2021-2022 Black & Veatch

Electric Report

About This Report

Mario Azar
President, Black & Veatch's energy and process industries business

Based on a survey of nearly 500 U.S. power sector stakeholders, the *Black & Veatch 2021-2022 Electric Report* explores an industry continuing a sweeping transformation, accelerated by carbon emissions goals, along with the rising tide of renewables — and the pressing need to integrate it into the grid.

Challenges — and opportunities — abound in this complex ecosystem, from conventional power generation to energy derived from the sun, the wind and clean fuels such as hydrogen, and the growing use of microgrids. Underscoring the evolution of the energy sector, aging infrastructure — for years, ranked by respondents as their foremost concern — this year tumbled to third, giving way to renewables integration and cybersecurity.

The push for sustainability, reliability and resiliency is driving utilities and power developers toward investments in decarbonization as more countries, states, counties and corporations mandate that power sources be cleaner and greener. The proliferation of electric vehicles is adding to charging needs and creating empowered, emboldened consumers. All the while, hydrogen grabs ever-widening attention, becoming a star, in tandem with rapidly advancing battery storage.

Regulation remains murky as cyber threats proliferate. Looking to help modernize the grid, the Biden administration and Congress successfully boosted federal funding to upgrade assets now obviously vulnerable to wildfires, hurricanes and other extreme events. Integration of generation, transmission and distribution assets is grabbing a stronger foothold. The COVID-19 pandemic was another complication.

This report takes the industry's pulse on those issues and more. It draws on survey findings and thoughtful analyses to paint a clear picture of a power sector repowering itself and modernizing with new technologies and improved concepts to keep the power flowing to industry, businesses and homes.

We welcome your questions and comments regarding this report and Black & Veatch services. You can reach us at **MediaInfo@bv.com.**

CONTENTS

4
Executive Summary

Power Sector's Transformation Keys on Clean Fuel Technologies, Energy Storage and Grid Modernization

12 | Decarbonizing a Carbon-Hungry World

17 | Cleaning Up the Power Industry

21 | Against Headwinds of Extreme Weather Events, Climate Resilience Pressures U.S. Electric Utilities

26 | Surges in Renewable Energy, Decarbonization and Extreme Weather Stoke Investment Uncertainty

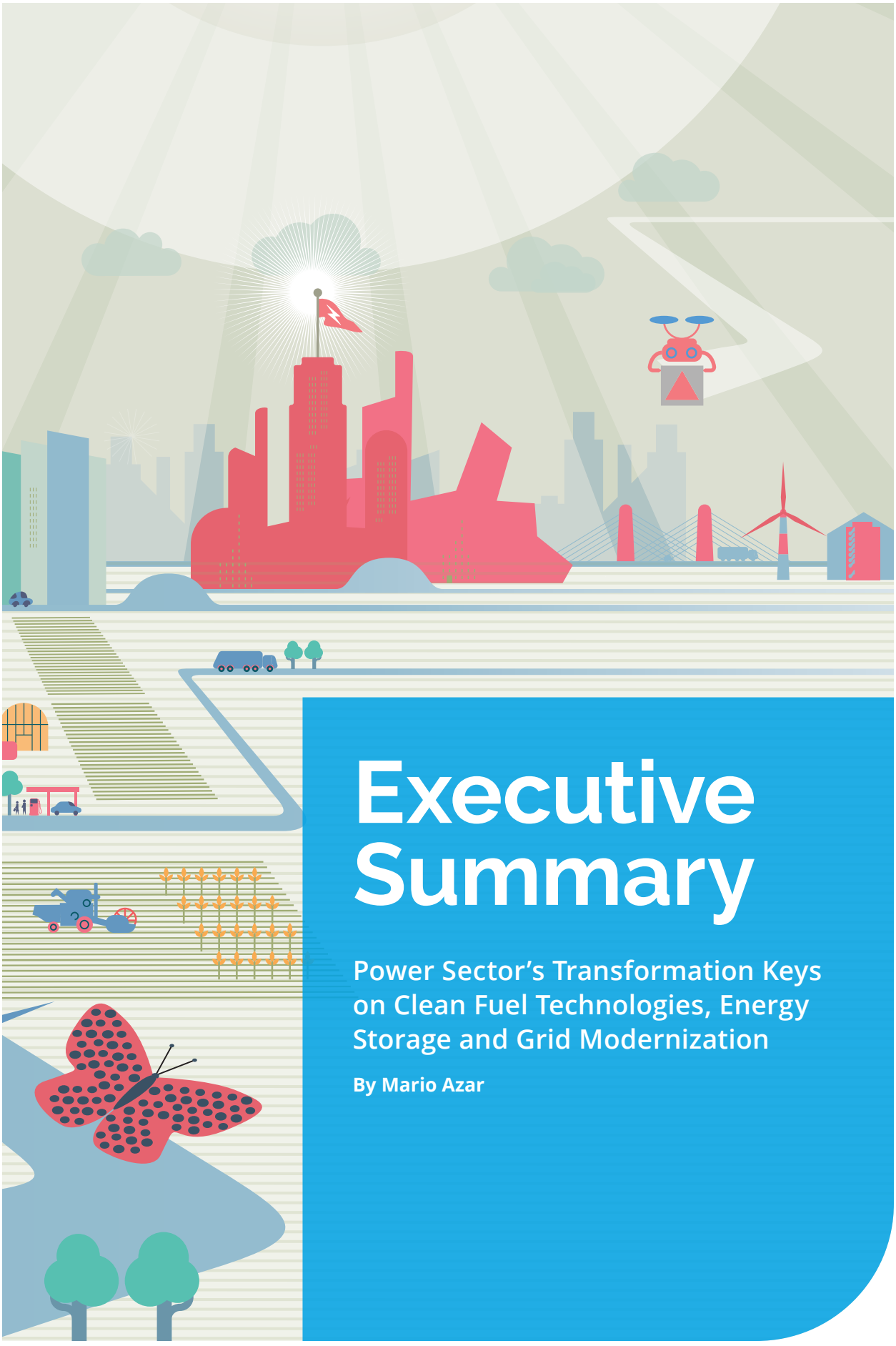
30 | Digitization at the Heart of Cybersecurity, Asset Management

34 | Powering the Future of Go

38 | Will Federal Funding Legislation, Incentives Reshape the U.S. Energy Market?

42 | Black & Veatch Electric Report

44
2021-2022 Report Background



Executive Summary

Power Sector's Transformation Keys on Clean Fuel Technologies, Energy Storage and Grid Modernization

By Mario Azar

ABOUT THE AUTHOR

Mario Azar *is president of Black & Veatch's energy and process industries business. He previously served as president of the company's power business, where he led all aspects of the business serving global power generation and delivery clients through comprehensive planning, consulting, engineering, construction, program management and combined engineering, procurement and construction solutions. Azar has more than 30 years of global leadership roles in power and oil and gas with a breadth of experience in adapting to global changing markets. He has overseen multiple power and oil and gas businesses spanning the globe.*

For more than 130 years, the U.S. power sector has remained committed to consistently overcoming regulatory challenges, climate headwinds and other hurdles to keep power flowing and drive the economy. But a mix of emerging challenges — from an escalation of power-disturbing weather events and wildfires to publicized cyber threats and advancements in clean-fuel technologies, energy storage and grid modernization — continue to reshape the industry.

Underscoring the need for making grids more resilient, widespread electric disruptions in 2021 spotlighted the vulnerability of electricity delivery to cataclysmic weather events and scorched earth. Such was the case when a powerful, deadly February winter storm blanketed much of Texas with snow, ice and record low temperatures, and months later when Hurricane Ida made landfall in Louisiana in late August. Adding to the misery: raging wildfires fueled by a combination of record temperatures and extreme drought in the western U.S.

At the same time, governments and corporations are striving ambitiously to decarbonize, turning to renewable energy drawn from solar and wind, both on land and offshore. This is forcing power providers around the world to thoughtfully plan and invest in ways to accommodate new green energy on the grid.

The bottom line: As assets become increasingly distributed across utility networks and are owned and operated by third parties, grid management is becoming more localized, demanding rigorous attention.

All the while, cyber threats and regulatory uncertainty remain among the top concerns. The ascendancy of new technologies — notably hydrogen, a rising star in tomorrow's energy mix — and wider use of battery storage are drawing more attention, prodding utilities to integrate them in a diversified, balanced energy portfolio.

Our new *Black & Veatch Electric Report* — based on survey data from nearly 500 U.S. electric sector stakeholders — details a complex industry transforming itself in a quest to become more reliable, resilient and responsive. Relying on expert analyses of the survey's data, key topics examined include utility investment uncertainty, hydrogen's vast potential in an increasingly decarbonizing landscape, climate change, clean energy trends, cybersecurity and fleet electrification.

And in many ways, the data is telling.

Figure 1

From your perspective, what are the most challenging issues facing the electric industry in your region today? *(Select the top three most challenging issues)*

Source: Black & Veatch

Renewable integration	**34.0%**
Cybersecurity	28.2%
Aging infrastructure	25.9%
Planning/forecasting uncertainty	21.4%
Aging workforce	21.0%
Lack of skilled workforce	19.9%
Environmental regulations	19.7%
Reliability	19.3%
Distribution system upgrades and modernization	18.0%
Distributed energy resources (DER) integration	15.6%
Energy storage	13.9%
Economic regulation	12.9%
Market structure	11.0%

Aging Infrastructure Still the Top Challenge, As Usual? Think Again

Aging infrastructure was the industry's most pressing worry in our reports for more than a decade. That's no longer the case.

Reflecting an industry repowering itself, roughly one-third of survey respondents (34 percent) now rate the integration of renewables as their foremost challenge, moving up one spot from last year (26 percent) to top the list ahead of cybersecurity (28 percent), which ranked sixth in 2020 *(Figure 1)*. Respondents cited the accommodation of renewables as the biggest challenge universally, regardless of their region or the size of their utility.

Aging infrastructure — No. 1 last year at 33 percent — has fallen to third at 26 percent, with planning and forecasting uncertainty, aging workforce, lack of a skilled workforce, environmental regulations and reliability were tightly bunched at about 20 percent.

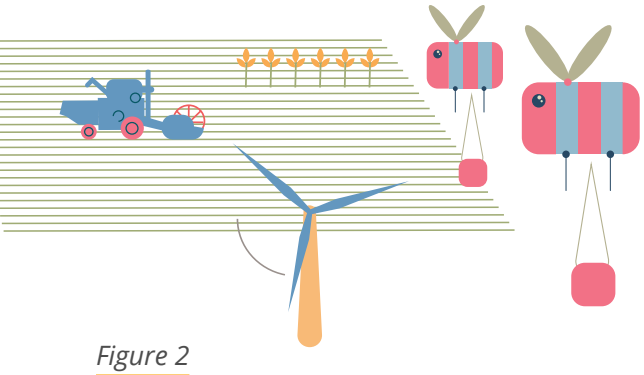


Figure 2

What are the top three biggest concerns for grid development in the next three to five years?

Source: Black & Veatch

67.3%
Generation mix, with fewer traditional base load units and more utility scale renewable sources

44.4%
Regulatory lag in meeting the needs for system changes

34.6%
Lack of qualified workers to engineer, maintain and operate the more complex system

32.3%
Ability to invest in and maintain a more resilient grid

25.6%
Lack of sufficient transmission facilities and system control assets

24.6%
Increases in DER

23.8%
Lack of sufficient investment to maintain and operate (including training of staff)

13.8%
Available capital

12.5%
Safety for energy professionals and the public with greater dispersed resources

7.5%
Other

The growth of renewable energy is undeniable. In July, the U.S. Energy Information Administration (EIA) reported that in 2020, renewable energy sources — wind, solar, hydroelectric, biomass and geothermal — generated a record 834 billion kilowatt hours (kWh) of electricity, or roughly one-fifth of all electricity produced in the U.S. Only natural gas produced more electricity than renewables, which surpassed nuclear and coal for the first time on record and shows no signs of abating.

Use of U.S. renewable energy — led by wind, along with the increasing growth of solar — reached record highs over the first half of 2021. Looking down the road, a U.S. Department of Energy study released in September found that solar energy has the potential to account for 40 percent of the nation's electricity by 2035, powering all U.S. homes while driving deep decarbonization of the grid. Last year, the U.S. added a record 15 gigawatts (GW) of solar to reach a total of 76 GWs, amounting to 3 percent of the current electricity supply.

With federal estimates predicting that wind and solar will provide three-quarters of U.S. electricity by 2035 and 90 percent by mid-century, utilities are feeling pressure to make their grids more flexible and resilient, adding battery storage and advanced inverters to accommodate the rapid growth of renewables.

Utilities see it coming. Two-thirds of respondents to a question about the top concerns for grid development over the next three to five years cited the generation mix, with fewer traditional base load units and more utility-scale renewable sources. The regulatory lag in meeting the needs for system change came in a distant second (44 percent), followed by a lack of a qualified workforce to maintain and operate the more complex system (35 percent) and the ability to invest in and operate a more resilient grid (32 percent) *(Figure 2)*.

On the investment front, 56 percent of respondents say government incentives or policies are driving renewable energy investments in their region. Half cited increased pressure or influence from governments. More than four in 10 (42 percent) pointed to increased demands from shareholders and a drive toward sustainability goals.

Climate Change, Electric Vehicles and the Call for Greater Grid Resilience

Although the pursuit of a more resilient U.S. grid isn't new, calls for resilience have intensified since Hurricane Sandy — better known as "Superstorm Sandy" — hit the northeastern U.S. hard in October 2012, exposing shortcomings in that region's grid. More broadly, that storm affected two dozen states and much of the eastern seaboard, leaving more than $70 billion in damage.

That disaster — proof of how 21st-century storms can overwhelm 20th-century power infrastructure — launched the conversation about U.S. grid vulnerabilities.

Figure 3

Which of the following methods do you expect will be included specifically to help meet your carbon/emissions reduction and/or clean energy goals? *(Select all that apply for each timeframe)*

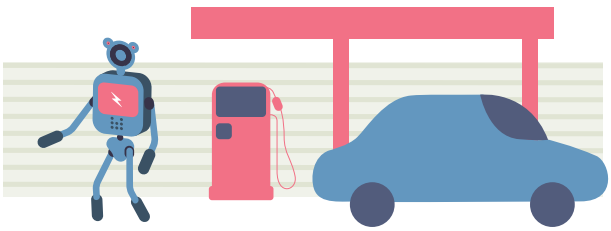
Source: Black & Veatch

Top five methods for next 10 years	2020	2021
Solar	78.9%	86.2%
Retiring traditional fossil-fueled generation sites	58.9%	75.2%
Battery energy storage	60.6%	72.5%
Natural gas	62.2%	68.8%
Wind	66.7%	67.9%

Top five beyond 10 years	2020	2021
Hydrogen	57.8%	63.6%
Solar	40.1%	52.3%
Battery energy storage	47.6%	51.1%
Wind	41.5%	48.9%
Power purchase agreements (PPAs)	29.3%	45.5%

The Biden administration has taken note, proposing an infrastructure spending plan that received final congressional approval in November 2021, to channel tens of billions of tax dollars into what the White House has called "our aging electric grid (that) needs urgent modernization," with wider adoption of renewable energy at its core. Under that measure, $73 billion — the single biggest federal investment in power transmission in U.S. history — would be committed to grid upgrades, including thousands of miles of new, resilient transmission lines to help expand renewable energy. The measure also will invest in research and development for advanced transmission and electricity distribution technologies while promoting smart grid solutions that deliver flexibility and resilience.

While climate change may amount to a moving target, utilities must think aggressively about mitigation strategies that look decades down the road and plan accordingly, accounting for the burgeoning new energy economy. As the survey makes clear, U.S. electric utilities confronting the shifting energy landscape are seeking a broad spectrum of solutions to meet their clean energy goals, with increasing use of hydrogen and renewable power, the retirements of fossil fuel-powered assets, and broader battery energy storage leading the way *(Figure 3)*.



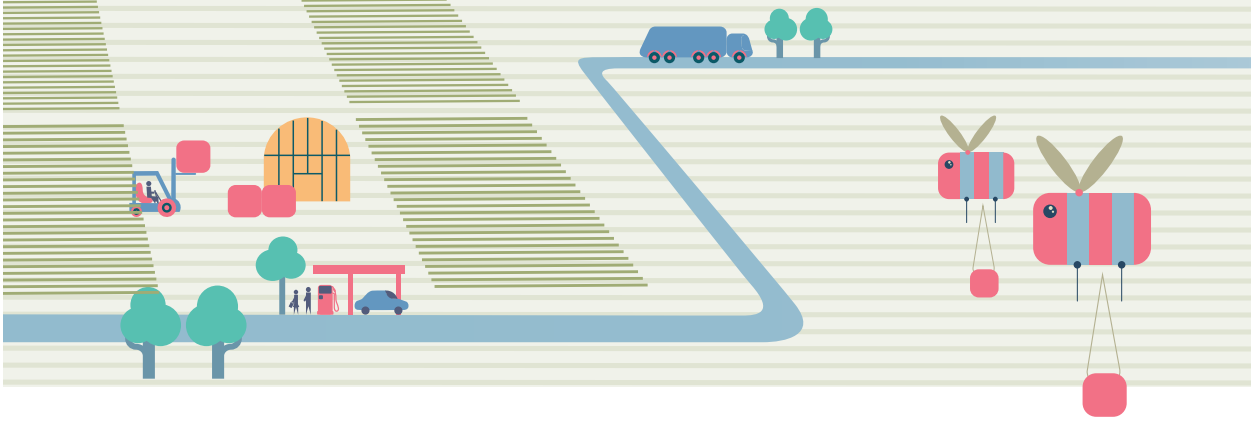


Figure 4

For each of the following categories, how do you expect new generation capacity investments to change over the next five years in your region? *(Select one for each row)*

Source: Black & Veatch

% Selecting More Investment	2020	2021
Energy storage	78.5%	91.0%
Solar *(ground or roof)*	81.8%	84.0%
Microgrids and other DER	64.9%	70.0%
Wind *(onshore)*	59.1%	64.0%
Hydrogen	26.4%	56.0%
Wind *(offshore)*	49.8%	52.0%
Solar *(floating)*	40.9%	47.0%
Gas-fired/LNG to power	38.8%	39.0%
Nuclear	16.3%	25.0%
Geothermal	17.7%	22.0%
Coal-fired	2.7%	1.0%

Not surprisingly, nine out of 10 respondents expect energy storage investments to increase in the next five years in their region, up from nearly 80 percent last year. More than half — 56 percent — expect their generation capacity investment in hydrogen to rise over the same half-decade, double the number of respondents (26 percent) who anticipated as much in 2020 *(Figure 4)*.

Envisioning a green future in which greenhouse gas emissions are slashed, President Biden in August signed an executive order calling for electric vehicles (EVs) to account for half of all U.S. auto sales by the end of this decade. While not legally binding, Biden's action as a key component of his climate change strategy is ambitious, considering that the share of new EV sales — including plug-in hybrids — was only 2 percent in 2020.

Given that EVs and electrified fleets are growing, power providers are being pressed to meet charging needs.

Figure 5

Which of the following methods do you expect will be included specifically to help meet your carbon/emissions reduction and/or clean energy goals? *(Select all that apply for each timeframe)*

Source: Black & Veatch

	Next 10 years	Beyond 10 years
Solar	86.2%	52.3%
Retiring traditional fossil-fueled generation sites	75.2%	35.2%
Battery energy storage	72.5%	51.1%
Natural gas	68.8%	19.3%
Wind	67.9%	48.9%
Power purchase agreements (PPAs)	66.1%	45.5%
Combined cycle	50.5%	22.7%
Making traditional fossil-fueled generation more efficient	46.8%	15.9%
Hydrogen	31.2%	63.6%

Hydrogen and Batteries

In pursuit of a decarbonized electric grid by 2035, the Biden administration is encouraging the U.S. economy to lower its carbon intensity, especially when it comes to buildings, transportation and heavy industry. Two emerging technologies — "green hydrogen" and battery energy storage — can help propel that quest for alternatives to fossil fuels.

Green hydrogen is produced when electricity from solar or wind or other carbon-free generation is used to power the electrolyzers that separate the hydrogen and oxygen atoms in a water molecule. That hydrogen gas then can be stored in a tank or cavern before being funneled into a fuel cell to create clean, emissions-free electricity. It can also replace natural gas or be blended with it to cut the carbon footprint of gas appliances. Complementing electrolysis, battery storage allows non-dispatchable resources like wind and solar energy to make energy that can be used precisely when systems need them most, helping balance load and generation across time and space.

Utilities envision hydrogen as tomorrow's transcendent energy source. Over the next decade, the survey finds, the energy sector expects solar (86 percent) and wind (68 percent) to help meet its clean energy goals or cut their emissions and carbon output, presumably because those options have established, matured technology and competitive costs. Those numbers drop to around 50 percent beyond 10 years, giving way to more deployments of hydrogen — at 64 percent, the most-cited option beyond the next decade — and battery energy storage (51 percent) amid expectations that the costs of those technologies at scale will continue to decline, widening adoption *(Figure 5)*.

Now more than ever, utilities — along with regulators and other industry stakeholders — must commit to and collaborate on tomorrow's energy mix that's virtually certain to be based on cleaner, greener options, using new strategic thinking, access to technology, proactive investments and aggressive planning.

Decarbonizing a Carbon-Hungry World

Let's cut to the chase — decarbonizing the world's energy systems is going to be a pretty heavy task. The global economy has been powered by fossil fuels for centuries, and we're a carbon-hungry world. It could be glib to say the time to move away from fossil fuels is long overdue — however, given the impacts to global warming and climate change, it is true.

But we also must recognize that the advanced technologies that will decarbonize at scale — carbon capture utilization and storage, hydrogen and low- and zero-carbon fuels — are only now arriving on the scene in viable capacity.

Decarb Marches Along

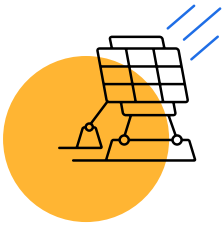
Nearly 80 percent of respondents to the *Black & Veatch Electric Report* survey are committed to reducing emissions of carbon dioxide (CO^2) and other greenhouse gases while furthering their own clean energy goals. More than half (57 percent) are doing this independently from any regulatory mandate.

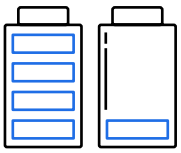
To get there, organizations are planning to embrace clean energy (e.g., solar energy, solar thermal, natural gas, wind and hydrogen), retire fossil-fueled generation, embrace battery energy storage, enter power purchase agreements, build combined-cycle plants and improve the efficiency of fossil-fueled generation over the next 10 years *(Figure 6)*.

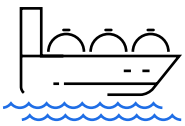
Figure 6

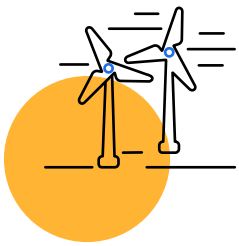
Which of the following methods do you expect will be included specifically to help meet your carbon/emissions reduction and/or clean energy goals? *(Select all that apply for each timeframe)*

Source: Black & Veatch









	Next 10 years	Beyond 10 years
Solar	86.2%	52.3%
Retiring traditional fossil-fueled generation sites	75.2%	35.2%
Battery energy storage	72.5%	51.1%
Natural gas	68.8%	19.3%
Wind	67.9%	48.9%
Power purchase agreements (PPAs)	66.1%	45.5%
Combined cycle	50.5%	22.7%
Making traditional fossil-fueled generation more efficient	46.8%	15.9%
Hydrogen	31.2%	63.6%

Figure 7

Which of the following is the largest barrier to implementing and integrating CCUS as part of your assets?

(Select one)

Source: Black & Veatch

44.2%
High technology and project costs

20.4%
Complex project execution to include all parts of CCUS

18.6%
Lack of infrastructure and limited regional geology capable for large-scale CO^2 storage

16.8%
Scalability and reliability of the technologies and related practices

When looking beyond that time, 64 percent of organizations see hydrogen as a viable solution, more than double the 31 percent that see hydrogen playing a role within the next decade. This isn't surprising, given that hydrogen — a carbonless fuel that can be generated with renewable energy — is trending to become a technologically, financially viable solution for decarbonization.

Hydrogen can serve as a zero-carbon fuel, feedstock, energy carrier and method of energy storage. It can be shipped, stored and managed using existing infrastructure, without major impacts to the value chain. It also can help decarbonize the hard-to-abate heavy industries where electrification and renewable energy are not sufficient.

There also are several other types of liquid and gaseous low-carbon fuels to be considered, particularly renewable natural gas (RNG). Over time, expect to see most of the RNG that's being produced saturate the transportation market; this is when it will start becoming more applicable to the electric power sector, among others.

Carbon Capture Offers Promise

Carbon capture, utilization and storage (CCUS) is a proven technology that can decarbonize — at scale — those industry sectors that want to maintain operations but lower their carbon emissions, e.g., utilities and heavy industry. While the world pushes for renewable energy and electrification, CCUS technologies are necessary to remove CO2 from the industrial processes that enable power generation, chemical production, mining, oil refining, steel and manufacturing.

A combined 89 percent of electric utilities know about CCUS technologies, with roughly half (45 percent) considering them a decarbonization solution. Respondents cited high technology and project costs as the main barrier to adoption, followed by complex project execution, lack of infrastructure, and issues around scalability and reliability *(Figure 7)*.

Figure 8

What factors are driving renewable energy investments in your region?

(Select all that apply for each timeframe)

Source: Black & Veatch

	2020	2021
Government incentives and/or policies	38.7%	**56.1%**
Increased pressure/influence from governments	38.7%	50.6%
Increased pressure/influence from shareholders and drive for sustainability goals	51.6%	42.4%
Increased demand from commercial and industrial clients	12.9%	33.9%
Improved pricing competitiveness and efficiencies from new technologies	48.4%	29.7%
Increased demand from residential customers	6.5%	25.5%
Lower levelized cost of energy	**61.3%**	22.2%
Reduced options to finance traditional solutions/comparatively increased ease of access to capital to finance renewable solutions	35.5%	13.1%

That said, various technology providers, developers, industry stakeholders, the U.S. Department of Energy, and engineering, procurement and construction (EPC) organizations are working to make CCUS feasible. These challenges of technology integration, project timing, costs and trade-offs most likely will resolve as the next generation of CCUS technologies come to market, improving performance and driving down cost. As more of these projects come to fruition, economies of scale should help reduce costs by an estimated 25 to 30 percent.

As for the lack of CCUS infrastructure, these costs can vary widely by region, application and location. As the infrastructure expands, there will be more opportunities for utilities and non-utilities to find infrastructure points to connect and manage their CO2 emissions. As a leading provider of CCUS technology services and solutions, Black & Veatch currently is advancing CCUS projects with clients in the cement, lime, aluminum and electricity industries.

Driving Investment in Decarbonization

Utilities increasingly see government incentives, regulatory pressure and increased demand from customers as driving investment in renewable energy, compared to last year. Pressure from shareholders, improved pricing, lower levelized cost of energy (LCOE) and ease of access to financing declined in importance year-over-year *(Figure 8)*.

The substantial drop in priority for LCOE — from 61 percent to 22 percent — is because utilities are in the planning stage, performing economic assessments as inputs to their strategic planning. The economics behind these technology investments has become an area of fact-finding and exploration, compared with a year ago.

Navigating the Path Forward

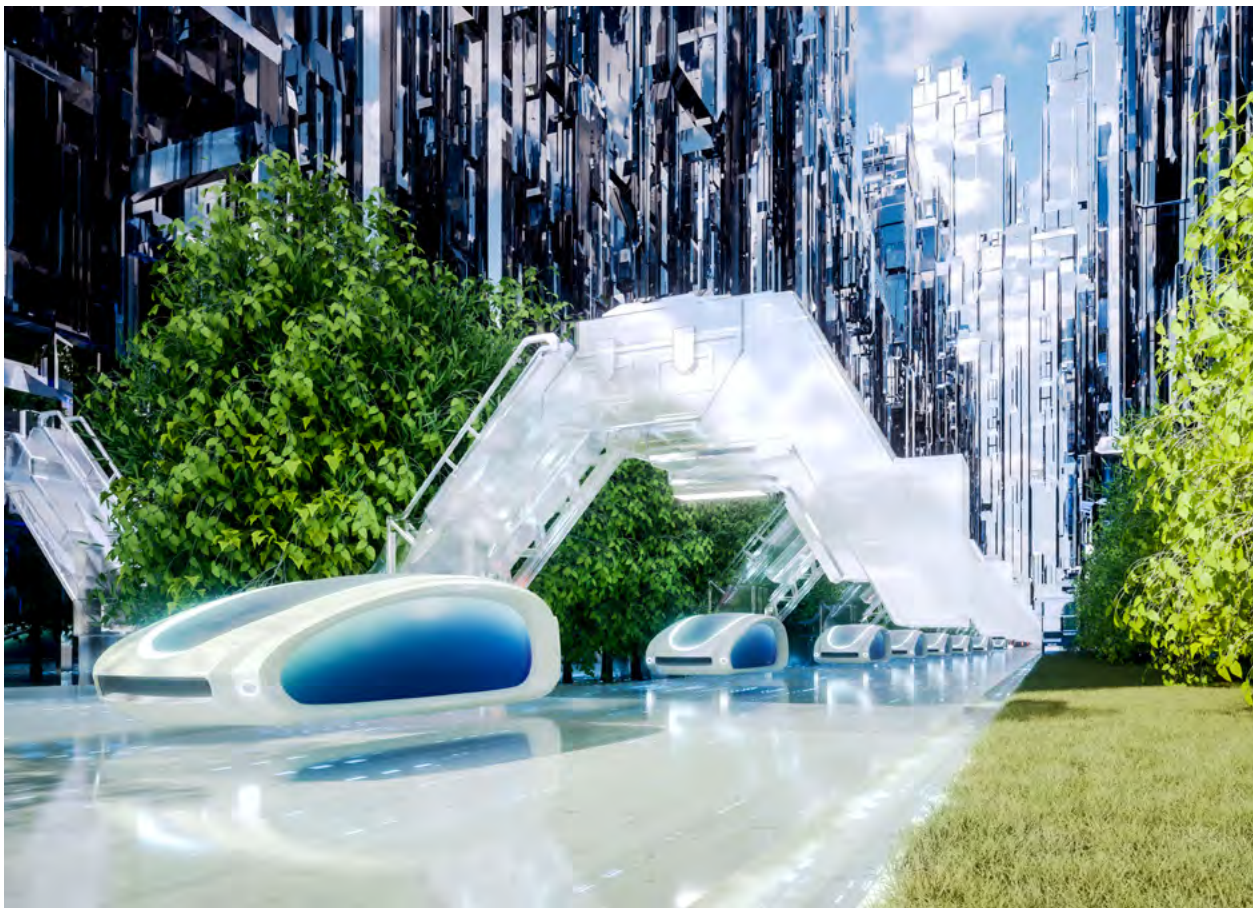
The decarbonization market is emerging rapidly as trillions of dollars in public and private sector investments are earmarked to drive a wide range of decarbonization initiatives. Organizations are placing big bets without a clear path to success and without experience to help them prioritize their decisions. In this emerging landscape, utilities' time-tested risk-management strategies and tools are being pressure tested.

These challenges are tough, but as the *Black & Veatch Electric Report* survey shows, organizations are focused on navigating this energy transition. Every organization has its own unique dynamics, challenges and opportunities. Black & Veatch has been focused on helping utilities, manufacturers and other stakeholders throughout the energy value chain to develop the fact base and cost/technology assessments necessary to meet their decarbonization goals.

This includes answering four core questions:

1. What combination of technologies will achieve my goals? What is the sustainability objective? Is the aim to be carbon-free, net zero or reduce emissions by a certain percentage?
2. How do new and emerging technologies integrate with existing assets?
3. How much will it cost to reach my goal?
4. Timing matters. What can I do now and what can I do later? Prioritizing investments based on impact and cost trajectories can maximize return on investment.

Black & Veatch is committed to working with organizations in this complex decarbonization landscape, providing business decision frameworks and flexible execution to meet companies where they are and help them navigate where they want to go.



Cleaning Up the Power Industry

The world wants clean energy. Renewables are rapidly proliferating, setting new records in project deployment and investment. Hundreds of new companies and traditional market players are seeking to capitalize on opportunities in carbon-free power generation, energy storage, grid optimization and more.

And although wind, solar and other clean-energy sources are increasingly being added to system operational and planning models, technological shortcomings will make it almost impossible to achieve 100-percent clean energy generation for decades to come.

In fact, as the electricity industry continues its transition to clean energy and the "electrification of everything," the overarching challenge of renewable integration now is seen as the largest obstacle facing the industry. This marks a first in the 15-year history of Black & Veatch's *Strategic Directions Report* series, which has mostly identified aging infrastructure as the primary challenge facing respondents.

As the industry moves forward, realistic expectations, careful planning and massive investment will be required to power the energy transition.

Setting Expectations

Seventy-five percent of respondents to the *Black & Veatch Electric Report* survey indicate they are directing their capital toward clean renewable energy investment, yet less than 10 percent believe a 100-percent clean energy generation model has been validated. While many industry leaders have publicized aggressive decarbonization commitments, this data describes an industry with high hopes but limited confidence.

There is an abundance of great ideas for decarbonizing the electric grid, but the roadblocks to realization are just as plentiful. The best real estate for renewable energy has already been developed. Land acquisition is getting harder, and site productivity challenges are increasing. Access to commercial roofs is getting harder, and concerns about structural integrity are growing. Storage costs and project funding concerns highlight the difficulty of remodeling a one-way grid to accommodate energy generation from sources far and wide.

We note this lack of confidence repeats sentiments found in our recent Corporate Sustainability Goal Setting and Measurement Report, in which hundreds of leading private-sector sustainability respondents and business leaders indicated they are making decarbonization commitments, but they do not believe the technologies needed to achieve these goals are available yet.

ROI Concerns are Real

Lack of confidence also may stem from disappointment with the production and financial return on clean energy assets already deployed. As distributed energy generation through renewables has gained traction, many have built out solar and wind capacity. With solar specifically, one-quarter of respondents reported their systems were producing less electricity than expected. *(Figure 9)*. This may be due to aggressive energy forecasting in solar project financial modeling that did not reflect the manufacturers' projected system decline.

Figure 9

How would you rate the performance of solar you've installed relative to expectations?

(Select one)

Source: Black & Veatch

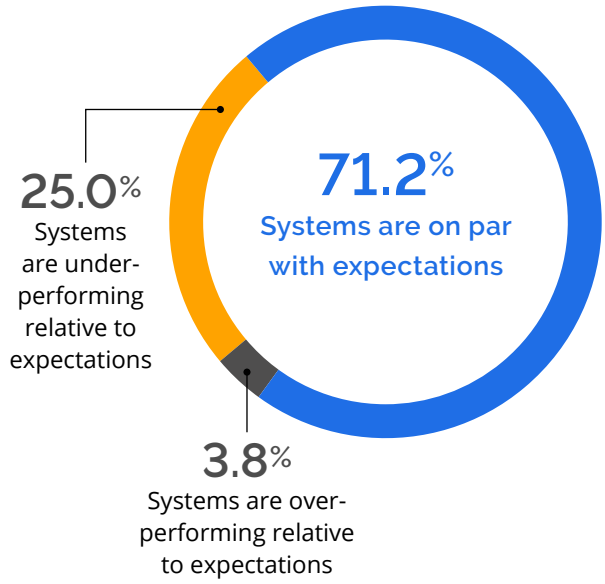


Figure 10

What is the largest barrier to wide-scale domestic renewable growth?

(Select one)

Source: Black & Veatch

29.7%
Cost

7.7%
Land acquisition

24.4%
Technological shortfalls

4.1%
Adequate workforce

17.9%
Transmission congestion

2.8%
Financing

8.5%
Local opposition

5.0%
Other

Industry concerns about renewables at scale center on three major barriers, with cost being the largest *(Figure 10)*. The popularity of this response could be influenced by current global supply chain issues driving up the cost of solar and wind units, as well as the need for robust supporting technologies and modules to counteract intermittency.

As generation shifts from natural gas and coal, regulations require — and customers demand — a level of dispatchable energy generation that renewables cannot provide.

Energy storage, both short and long term, is viewed as a critical piece of the green energy transition, yet more than one-third (36 percent) of respondents are not planning to build any storage to offset the fast ramping and high variability of wind and solar. A little more than one-quarter (26 percent) already have built or are building storage, while 38 percent are planning to build.

Likely, reluctance to build storage is related to both the cost as well as the limited types of storage available. As a new and evolving technology, storage can be cost-prohibitive for many smaller energy providers, and it has yet to become cost-competitive with natural gas.

Similarly, most battery storage development has centered on short-duration lithium-ion batteries that have achieved a production scale and cost decline that tracked solar modules. However, lithium ion is best suited to rapid charge/discharge scenarios and cannot provide the long-term storage required in the energy transition.

In places like California, for example, where hourly shifts in demand and in supply from renewables are massive, the norm is ramping simple cycle gas turbines. In areas where seasons impact solar production and days or weeks of storage may be needed, or in a clean energy world where more traditional baseload generation is unavailable, the storage challenge must be overcome.

The combination of regulation, public and shareholder pressure, and an industry embracing its role in stopping climate change is pushing the electric industry to shift to low- or no-carbon generation, even as it isn't sure how to get there.

Overall, the 2021 data describes an electricity industry that intends to move to clean energy, without only partial plans of how to get from point A to point B. Utilities are evolving their business models to be more competitive and innovative in the distributed energy resources (DER) space (52 percent); longer term, they expect that DER will dominate utility service offerings (61 percent in 15 years.)

As the energy sector works toward aggressive decarbonization goals — think "100-percent carbon free by 2050" — meticulous planning and calculated investment are crucial.

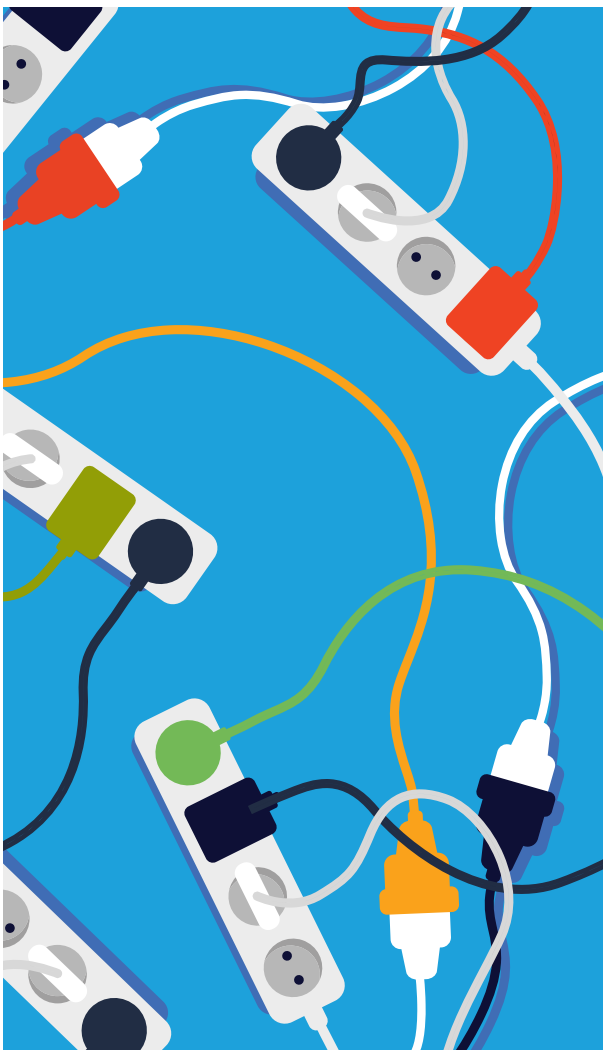


Figure 11

What are the top three biggest concerns for future grid development in the next three to five years?

Source: Black & Veatch

67.3%
Generation mix, with fewer traditional base load units and more utility scale renewable sources

44.4%
Regulatory lag in meeting the needs for system changes

34.6%
Lack of qualified workers to engineer, maintain and operate the more complex system

32.3%
Ability to invest in and maintain a more resilient grid

25.6%
Lack of sufficient transmission facilities and system control assets

24.6%
Increases in DER

23.8%
Lack of sufficient levels of investment to maintain and operate (including training of staff)

13.8%
Available capital

12.5%
Safety for energy professionals and the public with greater dispersed resources

7.5%
Other

Against Headwinds of Extreme Weather, Pressure Builds for Climate Resilience

The year 2021 marked a watershed for U.S. climate disasters as the increasing frequency and impact of severe weather battered millions of people, communities and major infrastructure systems across the U.S.

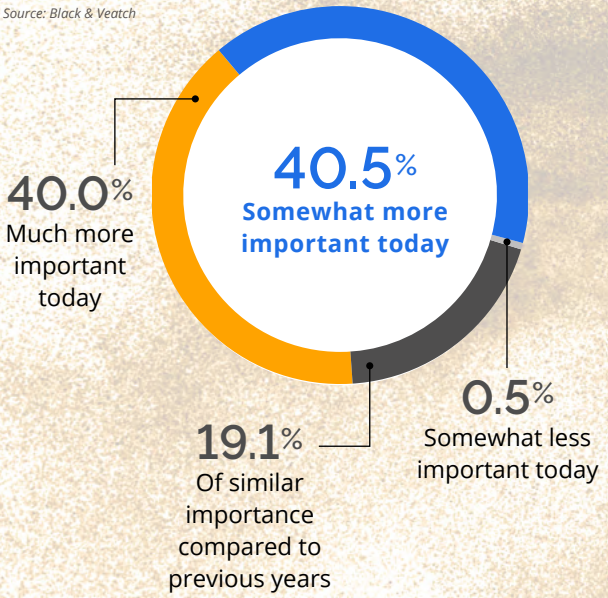
In this year alone, extreme heat generated by an unprecedented "heat dome" impacting the Pacific Northwest melted power cables and shut down Portland's streetcar service. February's Texas deep freeze not only took power from 5 million people, but it disrupted water service as well. Hurricane Ida shut down the grid for millions from Louisiana and Mississippi through to the Northeast. In fact, according to a *Washington Post* examination of federal disaster declarations, more than one-third of all Americans live in a county that experienced a climate disaster during the summer of 2021.

Figure 12

Compared to previous years, how important are asset hardening techniques today? *(Select one)*

Asset hardening is...

Source: Black & Veatch



Each of these extreme weather events brought devastation and frustration while serving as catalysts for change. Climate- and storm-related disruptions to the grid are nothing new — anything from a fallen tree to a wildfire can cause power loss — but the recent barrage of events has clarified the urgent necessity of sweeping updates to the power grid. The problem is more acute because customers are increasingly sensitive to system failures, and service providers have managed their expectations poorly.

The *Black & Veatch Electric Report* survey confirms that most utilities — four out of five respondents — consider asset hardening to be more important today than in previous years *(Figure 12)*. This may be due to this year's weather issues, but it also could reflect the business community's awareness of the significant financial and reputational risks they face from extreme weather events. This is outlined starkly in a report by CDP, a non-profit that runs a global disclosure program, which projects $1.26 trillion in supplier revenue losses by 2026 because of climate.

Gaining Insight

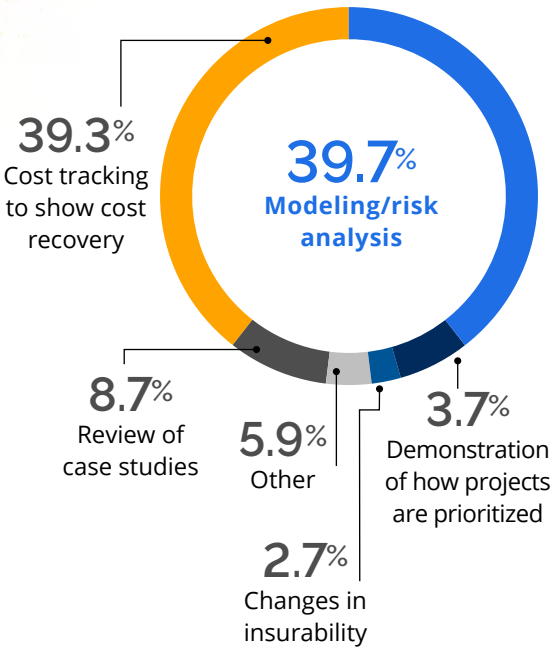
As utilities seek to make their systems more resilient, data-driven models tell the success stories of the energy sector. Power utilities can create models to predict system responses to events — and tell the story to regulators and investors. Forty percent of survey respondents selected modeling and risk analysis as effective strategies for justifying expenses for climate change adaptation and resilience projects *(Figure 13)*.

Because models can simulate climate events — they are the evidence that lays the foundation needed to persuade regulators and investors of the case for hardening.

Figure 13

What are some effective ways to justify the expense of climate change/resilience projects? *(Select one)*

Source: Black & Veatch



Such modeling capabilities open various doors for the nearly two-thirds (63 percent) of survey respondents who reported they have used risk analysis, modeling or similar inputs to prioritize resilience projects. Of the remaining respondents, the 26 percent who acknowledge they don't use it are likely kept away by costs or not knowing where to begin.

As electric utility workforces age and new technologies require advanced expertise, many smaller energy utilities may not have the in-house resources to take advantage of data-driven analysis. This may explain the 27-point disparity between larger utilities (those serving more than 2 million customers) and smaller ones (those serving less than 2 million customers) when it comes to who is leveraging risk analysis and modeling *(Figure 14)*.

Data-driven modeling and risk analysis can be difficult to implement, but Black & Veatch consultants can help energy providers collect, verify and interpret the information. With effective data collection and management, utilities can monitor a broad range of operational metrics.

Data collection and management can include devices to detect electrical, environmental and physical data such as flood-level sensors in and around facilities, artificial intelligence (AI) equipped cameras or drones that can identify damaged or at-risk equipment, temperature monitoring for both hot and cold weather threats, and much more. These assets, coupled with technologies that enhance reliability and efficiency, improve outage management and reduce energy consumption, and give greater focus to the development of the smart grid.

Figure 14

Have you used risk analysis, modeling or other similar inputs to prioritize resilience projects? *(Select one)*

Source: Black & Veatch

By population served	Less than 2 million	2 million or more
Yes	50.0%	76.9%
No, but we should	35.0%	15.4%
No, this is not necessary	15.0%	7.7%

Planning for the Future

Despite plentiful capabilities provided by data collection and digitization, these systems come with a drawback: energy asset owners and providers often come up with more information than they can manage. As a solution, a development project that integrates asset management services with data analytics capabilities can help utilities sift through mountains of data to glean the most critical actionable priorities.

As such services become more available, modeling and risk analysis likely are to become even more beneficial to energy providers. Not only can providers use them to organize and prioritize storm response, they also can deploy these capabilities to gather evidence when it comes time to make a case for investment.

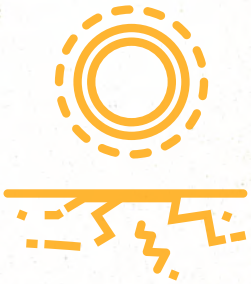


Figure 15

Which of the following hardening techniques are you planning to employ in the next five years?
(Select all that apply)

Source: Black & Veatch

57.4%
Vegetation management

55.0%
Smart grid improvements

48.1%
Structural T&D upgrades (poles and towers)

34.9%
Undergrounding

30.2%
Backup power

22.5%
Span or wire changes

20.2%
Heat tracing

19.4%
Flood hardening

8.5%
None of the above

Such investment will be prioritized, as more than half of survey respondents indicated that smart grid improvements were included in their five-year plans. Deploying systems to provide awareness of the current state of system assets came in a close second to vegetation management, which is included in the resiliency plans of 57 percent of surveyed energy sector stakeholders *(Figure 15)*.

Conclusion

When it comes to preparing grids for extreme weather events, there really is no one-size-fits-all approach. Each energy asset owner and provider will need a different strategy that accounts for system constraints, location, asset vulnerabilities, budgetary considerations, workforce availability and more. For example, electric utilities in the Northeast may focus more on vegetation management than their counterparts in the desert Southwest, where high temperatures and drought force new demands. In any case, as companies make their hardening plans based on today's key factors, new considerations such as insurability or the availability of recovery funding may impact future capital allocation.

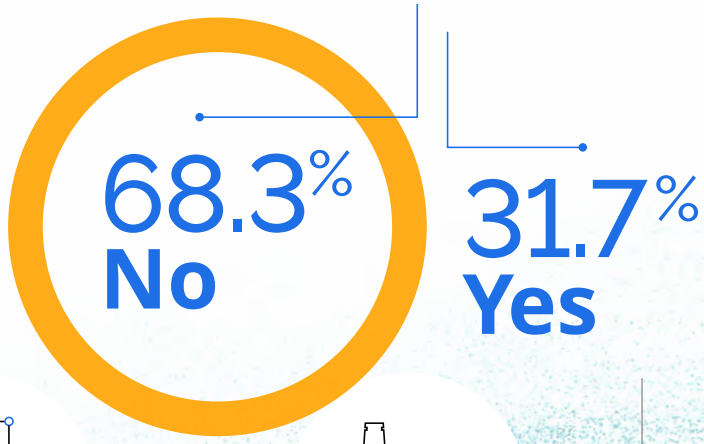
Combining these lessons with the prediction and monitoring capabilities provided by digitization and data management will allow utilities to confidently define effective resiliency plans.

Figure 16

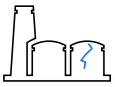
In the past year, have you deployed or piloted projects that help your utility respond faster to storms or environmental events?

(Select one)

Source: Black & Veatch

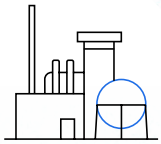


Advanced Distribution Management System and AMI deployment

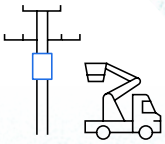


Replacing aging infrastructure and enhanced tree trimming

Smart meters to quickly identify and pinpoint outages

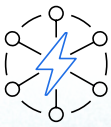


H2 generation for combustion and energy storage

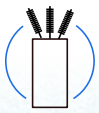


Designed and purchased Emergency Restoration Structures (ERS) and tooling in a containerized, ready to transport solution

Outage management system, central distribution control office, central issuing authority, enhanced visibility through AMI and substation automation



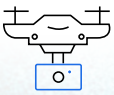
Microgrids



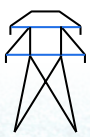
Inundation protection for substations

Undergrounding and distribution automation

Stationary fuel cells operating on the more resilient gas distribution system in micro-grid or distributed systems



Increased hardening of hardware and increased use of modeling of events and use of drones



Built new transmission to higher windspeeds and they have demonstrated the ability to perform

Surges in Renewable Energy, Decarbonization and Extreme Weather Stoke Investment Uncertainty

In a sector transforming at such a dizzying rate, there's little wonder why U.S. electric utilities feel a bit isolated and under pressure. The relentless advance of renewable energy is forcing power providers to find ways to integrate it onto the grid. On every level of the political spectrum and from electric customers directly, mandates and ambitious targets abound for decarbonizing and migrating exclusively to green energy. Extreme weather and wildfires are exposing the vulnerabilities of legacy grid infrastructure.

It's against that backdrop that U.S. utilities face one of their biggest questions: How and where can and should power providers invest in a sector so rife with uncertainty and change?

Backed by a survey of nearly 500 U.S. electric sector stakeholders, the *Black & Veatch Electric Report* pulls into sharper focus an energy

landscape being reimagined, with legacy power systems reliant on fossil fuels increasingly giving way to cleaner, greener energy options.

On the investment side, here are some key takeaways:

Utilities Say They're Using Climatic Modeling, But to What Extent

In February 2021, the U.S. Department of Energy's Argonne National Laboratory announced it was providing data from its high-resolution climate model to help California's biggest investor-owned utility — Pacific Gas and Electric Co. (PG&E) — safeguard its infrastructure and better plan for the future in a changing climate.

On many levels, it makes sense; as devastating, power-disrupting weather events ranging from Superstorm Sandy a decade ago to Texas' deep freeze and Hurricane Ida in 2021 demonstrate, both repairing storm damage and hardening infrastructure after a storm passes are expensive and daunting.

Forward-thinking utilities can and should embed climatic modeling into their road-mapping now — and rethink their old planning approaches — to avoid risk and ensure greater resiliency, with the caveat that climate models still hold uncertainties.

Black & Veatch's survey results suggest that's happening, with nearly half of respondents — 48 percent — insisting they're overlaying climatic modeling in their grid planning. An open question is the robustness of comprehensive climatic modeling methods and tools being utilized and how results are being interpreted.

Utilities that conflate using climate data in grid planning with simply reflexively hardening their assets against storms and wildfires for the short term are missing the mark. Incorporating actual climate science into the utility's grid analyses and forward-looking blueprint would be more robust and responsive, grasping the prospect that tomorrow's storms and other extreme climatic events may be more frequent and severe.

Either way — and to little surprise — utilities serving at least 2 million customers are far more likely to be working climate models into their grid blueprints of tomorrow, with 70 percent of those respondents affirming as much compared with just one-quarter of the smaller utilities. Larger utilities often have the financial means to turn such analyses into infrastructure action *(Figure 17)*.

Figure 17

Are you overlaying climatic modeling in your grid planning? *(Select one)*

Source: Black & Veatch

By population served	Less than 2 million	2 million or more
Yes	25.5%	70.2%
No	74.5%	29.8%

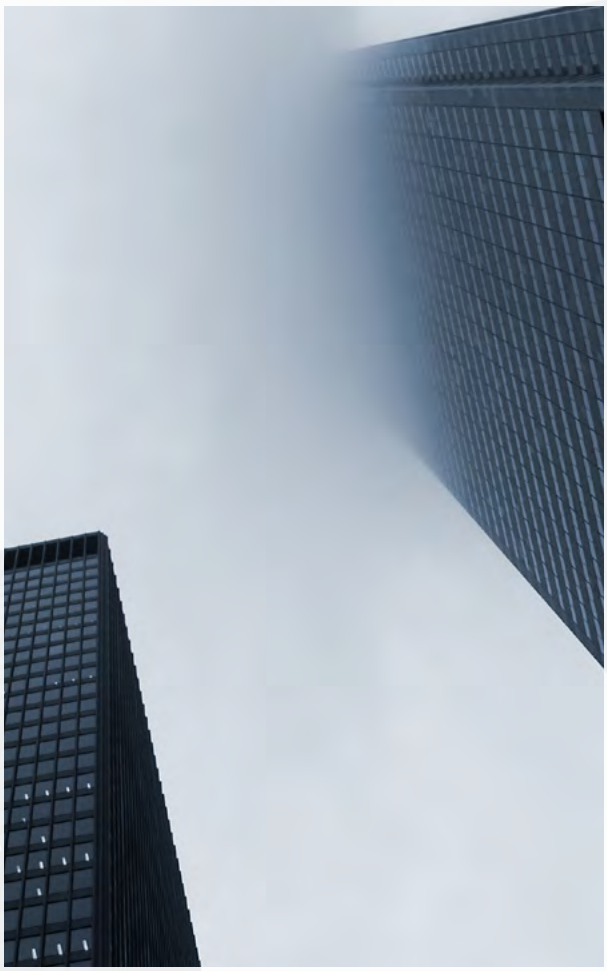


Figure 18

What factors are driving renewable energy investments in your region?

(Select all that apply for each timeframe)

Source: Black & Veatch

	2020	2021
Government incentives and/or policies	38.7%	**56.1%**
Increased pressure/influence from governments	38.7%	50.6%
Increased pressure/influence from shareholders and drive for sustainability goals	51.6%	42.4%
Increased demand from commercial and industrial clients	12.9%	33.9%
Improved pricing competitiveness and efficiencies from new technologies	48.4%	29.7%
Increased demand from residential customers	6.5%	25.5%
Lower levelized cost of energy	**61.3%**	22.2%
Reduced options to finance traditional solutions/comparatively increased ease of access to capital to finance renewable solutions	35.5%	13.1%

Utilities and grid operators truly committed to factoring climate modeling into their long-term grid strategies must get regulators and other key stakeholders on board with that at the outset and accept that the cost goes up with the adoption of each moving piece.

During a June 2021 conference by the Federal Energy Regulatory Commission (FERC) on the matter, some power sector experts — including New York City's deputy chief of infrastructure and energy, and a senior fellow at Columbia University's Sabin Center for Climate Change Law — pressed FERC to compel utilities to incorporate best-available climate data into their resource adequacy and transmission planning, which would be a key starting point.

Decarbonizing and the Age of DER

More than ever, decarbonization has a firmer grip on the evolving energy landscape, with more and more utilities taking a "green pledge" to rid their generation mix of harmful emissions — whether or not prodded by their constituents or regulators. The Biden administration wants U.S. greenhouse gas emissions to be cut in half by the end of this decade, with similar mandates increasingly being adopted by states.

Black & Veatch's survey findings reflect that utilities say that government incentives and policies, along with increased governmental pressure and influence, are the top two factors driving renewable energy investments in their respective regions. Last year, the lower levelized cost of energy and pressure from shareholders held the most sway *(Figure 18)*.

Nearly three-quarters of survey respondents — 72 percent — acknowledge there is local pressure on their utilities to commit to decarbonization. Roughly nine in 10 respondents from big utilities — those serving at least 2 million people — say they're feeling the squeeze, compared with just 60 percent of their smaller counterparts, perhaps because they simply have fewer generation assets. Roughly one-third of respondents (34 percent) say they're feeling increased demand for clean energy solutions from commercial and industrial clients, up nearly three-fold from last year.

While the U.S. relies on carbon-emitting fossil fuels for roughly 60 percent of its electricity generation, according to the U.S. Energy Information Administration, the accelerating migration to renewable energy reshaping tomorrow's generation stack is shifting how investment dollars are allocated across the system, though the exact mix of technologies and pace of the deployment remain elusive for now.

To accommodate the surge in renewables on the grid, the electric sector may need to move more swiftly if it wants to meet both regulatory and societal expectations. Yet even then there's uncertainty, if not a lack of commitment; when asked whether their utility will be open to providing DER and related services when the time comes, 61 percent said "probably," and 17 percent replied "probably not." Just 23 percent responded "definitely."

Again, bigger utilities responded more positively, with 94 percent saying they "definitely or probably" will offer DER to their customers, compared with three-quarters of smaller utilities.

Both time and the emergence of FERC Order 2222 will come to show where that money is spent, how utilities play in tomorrow's reshaped energy landscape, and whether they own DER or offer them to customers. Many of those outcomes will depend on how regulations change to allow utilities to compete in the market, both against other utilities and against commercial enterprises offering DER and other services to their clients.

As more conventional generation is driven out in the evolution to DER, the issues become increasingly localized, requiring more sophistication and investment in transmission and distribution assets, data analysis, load-balancing tools and communications infrastructure.

In the end, utilities are pressed to transition to cleaner, greener energy mixes, harden their infrastructure assets against extreme weather and integrate renewable energy onto the grid. They no longer have the luxury of being passive. Thoughtful, balanced decisions, plans and investments made today — whether or not influenced by regulatory or legislative pressure state by state — can help deliver better outcomes for a utility's reliability and resiliency when it's needed most.

Digitization at the Heart of Cybersecurity, Asset Management

Against the backdrop of headline-grabbing U.S. incidents of cyber and ransomware attacks, President Biden in August 2021 hosted executives from major energy, technology and financial companies for a summit about cybersecurity, calling the issue "the core national security challenge we are facing."

The Black & Veatch Electric Report underscores the growing extent to which that matter is on the electric sector's radar. Based on a survey of nearly 500 U.S. electric sector stakeholders, the report shows that while the integration of renewables onto the grid has usurped the sector's aging infrastructure as the industry's top challenge, cybersecurity has jumped into the second spot, up four from last year.

Drilling deeper, when it comes to the chief challenges with current distribution system automation and communication capabilities, cybersecurity topped the list at 46 percent, outdistancing old and obsolete equipment *(Figure 19)*.

All essentially are elements that contribute to the same modernization goal: the digitalization of energy infrastructure.

Across the grid, aging serial equipment is being replaced with IP-enabled digital equipment. It is only through the introduction of a smart digital grid that DER can become a functional element of the grid, but with the increased number of entry points for data comes increased vulnerability to cyberattack.

This proliferation of digital equipment in the grid's operational technology (OT) brings utilities nearer to the tipping point where they will need to reassess whether their equipment vendors' cybersecurity provisions are sufficient to keep the lights on.

Utilities need to be confident that the digital grid will be able to function properly in the event of a cyberattack. To get there, utilities must deepen their understanding of their vendors' cybersecurity features and determine whether they meet each utility's overall cybersecurity risk profile and regulatory requirements. In short, to ensure that power infrastructure is fit for purpose in the digital age, equipment specifications need to address cybersecurity as effectively as they address other aspects of performance — performance and security are now inseparable.

Figure 19

What are the top three major challenges your team is facing with your current distribution system automation and communication capabilities?

(Select top three choices)

Source: Black & Veatch

46.3%
Cybersecurity

35.5%
Old and obsolete equipment

34.7%
Integrating Distributed Energy Resources (Integrating DER)

30.6%
Interoperability and integrating multiple technology and vendor solutions

28.1%
Lack of staff to support future needs and requirements

24.0%
Data quality and management

22.3%
Do not have adequate remote monitoring, control, automation capabilities

12.4%
Gaining useful, actionable data

6.6%
Physical security

6.6%
Evaluating, testing and selecting a field area network technology

10.7%
Other

5.8%
None, we are not facing any challenges

Wherever an IP Packet Flows, Utilities Need Cybersecurity

For the past two years, the North American Electric Reliability Corp. (NERC)/Critical Infrastructure Protection (CIP) Standards have required high levels of utilities' technology investments — 14 percent in both 2021 and 2020, according to the survey.

Investment in supervisory control and data acquisition (SCADA) has remained a priority (12 percent of investment in 2021, 9 percent in 2020), as has asset management investment (10 percent in 2021, 15 percent in 2020) *(Figure 20)*. The three are interdependent; when it comes to cybersecurity, that interdependency probably is the most significant takeaway.

In this context, asset management is about understanding the asset inventory, planning and replacing serial technology with IP-based equipment. It is not possible to move to digital asset management programs without an effective SCADA system that also collects health- and operations-related information for the equipment and its controller.

The pace of technological change is moving beyond analog-to-digital replacement, and some older digital equipment now needs to be upgraded to match advances in cybersecurity and communications technology.

Figure 20

How would that investment be allocated across those technologies? *(Enter percent for each to total 100)*

Source: Black & Veatch

	2020	2021
Cybersecurity/NERC/CIP	13.6%	**14.2%**
SCADA	8.8%	11.7%
Distribution resiliency	7.8%	9.9%
Asset management	**14.8%**	9.8%
Distribution automation	8.3%	9.4%
Distribution management systems	7.7%	9.1%
Other 'smart grid' tech	8.3%	8.6%
Telecom	7.6%	6.6%
Private networks	6.5%	5.8%
Network management	6.3%	5.6%
Physical security	6.5%	5.6%
Pole assessment	3.9%	3.6%

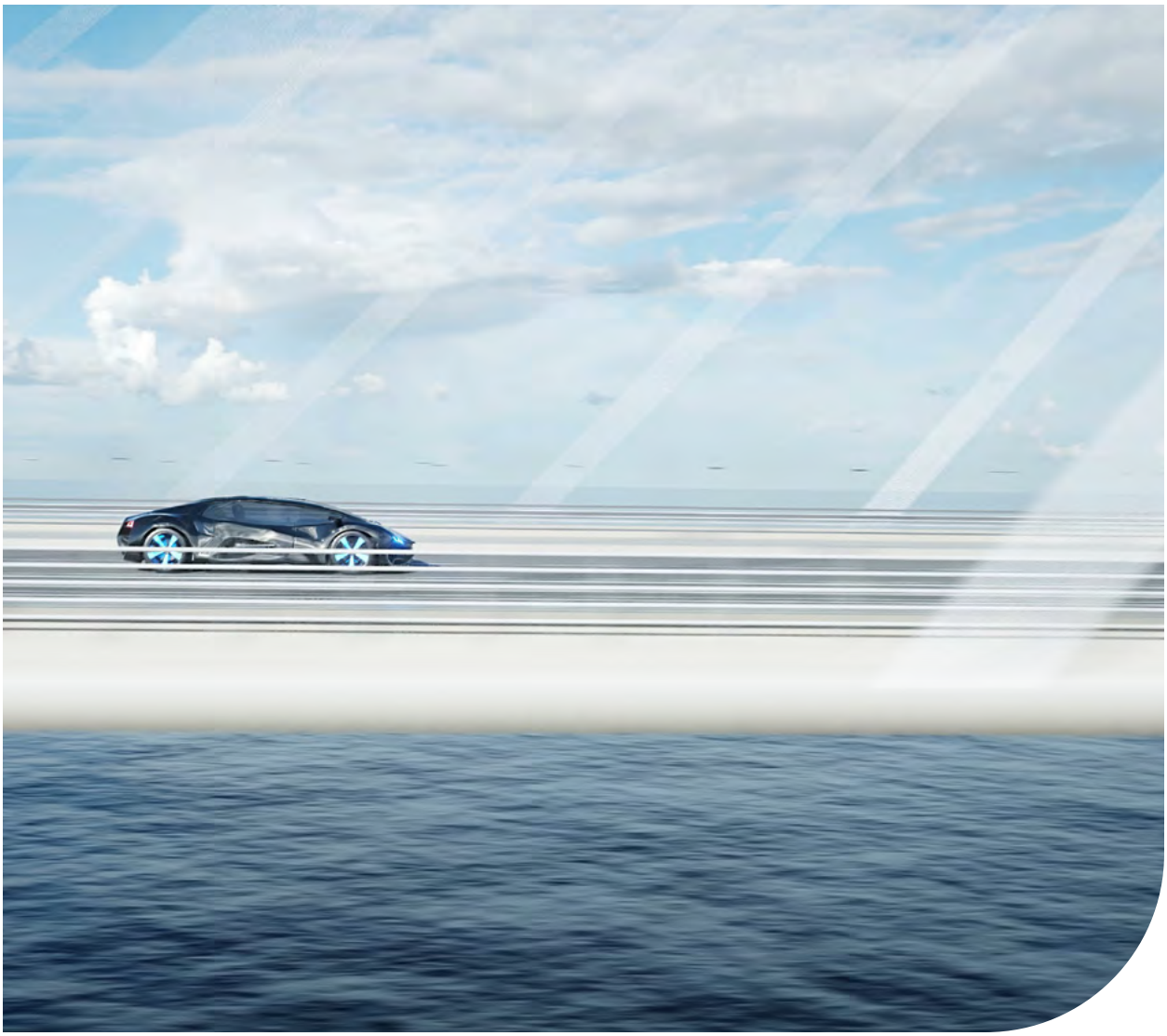
With digitalization comes the move toward an integrated, enterprise-wide technology infrastructure, and with that an increased vulnerability to cyberattack. Wherever an IP packet flows, utilities need cybersecurity. Because IP packets are transmitted throughout utilities' infrastructure, utilities now are dealing with cyberattacks that originate in information technology (IT) systems and migrate into OT.

As a result, effective cybersecurity needs to address the whole enterprise. But communications networks and their applications inherently run with various "assumed trust" states when interacting digitally. Unfortunately, assumed trust leads to cyber vulnerabilities that allow unauthorized lateral movement within a network once penetration is achieved.

When it comes to OT, one step that utilities can take is to move away from assumed trust in equipment vendors' cybersecurity measures. As ransomware attacks have shown, "zero trust" — and full encryption of all digital information — is preferable. With a zero-trust model, assumed trust no longer is accepted for cybersecurity posture or supply chain security.

The level of investment in meeting NERC CIP standards is welcome. It should be noted, however, that while CIP provides controls, the standard does not explain how they should be achieved. The specification's "how" is unspecified.

This — along with the move away from assumed trust in equipment suppliers — points to the need not just to invest in secure equipment, but also to ensure robust cybersecurity processes at the enterprise level, applicable to both IT, OT and the interfaces in between. Processes are essential to reduce the vulnerabilities to human error, which is the root cause of 23 percent of data breaches. This will help provide the "how" necessary to achieve CIP compliance.



Powering the Future of Go

More than a decade ago, Tesla kicked open the doors to public acceptance and mass market appeal of the electric car, laying the groundwork for electrification of passenger vehicles. Now, more and more auto manufacturers are announcing plans to stop production of combustion-engine vehicles within the next two decades.

Recognizing the benefits of an electrified fleet, the commercial and industrial (C&I) sector — with its hundreds of thousands of medium- and heavy-duty trucks, delivery vans and buses — is getting on board. CALSTART's Global Commercial Drive to Zero initiative reports that more than 108 models of commercial freight vehicles — e.g., zero-emission heavy-duty trucks, medium-duty truck and vans, yard tractors — will be available from 46 manufacturers in the U.S. this year.

As these medium- and heavy-duty EVs hit the streets, utility networks will have to handle simultaneous charging, corridor charging hubs and large charging depots, with some truck chargers imposing an instantaneous demand of 5 megawatts (MW), 10 MW or more.

This begs the question: How can electric utilities manage the incredible demand growth on their networks if nearly all company and private vehicles are electric by 2040?

Figure 21

Where is your utility on the 'road to electrification'? *(Select one)*

Source: Black & Veatch

1.5%
Late stage: Charging stations widely available in our market

13.7%
Middle to late stage: Many charging stations deployed

50.4%
Middle stage: Some charging stations deployed

14.5%
Middle to early stage: feasibility studies underway

10.7%
Early stages: considering feasibility studies

9.2%
Not even started

Preparedness for Load Growth

The *Black & Veatch Electric Report* survey found that demand for EV charging sites is up over last year. Slightly more than one-third (36 percent) of utilities reported an uptick in requests for Level 1 (120-volt (V)) charging sites, 52 percent saw increased requests for Level 2 (208/240V) charging sites, and 52 percent had more requests for Level 3, DC fast-charging sites.

The survey also found that two-thirds of utilities are involved in deploying charging stations *(Figure 21)*. One-quarter of the respondents said they are in the early stages of deployment and either are conducting or considering feasibility studies. Only 9 percent reported that they have not yet gotten involved in EV charging.

The largest issue, though, is that most utilities are not ready for the load if fleet electrification happens as planned. Over the next 25 years, utilities are going to see demand for electricity increase substantially — anywhere from 25 percent to 75 percent — depending on location. Some utilities are beginning their planning now to get ahead of the surge in need and have partnered on vehicle electrification pilot projects.

Coupled with the increase in load is a speed of deployment dynamic. Modularized construction of charging infrastructure leads to load growth that outpaces growth seen with more conventional infrastructure projects. Most respondents — a combined 62 percent — said they require a lead time of more than six months *(Figure 22)* to accommodate new EV loads. Sixteen percent can do it in less than six months, and 22 percent are ready to accommodate new load today.

These six-month-plus timelines are unrealistic when weighed against the speed of EV adoption. Utilities need to do something to speed up that timeline, but what?

Figure 22

From today, how much time is needed for your utility to enable new EV loads? *(Select one)*

Source: Black & Veatch

21.5%
We are ready today

13.3%
1 to 1.5 years

16.3%
Less than 6 months

11.9%
1.5 to 2 years

20.7%
6 months to 1 year

16.3%
More than 2 years

Survey respondents pointed to three primary lessons they've learned with EV charging infrastructure: 1) calculating return on investment (ROI) is difficult; 2) installation costs vary greatly across sites; and 3) it's more cost effective to develop new sites versus retrofitting existing structures *(Figure 23)*.

Quantifying ROI on charging stations comes down to the "U" word — utilization. Site owners have a tough time gauging the utilization of private vehicles, making it difficult to calculate ROI. For example, they may build a charging station that is rarely used because people can charge their passenger vehicles at home or at work. By focusing their efforts on dedicated fleets, utilities more accurately can gauge ROI because fleet managers have predictable information that can help dictate those returns.

When it comes to the cost of installation, utilities can start getting more involved in the site-to-site details to understand what drives cost and site selection. This also goes for installing EV charging in new developments versus existing structures. By increasing engagement and learning the language, utilities can create more compelling, cost-effective programs.

Another issue is the effect of location on EV adoption in private vehicles, and the related effect on charging infrastructure. Passenger EVs have a higher price tag and thus tend to concentrate in zip codes with higher incomes. Often, these residential areas do not align with the warehouse districts or distribution facilities where fleet vehicles — and associated charging infrastructure — are deployed. It's important to consider the feeders and substations that are likely to be constrained at certain hours on a time domain as the pace of EV adoption continues to increase. This understanding will ensure that investments in infrastructure upgrades are targeted in a strategic manner.

Figure 23

Are there any lessons you've learned from your experience with EV charging infrastructure?
(Select all that apply)

Source: Black & Veatch

42.3%
Return on investment for site owners is difficult to quantify

41.2%
Cost of installation varies greatly from site to site

40.2%
It's more cost effective to include EV charging in a new development versus adding to an existing structure

34.0%
Maintenance agreements are just as important as installation agreements

33.0%
Public-private partnerships are effective for cost sharing

24.7%
Installations in public spaces are administratively burdensome

24.7%
The price of charging equipment limits broader deployments

21.6%
Cost of installation varies greatly for different equipment manufacturers

13.4%
Standardization of signage is essential to improve communication of site locations

10.3%
Choosing between level 1 and level 2 can be a challenge

Utilities Must Step Up

So, how can utilities resolve these issues and prepare for the next wave of C&I electrification? Taking a leadership role in infrastructure deployment to meet the increasing demands of EVs will ensure that utilities maintain a prominent position in serving the electric delivery needs of customers.

The industry storyline is that fleet managers need to engage with their utility, but this also is true in reverse: Utilities must engage with their customers, particularly when it comes to C&I engagement. C&I customers will comprise a significant portion of engagement around EV charging going forward; by working directly with these customers, utilities will be better equipped to more accurately predict ROI and prepare for the infrastructure requirements that accompany EV charging programs.

Will Federal Funding Legislation, Incentives Reshape the U.S. Energy Market?

In November, President Biden signed an unprecedented $1 trillion infrastructure bill that includes $73 billion for grid modernization, sealing congressional approval for the bipartisan measure that had passed the Senate in August.

In normal times, we would expect something of this magnitude to be head and shoulders above other market dynamics competing for utilities' attention.

But this moment isn't typical, as a survey of nearly 500 U.S. electric stakeholders shows in the *Black & Veatch Electric Report*. The cost of commodities is demanding as much attention as the newly passed $1 trillion bill (49 percent to roughly 51 percent, respectively). The impact of COVID, at 45 percent, comes in third *(Figure 24).*

Figure 24

Which of the following market dynamics are receiving the most attention from your organization?

(Select up to three)

Source: Black & Veatch

50.9%
U.S. infrastructure bill

49.1%
Cost of commodities

45.1%
COVID impacts to global recoveries, material extraction and fabrication

30.5%
Global growth of EVs and battery energy storage

15.0%
Trade position by Biden administration

12.8%
Strength of the U.S. dollar

12.4%
Increased import controls for solar-related products

9.3%
Cost and availability of containers for shipment

7.5%
Other

Further, global economic factors are introducing a level of uncertainty about the ability to put the steel in the ground that he bill calls for. The cost of commodities, and the impacts of COVID-19 on recoveries, mineral extraction and fabrication, are two sides of the same coin. Raw materials are in short supply, constricting the availability of components and equipment and pushing up costs. Costs and availability of shipping containers feed into the mix.

In September 2021, container rates from China and east Asia to the U.S. were about $20,000 per 40-foot container, compared with about $4,500 for the same route at the same time last year. Surprisingly, this was among the lesser concerns (9 percent) of our respondents, but it may well rise if the situation persists.

These factors make cost forecasting harder, leading to the delay of some projects and the cancellation of others as they become less bankable. As the energy sector tries to expand renewable generation, this creates urgency and uncertainty for owners seeking to meet regulatory deadlines in order to qualify for renewable tax credits.

There is very little middle ground with respect to the market dynamics vying for respondents' attention. The Biden administration's trade position (15 percent), strength of the dollar (13 percent) and increased import controls on solar related products (12 percent) are relatively minor concerns in comparison with the infrastructure bill, commodity prices and the impacts of COVID.

Supply Chain Shock is Two-Fold

The supply chain shock is two-fold. Raw materials such as timber and steel required for construction projects are in short supply, along with the squeeze on the availability of components and equipment necessary for building power infrastructure.

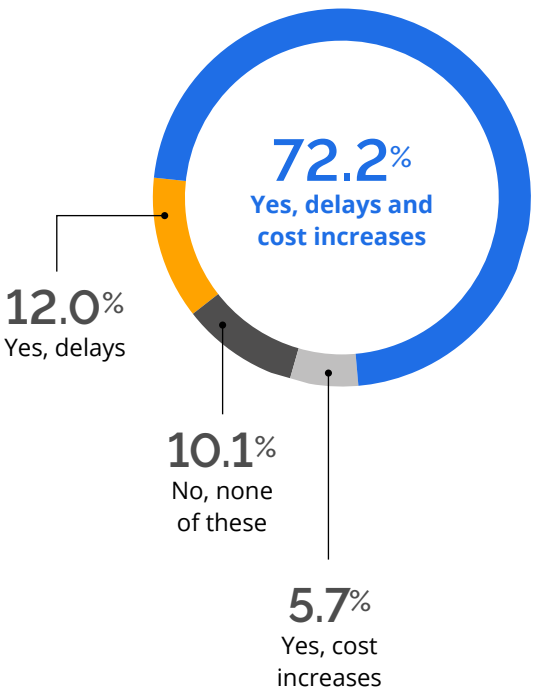
In areas where the materials and equipment are available, they cost more. But in some instances, they are simply unavailable on the schedule laid out in project planning.

The severity of the supply chain disruption is reflected in the response to our survey. Nearly three-quarters of respondents (72 percent) already are seeing project delays and cost increases stemming from supply chain issues. Add in those respondents only reporting delays (12 percent) and cost increases (6 percent), and we see 90 percent of respondents experiencing supply chain issues *(Figure 25)*. This is significant.

Figure 25

How do tax credits factor in the decision to invest in renewable infrastructure? *(Select one)*

Source: Black & Veatch



The solar sector provides a microcosm of broader challenges. A potent combination of supply chain constraints and growing demand means the sector is struggling to match the 15 GW of solar capacity installed in 2020. Curtailed manufacturing capacity has affected the supply and cost of batteries.

The situation is further compounded by the withhold release order — which forbids the importation of goods mined, produced or manufactured by convict labor and/or forced or indentured labor — that effectively blocks the import of silicon metal from China's Hoshine Silicon Industry Co., reducing the availability of solar array components.

Additionally, higher steel and aluminum prices have pushed up costs for projects underway. As a result, projects are being put on hold as developers wait to see if availability improves and costs fall.

Macroeconomics butt up against federal and state climate goals. U.S. Department of Energy modeling of a potential path to 95-percent clean energy by 2035 — and 100 percent by 2050 — found that the U.S. will have to double its yearly solar installations by 2025.

Renewables Can Stand on Their Own

Against a backdrop of uncertainty driven by rising costs and project delays, some good news remains. It's clear that renewables can stand on their own and no longer require tax credits to ensure bankability.

A significant majority of respondents to our survey (62 percent) say they will invest in renewable energy infrastructure regardless of tax credits. This leaves a sizeable minority — 38 percent — whose investment are contingent on tax credits *(Figure 26).*

While developers will take advantage of the tax credits likely to come from the federal or state governments to ensure their projects are not disadvantaged, survey responses show investment in renewable infrastructure is not dependent upon the infrastructure bill.

While change and uncertainty about the levels of credit and how they will be administered are not new, a newfound confidence to move forward regardless is the sign of a maturing sector.

Figure 26

What are some effective ways to justify the expense of climate change/resilience projects? *(Select one)*

Source: Black & Veatch

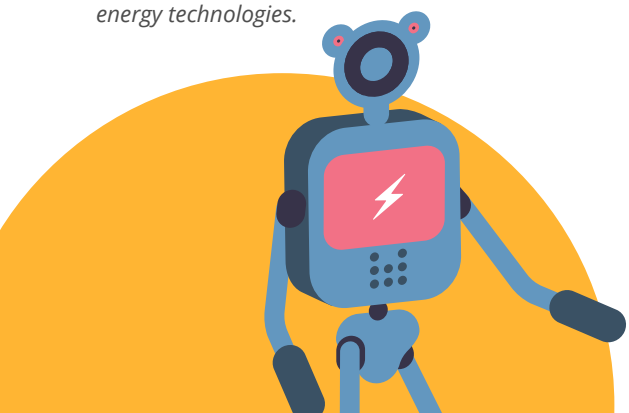
About The Authors

Mario Azar *is president of Black & Veatch's energy and process industries business. He previously served as president of the company's power business, where he led all aspects of the business serving global power generation and delivery clients through comprehensive planning, consulting, engineering, construction, program management and combined engineering, procurement and construction solutions. Azar has more than 30 years of global leadership roles in power and oil and gas with breadth of experience in adapting to global changing markets. He has overseen multiple power and oil and gas businesses spanning the globe.*

Stephanie Bache *is associate vice president and sub-region director for Black & Veatch's water business. She oversees a portfolio of projects for stormwater, water and wastewater, including a major stormwater project in Houston that was initiated in response to Hurricane Harvey and will help reduce impacts of future major flood events. Bache has worked on high-profile projects and programs in Texas, California, Nevada and in the Middle East.*

Alex Bettencourt *is a member of Black & Veatch Management Consulting group and leads the advanced transportation and decarbonization practices globally for the company. He and his team are working with many leading organizations around the world looking to meet their decarbonization goals, including through the electrification of their transportation fleets. Before coming to Black & Veatch, he led grid-modernization efforts of leading utilities around North America.*

Jonathan Cristiani *is a Black & Veatch project manager and engineer who is primarily focused on bioenergy and hydrogen consulting services, including technology evaluations, resource assessments, feasibility studies, proforma economic analyses, conceptual engineering and engineering/project management assistance. Cristiani has significant experience with the conversion of biogenic feedstocks to electric power, process heat, and solid, liquid or gaseous biofuels. His portfolio also includes the production of hydrogen for industrial, energy storage and transportation fuel applications. Over his career, Cristiani has worked in research and development with a variety of power and energy technologies.*



Kristie Deiuliis *is a managing director at Black & Veatch, leading decarbonization strategy and planning initiatives. With more than 25 years in the energy industry, Deiuliis leads strategic initiatives, driving the development of all economic, policy, technology and feasibility assessments for a broad range of global top-tier clients. Her experience spans energy industry domains, including wholesale and retail (regulated and competitive) markets, distributed energy resources, market entry and expansion business cases, and investment strategies for companies seeking to pivot or accelerate specific goals.*

Heather Donaldson *is managing director of Black & Veatch Management Consulting, where she is responsible for supporting clients through grid modernization, transportation electrification, DER integration and other transformations. A recognized expert in the energy industry, Donaldson has served as a special advisor to the California Public Utilities Commission, as a principal with Southern California Edison, and as a director with California ISO.*

Frank Jakob *is the technology manager for energy storage within Black & Veatch's power business. Jakob focuses on storage solutions for renewable and conventional electricity generation at distributed and utility scales. With more than 40 years of experience, Jakob advises industry, utility, developer and government clients, as well as the internal Black & Veatch engineering, procurement and construction (EPC) teams regarding the application, design and uses of energy storage systems for stationary power generation applications.*

Arron Lewis *is the global power distribution leader for Black & Veatch's distributed energy business. In this role, Lewis leads the global deployment of services for power distribution infrastructure. His focus is on the delivery of new services to address digitization and grid modernization, as well as infrastructure construction and upgrades required to meet the evolving needs of utility clients that deliver power to customers.*

Kevin Ludwig *is the global transmission technology portfolio manager for Black & Veatch's power business. Ludwig has more than 20 years of experience in the power industry. In his present role, he is responsible for monitoring technology changes, development of solutions and solution specific resource management for the transmission market.*

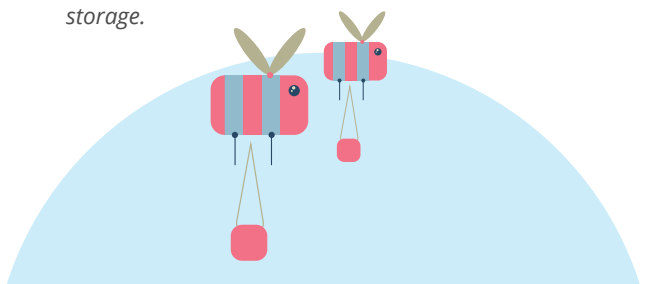
Leslie Ponder *is the technology portfolio director for global distributed energy at Black & Veatch, where she is responsible for evaluating and delivering technology solutions within distribution, asset management and distributed generation. Ponder has more than 30 years of experience and has led systems strategy and planning for communications, grid analytics, and grid control and security systems.*

Mike Prescher *is a network and cybersecurity architect for Black & Veatch's telecommunications business and is responsible for data network infrastructure architecture design and implementation. He has provided consultative expertise to Fortune 500 companies and utilities across North America on network design, operations and support methodology, application performance optimization and very large-scale implementation projects.*

Algert Prifti *leads decarbonization and carbon capture, sequestration and utilization (CCUS) efforts at Black & Veatch. His focus is on exploring existing and emerging decarbonization technology solutions that contribute directly to new and traditional industry clients seeking to manage their carbon emissions and generate value-add opportunities. In addition to CCUS, Prifti also leads direct air capture (DAC) technology scale-up and project development efforts, and is focused on the implementation of other advanced decarbonization technologies such as integration of hydrogen blending in fuels and energy storage solutions, development of low-carbon fuel and energy carrier solutions like methanol and ammonia; cleaner energy generation using supercritical CO2 technology and implementation of world-class efficient, low-carbon intensity gas power.*

Craig Preuss *is a system architect for utility automation at Black & Veatch. Preuss, who is a professional engineer in the states of Illinois and Washington, performs many different tasks since he works in utility integration and automation. Preuss is a senior IEEE member who chairs of the Power System Communications and Cybersecurity Committee (PSCCC), providing strategic electric industry direction in the PSCCC for cybersecurity standards and supporting the development of those standards as well as implementing cybersecurity designs on various projects for electric and gas utilities.*

Ralph Romero *is a senior managing director of Black & Veatch Management Consulting. He specializes in the assessment of novel technologies, product design, product performance and reliability, high-tech manufacturing and product quality, solar photovoltaic (PV) modules and energy storage.*



Dean Siegrist *is associate vice president of Black & Veatch's Transformative Technologies business. In this role, Siegrist leads the business that provides the vertically integrated services of site acquisition, design, permitting, construction and operation of distributed infrastructure with a focus on sustainable transportation. Siegrist works with vehicle original equipment manufacturers, utilities, transit agencies, cities and emerging transportation service providers to plan and build infrastructure for the electrification of transportation.*

Paul Skurdahl *is a senior vice President and director of solar energy within Black & Veatch's power business. Backed by more than 35 years in the power industry, including over 15 years in renewables, Skurdahl has deep expertise and EPC experience working across the renewables space, including all phases of development, engineering and construction. His experience with power purchase agreements, interconnect and partner agreements, and energy trading provide a unique client/market perspective.*

Paul Stith *is associate vice president of global transportation initiatives for Black & Veatch. He has served as director of global transportation initiatives for the company's growth accelerator, where he focused on building ecosystems needed to plan, finance, deploy and operate sustainable transportation and distributed clean energy infrastructure at scale. His projects support investors, utilities, fleets, energy and transportation providers in electrifying, decarbonizing and automating their ground, aviation and marine fleets. Stith has a decade of zero-emission vehicle infrastructure experience and serves on Forth and NACFE boards of directors.*

Rob Wilhite *is a senior vice president and leads Black & Veatch's global distributed energy business line. This includes the design, engineering, development and monitoring/maintenance of client sustainable power solutions, including distributed generation, microgrids, battery energy storage, asset management services and utility grid services.*

Shane Williams *is senior project manager for infrastructure modernization at Black & Veatch. Having built his career as a consultant to the utility industry, Williams' roots lie in the retail sector. Starting out as a developer on customer information systems and growing into a successful senior project manager, Williams has a deep understanding of the system development life cycle (SDLC) and has managed multiple projects throughout that life cycle.*

P +1 913 458 2000
E MediaInfo@bv.com
W bv.com

LEGAL NOTICE

Please be advised, this report was compiled primarily based on information Black & Veatch received from third parties, and Black & Veatch was not requested to independently verify any of this information. Thus, Black & Veatch's reports' accuracy solely depends upon the accuracy of the information provided to us and is subject to change at any time. As such, it is merely provided as an additional reference tool, in combination with other due diligence inquiries and resources of user. Black & Veatch assumes no legal liability or responsibility for the accuracy, completeness, or usefulness of any information, or process disclosed, nor does Black & Veatch represent that its use would not infringe on any privately owned rights. This Survey may include facts, views, opinions and recommendations of individuals and organizations deemed of interest and assumes the reader is sophisticated in this industry. User waives any rights it might have in respect of this Survey under any doctrine of third-party beneficiary, including the Contracts (Rights of Third Parties) Act 1999. Use of this Survey is at users sole risk, and no reliance should be placed upon any other oral or written agreement, representation or warranty relating to the information herein.

THIS REPORT IS PROVIDED ON AN "AS-IS" BASIS. BLACK & VEATCH DISCLAIMS ALL WARRANTIES OF ANY KIND, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT. BLACK & VEATCH, NOR ITS PARENT COMPANY, MEMBERS, SUBSIDIARIES, AFFILIATES, SERVICE PROVIDERS, LICENSORS, OFFICERS, DIRECTORS OR EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATING TO THIS REPORT OR RESULTING FROM THE USE OF THIS REPORT, INCLUDING BUT NOT LIMITED TO DAMAGES FOR LOSS OF PROFITS, USE, DATA OR OTHER INTANGIBLE DAMAGES, EVEN IF SUCH PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

In addition, user should place no reliance on the summaries contained in the Surveys, which are not intended to be exhaustive of the material provisions of any document or circumstances. If any point is of particular significance, reference should be made to the underlying documentation and not to this Survey. This Survey (and the content and information included therein) is copyrighted and is owned or licensed by Black & Veatch. Black & Veatch may restrict your access to this Survey, or any portion thereof, at any time without cause. User shall abide by all copyright notices, information, or restrictions contained in any content or information accessed through this Survey. User shall not reproduce, retransmit, disseminate, sell, distribute, perform, display, publish, broadcast, circulate, create new works from, or commercially exploit this Survey (including the content and information made available through this Survey), in whole or in part, in any manner, without the written consent of Black & Veatch, nor use the content or information made available through this Survey for any unlawful or unintended purpose.