In an accelerated energy transition, can US utilities fast-track transformation?

Magnitude of change puts utilities under pressure to reinvent themselves





In this report

This report, coproduced by the GridWise Alliance and EY Global Services Limited (EY), examines the changing state of the electric utility industry in the US. It explores distribution system solutions fit for a decarbonized, decentralized and digitized electric future.

It builds on the findings of a January 2019 report by EY and EU industry body Eurelectric, which considered the future responsibilities of distribution system operators and the ongoing role of the electricity grid in Europe.

What makes the US market distinct is that utilities — in almost all jurisdictions — manage both the distribution grid infrastructure and the customer relationship. Utilities in some states hold a monopoly over the customer relationship; in others, customers are able to choose their retail provider. Similarly, a significant number of US utilities are fully integrated — for example, managing generation and transmission in addition to distribution and the customer relationship.

Once varying levels of digital-grid maturity and differing state regulatory regimes are considered, it becomes difficult to ascertain the current state and predict the future trajectory of the US distribution system.¹ There is no one-size-fits-all solution. But, there are ways in which electricity providers can innovate, reinvent and secure their trusted provider status with consumers.

The observations made in this report are supplemented by face-to-face interviews with C-suite executives from some of the largest distribution operators in the US, as well as output from an industry workshop hosted by GridWise and EY in Denver, Colorado, in July 2019.

Many GridWise Alliance member companies participated in the study, however, the views expressed in this report do not necessarily represent any individual company's views.

¹A utility, as defined in this report, refers primarily to regulated electric distribution utilities that are investor-owned. While public electric utilities, including municipals and cooperatives, face many of the disruptive issues explored in this report, they operate under different governance and may not be subject to the same observations contained herein.



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Executive summary

The growth in renewables and distributed energy resources (DERs)², the endless possibilities of technology; more switched-on and demanding consumers — all have a role to play in reshaping our energy landscape.

But, as the US electricity industry gears up for transformation, where does today's distribution utility fit in? And, most importantly, what specific steps need to be taken to succeed in the future?

Utilities need to act now to secure a long-term, higher profile role as facilitators of markets, as platform providers for new innovations and as the preferred conduit through which electricity and information flow, both to the customer and back to the grid.

By planning for the future and investing in the new and enhanced capabilities required by a fit-for-purpose and fit-for-the-future distribution system, utilities can become more than trusted service providers. They can become the trusted orchestrators of local power reliability – and they should not delay.

Climate commitments and the relentless rise of renewables

The absence or potential withdrawal of the US from various global initiatives, such as the Paris Agreement, might cast doubts on its commitment to environmental stewardship and decarbonization. But, this perceived national stance belies remarkable renewable energy initiatives that are taking place at a state, local and corporate level:

- Since 2018, 10 states (Hawaii, California, New Mexico, Colorado, Virginia, Nevada, Washington, Maine, New York and New Jersey) plus Washington, DC and Puerto Rico, have committed to 100% renewable energy targets.³
- Over 100 cities across the US have committed to 100% renewable energy targets.⁴

 A record number of publicly announced, new US corporate renewable energy contracts were finalized in 2018, with a combined capacity of 6.5 gigawatts (GW).⁵

Facebook, Walmart, Apple, Alphabet and Microsoft are just some of the major corporations behind these corporate contracts. They are among over 50 companies with US headquarters that are members of RE100, a worldwide initiative that commits the most influential corporations to 100% renewable energy goals.⁶

The utility industry has also risen to the occasion. In 2018, several major utilities, including AEP, National Grid and Southern California Edison (SCE), committed to reduce their carbon emissions by 80% by 2050. Then, in December 2018, Xcel Energy became the first major US utility to commit to 100% carbon-free electricity by 2050.⁷ Since then, Duke, Avista, Idaho Power and others have pledged to attain similar climate goals.

While wind and solar generation grew significantly over the past decade, it is the shale gas revolution and corresponding switch from coal-fired to cleaner natural gas-fired generation that have really driven carbon emissions downward. Between 2008 and 2018, US carbon-dioxide emissions from electricity generation fell 26%.⁸

Natural gas-fired generation has now displaced coal-fired generation as the number one source of electricity generation in the US and is expected to retain this position at least through 2030.

However, it is non-hydro renewables, led by solar and wind, that will experience the most growth going forward. From a combined total of around 9% today, the share of solar and wind energy is expected to almost triple by 2050 when they will account for one-quarter of US generation.⁹

²DERs as defined in this report include distributed generation (e.g. solar photovoltaics, fuel cells, microturbines and diesel generators), distributed storage (e.g. advanced batteries and electric vehicles), and demand response and energy efficiency solutions (e.g. home/building energy management systems)

³⁴⁷States March toward 100% Clean Energy – Who's Next?" Ecowatch website, <u>https://www.ecowatch.com/clean-energy-united-states-2640084281.html?rebelltitem=1#rebelltitem1</u>, 28 August 2019 ^{4*}100% Commitments in Cities, Counties, & States", Sierra Club website, <u>https://www.sierraclub.org/ready-for-100/commitments</u>, 20 September 2019

- ⁶⁷The world's most influential companies, committed to 100% renewable power", RE100 website, <u>http://re100.org/</u>, accessed 28 September 2019 ⁷⁷More Utilities Make Big Commitments to Climate Action", Natural Resources Defense Council (NRDC) website, <u>https://www.nrdc.org/experts/sophia-ptacek/more-utilities-make-big-commitments-climate-action</u>, 5 March 2019 ⁸⁷U.S. Energy-Related Carbon Dioxide Emissions 2018", Energy Information Administration (EIA) website, <u>https://www.eia.gov/totalenergy/data/monthly/</u>, October 2019
- °EY analysis on EIA, International Data Corporation (IDC) data, for details see figure 2

⁵"The Power of Agreement, Rocky Mountain Institute website, <u>https://rmi.org/the-power-of-agreement/</u>, 21 December 2018



Distribution utilities must transform rapidly to keep up

While the upstream generation mix is getting cleaner, a parallel shift is occurring downstream. And that means distribution utilities must prepare now for a future that will see customers become increasingly empowered by opportunities to produce and sell their own electricity.

As in Europe and other geographies, the cost of installing rooftop solar systems in the US has declined dramatically. According to the Solar Energy Industries Association (SEIA), the pre-incentive price of installing an average-sized (five kilowatt), residential rooftop solar system has fallen by more than half since 2010, to around US\$18,000 today.¹⁰

Greater affordability and the low penetration of distributed solar in the US – it currently makes up less than 1% of total electricity generation – means the potential for rapid uptake is enormous. Distributed solar is expected to grow at a compound annual growth rate (CAGR) of over 10% and produce 165 terawatt hours (TWh) of electricity by 2030, which represents almost 4% of the US generation mix. Other DERs, including residential batteries and electric vehicles (EVs) will also experience double-digit growth over the next decade.¹¹

Another pressing consideration for utilities is transportation, the US's biggest carbon-dioxide-emitting sector. It is under pressure from state and local clean energy mandates to decarbonize, representing a significant game-changer in the industry in terms of potential electric load.

Electrification is expected to put almost 19 million EVs on US roads by 2030, compared with just over one million today.¹² The rise of EVs, in turn, will lead to new and variable load on the US distribution system. If they are well prepared, utilities can capture new revenue opportunities from emerging EV value pools that improve the reliability and resilience of the power system. These include:

- Time-of-use programs to shift EV charging to more preferable times
- Demand-response programs to reduce peak load
- Vehicle-to-grid (V2G) services that enable EVs to charge and discharge electricity to and from the grid

California accounts for almost one-half of the US EV market. It leads the way in fast-tracking EV deployment with a mix of state climate goals and consumer incentives, including EV rebates and access to high-occupancy vehicle lanes. More generally, the uptake of EVs in US cities is well above the 2018 national average of 2.1% of new passenger vehicle sales,¹³ which may lead to demand spikes in some urban and suburban clusters.

This great expansion of the DER ecosystem will create challenges and opportunities for US distribution utilities across the next several rate cycles and beyond. Unless US utilities set a course for change to capture the upside of this disruption, they will face long-term, top-line revenue constraints and rising costs, which will significantly challenge the traditional utility business model.

¹⁰"Solar Industry Research Data", Solar Energy Industries Association (SEIA) website, <u>https://www.seia.org/solar-industry-research-data</u>, accessed 30 October 2019 ¹¹EY analysis on IDC, Navigant Research, The Institute for Energy Innovation (IEI) and Edison Electric Institute (EEI) data, for details see figure 4 ¹²EY analysis on IEA. IEI/EEI data, for details see figure 4

¹³"The surge of electric vehicles in United States cities", The International Council on Clean Transportation (ICCT) website, <u>https://theicct.org/sites/default/files/publications/ICCT_EV_surge_US_cities_20190610.pdf</u>, June 2019



Navigating the challenges and opportunities ahead

The current model of rewarding utilities for capital-intensive infrastructure expansion is unsustainable. This approach functioned well as electricity consumption grew reliably over the course of the 20th century, but not anymore.

For more than a decade now, consumers, businesses and industry have grown accustomed to doing more with less energy. Energy efficiency has taken hold throughout the economy with wide adoption of green building codes, smart appliances, LED lighting and energy management systems. In 2017, energy efficiency programs offered by utilities saved enough electricity to power 22 million US homes for a year. Investment in these programs is only expected to grow in the years ahead.¹⁴

On top of this, expected growth in distributed solar will see California, Arizona, Hawaii and parts of the US Northeast, experience significant loss in traditional load and a decline in traditional electricity sales within the next decade.

There are other emerging challenges for US utilities:

- Reduced demand for additional grid-supplied electricity midday due to increasingly high levels of solar generation, followed by steep ramp-ups in demand by late afternoon.
- Unpredictable load from simultaneous EV charging, leading to demand surges and supply shortages, concentrated in some neighborhoods.
- Threats from cyber attacks due to the growing complexity of the digital grid, larger volumes of customer interactions, increased data, more points of entry and exposure at the utility perimeter.
- Impacts on the electricity system from increasingly frequent and intense weather events.

These challenges, together with the rising costs of grid modernization, grid resilience; and the need to replace, maintain and upgrade aging infrastructure, put greater pressure on utilities to increase rates to enable capital investment.



But there are upside opportunities on the horizon too, not least the prospects for deep electrification of the US economy. This will go some way to alleviate future revenue growth challenges from utilities' more traditional loads. Depending on electrification adoption scenarios, the National Renewable Energy Laboratory (NREL) estimates that electricity consumption in the US will increase between 21% and 41% by 2050.¹⁵

In addition to 56 TWh of increased load expected from EVs by 2030,¹⁶ electrification of buildings, heating and industry will increase electricity demand and offset usage decline. This will be driven by clean energy mandates and the potential conversion of gas and fossil-energy source applications to electricity. Utilities should be alert to the prospect of decarbonization initiatives across the residential, commercial and industrial segment, which accounted for 46% of US carbon-dioxide emissions in 2018.¹⁷

Utilities are also well positioned to develop new revenue streams from an evolving ecosystem of consumer products and services. Specifically, utilities can take advantage of opportunities in valueadded power solutions; enhanced energy services; microgrids, connected homes and intelligent buildings; V2G services; lightingas-a-service; smart heating, ventilation and air conditioning (HVAC); and home appliance solutions.

¹⁴"Energy Efficiency Trends in the Electric Power Industry (2008-2017)", Institute for Electric Innovation, <u>https://www.edisonfoundation.net/iei/publications/Documents/IEL Energy%20Efficiency%20Report_Mar2019.pdf</u>, March 2019 ¹⁵"Electrification Futures Study 2018", National Renewable Energy Laboratory (NREL) website, <u>https://www.nrel.gov/docs/fy18osti/71500.pdf</u>, June 2018 ¹⁶"Global EV Outlook 2019", IEA, June 2019

^{17&}quot;U.S. Energy-Related Carbon Dioxide Emissions 2018", Energy Information Administration (EIA) website, https://www.eia.gov/totalenergy/data/monthly/, October 2019

Toward a future distribution system

The current US electric grid was designed to support centralized generation and the one-way flow of power over large networks. Without a more flexible and agile architecture, it will not cope with bidirectional energy flows and decentralized generation. Nor will it realize the full value and potential of DERs as the ecosystem evolves over the next decade, at different speeds in different locations, depending on local economics, policy support and consumer appetite.

Failure to make changes now will see the system headed toward an increasingly complex operating scenario due to the rapid rise in DER participation in wholesale energy markets. Independent system operators (ISOs) and regional transmission organizations (RTOs) will become overburdened by the need to navigate a multitude of statelevel regulations to ensure that DERs comply with local reliability needs.

At the local level, growth in behind-the-meter (BTM) products and services will exacerbate the challenges in in coordinating a system-wide response. Managing congestion, peak load and power quality issues will require flexible and agile resources to balance supply and demand more effectively and to meet customers' higher expectations.

Distribution utilities have the opportunity to take on a leadership role and step up to new levels of responsibility. They can work with ISOs and RTOs to streamline the system in ways that:

- Reduce operational complexity
- Consider the interconnectedness of the bulk electric system
- Account for the downstream impacts of DERs and grid-edge digital devices

New and enhanced capabilities

As part of the redesign to deliver a fit-for-purpose distribution system, utilities will need new capabilities across every aspect of their businesses.

These capabilities will leverage vast quantities of new data that will be captured, stored and analysed from DERs, field sensors, BTM devices and automated electricity networks, and converted into actionable intelligence.



In fact, expenditure on analytics across grid, customer and demand-side segments in North America is expected to more than triple within the next decade, from US\$0.86 billion to US\$2.62 billion.¹⁸

Some of the critical capabilities for the future distribution system will include:

- Integrated planning customer adoption modeling; customer and demand-side analytics and standardized platforms for coordinating distribution-level and transmission system planning
- Asset management weather analytics; improved asset performance and condition data; real-time grid monitoring and predictive maintenance analytics
- System management remote sensing and drone technologies; wearables and augmented or virtual reality and back-office robotic process automation
- Systems operations DER Management Systems (DERMS); Advanced Distribution Management Systems (ADMS); real-time system optimization and enhanced forecasting and modeling tools
- Flexibility management advanced energy storage; non-wires alternative solutions; dynamic market-pricing mechanisms and ancillary DER services managed at the distribution-level
- Commercial operations and customer management EV charging; connected home and energy services; V2G services and peer-to-peer trading

Stakeholder trust

The journey to a fit-for-purpose distribution system, requires utilities to embrace a parallel strategy that wins the confidence and sustains the trust of *all* critical stakeholders — regulators, customers, investors, employees, vendors and partners and peers.

These relationships are founded on trust that may have been built over many decades, but can be lost in an instant.

At this critical time of transition, US utilities need stakeholder trust more than ever to secure support for and investment in the new and enhanced capabilities that will deliver the future clean energy vision.

The industry says:

"2045 or 2050 may sound as though it is a long way off, but what we are talking about is transformative. We have to invest now in the technologies we need to update our grid capabilities and have better real time understanding of what is happening on the grid. We can't afford to lose any more years."

Paul Grigaux,

VP, Asset Management, Strategy & Engineering, SCE

Board-level governance is required to embed trust at the forefront of a long-term strategy if it is to be integrated successfully into the culture of the utility.

Monitoring and measuring performance on trust can then become part of the utility's stakeholder management strategy and risk management toolkit.

Call to action

Change is needed now, and distribution utilities have the opportunity to deliver that change under a bold new vision.

The urgency that accompanies fast-track transformation will require utilities to consider the following.

Advocate the core principles for system redesign

Utilities will need to communicate effectively with key stakeholders that they are best placed to:

 Achieve continued power quality and reliability at the distribution level through the optimization and aggregation of local DERs

¹⁸"Al and Advanced Analytics Overview," Navigant Research, 3Q 2019

- Streamline DER participation in wholesale markets by aggregating excess supply or demand into single bids to balance local reliability needs
- Provide visibility and guidance to DER owners on avoiding conflicts with local reliability needs

Launch a three-phased investment approach

Utilities will need to work through three investment phases as they progress towards the future distribution system. These phases may be concurrent as they develop the new and enhanced capabilities that will enable them to take on higher-order responsibilities that will be integral to their future roles.

Phase 1: Connect and protect

To connect growing numbers of DERs, without compromising local power reliability, utilities will continue to invest in grid modernization. Granular modeling and forecasting methodologies, and greater visibility over connections, will be critical to better understand the scale and scope of DER deployment.

DERs, including distributed generation and batteries, will provide essential backup during extreme weather events. At the same time, investment in grid-scale storage will improve the overall responsiveness of the system and the means to restore balance to supply and demand.

DERs leave the grid edge exposed to physical and cyber threats at multiple entry points. Distribution utilities must invest in risk-informed approaches to manage security and protect the distribution system from attack.

Figure 1: Three-phased approach to US distribution-system investment

Far from a one-size-fits-all distribution system model, outcomes will be shaped by local circumstances, maturity and dynamics



Source: "Distribution systems in a high distributed energy resources future," Future Electric, and EY analysis

Phased investments

Phase 2: Sense and enable

Investment in sensors to automate and control the network will create situational awareness at the grid edge and enable improved real-time monitoring and control. Ultimately, as DER uptake accelerates, utilities will invest in DERMS, either as standalone implementations or phased into a broader ADMS strategy.

Increasingly, utilities will also invest in securing their future role as neutral market facilitators and platform providers for trading flexible energy resources.

Phase 3: Optimize and control

As the US energy model becomes increasingly decarbonized, decentralized and digitized, utilities must prepare to take on higherlevel responsibilities.

They will make investments in distributed intelligence at the gridedge through advanced, real-time management and control of local DERs. As platform providers, they will transact in innovative products and services offered by utilities, partners and other third parties. By streamlining and securing reliable power supply, they will become trusted system orchestrators.

And, by driving the transition agenda, utilities can emerge from their long-held status as providers of electrons to become lynchpins in a distribution system that is fit-for-purpose in the evolved, digitized and clean-energy world.



² Time is not on utilities' side as energy transition overturns conventional business models

The US electric utility industry faces unprecedented challenges, with more turbulence ahead. How well it adjusts and manages the transition will determine the durability of tomorrow's distribution system

The energy world is transitioning at a rapid pace. It is driven by the three Ds: decarbonization, decentralization and digitization. Long-standing industry conventions and operating models are being overturned, giving rise to a wave of new risks, challenges and opportunities that today's distribution utilities must address.

How utilities respond to disruption will determine the winners and losers in the new energy world.

Decarbonization and the energy-efficiency conundrum

Already, wind and solar resources are cost competitive with new fossil fuel–sourced power in most markets. The US is no exception. Wind capacity and solar capacity have experienced significant growth over the past decade and now account for 6.6% and 2.3% of total US electricity generation, respectively.¹⁹

Looking ahead, EY estimates that utility-scale solar will far outpace wind and account for 9% of US generation by 2050.²⁰ Wind will provide 8%. Once smaller, distributed solar photovoltaic (PV) systems are factored in, accounting for another 8% of generation by 2050, the US is set for a clean energy transformation.

Renewables tell a remarkable growth story. But, the US experience is underscored by a concurrent revolution in shale resources, which has prompted natural gas prices to drop to historic lows. Between 2008 and 2018, natural gas-fired generation increased from 21% to 35% of total US electricity generation. Coal-fired generation dropped from 48% to 28% over the same period.²¹

Asking the big questions

- What is the future role of distribution utilities?
- How are we going to use the grid?
- How do we ensure the grid evolves to keep pace with changing technology?
- What new and enhanced capabilities do we need?
- How do we sequence investment in the network?

¹⁹"Net Generation from Renewable Sources", EIA data, 2018
²⁰EY analysis on IDC data
²¹EY analysis on IDC data



But, natural gas is also facing challenges from decarbonization initiatives. New York state recently vetoed construction of new interstate natural gas pipelines, which will affect not only New York but also New England. This supply constraint, in turn, has led to several Northeastern utilities imposing moratoria on future gas connections for new customers. Elsewhere, in late 2018, PG&E and APS announced that they would replace natural gas power plants with battery storage, on the back of the improved performance and decreasing costs of batteries.

But for now, natural gas has displaced coal as the number one source of electricity generation in the US. And the EIA expects gas to retain this status for several decades to come.²²

The impact of energy efficiency

Total US electricity demand has remained relatively flat for the past decade. It is driven, largely, by declining energy consumption and supported by initiatives such as energy-efficient lighting, revised appliance standards and green building codes. Yet, energy efficiency continues to present a conundrum to US utilities. It runs counter to the traditional business model, which is about selling, not conserving, as much electricity as possible.

Digital technologies, including home energy management systems, smarter appliances and intelligent buildings, enable consumers to do more with less by managing electricity consumption more effectively.

Utilities' revenue challenges are often compounded by a lack of regulatory support for their investments in energy efficiency and demand-side management programs. According to the American Council for an Energy-Efficient Economy (ACEEE), "more states need to adopt and maintain an optimal mix of policies that align utility business models with energy efficiency."²³

Progress has been made where states set clear energy-efficiency targets and align them with traditional utility ratemaking. This is achieved through regulatory tools that include revenue decoupling, program-cost recovery and performance incentives.

For instance, New York investor-owned utility (IoU) Con Edison benefits from an earnings adjustment mechanism (EAM) for exceeding energy-efficiency program targets. In 2018, Con Edison was rewarded through the EAM for achieving 393.5 gigawatt hours (GWh) in energy savings and 85.0 megawatt (MW) in system peak reductions.²⁴

Energy-efficiency solutions and non-wires alternatives, including demand response and batteries, need to become key components in the resource mix. They will sit alongside renewable generation to enable US utilities to provide the most sustainable, low-cost energy to the end customer.

Decentralization: the big game changer for utilities

DERs, such as rooftop solar PVs, EVs and battery storage, are leading us into a more decentralized energy world.

This presents both upside and downside risks to utilities' revenues. Clearly, greater adoption of rooftop solar and energy-efficiency programs will undermine the traditional utility's need for electricity sales. Conversely, growing uptake of EVs promises a future boost.

Yet, without a guarantee of rate-based returns, many utilities are wrestling with the decision to invest in EV charging infrastructure. This, in turn, has consequences for EV adoption and invites greater competition from other market players.

The energy-efficiency conundrum

The more the world focuses on energy efficiency, the greater the hit on utility revenues. Comprehensive policies and incentives need to be applied more widely to encourage utilities' investment in energyefficiency programs.

"Annual Energy Outlook 2019", EIA, 2019

²³"Aligning Utility Business Models with Energy Efficiency", American Council for an Energy-Efficient Economy (ACEEE) website, <u>https://aceee.org/sector/state-policy/toolkit/aligning-utility</u>, accessed 25 September 2019

²⁴"Con Edison 2018 Energy Efficiency Earnings Adjustment Mechanism Achievement Report", State of New York Public Service Commission, 2018

Several DER tipping points are fast approaching that will escalate utility decision-making:

- Rooftop solar plus storage is becoming increasingly cost competitive with grid-supplied energy.
- Cost parity for new solar plus storage distributed systems is anticipated as early as 2026 in the US Western region.²⁵
- Cost and performance parity of EVs with conventional vehicles is possible as early as 2025, positioning them for mainstream US adoption.

These tipping points will arrive at different times in different geographies, with California at the vanguard of disruption. In 2018, its installed base of 7.1 GW of distributed solar capacity was more than the combined total of the next four top states (see Figure 3). By mid-2019, distributed solar capacity in California had grown to over 8.4 GW.²⁶

The state also leads in EV adoption, with over 655,000 vehicles as of October 2019, almost half the US total EV market.²⁷

The industry says:

"In the areas we serve we are supporting local and state goals as we continue to work toward a clean energy future. We believe an orderly transition is in everyone's best interests which is why we developed our Smart Solutions for Natural Gas program."

Matt Ketschke, SVP, Customer Energy Solutions, Con Edison

^{25*}<u>EY Countdown Clock analysis</u> (Western region includes California, Washington, Oregon, Nevada, Idaho, Utah, Arizona, Montana, Wyoming, Colorado, New Mexico)
^{26*}California Solar Initiative", <u>https://www.gosolarcalifornia.ca.gov/csi/</u>, accessed 5 October 2019
^{27*}Sales Dashboard", Veloz website, <u>https://www.veloz.org/sales-dashboard/</u>, accessed 5 October 2019

Figure 2: US renewable generation by source (TWh), 2008–50



US renewable generation by source (TWh), 2008–50

California's early lead may provide a much-needed kick-start to distribution utilities in other states. Right now, the DER footprint is relatively small compared with overall traditional grid infrastructure in the US. Indeed, current supply from distributed solar systems accounts for less than 1% of total US electricity generation.²⁸

But DERs are entering a period of dramatic growth. Over the next decade, most DER technologies are expected to experience double-digit CAGRs due to reductions in cost and improvements in performance (see Figure 4).

As DERs proliferate, demands on the system will intensify. Higher penetrations of distributed solar will exacerbate so-called "duck curves," where the drop in net electricity load due to solar generation midday gives way to steep ramp-ups in demand by late afternoon. California, Arizona and New England are already facing such challenges and need to ensure sufficient peaking capacity is available.29

Meanwhile, demand surges from simultaneous EV charging could create power quality issues or supply shortages. So, on top of understanding optimal EV charging patterns, utilities must invest in new wires to distribute more power, as well as transformers to step down high-voltage electricity to distribution levels.

By 2030, a DER ecosystem will emerge of significant scale and scope to support the larger transactional volumes that will be needed to enable a truly digital and decentralized energy marketplace.

As technology costs decline, customer interest in generating their own power increases. A 2019 EY study found that consumers were

The industry says:

"If you don't prepare the grid for the future, once you get to the future, it's too late. You end up playing catch-up."

Lee Mazzocchi, SVP, Grid Solutions, Duke Energy

It's a fact

In 2017, energy saved from energy-efficiency programs in the US would be enough to power 22 million homes for a year.

Investment in energy-efficiency programs is expected to reach US\$9 billion per annum in 2025, resulting in more than 250 million tons of avoided carbon dioxide emissions.

most interested in independent power generation to "save money in the long run." Saving money ranked ahead of environmental concerns, such as reducing their carbon footprint.³⁰

There is opportunity, though, for utilities to coevolve the grid in-line with the DER ecosystem.

By managing a flexible resources platform, and allowing DER owners and aggregators to participate and trade in a fair and open energy market, the grid becomes more relevant to the changing needs of tomorrow's customers.

Indeed, more than half (56%) of delegates at the GridWise and EY industry workshop said that in addition to providing reliable power, the most important role for the distribution utility of the future is as a neutral market facilitator and platform provider (see Figure 5). In Section 3 of this report, we explore the building blocks, including new and enhanced capabilities, that will enable the distribution utility to transition to that role.

Digitization forces utilities to embrace technology

Technology and innovation are enabling the energy transition. The ability to do things faster, smarter, more cheaply and more creatively is a consequence of the digital revolution. Consumers expect utilities

³"Electricity data browser,", ElA website<u>, https://www.eia.gov/electricity/data/browser/</u>, accessed 30 September 2019

²⁰¹ Massachusetts Is Staring Down a Duck Curve of Its Own. Storage Could Help," Greentechmedia website, <u>https://www.greentechmedia.com/articles/read/massachusetts-is-staring-down-a-duck-curve-of-its-own-storage-could-help</u>, 23 April 2019 ³⁰"US Fuels of the future survey", EY, May 2019



Top five US states for installed distributed solar* capacity (GW), 2018

Figure 3: Top five US states for installed distributed solar* capacity (GW), 2018

to deliver the enhanced digital experiences that they have become accustomed to in other sectors, such as telecommunications and online retail.

However, distribution utilities are challenged by growth in digital devices and convergence between the Internet of things (IoT), information technology (IT) and operational technology (OT). This convergence now contributes to a more interconnected and complex data-dependent energy world. Every sensor, smart meter and intelligent device adds to the exponential increase in data.

Utilities can tap into the upside of this disruption by investing in advanced analytics to transform big data into actionable intelligence that deciphers behaviors, detects load patterns and identifies faults and outages.

Navigant Research forecasts that expenditures on analytics across utility value chain segments* in North America will almost triple, from US\$1.1 billion to US\$3.1 billion, within the next decade. Growth in analytics will accelerate as utilities seek to automate back-office processes; transform operations through real-time sensing, monitoring and communications; and better understand customer behavior. But, as in Europe, proliferation in data is both an enabler and a risk. The growing complexity of the digital landscape creates new vulnerabilities, including the threat of cyber attacks and fears over data privacy.

Though the US is relatively advanced when it comes to cybersecurity of the bulk electricity transmission system and critical infrastructure, the distribution system is less well protected. So, as DERs and digital devices transform the utility perimeter, the overall system and data that drive it become more vulnerable. Distribution-level impacts have the potential to filter upstream, affecting transmission and generation, leaving the entire network exposed.

Utilities must manage the security profile of distribution-level assets — including DERs — more effectively. The National Institute of Standards and Technology (NIST) cybersecurity framework, and other risk management tools, will become increasingly relevant for managing the digital grid, data protection and distribution-level security.³²

³¹"Al and Advanced Analytics Overview," Navigant Research, 3Q 2019 * includes generation assets, grid assets and operations, customer operations and demand-side

includes generation assets, gnd assets and operations, customer operations and demand-side analytics
 "rybersecurity Framework Smart Grid Profile" [IS Department of Commerce National Institute

³² "Cybersecurity Framework Smart Grid Profile", US Department of Commerce, National Institute of Standards and Technology, <u>https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2051.pdf</u>

Projected growth in the US DER ecosystem



Figure 4: Projected growth in the US DER ecosystem

Electrification to counter shrinking demand

While rising energy efficiency and growth in distributed generation present a significant threat to utilities' traditional revenues, electrification offers tremendous upside potential, with transportation being the most significant growth driver.

The Edison Electric Institute (EEI) and the Institute for Energy Innovation (IEI) estimate that 18.7 million EVs will be on the road in the US by 2030, compared with just over 1 million today.³³

California leads the way, with almost one half of the current US EV market and 31% of all US public charging infrastructure.³⁴ Falling costs of batteries, combined with state climate goals, zero-emission vehicle regulations and consumer incentives, such as rebates and access to high-occupancy vehicle lanes, have boosted adoption. This, in turn, adds new and variable load to the electric distribution system.

Policy-makers in other states are taking steps to accelerate EV uptake. In Arizona, for instance, utilities are allowed to recover the "prudent costs" of investing in EV charging infrastructure through rate base.³⁵

Utilities need to take advantage of the significant growth opportunity in transportation electrification. By 2030, 9.6 million charge ports will be installed across the US. This will include around 900,000 public charging ports, up from approximately 54,000 in 2018,³⁶ representing a 26.4% CAGR. Some utilities will partner with car manufacturers to deliver vehicle plus clean energy packages; others will collaborate with manufacturers of charging stations and other associated infrastructure.

Beyond transportation, new technological advances, backed by policy measures, will accelerate electrification of heat and industry. Taken together, the transportation, residential, commercial and industrial segments account for almost three-quarters (72%) of US carbon dioxide emissions.³⁷ (see Figure 6).

³³"Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030", IEE/EEI, <u>https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.pdf</u>, November 2018
 ³⁴"California's continued electric vehicle market development", The International Council on Clean Transportation (ICCT) website, <u>https://theicct.org/sites/default/files/publications/CA-cityEV-Brief-ing-2018.pdf</u>, Nay 2018
 ³⁵"Arizona adopts new EV policy to spur new rate designs, pilot programs from utilities", Utilitydive website, <u>https://www.utilitydive.com/news/arizona-adopts-new-ev-policy-to-spur-new-rate-designs-pilot-programs-from/5448537</u>, 21 December 2018.

³⁶ Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030", IEE/EEI, <u>https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_</u> <u>Nov2018.pdf</u>, November 2018 ³⁷ U.S. Energy-Related Carbon Dioxide Emissions 2018", Energy Information Administration (EIA) website, <u>https://www.eia.gov/totalenergy/data/monthly/</u>, October 2019 Deep electrification throughout the US economy, using cleaner energy sources, holds enormous potential for meeting city- and state-level carbon reduction targets.

The upshot is a significant and ongoing increase in demand for electricity, which offsets some of the usage decline from increasing energy-efficiency. Data from NREL concurs. In its 2018 *Electrification Futures Study*,³⁸ NREL models the increase in US electricity consumption by 2050 under three electrification adoption scenarios:

- Reference 21% growth a world with least incremental change in electrification
- Medium 32% growth a future described as having widespread, "low-hanging fruit" electrification opportunities
- High 41% growth a future described as having undergone transformational electrification

Under the medium and high scenarios, transportation drives most of the demand increase, with more limited growth in the residential, commercial and industrial segments. This is due, in large part, to the high efficiency of heat pumps and replacement of inefficient electric heaters.³⁹

The industry says:

"We're in a period of transition towards a modern grid in which we are augmenting an aged asset base with new digital technology for enhanced planning and real time situational awareness. As our ability to manage the grid more granularly increases we expect to unlock new opportunities to improve efficiency and performance. Modernizing the entire grid will take time and until then we need to leverage the new and the old."

Chris Kelly, COO, National Grid

³⁸The Electrification Futures Study: Demand-Side Scenarios", National Renewable Energy Laboratory (NREL) website, <u>https://www.nrel.gov/docs/fy18osti/72096.pdf</u>, July 2018
³⁹"NREL study examines impact of vehicle electrification on electricity demand", Dieselnet website, <u>https://www.dieselnet.com/news/2018/08nrel.php</u>, 17 August 2018

Figure 5: GridWise and EY workshop polling result, July 2019

Besides continuing to distribute power reliably, what will be the most important role of the distribution utility of the future?



Why a one-size distribution system will not fit all

As the DER ecosystem expands, managing the distribution system becomes increasingly complex. There is no one-size-fits-all response.

Outcomes will be shaped by local circumstance, maturity and dynamics. Some states will be characterized by high EV adoption; others by low-technology implementation and lower levels of DERs. Some will serve progressive, early adopter urban communities; others will support mainly rural users, who place greater value on security of energy supply and affordability.

Perhaps weather-related resilience best highlights the challenges of implementing consistent and uniform solutions across the US. Resiliency has different meanings in different geographies, depending on local circumstances. From hurricanes that roll through the Atlantic, impacting the Southeast and East Coast, to tornados in the Midwest and South, ice storms in the North and Northeast, and wildfires on the West Coast, the US has it all.

The industry says:

"Expanded use of distributed energy resources creates more cyber attack surfaces. Our pilot programs are held up by security assessments, while we check that interconnecting customer devices do not introduce cyber risk."

Delegate at GridWise and EY event, Denver, Colorado, July 2019

In a 2018 EY study, business interruption from uncontrollable natural hazards and cyber attacks ranked as the number one critical operational risk facing utilities.⁴⁰

Figure 6: US carbon dioxide emissions by sector, 2018

⁴⁰"How to avoid being sunk by operational P&U risks", EY website, <u>https://www.ey.com/en_gl/power-utilities/how-to-avoid-being-sunk-by-operational-p-u-risks</u>, 1 September 2018



Carbon dioxide emissions from energy consumption by sector, 2018

Annual electricity consumption (TWh)



Source: NREL, Electrification Futures Study, June 2018

Figure 7: Annual electricity consumption (TWh) in the US by 2050

These events create urgent need for energy system hardening and resiliency across vast US terrains. The challenge is in finding the right balance between DERs and traditional grid infrastructure. Rather than improve overall system resiliency, overdependency on one or the other could result in loss of supply during a single weatherrelated event.

US utilities must consider the best ways to harden the system based on their unique circumstances, as well as invest in new and enhanced capabilities to meet tomorrow's energy needs.



The industry says:

"Because of our metered deployments, we were able to provide customer communications throughout Hurricane Harvey. We restored outages and switched circuits via our automated devices and intelligent grid, even when our crews couldn't access locations. Our investments enabled us to perform well and engage our customers like never before during such an extraordinary weather event."

Steve Greenley, VP, Distribution Operations, CenterPoint Energy

Capabilities needed today to prepare distribution utilities for tomorrow

As a new energy ecosystem emerges, utilities must acquire the right skills and capabilities to balance the influx of DERs and manage the arrival and impact of other disruptive technologies.

If utilities are to deliver a distribution system fit for our evolving energy future, they must address six key operational areas, which are discussed below. New and enhanced capabilities are needed in each area, which touch every aspect of the utility operating model.

Targeted investments will position distribution utilities to become essential linchpins for coordinating power reliability needs right across the electricity system, not just at the local level. New and enhanced capabilities will enable distribution utilities to take on more responsibilities for the management, control and aggregation of DERs.

In turn, ISOs and RTOs will be freed up to focus on their core responsibilities — overseeing the functioning and integrity of the wholesale energy markets and ensuring the reliability of transmission and the bulk electricity system.

Integrated planning to better understand DER uptake and impact

DERs will impact localized distribution as well as the broader transmission network. Utilities will need to develop better tools for identifying and planning capacity requirements, as well as coordinating and integrating decisions with the transmission system operator, where appropriate. Improved forecasting capabilities, designed to capture the granularity of DER integration and predict future uptake, will become increasingly valuable to utilities as they seek certainty around the deployment of BTM resources.

Traditional top-down forecasting, which focuses on historic DER deployment and expectations or targets for the entire distribution system, will be neither adequate nor robust enough to capture the variations and true impact of rising DER adoption.

Instead, utilities must make greater investment in bottom-up forecasting methodologies such as customer adoption modeling. This is a more dynamic and flexible approach that considers multiple scenarios under changing demographics, incentives and peer behavior. According to a U.S. Department of Energy study, customer adoption models represent the most comprehensive forecasting approach available today.⁴¹

The Electric Power Research Institute (EPRI) maintains that an integrated approach to T&D planning is critical. Given the lack of visibility over DER deployment, it will become increasingly difficult to measure their expected scale and scope.⁴² Newly emerging software tools can help utilities plan for increased DER adoption and better understand their likely financial and operational impacts.

⁴¹"Planning for a Distributed Disruption: Innovative Practices for Incorporating Distributed Solar into Utility Planning," US Department of Energy (DOE), Ernest Orlando Lawrence Berkeley National Laboratory, <u>https://pdfs.semanticscholar.org/2d76/a41ae069feba0e700f0386ccdc458993ffc6.pdf?_ga=2.243986757.1539587674.1573550274-1129422487.1573550274</u>, August 2016

^{42"}Integrated Grid, Realizing the Full Value of Central and Distributed Energy Resources," Electric Power Research Institute (EPRI), <u>https://www.energy.gov/sites/prod/files/2015/03/</u> f20/EPRI%20Integrated%20Grid021014.pdf, 2014





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Better and faster asset management with predictive analytics

Most utilities are familiar with the challenges of replacing, maintaining and upgrading traditional infrastructure, such as aging substations, poles and wires.

Now, however, new customer-owned DERs influence voltage, frequency and temperature patterns. These, in turn, impact asset life cycles. Utilities have responded with increased monitoring and automation at the distribution level.

But, as the digital ecosystem extends downstream, asset management at the distribution level will demand greater sophistication. Management of assets will become more predictive than reactive, backed by enhanced inputs from remotely sensed data, weather analytics and drone technology. The result will be better and faster insights from monitoring asset and network performance in real time.

The industry says:

"We have a half million poles and onethird of a million transformers in our system aging every year. In a perfect world, you replace the pole the day before it falls down and you replace the transformer the day before it fails. If you have enough data, you can get much closer to figuring that out. So, we want to be in a position to get the full life out of the asset. And that frees up resources to invest in other spaces."

Jacob Tetlow,

VP, T&D Operations, Arizona Public Service Company

Predictive maintenance analytics can optimize both capital and operational expenses for utilities. Used to identify failures before they happen, they can prevent outages and save millions of dollars.

According to Navigant Research, utility spending on asset management software (AMS) in North America will increase from US\$190.8 million in 2019 to US\$306.9 million in 2028, representing a 5.4% CAGR. Given the maturity of AMS, most of this spend will be on upgrades and replacement, rather than on new project installations.⁴³

Aging infrastructure and the rise in weather-related disruptive events are also prompting improvements to asset management for improved reliability and resiliency. The growing frequency and intensity of hurricanes, storms, wildfires and other disasters expose the vulnerability of critical utility assets, such as substation equipment and transformers. Higher levels of situational awareness, using technologies such as light detection and ranging (LiDAR) and weather analytics, enable more accurate forecasting to mitigate risks.

Real-time system management

The shift to digital and mobile devices is revolutionizing the way in which utilities and their employees interact. It makes real-time information available, improving accuracy in reporting, meaning reduced operational errors and better workflow due to more effective job scheduling and crew dispatch.

As enhanced mobile workforce applications and devices become further integrated into the digital grid, and as emerging technologies, such as drones, wearables and augmented or virtual reality (AR/VR) take off, the upsides will extend across the utility. They promise to change the ways utilities work in the future and how they invest to enhance system configurations and responsiveness.

Disruption is also underway in utility back-office processes. Administratively heavy and repetitive tasks are ripe for automated solutions, such as robotic process automation (RPA).

RPA streamlines processes so they can be managed more quickly, efficiently and with greater agility, reducing errors and enabling

⁴³"Market Data: Utility Asset Management Systems and Analytics," Navigant Research, 3Q 2019



Figure 8: New and enhanced capabilities for a fit-for-purpose distribution

24/7 availability, while providing evidence in the form of audit and compliance trails. Utilities using RPA will experience better supply chain management, contract management and vendor selection in tomorrow's distribution system.

Enhanced system operations for grid-edge control

The more digitized the energy ecosystem becomes, the more complex it is to monitor, manage and control distribution-level resources.

As more DERs are deployed, the need to balance supply and demand at the distribution level becomes more urgent. Central coordination and control of distribution is critical. Priority dispatch, instantaneous islanding, price signals and other mechanisms will each contribute to more flexible and constructive DER deployment and enhance overall system performance.

But, bringing visibility over power flows, loads and connections to a command center, via a communications network, might prove prohibitively expensive and time consuming. It demands situational awareness and distributed intelligence to extract information from digital devices and to respond in real time.

The industry says:

"The analytics behind asset management is still new. It tells you what you are actually seeing, rather than what you intuitively think. We learn from what the data shows us, rather than what we thought was the issue. But you have to have the right skill set within your company to do it right."

Delegate at GridWise and EY event, Denver, Colorado, July 2019

The integration of demand response (DR) and a DERMS with an ADMS is considered, by many in the industry, as the most holistic and effective solution for managing and controlling an increasingly complex grid.

The industry says:

"If you've got visibility over what is happening with DERs, crews will also know what they are walking into when they show up on-site. That is going to be really important in the future."

Delegate at GridWise and EY event, Denver, Colorado, July 2019

Utilities can typically approach this in two ways:

- Full-scale ADMS rollout DR and DERMS can be implemented over time, as part of a full-scale ADMS rollout. This may take years to achieve, depending on the utility's starting point and end-state aspirations. It will deliver realtime power flow information and take account of system conditions and limitations.
- Phased approach DERMS can be implemented as a stand-alone solution. This is a faster fix, enabling the utility to comply with regulatory mandates but still achieve significant value from managing DERs.

Real-time control capabilities at the grid edge are not widely available today. However, utilities recognize the value and promise of DERMS as the pace of change accelerates and as demands on the grid become more complex. Navigant Research says global expenditure on DERMS is expected to almost quadruple between 2018 and 2026, from US\$228.7 million to US\$912.6 million.⁴⁴

The sophistication and speed of communications technology will improve, and the cost of sensors and processors will continue to fall. Real-time control of grid-edge devices will become an industry norm. In the near term, utilities will focus on those circuits with high DER saturation levels. They can trial new technologies and processes and prove concepts before scaling and integrating ADMS and DERMS into their broader operations. Telemetering, switching, artificial intelligence, machine learning and predictive analytics can each be tested using a modular IT architecture to improve DER monitoring and control.

Flexibility management to balance volatility

US utilities have the opportunity to make strategic investments in building the grid as a platform. It will allow market participants to match grid capabilities, allocate resources efficiently and achieve high levels of capacity utilization.

Anticipated volatility in load patterns, due to the intermittency of distributed generation and unpredictable or clustered EV charging, will put a premium on timely and efficient balance in energy supply and demand.

Whether using batteries for peaking, ramping applications to better manage load profiles, or calling on demand-response solutions to reduce consumption, flexible resources will be critical to the success of the future US distribution system. Still to be determined is how utilities and other market participants will be compensated for leveraging flexibility and optimizing the electric distribution system.

The industry says:

"Architecturally, the big question is whether we believe a DERMS solution is something that we need to control at every point, or whether our system is simply a broader platform into which third parties flow."

Val Jensen, SVP, Strategy & Policy, Exelon

⁴⁴"Optimizing DER Integration and Grid Management with DERMS and ADMS," Navigant Research, 4Q 2018

Utilities might also deploy dynamic market pricing mechanisms to capture the changing value of flexible resources deployed across the network. This could include time-of-use price signals to prompt EV drivers to change their charging behaviors and reduce load on the network.

Such solutions will intensify competition between different technologies, leading to both better cost and power-quality outcomes for customers.

Alternative revenue streams and better customer management

Once the distribution system platform is established, the utility may start to engage in new commercial ventures. Some may take a passive role as neutral market facilitators, while others will participate more actively in direct ownership, strategic partnering and commercialization of DER opportunities.

For more active participants who have scale and regulatory support, commercial opportunities might include:

- Energy services energy portfolio advisory; energy efficiency; building optimization; load management; energy usage data and analytics
- Home solutions home warranty; appliance and HVAC equipment maintenance repair; plumbing and other inhome services
- Energy supply backup power; microgrids; rooftop and community solar; smart inverters and battery storage
- Transportation electrification fast EV charging stations and V2G services
- Lighting solutions outdoor security or private area lighting; energy-efficient lighting and billboards
- Connected homes home automation; smart thermostats; digital assistants; smart windows, plugs and devices; security cameras

The industry says:

"We need to be in partnership with companies providing behind-themeter services and facilitating, enabling and optimizing those resources for the benefit of all. With partners, we can satisfy customers in ways that we cannot achieve individually."

Barbara Lockwood, VP, Regulation, Arizona Public Service Company

Utilities entering these lines of business are well positioned to leverage their deep and long-standing relationships with customers.

An established brand, and the connotations of security that go with it, gives utilities a head start. It positions them to become key orchestrators of the digital grid and the connected home, enhances their relationship with customers and reinforces their status as trusted energy advisors.

Investment in new and enhanced distribution system capabilities can be achieved over three phases:

- Connecting growing numbers of DERs, while reinforcing and protecting the grid to provide resilience
- Improving situational awareness at the grid edge through advanced sensor deployment, while enabling platforms for flexibility services and new innovation
- Optimizing the dispatch of DERs to improve local power reliability, while engaging customers through digital channels and new BTM products and services

This phased investment approach is explored in Section 5 of this report. But the journey to a fit-for-purpose distribution system also requires utilities to embrace a parallel strategy that wins the confidence and trust of their most important stakeholders.

⁴ Why trust matters even more in the digital future

Trust between the utility and its stakeholders will secure support for and investment in new and enhanced capabilities to underpin the future distribution system.

The energy transition comes with significant upside. But, it also carries substantial risk that advances in technology, industry disruption and growing complexity will endanger the trust and goodwill that utilities have built with their stakeholders over many decades.

Self-generation and the changing customer dynamic

Chief among utilities' stakeholders are customers. Customers trust utilities to deliver low-cost, safe and reliable energy to their homes and businesses, to be responsive when things go wrong and to provide accurate billing.

But today's customers are more demanding and increasingly want cleaner energy options and the same digital experience they get from other service providers.

With distributed solar plus storage, customers can even take control of their own energy needs and become service providers to the utility through DERs. For that, they want timely and accurate information to make decisions and to maximize the return on their DER investment.

With the transition to a digital grid, the need to safeguard consumer privacy and data will become integral to bolster trust.

US distribution utilities might leverage lessons from the California Consumer Privacy Act (CCPA), which was signed into law in 2018. The CCPA protects the privacy rights of California's residents by dictating what consumer data can be collected by businesses, the need for explicit consents, the requirement to disclose data breaches and penalties for noncompliance. Similarly, the European Union provides protections to its residents under the General Data Protection Regulation, which may also provide valuable lessons to US utilities.

By getting a head start on forthcoming state or federal data protection mandates, distribution utilities will be well placed to achieve their commercial objectives without compromising consumer privacy.



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Keep your regulators close to accelerate the case for change

Trust is fundamental to constructive relations between utilities and their regulators.

Innovative regulatory frameworks, based on transparency between stakeholders, are being introduced in some states, with utilities incentivized to pursue more sustainable pathways.

In the Midwest, the Minnesota Public Utilities Commission (PUC) is spearheading a movement away from traditional cost-ofservice rate-making to performance-based regulation (PBR). Local utility Xcel Energy is expected to structure its future rate plans around new metrics focused on affordability, reliability and environmental performance, as well as cost-effective alignment of generation and load. Minnesota's approach is built on consensus between stakeholders, with Xcel itself a critical voice in designing the guiding principles and recommended changes to regulation.⁴⁵

The industry says:

"The customer is no longer a homeowner who wants service. The customer can be a battery owner or a solar facility operator. Think of customers more broadly as anyone or anything that wants to connect to the system and how you, the utility, can make it easier for those customers to do business with you."

Roger Kranenburg, VP, Energy Strategy & Policy, Eversource Rhode Island's PUC is also making strides to instill greater public trust and transparency by collecting feedback on PBR from multi-stakeholder groups. It recommends linking National Grid's profits to performance by using metrics and incentives that promote demand-side energy management and integrate DERs, such as rooftop solar and energy storage. ⁴⁶

On the West Coast, the California PUC has adopted a framework to better manage market and ratepayer expectations on IoU investments in charging infrastructure.⁴⁷

By engaging proactively in the process, and submitting joint proposals on rate setting, California's utilities can build trust with stakeholders. They can also become change agents by demonstrating how to achieve broader policy objectives on decarbonization. This raises market confidence and encourages third-party investment in the state's rapidly evolving DER market.

Alliances and partnerships built on trust

Notwithstanding future commercial opportunities, distribution utilities' core mission will remain the ongoing safety and reliability of the grid.

However, strategic alliances and partnerships between industry stakeholders and third-party vendors will be needed to help deliver solutions with wide applicability. Those relationships must be grounded in trust if parties are to invest early, and with confidence, and coalesce around the utility's growth strategy.

All participants will need fair and open access to the future market platform. However, the more parties and digital devices that interconnect, the more vulnerable the system becomes to security lapses. Robust vetting processes across data interfaces, networks and systems are already critical.

⁴⁶ "RHODE ISLAND POWER SECTOR TRANSFORMATION", State of Rhode Island, <u>http://www.ripuc.org/utilityinfo/electric/PST%20Report_Nov_8.pdf</u>, November 2017

^{4&}lt;sup>sr</sup>PUC order keeps Minnesota ahead of the curve on performance-based rates", Utilitydive website, https://www.utilitydive.com/news/puc-order-keeps-minnesota-ahead-of-the-curveon-performance-based-rates/545797/, 11 January 2019

⁴⁷ "Order Instituting Rulemaking to Continue the Development of Rates and Infrastructure for Vehicle Electrification," The Public Utilities Commission of The State Of California, <u>http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M252/K025/252025566.PDF</u>, December 2018



Figure 9: Ways in which trust among stakeholders is integral to a utility's growth strategy system

Failure to maintain trust will leave utilities exposed to competition from companies with stronger customer relationship and management capabilities. They will struggle to develop and share in the rewards of innovative digital solutions, products and services.

Digital skills shortages, but legacy know-how still relevant

Operationally, utilities have relied on a stable workforce model for almost a century. Operations have been managed by a long-term, dedicated workforce that is now beginning to retire.

Legacy skills and know-how on the operations and infrastructure side of the business remain relevant, valuable and transferable but could be lost. The trust of existing employees must be upheld as the industry embraces digital and customer-centricity and evolves its business model.

At the same time, the shift to digital is exposing a capability shortage. Identifying skills gaps and hiring senior executives and new talent from "early adopter" industries will become a key differentiator in building more digital-savvy utilities.

The industry says:

"We have a next generation of employees. We need to learn to tap into them more effectively to bring us along faster than we might otherwise achieve. That is a key element of the equation that needs solving. It's a conversation that we are having here as a company."

Barbara Lockwood, VP, Regulation, Arizona Public Service Company

Existing employees and new hires must trust that the organization will provide ongoing opportunities and rewards as it adopts nextwave technologies, including artificial intelligence and blockchain. Trust is a recognized driver of productivity. It galvanizes employees around a common purpose. In the Fortune 100 Best Companies to Work For®, trust makes up two-thirds of the assessment criteria. These companies beat the average annualized returns of S&P 500 companies by a factor of three.⁴⁸

Across the board, utilities will need to implement leading practices to retain talent and strengthen employee trust over the course of the future distribution system journey.

Investors want utilities to embrace disruptive trends

Utilities are under pressure to reaffirm investor trust in their performance.

Historically, investors viewed utilities as a stable asset class and a source of predictable, guaranteed returns. Now that the traditional utility business model is under threat, the investment paradigm is less certain, and priorities have shifted.

The industry says:

"A prerequisite to ensuring California's success in achieving its ambitious state objectives will be a strong and healthy set of partnerships, founded on trust across key stakeholders--including state and community leaders, customer advocates, regulators, utilities and other service providers."

Paul Grigaux,

VP, Asset Management, Strategy & Engineering, SCE

⁴⁸Covey, S.R., Merrill, R.R., 'The Speed of Trust: The One Thing That Changes Everything,' July 2018

Figure 10: Critical questions for sustaining trust



Investors now seek a balance between consistent returns and sustainable long-term performance. They expect utilities to embrace innovation and tap into new revenue streams that correspond with customers' increasingly complex demands. With greater confidence in the evolving business model, investors will reward utilities accordingly.

Indeed, rating agencies now view the speed at which utilities adapt to disruptive factors and derisk their strategies as positive indicators for credit quality and attractiveness to investors.⁴⁹

Becoming a leader on new distribution business models can become part of utilities' bolder, digital and clean energy growth strategies, which, increasingly, will receive investor approval.

Collaboration essential in energy transition

Proactive collaboration between utilities will continue to be essential. It helps with industry-wide understanding of and contributions to technology deployment, policy and regulation, as well as implementation of industry standards and leading practices.

Trust between parties extends to sharing information externally so that utilities can benchmark against peers and identify gaps in performance and skill sets.

Lessons can be learned from overseas too. We see, already, how EY collaboration with Eurelectric and utilities in Europe is relevant to the US market. In turn, the GridWise Alliance brings together utilities from across US states to learn from those European experiences and to share their own.

By embracing an "all in it together" approach, utilities can trust one another to unite around strategies that push the boundaries of possibility for the distribution system transition.

Once you've got trust, here's how to keep it

By embedding trust at the forefront of the strategy and backing it with board-level governance, it becomes woven into the culture of the utility. It gives stakeholders confidence that trust is integral to the operations of the utility and drives competitive advantage.

The industry says:

"A business needs to be accountable, but it also needs to be flexible in providing viable and sustainable customer solutions. If it is publicly traded, it is also dependent on its shareholders and needs to optimize its income and financial conditions in a manner that attracts future growth."

Mike Schneider, VP, Risk Management and Compliance, SDG&E

To make the journey toward a future distribution system more risk-informed, customer-centric and relationship-driven, critical questions must be asked up front (see Figure 10).

Utilities need to take a more formal approach to monitor and measure trust.

Standardized risk management reports and dashboards can include metrics to assess performance on:

- Relationship mapping of stakeholder behaviours, preferences and requirements to improve decision-making
- Technology implementation to capture data and insights on changing stakeholder attributes
- Product and service "guardrail" design to prevent mishaps and preserve reputations

With trust continually strengthened, maintained and monitored, utilities have a platform from which to confidently launch the core principles that will underpin the evolution of their role and enable the future distribution system.

⁴⁹How Quickly Utilities Adapt to Disruptive Factors Will Have an Increasing Impact on their Credit Quality", S&P Global website, <u>https://www.spglobal.com/en/research-insights/articles/</u> <u>How-Quickly-Utilities-Adapt-to-Disruptive-Factors-Will-Have-an-Increasing-Impact-on-their-Credit-Quality</u>, 1 November 2017

Delivering on the future distribution system vision

A new grid architecture will reduce operational complexity and streamline the electric system. It must address the interconnectedness of the bulk electric system and the downstream impacts of DERs and grid-edge digital devices. And it must engage the cooperation of all parties operating within it.

Utilities have the opportunity to assume a significant leadership role in enabling the distribution system transition.

Right now, the system is not fit to respond to the challenges and opportunities presented by decarbonization, decentralization, digitization, and deep electrification. As more DER participants engage, complexity will only increase.

What is needed, therefore, is a grid architecture that streamlines operations and reduces operational complexity. It should:

- Consider the interconnectedness of the bulk electric system *and* the downstream impacts of DERs and gridedge digital devices
- Enable better coordination of responsibilities between ISOs and/or RTOs, transmission operators and distribution utilities in a system that will be defined, increasingly, by two-way flows of power and information

Utilities can drive the transition to this future distribution system state.

Redesign distribution system from the bottom up

Distribution utilities need to engage with their key stakeholders on a bottom-up approach to system redesign. They will need to advocate for increased responsibilities to optimize DERs and to maintain reliability within their local distribution areas. This means communicating effectively on the core principles for redesign so that distribution utilities are best placed to:

- Achieve power reliability at the distribution level by managing the optimization and aggregation of local DERs
- Streamline DER participation in wholesale markets, once permitted to aggregate excess supply or demand into single bids, to balance local reliability needs
- Provide visibility and guidance to DER owners on how to avoid conflicts with local reliability needs when providing services

This evolution will streamline and simplify the coordination of power reliability across the bulk electric system. By accepting aggregated bids and offers from distribution utilities at each transmission distribution interface, ISOs and RTOs will be freed up to focus more exclusively on transmission system reliability and wholesale market efficiency, which both fall under federal regulation. And this, in turn, gets around the current complications of DER participation in wholesale markets, given that ISOs and RTOs must ensure that there are no conflicts with local reliability needs and state regulations.

With commitments in place to sustain stakeholder trust, and clarity on the principles for redesign, utilities can turn their focus to investments in the people, technology and processes that will enable a fit-for-purpose future distribution system.



Three-phase investment journey to the future state

US utilities need to prioritize investments across three critical phases as they venture toward a future distribution system.

DER penetration levels and maturity dictate where they are in the journey.

Phase 1: Connect and protect

The coming wave of DER deployment requires a commitment from utilities to accommodate the changing demands and expectations of customers, while maintaining and improving grid resiliency.

Utilities must continue to invest in grid modernization programs to connect growing numbers of DERs, while focusing on local power reliability. This calls for better visibility over the scale and scope of DER deployments across multiple connection points, using more relevant and granular forecasting techniques. It also requires an understanding of power flows at the distribution level and more active management of the distribution system.

DERs should coevolve with the grid and improve the resiliency and security of energy supply. Backup power will become increasingly available as more utilities include energy storage in their resourceplanning processes. Grid-scale energy storage will provide more capacity to improve the overall responsiveness of the system in balancing energy supply and demand.

At the same time, an expanding digital ecosystem will challenge the security of physical and cyber assets at the distribution level. To better prepare for and respond to threats, utilities will need to improve grid resiliency and security by incorporating risk-informed approaches into the management of their assets and operations.

Phase 2: Sense and enable

Phase two of the journey is defined by investment in a more advanced digital grid architecture and market platforms to enable the future distribution system. Wider deployment of sensors to automate and control the network will create situational awareness at the grid edge, with improved real-time monitoring capabilities.

As demands on the grid become more complex, modular IT and OT solutions may be used to better monitor and control flexible DERs. Utilities will recognize, increasingly, the value and promise of DERMS as the pace of DER uptake accelerates. They may take a phased approach to DERMS implementation as part of a broader ADMS strategy.

This phase will also see distribution utilities begin to step up to the role of neutral market facilitator and platform provider for trading flexible resources and innovative products and services. The utility will become the enabler of streamlined customer inquiries, connections and installations. It will also encourage deployment of non-wires alternatives to manage energy consumption in more sustainable ways across the network.

Meanwhile, local distribution area reliability will be enhanced by the procurement of power capacity, such as, energy storage, when needed, as well as other value-added ancillary services, including voltage support and frequency regulation.

The industry says:

"We need to build a system that can optimize itself. One that will dynamically reconfigure itself to take advantage of opportunities or to make itself more resilient to threats."

Lee Mazzocchi, SVP, Grid Solutions, Duke Energy

	Phase 1 — Connect and protect	Phase 2 — Sense and enable	Phase 3 — Optimize and control
Integrated planning	 Migrate to more granular bottom-up DER forecasting methodologies using: Technology diffusion analysis Customer adoption modeling 	 Assess likely financial/ operational impacts of changing DER penetration and profiles through advanced software implementation 	 Leverage customer behavior and demand-side analytics Integrate with grid analytics and smart city planning Standardize communications platforms with RTOs/ISOs
Asset management	Improve outage detection, automation and DER awareness through ongoing grid modernization programs	 Capture enhanced inputs from weather analytics, LiDAR applications Shift to real-time monitoring of grid assets and network performance under increasing DER penetration 	 Implement real-time monitoring of DER assets Leverage predictive maintenance analytics
System management	Improve workflow through mobile applications and field devices	 Deploy more remote sensing capabilities and drone technologies at the grid edge Transform administratively heavy and repetitive back- office tasks through automated solutions, such as robotic process automation (RPA) 	 Deploy future of work technologies to transform systems management at the grid edge, including: Wearables and augmented or virtual reality (AR/VR) Machine learning and artificial intelligence (AI)
Systems operations	 Manage reliable energy supply under increasing DER penetration Procure more grid-scale energy storage Manage load profiles through demand response 	 Implement modular IT solutions architecture to improve DER monitoring and control Adopt phased DERMS implementations as part of broader ADMS Monitor situational awareness at the grid edge Demonstrate instantaneous islanding capabilities 	 Integrate full DERMS/ADMS Prioritize DER dispatch to balance local supply and demand Leverage distributed intelligence at the grid edge for real-time system optimization Manage load profiles with batteries both in front of and behind the meter
Flexibility management	Pilot DER, microgrid deployments for improved resilience	 Establish platforms for DER energy trading, microgrid and virtual power plant (VPP) services Offer incentives for non-wire alternative solutions Procure local DER services, including back up power and ancillary voltage, frequency and capacity services 	 Leverage dynamic market pricing mechanisms and time of use incentives to capture changing DER value Introduce reward mechanisms for enhanced overall system performance
Commercial operations/ customer management	 Facilitate customer DER integration Implement energy efficiency and demand response programs Procure community backup power 	 Develop fast EV charging stations and other public charging infrastructure Commercialize energy usage data and analytics Offer home energy management systems, including smart thermostats, digital assistants and HVAC 	 Provide vehicle-to-grid services Integrate connected home and energy services offerings through building automation, smart windows/plugs/ devices, and lighting-as-a-service Facilitate peer-to-peer energy trading

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Distribution utilities will prototype technology solutions. They will enter strategic partnerships to take advantage of electrification opportunities in the residential, commercial, industrial and transportation sectors. They might venture into fast charging and other public charging infrastructure to encourage EV take-up or into clean energy programs to convert customers to electric alternatives, such as electric heat pumps and stoves.

Phase 3: Optimize and control

The third investment phase prepares distribution utilities for additional higher-level responsibilities and enhanced customer engagement.

Specifically, power reliability at the distribution level will become increasingly dependent on DER priority dispatch, and more value from BTM resources will be unlocked.

Distribution utilities will optimize DERs and capture more value through distributed real-time intelligence at the grid edge:

- Full DERMS and ADMS capabilities will allow distribution utilities to better manage load profiles and enable sophisticated real-time monitoring and control at the device level.
- Advanced analytics capabilities will derive actionable intelligence across customer, grid and enterprise domains.
- BTM storage and V2G services will deliver value as EVs' potential as grid assets is unlocked.
- Sophisticated demand-side management capabilities will be leveraged as connected home and intelligent building technologies evolve and optimize energy consumption.
- Peer-to-peer transactive energy trading platforms will enable greater resiliency and allow consumers to participate in a truly digital, distributed energy marketplace.
- Dynamic pricing mechanisms and time-of-use incentives will mature with superior outcomes for resource allocation.

By investing in these capabilities, the distribution utility will be better placed to balance local supply and demand in a more integrated way. This will be achieved through DER optimization and more streamlined coordination of wholesale energy market transactions. At the same, utilities and their partners will be able to provide customers with enhanced BTM experiences as innovation platforms continue to evolve and mature.

Trusted orchestrators of tomorrow's distribution system

Most US utilities are preparing for or are already immersed in Phase 1 of this journey; many are beginning to make progress in Phase 2. And a few are testing or implementing capabilities for some of the responsibilities described in Phase 3.

This three-phase journey will position the US distribution system for further evolution and secure the future role of utilities.

They will expand upon their existing capabilities and build new capabilities. They will evolve their current role as trusted service providers to become trusted orchestrators of local power resiliency and reliability.

And they will become platform providers for innovative products and services offered by utilities, their partners and other third parties — together building the grid we need for our future economy.

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