Outage Detection & Restoration
4. New Customer Services

WHAT'S NEXT

1. Next-Generation Energy Grid Management
2. DERs as Energy Grid Resources
3. Tailored Customer Services
4. Smart Cities

CHAPTER 2

DATA ANALYTICS

The U.S. energy grid is in the midst of a digital transformation, and data analytics are enabling new technical capabilities and new customer products and services. Electric companies are progressing from gathering, and possibly drowning in, data to developing actionable intelligence. A key component of this is prioritizing flexibility—by using standards-based tools and grid edge analytics—in their data analytics strategy. Data produced by smart meters, distributed energy resources (DERs), and other grid-connected devices are being used primarily in two areas today: to improve customer services and to manage a more complex distribution grid.

Data analytics at the edge of the grid, including inside the home, is an exciting new space. Moving beyond the artificial boundary of the customer meter is an essential step for electric companies to take given increasing customer expectations and interest in effective DER solutions. Using data from a multitude of sources to develop a deeper understanding of individual customers, to predict with accuracy who wants what, and to offer the right products and services seamlessly to each customer is just getting underway.

The fundamentals of distribution grid management and the importance of keeping the lights on 24/7 are indisputable; but now, the manner in which electric companies achieve this is enhanced by smart grid technologies and predictive data analytics. Across the nation, electric companies are incorporating a robust set of digital tools, technologies, skills, and processes to address adverse system conditions and to develop deep situational awareness. Advanced data analytics will continue to unlock numerous opportunities; early gains such as enhanced visibility into the distribution grid, expedited outage restoration or outage avoidance, and predictive maintenance are just the tip of the iceberg.

The authors of the essays in this chapter see data analytics driving the smart home, enhancing customer services, and forging a pathway to distribution grid optimization in an increasingly dynamic operating environment. Data analytics has moved beyond hype to producing results that add value.

"New data-generating technologies represent an opportunity to create value if analytics are pursued without placing unreasonable boundaries on how data will be used."

–RAIFORD SMITH

(I Can't Get No) Satisfaction—Analytics Done Without Flexibility Isn't Fun

RAIFORD SMITH
Vice President, Energy Technology and Analytics, Entergy

Around 980 A.D., Nordic explorers established a new colony on an island they named "Greenland." Unfortunately, the settlers soon discovered Greenland was covered in snow and not very green. Realizing success might be more difficult than originally envisioned, the Vikings abandoned Greenland, and a few hearty Danes instead conquered a much warmer island—Britain. While that course correction gave us the English words "blunder" and "ransack," it also provides an important lesson for electric companies considering big data analytics: remain flexible so you can pivot to the next opportunity.

For example, advanced metering infrastructure (AMI) originally was envisioned as a better billing platform. Over time, people realized smart meter data also could be used to manage power quality, detect and manage outages, and roll out new products and services. Unfortunately, enabling these new benefits proved costly if the original installation was designed only to bill customers. So, how might electric companies pivot to enable big data analytics and maximize future opportunities?

Simply put, electric companies need to pursue *flexibility* as the foundation of their analytics strategy. New data-generating technologies, from renewables to smart thermostats and other addressable devices, represent an incredible opportunity to create value if analytics are pursued without placing unreasonable boundaries on how data will be used. Data are not limited physically, so our imagination is the only ceiling to turning data into value. Thus, savvy electric companies focused on maximizing analytical value won't begin their data journey by limiting what they

might do in the future. Instead, they will use standards-based tools to store and manipulate data in a cloud so developers can pursue future opportunities. Implementing a flexible governance framework to allow partnerships to flourish also can aid this goal.

FLEXIBILITY FROM THE CLOUD

The first step to creating flexibility is to avoid the "curse of the use case"—e.g., implementing a company-specific, highly customized solution with rigid computing and data storage requirements. Cloud computing allows developers to set up a sandbox quickly, add data, and create something new without jumping through administrative hoops, engaging IT to set up a new system, or crashing a production server.

If the cloud includes a standards-based unstructured data store, developers can mix and match any type of data specific to each new use case. Similarly, developers can use standards-based tools like Java, R, and Gobblin to gain innovation and human capital advantages that company-specific tools can't deliver. Standards-based storage, computing, and tools in a cloud give electric companies access to the greatest innovations, the potential to hire from the biggest talent pools, and the ability to avoid being locked into brittle, one-trick-pony tools. After all, it is easier to find human capital familiar with Java or Apache Hadoop than it is to find someone who is trained on a company-specific widget. Similarly, developers continually are improving capabilities of these standards-based tools far faster than any company-specific application.

Prioritize Flexibility

FLEXIBILITY FROM THE NETWORK'S EDGE

Standards-based tools alone aren't enough if one doesn't also enable analytics to be placed anywhere on the network. Not all analytics deployed into production environments have the luxury of operating at a data center or in the cloud. The need for very fast decisions (e.g., microgrid management) and to avoid single-points-of-failure (e.g., any centralized decision-making system) inevitably means analytics need to be deployed in dispersed locations. Thus, technologies such as OpenFMB and IEC-61850 are necessary to enable data to be collected at the edge of the network rather than deep within a data center or cloud. This

allows decision-making to speed up because data are contextualized immediately and translated into a common semantic and protocol as they're generated. In fact, by adopting technologies that federate data at the network's edge, an electric company gains flexibility, analytical speed, and cyber security benefits together without having to re-architect their systems with each new use case.

FLEXIBILITY FROM GOOD GOVERNANCE

Good governance is the last, missing piece to achieving flexibility. Roger Milliken, a successful businessman and innovator, once said, "Operational excellence secures the present while innovation excellence secures the future." As leaders, we tend to focus on keeping the train running. However, well-intended governance choices based on tactical, myopic needs can restrict future growth if not aligned properly with the need for flexibility. Similarly, lack of governance means data will be insecure or of low quality. Even with ideal tools and data federation, bad governance can make an electric company's analytics journey a very short, unproductive trip. Good governance models need to ensure clear roles and responsibilities, a common data dictionary, and flexible oversight to share data securely while masking Personally Identifiable Information (PII) and enforcing user privileges. Done right, an electric company's data governance structure can enable future partnerships that provide immeasurable value to the company and its customers. Done wrong, the analytics team will spend months wondering when they can access their own data.

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Like the Rolling Stones' song, "Satisfaction," electric companies' initial foray into analytics may not have gotten them what they wanted, but, by emphasizing flexibility, electric companies can adjust their programs to get what they need. Good governance allows for high-quality data and secure partnerships to create value. Data federation at the network's edge enables analytics to go wherever each use case dictates. And, creating a cloud-hosted development environment using standards-based tools and unstructured data storage will allow developers to create a wide variety of analytical capabilities. Together, these three principles create analytical flexibility and will provide value to electric companies for years to come.

"Ironically, the very industry that brought light to the world now is sitting on a gold mine of dark data."

–TED SCHULTZ

Jumping the Big Data Hype Curve to Realize Value

TED SCHULTZ
CEO, TROVE Predictive Data Science

Electric companies are poised to jump the hype curve when it comes to realizing value from data. For more than a century, they built and operated an analog energy grid, where "insights" to problems often were gained by customer phone calls. The smart grid is catapulting electric companies into the analytical mainstream with an unprecedented amount of data being collected on customer usage and distribution grid operations.

Ironically, the very industry that brought light to the world now is sitting on a gold mine of dark data. The position is understandable, as electric companies went from collecting 12 data points on a customer each year to upwards of 35,000 per year. Priority one is collecting and storing this massive amount of data. In fact, the amount of data collected will grow exponentially as sensors become prevalent throughout the distribution network. The challenge is this: how can electric companies, which now are sitting on massive amounts of unused dark data, illuminate that data to drive value throughout their companies?

Fortunately, open-source-based technology is available today to process massive amounts of structured, semi-structured, and unstructured data through platforms that connect to a company's existing computing environment. These platforms are necessary for ingesting data from existing data stores, managing data quality, scaling self-learning data science models, and integrating results back into existing infrastructure and applications. A base platform that does not require extensive IT resources is a prerequisite, but that alone provides little tangible value.

To deliver value, data science solutions that drive action need to be added and configured for each individual company with continuous learning capabilities to improve results over time. As the value of data and analytics grows, electric companies will need to go a step further to build their own data science capability, which will become the

nerve center for delivering value from big data and for moving to a culture of data-driven decision making. Focusing on two key solution areas makes sense:

- Customer Engagement
- Distribution Grid Management

CUSTOMER ENGAGEMENT

Customer engagement is a broad term and often is combined with a customer experience and digital engagement initiative. The core of any good customer engagement strategy is data-driven marketing. Yes—marketing. Electric companies own a unique relationship with their customers and need to leverage it fully to improve their service. The first step is to consider everything offered to a customer as a service offering, each with a definitive value, which is managed as a portfolio for each individual customer. This includes paperless billing, automatic payment, budget billing, fixed bill options, energy efficiency programs, demand response (DR), renewable energy products, and different rate tariffs. The idea is to increase the mutual value of the relationship over time.

To provide value to customers, we need to know a lot more about them on the other side of the meter. Fortunately, a tremendous amount of customer data exists to generate a deep understanding of individual customers and to predict which offers will provide them with the most value. As campaigns are developed, customers can be segmented dynamically based on their probability to participate and the value contribution of a specific service offering. As campaigns are implemented, results are fed back continually to improve predictions. In 2002, when I launched Duke Energy's Energy Services Business—based on customer engagement technology that was primitive by today's standards—we increased the incremental financial value from our relationships and, at the same time, improved customer satisfaction. If companies really understand their customers, they can make personalized offers to customers for mutual benefit. In the best case, a company can create a new business line that is relevant to its bottom line. In the worst case, a company gets paid to increase customer satisfaction.

Many electric companies have found similar results over the years. With the technology tools available today, an electric company can build its customer engagement core marketing capability and fully integrate low-cost digital channels and a comprehensive customer experience.

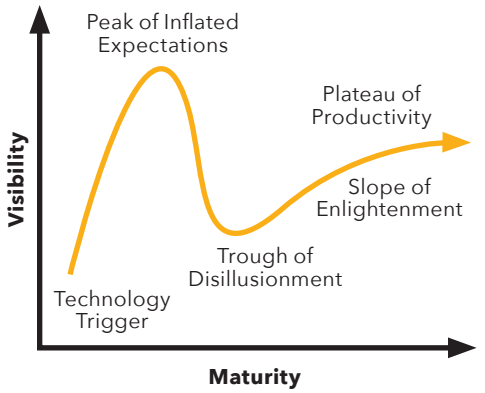
DISTRIBUTION GRID MANAGEMENT

When it comes to the distribution grid, every electric company has a similar challenge: balance supply and demand. Imbalances can carry heavy operational and financial costs, and distributed energy resources (DERs) make the balancing act even more complex.

Many electric companies today are positioned to facilitate a more efficient

and more effective distribution grid. It begins with the ability to forecast every service delivery point on the distribution network, to implement programs to address imbalances, and to facilitate investments. Using interval data, sophisticated data science models can forecast the day-to-day load of every customer in a matter of minutes. These forecasts enable the electric company to predict and to validate the results of a DR event, or the impact of DERs at the individual circuit level, and to optimize investments based on specific load profiles. This can have a dramatic and positive impact on distribution operations and planning.

Big Data Hype Cycle



Source: Gartner Research Methodologies, Gartner Technology Hype Cycle.

Forecasting also provides real-time situational analysis. In a recent situation, an electric company that implemented this approach for 400,000 enrolled customers improved the quality of its DR resource by more than 30 percent and validated results with 99 percent accuracy. Now, this company is moving DR from a regulatory compliance mechanism to a solution that helps to balance variable grid-connected DERs.

* * * * *

Electric companies have the technology available to jump cost-effectively over the peak of the big data hype curve to realize value.[1] But, how do you get started on this journey and build internal data science capability over time? Some advice from the field:

- Partner with a technology company on a proof-of-concept project targeted at a business imperative with the value of success clearly defined.
- Don't be paralyzed by poor data quality—it will clean itself up quickly as it gets used.
- Move into production on a platform that can scale with a deployment plan that shows returns quickly and captures the full value over time.
- Reinvest some of the value to start the next project and build out an internal data science team.

Does this sound a lot like a small startup business within the electric company focused on execution and charged with delivering financial and customer satisfaction results? It may lack hype, but that's not such a bad thing.

1. Gartner Technology Hype Cycle, available at www.gartner.com/technology/research/methodologies/hype-cycle.jsp.

"I believe a services mindset is the cornerstone of any successful customer initiative: Energy providers need compelling strategies and the right people to make results happen for customers."

–JANA SCHMIDT

Data Analytics Are Here to Stay, But How Do We Maximize Their Value?

JANA SCHMIDT
President and CEO, Ecova

The energy grid rapidly is becoming a platform for innovation. Energy providers across the United States are integrating data-collection mechanisms, software analytics, and smart devices into their networks. They also are bringing new products and services to their residential and commercial customers, ranging from more comprehensive energy efficiency offerings to distributed energy resources.

As these trends accelerate in the energy sector, there are lessons to be learned from other industries. Nearly a decade ago, the mobile industry began to encounter this same form of market transformation. The mass adoption of smartphones and tablets, improved wireless networks, and next-generation mobile apps revolutionized customer behavior. Customer mobile data usage grew seven-fold from 2010 to 2015.[1] All of these changes have had a profound influence on the way that wireless carriers managed their networks. The mobile industry overcame these challenges and adapted—largely because it had the tools to do so. The electric power industry now is deploying similar strategies, including new assets and incentives to optimize the energy grid and customer-centric data-driven services and technologies.

With change happening so quickly, we must be prepared to respond to evolving customer demands, even those we cannot yet predict or see. Ecova's approach to delivering these results distills down to three ideas: data, insight, and action. This framework—powered by technology, people, and processes—serves as a platform to help guide energy providers in their strategy and execution of customer initiatives.

DATA

The Internet of Things (IoT) is in motion. It is architecting a progressively interconnected and decentralized energy grid, underpinned by a host of innovative

services and technology systems. Electric companies are collecting more data than ever before—from the grid and from behind the meter—resulting in unprecedented visibility into customer behavior.

Ecova has millions of data streams across nearly 800,000 commercial and industrial sites under management—and we have learned from that experience. Capturing value from data requires a disciplined focus on harnessing the right type of data for a given solution. Energy consumption data is the foundation for customer-specific recommendations on how to save money and electricity, while residential and business firmographics add a layer of depth in understanding how electric companies can message to individual customers. Looking beyond the meter, grid-level data allows electric companies to improve resource planning, network performance, and system operations, as well as to inform demand-side management efforts to manage the grid.

A wealth of data points is only as powerful as the method of application. Big data and technology are the backbone of a new energy future—with energy providers as the integrators and enablers of analytics solutions that unlock value from the data.

INSIGHT

Historically, analytics often have focused on data visualization and basic normalization (e.g., the amount of energy consumed per square foot). But, that is changing. Analytics are now able to identify problems and the solutions to fix them, and even predict what is likely to happen in the future. A new class of analytics is unearthing highly precise customer intelligence, relieving the need to mine and sift through vast amounts of data manually—the proverbial needle in the haystack.

At Ecova, we developed rapid energy modeling software to remotely analyze how commercial business customers are using energy and how they can improve, delivering accurate and personalized recommendations in minutes per building. Our digital engagement portal, used by energy providers including Consolidated Edison (ConEd) and ENGIE Resources, engages businesses across their portfolios with operational and retrofit recommendations to save energy. The insights are often low-cost to implement, such as optimizing office thermostats based on hours of occupancy. Ecova also leverages propensity analytics to compare customer characteristics and behaviors algorithmically, mapping those against a set of target customers to extrapolate their propensity to act in the future. All of these analytics-based initiatives attract new customers to participate in energy efficiency programs, deepening engagement and increasing customers' satisfaction with their energy provider.

ACTION

As we think about the future of energy management, the low-hanging fruit is nearly gone. Large businesses and electric companies admirably have tackled lighting replacement, HVAC efficiencies, and high-leverage business process changes for energy-cost savings. What's next? Bigger actions. Solving more complex challenges. This is where data and insight evolve into action, and mastering that convergence is the key to sustainable results.

Data **Insight** **Action**

Sophisticated analytics may scale up processes and run on their own, but convincing a customer to implement an energy efficiency or renewable project is not something that can be fully automated. I believe a services mindset is the cornerstone of any successful customer initiative: Energy providers need compelling strategies and the right people to make results happen for customers.

Consider an online marketplace for energy management, a solution that Ecova recently launched for ConEd in New York City, to connect commercial customers interested in energy efficiency projects to specialized contractors who can implement those projects. Hosting this capability in a digital environment offers ConEd a platform to introduce new value-added services and to drive benefits for both buyers and sellers. However, it takes more than an "if we build it, they will come" approach of activating a commercial marketplace. People from both Ecova and ConEd are playing a key role in the process—in enrolling contractors, mobilizing projects, and working closely with businesses to develop the best solution for their needs.

* * * * *

The fast-changing energy technology landscape sets the stage for us to reinvent the role that electric companies will play in serving customers tomorrow. Customers are counting on us to be ready for that future and to pursue solutions. Market-tested algorithms and software automation will provide opportunities to think differently about the problem. And, turning challenges into opportunities is what will keep energy providers at the center of their customers' energy world, no matter what changes come our way.

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"Today's customers not only demand greater reliability, they expect resiliency. New technology is part of the answer."

–LESLIE SIBERT

Reliability, Resiliency, and Restoration: Service in a Crisis

LESLIE SIBERT
Vice President, Distribution, Georgia Power Company

OUTAGE MANAGEMENT: HURRICANES AND MORE

Hurricanes, ice storms, tornados, lightning, thunderstorms, microbursts, and even derechos. We see all of these severe weather conditions in the southeastern United States. As one of the four electric operating companies of the Southern Company, Georgia Power continues to cultivate and evolve a robust set of tools, technologies, skills, and processes to respond quickly to the impacts of weather on the power system and our customers.

Keeping power on—and restoring service when it's off—are fundamental to operating an electric power system, as customer expectations for more reliable power continue to grow. This is true not only for our business customers, but also for residential customers with home-based work environments. New smart grid technologies and improved tools for electric company employees have allowed us to make significant gains, and more are on the way. Our customers' desire for more information about power outages and restoration, delivered as soon as possible, also has added a new dimension to the job of the electric company.

OMS, AMI, BI

The Outage Management System (OMS) is the primary tool used by distribution system operators/dispatchers to identify and help to restore power. It serves as the core mechanism and data source for many steps in the process. Today's OMS at Georgia Power ingests electronic data from Supervisory Control and Data Acquisition (SCADA), Automated Metering Infrastructure (AMI), relays in substations, and distribution automation devices. It not only determines which device is out, but also estimates trouble spots and manages the entire restoration process and progression from beginning to end.

The OMS automatically utilizes AMI meter "pinging" to identify potential customer problems. If a problem is indicated, we contact the customer by phone to assist with checking or resetting breakers to restore power quickly, and save the cost of a truck roll. OMS enhancements soon will include identification of overload or over/under voltage alerts at the circuit segment level, integration of utility vehicle location data, and enhanced Fault Location Isolation and Service Restoration (FLISR) functionality.

While OMS consolidates, generates, and stores a wealth of detailed data essential to restoration and reliability, Business Intelligence (BI) dashboards, reports, and other tools provide near real-time and historical data analysis. During large storm events, BI information is critical for situational awareness and restoration management.

The OMS also generates and manages the entire Estimated Restoration Time process, essential to notifications to customers on outage status. Just as important as power restoration is our ability to provide customers the status of service at their homes or businesses even when they are evacuated. This data is fed to Outage Maps/Alert systems to provide timely, personalized outage information to customers using a variety of channels: online, mobile device apps, SMS texts, emails, and phone calls.

OUTAGE DATA UTILIZATION DURING HURRICANE MATTHEW IN 2016

Hurricane Matthew recently hit Georgia's eastern coast, causing more than 340,000 outages. With the state's mandatory evacuation of customers (and Georgia Power personnel) before the hurricane, customer calls were unavailable or extremely limited as the storm hit. Instead, SCADA and AMI provided data allowing us to "see" the extent and location of outages. Having this early insight into outage locations was essential for planning and mobilization as Georgia Power redirected key resources, added additional staging sites, and identified material delivery points in the most impacted areas.

SOCIAL MEDIA
updates reached nearly

4 million
people during
Hurricane Matthew

Georgia Power also leveraged the OMS data through external communications, including regular updates on restoration progress to news media, and in

real time to customers from the company's Social Media Center in Atlanta. The Social Media Center is an enhanced communications tool for the company, housing customer service and corporate communication staff and facilitating online dialogue with customers on Facebook, Twitter, and other social media channels. During Hurricane Matthew and throughout the restoration, Georgia Power issued more than 200 social media updates, reaching nearly four million people.

As restoration progressed, Georgia Power used its AMI system to:

- eliminate unnecessary truck rolls to locations that already had been restored; and
- verify whether locations had power by "pinging" the AMI meter.

This also allowed us to reduce restoration times significantly.

RESILIENCY, FLISR, AND MUTUAL ASSISTANCE

Today's customers not only demand greater reliability, they expect resiliency. New technology is part of the answer. Georgia Power currently has more than 1.2 million customers (or more than 50 percent of all customers) on more than 700 circuits with self-healing FLISR schemes. From January through August 2016, these schemes helped to avoid more than 17 million Customer Minutes Interrupted (CMI)—that's more than 280,000 customer-hours of avoided outages. This industry-leading effort will expand and provide greater value in coming years.

Enhanced planning and cooperation among electric companies during major storm events is another crucial aspect of our ability to respond better to major events like hurricanes. Using Mutual Assistance mechanisms to call on crews from electric companies across the nation is invaluable to restoration and recovery following major events.

MOVING FORWARD WITH ANALYTICS

Electric companies are beginning to take full advantage of smart technologies, using the immense volumes of smart grid and AMI data. Georgia Power already has found many ways to use this data effectively, but much potential still can be unlocked through advanced analytics to: identify the location of transient faults that may evolve into sustained outages; use AMI voltage data to identify malfunctioning and failing equipment; and identify trends through enhanced visualization.

Smart technologies, coupled with continuous integration of data into new systems and processes, are allowing Georgia Power to provide ever greater reliability and value to our customers.

"Electric companies have an important choice to make. They can stop service at the meter, or they can push forward to offer solutions that enable customers to solve energy use problems and secure an avenue of future growth."

–MANOJ KUMAR

Bridging the Smart Grid to the Smart Home

MANOJ KUMAR
CEO, Powerley

Every year, projections for the smart home market grow, but less than 5 percent of customers in the United States and Europe currently are using home automation, monitoring, or home energy management solutions.[1] Industry analysts and insiders are forecasting mass adoption within the next decade, with the value of the global connected home market reaching $200 billion to $350 billion by 2025.[2]

Are these projections overly optimistic considering current adoption rates? Do they assume we will overcome obstacles such as high costs, a market of disparate solutions from multiple suppliers, lack of a clear customer value proposition, and poor user experience?

According to Mark Lantrip, President and CEO of Southern Company Services, "We have yet to discover the iPhone for home energy management." He is spot on. Smart home technology solutions exist. But, without an integrated ecosystem, a value proposition, and a ubiquitous channel to facilitate accessibility, adoption will fail to scale.

The market is fragmented. There are energy efficiency solutions that measure consumption (most without real-time insight) and home automation products that monitor and control capability. The two are not connected, and the value proposition for the customer has been sub-par.

Technology companies, seeing the potential to fill this gap, are developing offerings for the home energy management space. For example, smart thermostats are anchoring electric companies' demand response programs and are attempting to provide additional revenue opportunities. Though some technology companies may tend to focus on isolated use cases that don't connect to a broader value proposition, many are making progress, and electric companies have taken notice of the movement into this space.

The increasing number of solutions offered in the market is confusing the average customer about the full value proposition presented, resulting in low adoption rates and high product costs.

The smart home is facing a "chicken-and-egg" dilemma. Without a higher adoption rate, production costs remain high; without lower cost to customers, adoption stalls. With significant cost differences—for example, prices of leading smart bulbs, outlets, and thermostats are more than five times that of their "non-smart" counterparts—it's no wonder adoption is in the doldrums.

While we've seen success with affluent, green, and tech-savvy customers, how do we move beyond these early adopters? Which of the dominant smart home channels—direct-to-consumer, electric company, cable, or telecom—is best positioned to establish a unifying ecosystem? One that can demystify the market, trim costs, and cut through the complexity to reach scale. The market needs a home ecosystem that bridges multiple devices across different categories throughout the home. Can electric companies be the bridge?

As disruptors outside the energy industry take aim at the opportunity ahead, they face a much steeper uphill battle. For starters, customers' relationships with their electric companies are generally grounded in trust. Few others are trusted to enter customer homes and install equipment. While the ongoing relationship typically stops at the meter, it's not a big jump for electric companies to move beyond the meter.

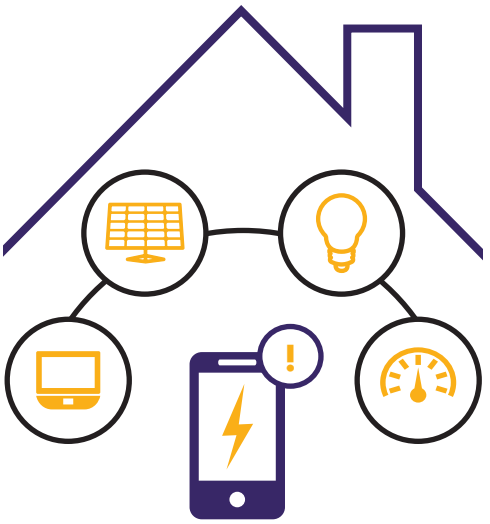
In fact, customers want their energy provider to add value beyond the meter. Studies show that 58 percent of customers would like their electric company to offer home energy management solutions, and 61 percent prefer that electric companies provide home monitoring and control solutions. This preference is 1.5 times greater than customers' preference for retailers, and more than double that for cable and communications companies.[3] Electric companies have created the largest, most reliable network in the world—the energy grid. The energy grid works so well that customers rarely even think about it. As a nation, we take the grid for granted, but, as energy professionals, we know the hard work that goes into delivering reliable energy.

THE MARKET IS "OURS TO LOSE"

A decade ago, adoption of wireless technology started slowly because users had to find and install their own devices. Cable companies became the catalyst for Wi-Fi adoption by seamlessly extending their services to include installation of cable modems. By leveraging their existing relationships with customers, cable companies created an entirely new revenue stream and simplified user adoption. The wireless market took off.

Similarly, home energy management, the central use case for the smart home market, is a natural extension of existing electric company services. When electric companies lead the charge, reduced energy bills and free supply or installation are very likely to positively influence adoption. This

is pivotal because it could ramp up user adoption of broader smart home technology significantly. Yet, there remains an imbalance between the smart home's value to the customer and its market potential. Considering the resistance to wider user adoption, electric companies are well-positioned to balance the scales in a way that has more appeal to customers.



Bridge To Smart Grid

When we balance the value ratio between electric companies and customers, the results are immediate and impactful. As a prime example, DTE Energy has tallied more than 200,000 downloads of its Insight app. Using a connection to the smart meter, DTE has successfully engaged customers in a new, real-time energy experience that has resulted in engagement of more than 110,000 unique visits weekly and average household energy savings of 7 to 10 percent. According to Steven Ambrose, CIO of DTE Energy, "We've translated technology into an experience that is driving excitement and efficiency for our customers and for DTE Energy."

Electric companies have an important choice to make. They can stop service at the meter, or they can push forward to offer energy management, appliance control, and home automation solutions to enable customers to solve energy use problems and secure an avenue of future growth. While doing so, they can meet energy efficiency goals, optimize peak load utilization, better meet environmental mandates, improve their carbon footprint, and develop new revenue sources.

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This is a pivotal point in energy industry history. Electric companies can be the victim of disruption or seize the opportunity to drive new levels of efficiency and growth. Their choice will determine the progress of the customer-focused energy industry.

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"Using data analytics can improve DR and EE program performance dramatically and provide operational benefits."

–GREG DUKAT & STEVE HAMBRIC

Data-Driven Performance: The Evolution of Demand-Side Management From Emergency To Critical Operational Resource

GREG DUKAT
Chairman, President, and CEO, Comverge

STEVE HAMBRIC
Senior Vice President, Comverge

Following widespread deployment of advanced metering infrastructure, home energy management devices, and distributed energy resources, there is now a growing volume of data that electric companies can crunch to improve the reliability and efficiency of the energy grid. In addition to harnessing data to reduce outages and to improve system maintenance, Comverge is working with electric companies to use big data to transform the performance of demand-side management programs in two ways.

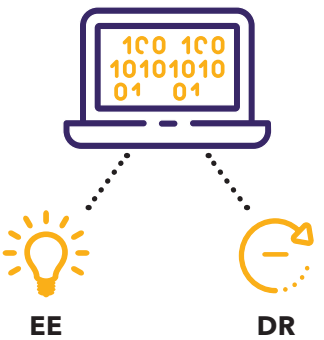
First, by analyzing the growing amounts of customer, energy, and grid data, Comverge is helping electric companies to deploy their demand response (DR) and energy efficiency (EE) programs as critical operational resources to help solve problems that traditionally were handled either by supply-side resources or investments in transmission and distribution infrastructure.

Second, by using data analytics to understand customer energy usage and behavioral patterns, Comverge is helping electric companies to engage better with their customers—from providing tailored services such as appliance tune-ups, to helping customers identify and take specific actions to save on their energy bills.

OPTIMIZE PERFORMANCE OF DEMAND RESPONSE ASSETS

Historically, electric companies projected curtailable load during a control event by using look-up tables and Excel spreadsheets. This manual approach made it difficult to respond to emergency situations, as well as to adjust to rapid, real-time changes in weather and grid conditions. Using machine learning to process data from smart meters, in-home devices, and weather, electric companies can harness and aggregate the power of detailed, customer-specific models to improve the forecasting and dispatching capabilities of DR resources substantially. This improved capability can transform a DR program into a more precise and trusted asset in the control room.

Managing EE and DR as Assets



For example, one electric company is in the process of migrating its award-winning home energy DR program from one-way-communicating to two-way-communicating load control devices. With more than 20,000 two-way devices currently deployed, the company is now able to forecast load reduction more accurately based not only on weather, but also device data. The company also can verify, in real time, how many devices are responding and then can adjust the control event to ensure the proper load targets are achieved.

DR typically has been used as an emergency resource to reduce load. Using data analytics to improve forecasting and dispatching capabilities, electric companies also can leverage DR as a strategic asset not only to improve grid reliability, but also to integrate variable renewable energy resources, to defer adding transmission and distribution infrastructure, to reduce reliance on inefficient peaking generation, and to optimize revenue from capacity and energy markets.

TARGET ENERGY EFFICIENCY OPPORTUNITIES TO INCREASE CUSTOMER BENEFIT

Electric companies today can build a model of how homes and businesses use energy using data collected during a thermostat installation for a DR program, telemetry from the thermostat itself, billing data, and other publicly available records. Electric companies then can identify specific actions customers can take to save energy and accurately estimate dollar savings that

would result from those actions. With this information, customers gain a better understanding of how they can save money on energy bills, and electric companies build a closer, more trusting relationship with their customers.

Comverge is working with electric companies to roll out a program to small business customers in the Southeast and Midwest. The energy management system that customers receive as part of their participation in a DR program also allows them to schedule regular "efficiency periods" when their businesses are typically unoccupied. By combining our thermodynamic model of customer premises with real-time weather data, we can maximize energy savings during unoccupied periods while ensuring that each business returns to the customer's preferred temperature before it is occupied again.

Comverge studies have shown this approach can deliver significantly more energy savings than the typical approach businesses take to scheduling their thermostats. Like other energy-saving suggestions, this information is appreciated by customers.

EE programs used to mean swapping out incandescent bulbs for compact fluorescents—and now LEDs—to provide incremental energy savings. Today's EE programs enable customers to achieve significantly more savings and provide a launch point for a closer relationship between the customer and the electric company. Integrating DR and EE into one program yields even better outcomes.

* * * * *

DR and EE programs always have provided a significant benefit to electric companies and their customers. Using data analytics can improve program performance dramatically and can provide new system operational benefits, greater customer benefits, and an overall better customer experience.

"Today's energy users not only want a reliable supply of electricity, they also want better communication and more choices from their electric company."

–ANDY BAYNES

Using Digital Technology to Bridge the Customer Gap

ANDY BAYNES
Head of Energy, Nest Labs

For more than a century, electric companies followed a simple business model: Generate and deliver electricity to customers reliably through a centralized power system. That's no longer enough. Today's increasingly complex energy system has created more active and demanding energy users. But there's an upside to this challenge: Today's expanded technological options also will enable easier and more useful interactions between the electric companies that provide and the customers who use electricity.

The increasing volume of renewables on the energy grid and the emergence of new technologies—smart meters, energy storage, and an array of new smart devices—are leading electric companies to pay more attention to an increasingly active energy player: their customers.

Typically, customers use electricity without paying much attention to it. That's its magic. Today's energy users not only want a reliable supply of electricity, they also want better communication and more choices from their electric company.

The power of the customer clearly is reflected in the rising popularity of demand response (DR) programs across the United States. DR, prominent at the bulk power level in regional systems like PJM and elsewhere, gained importance with the willingness of large commercial and industrial customers to release their demand on the system in response to system operators' actions to avoid supply shortages or extreme price spikes. The customers were well-compensated for their curtailments, and everyone benefited.

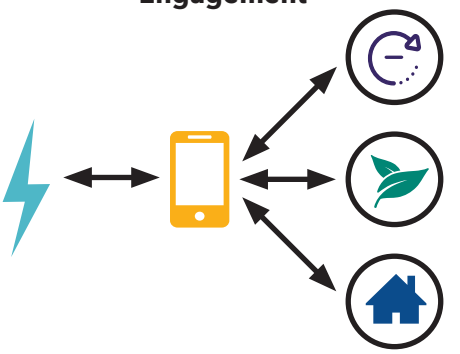
More and more, electric companies are bringing DR programs to their residential customers—a group that also must be engaged—along with commercial and industrial customers, to enable

cost-effective resource solutions at the distribution level. These programs will expand in the United States and around the world, allowing electric companies to include residential space conditioning, water heating, plug loads, electric vehicles, and other energy solutions, in their DR programs. The growing list of connected products in use at the residential level presents both opportunity and complexity for electric companies, while offering comprehensive—and money-saving—DR options to residential customers. These offerings will be increasingly important as companies' residential program offerings grow and reach scale.

A recent example demonstrates the clear benefits of engaging residential customers in mass-market energy programs. Southern California Edison (SCE) quickly expanded one of its residential DR programs to address the serious supply challenge that resulted from the shutdown of the Aliso Canyon natural gas storage facility in Southern California. SCE accelerated its residential DR programs, setting the ambitious goal of enrolling 50,000 customers with smart thermostats across the Los Angeles basin in just under two years to offset 50 megawatts of demand.

And it's working. Just three months into the program, with marketing activities still in their infancy, hundreds of customers with Nest thermostats are enrolling in SCE's program each week, and that pace is accelerating. Companies increasingly are seeing residential loads as a meaningful and active resource for the energy grid. Indeed, it seems that we have reached a time when electric company obligations for safety, reliability, and efficiency cannot be met without substantial participation from residential customers.

Seamless Customer Engagement



Nest's partnership with SCE is just one example of such collaborations. In Chicago, Nest has been working with Commonwealth Edison and other partners since 2015 on what could be the most ambitious smart thermostat program ever, with a goal of installing 1 million smart thermostats in residences by 2020. This program involves the electric company not just in incentivizing installation of new smart thermostats, but seeking out and replacing the programmable thermostats it helped to install years ago. This underscores the value

of smart thermostats and the modern DR programs they enable as wise investments for electric companies.

Smart thermostats are also a portal to more positive and streamlined relationships among electric companies and their customers. Smart thermostats, like Nest's, open the door to a real upgrade in customer engagement with their electric company. Few customers will tell you that they thoroughly read bills or other paper communications from their electric company. While many electric companies have adopted email and online interactions with their customers, a recent survey found that the average customer spends just eight minutes per year (40 seconds per month) on digital interactions with their energy company.[1] Half of respondents reported no digital interaction at all.

Smart thermostats have great potential to change that level of interaction by offering an alternative to the one-way communication and static information that have been the norm until recently. Now, smart thermostats provide detailed data on customers' heating and cooling energy consumption patterns, enabling them to make more informed energy use choices.

In today's smartphone society, communications from energy companies to customers via a mobile app are more likely to be read and acted upon than a paper letter or even an email. And, as the smart home and Internet of Things (IoT) expand to include more energy-dependent devices and appliances, smart thermostats like the Nest Learning Thermostat can function as hubs for other smart devices while continuing to be the main point of digital communication with electric companies. Soon, more interested customers will be able to enroll their water heaters, refrigerators, and pool pumps in DR programs, with the smart thermostat acting as the central point of control and communication between company and customer.

* * * * *

Through smart thermostat programs, electric companies are becoming digitally connected to millions of their customers, delivering programs that customers deeply appreciate. Letting the tech company worry about the algorithms, hardware, software, and cloud interface frees the electric company to do what it does best—seamlessly engaging customers along their energy journey while keeping service reliable and resilient. Communicating thoughtful, money-saving opportunities will deepen the trust customers have in their electric company.

1. Accenture Consulting, The New Energy Consumer: Thriving in the Energy Ecosystem, www.accenture.com/us-en/insight-new-energy-consumer-thriving-new-retail-ecosystem.

"Big data and data analytics are helping to integrate electric company operations with other parts of the business—enabling operational efficiencies and optimization."

–BRAD GAMMONS & STEVE CALLAHAN

A Structured Approach to Stepping Into Big Data Analytics

BRAD GAMMONS
Managing Director, IBM Global Energy and Utilities

STEVE CALLAHAN
Vice President, Energy & Utilities, Global Strategy and Solutions, IBM

With the profusion of data from grid instrumentation, advanced meters, and connected consumer devices, electric companies can apply analytics to unlock the immense value of big data. Analytics allow electric companies not only to improve their current business processes, but perhaps also to transform them altogether. Success in applying analytics is best achieved by building a foundation of common capabilities that applies to—and integrates—various company domains and systems.

Analytics can turn information from smart meter and smart grid investments into meaningful operational and customer behavior insights. For example, earlier this year, Consolidated Edison Company of New York (ConEd) was granted final approval for an Advanced Metering Infrastructure (AMI) rollout, with installation of more than 3.9 million smart electric meters and 1.3 million smart natural gas meters. This will bring ConEd data for each residential customer every 15 minutes and for each commercial customer every five minutes. Based on the experiences of other electric companies with full smart meter deployments, AMI offers a new, deeper way for ConEd to understand and respond to customer needs, to modernize energy infrastructure, and to improve energy grid management.

Smart grid technology and smart meters are generating hundreds of terabytes of data, compiling everything from maintenance records to Twitter feeds. The accuracy, breadth, and depth of these new data points present new opportunities for electric companies that are prepared to take advantage of them.

For companies to thrive in this new environment, they will fundamentally have to transform their current business processes. That means leveraging big data and data analytics to form actionable insights, enabling better operational decisions, predictive maintenance, power quality optimization, and more effective demand response analytics, among other values.

Many companies are refocusing their priorities to greatly improve their own operations and to become more customer-focused. Today's emergence of customers that are both demanding and empowered requires a new approach to customer engagement. Through analytics, electric companies are beginning to engage with customers in specific and personalized ways, offering value that increases customer satisfaction, while also lowering the cost of service. That engagement opens opportunities to promote new products and services.

The analytics opportunity for companies is clear, yet there continues to be a lack of a committed technology push from many companies and, therefore, an inability to deliver the values that are possible. What is holding so many electric companies back?

Of course, companies are concerned about the high costs and complexity of both data and its application. To reduce those concerns, here are a few guidelines:

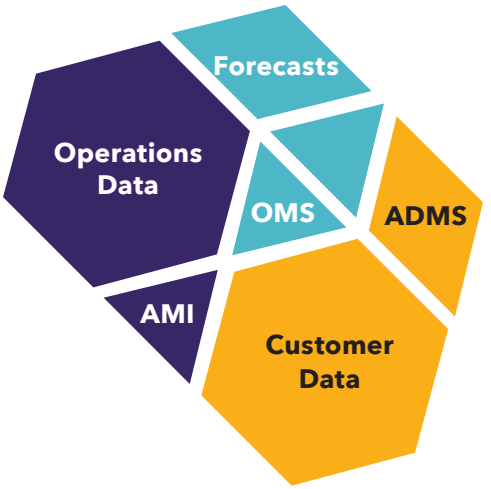
- Begin with a structured and focused approach, starting with a realistic review of analytics maturity. Companies should decide where they want to get to and what they want to achieve. Answers to these questions will provide a baseline for investments and initiatives.
- Identify the needed data sets and smart systems, invest in needed skills, and establish the proper data governance models.

Within this structured approach, electric companies can be pragmatic; hitting the sweet spot they are aiming for, while being cost-effective.

With built-in analytics, some electric companies already are seeing comprehensive information about each of their assets: history, maintenance records, and operating data. This information can be mobilized in new ways to improve planning, construction, operations, and maintenance practices. Such innovation helps companies to transition from traditional and costly time-based asset management, with network repairs done on a fixed schedule (regardless of the useful life remaining in an asset) to a more-informed, reliability-based approach, making repairs only when appropriate.

Big data and data analytics are helping to integrate company operations with other parts of the business—enabling operational efficiencies and

optimization. This involves deploying advanced distribution management systems (ADMS) that use telemetry of monitored assets in the company network. Information from an ADMS can be combined with customer data from smart meters and with more sophisticated analytics to enable dispatchable demand response.



At some companies, forecasting technologies are being deployed to provide more accurate projections of power from variable resources and to better meet customers' reliability and sustainability expectations. By better understanding resources and weather conditions that affect system performance and customer behavior, IBM is helping electric companies to develop supply and demand strategies capable of responding to a variety of situations ahead of a crisis.

Through analytics, electric companies are starting to digitize our world, enabling a 24/7 energy grid-connected ecosystem of smart energy infrastructure, smart consumer devices, cleaner energy resources, and enhanced energy products and services. In doing so, they are beginning to find ways to create more customer value and to promote better customer engagement.

* * * * *

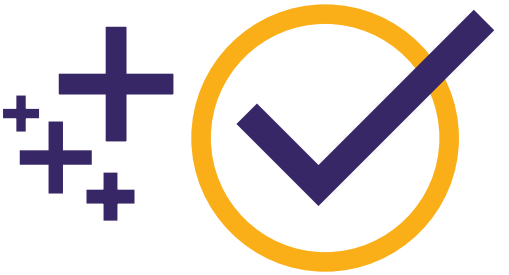
The electric power industry uniquely provides products and services that are central to the well-being of its customers and the overall economy. By adopting analytics that evaluate and make use of the vast sea of data they and their customers are generating, electric companies can expand their business, increase their agility and responsiveness, reduce operating costs, and continue to deliver safe, reliable, affordable, and sustainable energy. This is not only the future, it is also happening today.

At A Glance: Grid Modernization

DRIVERS

1. Customer Wants & Needs
2. Environmental Goals
3. Growth in Distributed Energy Resources
4. New Technologies

BENEFITS



1. Enhanced Reliability
2. Increased Resiliency
3. Reduced Carbon Emissions
4. Empowered Customers
5. Flexible & Responsive Energy Grid Platform

CHAPTER 3

GRID MODERNIZATION

The energy grid integrates energy technologies with information and communications technologies to power our economy and our way of life. Today, electric companies are developing a digital energy grid that empowers customers, ensures reliability, reinforces resiliency, and integrates distributed energy resources (DERs). As part of their efforts to build smarter energy infrastructure, companies are deploying advanced technologies, improving power lines and substations, hardening the system against severe weather, and enhancing cyber and physical security. In 2016, U.S. investor-owned electric companies are expected to invest $52.8 billion in transmission and distribution to make the energy grid more dynamic and more secure.

Public policies, new technologies, and changing customer expectations are the drivers behind a modern energy grid. By year-end 2016, 70 million smart meters will be installed across the United States. Smart meters, combined with advanced sensors, communications, and automation, are key building blocks to support an increasing number of DERs, to provide more customer options, and to improve system reliability and resilience.

While the rate of change varies by state, most electric companies are moving forward to build smarter energy infrastructure. Preparing for the future involves using software platforms to anticipate, optimize, and make the best use of DERs as system resources. Looking into the future, some see a future where load follows generation and where behind-the-meter energy storage becomes an integral part of a modern distribution grid, with cloud-based intelligence connecting, coordinating, and automating these resources. In the space between the distribution system and the customer, new electric company business models are taking shape.

Using electricity has been a seamless process for 100+ years; it is essential that this continue for the next 100 years. This requires investment, technology, and the right policy support. The authors of the essays in this chapter paint a vibrant picture of progress amidst change, aligned to realize the full value of grid investments and clean energy. They are aware that flexibility is key to developing a smarter, cleaner, more reliable, and more secure energy grid.

"To facilitate the transformation, the local energy grid must become a "plug-and-play" platform that integrates an ever-growing set of distributed energy technologies."

–KEVIN PAYNE

The Emerging Clean Energy Economy

KEVIN PAYNE
CEO, Southern California Edison

All of us in the electric power industry are keenly aware that a profound shift is underway that is unlike anything we have experienced. It involves nothing less than the complete transformation of the electric power system from a "one-way" energy grid into a dynamic, innovative network. This emerging, modern grid will enhance system safety and reliability, provide customers with more choices and flexibility in managing their energy use, and hasten the decarbonization of our economy.

At Southern California Edison (SCE), we are at the forefront of this transformation. California has adopted an ambitious carbon reduction goal—40-percent below 1990 emissions levels by 2030. The state is experiencing a rapid increase in the use of distributed energy resources (DERs), including private rooftop solar, on-site energy storage, plug-in electric vehicles, and energy management systems. In fact, California is home to 50 percent of the nation's private solar systems—more than half a million businesses and homes. There are also more than 200,000 plug-in electric vehicles in California, and the state has a goal of 1.5 million zero-emission vehicles by 2025. A modern, digital energy grid is essential as we strive to optimize the use of these clean energy resources, including DERs, to support California's greenhouse gas target.

As our customers adopt these new resources, they continue to look to us to provide safe, reliable, and affordable service, as well as for ways that both they and the grid can benefit from the value that distributed energy brings to the grid. With proper support, DERs can benefit individual customers and contribute significantly to local economies, clean energy, and grid resiliency.

SCE is exploring the implications that all of these new technologies will have on the energy grid and on customers. In September 2016, we published a white paper that lays out a vision of

what a modernized energy grid could look like: "The Emerging Clean Energy Economy: Customer-Driven. Modernized. Reliable."[1] The paper proposes a framework for the evolution of an energy grid that places the customer at the center, with enhanced safety and reliability. Under this modern energy grid, the electric company facilitates customer choice and unlocks the benefits of distributed energy.

Decisions made now on how to embrace this change will have profound implications for how the energy grid adapts to ensure the reliability, affordability, and safety customers count on, while meeting evolving customer needs and reducing carbon emissions for the rest of the 21st century.

To facilitate the transformation, the local energy grid must become a "plug-and-play" platform that integrates an ever-growing set of distributed energy technologies. Such a platform will give DER owners access to both a grid that supports their needs and markets that can increase the value of their investment. Maximizing this potential for all customers requires a thoughtful approach that: (1) modernizes and reinforces the grid to improve reliability, assure safety, and ease the integration of DERs; (2) connects customer-owned DERs to markets that provide new revenue opportunities; and (3) updates customer rates and programs to better reflect the benefits and costs of distributed resources and the grid. Each of these aspects is summarized briefly below.

MODERNIZING AND REINFORCING THE GRID

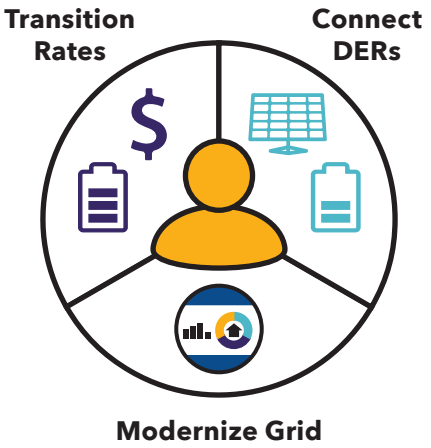
Customers who adopt DERs want to connect to the grid quickly and without hassle. Electric companies must anticipate future DER growth and reinforce local grids to accommodate these new resources, and meet customer expectations. However, once connected, clusters or concentrations of distributed resources can complicate grid operations. Grid operators need advanced sensors, communications, and automation so they can see what is happening in real time, minimize disruptions, and enhance system reliability and safety.

CONNECTING DERS TO MARKETS

New revenue opportunities from wholesale markets, distribution grid services markets, and later, possibly peer-to-peer transactions can encourage innovations that expand customer choices and benefit the energy grid. Coupled with declining prices of DERs, these markets eventually could eliminate the need for subsidies and administratively determined tariffs. Companies will need to work with resource providers and other stakeholders to shape markets and solutions that work in concert with distribution and/or transmission systems.

TRANSITIONING RATE DESIGNS

To maintain affordability for all customers, rate designs and programs must share the benefits and costs appropriately among customers who deploy DERs and those who do not. Rates should account for the fixed costs of the energy grid so all customers, including owners of DERs, pay for access to the modernized and reliable distribution grid and the critical services it provides. DER owners should receive compensation based on the value at the time and location of the services they deliver.



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To meet these challenges, companies like SCE must expand their capabilities as distribution system operators that plan and manage a modernized plug-and-play grid, ensuring that all customers receive safe, reliable, and clean energy, while seamlessly integrating rapid growth in distributed resources.

These massive changes to the energy grid and markets will take time—possibly more than a decade—to accomplish. Hence, it is critical that electric companies, regulators, distributed energy providers, and other stakeholders come together now with a sense of urgency to develop the foundation for these changes. Doing so now will pave the way to a modernized energy grid in priority locations, functioning markets for DERs, informed customers, proven resource providers, and reduced carbon emissions. It will enable a new, clean energy future that exceeds anything that our industry, or any other, has accomplished in the past.

1. The complete SCE white paper can be viewed at www.edison.com/transformingthegrid.

"Our customers value both the improved outage restoration of our grid modernization efforts and the opportunity for energy savings."

–SCOTT PROCHAZKA

Digitizing Data Accelerates Benefits to Customers, the Environment, and Energy Companies

SCOTT PROCHAZKA
President and CEO, CenterPoint Energy

In Houston, Texas, known as the "energy capital of the world," CenterPoint Energy (CNP) continues to extend the benefits of our transformative Smart Grid to improve safety, efficient operations, reliability and resiliency, the environment, and the customer experience.

CNP's Smart Grid is composed of our Advanced Metering System (AMS), Intelligent Grid (IG), Advanced Distribution Management System (ADMS), and private telecommunications network. Since 2009, we have deployed fully operational advanced meters to virtually all of our 2.4 million customers; automated 31 substations; installed 861 intelligent grid switching devices (IGSDs) on more than 200 circuits; and built a wireless radio frequency (RF) mesh telecommunications network across our 5,000-square mile electric footprint. We also have enabled real-time grid monitoring and control, leveraging information from smart meters and field sensors to manage system events through the ADMS, the brain of our Smart Grid. We have moved well beyond deployment and now are realizing more and more benefits.

DIGITAL GRID: SAFER AND MORE EFFICIENT OPERATIONS

Since 2009, we have completed more than 16 million service orders electronically, reducing crew miles driven on Houston's busy roads, which has a direct impact on safety and congestion. Moreover, our IG sensors have improved fault location so that crews can be safely directed straight to the fault rather than walking miles of lines in the dark.

Digitizing our energy grid also has made our operations more efficient.

- We moved from 2.4 million manual meter reads per month to more than 230 million electronic reads per day.
- We execute remote disconnections and reconnections within 30 minutes, 16 hours per day, six days per week (24/7 for reconnections).
- We are localizing fuse- and transformer-level outages 50 to 70 percent faster using digital meters and advanced analytics.

Our in-house analytics team also has helped to improve revenue recovery through improved detection of electricity theft and improved revenue forecasting, which has gone from 90 percent estimated to 0.1 percent estimated. CNP has saved more than $100 million to date through operational efficiencies driven by grid modernization.

Analytics have greatly improved our real-time situational awareness of grid conditions, including outages, giving controllers and dispatchers the ability to locate and isolate faults more quickly and to send the right crew to the right place for faster outage restoration. Here are some examples:

- Since 2011, we used our Intelligent Grid in more than 1,800 outage events to save customers more than 188 million outage minutes.
- In 2016 alone, we improved reliability 33 percent.
- Since 2015, more than 660,000 customers have avoided sustained outages.

Moreover, our advanced metering system's automated outage notification ability has allowed us to restore power to well more than 1.5 million customers *without a single phone call*.

SMART GRID TECHNOLOGY
saved customers
$100+ Million

DIGITAL GRID: CUSTOMER AND ENVIRONMENTAL BENEFITS

Indeed, we no longer rely on customers to tell us their power is out. We tell them. Our Power Alert Service (PAS) sends phone, email, and/or text alerts to more than 580,000 enrolled customers when their power goes out, with estimated times of restoration, status updates, and restoration confirmation. PAS, which has resulted in 93 percent call deflection, also has 90 percent customer satisfaction. When customers with an outage do call, our predictive analytics engine recognizes the likely reason, and our natural language Interactive Voice Response can enroll them in PAS.

Eighty-six percent of customers we surveyed value both the improved outage restoration of our grid modernization efforts and the opportunity for energy savings provided by our digital metering, which makes their usage data available to them in 15-minute intervals (or near real-time through an In-Home Display), facilitating new retail services such as free nights and weekends, peak time rebates, and pre-paid service, which hundreds of thousands of Texans now enjoy. Our customers save $20-$25 million per year in fees eliminated by electronic service orders, through which CNP also has avoided emissions of more than 14,000 tons of carbon dioxide. That is equivalent to the emissions associated with powering 1,200 homes with coal for a year.

Two events this year illustrate the benefits we and our customers receive from our modernized grid. In April, more than 240,000 customers suffered more than 415,000 outages from a storm that brought historic flooding to greater Houston. We used the remote switching of our ADMS and 72 IGSDs to restore power to 90 percent of those customers within 27 hours and 99 percent of customers within three days. Our Smart Grid saved customers 26 million outage minutes in April, more than in all of 2014. In August, a substation fire at rush hour knocked out power to more than 70,000 customers, but, by using 13 automated switches, we were able to restore nearly all customers by midnight.

A grateful student tweeted: "If CenterPoint energy can restore power to 78,000 + customers in one night, I can finish my calc packet by Friday #inspired."

Now that's smart!

"FPL customers now can see the benefits of a smarter and stronger energy grid when they need us the most—and when they count on us for everyday reliability."

—ERIC SILAGY

Seeing Is Believing: How Customers Experience the Benefits of a Smarter Grid

ERIC SILAGY
President and CEO, Florida Power & Light Company

The conversation went something like this:

FPL: *"Good morning, ma'am, I'm with FPL. I'm here to let you know of an electrical problem in your house."*

Customer: *"What problem? My electric service is fine."*

FPL: *"Well, apparently there's a problem, and it's not with our equipment."*

Customer: *"How do you know what's going on at my home?"*

FPL: *"I don't know."*

Customer: *"What do you mean you don't know?"*

FPL: *"I don't know! Corporate told me there's a problem in your house so I'm here to help."*

* * * * *

A few years ago, this kind of conversation was too common. FPL was just beginning to send out service technicians based on information that we had never had before. But many of our customers were skeptical—or even incredulous—at what we told them we knew. And many of our service technicians didn't have much experience explaining how and what we knew to customers. It all made for some awkward exchanges.

So FPL trained its service technicians to tell a simple but powerful story about the expansion of knowledge in our industry.

The story begins with something customers can see: the smart meters on their homes and businesses. We've installed 4.8 million smart meters that now let us know when individual customers are out of power. We've also

deployed more than 36,000 intelligent devices and smart switches that help detect and prevent issues before they become problems for our customers.

The story continues with data. Some of the data generated by these intelligent devices is available for customers to see for themselves, using the FPL energy dashboard available through our website. This tool allows customers to understand their own energy use and to take control of it.

But the vast majority of the data generated by our smart grid is not immediately useful to customers. Instead, it's studied and analyzed by our electrical engineers. They, in turn, can develop algorithms to detect patterns in real-time data, compare them to patterns we now understand are associated with failure of electrical equipment, and identify equipment that we can repair or replace before it fails.

Sometimes an analogy helps bring the story home. Imagine if roads were as smart as FPL's energy grid. Long before a pothole actually appears, sensors in the roadway would detect the structural changes that are the precursors to pothole formation. These sensors would alert transportation engineers to schedule maintenance when it's least disruptive to travelers and to redirect traffic automatically away from the problem so it doesn't get any worse.

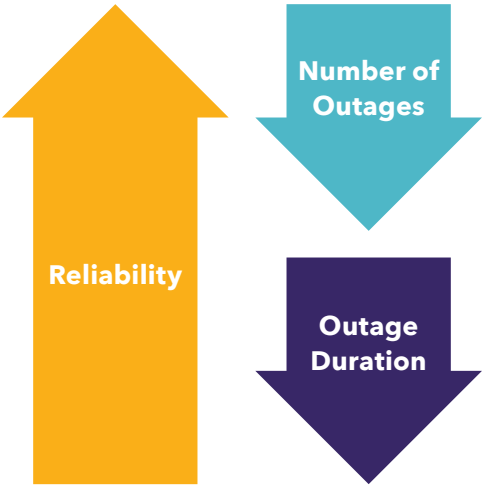
That scenario may sound like science fiction to the driver, but the future is here for FPL customers! Our proactive ticket notification system uses smart grid data to predict when a customer is about to experience an outage, enables crews to deploy to the area, and, in many cases, resolve the issue before a customer is even aware there was a problem. In 2015, this system helped to avoid more than 3,000 single customer outages and to reduce the average interruption duration by approximately 50 minutes.

FPL's smart grid technology, together with our $2 billion investment to strengthen our network to be more resilient in severe weather, also delivered for customers when two hurricanes impacted Florida in the fall of 2016. In September, Hurricane Hermine interrupted service for 112,000 FPL customers, but automated switches prevented outages to 25,000 more. Information from smart devices helped us to restore power to all of our impacted customers within 24 hours, with an average outage duration of less than three hours.

In October, Hurricane Matthew provided a much tougher test, as 1.2 million customers lost power. But automated switches prevented more than 118,000 customer outages, and the data generated across the impacted areas helped

us restore power to 98.7 percent of those who lost power by the end of the second full day of restoration.

Smart Grid Benefits



FPL received widespread thanks and appreciation for our work following Hurricane Matthew—and many customers saw the link between our performance and our investments. "FPL's re-posting and wiring of Cape Canaveral the past two or so years really paid off," wrote Bernie McShea of SpaceFlorida, a regional economic development agency. "We evacuated to Orlando but judging by the clocks our power was only out for about 2.5 hours, not bad at all for a major hurricane!"

* * * * *

FPL customers now can see the benefits of a smarter and stronger energy grid when they need us the most—and when they count on us for everyday reliability. FPL is now recognized as having the best comprehensive service reliability in the nation—nearly 50 percent better than the national average. We have improved our service by more than 25 percent in the last five years, with an overall electric service reliability of greater than 99.98 percent.

Today, when one of our service technicians knocks on a customer's door to address an issue proactively, the conversations go a lot more smoothly. All of our team members can explain how we understand our system better than we ever did before. And, our customers can see our passion and commitment for using our growing knowledge to serve them even better.

"The grid of tomorrow will be multi-directional and transactive. Grid modernization demands an innovative approach to DER investment and planning."

–ARLEN ORCHARD

Grid Modernization Will Help SMUD Reach Clean Energy and Reliability Goals to Benefit Customers

ARLEN ORCHARD
CEO and General Manager, Sacramento Municipal Utility District

Serving California's capital region, SMUD is on the front lines of the changes shaping the electric power industry. Modernizing the energy grid is an imperative, not an option, in Sacramento.

I am proud to report that SMUD is on track to meet the greenhouse gas reduction goals called for in California's Global Warming Solutions Act of 2005. Subsequent state legislation raised the stakes significantly, requiring SMUD and the state's other electric companies to have state-classified renewable resources account for 50 percent of their energy mix by 2030.

As environmentally progressive as we are at SMUD, the challenges are considerable:

- Declining load growth (due in part to the success of our energy efficiency programs), coupled with rising fixed costs;
- Technological advances presenting customers with cost-effective alternatives;
- Regulatory pressure to accelerate a low-carbon and distributed energy future; and
- Changing customer expectations.

Rooftop or private solar in SMUD's service territory climbed from 733 kilowatts in 2007 to a projected 140 megawatts (MW) by the end of 2016, a figure representing 5 percent of overall system peak. Our forecasts place the figure as high as 450 MW by 2020, at which point the high penetration may create locational operational challenges for SMUD's distribution system.

Given the expected increase of distributed energy resources (DERs), SMUD's distribution operators will need more visibility at granular levels to keep outage times low, protect equipment, and maintain grid reliability. New systems will enhance our ability to incorporate customer and third-party DERs safely, reliably, and economically while optimizing value for our customers and SMUD. Over the next few years, we will invest in an Advanced Distribution Management System, Distributed Energy Resources Management System, and Distribution SCADA to support grid modernization.

To complement these new systems, SMUD is testing smart inverter functionality with industry partners, including the Electric Power Research Institute. The automation of switches and upgrades to our communications network round out the investments SMUD is making to ensure we continue meeting reliability metrics for our customers in an increasingly distributed future.

Our ongoing investments in grid modernization build on the foundation SMUD laid in 2009 with the assistance of a $127.5 million smart grid grant from the U.S. Department of Energy. The scope of the $308 million *SmartSacramento®* project ranged from the installation of 617,000 smart meters and distribution automation to pilot programs that included plug-in electric vehicle charging stations, battery storage, and time-based rates.

Looking ahead, the expansion of DERs will render the one-way model of electricity generation, transport, distribution, and retail obsolete. The grid of tomorrow will be multi-directional and transactive. Grid modernization demands an innovative approach to DER investment and planning. With our customers' significant investments in DERs, SMUD is committed to helping leverage and optimize these investments to benefit our customers, our community, and our company.

Accordingly, SMUD is working on demonstration projects for distribution asset deferral by leveraging customer DER investments. This will help us to understand the system value of customer DERs considering our changing rate structures, customer demographics, and falling technology costs.

Our DER strategy aims for the following outcomes:

- SMUD will be the preferred energy services provider/ advisor to help customers reach their energy goals;
- SMUD will use strategic deployment of DERs to provide outstanding, cost-effective reliability, particularly with increased penetration of variable renewables such as solar;

- SMUD's business model will transition to create operational efficiencies and new net revenues;
- SMUD will leverage DERs to help meet its aggressive greenhouse gas reduction goals; and
- SMUD will enable customer choice and tailored solutions that provide value to all customers.

These strategies embrace distributed generation like private solar, but also extend to electric vehicles, energy efficiency, demand response, and distributed storage. SMUD's research and development efforts currently are centered on supporting DERs and grid modernization.

AMBITIOUS CARBON GOAL

10%
OF 1990 LEVELS
by 2050

SMUD's commitment to clean energy is part of our DNA. Shortly after Sacramento residents realized their goal of forming a community-owned utility in 1946, SMUD planned and built the 688 MW hydroelectric system that now meets 20 percent of our customer demand during peak hours. We were the first large California utility to meet the 20 percent renewable mandate, and more than 50 percent of our supply is now carbon-neutral. Additionally, SMUD has adopted the state's most ambitious carbon reduction goal, committing to reduce our emissions to 10 percent of 1990 levels by 2050.

SMUD recognizes that companies will transition to different business models to remain financially viable, while also meeting customer and regulatory expectations and embracing technological changes like DERs. Looking ahead, we see fundamental changes in the wholesale and retail sides of the business that will drive significant investments in information and communications systems, while also creating new market opportunities for SMUD, our customers, and third parties.

While the timing of investments in grid modernization and the transition to a more transparent and transactive grid will vary, we must remain mindful of meeting our obligations and our commitment to provide great customer service and reliable, affordable, and clean energy. SMUD looks forward to working collectively with all stakeholders in creating the new energy future.

"Distributed Low Voltage Regulators deployed on the electric company side of the meter bring new agility to the legacy asset base, unlocking value from DERs."

–NAIMISH PATEL

New Distributed Building Blocks Are Powering Grid Modernization

NAIMISH PATEL
CEO, Gridco Systems

Today's energy landscape is undergoing a fundamental shift driven by several trends. Distributed energy resources (DERs), including private rooftop solar PV and intelligent energy storage, are on the rise. Electric companies are implementing a growing mix of energy efficiency, demand response, and customer-focused renewable energy programs. New sources of customer demand, such as electric vehicles (EVs) and corresponding battery systems, are emerging. These trends are harbingers of a future in which our electric distribution system will evolve into a multi-service energy delivery platform.

The energy grid was designed and built over the past 100 years to support predictable, unidirectional power flows from centralized generation sources. The challenge of grid modernization is to convert that safe, reliable system into one that also can accommodate fast-changing bi-directional power flows, instantly balancing supply and demand to maximize capacity utilization while maintaining even higher levels of voltage and power quality.

It should come as no surprise that when industry leaders and visionaries look to the future, they see gaps in the mix of available solutions that hinder development of this customer-driven, flexible, sustainable energy grid. But those gaps are closing.

AGILITY TRANSFORMS THE GRID

It all starts with power electronics. The technology already has proven its value in commercial applications ranging from consumer electronics and lighting to energy-specific applications, including solar inverters. Distributed Low Voltage Regulators (DLVRs)—a new set of flexible distribution grid building blocks—use power electronics with intelligent software controls to simplify integration of renewables, increase energy efficiency, and support new load types, helping electric companies empower customers and drive clean energy initiatives.

These multi-function systems can be deployed where needed, offering fast response, local control, and plug-and-play integration. DLVRs essentially integrate automation capabilities previously reserved for substations into a single element that can be placed right where the action is—at the distribution transformer. These devices can be mass-produced cost-effectively using commercial electronics assembly processes, while offering easy installation and long, maintenance-free lifetimes.

In contrast to "wire-based" approaches, which basically increase capacity in an attempt to relieve all manner of system constraints, DLVRs deployed on the electric company side of the meter bring new agility to the legacy asset base, unlocking value from DERs and forming part of an emerging distribution system platform. It comes down to simultaneously controlling and regulating both capacity and voltage near the point where distributed resources connect. Electric companies now can use DLVR solutions to fill an important need left unaddressed by today's business-as-usual tools.

CREATING AN AGILE ENERGY GRID TODAY

Gridco Systems has pioneered development of DLVRs. In partnership with leading electric companies, Gridco is helping to create a smarter grid that can integrate more renewable and distributed generation, increase energy efficiency, and manage peak capacity, thereby improving system utilization and transforming the legacy grid in the process.

ENABLING MORE PRIVATE ROOFTOP SOLAR PV

One of the first challenges DLVRs are helping to address is increasing renewable energy hosting capacity in the distribution grid. Hawaiian Electric uses Gridco DLVRs to integrate increasing amounts of private rooftop solar PV, supporting the company's goals to triple distributed generation on its system by 2030 and to achieve 100 percent renewable energy by 2045.

Hawaiian Electric leads the nation in residential PV per capita. However, because private solar systems provide little or no information to system operators, maintaining reliable power delivery is difficult. A PV-saturated circuit strains the energy grid by adding electricity when demand isn't there, raising circuit voltage in the process. Starting early in 2015, pole-mounted DLVRs began to alleviate voltage issues in Hawaii. The devices enable Hawaiian Electric to identify high-voltage or reverse power flows when they arise, and actively regulate voltage at locations as needed. As a result, the distribution system's PV hosting capacity continues to increase at the lowest overall cost.

Duke Energy and National Grid are using DLVRs in areas of high private solar penetration in the Carolinas and Massachusetts, respectively, mitigating voltage side effects of these DERs and gaining better understanding in the

process. The DLVRs dynamically regulate voltage and allow customer inverters to transmit power onto the energy grid without impacting the voltage performance of neighboring customers.

INCREASING ENERGY EFFICIENCY

Electric companies also have an eye toward linking DLVRs into energy efficiency programs, in particular Conservation Voltage Reduction (CVR), where energy consumption can be reduced by delivering power at a lower, but acceptable, voltage level. In Ohio, for example, Duke leverages DLVRs to assure voltage compliance at particular locations that otherwise would limit program benefits. Combined with existing automation systems, DLVRs help companies to increase energy savings per circuit while lowering customer energy bills and reducing greenhouse gas emissions.

SUPPORTING TRANSPORTATION ELECTRIFICATION

A number of electric companies are investigating how DLVRs can play a role in managing other resources and loads, such as EV chargers, in order to improve system capacity utilization. California's Roadmap to 1.5 million zero-emission vehicles by 2025 is another example where simple wire-based upgrades will not be sufficient. Distributed controls that can help to manage third-party assets, while also providing visibility to the grid operator at the system level, will play a key role.

GRID MODERNIZATION GETS DISTRIBUTED

As more states chart new policy paths toward defining the electric company of the future, and technologies such as renewables, storage, and EVs jockey for position in the marketplace, the path to grid modernization is hard to predict. But quietly, away from the clamor of the daily energy news cycle, new distributed automation systems are emerging that combine intelligence and control with sensing and communications.

DLVRs are now in use at more than 20 electric companies worldwide, proving that they can meet the safety, reliability, security, and cost-effectiveness requirements for specific near-term needs, while also helping to increase private solar PV hosting and to optimize energy efficiency programs. By bringing electric company-managed automation close to where distributed resources are deployed, a simple and highly scalable platform is emerging. DLVRs and related systems may very well be the next key building blocks powering the distributed, modernized energy grid.

"A critical success factor in working with DERs is having an underlying software platform capable of optimizing these resources while coordinating their operations with conventional grid systems."

–ARTHUR "BUD" VOS

The Power of Distributed Energy in a Modern Energy Grid

ARTHUR "BUD" VOS
President and CEO, Enbala Power Networks

A new solar installation goes live in the United States every 2.5 minutes.[1] Led by solar and wind energy, renewables accounted for 87 percent of new U.S. electricity generation capacity in Q1 of 2016.[2] Electric companies must deal with the increasing amounts of these variable distributed energy resources (DERs) and the operating and reliability concerns they present.

DISTRIBUTED ENERGY RESOURCES: THE CHALLENGE AND THE SOLUTION

There are several trends driving the rapid adoption of DERs as a means to meet the world's energy supply and environmental goals. The cost of popular renewable energy options are dropping rapidly. State renewable energy mandates and grid security concerns also have spurred policy changes that recognize the value of DERs as an integral component of the energy grid. New York's Reforming the Energy Vision (REV) initiative is at the forefront of this movement, and at least 21 states have DER-related regulatory or legislative initiatives underway.[3]

Given these trends, electric companies, using sound business acumen, are embracing new business models that view DERs as financially viable investments. Forward-thinking electric companies regard DERs as opportunities to move beyond traditional regulation and toward new revenue streams, based on performance-based incentives and service fees, while deferring capital investments. Some companies are investing in businesses that sell or service DERs, while adopting software technologies needed to manage a more DER-rich energy grid.

IT'S ALL ABOUT CONTROL

The coming years will bring more solar, wind, and battery storage—more of everything. Enbala has learned to leverage DERs as network-stabilizing resources through its work with electric companies and grid operators. A critical success factor in working with DERs is having an underlying software platform capable of optimizing these resources while coordinating their operations with conventional grid systems.

With recent technology advances, this coordination is being put to the test around the world to support renewable energy firming, to address voltage degradation, to improve DER hosting capacity, and to defer the need for substation investments. DERs also are supporting the wholesale system, providing fast demand response, operating reserves, and frequency regulation.

FINDING ENERGY BALANCE–CASES IN POINT

Enbala is working with New Brunswick Power (NBP) to achieve a goal of generating 40 percent of NBP's portfolio from renewable energy by 2020. NBP has worked with Enbala to implement a renewable firming application that connects some 2,000 DER assets—primarily HVAC and municipal water pumping stations—to the energy grid. The network of participating load allows NBP to use this network as a single, dispatchable resource to manage variability in renewable energy output.

PJM Interconnection is a grid operator that used DERs to achieve its goals of increased system reliability and efficiency. Working with retail customers and others, PJM leveraged DERs to develop 12,314 megawatts (MW) of demand response and energy-efficiency resources for the 2017/2018 delivery year.

In Europe, Enbala is working with an electric company that leverages DERs as an aggregated virtual power plant (VPP). The VPP enables DERs to participate in electricity markets, enhances system reliability and efficiency, and increases customer participation in demand-side management.

INFRASTRUCTURE INVESTMENT DEFERRAL

As DERs become more ubiquitous on the energy grid, supply and demand will respond to each other dynamically. Enbala is working with two large electric companies—one on the West Coast and one in Canada—on non-wires alternative grid stability projects. In the West Coast project, DERs are aggregated, optimized, and controlled to enable Volt/VAR optimization, optimized power flow, and microgrid control. In Canada, we're partnering with a large hydroelectric company on a capital deferment project that leverages 8 to 10 MW of flexible load from commercial and industrial facilities to keep substation loads below peak thresholds.

THE ELECTRIC COMPANY'S PATH FORWARD

As we evolve beyond demonstration projects into the mainstream, Enbala believes the industry will experience three major waves on this growth path.

Wave One will be the proliferation of a distributed control system that utilizes smart inverters to manage voltage. This will allow DER penetration to grow beyond the 20 percent system limit some electric companies place on solar penetration. Smart inverters can increase the grid's hosting capacity for DERs and for proactively addressing voltage degradation. Using new

technologies and methods, Enbala has modelled lines with up to 200 percent solar capacity compared to the feeder load. In the model, smart inverters are managed to minimize line losses and to maintain voltages within constraints. Voltage performance actually improves as DER penetration increases, and, at 200 percent capacity, the need for tap changers and static capacitors almost is eliminated, because there is enough inverter capacity to deliver the reactive power needs of the entire feeder.

Wave Two takes DER management to the distribution side of the grid, using customer-sited resources to smooth load and to provide local firming for variable resources. This also reduces marginal losses and grid volatility. For example, if a large solar panel stops generating for a short time, the conventional system would increase the capacity on a remote generator. This is inefficient. Wave 2 will firm variability by managing load and storage devices locally. For example, if a solar array stops producing energy, a local shopping center can react by reducing its use of air conditioning, provided this can be done without exceeding temperature constraints.

Wave Three will optimize the overall supply with the operation of distributed resources. Central generation and transmission systems perform best at an optimized level. Current practices, where generation follows load, result in operating generation at suboptimal levels, and, at the same time, running the transmission system at near 50 percent of its peak capacity, on average. By utilizing managed loads, local storage, and DER controls, the transmission system can be operated at a higher average capacity factor, and generation levels can be closer to the optimal values, while meeting all of the key needs and constraints of the users.

UNLEASHING THE OPPORTUNITY

Distributed energy resources are here to stay … and to proliferate. Combining many different types of DERs—renewables, loads, smart inverters, and storage devices—into one centrally coordinated network offers a high degree of precision in demand management. It also results in large customer and electric company savings; enables a more reliable and secure energy grid and provides significant environmental benefits. The industry is making big strides in leveraging DERs to enable a brighter energy future. In continuing to walk down this path, we'll be able to look back a few years from now and say, "Look what we've accomplished together!"

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"With a cloud-based management platform that effectively automates the creation of virtual power plants, electric companies can draw on them to better manage supply."

–KEN MUNSON

The Energy Cloud

KEN MUNSON
Co-Founder and CEO, Sunverge Energy

The energy grid is transforming into an intelligent network, host to the emerging "Internet of Things." Yet, while millions of people live in "smart" homes and many more install private or rooftop solar panels, the energy grid today still is largely a one-way system for delivery of centrally generated electricity. Increasingly, distributed energy resources (DERs) like energy storage are a catalyst for grid transformation, changing both the traditional electric company business model and the ways in which customers interact with their electric company, and other energy providers.

The immense amount of data now collected by grid-connected devices will provide information that allows homeowners, electric companies, and new market entrants to provide energy more efficiently and to execute complex market decisions automatically. Such information is transforming customers from being just consumers to being both consumers and suppliers. And it offers electric companies the challenge of providing customers with premium value-added services in addition to their delivery and power supply functions, a business that has a lot in common with Silicon Valley.

DERs are proliferating. In Northern California alone, a new residential PV array is deployed every seven minutes. Behind-the-meter storage will become an integral part of some of these DER installations, along with the intelligence to manage the system.

Sunverge has been partnering with forward-thinking investor-owned and municipal electric companies as they begin to reimagine themselves and the energy grid for the decades ahead. Already, they are taking advantage of three key developments driving this transformation.

1. An exponential increase in behind-the-meter storage. Storage technology today is a nascent market, but it's growing rapidly as costs come down. A recent report by Bloomberg New Energy Finance projects $44 billion will be invested in storage from now to 2024, with 64 percent of that behind-the-meter.[1]

Part of this demand is driven by the installation of private or rooftop solar and other generation by customers. It's a natural fit—storage both increases the reliability of the DER and maximizes its value, capturing power that otherwise would go unused. Storage also offers reliable backup power and savings opportunities, as customers draw power from the energy grid at times of low demand, and tap storage when demand is higher. That's the basis of a pilot we're conducting with the Glasgow Electric Plant Board, a municipal power partner in Kentucky.

Policy makers are driving this demand as well. California just enacted AB 1637, doubling funds available for residential DER, including storage, over the next two years and mandating a significant increase in storage deployment.[2]

2. Virtual power plants go mainstream. An individual storage installation may be fine for an individual customer but likely isn't large enough to be of interest to an electric company. That changes when power from a critical mass of DERs is aggregated and treated as a single source, a virtual power plant (VPP). With software to manage VPPs, electric companies can draw on them to better manage supply, reducing the need to start peaker plants.

Sunverge is involved in a number of VPP pilot projects, including one with Con Edison launched this past summer that eventually will involve more than 300 New York households and integrate 1.8 megawatts of solar power and about 1.8 megawatts of battery storage. That makes it the largest residential distributed energy storage program in the nation.

3. Development of markets for excess DER power. As customers deploy more DERs and more advanced storage capacity, they may seek to sell or trade what they don't self-consume. This could lead to creation of a local market for excess power offered by individual sellers or VPPs. Buyers might be other customers, brokers, or the local electric company. Individual users would need to rely on automation and a trusted partner to deal in this market.

None of this will happen, however, without deploying advanced intelligence to manage the energy grid's physical assets and for automation. This requires a cloud-based platform to maintain standards for connection and coordination, provide vital shared data, coordinate decision making among participants, and manage the movement of power on the grid. This is where we see a new electric company service model taking shape.

Southern California Edison sees electric companies as "Distribution System Operators" that manage a plug-and-play grid, in which customers and suppliers can participate seamlessly.[3] In that role, electric companies might offer things like storage as a service, for example. In such a service-based market, tracking resources, pricing, and dynamic bidding will exceed the reach of individual customers, who will pay to have intelligent decisions made for them.

Sunverge is focusing its efforts on creating the centralized intelligence for such a market, with a cloud-based management platform that effectively automates creation of VPPs and extends it with predictive analytics.

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We are moving rapidly to an intelligent energy future that will create tremendous opportunities and benefits. This won't be an overnight transformation; it will take time, continued innovation, and new approaches to regulation. But it is, we believe, the future.

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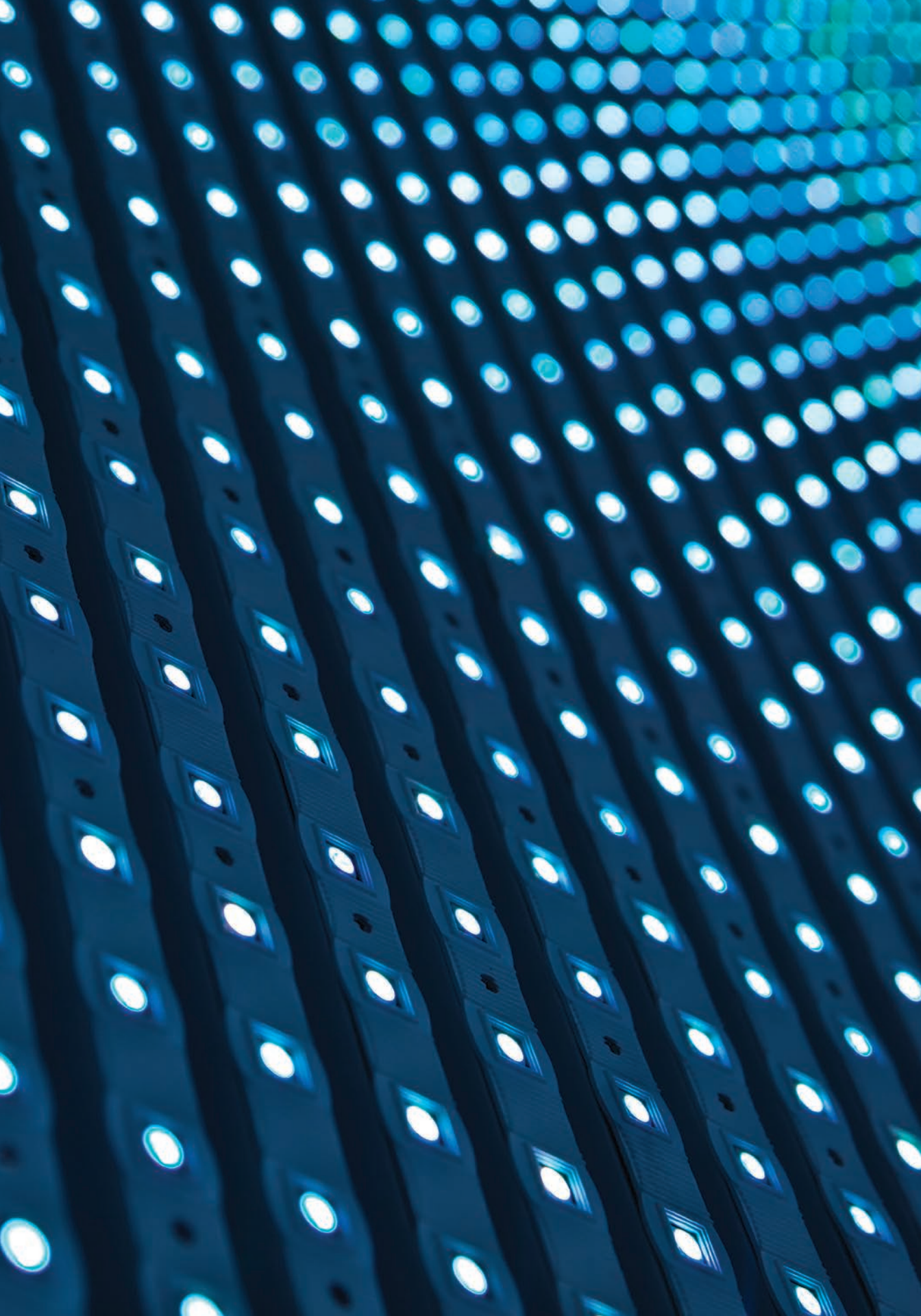

About the Institute for Electric Innovation

The Institute for Electric Innovation focuses on advancing the adoption and application of new technologies that will strengthen and transform the energy grid. IEI's members are the investor-owned electric companies that represent about 70 percent of the U.S. electric power industry. The membership is committed to an affordable, reliable, secure, and clean energy future.

IEI promotes the sharing of information, ideas, and experiences among regulators, policy makers, technology companies, thought leaders, and the electric power industry. IEI also identifies policies that support the business case for the adoption of cost-effective technologies.

IEI is governed by a Management Committee of electric industry Chief Executive Officers. In addition, IEI has a Strategy Committee made up of senior electric industry executives and a select group of technology companies on its Technology Partner Roundtable.

About the Edison Foundation

The Edison Foundation is a 501(c)(3) charitable organization dedicated to bringing the benefits of electricity to families, businesses, and industries worldwide. Furthering Thomas Alva Edison's spirit of invention, the Foundation works to encourage a greater understanding of the production, delivery, and use of electric power to foster economic progress; to ensure a safe and clean environment; and to improve the quality of life for all people. The Edison Foundation provides knowledge, insight, and leadership to achieve its goals through research, conferences, grants, and other outreach activities.

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