Rethinking the Modern Grid

Black & Veatch 2022-2023 Electric Report

About This Report

Based on a survey of roughly 250 U.S. power industry stakeholders, Black & Veatch's 2022-2023 Electric Report explores a sector transforming itself at an undeniably transformative time.

This repowering of the power sector is profound in an increasingly complex energy ecosystem involving not only the rapid growth of hydrogen, microgrids and distributed energy, and power generation from the sun, wind and conventional sources but also changes being driven from the customer space.

Aging infrastructure – long the industry's chief challenge – this year shares the top spot among the list of survey respondents' concerns with the need to integrate the surging influx of renewables and distributed energy sources onto the grid. That challenge of accommodating green energy on the grid last year surpassed aging infrastructure as the industry's foremost challenge for the first time in our reports in more than a decade.

Investment and regulatory uncertainty remain headwinds, along with pressures to bolster grid resilience against droughts, floods, hurricanes, wildfires and other extreme events brought about by climate change – the bedrock of global pushes by countries, states, counties and corporations to decarbonize. Amid the migration toward cleaner, greener energy and quests for lower carbon footprints, the proliferation of electric vehicles is stoking pressure on power providers to find ways to meet the expected, sizable charging needs.

As electric utilities pursue heightened sustainability, reliability and resiliency, help appears to be coming from federal taxpayers in the form of welcomed, generational spending mechanisms pointing billions of dollars to grid improvements.

This report takes the industry's pulse on those issues, the need for more robust cybersecurity positions and more, drawing on survey findings and thoughtful analyses to paint a clear picture of a power sector 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.

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Executive Summary

U.S. Electric Sector's Repowering Hinges on Grid Modernization, Renewable Energy Sources and Storage

By Laszlo von Lazar

ABOUT THE AUTHOR

Laszlo von Lazar *is president of Black & Veatch's Energy & Process Industries (E&PI) business and serves on the company's board of directors and leadership team. Before being named to head E&PI, he was president of BV Operations and was a key architect in successfully establishing the group as part of a companywide transformation. Von Lazar joined Black & Veatch in 2019 to guide global projects for the company's previous power organization, for which he led engineering, procurement, construction, project controls, quality and business excellence. His 33 years of experience, including global project leadership for GE and Bechtel, comprises work in conventional power generation, solar and wind generation, transmission and distribution, oil and gas, and industrial markets.*

Since its humble roots in the late 1800s, the U.S. electric grid has evolved, dutifully moving the electrons that did everything from powering the nation's industrialization and wartime machines to being the lifeblood of today's factories, computers and appliances.

As that infrastructure continues to show its age, a repowering of the power industry through a transformation toward lower- or zero-carbon generation to power a cleaner, even more electrified world — from the electric vehicle (EV) sector to automation and beyond — is afoot, forced by today's complex, diverse and unyielding challenges.

Droughts, floods, wildfires, hurricanes and other extreme weather events attributed to climate change increasingly are straining the grid, stoking questions about its resilience. In May, Reuters reported that power outages have more than doubled in the past six years compared to the previous six, according to the media outlet's examination of federal data.

As the global push for decarbonization intensifies, the U.S. clean energy business — power from the sun and the wind, both on land and offshore — is booming, forcing utilities to sort out the strategy and investment needed to accommodate those green sources of power. Pressure to make that happen is coming from the top of the U.S. political establishment, with President Joe Biden's administration ambitiously wanting a decarbonized grid by 2035 and zero emissions economywide 15 years after that.

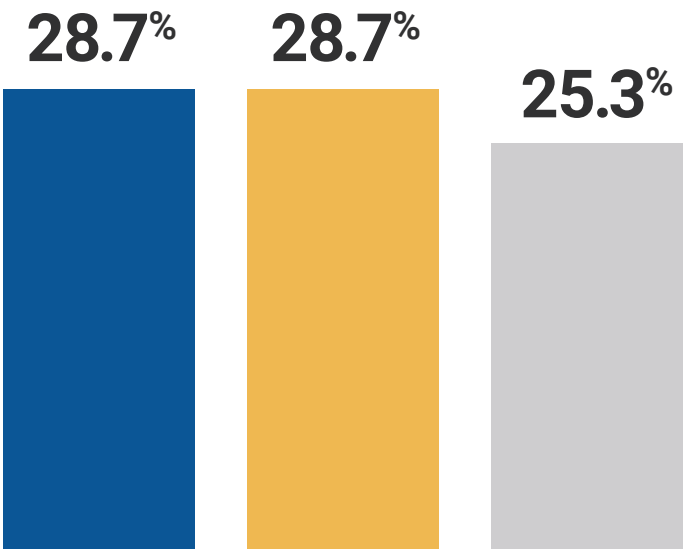
The electrification of the nation's transportation sector is accelerating, prompting the power sector to accommodate the ever-increasing charging demands — now rivaling aging infrastructure as a chief concern of electric utilities. Regulations continue to shift in fueling uncertainties, and cyber threats haven't abated, exposing grid vulnerabilities.

All the while, new technologies such as hydrogen — widely viewed as an ascending star in tomorrow's energy ecosystem — and wider use of battery storage and distributed energy sources are enjoying greater attention, giving utilities even more to think about as pressures mount for them to reimagine tomorrow's diversified, balanced energy portfolios.

Figure 1

What are the top three most challenging issues facing the electric industry in your region today? (Select up to three)

Source: Black & Veatch



Lack of skilled workforce	21.9%
Aging workforce	21.1%
Reliability	20.7%
Planning/forecasting uncertainty	19.4%
Cybersecurity	17.7%
Distribution system upgrades and modernization	16.9%
Economic regulation (i.e., rates)	15.6%
Distributed Energy Resources (DER) integration	13.1%
Resiliency	13.1%
Energy Storage	12.2%
Grid Stability	11.0%
Uncertainty of investment	10.1%
Grid congestion	5.9%
Market structure	5.5%
Access to capital investment	3.0%

Despite the headache-inducing headwinds, opportunity knocks, most notably in the infusion of hundreds of billions of dollars in available federal funding meant to modernize the grid to lower the United States' carbon footprint.

The Black & Veatch *2022-2023 Electric Report* — based on survey data from roughly 250 U.S. electric sector stakeholders — details it all, shining a light on the power sector repowering itself to bolster its reliability, resilience and responsiveness.

Grid Integration of Renewables, Aging Infrastructure Top Challenges

With ever-widening adoption of renewable energy, it stood to reason that integrating green energy onto the grid last year surpassed aging infrastructure as the industry's top challenge for the first time in our reports in more than a decade. And it was no fluke.

Renewable integration tied aging infrastructure atop the list this year, with roughly three in 10 survey responses citing either as their foremost challenge. Staffing issues continue to be a headwind, with a combined 43 percent either citing the lack of a skilled workforce (22 percent) or the industry's aging workforce (21 percent) as challenging. Environmental regulations drew one-quarter of the responses in rounding out the top five.

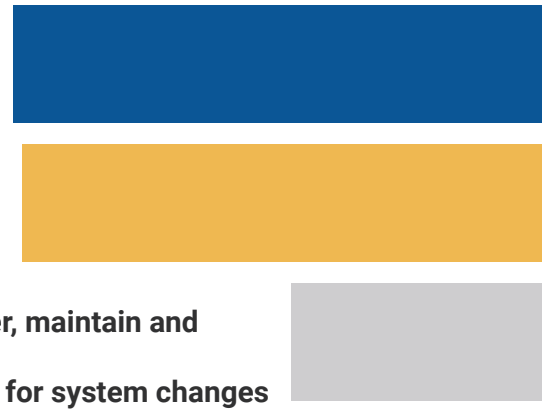
Cybersecurity — sixth in 2020 before rising to second last year — fell to eighth this year at 18 percent, giving way to tightly grouped concerns about reliability (21 percent) and planning and forecasting uncertainty (19 percent) *(Figure 1)*.

By virtually any metric, the growth of renewable energy remains robust. In August, the U.S. Energy Information Administration (EIA) reported that renewable sources such as wind, solar and hydropower are expected to account for 22 percent of U.S. electrical generation, up from 20 percent each of the past two years. The EIA anticipates that figure will rise to 24 percent next year as other generation sources such as coal and nuclear are retired in some parts of the United States.

Figure 2

What are the top three biggest concerns for future grid development over the next three to five years? (Select up to three)

Source: Black & Veatch



53.6% **Supply chain issues for equipment**

52.7% **Generation mix, with fewer traditional base load units and more utility scale renewable sources**

25.4% **Tie:**
1. Lack of qualified workers to engineer, maintain and operate the more complex system
2. Regulatory lag in meeting the needs for system changes

Talent availability	23.7%
Ability to invest in and maintain a more resilient grid	20.5%
Lack of sufficient transmission facilities and system control assets	14.3%
Increases in DER	12.5%
Commodity inflation	12.1%
Supporting systems/component availability	9.4%
Lack of sufficient levels of investment to maintain and operate (including training of staff)	8.0%
Firm pricing of equipment	6.7%
Other	6.7%
Available capital	5.4%
Safety for energy professionals and the public with greater dispersed resources	3.1%

Longer term, the EIA forecasts in its 2022 Annual Energy Outlook — widely considered the gold standard of U.S. energy projections — that the share of renewables in the U.S. electricity generation mix will more than double from last year to 2050. This comes as state and federal policies continue to incentivize investment in green energy resources for power generation and transportation fuels. New technologies are expected to continue driving down the cost of wind and solar generators, stoking their competitiveness in the electricity market.

More than ever, given the robust projections for renewables, utilities will feel added pressure to bolster the flexibility and resilience of their grids, adding battery storage and advanced inverters to accommodate the rapid transition to a greener energy ecosystem.

Promisingly, that's something clearly on the sector's radar. When asked about their top concerns for grid development over the next three to five years, more than half of respondents — 53 percent — pointed to the generation mix, with fewer traditional baseload units and more utility-scale renewable sources. That's narrowly second only to supply chain issues for equipment (54 percent), a lingering headache from the global COVID-19 pandemic.

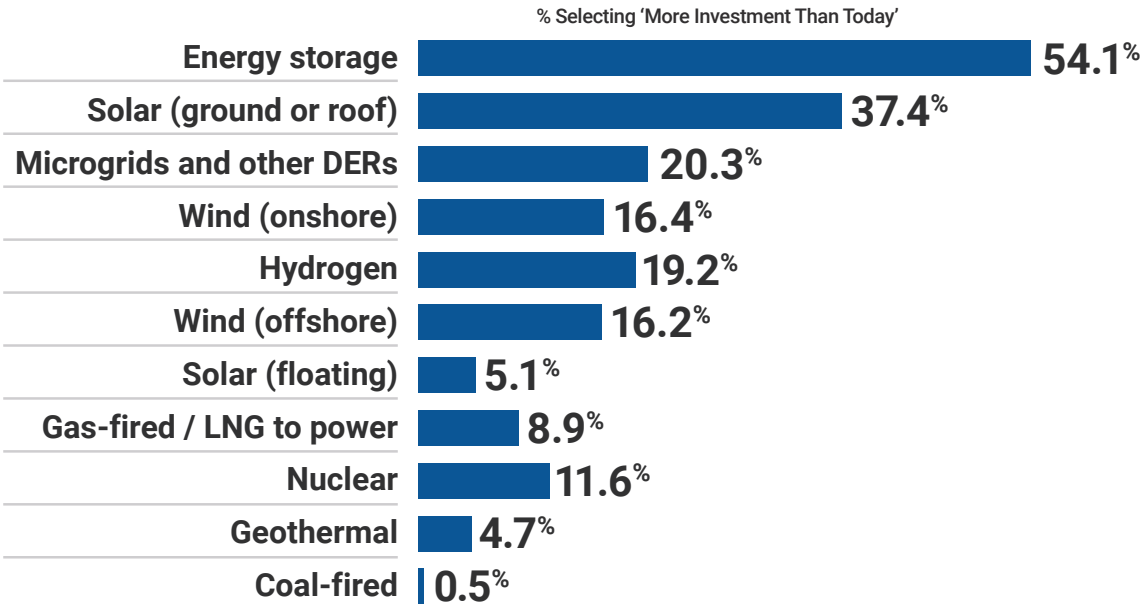
Workforce issues again are worrisome to the survey takers. The lack of qualified workers to engineer, maintain and operate the more complex system came in a distant third at 25 percent — tied with the regulatory lag in meeting the needs for system changes. Questions about the availability of talent — made more acute by a tight job market and an ever-thinning pool of recruits who enjoy more career options and greater leverage for various reasons — drew 24 percent, followed by the ability to invest in and maintain a more resilient grid (21 percent) *(Figure 2)*.

Yet when it comes to funding, at this crucial moment, there's reason for optimism, courtesy of federal taxpayers.

Figure 3

How do you expect new generation capacity investments to change over the next five years in your region?

Source: Black & Veatch



Uncle Sam's Help Spurs Opportunity

Deep worries about the resilience of the U.S. grid, and the imperative to dramatically modernize it to bring about climate-resilient infrastructure while accommodating ever-growing charging needs of electric vehicles, have become a Capitol Hill priority. Federal lawmakers are aware of the enormous price tag that such long-overdue grid upgrades carry, and they have responded with a generational influx of funding and, by extension, optimism.

With taxpayer help already in the pipeline through the $1.2-trillion Infrastructure Investment and Jobs Act (IIJA) signed into law by President Joe Biden in late 2021, the Inflation Reduction Act (IRA) enacted in August commits an additional $369 billion over the next decade to energy security and climate change efforts. The goal: reduce carbon emissions by 40 percent by 2030, though current investment in electric infrastructure to get there still doesn't match the need.

Even so, survey respondents appeared forward-looking and receptive to greener energy sources when asked where they'll be investing more in generation capacity over the next five years in their regions. More than half — 54 percent — cited energy storage, outdistancing solar (37 percent), microgrids and other distributed energy resources (20 percent), onshore wind (16 percent) and hydrogen (19 percent), which has emerged as a rising star in tomorrow's energy ecosystem. Nuclear power — now accounting for one-fifth of the nation's electricity supply — drew 12 percent of responses amid renewed attention for its potential in helping reduce greenhouse gas emissions blamed for global warming and extreme weather events such as floods and wildfires *(Figure 3)*.

The Promise of Hydrogen

When it comes to what methods utilities expect to include in helping meet their clean energy and emissions reduction goals over the next decade and beyond, our survey showed a profound intention to migrate to a cleaner, greener energy landscape.

Over the next 10 years, nearly 70 percent of respondents said they planned to make traditional fossil-fuel generation more efficient, though that approach drew only 16 percent of responses

beyond that timeframe. Natural gas, favored by three-quarters of respondents for the next 10 years, slumped to 24 percent longer term. Sixty percent said they looked to retire fossil-fueled generation sites by 2032.

Over the next decade, the energy sector expects solar (83 percent) and wind (70 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 below 30 percent beyond 10 years, giving way to more deployments of hydrogen (60 percent) and battery energy storage — at 64 percent, the most-cited option beyond the next decade amid expectations that the costs of those technologies at scale will continue to decline, widening adoption.

At least for now, while utilities envision hydrogen as tomorrow's transcendent energy source, the technology remains unproven. Still, ambitious projects underway hope to eliminate the uncertainty.

A shining example: Black & Veatch announced earlier this year that it has been chosen by Mitsubishi Power Americas and Magnum Development to provide engineering, procurement and construction (EPC) services for what will be the world's largest industrial green hydrogen production and storage facility.

As the keystone of the Advanced Clean Energy Storage project in Delta, Utah, the hub will be adjacent to the Intermountain Power Agency's (IPA) IPP Renewal Project and support that 840-MW, hydrogen-capable gas turbine combined cycle power plant being built. That plant initially will run on a blend of 30 percent green hydrogen and 70 percent natural gas starting in 2025 before incrementally expanding to using 100 percent hydrogen two decades later.

Black & Veatch announced earlier this year that it has been chosen by Mitsubishi Power Americas and Magnum Development to provide engineering, procurement and construction services for what will be the world's largest industrial green hydrogen production and storage facility.

With a $504-million commitment from the U.S. Department of Energy, the hydrogen hub initially will be designed to convert more than 220 megawatts (MW) of renewable energy daily to 100 metric tons of green hydrogen that will be stored in two sprawling salt caverns. Storing excess renewable energy as hydrogen yields a long-term, long-duration energy storage solution, allowing renewable energy to be deployed in times of highest demand, helping balance load and generation across time and space.

While the Utah project illustrates the promise of tomorrow's energy ecosystem, utilities, regulators and other industry stakeholders must commit to and collaborate on forward-thinking approaches that virtually are certain to be based on cleaner, greener options, using new strategies, access to technology, proactive investments and aggressive planning.

Money & Politics

Federal Funding and the Grid: Infusion of Investment Stirs Opportunity

Timing is everything, and the political whipsaw that was the summer of 2022 highlighted this in Technicolor®. Each year, as we consider the topics and questions to be addressed in our annual Black & Veatch Electric Report, we understand we're capturing a moment in time in the perspectives of our survey respondents. For a section focused on the potential impact of government funding — including the Infrastructure Investment and Jobs Act (IIJA) — on the future of the grid, our timing arguably couldn't be worse.

How so? After weeks of careful planning, imagine our surprise as our survey launched to reports that the remaining clean energy elements of the "Build Back Better" framework were dead in the water, only to close it out a few weeks later with late-breaking word the Manchin-Schumer "Inflation Reduction Act" was alive and well, ultimately making its way through Congress and being signed into law.

With that backdrop in mind, we were struck by several themes emerging in 2022, including that government funding though the IIJA is expected to play a role in underpinning investment decisions for nearly 60 percent of respondents. This includes nearly two-thirds of those serving less than 2 million customers, demonstrating a favorable outlook on the role of federal funding in their planning. Optimistically, given the broad financial incentives targeting clean energy in the Inflation Reduction Act, and its passage through budget reconciliation, we expect these figures would reflect even greater optimism in a follow-up survey *(Figures 4 & 5)*.

Figure 4

To what extent are you counting on IIJA (or Bipartisan Infrastructure Legislation) grant funding to drive or underpin your investment decisions? (Select one)

Source: Black & Veatch

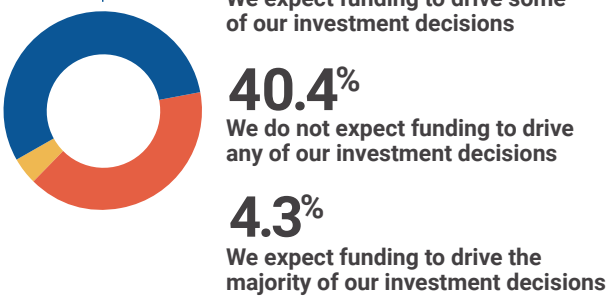
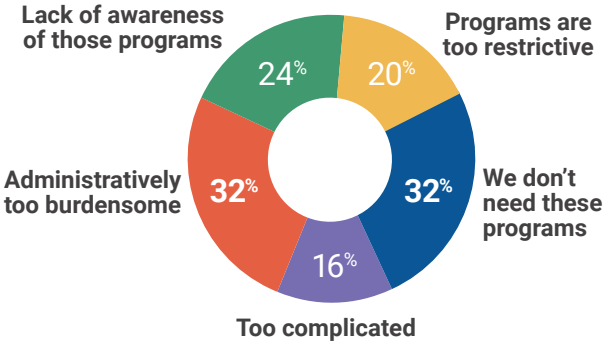


Figure 5

What are the main reasons your organization has not taken advantage of some of the Infrastructure Investment and Jobs Act (IIJA)? (Select one)

Source: Black & Veatch

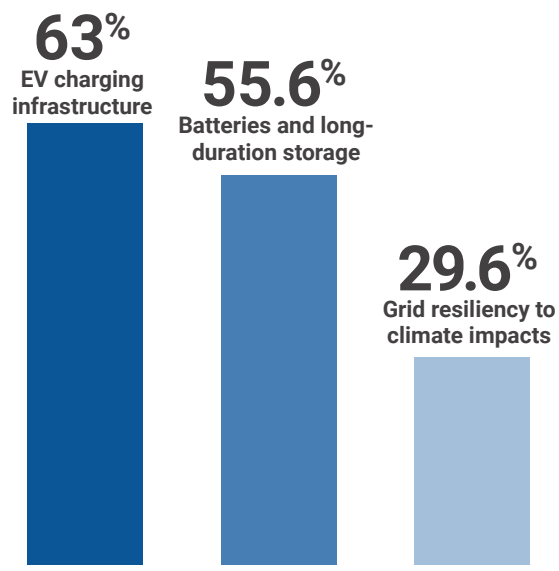


Timing aside, when it comes to expectations of how and where IIJA funding for grid-related projects will be prioritized, two areas — EV charging infrastructure and energy storage — were clear winners. This is consistent with the considerable efforts of the Biden Administration to support growth in the electrification of transportation, highlighted by the call to deploy 500,000 charging stations nationwide. The fact that federal funding will support the millions of EVs entering service and provide a significant business opportunity to a market that experienced years of flat load growth is not lost on industry stakeholders. Similarly, awareness of the critical role energy storage will play in providing grid-balancing support comes as the pace of renewable energy deployment accelerates. Grid resilience to climate impacts, cybersecurity and a series of interconnected elements round out a range of choices reflecting the competing priorities within the broader grid modernization effort *(Figure 6)*.

Figure 6

What are the top three priorities for your organization, if IIJA funding is granted?

Source: Black & Veatch

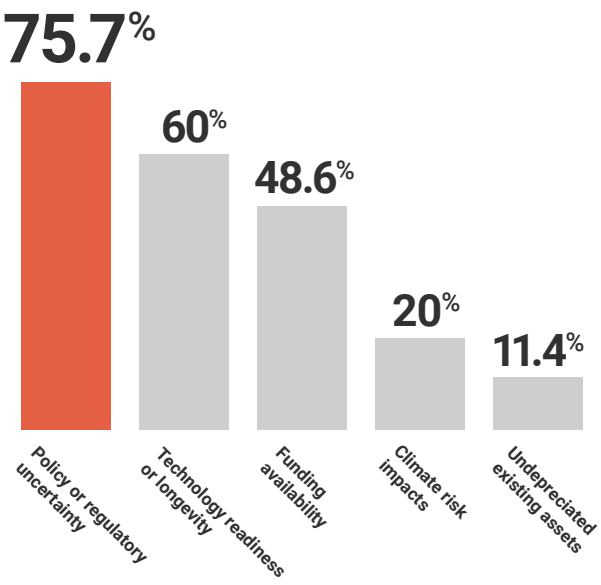


Grid cybersecurity	22.2%
Microgrids and distribution infrastructure	22.2%
Improved DER integration	18.5%
Other	18.5%
Reliability for underserved communities	14.8%
Fiber network communications technology	11.1%
Enhance grid physical security measures	3.7%
Digital transformation for resiliency	3.7%
Non-wired alternatives	3.7%

Figure 7

Which factors drive the highest uncertainty in your investment decisions? (Select all that apply)

Source: Black & Veatch



For as much as the electric sector seeks to decide its own fate, policy and regulatory uncertainty represent the greatest factors impacting decisions to invest in electric sector infrastructure, followed closely by concerns over technology time horizons. Simply put, political decisions being made to drive decarbonization and evolve the regulatory compact reshape how service providers can look at a range of capital and operational expense planning scenarios. For example, in California, the state acknowledges its need to deploy large-scale natural gas technologies to ensure grid reliability, but its decision to phase out natural gas by 2045 means these technologies are to be taken out of service before the traditional asset lifecycle is complete, disrupting traditional market dynamics *(Figure 7)*.

One area where respondents are shedding significant insight relates to the ongoing challenges the Department of Energy (DOE) faces in streamlining the complex process of securing government funding for energy projects. Fully 35 percent of survey participants indicated their organization would not pursue funding due to factors ranging from lack of awareness to overly restrictive conditions or administratively burdensome applications.

With the passage of the Inflation Reduction Act, the DOE now has roughly $110 billion in loan authority to support innovative clean energy, advanced transportation and tribal energy projects. But to receive funding, the DOE must be comfortable with a project plan that addresses everything from design through commercial operation. The DOE's commitment of $504 million for the Advanced Clean Energy Storage green hydrogen production and storage project in Delta, Utah, reflected their confidence in the comprehensive framework the development partners and engineering, procurement and construction (EPC) provider developed to meet their standards. Working with stakeholders who understand the DOE's approval processes will be essential to accelerating the flow of capital to worthy programs.

Despite the timing of our survey, we find reasons for optimism abound throughout this report. Efforts to address the digital and advanced infrastructure divide, highlighted during the COVID-19 pandemic, are top of mind for more than three-quarters of 2022 respondents. This reflects the industry's effort to ensure that breakthroughs in clean energy will be deployed and benefit low-income communities in both urban and rural parts of the nation.

From a funding perspective, which cannot be overlooked as typically the most challenging aspect in developing next-generation infrastructure programs, billions of dollars in investment will be fueled by tax credits, loan programs and direct investment from the American taxpayer. This effort to modernize our grid reflects the type of transformative, Hoover Dam-like project that will reimagine countless sectors and decarbonize the U.S. economy.

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Despite New Federal Funding for the Electric Sector, Investment Uncertainty Lingers

With most capital investments in the power sector typically measured in multi-decade terms, how do service providers balance the necessity for long-term planning and the need to achieve near-term goals associated with changing policies, decarbonization objectives and an increasing need for resilience?

And with the relentless surge of renewables, how do U.S. electric utilities find ways to integrate it all onto the grid — a task that our survey of about 250 power sector stakeholders cite for the second consecutive year as their top challenge, along with aging infrastructure?

Funding from the Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law and signed into law in November 2021, certainly helped impact at least some of this investment decision-making by virtue of the $107 billion it ultimately will provide in funding and incentives for clean energy, power and electricity grid reliability projects. The more recently enacted Inflation Reduction Act (IRA) — approved by Congress and signed into law in August — provides another $369 billion in funding incentives for clean energy, arguably making it the most impactful piece of energy policy ever enacted in the United States.

One example highlighting this "power of policy": Prior to the passage of the IRA, our survey queried respondents on which types of projects they would prioritize if the legislation was approved. Resoundingly, two of the project types featured most prominently in the bill — electric vehicle (EV) charging infrastructure (63 percent of respondents) and batteries or long-duration storage (56 percent) — topped the list *(Figure 8)*. Even though our survey was completed prior to the IRA's enactment, it's clear this landmark legislation will have an even greater influence and impact.

Yet despite nearly a half-trillion dollars across both bills in total funding intended to further catalyze the energy transition, uncertainty among decision makers still abounds. Affordability, shifting public perceptions, political instability, stranded asset risks, regulatory jurisdictional differences and technology uncertainty all factor into play.

Figure 8

What are the top three priorities for your organization, if IIJA funding is granted?

Source: Black & Veatch

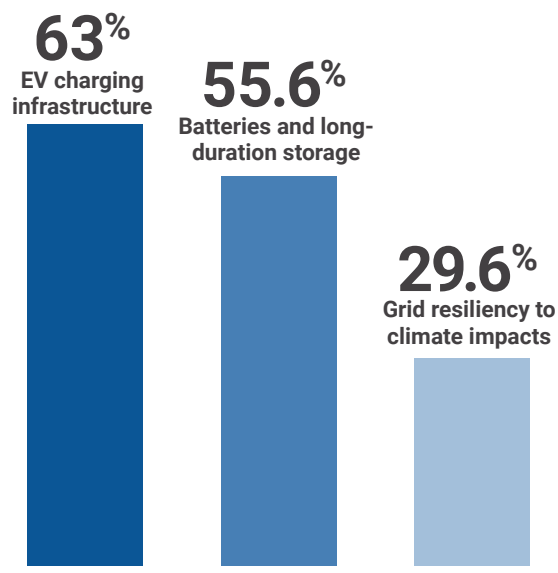

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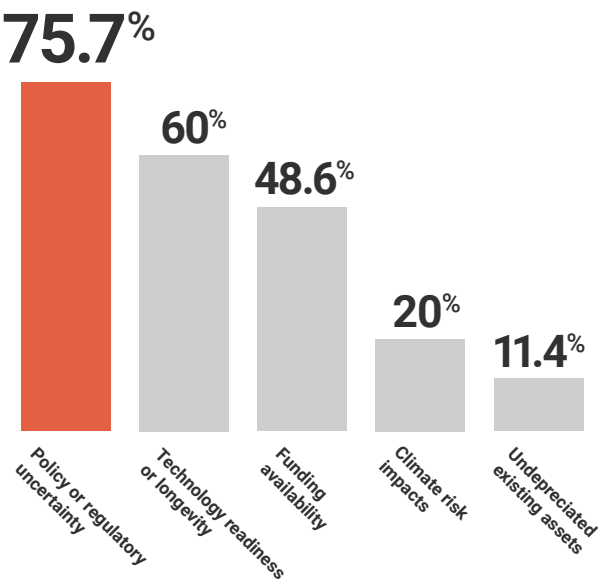
Figure 9

Which factors drive the highest uncertainty in your investment decisions? (Select all that apply)

Source: Black & Veatch



To wit, three-quarters of respondents said the inability to predict future policy and regulatory changes makes investment decisions difficult. Six in 10 cited concerns about the readiness or longevity of certain technologies as a challenge, and nearly one-half cited lack of clarity around funding sources as problematic *(Figure 9)*.

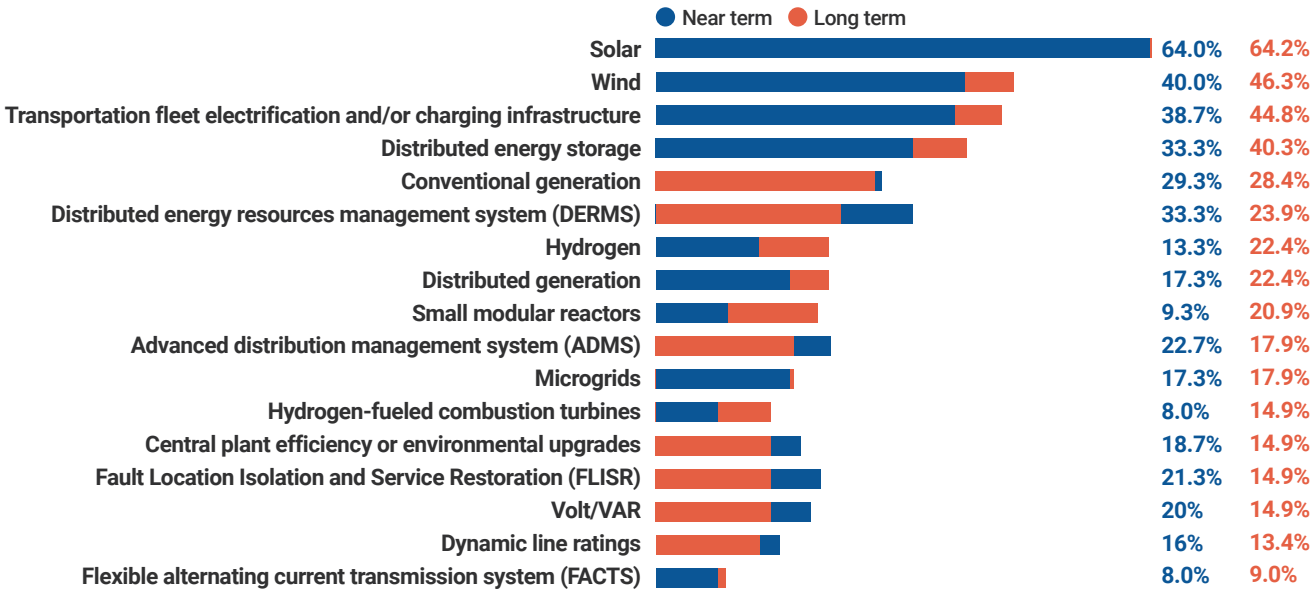
As one respondent noted, these days it can sometimes feel like 20-year utility resource plans need to be updated every two years.

Nevertheless, some broad patterns are emerging.

Figure 10

Which technologies do you intend to make investments in in the near term (one to five years), as well as beyond five years? (Select all that apply)

Source: Black & Veatch



Over the near term — the next five years — respondents are particularly bullish about solar and wind projects, as well as fleet electrification. Sixty-four percent expect to invest in solar projects, and roughly 40 percent plan to earmark funds for wind and/or EVs *(Figure 10)*. These findings appear to validate predictions by the U.S. Energy Information Administration that solar power generation will outstrip wind power generation by a factor of two by 2040.

Solar, wind and EVs remain popular priorities for respondents when asked to look further out into the horizon — beyond five years. But the survey shows that other technologies not presently commercially viable stand to garner more investments as time passes.

For instance, while only 13 percent of respondents intend to invest in hydrogen over the next five years, more than 22 percent expect to invest in it in the long term. Similarly, only 9 percent of respondents plan to invest in small modular reactors in the short term, but more than 22 percent expect to allocate dollars on that energy source beyond five years from now.

Balanced Planning, Decisions Essential

As the sector transforms at such a dizzying rate, mandates and ambitious decarbonization targets have brought clean energy forces to the forefront as a solution. Integrating that green energy onto the grid — and finding ways to pay for it — while hardening infrastructure assets against extreme weather and other threats present some of the industry's most-pressing challenges.

Now more than ever, utilities again must balance long-term investments with an open eye on short-term, emerging needs as a continuous process, unlike previous decades of resource planning in this industry. Perhaps by leveraging Black & Veatch's expertise, utilities should embrace the importance of an early, integrated and executable strategy that combines strategic, financial, regulatory, technical and digital considerations.

Decarbonization

Accelerating Decarbonization: Investments, Trade-offs and Technology Alternatives

Viewed a half century ago as the energy source of the future, hydrogen applications are emerging as a critical and viable solution to help companies across many sectors achieve their decarbonization goals.

Some proof: The world's largest hydrogen energy hub is under construction in Utah, with Black & Veatch supplying its key expertise. The U.S. Department of Energy has guaranteed a half-billion-dollar conditional loan guarantee for that planned green hydrogen hub meant to convert renewable power to hydrogen, store it underground and use it to generate power. The first customer of that Advanced Clean Energy Storage project will be the Intermountain Power Agency (IPA) — the power supplier to Utah and Los Angeles. Also underway at IPA is the first power plant conversion to 100 percent hydrogen by 2045.

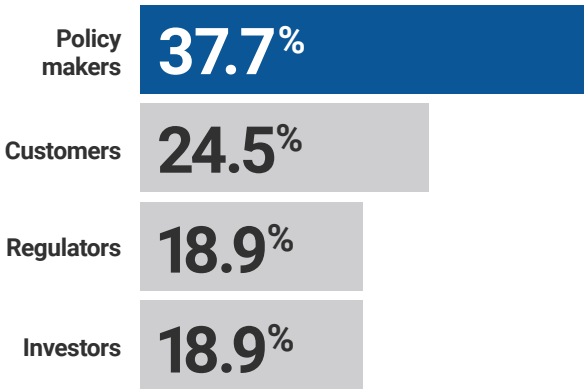
With that as context, we examine the role that hydrogen — as well as wind, solar, natural gas and batteries for storage — will play as the industry continues to sharpen its focus on achieving decarbonization at scale.

What about other sources? Where does nuclear fit in? And what about carbon capture? Utilities, asset owners and companies across sectors are undertaking concerted efforts to analyze which technologies and low-carbon fuels will allow them to achieve their emissions reduction goals,

Figure 11

From which of the following does your organization feel the greatest pressure to be committed to decarbonization? (Select one)

Source: Black & Veatch



and the answers may be different depending on portfolio, risk appetite and geography. But what's undeniable is that the industry finally has reached a consensus understanding that decarbonization must happen — and soon.

Our survey of some 250 U.S. power sector stakeholders for Black & Veatch's *2022-2023 Electric Report* shows that now more than ever, utilities are feeling significant pressure from multiple external sources — including policy makers, customers, regulators, and investors (in that order) — to get it done. *(Figure 11)*.

With the "Inflation Reduction Act" — signed into law Aug. 16 by President Joe Biden — and its clean energy provisions now a matter of policy, additional funding and tax credits to allow firms to further accelerate the pursuit of lower-carbon fuels and technologies have been formalized.

The Biden administration's goals are ambitious: Get the United States to 100 percent clean electricity by 2035, with net zero emissions by 2050. But how do we get there?

Outlook: Renewables Rule, With Hydrogen the Rising Star

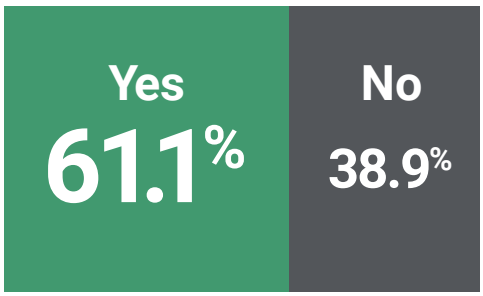
Electrification increasingly has been a focus to deliver power from a range of renewable energy resources and low-carbon fuel sources. That's particularly true when considering transitioning fleet and passenger vehicles away from the combustion of fossil fuels. However, substantial reforms are required to address challenges such as aging infrastructure and onerous interconnection queues.

Survey respondents view the role of electrification as complementary to other low-carbon fuels and technologies. However, the timeline and runway to transition to low-carbon fuels and carbon capture solutions, while under review by most companies, vary across different planning horizons. Roughly 40 percent of survey respondents currently are not incorporating non-electric means of decarbonization as complementary to their electrification, due to commercial viability and investment returns *(Figure 12)*. Promisingly, that number has decreased from past surveys.

Figure 12

Do you view non-electric means of decarbonization (e.g., low-carbon fuels, CCUS, etc.) as complementary to your current electrification efforts? (Select one)

Source: Black & Veatch



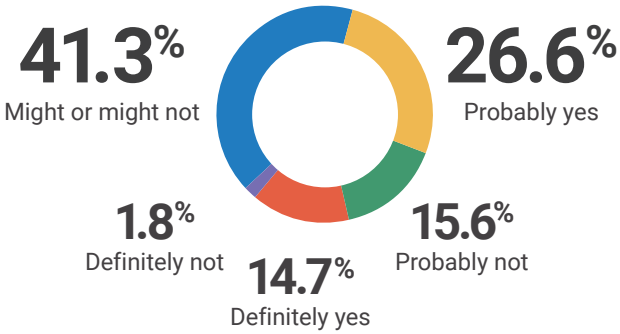
Hydrogen, as previously mentioned, is one alternative fuel that will be an important consideration as companies look across their portfolio, assets and trade-offs. As a leader in the hydrogen power generation industry, Black & Veatch is bullish on its potential but also recognizes that adoption of the technology has not yet been demonstrated to be advantageous on technical and economic bases across a wide spectrum of geographies. Perhaps unsurprisingly, many survey respondents are continuing to take a wait-and-see approach, with more than 41 percent saying that hydrogen "might or might not" be a viable means of long-duration energy storage compared to more traditional technologies. That said, survey respondents also shared their growing

The Biden administration's goals are ambitious: Get the United States to 100 percent clean electricity by 2035, with net zero emissions by 2050. But how do we get there?

Figure 13

Do you view hydrogen as a viable means of long-duration energy storage in your service territory to more traditional technologies (e.g., batteries, pumped hydroelectric, etc.) (Select one)

Source: Black & Veatch



excitement around hydrogen as an alternative fuel to facilitate low-carbon energy storage and power generation, with another 41 percent saying that hydrogen will "definitely" or "probably" become a viable alternative *(Figure 13)*.

Respondents expect that solar (83 percent), natural gas (77 percent) and making traditional fossil-fueled generation more efficient (69 percent) will be the top three methods for meeting clean energy goals over the next decade. Looking further into the future beyond 10 years, however, respondents predict that batteries (51 percent), long-duration energy storage (64 percent), hydrogen (59 percent) and renewable natural gas (31 percent) will emerge as the leading preferred sources.

Another alternative — nuclear energy resources — represents about one-fifth of the United States' baseline power — and half of its current low-carbon-emissions energy strategy. When asked which technologies they intend to invest in over the next five years, just 9 percent cited small modular reactors, well below the top choices of solar (64 percent), wind (40 percent) and fleet electrification (39 percent). But looking beyond five years, those modular reactors were picked by one in five respondents.

"The whole world has to lean into getting to net zero and addressing climate change," Energy Department Secretary Jennifer Granholm told The Associated Press in August. "Nuclear is such a clear part of that. I meet with my counterparts from all over the world, and everywhere people are looking to us to help them reach their goals with nuclear."

Despite the momentum associated with the Inflation Reduction Act, significant obstacles exist. Chief among them — in addition to the obvious cost-based concerns, cited by 28 percent of respondents — is a lack of infrastructure. In fact, more than 43 percent of respondents see these infrastructure inadequacies as a primary barrier.

Indeed, for hydrogen to actually emerge as a scalable energy source, there must be many places to produce, blend and store it. The same, of course, applies to renewable natural gas.

While meaningful inertia continues to build around next-generation, low-carbon alternatives, the timing of the deployment of these technologies is inextricably limited by the currently slow pace of the development of the infrastructure that allows that technology to be deployed and monetized.

These kinds of technologies are critical for meeting our aggressive decarbonization targets. We are hopeful that new policy enacted by way of the Inflation Reduction Act and other measures will fast-track many of these much-needed infrastructure projects.

Unrelenting Climate Change Presses Need for Grid Modernization, Resilience

Already grappling with wildfires in the West, the unceasing threat of hurricanes along the eastern seaboard and ravaging drought in between, U.S. electric utilities seeing climate change test their grids can't escape the drumbeat of news warning that the headwinds may only worsen.

That latest harbinger came in August, when the nonprofit First Street Foundation research group unveiled a peer-reviewed report suggesting an "extreme heat belt" is forming, stretching from Texas, Louisiana and the Southeast north to Wisconsin. The corridor covering one-quarter of the country's land mass reportedly would affect 107 million people over the next three decades, bringing upticks in the number of days with the heat index — the combination of air temperature and humidity — above 100 degrees, challenging the electric infrastructure's ability to keep air conditioners running, much less withstand the heat itself on an aging grid.

On the heels of a July that the National Oceanographic and Atmospheric Administration said was the country's third-hottest since record-keeping began nearly 130 years ago, the foundation's report adds grist to the call for the U.S. power sector to ramp up their resiliency against escalating effects of a warming climate.

None of that appears lost on the U.S. electric industry, Black & Veatch's *2022-2023 Electric Report* finds.

Among roughly 250 power sector stakeholders surveyed, roughly three in 10 respondents — 28 percent — point to heat as the climatological event posing the biggest risk for delivering reliable system operations in the next three to five years. Cold and ice drew 19 percent of the responses, followed by wildfires (14 percent) and hurricanes (11 percent).

But what are utilities doing long-term to harden their systems against climate change? The findings may be surprising, given the warnings.

'No Silver Bullet'

Noting that U.S. power outages from extreme weather have doubled over the past two decades, the U.S. Department of Energy warned in July that "as much of the U.S. now braces for hurricane season, soaring temperatures and wildfires, climate change is threatening the reliability of our current power system. Business-as-usual planning and operations are insufficient to produce resiliency against these threats."

"There is no silver bullet technology to guarantee a reliable system, and every resource and system is at risk for failure: coal or natural gas fuel supplies can freeze, extended periods of low wind resource can occur, and transmission lines can fail," the DOE added. "Reliability and resilience of the system stems from a portfolio of technologies and strategies that limits exposure to common risks and includes forward planning that considers the evolving threats from climate change, extreme weather and other unknown sources."

Such look-ahead approaches could and should start with infusing extreme climatological event mitigation into long-term system strategies; however, just one-third of survey respondents confirm they're doing this. Twenty-eight percent say they're not including it, while four in 10 say they simply don't know. Parsing those results shows that those who either are or are not using climatological event mitigation as part of their planning are close to parity — perhaps reflecting a lack of regulatory certainty about how such plans might be received.

U.S. power utilities are keenly aware of the impact that weather and the environment can have on their system operations, with many even having onsite meteorologists who prove crucial in helping stage crews at infrastructure vulnerabilities in advance of the storm, hastening response time when disruptions happen.

Climate Mitigation: An Abundance of Options

Yet not planning appropriately — even aggressively — for weather scenarios can exact a steep price. Case in point: The powerful, deadly winter storm in February 2021 that blanketed much of Texas with snow, ice and record low temperatures, disrupting power to 5 million people while wreaking havoc on water service.

Such disasters prove to be eye-openers for utilities, awakening them to extreme weather's consequences, the prudency of hardening their systems against it and the need to commit to the sizable investment to make it happen.

While the possible scenarios are numbingly countless, half of the survey's respondents say their utility does climate-related disaster scenario

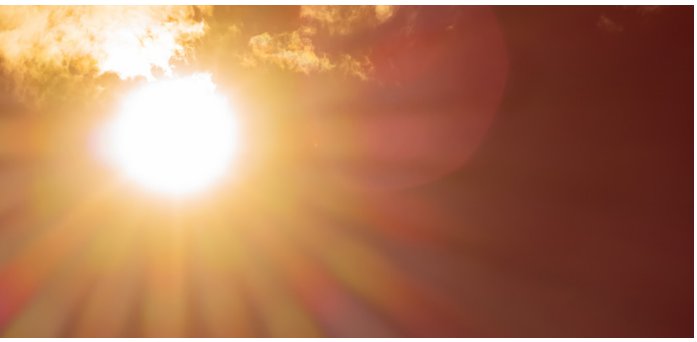
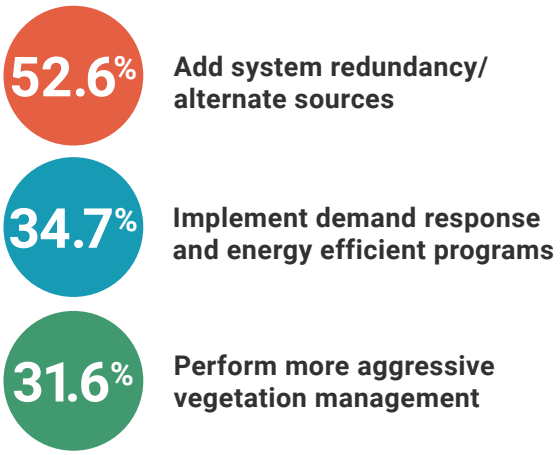


Figure 14

What are the top three strategies or risk mitigation that you are using to address the impacts of climate change?
(Select top three strategies)

Source: Black & Veatch



Implement freeze protection/ winterization upgrades	27.4%
Invest in generation sources that are less dependent on water supply	23.2%
Advanced grid control systems	22.1%
Enhanced transmission and distribution planning to the feeder level	22.1%
Harden distribution by increasing sectionalizing / automation schemes	14.7%
Harden distribution by undergrounding of overhead circuits	13.7%
Harden distribution by strengthening / insulating overhead circuits	12.6%
Encourage / develop distributed energy resources as non-wired alternatives	12.6%

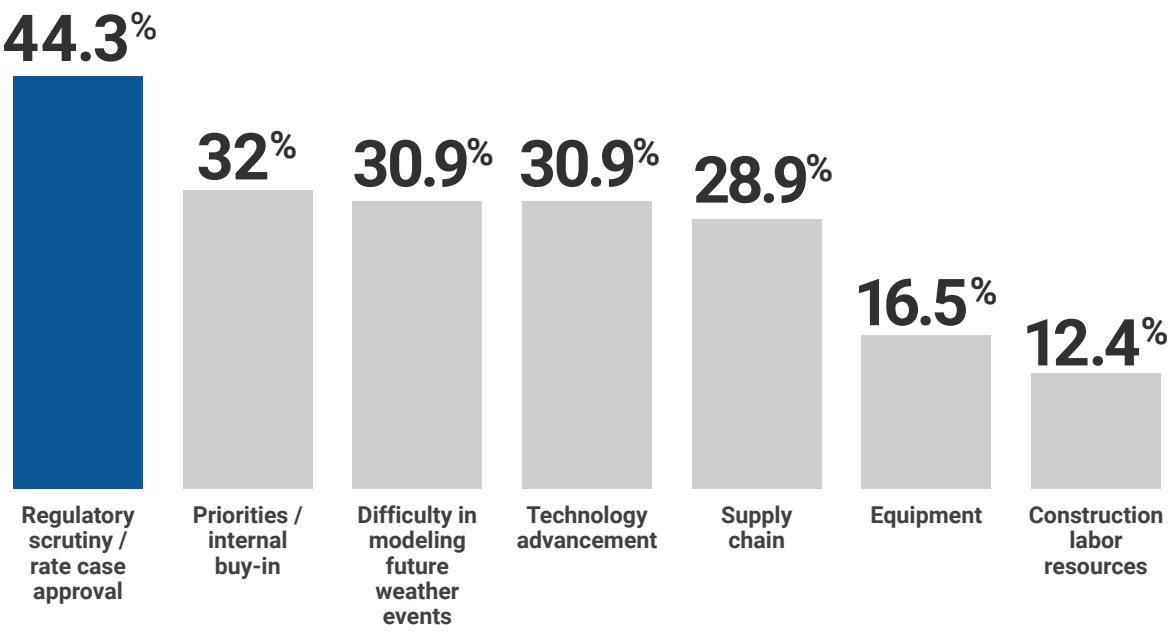
planning to prepare for potential disruptive events. An additional 23 percent acknowledge they don't — perhaps given that storms seldom are the same, and it's impossible to account for anything and everything that might transpire when it comes to climate, which itself can be acutely abstract.

Strategies or risk-mitigating techniques being used to address climate change run the gamut, according to the survey. More than half of respondents (53 percent) report adding system redundancy and alternate sources, followed by those who are adopting demand response and energy-efficient programs (35 percent), those doing more aggressive vegetative management (32 percent), and utilities winterizing their assets against freezing (27 percent) *(Figure 14)*.

Figure 15

What are the biggest hurdles to obtaining investment in climate-related mitigation measures? (Select all that apply)

Source: Black & Veatch



Making the Case for Funding, Investment

While many electric utilities see merit in bolstering their infrastructures' climate resilience, getting regulatory signoff for the often-steep price tag — and recovering that cost from ratepayers likely to object — keeps such projects from being viable, no matter the utility's commitment to it.

More than four in 10 — 44 percent — of respondents cited regulatory scrutiny or rate case approval as the biggest hurdle to obtaining investment in climate-related mitigation measures, with priorities and internal buy-ins, the difficulty in modeling future weather events, and technology advancements tightly grouped around 31 percent *(Figure 15)*.

When it comes to best justifying the expense of climate change and resilience projects, it appears to be all about data. Roughly one-third of respondents cited modeling and risk analysis — or cost tracking to show cost recovery or system operational improvements — as the top two effective ways to make a case for such undertakings *(Figure 13)*. One in five pointed to

case studies and the precedence of peer utilities, though citing what others have done may hold less sway with regulators or other stakeholders in light of each utility's varying and sometimes unique local and regional operational nuances.

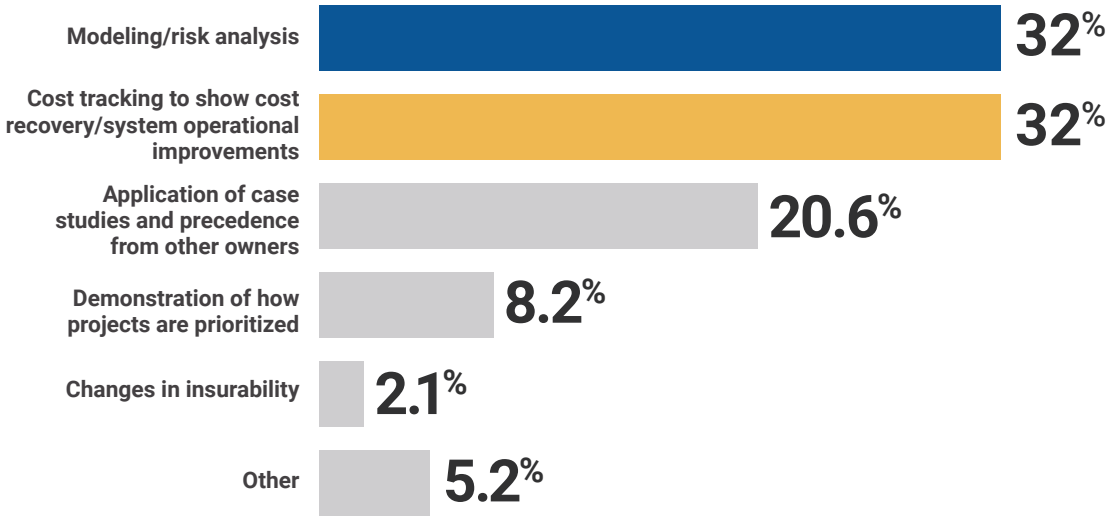
Uncle Sam Steps In: A Time for Optimism, Action

The U.S. electric sector, long having wrestled with ever-aging infrastructure without adequate funding to modernize it, is getting some help from federal taxpayers.

Figure 16

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

Source: Black & Veatch



Signed into law by President Joe Biden in November 2021, the $1.2-billion, bipartisan Infrastructure Investment and Jobs Act (IIJA) earmarks $73 billion for grid upgrades, including the buildout of thousands of miles of new, resilient transmission lines to help expand renewable energy ostensibly meant to mitigate climate change. That single biggest federal investment in power transmission in U.S. history comes at a time of runaway expansion of renewables.

Then in August, the "Inflation Reduction Act" became the single biggest climate investment commitment in U.S. history, with $369 billion over 10 years devoted to climate and clean energy provisions. That includes some $30 billion in grant and loan programs for electric utilities and states to advance the transition to cleaner, greener energy.

All of it is rooted in the premise that climate change is real, and the time to act is now. Forward-thinking utilities can and should embed climatic modeling into their road-mapping now, appreciating the mantra that "if you can't measure it, you can't manage it."

With a myriad of climate-mitigation approaches at their disposal, utilities also would be wise to rethink their old planning approaches to avoid risk, ensure greater resilience and prioritize such projects.

Granted, climate models still hold uncertainties. The only thing that is clear is that weather stops for nothing and no one.

Amid Decarbonization Momentum, Renewables Help Drive Electric Utility Sustainability Plans

Second only to transportation as the biggest source of U.S. greenhouse gas emissions, the nation's electric utilities are aligning around energy mix adjustments sought by regulators, consumers and shareholders to get greener by infusing more renewables into today's energy ecosystem.

In modern lexicon, that's decarbonization. By extension, it's sustainability, a noble pursuit requiring thoughtful roadmaps of how to lower carbon footprints while still meeting shifting customer demands, keeping costs in check and embracing innovation.

Black & Veatch's *2022-2023 Electric Report* and its survey of about 250 U.S. power sector stakeholders bring such sustainability challenges into focus. A glaring takeaway: as the industry continues to wean itself of fossil fuels largely in the form of coal and natural gas — accounting for roughly 60 percent of U.S. electricity in 2020 — low-carbon energy from the wind and the sun is helping fill the void. All the while, hydrogen and battery storage are enjoying a wider spotlight for their promise in tomorrow's energy mix.

Left to question, at least for now, is sustainability of the energy transition and what combination of technologies will support reliable delivery of electricity to consumers.

Out with the Old, In With the Re(New)ables

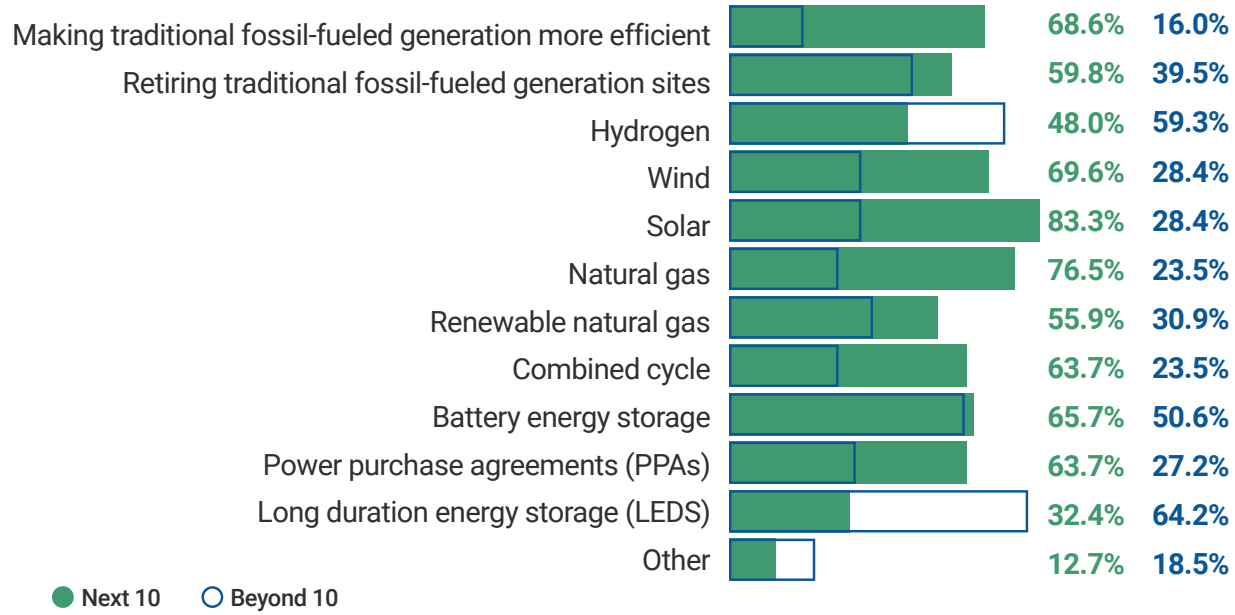
Without question, sustainability pursuits through decarbonization remain top of mind in the industry. More than three-quarters of respondents to Black & Veatch's survey have goals involving adopting more clean energy and renewables — or reducing carbon or greenhouse gas emissions, with roughly half of them saying such aspirations are separate from any regulatory mandate. In other words, they're commendably proactive.

So what energy options do they deem most favored in achieving such goals over the next decade, then beyond? At least until 2032, 83 percent of respondents cited solar power, 77 percent pointed to natural gas and 70 percent said wind energy as their top methods, followed closely by battery energy storage (66 percent), and combined cycle at 64 percent.

Figure 17

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



Looking past a decade from now, according to the survey, fossil fuels are expected to continue falling out of favor. While 69 percent said they look to make traditional fossil-fuel generation more efficient over the next 10 years, that number plummets to just 16 percent after that. Natural gas also shows a 53-point plunge during that span. Six of 10 respondents say their game plan over the next decade includes mothballing traditional fossil-fueled sites *(Figure 17)*.

Enter hydrogen and long-duration energy storage, both evolving but rapidly trending upward.

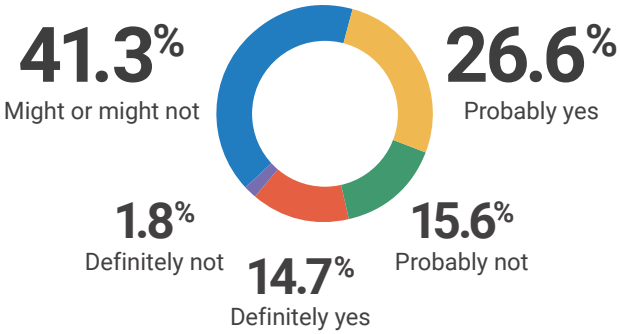
Hydrogen, Long-Duration Storage: Jury Still Out – For Now

Underscoring optimism about tomorrow's cleaner energy mix, 47 percent of respondents cited around-the-clock firm dispatchable electricity from renewable resources and storage — essential, given the intermittency of solar and wind power — as the trend they consider most exciting. Forty percent pointed to long-term energy storage

Figure 18

Do you view hydrogen as a viable means of long-duration energy storage in your service territory to more traditional technologies (e.g., batteries, pumped hydroelectric, etc.) (Select one)

Source: Black & Veatch



in the form of hydrogen, followed closely by funding availability for long-term energy storage projects (39 percent) and expansion of fuel cell use — e.g. hydrogen fuel cells — at 36 percent.

Like hydrogen, long-duration energy storage remains unproven, tamping down commitments to either for now *(Figure 18)*.

But in the western United States, an ambitious effort now underway could sort it all out, offering a peek at what tomorrow's energy picture may look like.

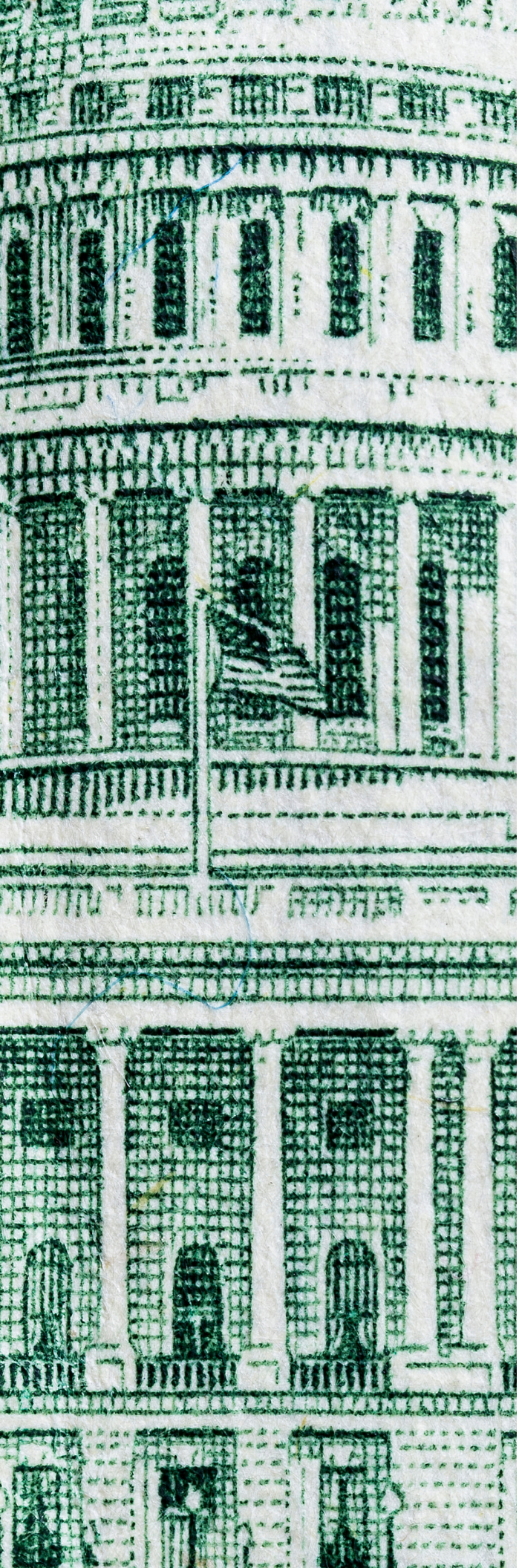
Earlier this year, Black & Veatch announced it has been chosen by Mitsubishi Power Americas and Magnum Development — co-developers of what will be the world's largest industrial green hydrogen production and storage facility — to provide engineering, procurement and construction (EPC) services for that Advanced Clean Energy Storage project in Delta, Utah.

That new hydrogen hub initially will be designed to convert more than 220 megawatts (MW) of renewable energy daily to 100 metric tons of green hydrogen that will be stored in two sprawling salt caverns. Storing excess renewable energy as hydrogen yields a long-term, long-duration energy storage solution, allowing renewable energy to be deployed in times of highest demand.

That hub will be adjacent to the Intermountain Power Agency's (IPA) IPP Renewed Project and support that 840-MW, hydrogen-capable gas turbine combined cycle power plant being built. That plant initially will run on a blend of 30 percent green hydrogen and 70 percent natural gas starting in 2025, then incrementally expand to using 100 percent hydrogen by 2045.

Sustainability Help, from Uncle Sam

Long having lamented the lack of funding for infrastructure upgrades that would bolster sustainability, U.S. utilities are getting welcomed help from federal taxpayers. The "Inflation Reduction Act" — the most sweeping climate measure in U.S. history — includes $369 billion in climate- and energy-related funding over 10 years, with huge incentives to ramp up carbon-capture

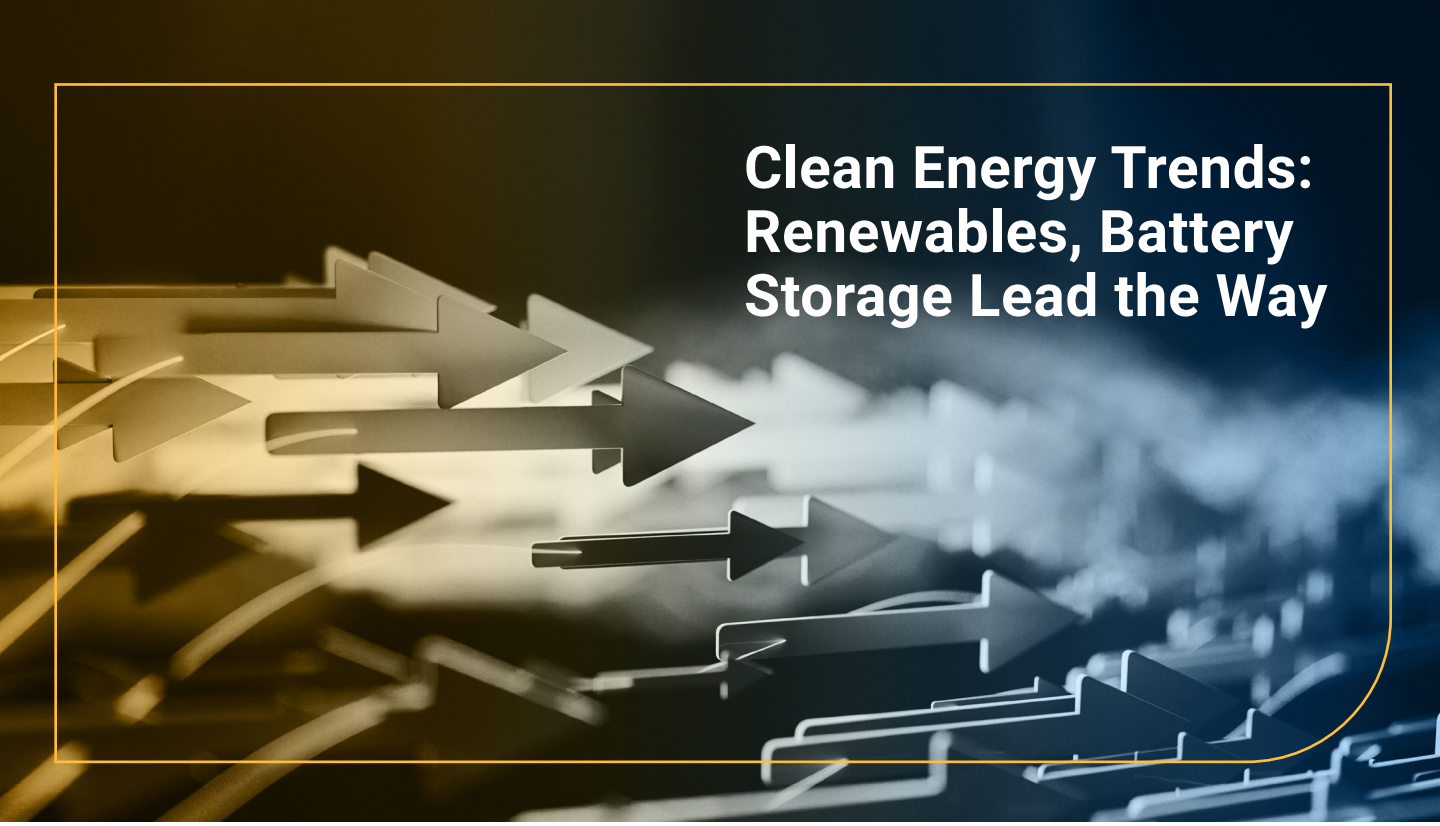


Under the IIJA, $73 billion — the single biggest federal investment in electricity grids in U.S. history — would be committed to grid upgrades, including thousands of miles of new, resilient transmission lines to help expand renewable energy.

sites, urge green hydrogen production and boost U.S. production of solar panels, wind turbines and next-generation batteries.

This spending measure follows the bipartisan, $1.2-trillion infrastructure plan signed into law in November 2020, channeling tens of billions of tax dollars into what the White House called "our aging electric grid (that) needs urgent modernization," with wider adoption of renewable energy at its core. Under that legislation, $73 billion — the single biggest federal investment in electricity grids 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 — along with sustainability.

Electric utilities would be well-served pursuing any of that funding independently — or by enlisting guidance from a critical human infrastructure expert such as Black & Veatch — to further demonstrate that their understanding that decarbonization and sustainability is critical to them. Sitting idle means tragically missing out on a generational opportunity in a rapidly transforming energy landscape propelled by renewables and battery storage unimaginable just a decade ago.



Clean Energy Trends: Renewables, Battery Storage Lead the Way

As decarbonizing takes a deepening root around the globe, clean energy solutions such as wind and solar power complemented by battery storage quickly are becoming more of a fixture in today's energy ecosystem. That landscape cannot continue to evolve without the help of utilities, and it's crucial for them and their stakeholders to understand clean energy trends to reach a net-zero future.

Decarbonization will require integrating more renewable energy onto the grid, which has recently become a significant concern for utilities. In fact, in our 2021 Electric Report, utilities ranked renewable integration as their top challenge — above aging infrastructure — for the first time ever.

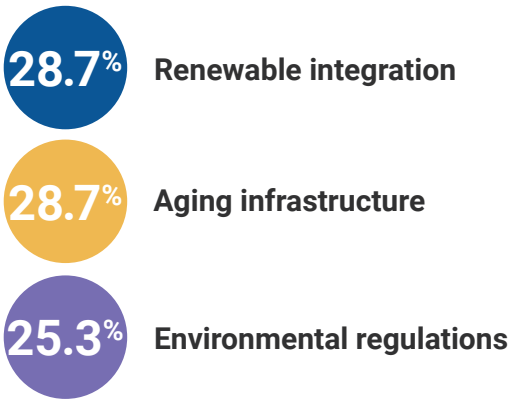
Again, that parity remains this year. In our survey of about 250 electric industry stakeholders for Black & Veatch's *2022-2023 Electric Report*, roughly one in three respondents (29 percent) ranked renewable energy integration as their top challenge, tied with aging infrastructure. While renewable integration remains in the No. 1 spot, fewer respondents are concerned about it than in last year's report, where a whopping 34 percent voted for it *(Figure 19)*.

The lowered percentage from last year may indicate that there is an increasing migration to an

Figure 19

What are the top three most challenging issues facing the electric industry in your region today? (Select up to three)

Source: Black & Veatch



Lack of skilled workforce	21.9%
Aging workforce	21.1%
Reliability	20.7%
Planning / forecasting uncertainty	19.4%
Cybersecurity	17.7%
Distribution system upgrades and modernization	16.9%
Economic regulation (i.e., rates)	15.6%
Distributed Energy Resources (DER) integration	13.1%
Resiliency	13.1%
Energy Storage	12.2%
Grid Stability	11.0%
Uncertainty of investment	10.1%
Grid congestion	5.9%
Market structure	5.5%
Access to capital investment	3.0%

awareness of renewables among utilities — a promising sign for the future of green energy.

However, it should be mentioned that last year, the 2021 Electric Report survey was released last November around the time of hope — albeit waning — that the massive "Build Back Better" spending plan targeting physical infrastructure improvements would get through Congress, and responses may have reflected optimism. At that time, renewables were top of mind for utilities. By comparison, this year's report survey was released before a far narrower version of Build Back Better was hammered out and eventually signed into law by President Joe Biden in August, perhaps negatively skewing survey responses slightly.

Nevertheless, the numbers still show utilities' growing emphasis on renewable generation capacity.

Upgrading the Power Grid

While the future of renewable energy continues to gain more acceptance among utilities, the power grid needs a major upgrade to accommodate the energy transition. And such grid modernization certainly will present its own challenges.

According to survey respondents, the top two concerns for future grid development over the next three to five years are supply chain issues (54 percent) and generation mix (53 percent). These concerns aren't minor, considering that their percentages nearly double any other option on the list. With the supply chain crisis ongoing at the time of this report, that number isn't too surprising.

Planning for Decarbonization

Across the country, utilities must start strategizing about their decarbonization goals. According to our respondents across the Northeast, Midwest, South and West regions of the United States, the percentage of utilities with a carbon reduction goal apart from any mandate was on average 56 percent. Among respondents with a carbon-reducing blueprint, 41 percent consider it well-defined to meet their goals.

When it comes to mapping out investment in new generation capacity over the next five years,

solar, microgrids and energy storage are leading the charge in what respondents say they'll spend much more or somewhat more on. These results aren't too shocking considering how well solar and battery energy storage work together. Some 60 percent of respondents expect some increase in hydrogen-related investment over the next five years. *(Figure 20)*.

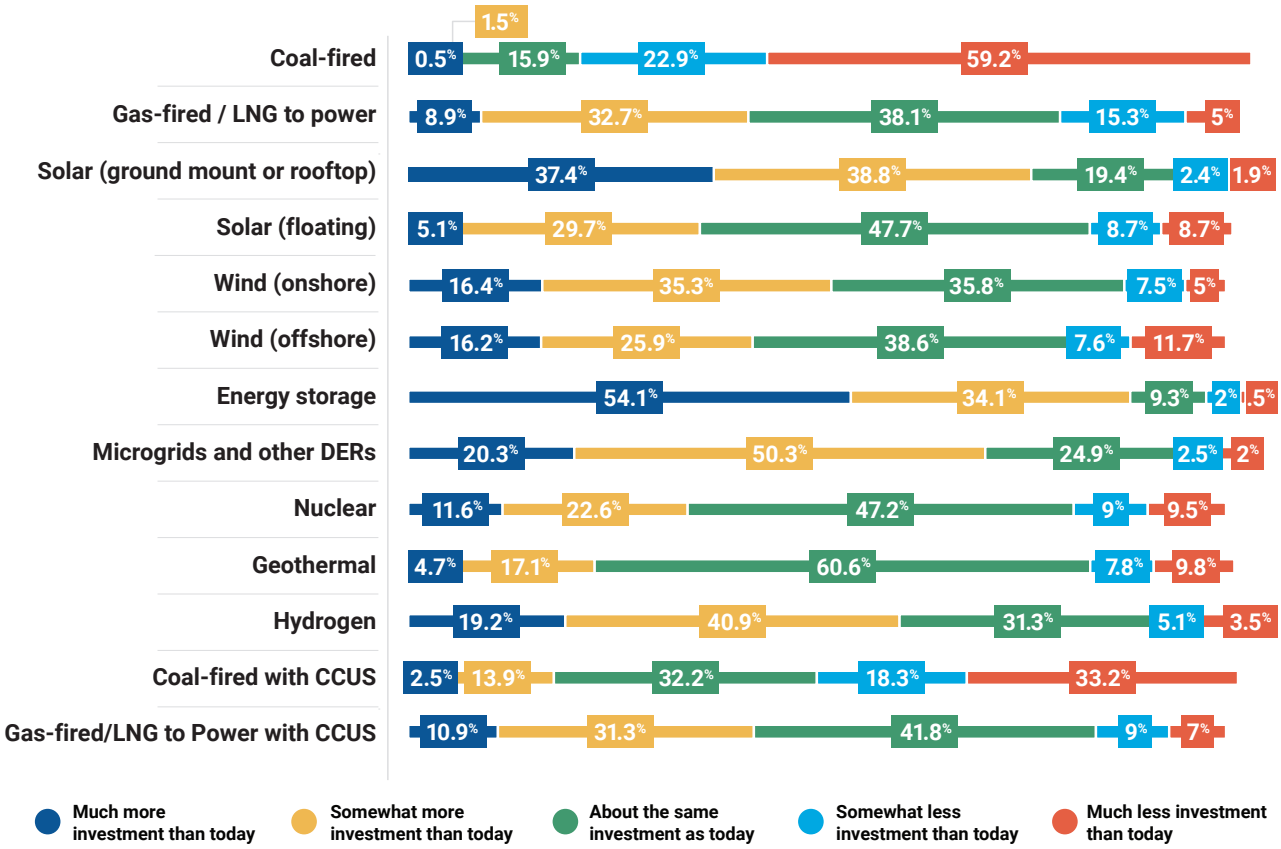
Investing in Clean Energy

When respondents were asked which technologies they intend to invest in the near-term (one to five years) and the long-term (more than five years), solar and wind both remained atop the heap in both categories — unsurprising, given their status as relatively established technologies. Looking ahead, hydrogen climbed significantly from just

Figure 20

For each of the following categories, how do you expect new energy generation capacity investments to change over the next five years in your region?

Source: Black & Veatch



14 percent in the short term and 22 percent past five years, while distributed energy storage rose to 40 percent, from 33 percent. *(Figure 21)*.

Longer term — looking out the next five years to a decade in actual investment spending — respondents appear to be prioritizing big investments (those of more than $10 million) in conventional generation while increasingly aligning behind energy from wind, the sun, hydrogen and small modular nuclear reactors.

As is the case for many technologies, they often start out slow and pick up momentum at the drop of a hat. A few decades ago, light-emitting diodes (LED) took a room full of equipment and tens of thousands of dollars to get a fraction of a lumen of light. Now people can buy a string of 100 for a dollar during Christmas time.

The same can be said for clean energy technology, where there's a consistent positivity surrounding renewables that wasn't there just 20 years ago. That appears true about hydrogen, a technology prone to skepticism today but poised to become the next big trend a decade or 15 years from now.

The fact of the matter is, decarbonization is on the minds of nearly every utility right now. And while utilities may be adopting new technologies at different rates, the enthusiasm towards renewable energy is ever-present — and building.

Energy Storage in Power

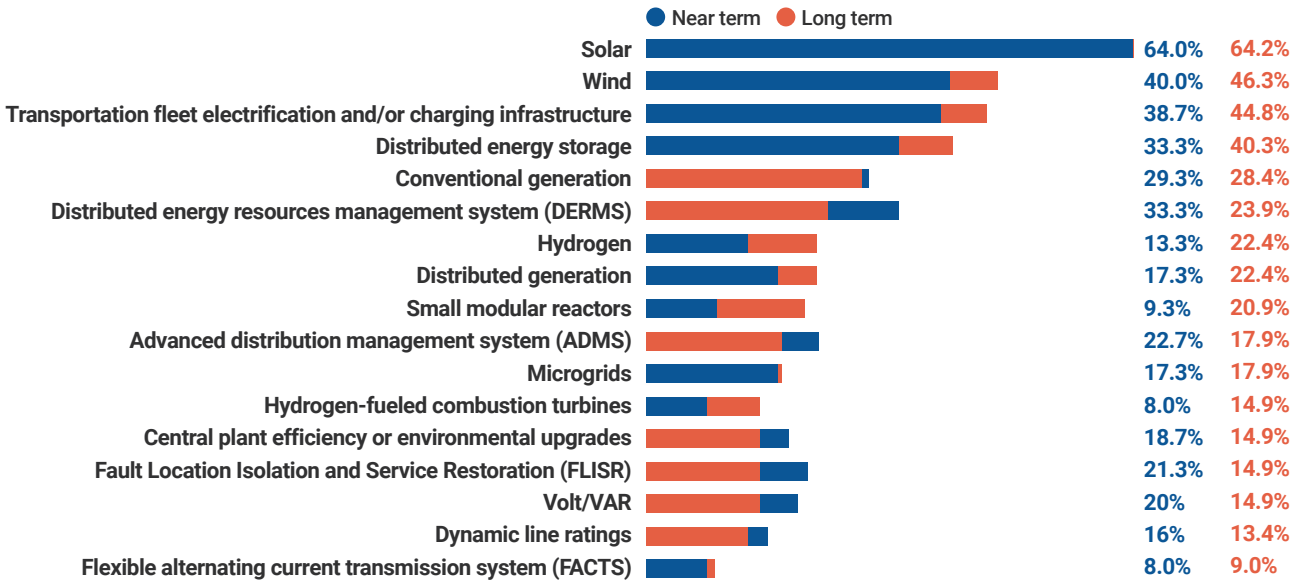
As renewable solar and wind developments continue their rapid growth across the country, energy storage increasingly is viewed as a critical component to decarbonization, given that the intermittency of renewables means there are times — days or even weeks — when there won't be the appropriate amount of generation throughout the day to satisfy load needs. While at first glance it may appear that the two key energy storage technologies — battery energy storage systems (BESS) and hydrogen — are in competition, the two technologies in important respects are complementary to each other, particularly suited to addressing hourly and daily shifting versus longer duration and seasonal shifting of energy supplies, respectively. The two can be used in tandem to maximize the value of electrons from green energy.

The investment tax credits and production tax credits made available to BESS and clean hydrogen in the Inflation Reduction Act would be significant as it would materially reduce the cost of both energy storage technologies and resultingly improve the resiliency of the grid. Investment spending in both technologies could continue to increase in utilities' planning budget.

Figure 21

Which technologies do you intend to make investments in in the near term (one to five years), as well as beyond five years? (Select all that apply)

Source: Black & Veatch



With Momentum from Federal Funding, Vehicle Electrification Must Stoke Utility Planning, Investments

As the world pushes to decarbonize, electric vehicles are proving ever more crucial in helping mitigate climate change. And utilities must answer the call in delivering the energy needed for that evolving transportation mix turning cleaner and greener by the day.

It's no secret that transportation is the leading source of greenhouse gases (GHG) in the United States. Burning fossil fuels such as gasoline and diesel releases carbon dioxide, trapping heat in the atmosphere and causing global warming. From increases in everything from the frequency and severity of wildfires, droughts and other severe weather events, the fallout is inescapable and alarming.

As the world pushes to decarbonize, electric vehicles (EVs) are proving ever more crucial in helping mitigate climate change. And utilities must answer the call in delivering the energy needed for that evolving transportation mix turning cleaner and greener by the day.

More electric vehicles are on the road, and companies such as Amazon and FedEx are taking action by electrifying their large vehicle fleets. On the funding side, the Infrastructure Investment and Jobs Act (IIJA) included significant funding to support and incentivize the buildout of electric vehicle charging infrastructure, and the newly passed "Inflation Reduction Act" expands tax credits for the purchase of new electric vehicles.

Black & Veatch's *2022-2023 Electric Report* — based on expert analysis of a survey of about 250 U.S. electric sector stakeholders — illustrates that vehicle and fleet electrification is top of mind. However, more education among utilities and clarity around budgeting and planning are necessary pieces to the puzzle that, when complete, potentially can make significant advances to the industry.

New Funds Pave the Way for Lasting Change

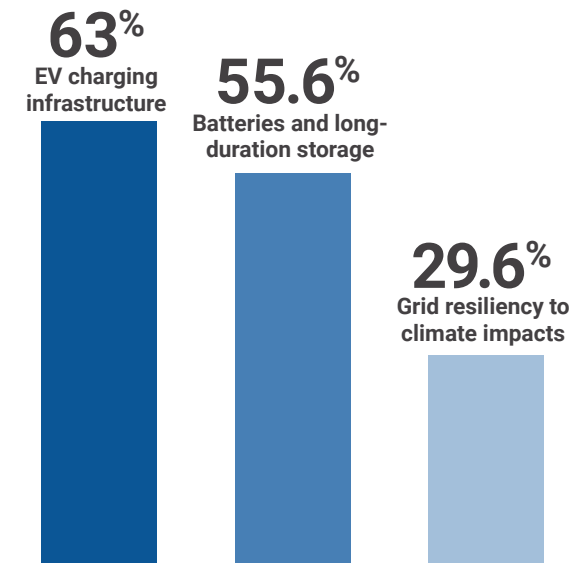
Utilities understand that loads are shifting away from fossil fuels towards cleaner forms of energy, and the move to electric vehicles isn't just a trend or a key part of climate change mitigation; it's a durable market that must be prioritized to remain relevant and competitive.

Figure 22

What are the top three priorities for your organization, if IIJA funding is granted?

(Select three options)

Source: Black & Veatch



Grid cybersecurity	22.2%
Microgrids and distribution infrastructure	22.2%
Improved DER integration	18.5%
Other	18.5%
Reliability for underserved communities	14.8%
Fiber network communications technology	11.1%
Enhance grid physical security measures	3.7%
Digital transformation for resiliency	3.7%
Non-wired alternatives	3.7%

The United States is at a tipping point of EV adoption, meaning there's a huge opportunity for utilities to be the Swiss army knife the country needs to meet the Biden Administration's goal that half of all new U.S. vehicle sales be zero-emission by 2030. Electric vehicle and fleet charging infrastructure is imperative to achieving that goal, and with billions of dollars in available funding, utilities want their fair share.

When asked about the top three priorities for their organization if IIJA funding is granted, EV charging infrastructure received the highest marks, with 63 percent of respondents noting that it would be a top priority *(Figure 22)*. Couple that sentiment with the fact that 39 percent of respondents intend to make investments in transportation fleet electrification and/or charging infrastructure in the next one to five years, and it's clear this issue is top of mind for utilities, and planning is underway.

When asked how much money their organization is planning to invest in transportation and fleet electrification and/or charging infrastructure over the next one to five years, 16 percent said they expect to spend more than $10 million. Other investment amounts range from less than $500,000 (24 percent), $500,000 to $1 million (20 percent), $1 million to $5 million (16 percent), and $5 million to $10 million (4 percent). One in five respondents reported they aren't sure how much money they'll devote to that.

While the funds are available and money is earmarked for electrification and charging infrastructure, questions remain about how best to budget that money as well as to accurately forecast the load requirements coming down the pike.

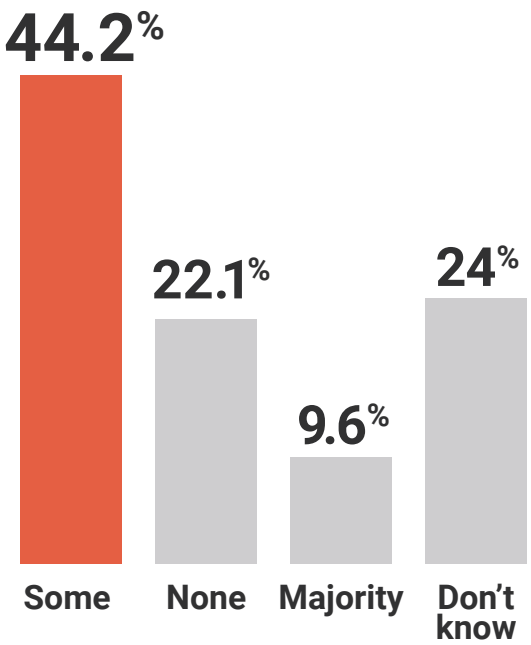
The Need for Education, Effective Forecasting

While the survey demonstrates robust plans for investment in vehicle and fleet electrification and required charging infrastructure, the data turns murky when respondents weighed in about how much of their forecasting for future load is integrated into the expectation for vehicle electrification. More than four in 10 respondents — 44 percent — replied that at least some of their forecasting included vehicle electrification and fleets, while 22 percent said none of their forecasting involves vehicle and fleet electrification. Twenty-four percent said they don't know *(Figure 23)*.

Figure 23

How much has your forecasting for future load integrated the expectation for the vehicle electrification, including fleet? (Select one)

Source: Black & Veatch



This begs the question: if utilities are planning to invest in this area, as the survey results clearly illustrate, why aren't they planning to accommodate the increased demand for electricity that these investments in EV charging buildout will inevitably require? What might explain this disconnect?

One answer is that it's hard to predict the future. Load forecasters have a difficult job, and their predictions can drive billions of dollars in investments and real changes to electricity rates. Estimate too high, and a utility has stranded assets and unnecessarily high rates. Estimate too low, and the utility risks not having enough power to serve its customers. Since the 2008 financial crisis, the usual link between growth in the gross domestic product (GDP) and electricity demand has decoupled. This means that even though the economy is growing, a utility shouldn't necessarily assume that this will result in higher electricity demand as our economy has de-industrialized and things have become more efficient. The period of flat load growth has made load forecasters more cautious when forecasting future load.

Another answer may be that work is needed to educate the utility sector on effective planning and budgeting as the adoption of EVs continues to pick up speed. Consider this: Just 5 percent of all new car sales today in the United States are electric; in five years, that number is only expected to increase, especially considering the expanded tax credits for EVs now available through the recently passed "Inflation Reduction Act." Similarly, the number of electric fleets also is expected to rise, as is the electrification of heavy machinery such as forklifts and other equipment. According to the survey, three-quarters of respondents reported an increase in EV charging site requests, spanning both Level 2 (38 percent increase) and Level 3 (38 percent increase) charging sites requests.

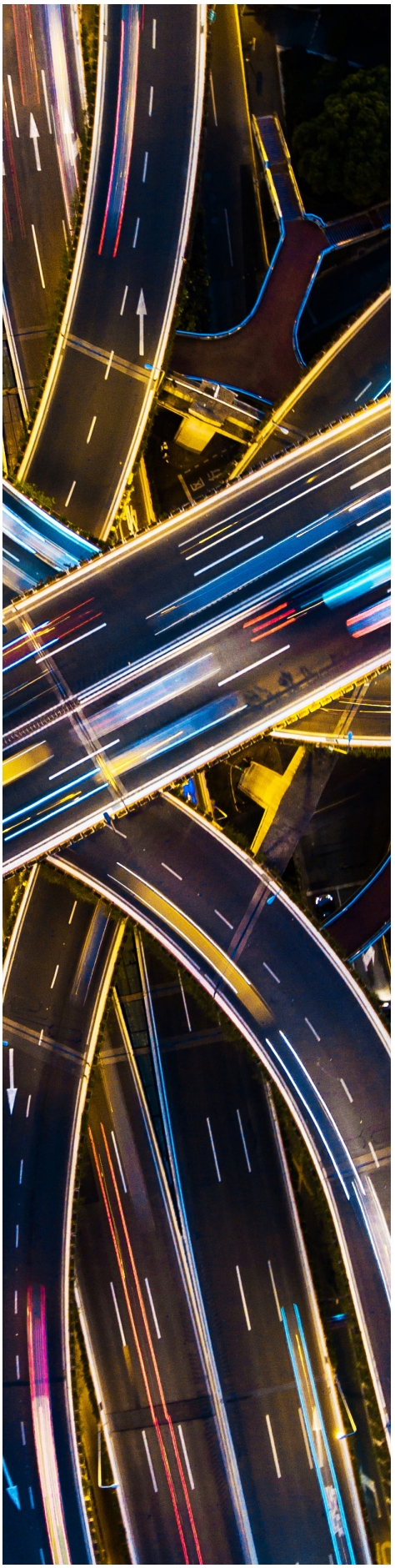
Black & Veatch recently has completed an important project for the strategic planning group at San Diego Gas & Electric (SDG&E). SDG&E set out to establish the most viable pathways for economy-wide decarbonization, with Black & Veatch providing technical advising, subject matter expertise and economic and power market modelling services to the utility. This work was published in "The Path to Net-Zero: A Decarbonization Roadmap for California," a comprehensive decarbonization blueprint to meet the state's goal of achieving carbon neutrality by 2045. The work showed that electric consumption is expected to double as the economy decarbonizes, and the majority of that additional demand will come from electric vehicles. The industry can't ignore the increase in demand in the very near term, which is only expected to grow. Growth in electrification also means increases of the load on the grid, making it imperative that utilities properly forecast the load requirements of those vehicles. The inescapable fact is that that the rising number of EVs and fleets expected to be on the road in coming years won't be sustainable without proper charging infrastructure.

No Time to be Passive

With President Joe Biden having signed an executive order calling for EVs to account for half of all U.S. auto sales by the end of this decade — and automakers making EVs a bigger part of their inventories in a world increasingly embracing decarbonization — it's incumbent on electric utilities to respond. Many are, reflected in the survey findings showing attentiveness to the need to invest in and prioritize the required infrastructure.

But more education around the need for effective planning and investment remains essential, especially considering that only half of respondents to Black & Veatch's survey say they're ready to enable new EV loads over the next year. Breaking that down further, 22 percent say they're ready now, 15 percent say they'll be good to go in less than six months, and 14 percent saying they'll be ready in six months to a year.

When utilities meld that confidence in readiness with more education and effective, thoughtful planning, the vehicle and fleet electrification sector will be on track to make lasting, sustainable change.



Energy Storage, Now (But Not Necessarily Here)

In what is a first in the more than 15-year history of Black & Veatch's annual electric report, we begin this preview section with a disclaimer: How were we supposed to know that the most significant energy policy legislation in generations would go from "not happening" to "let's wrap it up before the August recess" by Congress, right in the midst of our survey period?

Besides the obvious "it's not our fault" elements, we note this for a specific purpose: While many of this year's responses regarding energy storage reflect a positive sector outlook, we feel our data likely reflects some negative bias later mitigated by the August signing of the Inflation Reduction Act (IRA).

The IRA package is critical as electric grids across the United States creak under the strain of excessive heat, droughts, aging infrastructure and the challenges of renewable integration. Across respondent groups, energy storage is viewed as having a critical role in supporting decarbonization plans by boosting grid flexibility and reliability, particularly as service providers work to address the issue of renewable generation variability. With greater amounts of generation that varies as its resource varies, and with fewer traditional baseload assets that have a predictable resource supply, a consensus is emerging that reliability cannot be maintained without more energy storage on the power grid. In fact, more than eight in 10 respondents — 84 percent — anticipate a greater risk of load shedding, a last resort for grid operators, as renewable, variable resources play a larger role in power production *(Figure 24)*.

The IRA's $369 billion will accelerate the clean energy transition with billions in dedicated funds for energy storage research and development.

Figure 24

As the system becomes more reliant on renewable, variable resources, do you see increasing risk of more load shedding? (Select one)

Source: Black & Veatch

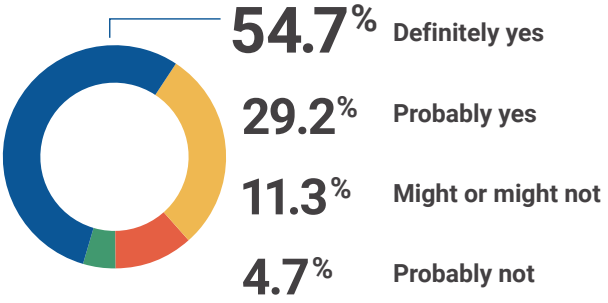
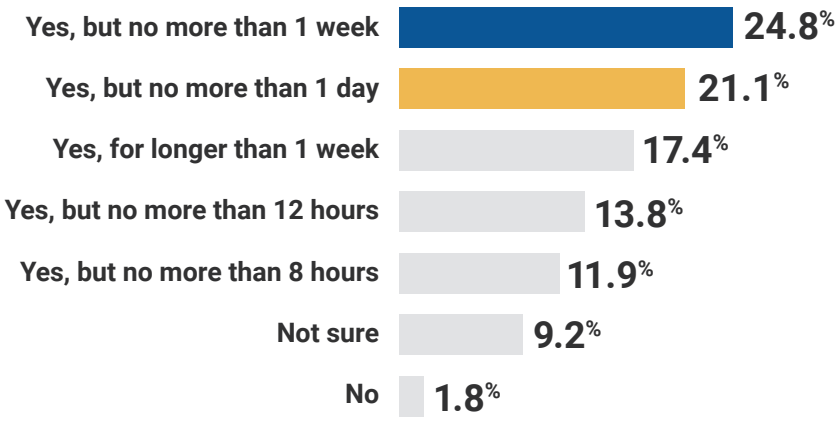


Figure 25

Do you see a need for medium- and long-term energy storage? (Select one)

Source: Black & Veatch



This is key, given that 89 percent of respondents indicate a need for medium- and long-term energy storage, though some disagreement remains on the definition of medium- and long-term storage. With eight hours as the current benchmark for long-term storage, more than 40 percent see a need for capacity of up to — or longer than — one week *(Figure 25)*.

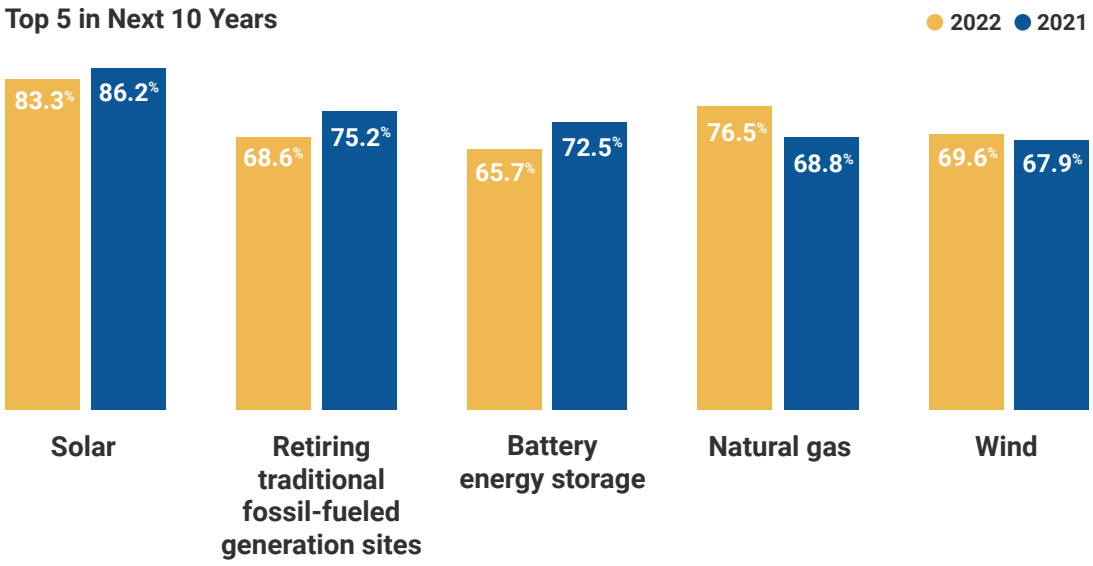
To address clean energy pledges within the next 10 years, electricity service providers ranked solar generation No. 1, with new natural gas generation a close second and retirements of traditional fossil assets also among the top four. While the respondents view storage among the most critical methods to be deployed over the time horizon, it seems only logical that responses to the question would have reflected more optimism for storage had the IRA been passed earlier *(Figure 26)*.

Black & Veatch's experts did find it interesting that optimism for long-duration energy storage was the leading method to achieve carbon reductions beyond 10 years. This likely reflects the impact of the technology curve at work as storage is both a mature technology for electrochemical battery technology and one in the early stages of its development for thermal/mechanical/chemical storage technologies. For example, just 10 years ago, the 2013 EPRI Energy Storage handbook did

Figure 26

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, by year)

Source: Black & Veatch



not include lithium-ion battery technologies as (then yet) capable of providing utility scale storage solutions; today, gigawatts of battery storage have been deployed nationwide, with the vast majority utilizing lithium ion battery technology.

Further reflecting the overall optimism for battery storage is the growing trend in "solar plus" — hybrid solar projects that incorporate energy storage from the outset of their design. In 2021, these projects surpassed pure play solar generation development in terms of the number of interconnection queue requests, a trend likely to continue in 2022 and beyond.

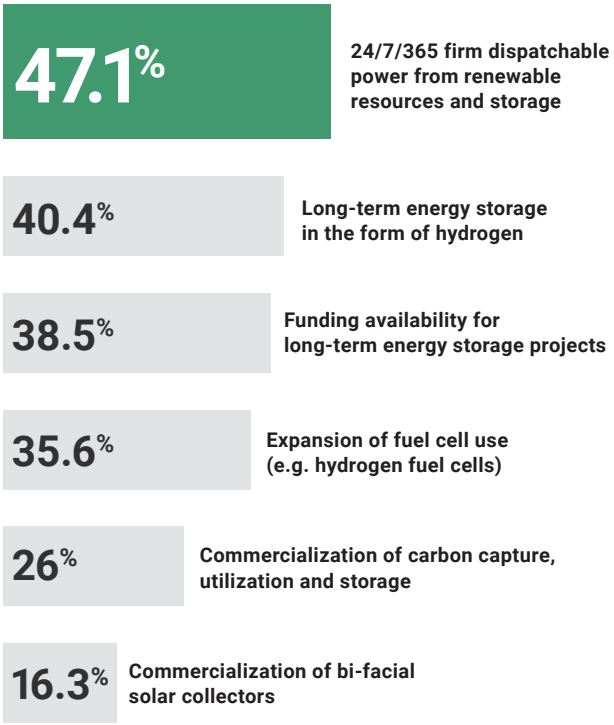
We also note that supply chain woes have not hit the battery storage field as badly as that for certain components of the energy value chain, in particular solar panels and transformers. While no technology combining commodities and semiconductors can emerge unscathed in a period of high inflation, batteries have been fairly insulated to this point. From Black & Veatch's perspective, nearly one-half of the price increases that our experts have observed are tied to increases in the cost of shipping versus other cost factors in the supply chain.

Without question, the disruption shaping the future of the electric sector is accelerating, and management of the grid increasingly mirrors the delicate balancing act of circus high-wire performers. For a century, the traditional grid operated like one performer walking the wire, or at most two performers that cross by each other. Yet as renewable generation expands, not only is the load varying, so are the generation sources, thereby creating levels of complexity unmatched in the industry's history.

Figure 27

What trends are you most excited about?
(Select all that apply)

Source: Black & Veatch



Yet it is also an exciting time to be participating in the operation of the world's most complex machine. When asked to identify the trends survey participants were most excited about, 24/7/365 dispatchable power from renewable resources with storage was selected by nearly half. Inherent in this response is the belief that storage meeting the requirements for both scale and capacity will be available to help balance and shift electricity generation and load *(Figure 27)*.

As we look ahead, we see a bright future for the energy storage market for the power grid and new opportunities to leverage technology to decarbonize the U.S. economy in commercial and the industrial, manufacturing and process industries sectors.

The State of Cybersecurity Technology in the Electric Sector

Because of the highly dynamic technology and threat environment, cybersecurity has its tentacles in nearly every aspect of the electric industry, from assessing ongoing threats to identifying and mitigating system vulnerabilities, commissioning new devices that monitor air quality, and securing weather stations.

As if that weren't enough, cybersecurity experts in the electric sphere are responsible for maintaining compliance with the North American Electric Reliability Corporation Critical Infrastructure Protection (NERC-CIP) standards.

Long story short, the industry's cybersecurity professionals have their hands full. But Black & Veatch's *2022-2023 Electric Report* — expert analysis of a survey of about 250 U.S. electric sector stakeholders — illustrates that these professionals are rising to the occasion, performing regular cybersecurity assessments, showing awareness of the latest threats, and exploring new technologies and platforms to modernize their organizations.

Responding to the threat landscape

When asked about the top challenges facing the electric industry today, a relatively low number (18 percent) of respondents selected cybersecurity — a promising sign that the majority of respondents feel they could have cybersecurity under control. This might be due in part to the high number (45 percent) of respondents stating that the last cybersecurity assessment was done in 2022 or is currently being conducted.

Figure 28

Which cyber threats is your organization most concerned about?
(Select all that apply)

Source: Black & Veatch

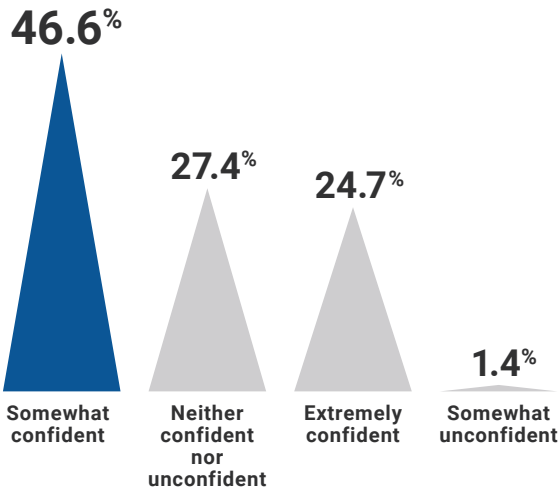
Cybersecurity assessments are not a one-size-fits-all endeavor. But this high number of positive responses — coupled with that 46 percent of respondents are in the implementation phase of their security plans — demonstrates that cybersecurity professionals are cognizant of and responding to the current threat landscape.

Phishing (79 percent) and ransomware (67 percent) took the top two spots as the cyber threats drawing the most concern among respondents *(Figure 28)*.

Figure 29

How confident are you in your utility's ability to recover from a cybersecurity attack? (Select one)

Source: Black & Veatch



When asked to assess their confidence in recovering from a cyberattack, just one-quarter reported they were "extremely confident," with 47 percent "somewhat confident." *(Figure 29)*. Low confidence levels may point back to maturing incident response plans using a variety of incidents, including the top cited concerns about phishing and ransomware.

Embracing digital transformation

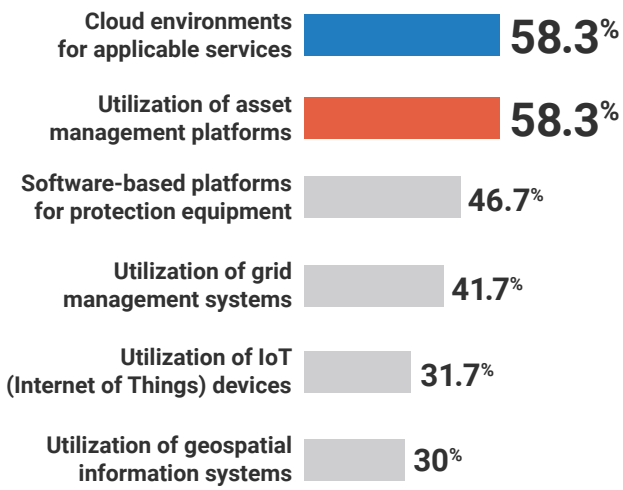
It's no secret that cloud computing is here to stay. Organizations of all sizes now understand that cloud technology allows for increased agility, collaboration and ability to scale, among a host of other advantages. The electric industry has taken note; 58 percent of respondents are considering the adoption of cloud environments to modernize their organization *(Figure 30)*. However, questions remain about Supervisory Control and Data Acquisition (SCADA) in the cloud, as well as using the cloud for operational technology (OT) environments.

When it comes to modernization, electric sector cybersecurity professionals also have their sights on the adoption of emerging technologies. One-third — 32 percent — reported that they are considering the use of the internet of things (IoT) — a somewhat high number considering IoT technologies are vastly different from the traditional, regimented structure of the electric utility. On a similar note, 47 percent are considering the adoption of software-based platforms for protection equipment. Additionally, the Department of Energy recently published the National Cyber-Informed Engineering (CIE) Strategy to develop reference architecture for electric energy OT, which

Figure 30

What technologies are you considering to modernize your organization? (Select all that apply)

Source: Black & Veatch



has the potential to be a game changer for industrial control system cybersecurity in the electric sector.

While it's clear that utilities are making moves to modernize, 72 percent of respondents don't know if their utility is aware of and considering a Zero Trust architecture. Given that Zero Trust is still an emerging security framework, the uncertainty here may point to the fact that 21 percent of respondents listed an aging workforce as one of their top concerns. Many utility professionals who have been in the industry for decades and are nearing retirement simply may not know what Zero Trust is or how to implement it, illustrating the potential for Zero Trust architecture to be adopted more broadly as the sector continues its modernization.

Looking ahead

As a traditionally regimented industry, the electric sector is showing signs of a digital transformation. Cloud adoption and emerging technologies such as IoT are entering the industry at high rates. With new technology comes new vulnerabilities, and while the sector has security plans and regular assessments in place to mitigate those threats, confidence in surmounting attacks remains low.

Questions remain about SCADA in the cloud, Zero Trust adoption and the regulatory environment. But opportunity abounds for those who continue to embrace technology in safeguarding their systems and ultimately transforming the electric sector.

With new technology comes new vulnerabilities, and while the sector has security plans and regular assessments in place to mitigate those threats, confidence in surmounting attacks remains low.

About the Authors

Alex Bettencourt is a member of Black & Veatch Global Advisory 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.

Shibu Cherian is the global chief information security officer at Black & Veatch. He leads all aspects of the cybersecurity management program and strategy aligned to industry-leading controls and regulatory best practices to ensure that confidentiality, integrity and availability of critical systems are implemented and maintained to enable the business to deliver secure solutions to build and protect critical human infrastructure. The cybersecurity program aims to provide standardized procedures and capabilities that address enterprise security needs with sustainable cybersecurity controls to detect and defend the infrastructure and business operations against cyber-attack. Cherian has more than 20 years of global experience in cybersecurity strategy and risk management and has led in the areas of cybersecurity program management, security architecture, security engineering, cloud enablement, cyber operations and risk management in various industries, including financial services, retail and ecommerce, consulting, healthcare and telecommunication.

Jonathan Cristiani is a Black & Veatch technology manager and clean fuels specialist with nearly two decades of experience in a host of renewable and alternative energy technologies. His duties include low-carbon fuel technology expertise, front-end project development/consulting, and engineering/project management support. Cristiani has significant experience with the conversion of bio-based feedstocks into energy products as well as with the production, storage, and utilization of hydrogen for numerous end use applications.

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.

Nigam Desai is a managing director and project management professional in cybersecurity at Black & Veatch, working with utility companies on performance improvement, project and program management, IT software integration and solution architecture projects. Desai has a very good understanding of the entire transmission and distribution ecosystem

in the utilities space and provides his expertise in a myriad of projects. He has worked on successful implementations of advanced metering infrastructure (AMI), grid modernization (grid mod), product integrations and implementations, and implementing cyber guidelines for transmission lines. He has 30 years working on IT projects in India and the United States and has been in the utilities space for 24 years working for meter manufacturing and consulting firms. He has knowledge and experience in meter installations and field operations, integration of AMI, grid mod and related applications, business and IT SDLC projects, cybersecurity, consulting and leading teams across various challenging and modern utility projects.

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.

Hua Fang is a managing director, co-leading Black & Veatch's strategy and planning practice and technical and commercial due diligence practice. As a Ph.D. economist with more than 20 years of experience in integrated energy market modeling and forecasting, asset valuation and commercial strategy, Fang has led several recent projects advising utility clients on economic assessments, investment strategies and customer impacts to meet their decarbonization objectives. She also leads Black & Veatch's economic and market assessments for emerging zero-carbon technologies such as clean hydrogen and green ammonia. She also oversees Black & Veatch's Energy Market Perspective (EMP), a comprehensive long-term projection of North America's energy market outlook that incorporates technology and policy trends across the energy industry.

David Hulinsky is the private networks leader in Black & Veatch's energy and process industries business. He previously served as the company's director and business unit lead for telecom, automation and distribution services for electric utilities. Hulinsky has more than 20 years of experience successfully developing and leading some of Black & Veatch's largest utility turnkey communications and smart grid EPC projects for leading utilities.

Frank Jakob is the director for advanced energy storage solutions within the Black & Veatch's energy and process industry business line. Jakob focuses on storage solutions for renewable and conventional power generation in both distributed energy and utility sectors. He also focuses on decarbonized thermal and electrical solutions for process industries. With more than 40 years of experience, Jakob advises industry, utility, developer, owner operator 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 (ESS) for stationary power generation applications and industrial thermal storage applications.

Kyle Kuhn is an engineering manager and grid integration portfolio manager at Black & Veatch. With nearly 10 years of industry experience, Kuhn has been heavily involved with business development and technological solutions for renewable collector and interconnect substations as well as EPC project execution.

Arron Lewis is a vice president and the energy utility West Region leader at Black & Veatch. With more than 29 years of experience, Lewis previously served as Black & Veatch's global power distribution business, heading the global deployment of services for power distribution infrastructure. His focus is on the delivery of solutions to client's needs for the energy transition, digitization and grid modernization, as well as infrastructure construction and upgrades required to meet the evolving needs of utility clients that deliver energy to customers.

Kevin Ludwig is a vice president and grid solutions leader at Black & Veatch. With more than 20 years of experience in the power industry, Ludwig serves as the solution leader for Black & Veatch's offerings in transmission, distribution and private networks across all markets and industries.

Ryan Pletka is a vice president of innovation and strategy at Black & Veatch. Pletka also helped found the company's growth accelerator, for which he leads investments in internal and external startups, incubation and mentoring of new businesses, advising on corporate strategy, and scouting for new technologies and trends.

Deepa Poduval is a senior vice president, leading the global advisory practice within Black & Veatch. In this role, she provides executive leadership for Black & Veatch's strategic and digital advisory services, including expertise related to transaction due diligence, regulations, business strategy, energy market planning, asset and risk management, operational technologies and infrastructure modernization needs. Poduval and her team partner with a wide variety of clients spanning governments, and electric, water, oil and gas, commercial, industrial and financial sectors across the Americas, Europe and Asia who seek strategic, digital and technical expertise related to their critical infrastructure as they pursue goals around sustainability, growth and resilience.

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.

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.

Algert Prifti leads the carbon capture, sequestration and utilization (CCUS) efforts at Black & Veatch. He focuses 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. Prifti has experience assessing and implementing CCUS solutions across the value chain, including point-source, carbon capture and sequestration (CCS), CO2 dehydration and compression, CO2 pipeline and storage, and CO2 utilization technologies. In addition to point-source CCS, he also is leading the direct air capture (DAC) technology scale-up and project development efforts at Black & Veatch. He has experience working directly with diverse industry stakeholders and

utility owners to develop and navigate custom decarbonization roadmaps that pave the way to a low-carbon footprint future. As part of the New Energy Solutions team at Black & Veatch, Prifti also is involved with projects focused on implementation of other advanced decarbonization technologies.

Ralph Romero is senior managing director at Black & Veatch Management Consulting LLC, leading the independent assessment of novel technologies practice. Romero joined Black & Veatch Management Consulting in 2010 and has been the principal investigator in more than 180 technology assessments in the areas of hydrogen, chemical and mechanical energy storage, power conversion systems, photovoltaic cells and modules, mechanical tracking systems and advanced water technologies. He advises domestic and international manufacturers, developers and financial institutions in the areas of technology, manufacturing, product and process design, among others.

Paul Stith is associate vice president of global transportation initiatives for Black & Veatch Strategic Growth. He focusses on building the ecosystems needed to plan, finance, deploy and operate sustainable transportation and distributed clean energy infrastructure at scale. Stith's projects support investors, utilities, fleets, energy and transportation providers in electrifying, decarbonizing and automating their ground, aviation and marine fleets. With more than a decade of zero-emission vehicle infrastructure experience he is a member of numerous industry advisory and working groups and serves on the Forth and NACFE boards of directors.

Sean Tilley is the emerging renewable energy solutions leader within Black & Veatch's Energy & Process Industries' power business. He is responsible for the optimization and growth of the company's portfolio of renewable energy project solutions, with the expertise to meet current and future client needs. Tilley leverages more than 20 years of global experience on more than 100 renewable energy projects ranging from 1 MW to 3 GW in capacity. His experience across the lifecycle of projects includes portfolio planning, project development, technology selection, detailed design engineering, major equipment procurement and construction contracting, project execution and repowering for a wide range of clients. His experience also extends into strategy development, marketing and business development, technology innovation and process improvement.

Rob Wilhite is a senior vice president and leader of the strategic advisory business line at Black & Veatch. He and his team provide advisory services on the topics of zero-emission transportation, distribution grid planning, decarbonization, strategic planning, clean fuels strategies, transaction services, and rates and regulatory services. With 37 years of experience in energy business strategy and utility operations, Wilhite serves as a board director and executive committee member for GridWise Alliance, is chairman for the city of Belmont's Environmental Sustainability Board and is co-chair of the technology & innovation pillar for Dentons' Smart Cities & Community Think Tank. In 2009, he was recognized as one of the top 25 consultants in the United States by Consulting Magazine in 2009.

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

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