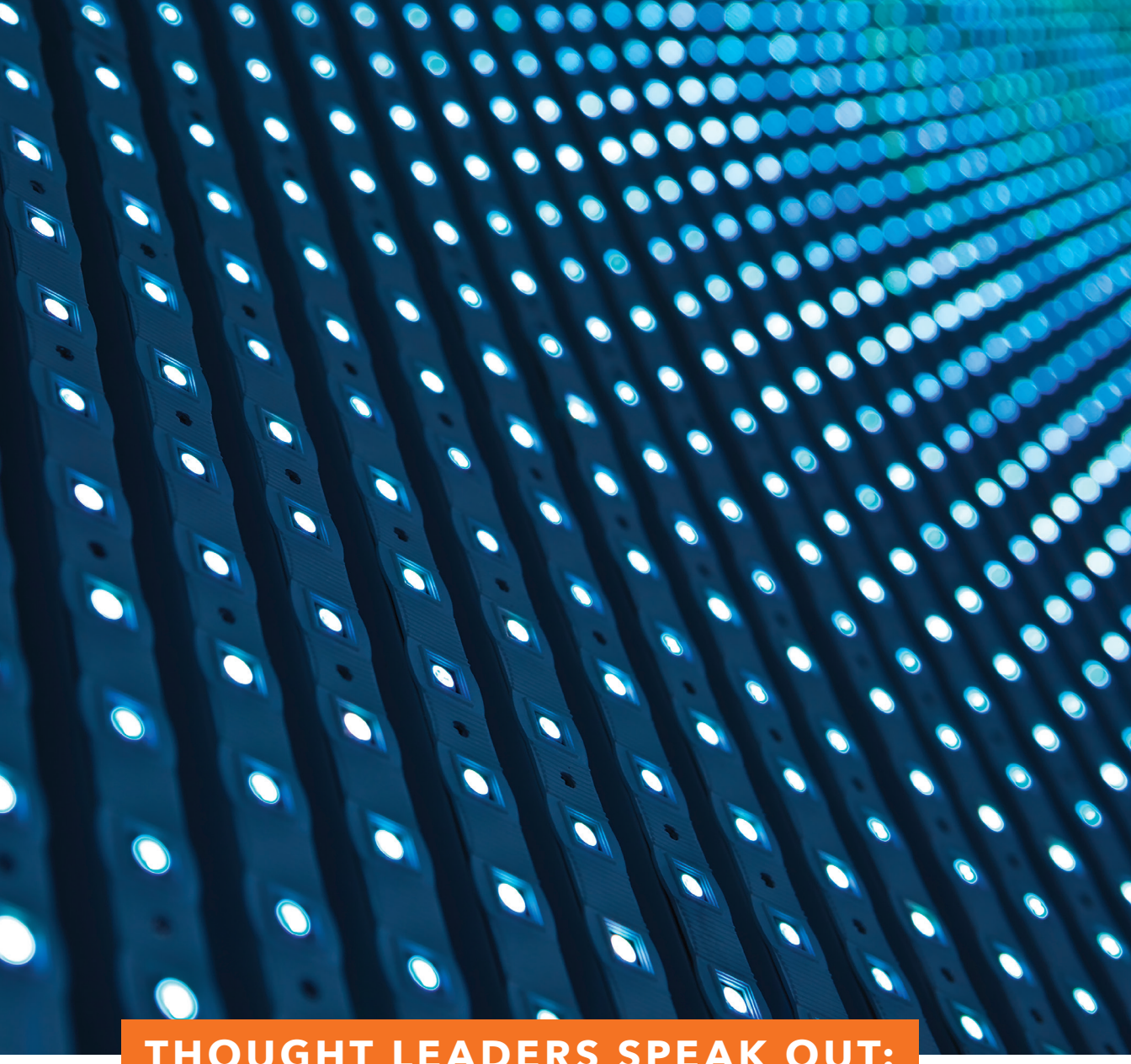
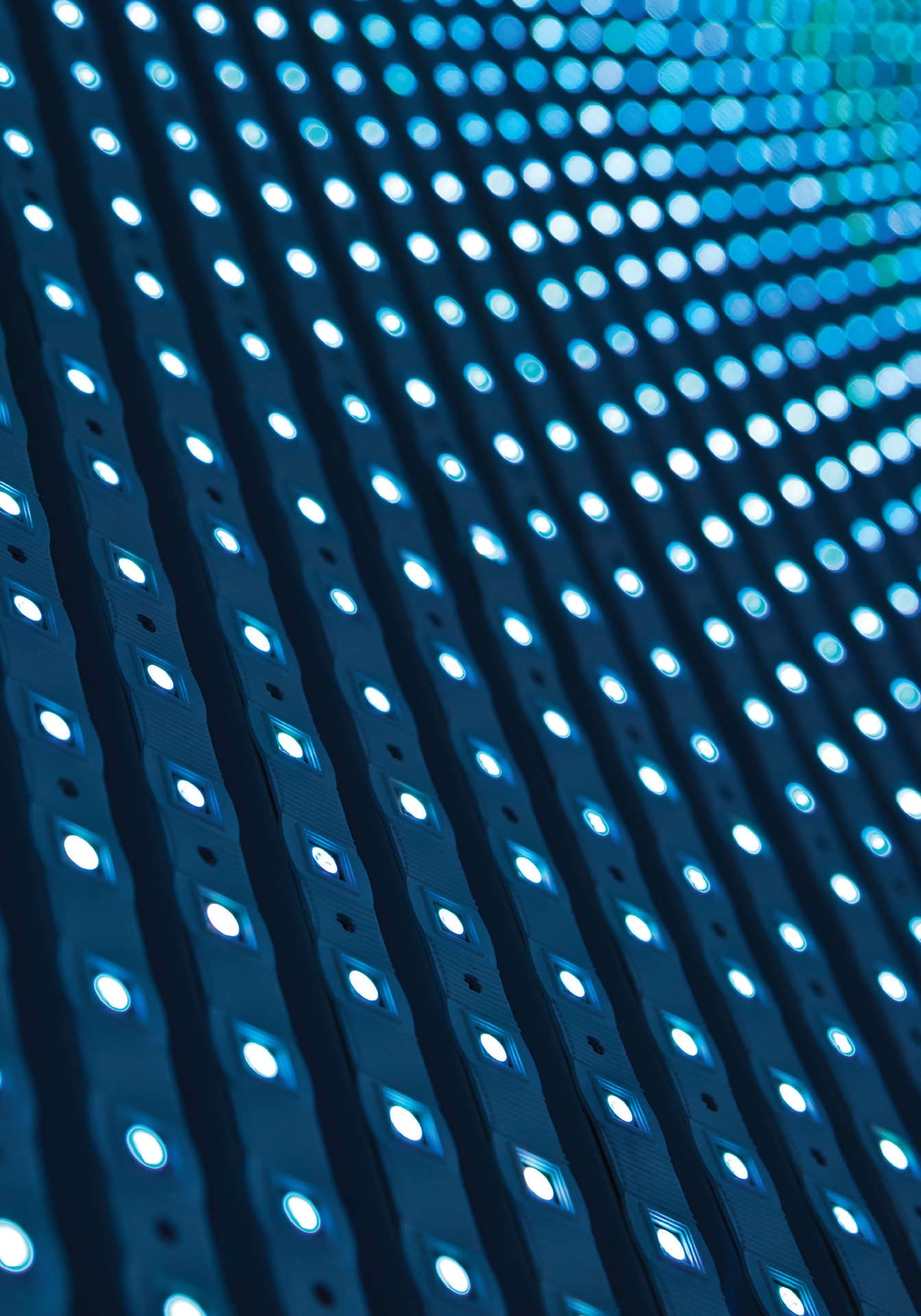


THOUGHT LEADERS SPEAK OUT:

Key Trends Driving Change in the Electric Power Industry

The Edison Foundation
INSTITUTE for ELECTRIC INNOVATION



THOUGHT LEADERS SPEAK OUT:

Key Trends Driving Change in the Electric Power Industry

Edited by:

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

with

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"As this transition unfolds in the regulated electric power industry, it is about balancing affordability, reliability, clean energy, and individualized customer services."

–LISA WOOD

Introduction

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

America's electric utilities—which provide the critical infrastructure that enables all other infrastructures—are at the beginning of a profound but quiet transformation. That transformation, more evolutionary than revolutionary, is largely invisible but it is underway and is being driven largely by:

- Technological innovation;
- Federal and state policies that favor competition in some aspects of providing electricity service;
- Regulation of the non-competitive components of electricity service; and
- Changing customer needs and increasing expectations.

KEY TRENDS DRIVING CHANGE

Three "megatrends" are at the core of this transformation.

The transition to a clean energy future

The energy mix we use to generate electricity is changing. By investing in renewable energy, transitioning from coal to natural gas, and pursuing energy efficiency, the U.S. electric power industry has already reduced carbon dioxide emissions 15 percent below 2005 levels; other emissions have also been reduced. At the same time, modernization and digitization of the grid enables the integration of more carbon-free renewables, both large-scale and distributed. In fact, we expect exponential growth in solar over the next decade, in all sizes. Wind energy, already competitive with other fuels, is projected to increase substantially as tower heights increase to produce more energy. Today, the electric power industry is the largest investor in carbon-free renewable energy in the U.S.

A more digital and distributed grid

The power grid itself is changing, becoming "smarter" by virtue of a digital communication overlay, with millions of sensors that will make the grid more controllable and potentially self-healing. The electric power industry is investing more than $20 billion per year in the distribution grid alone, which will enable the connection of distributed energy resources as well as devices

in our homes and businesses. Many of these resources and devices will interact with the grid, resulting in more efficient grid operations. The digital grid is evolving into a multi-path network of power and information flows that will use data analytics for grid management and optimization from end-to-end.

Individualized customer services

As the grid becomes increasingly digital and distributed, customization of services for electricity customers will continue to grow. Here are some examples. Large commercial customers increasingly want renewable energy to meet their corporate sustainability goals. Cities and towns are requesting customized services such as help with micro-grids, smart city services, or renewable energy. Some residential customers want rooftop solar to generate their own electricity. And, residential customers increasingly want to manage their energy use using connected devices like iPhones and Nest Learning Thermostats, and through web-based platforms. At the same time, for many, many customers, safe, reliable, and affordable electricity will continue to be the preferred service option.

Although these mega-trends are driving change, it's important to recognize that the speed of transformation will depend to a great extent on whether regulation evolves to accommodate these changes. Just as the business model of electric utilities must change because the power mix is undergoing transformation, the grid is more complex, and customers have different expectations, so too must the regulatory model change. Regulation will have to provide a glide path for utilities to achieve corporate and policy goals, while also setting incentives and penalties for utilities based on meeting agreed-upon performance objectives.

THE NEXT DECADE

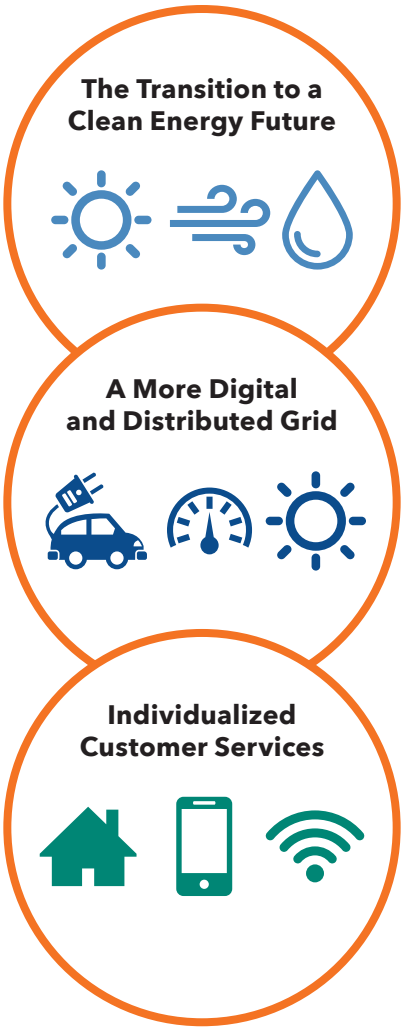
Many of us would agree that, a decade from now, the U.S. electric power industry and energy services will look something like the following:

- We will have a cleaner electricity generation mix, with lower carbon emissions;
- The power grid will increasingly integrate a mix of central and distributed resources;
- The grid will become more digital, more controllable, and more interconnected. PG&E aptly calls this the Grid of Things™;
- A mix of entities—both utilities and other companies—will provide distributed energy resources both on the supply side and the demand side; and
- Suppliers—both utilities and others—will offer customers a wide range of individualized and customized services.

Ultimately, as this transition unfolds in the regulated electric power industry, it is about balancing affordability, reliability, clean energy, and individualized customer services. This is largely the job of regulators and other policy makers. But the ultimate challenge is to make this transition of the electric power industry affordable to all Americans! And this is the job of all stakeholders.

* * * * *

The authors of the essays that follow provide their unique views on the three key trends that underpin the profound transformation of the electric power industry—increasingly clean electricity generation; a more digital and distributed grid; and individualized customer services. These essays are an important addition to the conversation.



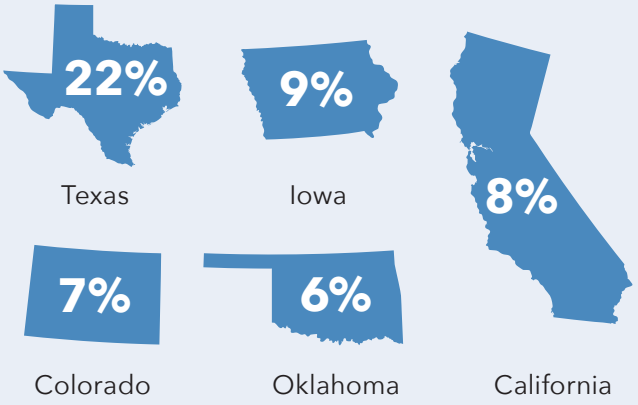
Fact Sheet: Transition to a Clean Energy Future

National Power Generation Mix

	COAL	NATURAL GAS	NUCLEAR	HYDRO AND OTHER RENEWABLES	OTHER
2005	49.6%	18.8%	19.3%	8.8%	3.7%
TODAY	38.6%	27.5%	19.5%	13.2%	1.4%

Wind

5
STATES
generate
MORE THAN
50%
of wind energy
nationwide



Solar

Over the
past 2 years,
SOLAR CAPACITY ALMOST
doubled
in the U.S.

SOLAR
accounted for
28%
of all capacity
additions in
the last year

U.S. Installed Solar Capacity

2011
3.9GW

2015 Q2
19.6GW

CHAPTER 1

TRANSITION TO A CLEAN ENERGY FUTURE

Electric utilities have moved with vision and agility, away from carbon-based fuels and toward carbon-free and low-carbon resources in a very short time, and ahead of policy mandates. In just ten years, the nation's power generation mix has changed dramatically—adding significant amounts of natural gas, wind, and most recently solar. The authors of the essays in this chapter not only examine the transition toward a clean energy future but point to the fact that it is well underway.

The Southern Company is on the cutting edge. As CEO Tom Fanning's essay makes clear, Southern has cut its coal use from 70 percent to 36 percent, while quadrupling its natural gas use from 11 percent to 46 percent. Also, it has added or announced 3,600 megawatts of renewable energy projects since 2012.

Nancy Pfund and Mark Perutz of DBL Partners, a sustainability-oriented venture capital firm, focus on the clean energy transition, observing that advances in software are "eating [the grid] from the edge"—the space between the distribution system and the customer. The grid edge is where innovation will uncover previously undiscovered clean resources, both on the supply and demand side.

Xcel Energy Vice President Frank Prager is proud of the wind energy in the company's mix. Renewables comprise more than 20 percent of Xcel Energy's energy portfolio, most of it wind. "We have more than 5,700 megawatts of wind power on our system today," he says. In fact, Xcel Energy has been the nation's top utility provider of wind energy for 11 years, as wind displaces millions of tons of carbon dioxide (CO_2) and protects Xcel customers from variable natural gas prices.

Finally, SunPower CEO Tom Werner focuses on the exponential growth in solar energy, the fastest-growing source of renewable energy in the U.S. Already solar reduces CO_2 emissions by 23.5 million metric tons each year—the equivalent of taking 4.9 million cars off the road. He urges focus on R&D to drive down costs further.

"If we embrace the challenges presented by a changing fuel mix and an increasingly cleaner generation portfolio, we will have succeeded in delivering value to customers."

–THOMAS A. FANNING

Using the Full Energy Portfolio

THOMAS A. FANNING
Chairman, President and CEO, Southern Company

Southern Company's commitment to providing a full portfolio of energy resources—including nuclear, natural gas, a lignite-fired integrated gasification combined-cycle (IGCC) carbon capture and storage (CCS) project, wind and solar energy and other renewable energy, as well as energy efficiency and demand response—to our customers remains paramount. The Southern Company has always been laser-focused on providing the best combination of safe, reliable, affordable, and environmentally responsible energy to the people and businesses we serve.

Our shift from coal-based generation to natural gas has been fundamental and significant, and has resulted in greater availability and lower prices. Where ten years ago the Southern Company system relied on coal for about 70 percent and natural gas for about 11 percent of our generation, we are now at about 36 percent coal and 46 percent natural gas. For a company that serves more than 4.5 million customers, that is a remarkable turnaround in a short period of time.

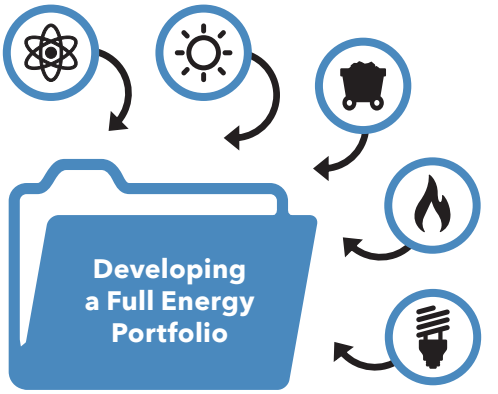
Nuclear energy, which today provides 63 percent of America's emission-free electricity, must be a dominant solution in a lower-carbon world. We are, through our Georgia Power subsidiary, constructing two new units at Plant Vogtle, which when complete, will supply enough safe and emission-free electricity to serve a half-million homes and businesses. These new nuclear units are expected to offer economic benefits to our customers and, in view of the goal of the Environmental Protection Agency's Clean Power Plan, will discharge no carbon into the atmosphere, as compared with what gas-based or coal-based plants of equivalent size would have emitted. We need more nuclear in America and in the world, but not every utility can build nuclear generation: it takes scale, operational credibility, a strong balance sheet, cooperative regulation, and financial integrity.

Coal use is on the decline in the United States, but coal still is used to provide more than one-third of the nation's electricity and is widely deployed elsewhere around the world. The IGCC coal gasification facility being built by our Mississippi Power subsidiary represents a way to keep coal viable while capturing most of the emitted carbon and using it for enhanced oilfield recovery. This Kemper County energy facility is designed to produce electricity from locally mined lignite with 65 percent carbon capture—a carbon profile better than a similarly sized natural gas plant. In countries with high natural gas prices and significant coal reserves, such as in Eastern Europe and Asia, the IGCC technology we are pioneering could contribute to a global solution that is good for customers and for the environment.

Renewable energy is also an important and fast-growing part of our full portfolio. Across the Southern Company system, we have added or announced more than 3,600 megawatts of renewable energy projects since 2012. That includes solar and wind facilities in six states, one of the nation's top biomass plants and, in Georgia, the largest voluntary solar program of any state.

The Southern Company system is also partnering with all four major branches of the United States military to develop renewable energy projects both on- and off-base. To date, that includes 11 solar projects totaling 310 megawatts. As Dennis McGinn, Assistant Secretary of the Navy, Energy, Installations and Environment, said about the Naval Submarine Base at Kings Bay, Georgia, such efforts have many benefits, including physical security, energy diversity, and regional resiliency.

All this activity underscores our belief that customers' energy needs are best met by a balanced portfolio of electricity generation resources, each of which offers its own distinct advantages.



Our vision of the balanced portfolio also embraces energy efficiency. If we can produce and deliver electricity more efficiently and help customers use it wisely, we can do more to harness energy's great potential to grow the economy and improve people's standard of living. Among the ways we do this is by partnering with

customers—for example, helping businesses and local governments switch to high-efficiency LED lighting systems, which have longer life spans and much reduced energy requirements as compared with conventional lighting. We also offer customers who drive electric vehicles lower electricity rates for off-peak usage to save on their charging costs. These kinds of solutions make a real difference for customers.

Developing the full portfolio is a central component of our broader commitment to strengthening a culture of innovation at Southern Company. Initiatives such as SO Prize—a recent internal ideas competition—and the new Energy Innovation Center in Atlanta seek to engage all of our employees and are driven by a desire to deliver the best reliability, the lowest prices, and the cleanest technologies for the benefit of our customers. It's about integrating new thinking in how electricity is used in homes, businesses, and factories. If we embrace the challenges presented by a changing fuel mix and an increasingly cleaner generation portfolio, we will have succeeded in delivering value to customers. That is where our focus is and should be—transforming our business to benefit our customers.

"With respect to the power grid, software is eating it from the edge, as distributed energy resources of both energy supply and demand are bringing the grid from its cable TV past into its Internet future."

–NANCY PFUND & MARK PERUTZ

Modernizing and Decarbonizing the Grid From the Outside In

NANCY PFUND
Managing Partner, DBL Partners

MARK PERUTZ
Partner, DBL Partners

As venture capital investors in the energy sector, the biggest (and still accelerating) change that we've seen to the power grid over the past decade is the transformation from a centralized broadcast-based system like cable TV to a network-based system like the Internet. This transformation is largely driven by the dramatic evolution happening at the edge of the grid: behind-the-meter customer proliferation of new distributed energy resources and the growing application of energy-saving software. To borrow a phrase from Marc Andreessen, software is eating the world.[1] With respect to the power grid, software is eating it from the edge, as distributed energy resources of both energy supply and demand are bringing the grid from its cable TV past into its Internet future.

The first digitization wave of behind-the-meter resources began with smart meters (introduced by companies like CellNet, Itron, Silver Spring and eMeter), which opened the door to myriad policies, programs, and applications. Some of them are still at an early stage, including: time-of-use rates, net energy metering, demand charges, demand response, and energy disaggregation diagnostics.

The second behind-the-meter digitization wave is the accelerating rollout of the Internet of Things (IoT) in homes and businesses.

Adoption of IoT in homes (introduced by companies like Google/Nest and Apple) is likely to be driven by the homeowner's desire to have control over all her home appliances, lighting, temperature, media and home security from a mobile phone, as well as for energy choice (particularly clean energy), rather than by her desire to

help modernize the grid. It will, however, have just that valuable side effect by enabling the widespread deployment of automated demand response—an often unnoticeable demand adjustment that will neatly and automatically help to balance supply and demand on the grid while providing energy bill savings to the homeowner. IoT in the home will also enable effective integration of electric vehicles (EVs), eventually allowing large-scale distributed EV charging and discharging to help stabilize the power grid.

The rollout of IoT in businesses is likely to be driven by the motivation to reduce energy costs. By using sensors and software to measure and see their energy usage profile, businesses can execute an informed deployment of solar, storage, load reshaping, and energy efficiency retrofits to evolve their facilities into "hybrid-electric" buildings that reduce their electricity bills and optimize comfort for building occupants, while having the key side effects of improving grid operation and facilitating achievement of state-level renewable energy targets and energy conservation goals. This commercial behind-the-meter evolution (introduced by companies like Advanced Microgrid Solutions, Stem, SCIEnergy, Enbala, and Renew Financial) brings these benefits to the power grid: peak shaving by automated demand response (obviating the need to retain old or build new fossil-fueled peaker power plants), new dispatchable capacity, avoidance or deferral of transmission and distribution upgrades, mitigation of energy islanding, and integration of renewables and EV charging. Case in point: In October 2015, for the first time, energy storage resources aggregated across multiple commercial buildings were bid into the California ISO real-time market as a demand response resource.

The grassroots proliferation of distributed energy resources—supported by software and IoT in behind-the-meter deployments—is crucial to the transformation from a centralized to a networked power grid. Generating renewable energy close to load is the most efficient and sustainable approach to establishing a flexible power grid for the future, and complements utilities' larger centralized power plants. This combination of distributed and centralized generation will help reduce the need for new transmission and distribution (T&D) infrastructure.

Obtaining permitting and public support for new T&D infrastructure is challenging, and contributes to rising grid operating costs on customer bills. In 2014, separate studies of the effects of behind-the-meter solar generation conducted for the Nevada PUC and for the Mississippi PUC—although controversial and much debated—found that distributed solar provided a net benefit for all

ratepayers, both those with and without solar. The net benefit in both cases was driven by savings on the cost of energy and generation capacity, savings on maintenance and upgrades to transmission and distribution infrastructure, and reduced transmission losses.

The strong desire of consumers and brand-conscious businesses to play an active role in producing and consuming clean energy is an added driver toward the growth of distributed renewables. This is reflected in the sizeable and growing renewable energy goals of state governments. For example, in October 2015, California increased its renewable energy mandate to 50 percent renewables by 2030. Finally, when the scale of job creation from the deployment of distributed energy systems is taken into account, along with health benefits resulting from fewer fossil fueled power plants under the Obama Administration's Clean Power Plan, and the environmental benefits of reduced greenhouse gases, the benefits of a future with both utility-scale and widely deployed distributed renewable resources becomes even clearer.

The fundamental construct of the power grid, which has remained remarkably unchanged for most of the past century, despite tremendous advances in nearly every other industry, is now transforming from a rigid, unidirectional, and centralized system to a more flexible, networked system. This transformation is powered in large part by customers' new behind-the-meter approaches. Innovative private and public companies are tapping into a variety of motivations to sell IoT software and distributed energy resources to homeowners and businesses, and to evolve the power grid, beginning at the grid edge.

Continuing this evolution inward from the grid edge will require some regulatory changes, such as allowing utilities to purchase (and add to the rate base) infrastructure-as-a-service, rather than only adding infrastructure via capital expenditures. By purchasing operational services such as capacity, power quality, voltage control, and frequency support from the grid edge, and by adding software at the utility level to manage this infrastructure-as-a-service on demand, utilities could lower their costs and increase the overall resiliency of the grid.

* * * * *

Going forward, everyone will benefit when utilities, regulators, energy companies, and software companies work together to extend this transformation from the grid edge throughout the entire electric system for a power grid that is more robustly and efficiently designed for the 21st century.

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1. Marc Andreessen, *Why Software Is Eating The World*, The Wall St. Journal, Aug. 20, 2011. *Available at* http://www.wsj.com/articles/SB10001424053111903480904576512250915629460.

"Xcel Energy's strategy to decarbonize rests on three principles: renewable energy leadership, system modernization, and sound regulatory policy."

–FRANK PRAGER

Clean Energy is Good Business

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

Xcel Energy, which serves Minnesota, Colorado, the Texas Panhandle, and parts of five other states, is located adjacent to some of the best wind energy resources in the nation. Beginning in 2005, we committed to a path of clean energy and environmental leadership. Ten years later, we have reduced our carbon dioxide (CO_2) emissions by more than 20 percent and are on track to achieve a 30-percent reduction by 2020. Our strategy to decarbonize rests on three principles: renewable energy leadership, system modernization, and sound regulatory policy.

RENEWABLE ENERGY LEADERSHIP

Renewable energy now makes up more than 20 percent of Xcel Energy's energy portfolio, with the majority coming from wind. We have more than 5,700 megawatts of wind power on our system today and have been the nation's number one utility provider of wind energy for 11 years.

Our wind portfolio has displaced millions of tons of CO_2 while protecting our customers from the risk of volatile natural gas prices. In the last several years, we have acquired new wind energy at prices below the cost of the next-best natural gas alternative. This wind energy acts as a hedge against volatile gas prices, while saving our customers money today.

Xcel Energy has adapted its system to accommodate this extraordinary amount of renewable energy resources. Working with the National Center for Atmospheric Research, we developed forecasting expertise that enabled us to integrate unprecedented amounts of wind energy. On October 2, 2015, 54 percent of the electricity supplied to our Colorado customers was generated by wind energy for the entire day.

Customers want renewables in their energy mix, and we're happy to oblige. Our renewable energy portfolio is growing and helping to reduce CO_2 emissions at low cost.

SYSTEM MODERNIZATION STRATEGY

Xcel Energy began modernizing its generation resources over a decade ago. In Minnesota, we implemented the Metro Emission Reduction Project (MERP), which retired aging coal-fired power plants and replaced them with efficient natural gas facilities. We worked with our stakeholders, including customers and environmental groups, to craft a plan that reduced emissions and met the needs of the community.

In Colorado, we followed a similar approach. In 2010, the Colorado Legislature passed the Clean Air-Clean Jobs Act (CACJA), requiring Xcel Energy to develop a plan for reducing emissions. By 2018, we will have retired or switched to natural gas more than 1,000 megawatts of coal-fired generation. As with the MERP, CACJA grew from a collaborative effort. We took advantage of changes in the natural gas marketplace to reduce CO_2 emissions from our Colorado operations with minimal cost increases to customers.

Our carbon reduction strategy extends to other initiatives.

- We have some of the nation's most aggressive customer energy efficiency programs, which last year avoided the emission of about 550,000 tons of CO_2.
- Our decision to relicense and upgrade our zero-carbon nuclear plants in Minnesota avoids about six million tons of CO_2 emissions annually (compared to the most efficient fossil-based alternative).
- And, we have made substantial investments in our transmission system in Texas, Minnesota, and Colorado to deliver renewable energy to customers. As distributed and new grid technologies advance, we are committed to enabling interested customers to access more distributed low-carbon energy.

GOOD PUBLIC POLICY

Decarbonization requires substantial investment in the electric system, and appropriate regulatory strategies are critical to its success. Xcel Energy's success in reducing emissions depends on partnerships with regulators and other policy makers that encourage financially sound emission-reduction programs. For example:

- In Minnesota and Colorado, we helped design renewable portfolio standards that enabled competitive renewable energy acquisition and protection of customers from excessive rate increases.
- The state statutes that authorized our MERP and CACJA plans set the parameters for the programs and ensured timely, fair recovery of costs.

- We developed regulatory programs like CapX 2020 to create the framework for critical transmission investments in North Dakota, Minnesota, and Wisconsin that help integrate wind into the regional resource mix.
- In Minnesota, we are engaged in the collaborative "e21" effort with other stakeholders to consider regulatory policies that will facilitate a low-carbon grid transformation.

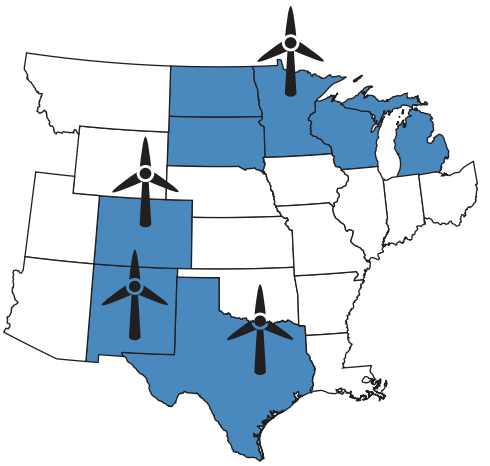
THE FUTURE

Today, we are working with our states to prepare plans to meet the requirements of the EPA's Clean Power Plan (CPP). We are committed to the approach that has proven so successful in the past: collaboration and good public policy. Xcel Energy will continue to grow its renewable energy portfolio, reducing emissions along the way.

In fact, we have already started. In the Upper Midwest, we've proposed a new resource plan that will result in the retirement of more than 1,000 megawatts of coal capacity and the construction of new natural gas generation and 3,500 megawatts of large-scale wind and solar. This plan will bring economic development opportunities to Minnesota, North Dakota, South Dakota, and our other states while helping to meet CPP obligations. For our Minnesota system, the plan will result in a 60-percent reduction in CO_2 from 2005 levels by 2030.

* * * * *

By looking for economic and efficient ways to decarbonize our energy portfolio while recognizing and respecting the unique differences of the jurisdictions we serve, our approach has resulted in significant emission reductions at a reasonable cost.



Xcel Energy's Wind Resources

"We are entering an unprecedented solar revolution that will forever transform how we power communities, businesses both large and small, individual households, and governments."

–TOM WERNER

An Energy Road "Less Traveled By" Begins With Solar

TOM WERNER
President and CEO, SunPower

In one of his most famous poems, "The Road Not Taken," the 20th century poet Robert Frost is famously remembered for his concluding passage: Two roads diverged in a wood, and I – I took the one less traveled by. And that has made all the difference."

By all accounts, the U.S. is on the cusp of a "less traveled by" road as it relates to energy sourcing and delivery. According to estimates by the Energy Information Administration, roughly two-thirds of U.S. electricity consumption is met by fossil fuels. The rest–comprised of nuclear, solar, wind, hydro, geothermal and other sources–has steadily increased in recent years, with solar increasingly playing a leading role in the transition to a low-carbon economy.[1]

We are entering an unprecedented solar revolution that will forever transform how we power communities, businesses both large and small, individual households, and governments. At SunPower, we have the privilege of being on the front lines of this transformation every day, and our partnerships with utilities are critical to decarbonizing electricity generation.

The United States currently has enough solar capacity installed to power approximately 4.6 million homes. Solar is the fastest-growing source of renewable energy in the U.S. Already it reduces carbon dioxide emissions by 23.5 million metric tons each year–the equivalent of taking 4.9 million cars off the road.

According to the International Energy Agency, solar energy could supply more than one-quarter of the world's electricity by 2050. This projection would have been easily dismissed just a few years ago.

Fortunately, the world continues to move in this direction. President Obama's recently published Clean Power Plan is a significant step forward,

creating a tangible strategy for reducing carbon emissions—and along with it, other pollutants. Subsequent commitments by the U.S. and China to work together to reduce emissions and promote clean energy have helped set the tone for a more forward-looking discussion and actions.

Without question, solar adoption in the U.S. can help provide a blueprint for the rest of the world as we shift our focus from rhetorical conversation to accomplishments. Three key areas should help guide our collective strategy:

First, we must learn from what is working. From large businesses to utilities to universities to individual households, every solar installation serves as a learning experience and a series of data points that can help inform our shared efforts going forward.

For example, the University of California, Davis now has the largest solar power installation in the UC system, a 16.3-megawatt SunPower system that is also the largest solar power plant to meet the electricity demands of a U.S. university campus. The project is playing an important role in helping the UC system achieve its goal of carbon-neutrality by 2025, a commitment that establishes UC as a role model for other universities.

Similarly, utilities across the U.S. are launching innovative new programs to support the development of distributed solar generation in their service areas. These include community solar and local capacity requirement programs, as well as partnering with solar providers to market solar power systems directly to homeowners. New York's "Reforming the Energy Vision" proceeding is an interesting model encouraging participation by third-party providers; and utilities have responded with initiatives like Con Edison's proposed 'solar plus storage' pilot with SunPower.

Second, it's critical that we reduce the barriers to access for anyone who stands to benefit from solar energy.

16.3 MW

SunPower solar system at UC Davis Campus

Recent momentum in the solar market creates an ongoing opportunity to highlight the economic potential of solar energy. By partnering with our customers to develop new business and financing models, SunPower is helping to lead the conversation with households, businesses and utilities.

For the solar market to maintain the level of growth it is experiencing, we must prioritize public policies. The solar investment tax credit, as an example, has done its job in spurring the transition to a clean energy economy. We must make clear how long-term certainty in public policy aligns with what customers value.

Third, it's critical that we double down on industry-wide innovation in deployment of solar technologies and related energy services such as battery storage and energy management. We are on the cusp of significant breakthroughs similar to what we've seen in information technology, focusing on high performance, fully integrated system solutions to accelerate the mainstreaming of solar. A laser focus on R&D and its role in continuing to lower the cost of owning and operating solar systems will help cement this transition.

* * * * *

Ten years from now, we will look back at this moment in time when we took the road 'less traveled by.' We'll contemplate the difference it has made in how we manage and control energy, and the positive effect it has had on our planet and prosperity. The goals have been set and the blueprint is in place. It's not a question of whether the world goes solar. It's a matter of how fast it will happen—and the difference it will make.

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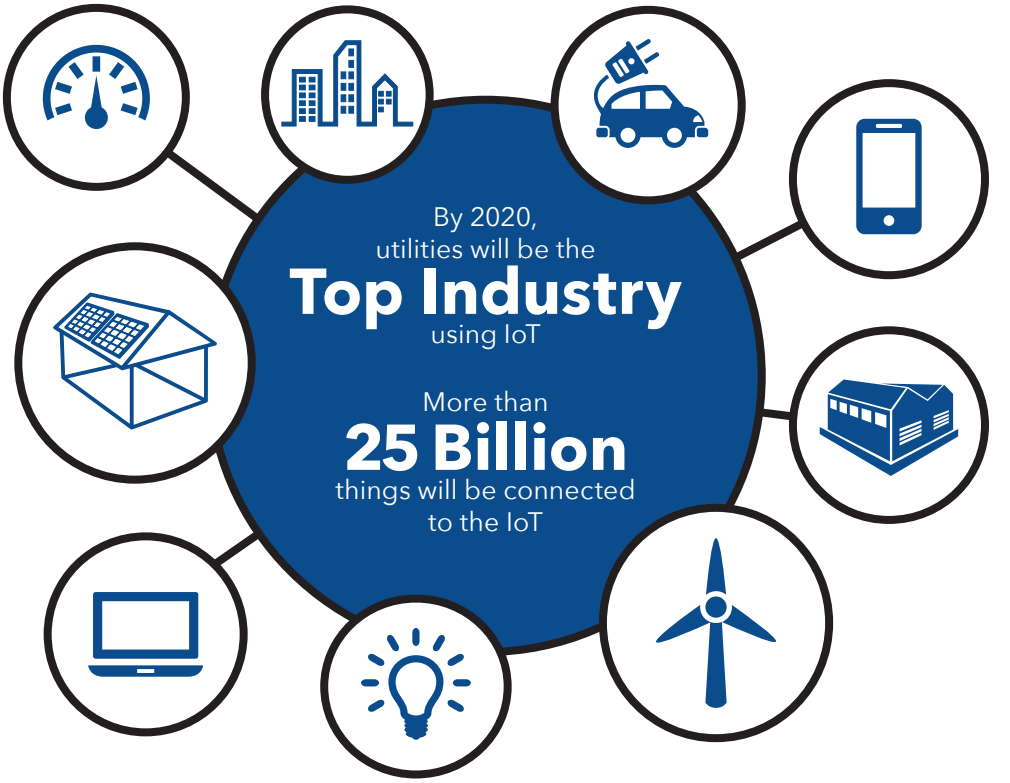
1. *See* U.S. Dept. of Energy, Energy Information Agency, Annual Energy Outlook 2015, Table A8.

Fact Sheet:
Digital and Distributed Grid

Grid of Things™



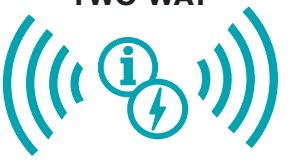
Digital and Distributed

As of 2015,
utilities deployed

SMART METERS

Utilities are
investing
MORE THAN
$20B
ANNUALLY
in the
distribution grid

Digital grid enables
TWO-WAY



power and
information flows

CHAPTER 2

DIGITAL AND DISTRIBUTED GRID

In the U.S., the movement toward a more digital and distributed power grid is well underway. The need for more reliable and resilient grid operations, for greater efficiency and control, and for the connection and interaction with the "Internet of Things" (IoT)—every device with an IP address—creates new challenges, roles, and opportunities. The deployment of more than 60 million digital smart meters is one key building block. The authors of the essays in this chapter point to utilities as becoming the top industry using IoT by 2020, partnerships for smart cities, and the grid as an integrating platform. Today, U.S. utilities are investing more than $20 billion annually in the distribution grid—they have a central role to play as the integrators and enablers of the evolving Grid of Things™.

Scott Lang, Executive Chairman of Silver Spring Networks, sees utilities and cities partnering to bring the benefits of a digitized distribution system to urban centers—smart cities. ComEd is leveraging its AMI canopy in Chicago to create a distribution automation program that is preventing significant numbers of customer outages and is connecting other digital assets.

Southern California Edison's Pedro Pizarro and Erik Takayesu see the landscape of SCE's distributed energy future unfolding as each year more customers install solar arrays and use smart phones to control devices in their homes and businesses. Tomorrow's digital and distributed grid will manage centralized generation and hundreds of thousands of distributed energy resources (DERs). SCE expects to be the critical integrator of the technologies that link customers and resources.

The IoT is transforming the grid infrastructure, says C3 CEO Thomas Siebel. By 2020, 25 billion connected things will be in use and utilities will be the top industry using IoT. Big data, elastic cloud computing, and machine learning are already being applied to solve utilities' business challenges.

Oracle Utilities Senior Vice President and General Manager Rodger Smith notes that consumers, businesses, and utilities are adopting DERs—and far faster than anticipated. The utility of the future, he says, is the platform for delivering new processes and programs, integrating data and analytics to model and manage the new grid.

"Utilities are now in a position to partner with, if not lead, cities to perform functions together that were not possible before the smart grid became a reality."

–SCOTT LANG

In the Transformation of Smart Grids Into Smart Cities, the Only Limit is Imagination

SCOTT LANG
Executive Chairman, Silver Spring Networks

The McKinsey Global Institute estimates that between now and 2025, the world's urban population will grow by 65 million people a year, or almost 179,000 each day. Virtually every major city projects itself as an innovation hub, a "smart city." The consensus among stakeholders is that a smart city involves disruptive technology and that utilities are essential in implementing it. Today, utilities have an opportunity to do far more than provide reliable, ubiquitous electricity to consumers. They can dramatically improve the quality of life in their communities.

Electric utilities across the country are transitioning to a new, technological, business, and social environment largely defined by advanced information technology. The evolution of the smart grid, right down to the device level (and the consequent ability to transform what once was a static structure into a dynamic, information-based interactive system) means the infrastructure is in place to perform functions in real-time, and in a systemic way, to achieve significant cost and energy efficiencies.

It also means that utilities are now in a position to partner with, if not lead cities to perform functions together that were not possible before the smart grid became a reality—provide clean and reliable energy, alleviation of congestion and improved transportation networks, adaptive street and area lighting, the conservation and efficient use of resources, among many others.

As customers—retail, commercial, industrial, and municipal—evolve from passive consumers to active participants

in managing how and when they use power, utilities are finding that they must radically redefine their role to focus more on the critical infrastructure that powers their customers and communities. This not only provides utilities an opportunity to realize new efficiencies and define new revenue streams, it also positions them as the platform on which to build smarter cities.

Utilities and cities are becoming aware that their continued success and relevance are best served by working together toward the common goal of providing innovative, highly reliable, safe, and responsive services. Both are moving from a centralized, top-down model to a distributed, horizontal structure; their relationships with customers and constituents are becoming much more collaborative. In the process, their digitized interactions with customers will yield massive amounts of information in real-time. At the core of the challenge that both face—but particularly utilities—is how to make effective use of this data.

Smart City

Smart grid technology has driven operational efficiency, dramatically improving outage response and restoration time and managing distributed and intermittent generation. That same technology platform, particularly its advanced communication and control capabilities, can also be harnessed by municipalities to create a platform upon which they can deploy additional smart city services over time.

Silver Spring Networks partners with customers around the world to implement smart energy and smart city platforms. In the course of that work, we have seen incredible results when utilities and cities collaborate.

Street lighting can easily account for up to 40 percent of a city's energy budget. That's a very large chunk of a municipal budget at a time of increasing demand for city services and severe budget constraints. To cut costs and improve quality of service, Florida Power and Light (FPL) in South Florida, including Miami, is leveraging its existing smart grid to connect and manage a network of 500,000 street lights, creating the largest smart Internet Protocol (IP) networked street light deployment in the world.

In the past, almost all the lights in their network had to be manually inspected to see if they were functioning properly. Now, the network will save what were thousands of wasted man-hours, and

outages and voltage problems will be much more quickly addressed, improving reliability and quality of service for customers.

The lesson here is the importance of networking. Replacing aging lights with LEDs is not enough. When networked, LED lights can save approximately 65 percent in energy costs and reduce maintenance by as much as 90 percent.

Smart grid networking can also provide communities with a wide variety of quality of life benefits as well as cost savings. In Chicago, ComEd is leveraging its AMI canopy for a very progressive Distribution Automation program that has already prevented more than 1.2 million customer outages, and is beginning to connect street lights and other digital assets across its territory. Denmark, Copenhagen, often called the most livable city in the world, is networking street lights to enable automatic dimming or illumination at dangerous road junctions and in inclement weather.

These and other "smart city" smart grid infrastructures provide immediate quality of life benefits to residents and a source of cost-savings for the city. They also establish a city-wide network canopy upon which additional smart city services can quickly and cost-effectively be deployed in the future, allowing cities to quickly recoup their investment and deliver additional value to their citizens.

This canopy, for example, can be extended to connect other smart-city assets including smart water networks, pollution and environmental sensors, EV chargers, parking meters, and traffic lights, among many others. Intelligent traffic systems can detect vehicle volume in all directions and quickly adjust to allow the most efficient flow. Estimates say 70 percent of all wasted fuel results from sitting at traffic lights in a city, so using this intelligent, interconnected system could significantly cut pollution and waste.

As utilities continue to rapidly install the infrastructure and software essential to manage a smart grid, and as cities compete with one another to attract new, technology-dependent industries, it's clear that a partnership between the two is more than mutually beneficial—it's critical.

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In many cases the infrastructure to support these partnerships is already in place or quickly being deployed to support other assets. What's needed now is the imagination to take full advantage of a new, highly cooperative environment to build smarter cities today.

"The evolving DER landscape offers companies like SCE a rare opportunity to redefine what it means to be an electric utility in the 21st century."

–PEDRO J. PIZARRO & ERIK TAKAYESU

Building Tomorrow's Digital and Distributed Power Grid Today

PEDRO J. PIZARRO
President, Southern California Edison

ERIK TAKAYESU
Director, Electric System Planning, Southern California Edison

Driven by accelerated technological innovation, electric utilities today have the opportunity to redefine and modernize the electric grid, making it even more secure, reliable, resilient, efficient, interactive, and clean. This next generation power system will enable our customers to seamlessly integrate distributed energy technologies and contribute directly to effective, efficient grid management. This system will also maximize energy from integration of renewable and low-carbon energy sources such as solar and energy storage, thereby lowering greenhouse gas emissions from the electric sector.

Southern California Edison (SCE) has launched efforts to prepare our employees and our grid for this more customer-driven, distributed, clean energy future. As these efforts move forward, we will continue fulfilling our commitment to safely provide reliable, affordable, and clean energy to all of our customers. These concurrent responsibilities require us to implement this transition thoughtfully, engaging with and enabling our customers at the forefront of technology adoption, while continuing to control costs.

At SCE, the landscape of a distributed energy future is easy to envision. Each year, more of our customers are installing photovoltaic solar arrays and using intelligent devices like smart phones to control temperature, lighting, and even appliance operations in their homes and businesses. They are buying electric vehicles and battery storage units. They will connect to community solar and community storage units in ever greater numbers. Our customers—more than 14 million people across a 50,000 square mile service territory—expect us to be ready for that future.

Tomorrow's digital and distributed power grid will manage centralized generation in concert with hundreds of thousands of distributed energy resources (DERs). We anticipate the development of local retail markets, which will be a platform for DERs to provide grid services in order to maximize the value for both DERs and other customers. These markets could include both aggregators and direct participants who will create their own programs and contracts and compete to provide services. Future markets may also include multiple customers and devices interacting in microtransactions to share supply and demand across the grid.

The State of California and our Public Utilities Commission (CPUC) recognize that grid modernization is essential to realizing energy and environmental goals. In July 2015, California's investor-owned utilities filed Distribution Resources Plans (DRPs) with the CPUC that detail necessary actions to realize the vision of a 21st century power grid.

SCE's job, as a utility and distribution system operator, will be to project future grid needs, maintain a grid that enables customers to seamlessly connect any resource or device, and operate a market that creates opportunities for customers to provide grid services and be appropriately compensated. Some key elements of the 21st century power grid include:

PLANNING & OPTIMIZATION

To support the DRP, SCE is developing methods to plan for and integrate DERs, including:

- *Integrated Capacity Analysis* to systematically model, study, and publicly display circuit capacity for the integration of DERs;
- *Modernized Planning Processes* that identify optimal locations to encourage DER adoption, forecast future DERs on the distribution system, and zero in on areas that require additional grid reinforcement to support higher penetration;
- *Integration of Smart Inverters* that optimize the regulation of voltage and provide additional stability during outage events; and
- *Distribution Volt/VAR Control* (DVVC) that regulates voltage through advanced capacitor control technology. By reducing and tightly managing voltage on the distribution system, SCE expects to lower customer energy consumption by one to four percent. Integrating DVVC technology into the grid could save customers hundreds of millions of dollars.

ADVANCED AUTOMATION

SCE is testing and preparing to install new automated technology solutions that improve the reliability, flexibility, and resilience of the grid, such as:

- *Real-time Visibility* that utilizes more state-of-the-art digital sensors and intelligent circuit devices to provide

system operators greater visibility into the real-time status of load, DERs, and multi-directional flows. Improving situational awareness for operators should reinforce reliability and power quality.

- *Self-Healing Distribution Circuits* that use new intelligent switches with sensing capabilities to automatically detect and isolate faults and instantly reroute power from DERs to other functioning circuits—reducing the number of utility customers affected by outages, and facilitating faster repairs and service restoration.
- *Substation Automation 3* (SA3), the latest automation package that will improve the responsiveness of the system and enable broader implementation of new customer technologies on the grid. SCE plans to deploy SA3 to some 400 distribution substations over the next decade.

IT PLATFORMS, COMMUNICATIONS, & SOFTWARE

SCE will deploy advanced tools and systems that enable the grid to serve as a DER platform, and for operators to manage more complexity, including:

- *New Grid Analytic Tools* to support asset management decisions, leveraging data from sensors and smart meters; and new long-term planning tools to better forecast the ability of DERs to meet grid needs.
- *Communication Systems* with higher bandwidth, faster backhaul, and field area networks to support additional data flow from sensors and smart meters to enable better control of grid components.
- *Grid Management Systems* based on innovative architecture that ultimately would replace current legacy technology to support both operations and market functions.

This evolving DER landscape offers companies like SCE a rare opportunity to redefine what it means to be an electric utility in the 21st century, and to transform our industry and our relationship with our customers.

With more renewable energy generated by both power producers and customers, and shared by all, the grid will be much more complicated to operate. Utilities like ours will be critical integrators of these technologies, linking customers and resources. In this scenario, the role of the utility will be like that of a conductor, bringing each component of an orchestra into harmony, with each participant's contribution benefiting the whole in a system that is interactive, efficient, and reliable.

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Like the engineers who constructed the 20th century electric grid, SCE is developing a 21st century grid today that will provide the platform for a future energy model that is only beginning to be conceived. We are truly excited about the road ahead.

"By 2020, 25 billion connected things will be in use, and utilities will be the top industry using the 'Internet of Things'."

–THOMAS M. SIEBEL

How the "Internet of Energy" is Driving the Digital and Distributed Power Grid

THOMAS M. SIEBEL
CEO, C3 Energy

The "Internet of Things" (IoT) is transforming the next generation of global energy grid infrastructure. Simply put, the IoT leverages the Internet to connect machines, devices, systems, and other "things," resulting in a convergence of physical and virtual worlds. Gartner predicts that by 2020, 25 billion connected things will be in use, and utilities will be the top industry using IoT, followed by manufacturing and government, driven partially from investments in smart meters.[1]

This decade, an estimated $2 trillion will be invested in upgrading electric grid infrastructure globally, including the addition of millions of sensors to devices throughout the grid. More than 400 million smart meters have been installed globally as of 2015; that number will double in the next ten years. Although smart meters receive much industry attention, they represent just a fraction of the sensors being deployed on the physical grid infrastructure. Consider smart thermostats, home appliances, HVAC equipment, factory equipment and machinery, transformers, substations, distribution feeders, power management units, and power generation and control components. These sensored devices can send and receive information across a computer network, and collectively generate massive amounts of information—an increase of six orders of magnitude.

To optimize the power value chain, utilities require next-generation technologies to integrate and aggregate data, apply sophisticated analytics in real time, and generate actionable insights in a way that directs business outcomes through a common data- and intelligence-driven solution.

NEW TECHNOLOGIES FOR GRID OPERATORS

Big data, elastic cloud computing, and machine learning are now being applied to solve utilities' business challenges, such as improving customer engagement, managing the operational health of advanced metering infrastructure (AMI) assets, preventing revenue loss due to theft and meter malfunctions, optimizing the maintenance of network assets, and increasing grid resilience.

For example, utilities now can use machine learning—the ability of computers to learn without being explicitly programmed and to continually improve their predictive precision—to classify network assets at high risk of failure, segment customers for targeted marketing campaigns, predict load, and manage the complexities of distributed energy resource management.

Just as a credit card company uses historical spending data to flag potential fraud, utilities can use historical and real-time data to identify energy theft. Baltimore Gas and Electric Company (BGE) proved this when it deployed the C3 Revenue Protection™ application across its full service territory of two million meters. In just six months, the solution identified more than 8,000 cases of potential theft with approximately 90 percent accuracy.

By leveraging machine learning and the science and tools of big data, a new generation of smart grid analytics is enabling grid operators to predict future demand, distributed generation capacity, technical and non-technical losses, electric vehicle load, and variable generation capacity across the entire energy value chain.

In another BGE example, the utility used the C3 AMI Operations™ application to identify 3,600 meter health issues with 99 percent accuracy to streamline critical maintenance of AMI assets.

By correlating and analyzing the dynamic interactions associated with the end-to-end power infrastructure as a fully interconnected and sensored network, utilities are realizing dramatic advances in safety, reliability, cost efficiency, and environmental benefits.

PREDICTIVE ANALYTICS HAVE GLOBAL IMPACT

With the European Union's recommendation of 80 percent smart meter penetration by 2020, EU member countries are seeing strong drivers for next-generation analytics solutions, including large smart meter deployments in Italy, the United Kingdom, France, and Spain. Such large-scale deployments may yield lessons for the United State's energy sector, which has deployed more than 60 million smart meters to date.

Enel, a leading integrated player in the global power and natural gas markets serving 61 million customers, was the first utility in the world to replace traditional electromechanical meters with digital smart meters. By 2006, Enel had installed 32 million smart meters across Italy. With 38 million smart meters today, Enel is on track to deploy approximately 46 million across Europe by 2019. Enel represents more than 80 percent of all smart meters on the continent.

To unlock operational value from big data in the smart grid, Enel deployed two of C3 Energy's data analytics applications across an initial set of ten million smart meters and grid sensors in Italy and Spain—the largest deployment of a machine learning-based analytics platform to date.

Deployed in just eight months, the solution integrated, normalized, and aggregated seven trillion rows of data from 13 unique data sources—customer information, billing, and work order systems; outage management, producer, and meter data management systems; and SCADA and validated theft case data, as well as weather data and Google terrain information—into a 700 terabyte data image updated in near-real time. More than 2,500 analytics generate ten million predictions per day to identify anomalous meter activity and predict asset failure to improve Enel's grid reliability, reduce energy loss, and decrease maintenance operating costs. The initial deployments proved that the data analytics solution could readily handle Enel's smart grid data processing and aggregation needs, and deliver more than 200 million Euros in operational efficiencies to Enel. C3 Energy and Enel are working to expand the deployment of this solution widely across Enel's distribution network.

McKinsey & Co. estimates the value of C3 Energy's end-to-end smart grid analytic solutions for a typical integrated U.S. utility and its customers is approximately $300 per meter per year, based on lower operational expenses, more efficient use of capital, higher customer value, and improved safety and reliability of energy delivery.

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Utilities are realizing significant returns by embracing cutting-edge technologies, such as cloud-scale computing, advanced smart grid analytics, and machine learning, to benefit their communities, consumers, other stakeholders, and the environment. With continued innovation, the energy industry is rapidly driving toward the Internet of Energy.™

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1. *Gartner Says 4.9 Billion Connected 'Things' Will Be in Use in 2015*, November 11, 2014 (www.gartner.com/newsroom/id/2905717).

"The utility of the future needs to become the platform for delivering new processes and programs, integrating data and analytics to manage the new grid."

–RODGER SMITH

Leading at the Edge of the Grid: An Integrated Platform for the Future

RODGER SMITH
Senior Vice President and General Manager, Oracle Utilities

We are now at the leading edge of what has long been thought of as unachievable, part of a very distant future: grids that can readily accommodate distributed generation of all types; solar generation at all size levels; battery storage; electric vehicles that can be used as load balancing tools; and more, including combined heat and power, wind, and demand response.

Now apply an accelerant to that change: data produced by the growth of connected devices. A new concept—the Internet of Things (IoT)—has been coined to describe this phenomenon, one of the most profound technological growth periods in human history. As these distributed resources continue to interconnect and add data to the distribution grid, utilities are being tasked with providing infrastructure and keeping pace, and ensuring that the data from these resources can be made actionable.

Meanwhile, severe weather, solar flares, and cyber threats to the system are prompting increased interest in cybersecurity, micro-grids, and improving grid resiliency.

These are indeed challenges, but they also present a bridge to innovation and business renewal, as utilities and wider society explore solutions where the greatest change is occurring—at the grid edge. Many utilities are beginning to turn these challenges into opportunities. They are embracing a smarter, digitized grid and leveraging it to improve reliability and outage response, while delivering high value services to customers and gaining new revenue in doing so.

EMBRACING AND LEVERAGING THE DIGITAL GRID

Empowered by technology innovation and supported by policy, consumers, businesses, and even some utilities are

choosing to adopt distributed energy resources (DERs) at a pace far faster than anticipated. Not so long ago, the International Energy Agency (IEA) projected solar and other DER growth out to 2030, but the development IEA forecasted was actually achieved by 2012, almost two decades faster than expected.[1]

These DERs may enable utility customers to manage their energy choices with little or no input from the utility. If customers do this, however, they introduce more reliability and service quality risks into the picture as many DERs produce energy intermittently. Alternatively, if utilities support customers' growing adoption of DERs, integrating them into the overall network, they can leverage the DERs as on-demand, low-cost tools for improving reliability and outage response.

By proactively integrating these resources into an intelligent network model, utilities can use DERs to:

- Predict asset risk and reduce capital and maintenance expense;
- Improve energy capacity to meet demand;
- Reduce customer minutes of interruption through more accurate load profiling;
- Deliver flexibility to meet peak demand; and
- Improve utility resource planning.

Oracle is a key partner in helping utilities mitigate the risks of rapid DER integration. Our connected solutions enable DER lifecycle management through operations, data management, risk analysis and planning, service and maintenance, outage management, and customer interaction. Our tools enable utilities to profile DER load by location and condition of use, which is a necessary step to understanding and managing the impacts—both positive and negative—that DER can have on the distribution grid.

CONNECTING CONSUMERS WITH VALUE-CENTERED SERVICES

Energy consumers are showing greater interest in products and services to help them use electricity wisely and cost-effectively. The number of new entrants in the home energy management (HEM) solutions market in recent years is indicative of the growing interest by consumer technology vendors. But this market shift actually offers utilities a pathway to advising customers about HEM solutions.

With an unparalleled window into consumption data and consumer behavior, utilities can expand the scope of their mission by facilitating and enabling energy consumption choices. Indeed, regulatory bodies are becoming more willing to consider the role of utilities as

the provider of the enabling infrastructure in a dynamic, real-time marketplace, as seen in emerging market rules and legislation around the globe in places such as California, New York, Hawaii, Germany, Australia, and New Zealand.

By connecting consumers with value-centered services, utilities can:

- Expand revenue potential by providing consumers with lifestyle-based energy services;
- Harness the value of real-time data to increase sales of excess and stored DER generation into other markets; and
- Offer new services, such as segmentation, energy trading, and construction and operation of community-owned DER services.

Unlocking Value in Data

THE FUTURE REAL-TIME UTILITY ENVIRONMENT

The new technology infrastructure being developed is critical to managing the digital power grid going forward and creating new business opportunities for utilities. Within today's real-time utility environment, operational technology (OT), consumer technology (CT), and informational technology (IT) business models and processes are overlapping and converging.

Customers are no longer complacent and disengaged. They are becoming increasingly engaged in monitoring and managing their usage; having a 24/7, multi-platform, real-time connection with their utilities; and connecting DERs to the utility's distribution grid. The utility that maintains a siloed approach to these newly engaged consumers stands to lose them.

Integrating OT, CT, and IT business models and processes to deliver customer-focused solutions will be critical for the utility to succeed in this evolving system. The utility of the future needs to become the platform for delivering new processes and programs, integrating data and analytics from across the enterprise to model and manage the new grid. A utility that falls short will be bypassed by competitors. It's time to stop looking at today's rapid changes as challenges, and turn them into opportunities.

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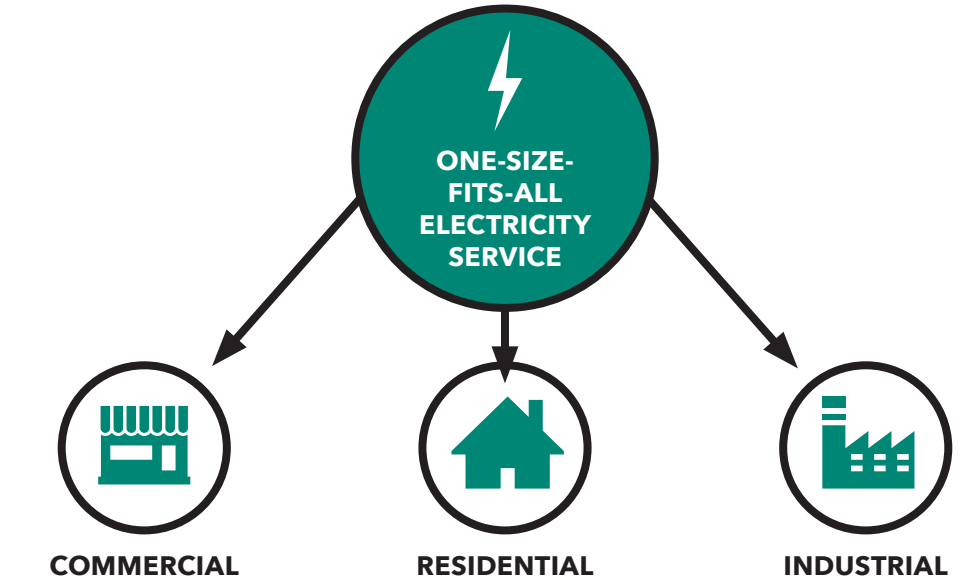
1. International Energy Agency, World Energy Outlook 2012.

Fact Sheet: Individualized Customer Services

Past



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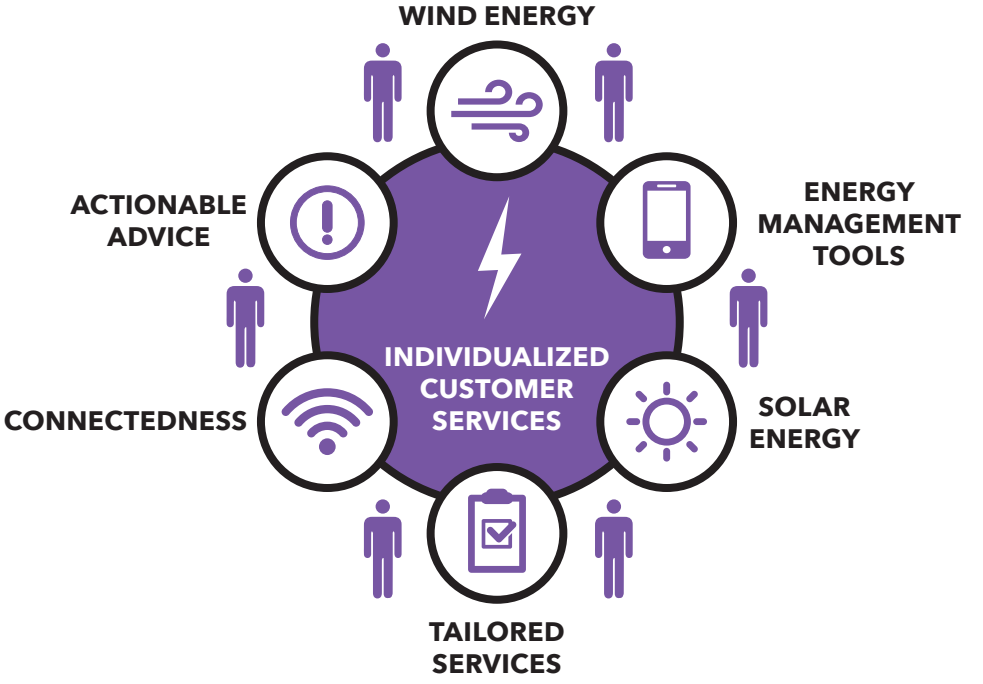


CHAPTER 3

INDIVIDUALIZED CUSTOMER SERVICES

Increasingly, electricity customers want customized services. Some large commercial customers want 100 percent renewable energy to meet corporate sustainability goals. Cities and towns want help establishing clean city initiatives. Many customers want tools to manage and control their energy use. And most customers still want basic electricity service—safe, reliable, and affordable electricity. The authors of the essays in this chapter point to how technology, innovative solutions, and policy leadership all will play a role in providing changes that customers want.

Former Colorado regulator Ron Binz reminds us that a new generation of Americans—those born after 1980 and sometimes called "digital natives"—are comfortable with the digital world. By 2020, they will comprise more than half the U.S. population. Digital natives will be demanding and leading the change to which both utilities and policy makers must respond.

Mary Anne Brelinsky, president of EDF Energy Services, describes how her company is putting the energy value chain pieces back together. "We are knocking down the walls between our retail business teams and the wholesale markets that support them," she says. EDF is also stirring its trading operation into the mix of services it offers larger customers.

In "Making Energy Personal," Tony Fadell, CEO of Nest, says people give Nest Learning Thermostats as gifts. They're fascinated with them and often check on the data they generate. This interactive technology opens the door to more personalized service, as utilities and customers collaborate to find solutions that customers want.

To truly realize the potential of electricity service in 2025, writes Peter Kind, policy makers must chart the path forward. In this "reformed" industry model, utilities will be incented to provide customers the advice and services they want, while meeting regulators' and policy makers' goals and metrics.

Opower President Alex Laskey reminds us that utilities lag behind most other industries in providing a responsive customer experience. Customers want actionable advice, not data, on ways to lower their bills and other service options. Companies like Opower are using cloud software and data analytics to help utilities forge those improved customer relationships.

"For electric service, advances in clean energy technology, changing demographics, and how utilities are regulated will determine the speed of change."

–RON BINZ

No More Average Customers

RON BINZ
Past Chair, Colorado Public Utilities Commission

Think of the many ways you can configure your home entertainment: broadcast, cable, satellite, or phone company TV; streaming Netflix, Roku, Hulu, Sling TV, Apple TV and Amazon TV, just to mention a few. We're a long way from the days when baby boomers had three broadcast TV channels and a few squirrelly UHF options.

This array of choices is made possible by the combination of digitization and massive connectivity. Those two characteristics describe the Internet, which has fundamentally changed many U.S. institutions—entertainment, shopping, banking, libraries, travel, personal communications, and even social relationships. Something similar is coming to electricity service as the Internet meets the electric grid.

It's too early to predict exactly what the change will look like, but we can make some educated guesses based on the industries that have been reinvented by the Internet. Almost certainly there will be energy products and services that we "didn't know we needed and now can't live without"—think about smart phones, iPads, texting, and Google!

For electric service, advances in clean energy technology and changing demographics are driving the change. A third factor will determine the speed of the change: how utilities are regulated.

Let's start with demographics. People born after 1980 are often called "digital natives," since they were born into a digital world. When the first digital natives turned four, compact discs had just arrived in the U.S.; at age six, they witnessed the widespread use of personal computers; and when they reached age 11, web browsers were invented and the World Wide Web as we know it began to emerge.

Digital natives probably don't perceive the rapid growth in digital-ness because they've known nothing else. Expectations of what can be done and

what should be done are much different for them, compared to people born in the analog era. Digital natives are the new baby boomers. By 2020, digital natives will comprise more than half the U.S. population. Fifteen years after that, two-thirds of the country will have been born after 1980.

Digital Natives Think Different

What's this got to do with electricity?

Simply put, digital natives, in the words of Apple Computer, "think different." Marketing experts report that digital natives adapt easily to advanced technologies, show a "contentedness with complexity," and "have a desire to control their own lives." Back in the day, everyone knew to ask a ten-year-old to program the VCR. (Remember VCRs?) We can safely predict that this generation—which will be the first to use self-driving automobiles—will also be comfortable trusting digital "expert systems" to assist with complex choices and complicated decisions. In short, the skills and predilections of digital natives match up well with the coming changes in the electric sector.

The second factor propelling change in the consumer electric sector is on the hardware side: the pace of clean energy and grid technology. Even the most bullish projections two years ago did not foresee the recent breathtaking decline in costs of photovoltaic electricity. And there is no end in sight: "Swanson's Law" asserts that, with every doubling of new solar capacity, the cost of solar generation falls 20 percent. While the trajectory of this "law" is not as steep for solar as "Moore's Law" is to electronics, it does describe a sector with exponential cost declines, while costs for traditional energy sources are going the other way. This also means that small-scale, distributed energy resources will continue to evolve even as their costs drop.

Within 10 to 15 years, we should expect that every device that touches the electric grid—from power plants to rooftop solar systems, from batteries to street lights, from toasters to transformers to electric vehicles—will have an internet address. This will be the "Internet of Things" and it will completely remake the physical electric grid. Any device will be able to "see" any other device on the grid. With complete connectivity, electricity producers (large and small) will communicate real-time "prices to devices,z" and electricity users will convey supply or demand "offers" to the grid operator or directly to generators.

The resulting web of transactions among billions of nodes in the electric grid is called "transactive" energy. It sounds complex, but don't worry: consumers will be spared the task of managing electric imports and exports for their freezers, hot water heaters, and vehicle batteries. Those tasks will be performed by an expert system—sophisticated software that will manage all the necessary transactions in line with the consumer's desired profile. Just as consumers don't need to know the details of packet-switching in order to send a text or post on Facebook, consumer access to the transactive energy market will be enabled by software that hides the messy details and simplifies the choices.

What will this mean to the average consumer? For starters, "average" will become much less meaningful. Each consumer will have the choice of how fully to participate in the new electric grid and will be able to select among many individualized profiles. Consumers might self-generate in part, buy only renewable energy, offer demand response, plug into a micro grid, time shift usage, or offer local storage to the rest of the grid. The uptake of these new technological choices will probably follow the customary "S-curve" of adoption. Early adopters will emerge, followed in time by most of the consumer base.

How rapidly these changes happen will depend in large part on how today's electric utilities are allowed by regulators to evolve. The way we regulate electric utilities hasn't changed much in five decades. Utilities will need much more flexibility than traditional regulation affords today. That means that the focus of regulation should accommodate the far more complex grid—and its opportunities—that will entice competitors at every turn.

Regulators need to turn to incentive regulation—an approach that rewards utilities for achieving desirable policy goals, or penalizes them for failing to do so. This approach will provide adequate or even increased earnings, while encouraging utilities to embrace and excel in fundamentally new roles—providing *energy services* and being the "orchestra conductor" for all the instruments in the new electric grid.

To some readers, this may be an unsatisfying vision. It predicts profound changes for consumer electric service, but offers few details or assurances. It projects a future by analogy to other sectors of the economy that have been transformed by information technology. But in 1980 few could foresee the profound changes the Internet would bring to so many aspects of our lives today.

Predictable or not, the Internet of Things is coming to electricity.

"We are putting pieces of the energy puzzle back together and providing innovative customer solutions– redefining customer expectations in the energy space much like Uber did for the taxi industry."

–MARY ANNE BRELINSKY

Putting the Energy Puzzle Pieces Back Together

MARY ANNE BRELINSKY
President, EDF Energy Services

I was standing in my parents' kitchen over the holidays and my youngest son, Noah, asked me, "Mommy, is Grandma afraid she's going to lose her phone?" I gave him a quizzical look and replied, "No, I don't think so. Why?" My bright, inquisitive child asked, "Well, why does she have it tied to the wall?"

It is easy to forget that this generation of Millennials has never had to untangle the long curly phone cord tied to the wall, hold a tape recorder next to the radio to record their favorite Cindy Lauper song, or drive to Blockbuster to rent a movie. Uber is yet another example of the same evolution and the continuing change in paradigms. Uber has forever changed the way we get from point A to point B. Uber has single-handedly turned the taxi industry on its head—no small feat, given the industry has employed the same basic business model since horse-drawn for-hire carriages began operating in Paris in the early 17th century. Since the introduction of Uber in NYC, the value of a single taxi medallion has gone from a high of $1.3 million to a mere $650,000.

Technology advancement is happening at an ever-increasing pace. Imagine if Alexander Graham Bell was alive today and you handed him a cell phone. He would have no idea what it was or how it worked. The technology in our phone looks and functions nothing like the old-school rotary phone of my childhood.

But if you dropped Thomas Edison in the middle of a switchyard next to a power plant, he could follow the turbines in the electric generator and the transmission and distribution lines and find the light bulb at the end of the line. We haven't experienced a revolutionary change in our electric industry in several generations. Yes, the industry has added renewable resources to the generation stack, provided demand response opportunities for industrial and residential customers, and

developed innovative products that allow customers to tailor their energy procurement strategies. That said, our industry hasn't experienced true transformational disruption, but it will.

As an industry, are we laser-focused on these real challenges? Are we pushing our teams outside their comfort zones and traditional paradigms and forcing transformation through technology like others have done? How do we put ourselves in the driver's seat rather than continuing to wait for the taxi?

In the 1990s, our industry in the U.S. was partially unbundled and deregulated. The generators were separated from the traders, and the wholesale traders were separated from the retailers. Competition drove efficiency in these segments, which helped drive down prices to the consumers. But competition and unbundling came with an unintended consequence: those companies could no longer provide robust solutions across the entire energy value chain. I believe that transformational disruption for our industry is in how we put the pieces of the energy puzzle back together.

Putting the Energy Value Chain Pieces Back Together

At EDF, we have been experimenting with putting the energy value chain pieces back together using technology and offering unique products. We are knocking down the walls between our retail business teams and the wholesale markets that support them. Our EDF Energy Services customer business works collaboratively with EDF Trading to provide our commercial and industrial customers access to wholesale markets, while also providing expert retail service. Sometimes that means providing integrated products that combine renewable generation, load shifting, and price alerts in a single, integrated offering. We are putting pieces of the energy puzzle back together and providing innovative customer solutions—redefining customer expectations in the energy space much like Uber did for the taxi industry.

By employing both our Retail business and our Generation Services business in a single organization, we've created a unique, integrated corporate structure. This incents our people to work together to foster creative customer solutions. I realized the power of this structure a few years ago when one of our global industrial customers asked us to find a wind generator to supply a large manufacturing facility. This particular customer wanted a "green" energy retail supply deal with EDF and they wanted that "greenness" to

be steel in the ground, not just paper certificates. This customer also wanted its logo painted on the wind turbine and photos for its annual report. We approached one of our wind generator clients whose response was, "If they give me a reasonable price for the energy they can paint anything they want on the turbine." When you walk into the lobby of this customer today, a photo of the logo-decorated wind farm with longhorn cattle grazing nearby is front and center.

In addition to integrated products, speed is also becoming more important to consumers. At EDF Energy Services, we are taking "big data" and turning it into information that our customers can use to make energy consumption decisions in real time. Our customers need information at a faster and faster rate. Turning energy data streams into information that our customers can use to run their businesses is our primary objective. For example, we've developed an iPhone app that allows customers to monitor their power stations from their phone; it displays current wind speeds and weather near their facilities, and allows retail customers to see their power and gas consumption alongside the appropriate real-time energy prices. Customers who have facilities in multiple locations can use this information to shift consumption from their facilities in areas with high prices to facilities in areas with lower prices. Yes, we have an app for that!

As an industry, we've spent billions installing smart meters. We should take advantage of that and make flexible, real-time pricing available on a wide scale. It would make us all as consumers of energy much more aware of how and when to use energy and get more efficient results in the process.

On a more personal note, my home electricity bill is indexed to the spot market. The price I pay for electricity at my home in Houston changes every 15 minutes. I have saved money for more than ten years paying spot-index prices for electricity, but that's not why I do it. I want to ride the wave of energy innovation. I have a smart meter. I have a smart thermostat. The cost of electricity at 4:00 p.m. on a hot afternoon in Texas is not the same price as it is on a mild Saturday morning. Over the last ten years, there have been brief periods of very high prices. On one occasion when my electricity price increased to more than $1,000 per MWh, I called home and asked my husband to go out to the garage and unplug the beer fridge. You would have thought I asked him to fly to the moon. At that moment, I'm sure he wished I was like the taxicab, but I really like being more like Uber.

"How can utilities add a new layer on top of their existing services—something to make customers happy and broaden the customer relationship? The answer is personalization."

–TONY FADELL

Making Energy Personal

TONY FADELL
Founder and CEO, Nest Labs

Keeping energy flowing safely and reliably into homes and businesses is challenging and complicated. But, for most utilities, the relationship with customers is—at a high level—pretty simple: The utility brings energy to a customer's home—the customer uses a certain amount of that energy, and the utility sends a bill for the amount used. It's straightforward, and it's worked the same way for a really long time.

It's also very limiting.

Say a utility wants to build a better relationship with customers and set itself apart. If the only interaction with those customers is the product they're being sold (which they don't really think about unless the power is out) and the bill they receive (which they don't really like because it costs them money), then the utility doesn't have many options. And that's especially problematic when utilities want customers to do something different—like using less energy on a hot summer day or engaging around other energy programs and services.

So how do we fix that? How can utilities add a new layer on top of their existing services—something to make customers happy and broaden the customer relationship?

The answer is personalization.

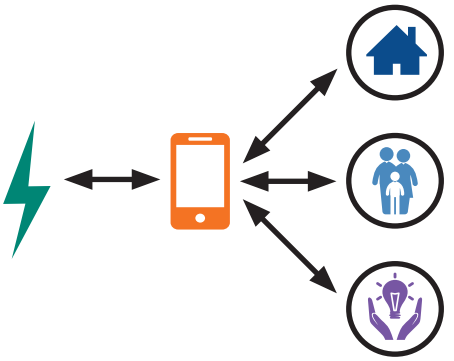
When we launched Nest four years ago, we wanted to take the technology inside our smartphones and put it inside the devices in our homes that have looked and functioned the same way for decades. We wanted to give people greater control over their energy use; the safety of their families; the security of their homes.

That's how the Nest Learning Thermostat was born.

Instead of asking people to set their own energy usage schedules (which most people never do) we designed a thermostat that learned home consumption patterns and programmed itself. And it worked. This year, independent studies proved that, on average, the Nest Learning Thermostat saved

U.S. customers about 10–12 percent on their heating bills and about 15 percent on their air-conditioning (A/C) bills.

So what does this mean for utilities? First, it proves that utilities can use personalized technology to give their customers an experience they really want and begin to build a better, stronger relationship.



Technology Enables Energy Personalization

For years, most people didn't give their thermostat a second (or first) thought. When their HVAC system broke, they had the repairman install a new one.

Today, that's changed. People don't just buy our thermostats when their old ones break. They get excited about them, give them as gifts, perform the installation themselves, and check on them through a mobile app multiple times a week. And, every month we send a Home Report with data about how much energy they used.

For a utility, that opens up a whole world of possibilities. All of a sudden, customers don't just see the utility as the entity that sends them a bill at the end of the month. Instead, the utility is providing a product that knows them; responds to them; and stays connected to them no matter where they go. The utility's brand gets stronger, and the relationship with customers goes from a transactional one to something much more meaningful.

So that's the first way personalized technology can help a utility build a better relationship with customers: by creating a great experience. The second way is by using technology as an incentive to transform how and when customers use energy.

Two years after we launched the Nest Learning Thermostat, we announced an opt-in program for our customers called Rush Hour Rewards (RHR). RHR helps people earn money or credits from their energy providers by using less energy when everyone else is using more. Unlike traditional demand response programs that are one-size-fits-all, RHR takes into account when people are home or away, their preferred temperatures, the "profile" of the home (large/small, how quickly it loses cooling), and only deploys to homes that can help reduce A/C use during

peak periods. Most important, RHR customers are always in control of the temperature to ensure their comfort.

To date, Rush Hour Rewards has helped achieve an average of 55 percent energy reduction in residential air conditioning loads during peak periods. And while customers can adjust the temperature at any time, just 14 percent of RHR participants changed the temperature during an event.

For utilities, this is an example of a potential game-changer. It's easy to imagine a future where technology takes complex and difficult energy programs and makes it easy for every consumer to understand and participate in them.

That's why personalization is so important—and why it holds so much promise. Today, we're seeing the first glimpses of how personalized technology can give customers and utilities more control and help them build a better relationship over time.

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The next decade will bring even more examples like this, with utilities and technology companies working to make tools that people actually use and love. And together, those tools will make a huge difference.

"We now need policy makers to take the lead in charting the path forward to accelerate our electricity and environmental future by defining the framework and incentives to make this vision a reality."

–PETER KIND

Residential Electricity Service in 2025

PETER KIND
Executive Director, Energy Infrastructure Advocates LLC

With a push from innovative approaches to regulation and reliance on realized and future advances in technology—smartphones, remote sensors, renewables, storage, and much more—electricity service in 2025 can be cleaner and more omnipresent than it is today. Customers' reliance on their smartphones is but one portal to achieving a deeper penetration of electricity throughout the economy, including the transportation sector.

But to make this vision a reality, policy makers—legislators, energy regulators, and perhaps other stakeholders—must provide an appropriate framework, including standards, incentives, and accountability to promote and produce the desired behaviors.

Few will argue with the benefits that customers, our economy, and society overall can realize from an enhanced commitment to efficient energy consumption, deployment of cost-effective clean energy resources (CERs), optimization of capital deployment, and a reduced carbon footprint.

But we must not get ahead of ourselves. To bring these benefits to fruition we should bring all the players along, beginning with the public: that is, customers. How do we reach customers, who are distracted by countless other concerns, with something they take for granted—their electricity service? There is no easy answer to that, but appearances before civic, neighborhood, and business groups by both utility and regulatory officials to discuss topics of interest would be one opportunity. For example: utility and regulator readiness to speak after severe weather or other significant events could offer an important opportunity to gain credibility with such groups.

In any case, studies suggest that energy efficiency and CER adoption levels are still much lower than they should be, while the opportunity to increase adoption, based on available technologies, is great. Enhancements in internet and smartphone technology can also improve how we educate our constituents about available opportunities.

My vision for future electric services is premised largely on broadened smartphone applications ("apps") and remote wireless sensors. While some utilities have introduced app-based efficiency tools, they are still in their infancy and have not yet been deployed at scale. In the future I envision, these energy saving enabling tools will:

- Allow customers to remotely control and program their lighting, appliances, heating and air conditioning;
- Connect customers to opportunities to participate in CERs, including community and distributed PV, storage, and demand response;
- Allow utilities to cycle their customers' air conditioners and chip-enabled appliances during peak periods to save their customers money and reduce the need for new energy resources that would otherwise be required; and
- Allow electric vehicles to be charged and discharged at optimal times to enhance customer economic value.

Smart meters and energy billing apps can also provide customers with actionable information about their usage, how it compares with similarly situated neighbors, and potential energy saving opportunities. Providing customers appropriate education and financial incentives will be key to achieving significant customer acceptance and adoption.

How do we encourage this vision and accelerate the pathway to a clean, efficient, and more profitable energy future?

Educating customers about opportunities that exist must be a priority. Utilities have access to dwelling size and age and energy usage. They can make it easy and profitable for customers to learn about and adopt energy savings tools. A commitment to outreach and education will drive increased demand for efficiency technologies and practices.

Utilities, empowered by clear regulatory policy, should take the lead in educating customers on opportunities to save. For the most part, customers trust their utility. But, for utilities to be trusted advisors to their customers, they must be indifferent to customers' preferences for specific technologies, vendors, or services.

Why aren't distribution utilities rushing in to assume this advisor role today? It's complicated, but generally utilities lack regulatory incentives to benefit from selling less electricity and deploying fewer resources. While many jurisdictions offer programs to compensate utilities for sales lost to efficiency—through

decoupling and performance incentives—these are not sufficient to induce utilities to wholeheartedly promote more efficient outcomes. Today's regulatory frameworks are weak band-aids, not transformational.

For utilities to adopt a business model that places a premium on energy efficiency and making this energy and economic transition a reality, we need transformational reform.

In this "reformed" industry model, utilities would be incented to earn profits—in addition to a nominal return on invested capital—by providing customers valued advice, services, and efficiency measures. Of course, utilities that take on this challenge must be accountable for achieving the objectives and metrics adopted by policy makers.

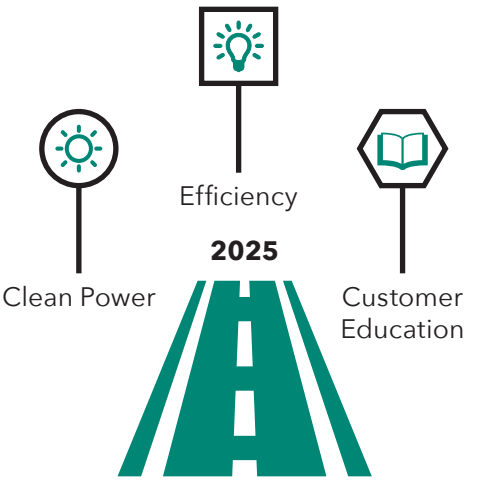
In addition to this regulatory reform, policy makers must set forth new standards for buildings, appliances, and energy consuming equipment that encourages both efficient use of energy and interconnection with today's energy management tools, smartphones, smartphone apps, and home energy management technologies.

We now need policy makers to take the lead in charting the path forward to accelerate our electricity and environmental future by defining the framework and incentives to make this vision a reality.

With policy makers' leadership:

- Customers will have new tools to control their energy use, manage their energy costs, and improve their carbon footprint;
- Utilities will be re-energized by this new model and approach—doing well for their investors and enhancing customer value;
- Technology providers will benefit from broader market opportunities and distribution channels for their offerings.

If policy makers will chart a pathway forward, our entire society will benefit—customers, technology providers, utilities and their investors, and the global economy and environment. There's no time to waste. Seize the day!



Charting the Path Forward

"Cloud software can help utilities deliver personalized digital experiences at every customer touchpoint—from the day a family moves into a new home through every bill, outage, or change they experience."

–ALEX LASKEY

Unlocking Value Through Customer Engagement

ALEX LASKEY
President and Founder, Opower

The world is embarking on a new chapter in energy use, generation, and distribution. In the United States and Europe, utilities and retailers are watching energy demand level off for the first time in history. Globally, new technologies and regulatory approaches are giving consumers more control over their energy use.

In the 20th century, the goal was to bring electricity to people. The advent of cheap, abundant energy sparked revolutions in science and technology, and utility companies focused on growing their generation fleets to meet the mushrooming demand for power. Today in the 21st century, utilities face new challenges, as electricity demand stagnates. Rising consumer expectations for new service offerings and competition from distributed generation are forcing a transformation of the industry.

No companies are better positioned than utilities to lead the way forward. Electric utilities have accumulated more than a century of experience and developed valuable customer loyalty. Research by Accenture shows that consumers trust their utilities to deliver helpful energy advice more than any other service provider.[1] Now utilities and others they may work with must deepen these relationships and provide valuable *individualized services* to residents and business owners.

Globally, energy providers spend $30 billion a year on customer service, with the largest of that expenditure going toward billing and call center operations. Despite this massive investment, research shows that interactions between utilities and their customers lag behind most other consumer-facing industries.[2] Companies in the banking, retail, and transportation sectors have made dramatic improvements to the customers' experience, leaving the energy industry with a challenge just to catch up.

Surveys and data make it clear what customers want: lower bills, more ways to save, and personalized energy service options. With the growth of smart meter infrastructure, utilities are managing more customer data than ever. Their first impulse is often simply to report this data back to customers online, but the great majority of customers want utilities to give them simple, easily accessible, actionable advice—not data.[3]

With the help of companies like Opower, utilities are using cloud software to increase customer satisfaction while lowering their overall service costs. Focusing perceptively on the experience customers want, energy providers can forge new business models that position them to lead in the new energy economy.

Personalizing Offers to Households

Thanks to the growth of smart meter deployment, energy usage data from households and businesses have become increasingly available to utilities. Behavioral demand-side management technologies—including Opower's "Behavioral Energy Efficiency" and "Behavioral Demand Response" solutions—can play a significant role, as utilities look to reduce costs while improving the customer experience.

Utilities also realize that they need to accelerate the digitization of their customer service. Cloud software can help utilities deliver personalized digital experiences at every customer touchpoint—from the day a family moves into a new home through every bill, outage, or change they experience.

NEW TOOLS FOR ENGAGING CUSTOMERS

Already, many utilities are meeting rising customer expectations with innovative technologies. In regulated and competitive electricity markets, technology companies like Opower are giving utilities and energy providers the tools they need to unlock strategic business value from improved customer engagement.

Puget Sound Energy (PSE) first partnered with Opower to engage its customers through Home Energy Reports (HERs), which provide customers with insights about their energy use and tips to help them save. PSE saw significant

results from its HER deployment; it was able to meet its energy efficiency targets while adding a new, high-quality touch point with its customers. That success led PSE to be the first utility to launch Opower's Bill Advisor solution, which provides customers with proactive alerts about their usage, intuitive self-service tools, and integrated call center software.

Billing issues are the number one driver of customer calls to utility call centers. Fully 80 percent of customers say they want advance notification if they are on track for a large bill.[4] PSE now directly addresses these concerns through its deployment of Bill Advisor.

Technologies that manage ways of meeting heightened customer expectations can also address the increasing number of customers who want access to distributed energy resources (DERs). This is a boon for solar companies, but customers may also benefit from expanded options when considering whether and how to go solar. This also offers a valuable opening for utilities seeking to advise their customers' energy purchases.

Con Edison, the utility that serves New York City and Westchester County, N.Y., is striving to position itself as a trusted energy adviser to its customers. To guide the conversation around DERs and accelerate uptake, the utility is partnering with Opower to deliver personalized offers to households that are most likely to take advantage of new programs, products, and services—from self-generation technology to smart thermostats.

This strategy represents a win-win-win. Customers benefit from helpful, trustworthy advice about what products are right for their homes; DER providers get an opportunity to expand their customer base; and Con Edison is able to earn new revenue with a new platform to market targeted products and services. And all of this benefits the environment by promoting energy efficiency and clean forms of generation.

As energy providers look to evolve their business models and take a leadership role in the industry's transformation, Con Edison is demonstrating how a strategic, customer-focused approach can bring value both to their business as well as to the customers they serve.

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1. Accenture Energy Consumer Services, THE NEW ENERGY CONSUMER: UNLEASHING BUSINESS VALUE IN A DIGITAL WORLD 2015, *available at* https://resapps.accenture.com/newenergyconsumer/unleashing-business-value-main.html.
2. 5 Universal Truths About Energy Consumers, https://opower.com/fivetruths/index.html.
3. *Id.*
4. Opower, MOMENTS THAT MATTER: A CUSTOMER-CENTRIC APPROACH TO EXPERIENCE MANAGEMENT 2015, http://www2.opower.com/moments-that-matter-whitepaper.

"I think of the evolution now underway as a movement from the utility as an infrastructure and commodity provider to being an essential infrastructure and service provider."

–BOB ROWE

Conclusion

BOB ROWE
President and CEO, NorthWestern Energy

The Institute for Electric Innovation and the Edison Electric Institute perform a great service by keeping us informed about and focused on the exciting changes in how energy is produced, distributed, and used. As you've read throughout *Key Trends Driving Change in the Electric Power Industry*, these changes are happening quickly, with common elements, but in each instance on a timeline and with approaches tailored to local requirements and expectations.

This timely volume has focused on:

- **The rapid transition to clean energy.** This is remarkable given the complexity of the supply system and its capital intensity. Most of this transformation has been industry-led, as part of thoughtful supply planning, and in response to economic signals and customer interests.
- **The evolution of the grid to be more digital, flexible, reliable and resilient.** It's never quite been true that "Edison would recognize today's grid," and I've never heard a system engineer utter that canard. Companies across the country are investing in grid modernization in ways that balance near-term price impacts with long-term system and customer benefits.
- **Increasingly individualized services.** While most customers continue to expect a foundation of reliable, safe, and affordable service, increasing numbers also demand especially high levels of service quality (e.g., stable frequency or voltage), exceptionally high reliability, or an especially low carbon energy source. Notably, some customers even want a high degree of engagement with production, distribution, and use of their energy.

My company, NorthWestern Energy, is an electric and natural gas provider in Montana and South Dakota, also with natural gas service in Nebraska, and electric service in Yellowstone Park, Wyoming. We're making progress on each of these fronts in ways that make the most sense for our customers and our region. Our Montana electric supply portfolio is now, by nameplate, almost 70-percent carbon free (hydro-based, with wind), but with a diverse set of assets that complement one another.

Given our largely carbon free supply portfolio, we are very concerned about policies that mandate specific supply choices that do not meet our portfolio needs and eventually drive up costs to customers.

We've also been engaging with our stakeholders to plan for the network's future. Building on success with our ongoing Distribution System Infrastructure Plan, we've now launched an Infrastructure Stakeholder Group that will help us take an end-to-end look at our gas and electric transmission, substation, and distribution systems—including the value proposition—and customer expectations for even more technology deployment. We will also benefit from our participation in the Pacific Northwest Smart Grid Pilot, results from which will inform our planning and investment over the next decade.

Simultaneously, we've launched a Community Sustainable Energy Work Group. This stakeholder group is facilitated by the Solar Electric Power Association and includes, among others, parties with whom we do not always agree on subjects such as expansion of current net metering programs or implementation of the EPA's Clean Power Plan. We're asking this group to help us design specific projects, for which we have set aside capital, that will help us understand how distributed technology, including solar and storage, may fit with our system and respond to specific customer expectations. A related project involves the use of solar, storage, and controls on exposed rural radials to enhance reliability. With a large, rugged, dispersed system—in many areas characterized by miles of line per customer rather than customers per miles of line—we are interested to see what applications may become cost-effective over time.

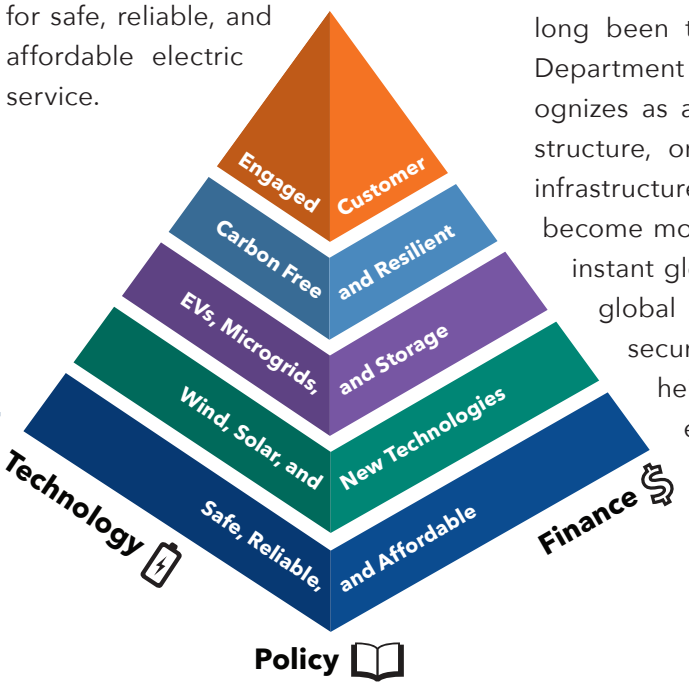
Also, while many companies are closing local customer offices, we are reopening local customer offices and providing our employees access to more tools, information, and mobility in the field. We want to be there for our customers in the ways that are most valuable to them, including face-to-face.

As Tom Fanning describes in his essay, the modern supply planning process, which has been a great success over recent decades, has worked well to achieve long-term, least-cost, least-risk supply choices and increasingly clean electricity. That continues to provide a foundation for good decision making. The Southern Company, Xcel Energy, Southern California Edison, and many other electric utilities are in the process of transforming their supply portfolios.

Current planning regimes may be less satisfactory in meeting the more specific

expectations of some customers for specific attributes, or to meet emerging policy goals. Xcel Energy's Frank Prager highlights innovations in a number of states, including Minnesota's "e21" project, which addresses multiple goals and processes and the potential benefits of a collaborative approach to achieving regulatory reform.

In a sense, Abraham Maslow's "hierarchy of needs" describes how our energy supply planning processes to-date have allowed us—and challenged us—to meet our customers' changing needs for more sustainable energy and greater resiliency, for example, while still meeting customers' basic needs for safe, reliable, and affordable electric service.



Key Drivers of Change: Technology, Policy, and Finance

Both customer advocates and utility companies want to protect customers who simply expect safe, reliable, and affordable service, while also working with customers who have more specific goals. Our ability to meet both basic and evolving customer expectations depends on

- *Technology*—what can be done?
- *Policy*—what either is required to be done or is permitted to be done?
- *Finance*—what will debt and equity investors support being done?

MEETING COMPLEX CUSTOMER EXPECTATIONS

Electric and natural gas utilities have long been the trustees of what the Department of Homeland Security recognizes as a uniquely essential infrastructure, on which all other critical infrastructures depend. That role has become more important in an age of instant global communications and global risks, including physical security, cyber security, and heightened preparation for extreme weather events.

In California, Southern California Edison's Pedro Pizarro is helping lead one of the most dramatic and complex transitions in the industry, while fulfilling multiple, important commitments. Pedro speaks for the industry when he says this requires us "to implement this transition thoughtfully, engaging with our customers at the forefront of technology adoption, while continuing to control costs."

As the articles in this volume make clear, infrastructure now includes hardware and software, and assets with very different characteristics, operating together in complex ways. Nancy Pfund and Mark Perutz describe a technology-driven evolution to a flexible, web-like network. This infrastructure enables and requires new ways to manage and use unprecedented volumes of data, converting noise to useable information.

C3's Tom Siebel describes an ecosystem of addressable devices generating data, which enable utilities to tackle multiple subjects involving asset management and predictive maintenance, reliability, and revenue assurance.

Oracle's Rodger Smith describes how the industry is at the leading edge of power grids that can readily accommodate distributed generation of all types and how the utility of the future will be the platform for delivering new processes and programs, integrating data and analytics to manage the grid.

The evolution has also enabled new ways of meeting customer expectations for a range of energy services, including—but also well beyond—the efficient delivery of electrons and molecules. Opower's Alex Laskey explains how utilities can meet rising customer expectations, offer more personalized services, and ultimately function as "trusted energy advisors."

Service both more automated and more personalized will increasingly be expected by Ron Binz's "digital natives," who have lived their entire lives with technologies that were commercialized only when the Boomers were buying their mini-vans. The "natives" are comfortable with complexity and want to participate in decisions—and the natives are impatient.

I think of the evolution now underway as a movement from the utility as an infrastructure and commodity provider to being an essential infrastructure and service provider. Serving as "trusted energy advisors" fits perfectly with the infrastructure and service model. Sunpower's Tom Werner also emphasizes the value of partnerships, including

some very non-traditional partnerships among utilities and a whole range of entities relatively new to the space, including some of the authors who contributed to this volume.

Peter Kind says utilities can serve as customers' trusted advisors if regulation can be modernized so that utilities are compensated for meeting policy goals, like helping customers achieve cost-effective energy efficiency, rather than solely from earning based on their capital investment. Then, he says, utilities will be able to use all the tools of modern technology to achieve the most desirable goals for customers.

One of those technology tools could benefit utilities as well as customers, says Tony Fadell, as the NEST Learning Thermostat and its opt-in Rush Hour Rewards (RHR) program offer opportunities for both peak-period capacity savings for the utility and money savings for the customer. Perhaps more important, a personalized technology like the NEST Thermostat can help utilities give their customers an experience they want, even if they didn't know they wanted it, and begin to build a better, stronger relationship.

Mary Anne Brelinsky reports that her company, EDF Energy Services, is experimenting with putting the energy value chain pieces back together—using its retail business teams, its trading operation, and wholesale markets—to provide commercial and industrial customers the solutions they desire.

Scott Lang describes an exciting new area for collaboration, going beyond the smart grid to the smart city, in which Silver Spring Networks is much involved. Smart city projects range in both size and scope. As Scott states, the only limit is imagination.

Moving relatively toward a services model rather than a throughput model does require those of us in the industry to "think differently" about how we do our work and engage with our customers. Technology innovation also requires business innovation. Because we—as electric and natural gas utilities—are trustees of essential infrastructure and service, the business model must be sustainable as well as nimble and efficient. It must be able to earn the support of long-term investors, because the capital requirements are both large and ongoing.

Finally, both technology and business innovation require policy makers to support the transition, including modified cost recovery and pricing mechanisms, and also less litigious and more collaborative ways to make decisions

and provide guidance. Ron Binz asserts that regulation has changed little in decades, and that utilities must "be allowed to evolve" by regulators. Frank Prager says that collaboration, good public policy, and appropriate regulatory policies are critical for the successful transformation of the power sector. For all of us—policy makers and regulators, electric service providers, technology partners, and investors—to meet policy goals and especially customer expectations, that kind of alignment will be necessary.

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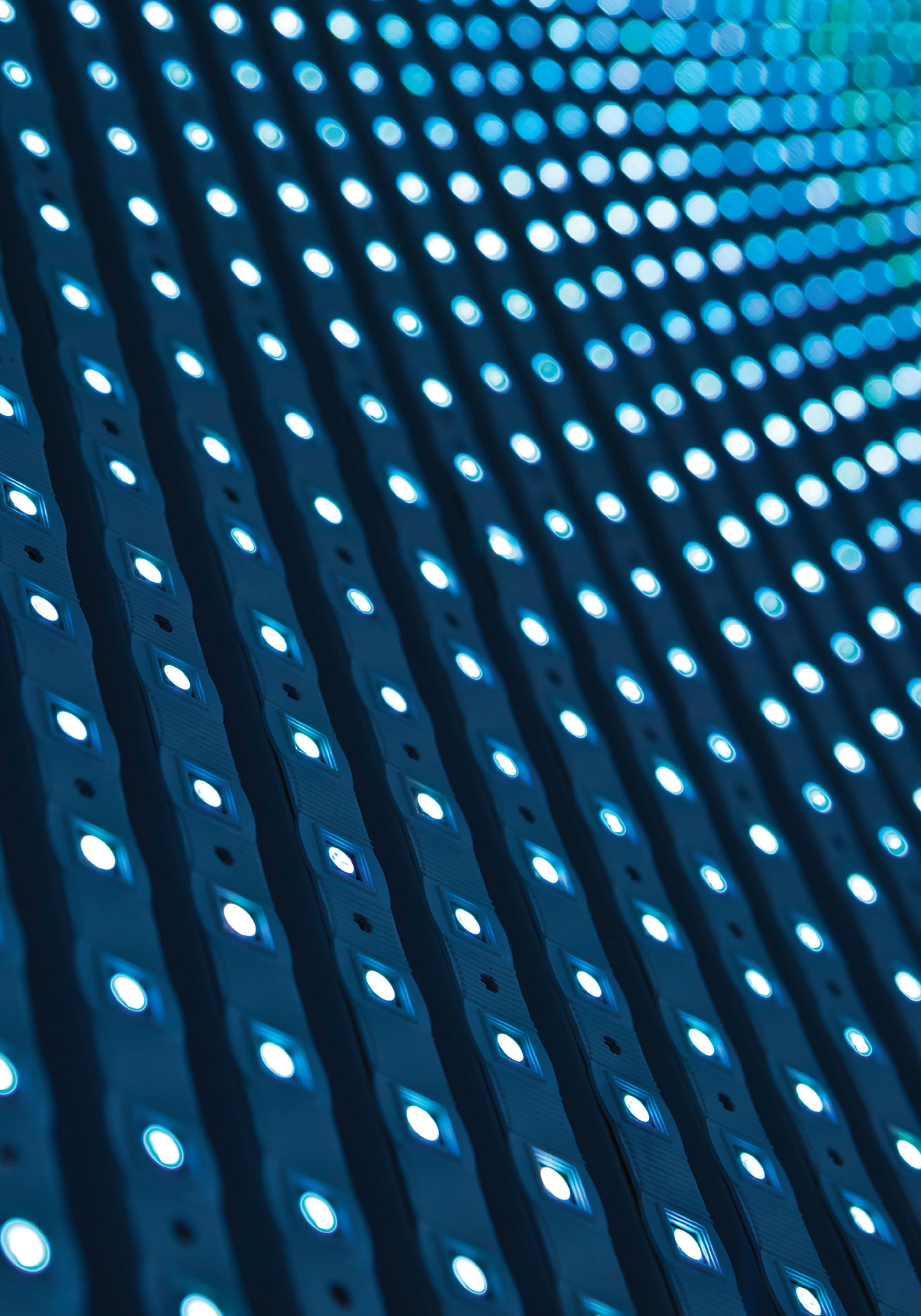
The path to the future is never quite clear. As we identify the challenges we face and pursue solutions, it becomes clearer with every step we take. The customers we serve are counting on us to take those steps.



About the Institute for Electric Innovation

The Edison Foundation Institute for Electric Innovation focuses on advancing the adoption and application of new technologies that will strengthen and transform the power grid. IEI's members are the investor-owned electric utilities that represent about 70 percent of the US 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 more than 30 smart grid technology company partners.

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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