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2024
Electric Report

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Based on a survey of nearly 700 U.S. power industry stakeholders, Black & Veatch's *2024 Electric Report* explores an evolving sector grappling with a slew of challenges mixed with opportunity.

In an increasingly complex energy ecosystem, survey respondents again cited the need to integrate the unabated influx of renewables and distributed energy resources (DER) onto the grid — and the nagging issue of aging infrastructure — as their foremost challenges in maintaining a healthy national grid infrastructure.

U.S. electric utilities are continuing to press for ways to lower their carbon footprints and bolster grid resilience against the impacts of climate change, including severe flooding, hurricanes, droughts and wildfires. Lingering supply chain issues manifested by the COVID-19 pandemic continue to hamper grid modernization efforts, slowing access to key components.

The proliferation of data centers and the continued adoption of electric vehicles are pressuring U.S. power providers to find ways to meet that intensifying demand for electrons. Cybersecurity threats haven't abated, requiring renewed and robust vigilance and investment.

All the while, new generational federal funding — through the Bipartisan Infrastructure Law and the Inflation Reduction Act — is making its way slowly through the system, committing billions of dollars to grid upgrades by those willing to pursue it.

As the sector pursues heightened sustainability, reliability and resiliency, this report takes the pulse of an industry modernizing with new technologies and improved concepts to keep the power flowing to industry, businesses and consumers.

We welcome your questions and comments regarding this report and Black & Veatch services.
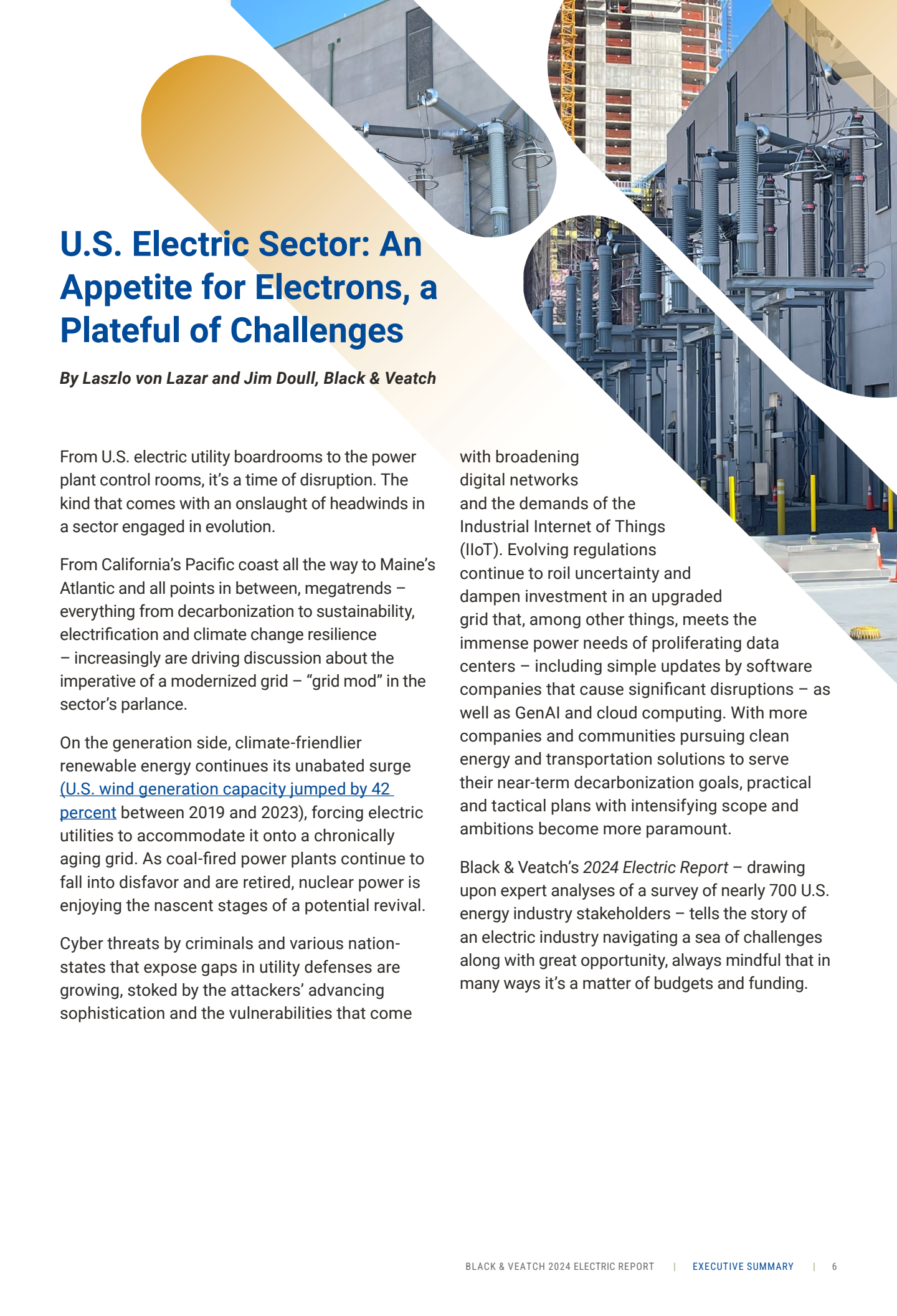
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Laszlo von Lazar, *President leading Fuels and Natural Resources, which provides critical infrastructure services and solutions to fuel producers through process solutions such as FLNG, ammonia, biofuels and hydrogen. Appointed to the Black & Veatch Board of Directors in August 2022, he previously served as president of the company's energy and process industries (E&PI) sector. 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. Having joined Black & Veatch in 2019 as leader of global projects for the company's previous power organization, he oversaw engineering, procurement, construction, quality and business excellence. He has more than three decades of worldwide project experience.*

Jim Doull, *Executive Vice President leading Power Providers which focuses on the electricity-producing client segment that includes renewables and advanced power generation solutions. In his nearly 35 years at Black & Veatch, Doull has experience leading businesses and executing major EPC and construction projects around the world, with portfolio values of $1.5 billion. He led Black & Veatch global power generation and Fuels and Natural Resources sectors and now leads the company's renewable and advanced power generation business. He has a history of turning around challenging projects and achieving successful results.*

U.S. Electric Sector: An Appetite for Electrons, a Plateful of Challenges

By Laszlo von Lazar and Jim Doull, Black & Veatch

From U.S. electric utility boardrooms to the power plant control rooms, it's a time of disruption. The kind that comes with an onslaught of headwinds in a sector engaged in evolution.

From California's Pacific coast all the way to Maine's Atlantic and all points in between, megatrends – everything from decarbonization to sustainability, electrification and climate change resilience – increasingly are driving discussion about the imperative of a modernized grid – "grid mod" in the sector's parlance.

On the generation side, climate-friendlier renewable energy continues its unabated surge [(U.S. wind generation capacity jumped by 42 percent](between 2019 and 2023), forcing electric utilities to accommodate it onto a chronically aging grid. As coal-fired power plants continue to fall into disfavor and are retired, nuclear power is enjoying the nascent stages of a potential revival.

Cyber threats by criminals and various nation-states that expose gaps in utility defenses are growing, stoked by the attackers' advancing sophistication and the vulnerabilities that come with broadening digital networks and the demands of the Industrial Internet of Things (IIoT). Evolving regulations continue to roil uncertainty and dampen investment in an upgraded grid that, among other things, meets the immense power needs of proliferating data centers – including simple updates by software companies that cause significant disruptions – as well as GenAI and cloud computing. With more companies and communities pursuing clean energy and transportation solutions to serve their near-term decarbonization goals, practical and tactical plans with intensifying scope and ambitions become more paramount.

Black & Veatch's *2024 Electric Report* – drawing upon expert analyses of a survey of nearly 700 U.S. energy industry stakeholders – tells the story of an electric industry navigating a sea of challenges along with great opportunity, always mindful that in many ways it's a matter of budgets and funding.

Renewables and the Grid

Renewable energy continues to drive capacity in new U.S. energy markets, with solar power the fastest-growing source of new electricity generation nationwide. The reasons are many, largely driven by fundamental economics of renewable energy. In addition, customer decarbonization goals, the continued declining costs of photovoltaic cells, tax credits and other policies make renewables an unstoppable force.

Last year, the electric sector began operating 19 gigawatts (GW) of new utility-scale solar photovoltaic generating capacity, up 27 percent from 2022. That growth comes despite the downside that solar and wind power are prone to intermittency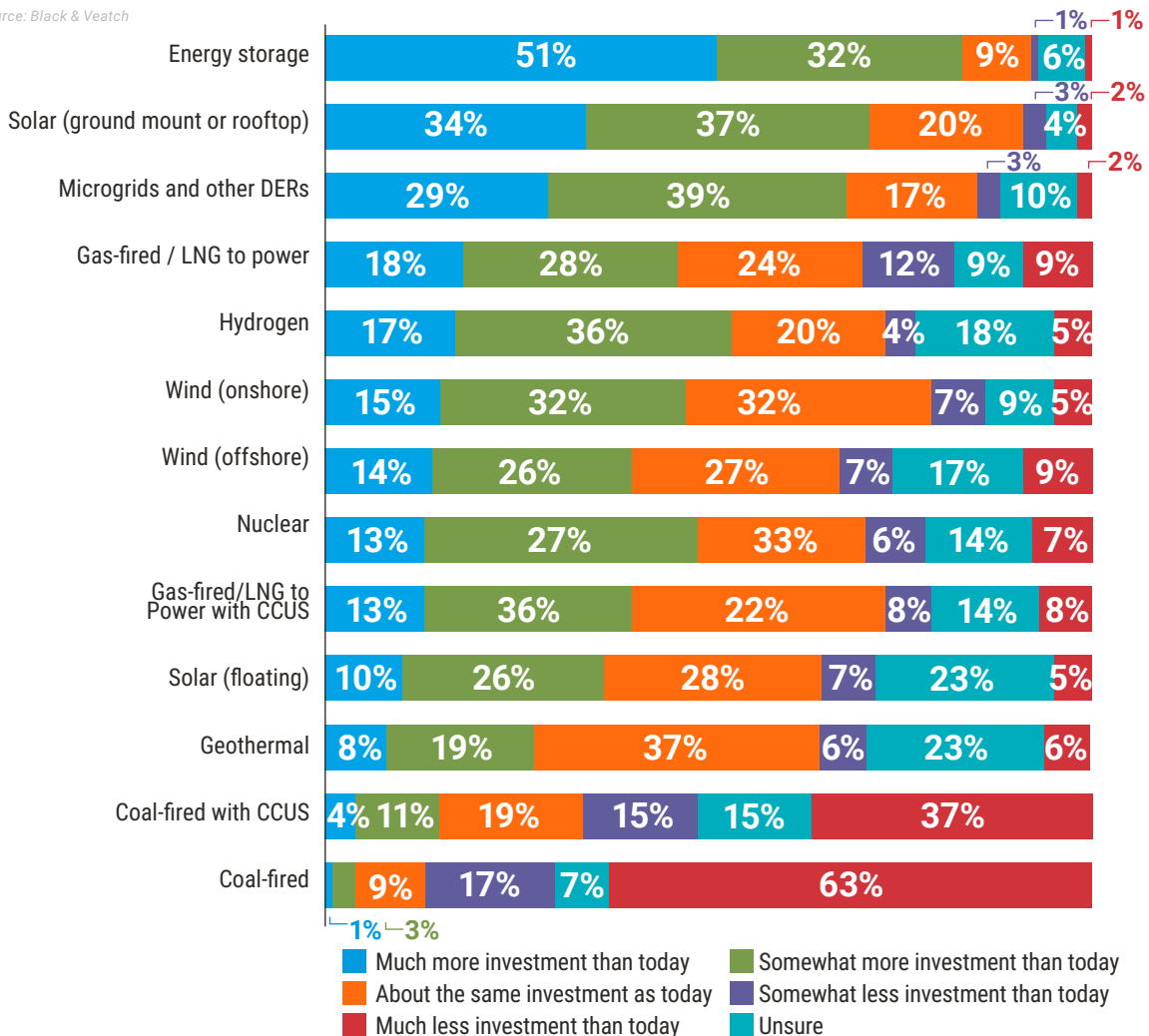 – the lack of energy produced when the sun isn't shining and the wind isn't blowing – and must be paired with batteries or other energy storage types. The U.S. Energy Information Administration (EIA) has forecasted that by 2050, solar and wind power will account for 40 to 69 percent of U.S. electricity generation. It appears the industry has leveled off at roughly 20 GWs per year.

Utilities see it coming. When asked how they expect new generation capacity investments to change over the next five years in their service territories, half of respondents – 51 percent – anticipate energy storage in need of "much more investment than today," followed by ground-mounted or rooftop solar (34 percent), microgrids and other DERs (29 percent) (Figure 1).

Figure 1

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

Source: Black & Veatch

Category	Much more investment than today	Somewhat more investment than today	About the same investment as today	Somewhat less investment than today	Unsure	Much less investment than today
Energy storage	51%	32%	9%	1%	6%	1%
Solar (ground mount or rooftop)	34%	37%	20%	3%	4%	2%
Microgrids and other DERs	29%	39%	17%	3%	10%	2%
Gas-fired / LNG to power	18%	28%	24%	12%	9%	9%
Hydrogen	17%	36%	20%	4%	18%	5%
Wind (onshore)	15%	32%	32%	7%	9%	5%
Wind (offshore)	14%	26%	27%	7%	17%	9%
Nuclear	13%	27%	33%	6%	14%	7%
Gas-fired/LNG to Power with CCUS	13%	36%	22%	8%	14%	8%
Solar (floating)	10%	26%	28%	7%	23%	5%
Geothermal	8%	19%	37%	6%	23%	6%
Coal-fired with CCUS	4%	11%	19%	15%	15%	37%
Coal-fired	1%	3%	9%	17%	7%	63%

Legend:
- Much more investment than today
- Somewhat more investment than today
- About the same investment as today
- Somewhat less investment than today
- Much less investment than today
- Unsure

Accommodating all that renewable energy onto the grid is a major headwind, with one in four respondents again characterizing that as the U.S. power sector's foremost challenge, tying it with the incessant headache that is aging infrastructure.
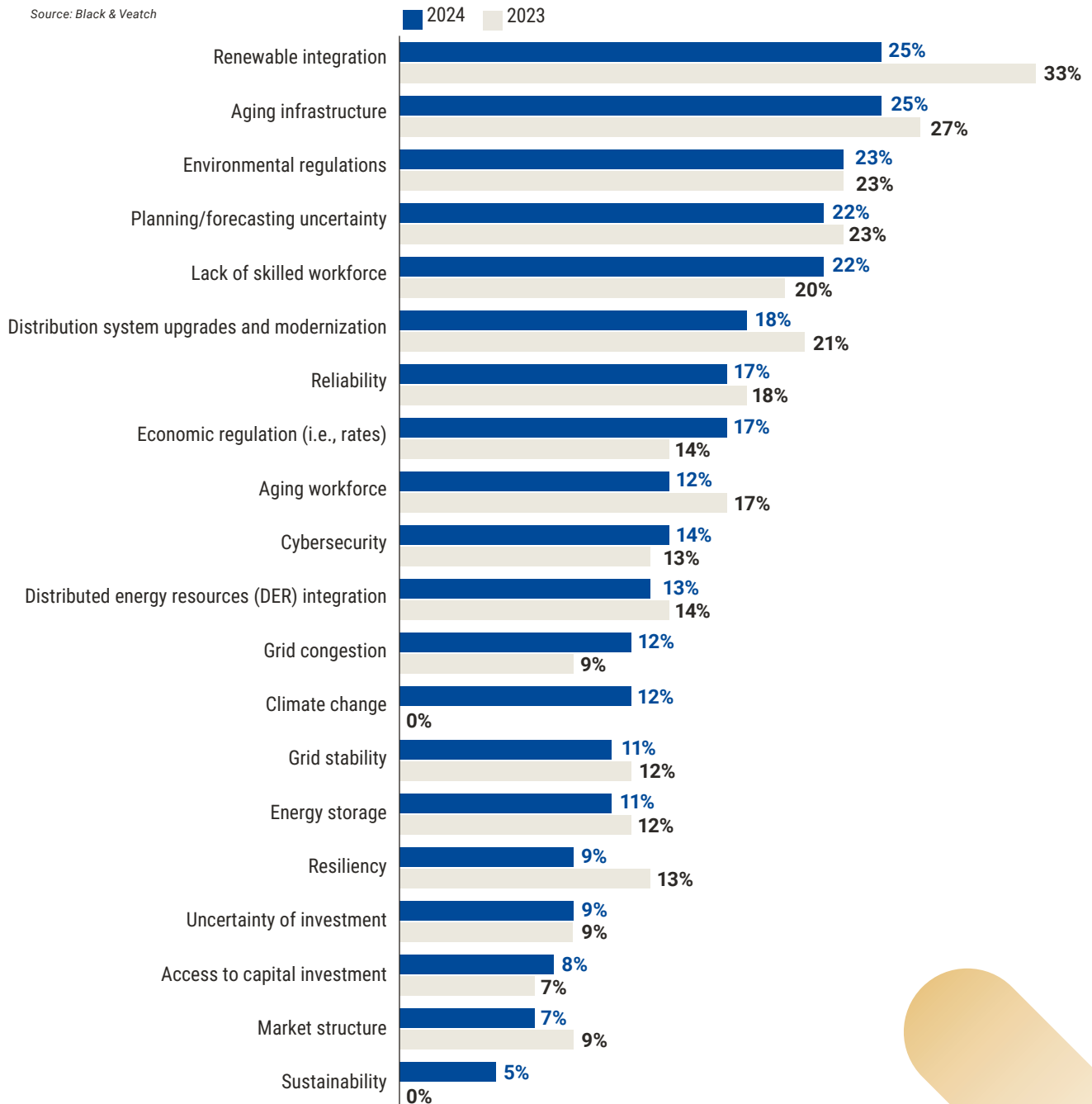
Environmental regulations, planning and forecasting uncertainty, and the lack of a skilled workforce were the only other issues that drew at least 20 percent. Of note: workforce issues – the lack of a skilled workforce, along with its aging employees – accounted for a combined 36 percent of responses *(Figure 2)*.

Figure 2

What are the TOP THREE most challenging issues facing the electric industry in your region today?

(Select up to three issues)

Source: Black & Veatch

■ 2024 ☐ 2023

Issue	2024	2023
Renewable integration	25%	33%
Aging infrastructure	25%	27%
Environmental regulations	23%	23%
Planning/forecasting uncertainty	22%	23%
Lack of skilled workforce	22%	20%
Distribution system upgrades and modernization	18%	21%
Reliability	17%	18%
Economic regulation (i.e., rates)	17%	14%
Aging workforce	12%	17%
Cybersecurity	14%	13%
Distributed energy resources (DER) integration	13%	14%
Grid congestion	12%	9%
Climate change	12%	0%
Grid stability	11%	12%
Energy storage	11%	12%
Resiliency	9%	13%
Uncertainty of investment	9%	9%
Access to capital investment	8%	7%
Market structure	7%	9%
Sustainability	5%	0%

Resilience and Reliability: The Need for Grid Mod

Talk of upgrading and hardening the grid has been a hot topic for decades, and the calls for such change in the name of greater resilience are growing louder, knowing that reliable service always has been a core of every utility's mandate. Unquestionably, utilities recognize the need to be more resilient than ever.

So, what's crimping future grid development in the short term of the next three to five years? Nearly half of respondents – 46 percent – cite the generation mix, with more utility-scale renewables and fewer traditional base load units. Supply chain
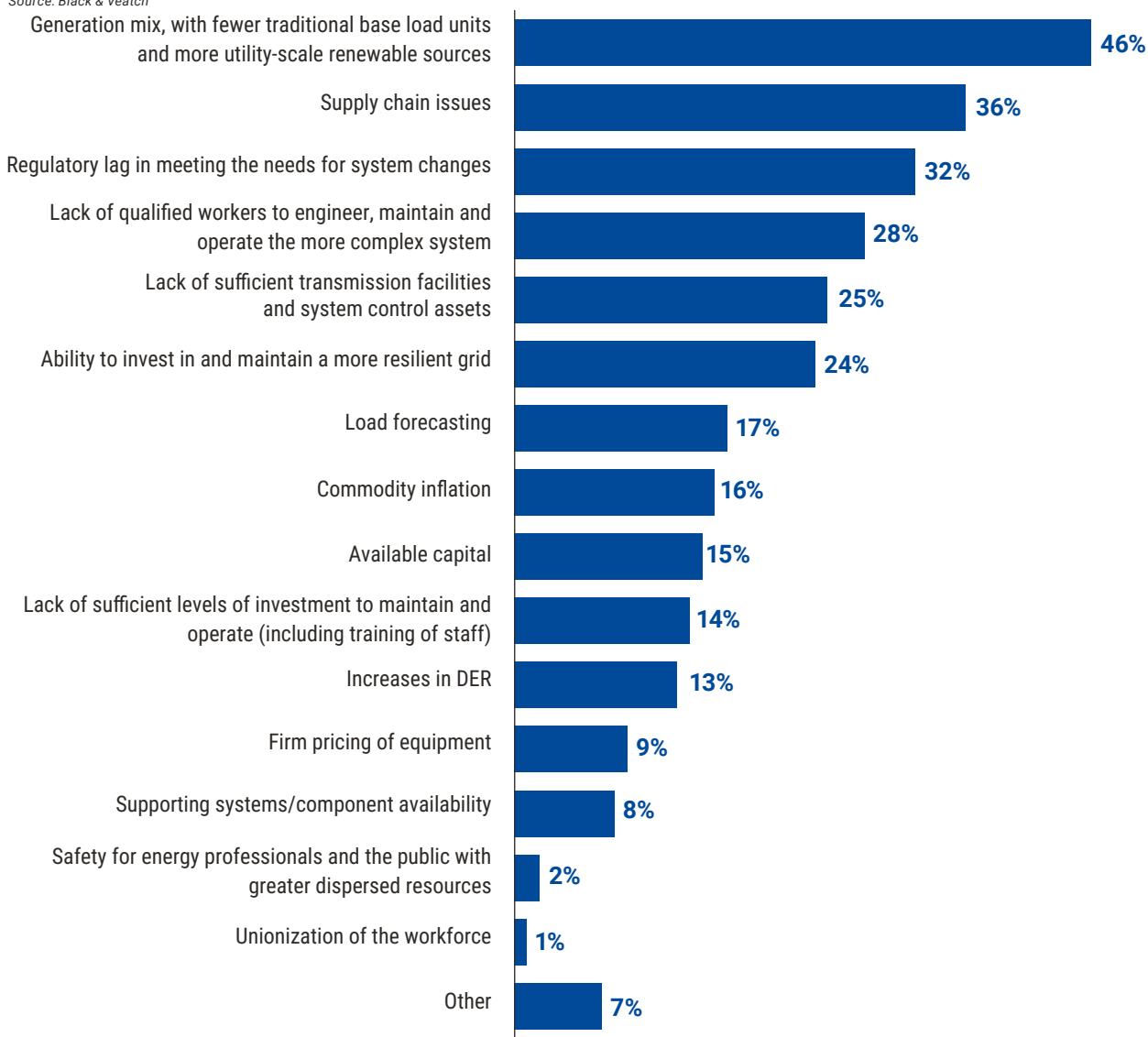
bottlenecks (36 percent) in trying to procure what's needed to build out a modernized grid, regulatory lag in addressing the needs for system changes (32 percent), and the shortage of qualified workers to design and run more complex systems follow *(Figure 3)*.

With the push and pull of competing interests, many things on the industry's "to-do" list are nowhere close to cheap. So, who's going to pay for it? Under today's regulatory models, utilities typically don't have a way to recapture all the fixed

Figure 3

What are the TOP THREE biggest concerns for future grid development in the next three to five years? (Select up to three concerns)

Source: Black & Veatch

Concern	Percentage
Generation mix, with fewer traditional base load units and more utility-scale renewable sources	46%
Supply chain issues	36%
Regulatory lag in meeting the needs for system changes	32%
Lack of qualified workers to engineer, maintain and operate the more complex system	28%
Lack of sufficient transmission facilities and system control assets	25%
Ability to invest in and maintain a more resilient grid	24%
Load forecasting	17%
Commodity inflation	16%
Available capital	15%
Lack of sufficient levels of investment to maintain and operate (including training of staff)	14%
Increases in DER	13%
Firm pricing of equipment	9%
Supporting systems/component availability	8%
Safety for energy professionals and the public with greater dispersed resources	2%
Unionization of the workforce	1%
Other	7%

costs required for critical upgrades, and ratepayers are likely to object to chipping in more for their electrons, making it even more paramount for utilities to present a thoughtful case to regulators – or seek out outside guidance from companies such as Black & Veatch to help make that happen.

Cybersecurity

As power utility IT and OT networks grow in technological complexity and sophistication, so are the cyber criminals looking to attack it as ever-widening use of internet-connected components expand the potential attack surfaces, exposing vulnerabilities in grid security. It's a high-stakes chess match pitting cyber invaders against power plant systems as the sentries guarding the gates.

The IT threats are diverse and potentially devastating, with survey respondents deeming phishing attacks (69 percent) and ransomware and malware (both at 45 percent) as the most concerning. Meanwhile, seven in 10 respondents report at least some level of confidence in their utility's ability to recover from a cybersecurity attack, but that's merely reactive after the intrusion already has happened and, unfortunately, the damage is done.

The bigger concern likely is the level of confidence in preventing an attack. Topping the list of efforts utilities see most essential in mitigating cybersecurity risks are threat intelligence (36 percent), monitoring and response (34 percent), vulnerability assessment and management (31 percent) and an incident response plan (25 percent).

When it comes to cybersecurity, nothing is easy. The regulatory landscape is constantly shifting and maturing, hoping to keep step with emerging risks through new and evolving minimum compliance standards. Grid-modernizing efforts will spur more connectivity, broadening potential vulnerabilities. And, once again, it takes money to fortify, thoroughly adopt and consistently monitor cyber protections while making needed investments in robust risk assessments and the latest technologies.

As with so many other things on the plate of U.S. power utility stakeholders, it all starts with a plan that makes headway in incremental, manageable bites. Reshaping tomorrow's more resilient grid means being proactive now.

Elsewhere in This Report

Energy Transition: As the energy ecosystem increasingly favors greater adoption of renewable energy, with solar leading the way, utilities are examining their priorities to develop programs to accelerate cleaner, carbon-cutting energy solutions. It's a crucial time in this unfolding energy transition, which demands thoughtful approaches and investment. Industry stakeholders, through their survey responses, provide their insights and expertise on this hot topic.

Climate Change: As climate change brings about more frequent and intense weather events, U.S. electric utilities plagued by a chronically aging infrastructure are facing mounting calls to harden their assets to bolster resiliency against nature's assaults, not to mention increasing cybersecurity threats. We take the industry's pulse to better understand what comes next.

Data Centers: Data centers rapidly are spreading across the United States, adding pressure to power suppliers to accommodate the sizable need for electrons. E-commerce proliferation and the push of generative AI (GenAI) is increasing the power requirements for these data centers. Such load requests often are wide-ranging and have an uncertain timeline, and many utilities are having a tough time forecasting those power demands. Read more about this intensifying power sector challenge.

Grid Modernization

Grid Modernization Focuses on Renewables, Battle for Expansion Funds

As energy stewards, utilities continually strive to balance grid expansion needs with competing interests, including operating and managing aging infrastructure, renewable interconnection and improving resiliency and reliability..

Welcome to the world of "grid modernization," which encompasses the frustration and promise of updating and hardening old infrastructure. This opportunity encompasses preparing for current and future threats — from the cyber-related to the outage-causing effects of a changing climate — while capitalizing on emerging opportunities.

What is the posture about grid modernization across America? Black & Veatch's *2024 Electric Report* — an expert analysis of a survey of nearly 700 U.S. electric sector stakeholders — provides many key answers.

When do you anticipate the following to be drivers of grid modernization for your organization?
(Select one for each)

Source: Black & Veatch

Driver	Now	Less than 3 years	3-5 years	More than 5 years	Don't know	Never
Renewable energy penetration	57%	14%	11%	8%	9%	1%
Low-probability, high-impact events	43%	19%	16%	6%	14%	2%
Technology advances	41%	25%	14%	8%	11%	1%
Increased DER penetration	35%	21%	10%	11%	19%	3%
Building and transportation electrification	29%	25%	18%	14%	11%	2%

Now ■ Less than 3 years ■ 3-5 years ■ More than 5 years ■ Don't know ■ Never
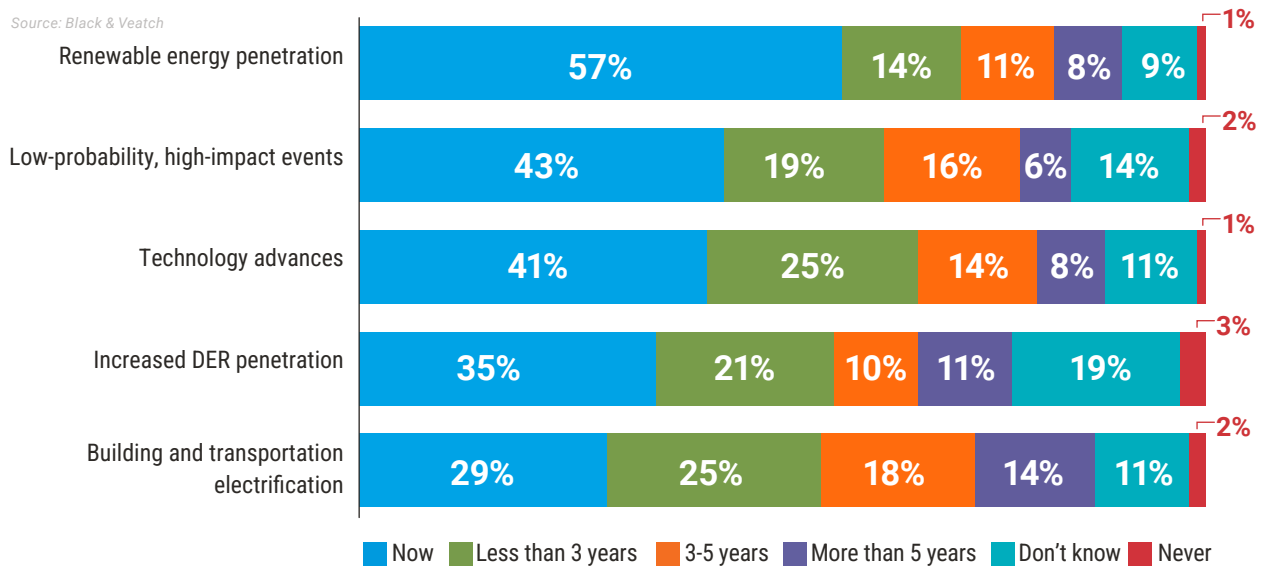
The Surge of Renewables

On the matter of when survey respondents anticipate various factors to be drivers of grid modernization for their organization, renewable energy penetration was listed as the most significant current driver at 57 percent, followed by low-probability/high-impact events (e.g., weather) at 43 percent *(Figure 4)*. Renewable reliability at a large scale is an issue for utilities due to intermittency of renewable sources of power. Utilities want to be in control of their power availability, but as more distributed generation enters a system, it becomes harder to control.

These concerns can be viewed from two perspectives. A distribution-only utility would view this question as a behind-the-meter application, whether it is microgrids or stand-alone distributed energy resources (DERs) such as rooftop solar. A transmission utility would see the issue from the perspective of dealing with large-scale solar and wind farms that seek to interconnect with the transmission system. In short, distribution system operators are focused on visibility and control, while transmission systems are concerned with having the necessary transmission capacity to operate.

It's worth noting that building and transportation electrification garnered just 29 percent as a driver now, yet it appears to be the most significant issue on utilities' radars in the next three to five years.

There is a lot of uncertainty surrounding electrification — exactly what it will look like and its resulting demands. But electrification is coming, with the only uncertainty being a matter of when. Some of the uncertainty is tied up in politics. In addition, electric vehicle (EV) demand has slowed — perhaps a reflection of high interest rates and the price point of such vehicles. But those declines are more than replaced by the energy-intensive requirements of data centers being built nationwide to support artificial intelligence applications.
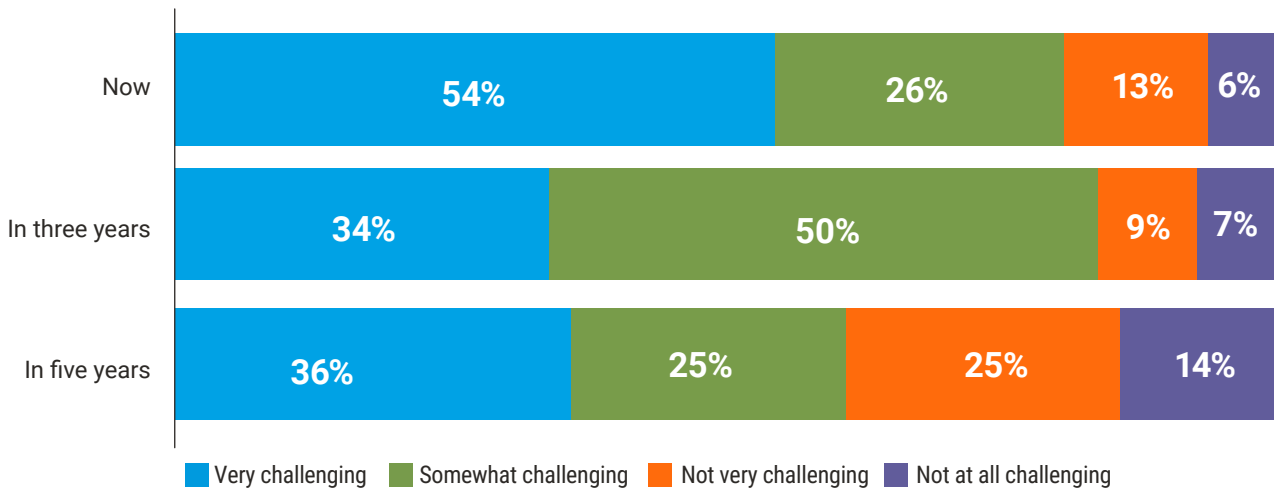
Building electrification is moving forward in some regions, but pushback is rising in other areas of the country. For instance, where discussions are taking place about outlawing natural gas, some sentiments are developing against that notion. This is the conundrum in which utilities find themselves.

In general, utilities primarily are dealing with the problems directly in front of them and worrying less about what's five or 10 years down the road, given ongoing expansion demands and operations and maintenance challenges. This isn't surprising. Utilities have to report to regulators, and it's difficult to convince them that now is the time to begin planning for the impacts of building and transportation electrification in the coming decade(s).

How challenging is regulation for your organization currently and how challenging do you anticipate it to be in the following time periods? (Select one for each)

	Very challenging	Somewhat challenging	Not very challenging	Not at all challenging
Now	54%	26%	13%	6%
In three years	34%	50%	9%	7%
In five years	36%	25%	25%	14%

An Optimistic Future Concerning Regulations

Survey respondents were asked about how challenging regulations are now — and their outlook for the future *(Figure 5)*. More than half (54 percent) listed regulations as very challenging now, with an additional 26 percent saying they're somewhat challenging. Interestingly, while a combined 80 percent find regulations very or somewhat challenging, that number drops to just 61 percent for five years from now.

While this outcome is hard to imagine in light of the constant battle over rate cases and various siting proposals, two Federal Energy Regulatory Commission (FERC) orders in early 2024 are considered positive signs.

One of those orders — No. 1977 — gives FERC siting authority for inter-regional transmission lines of national significance if the states don't act — a substantial action in getting important transmission projects moving forward.

There is a half dozen or more merchant transmission line proposals that have been in the works for more than a decade, yet they remain stagnant while waiting for state or local regulatory approvals.

The other FERC action, No. 1920, addresses long-range transmission planning and cost allocation. FERC's goal is to have transmission owners build into their transmission plans the infrastructure needed to support renewables and increased load growth as opposed to having a more reactive response toward expansion. With the support of this FERC order, transmission owners and developers may be able to make a stronger case to their local public utility commissions (PUCs) versus PUC for future transmission siting and development.

The fact that FERC is trying to streamline regulations in these two important areas is a positive development.

The Battle for Funds

The need for capital expenditures (CapEx) continues to be a driver for all organizations. Furthermore, CapEx versus operations and maintenance (O&M) almost always is present as a potential conflict, given that funding new expansion (hence, additional revenue) can compete for money to maintain assets already in the field. Even though today's CapEx eventually becomes tomorrow's O&M, it may be hard to see behind all of the pressures utilities face today.

That said, O&M still came out on top by a narrow margin as the most significant challenge organizations face in modernizing the grid (*Figure 6*). Sixty-two percent of respondents listed concerns with ongoing maintenance costs as their most significant current challenge, compared with 56 percent that cited competition for capital dollars.

There are ongoing efforts to use technology to lessen O&M expenses. More extensive use of sensors to detect issues or flying drones for inspections are two examples of how utilities are trying to adopt new technology. The pressure to spend less on O&M to push those dollars to CapEx is likely increasing because of all the work that needs to be done on grid expansion to meet increasing load growth.

Figure 6

When do you anticipate your organization facing the following challenges to grid modernization?
(Select one for each)

Source: Black & Veatch

Legend: Now | Less than 3 years | 3-5 years | More than 5 years | Don't know | Never

- Concerns with ongoing maintenance costs (O&M): 62% Now, 14% Less than 3 years, 6% 3-5 years, 5% More than 5 years, 11% Don't know, 2% Never
- Competition for capital dollars: 56% Now, 10% Less than 3 years, 8% 3-5 years, 2% More than 5 years, 19% Don't know, 6% Never
- Resource constraints: 54% Now, 14% Less than 3 years, 13% 3-5 years, 5% More than 5 years, 14% Don't know, 1% Never
- Regulatory approval: 49% Now, 17% Less than 3 years, 7% 3-5 years, 5% More than 5 years, 19% Don't know, 3% Never
- Insufficient load forecasting: 38% Now, 14% Less than 3 years, 5% 3-5 years, 4% More than 5 years, 22% Don't know, 18% Never
- Lack of integrated planning (eg. transmission/distribution): 30% Now, 16% Less than 3 years, 7% 3-5 years, 6% More than 5 years, 22% Don't know, 19% Never

A Rapidly Changing Future

For decades, utilities have engaged in integrated resource planning (IRP), which is a long-range outlook of their region and the anticipated CapEx needs to meet projected changes. In the past, an IRP was updated every five or 10 years as growth was relatively flat, and the economics didn't change. But many utilities today update their IRP every other year, or even annually. The increased frequency of updating IRPs is necessary due to the exponentially growing demands placed on the utility and the rising uncertainty associated with customer load growth due to growing data centers, domestication of clean tech and electrification.

As utilities keep one eye on the immediate future and the other on the coming decades, they must continually find the right balance for affordability, equitability, reliability and sustainability.

Data Centers

Data Centers Add Twist to Complex Challenge of Load Forecasting for U.S. Power Utilities

Data centers have proliferated on the commercial power landscape, and their load requests — from several hundred megawatts to 1 or 2 gigawatts — are exponentially larger than anything previously seen, compounding challenges in the U.S. power industry.

Utilities already were facing a demand boom from myriad elements before traditional data centers began surging across the United States in recent years. New artificial intelligence (AI) data centers and their power demand five to 10 times greater than traditional data centers are compounding the data center power demand boom.

The Inflation Reduction Act (IRA) has helped stoke manufacturing demand, and electrification is accelerating across the country. Population shifts also are causing a significant rise in demand. Continued shutdowns of coal-fired power plants in certain U.S. areas is lessening capacity. Add in the massive load requests from the data center sector, and utilities have their hands full trying to meet the demand and accurately forecast future load.

Black & Veatch's *2024 Electric Report* — based on expert analyses of survey responses from nearly 700 U.S. power sector stakeholders — puts it into sharper focus, beginning with the unease in the power sector when it comes to accommodating data centers.

Forty-five percent of respondents say they have no confidence or are not very confident in their forecasting for data center loads, perhaps due to the large amount of uncertainty that can come with data center power requests and expectations *(Figure 7)*. Industry professionals say the load requests often are wide-ranging and have an uncertain timeline — other than fast.

Figure 7

How confident is your utility in forecasting for data center power load? (Select one)
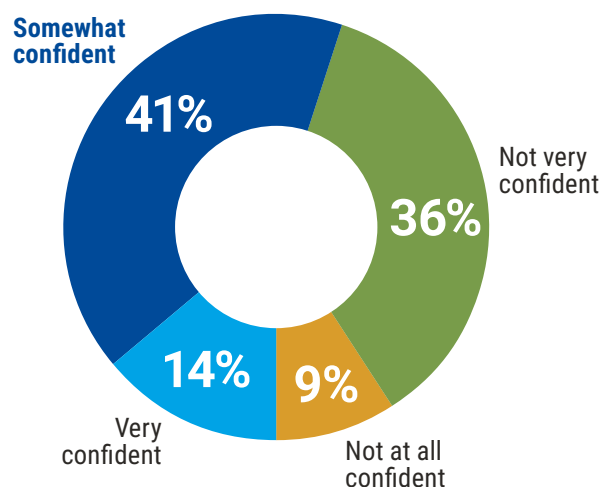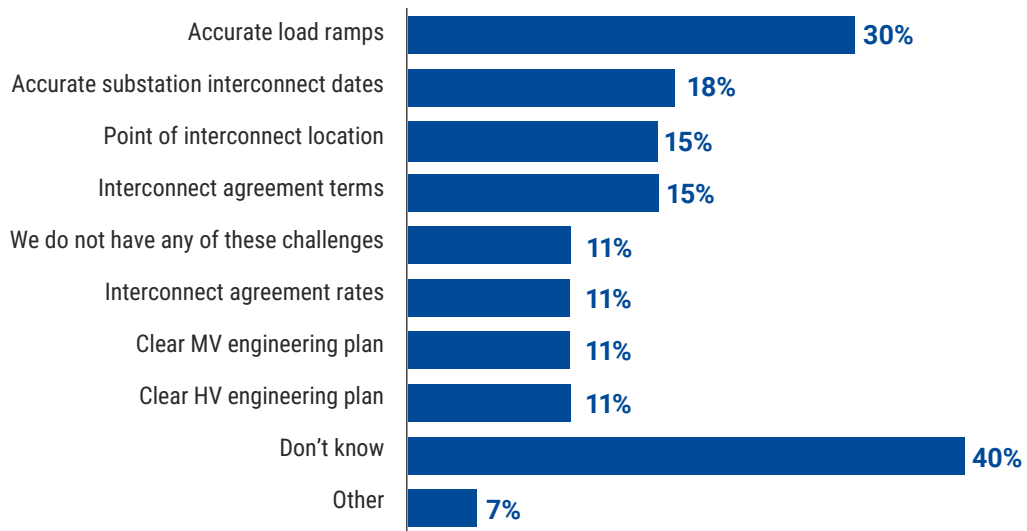
Source: Black & Veatch

- **Somewhat confident** 41%
- Not very confident 36%
- Not at all confident 9%
- Very confident 14%

Figure 8

What information from data center clients has made it challenging to plan for? (Select all that apply)

Source: Black & Veatch

Category	Percentage
Accurate load ramps	30%
Accurate substation interconnect dates	18%
Point of interconnect location	15%
Interconnect agreement terms	15%
We do not have any of these challenges	11%
Interconnect agreement rates	11%
Clear MV engineering plan	11%
Clear HV engineering plan	11%
Don't know	40%
Other	7%

Such lack of certainty was evident when respondents were asked what information from data centers made planning challenging. Nearly one-third (30 percent) pointed to accurate load ramps, while another 18 percent said accurate substation interconnect dates would be helpful *(Figure 8)*. The numbers here paint a picture of contrasting accuracy, with one group of respondents asking for full load capacity on day one with peak demand only being a fraction of that, while increasing demand comes years later and creates grid operation challenges as well as forecasting challenges.

A Changing Equation

Data centers used to have a specific location in mind — along with the size of the proposed data center, based on the clients wanting data space — when they approached utilities. But with the uncertainty of AI data center demand and their much larger power requirements, existing power supply is strained, and the equation has flipped.

Figure 9

What can data centers do to improve the speed of their project getting completed?

(Select all that apply)

Source: Black & Veatch

Load clarity	40%
Advanced payment	29%
Client furnished equipment	19%
Client exporting power to grid	11%
Other	8%
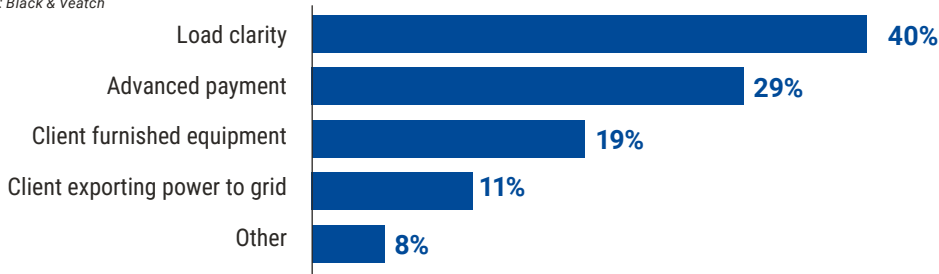
Data centers are reporting that if they find the power or build the power generation themselves, then they'll just build on the open market and plan for flexibility and expansion, due to the seemingly insatiable appetite for traditional and AI data center space. This does not bode well for utilities that must go before their local public utility commissions (PUC) and justify new power generation to meet the demands.

When asked what data centers can do to improve the speed of their project getting completed, 40 percent unsurprisingly pointed to load clarity *(Figure 9)*. An additional three in 10 cited some form of advance payment, which would help solidify proposals and somewhat pacify the budget question in that its already paid for. Nearly one in five (19 percent) mentioned that client-furnished equipment is helpful — a method data centers are using to advance their projects. Specifically, many are building their own substations or contracting them to an engineering, procurement and construction (EPC) provider, a strategy that can cut the project construction timeline by one-half or even more.

But this tactic isn't a given, as some utilities do not allow clients to build their own substations — or if they do, they don't allow the data center to operate that energy asset. On that topic, one-fifth — 21 percent — of respondents said they do not allow clients to build substations, citing their desire for component standardization and their concerns about client capabilities. Eleven percent permit the construction of substations but not the operation, while 27 percent said they allow both the building and operation of the substation by the client. Working with an EPC familiar with their standards could expedite development.

Figure 10

What are the biggest challenges your utility is facing in getting data centers operational?

(Select all that apply)

Source: Black & Veatch

Challenge	Percentage
Available power	39%
Don't know	34%
Substation upgrades	30%
Transmission capacity	27%
Equipment availability	24%
None of the above	11%
Engineering labor	8%
Construction labor	5%
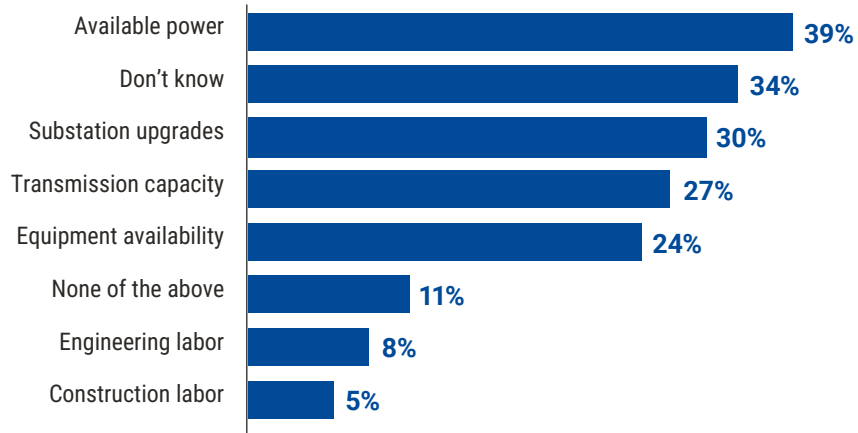
In looking at the biggest challenges utilities face in getting data centers operational, nearly four in 10 (39 percent) cited available power while 30 percent pointed to necessary substation upgrades. Interestingly, almost one in four (24 percent) stated equipment availability was a major concern *(Figure 10)*. In many cases, the wait times for circuit breakers, switchgears, transformers and gas turbines could be three years or more, something entities building substations or their own power generation must consider.

Two Different Worlds Coming Together

Clearly, data center appetite and demand for power exceeds what utilities can currently provide, both from a capacity and transmission standpoint. In most cases, what the data center industry is asking for doesn't exist — it needs to be built.

Utilities and data centers also operate at entirely different speeds. Data centers often are backed by huge venture capitalists and investment funding to meet the ever-increasing traditional data center demand and the currently insatiable AI needs. Data center owners, developers and operators with available capital investment dollars make decisions very quickly and expect their partners to move swiftly on their projects. Conversely, utilities must seek the permission of their regulatory public utility commission (PUC) to build any new generation, forced to plan in terms of years and are continually scrutinized by the PUC, activists and other local influencers.

The bottom line: the two industries have fundamentally different DNAs and must find a consistent, meaningful way to communicate and coordinate, especially as the escalation in demand is in early stages. As AI and digital commerce continue to grow, the demand for co-location and data centers will only intensify. Some utilities have set up data center committees or have special team members to deal with the distinctive nature of data centers, but not enough utilities are set up with this purposeful structure.

Supporting both data center and utility clients, Black & Veatch understands both worlds and can operate as an intermediary, helping navigate the path forward.

Energy
Transition
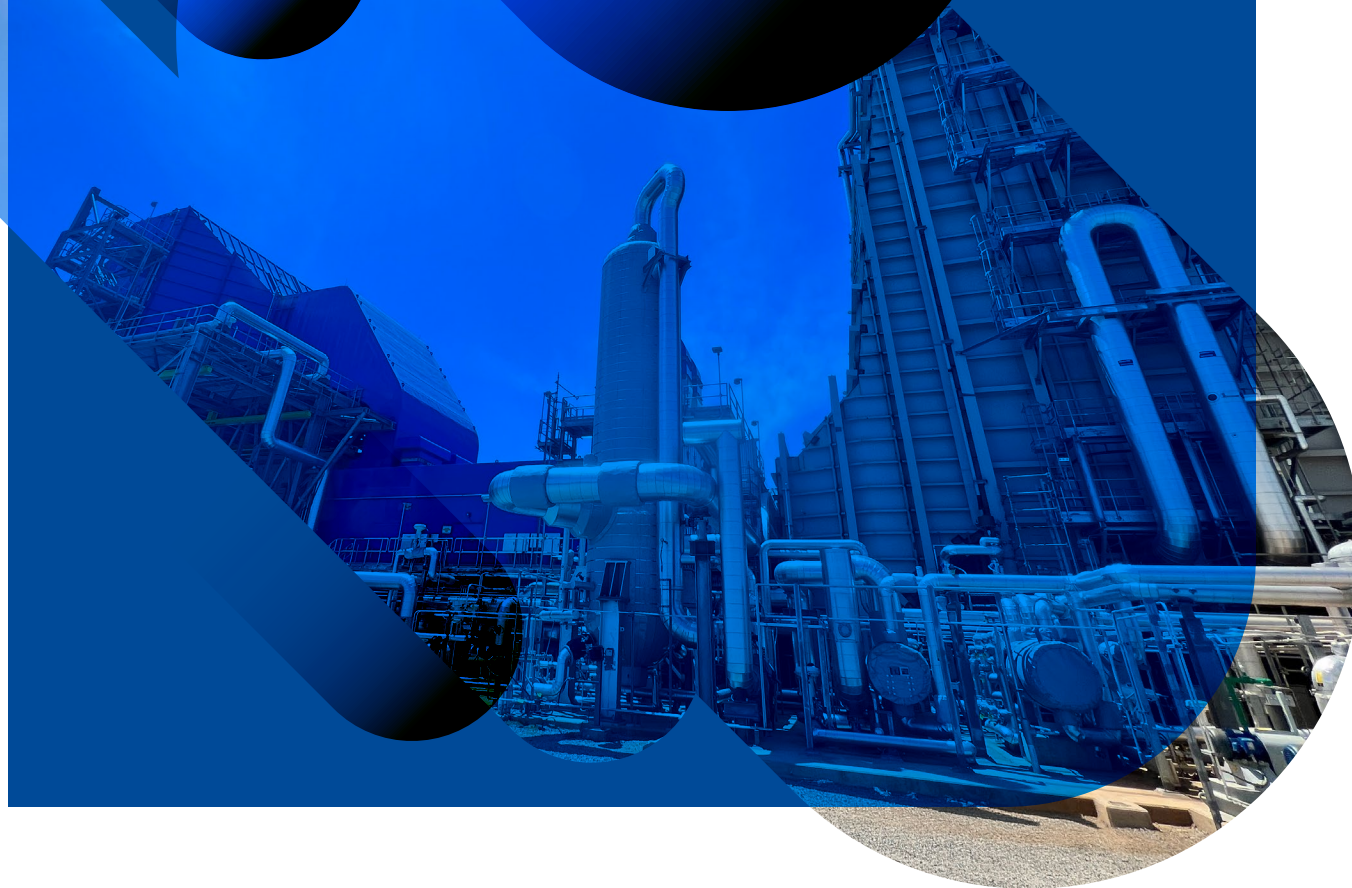
Keys to the Energy Transition

On April 25, 2024, the Biden Administration approved new rules to establish carbon capture and clean fuels guidelines, along with standards for utilities related to certain types of fossil-fuel generation assets. The U.S. Environmental Protection Agency (EPA) estimates that these measures will prevent 617 million metric tons of carbon pollution from existing coal and new natural gas-fired plants between 2028 and 2042. These EPA rules are part of a larger suite of regulations over the past few years aimed at creating market and technology opportunities to achieve the ambitious federal target of 100 percent clean energy by 2035.

Black & Veatch's *2024 Electric Report* — based on expert analysis of almost 700 respondents to a survey of U.S. electric stakeholders — takes the pulse of the U.S. utilities against the headwinds of change in this evolving energy ecosystem, propelled by megatrends such as decarbonization and sustainability.

> New carbon capture and clean fuel guidelines aim to prevent 617 million metric tons of future pollution.

Figure 11

For your organization, how much of a priority is investing in each of the following approaches to reducing greenhouse gas emissions over the next two years? (Select one for each)

Source: Black & Veatch

■ 2024   ▢ 2023

Category	2024	2023
Solar	54%	48%
Energy storage systems	41%	43%
Energy efficiency	40%	50%
Wind	23%	29%
Renewable natural gas	19%	20%
Carbon capture, utilization & storage	16%	20%
Hydrogen	11%	17%
Nature-based solutions	8%	13%
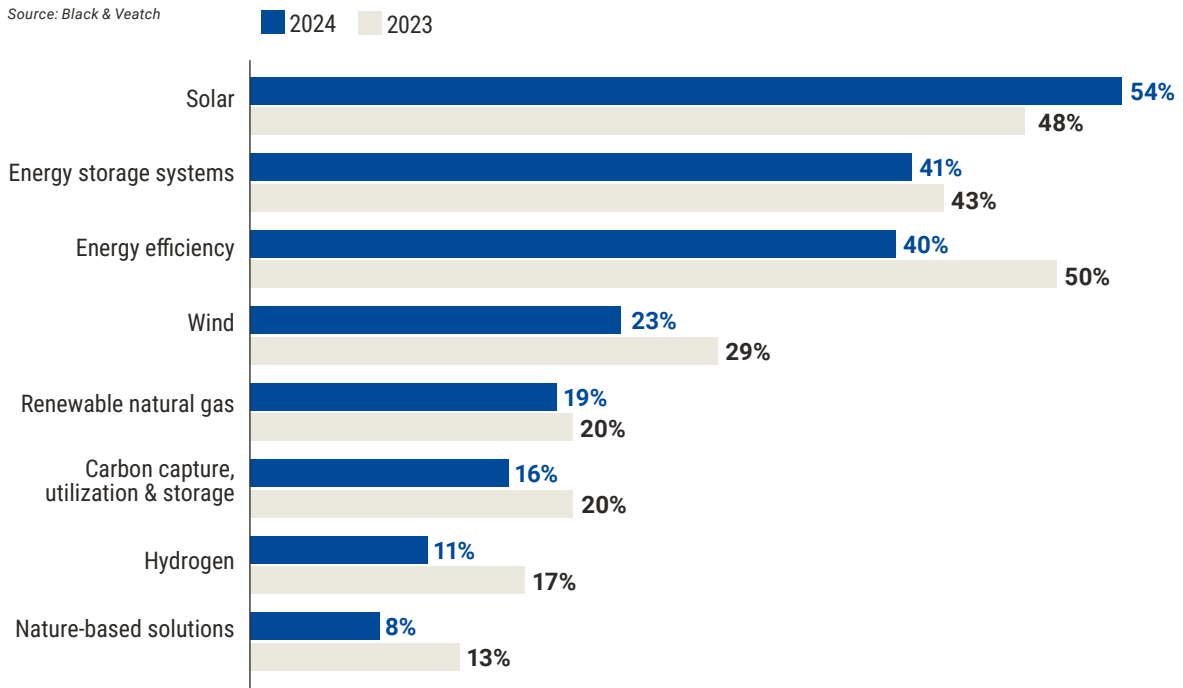
Prioritizing Power Planning

At a time when utilities are examining their priorities to develop energy programs that support their end-users' energy efficiency and initiatives to accelerate cleaner energy solutions, Black & Veatch's latest survey distills important insights about investment priorities, decision trade-offs and drivers.

Perhaps predictably, respondents increasingly are investing in solar technologies. More than half of respondents (54 percent, up 6 percentage points from last year) categorized solar as a high investment priority when it comes to reducing greenhouse gas (GHG) emissions *(Figure 11)*.

Energy storage systems jumped to second as a utility priority at 41 percent (consistent with 43 percent in 2023), passing energy efficiency, which fell to third, dropping 10 points to 40 percent. Utility demand-side management programs have been in place for decades as an important collection of incentives and solutions, but reducing, shifting or optimizing existing energy usage only allows utilities and their customers to address part of their sustainability and emissions reduction requirements.

On April 4, 2024, the EPA announced $20 billion in awards to accelerate clean energy projects across the United States, under the Greenhouse Gas Reduction Fund authorized under the Inflation Reduction Act (IRA) in 2022 to offset the costs of pursuing emissions reduction projects. However, under a broader range of IRA grants, loans and tax incentives, it is challenging for utilities (and private companies) to have clarity about eligibility and the overall potential impact on project economics, which could result in some utilities temporarily holding off on prioritizing investments in renewable natural gas, hydrogen or wind or solar-based solutions until the pathways to funding are clearer.

In a crucial time for the energy transition, integrating supply-side and demand-side energy resources, as well as stacking multiple technologies to determine the net effect in reaching decarbonization goals, is more challenging than ever. The Pew Research Center finds that most Americans support developing alternate energy sources. It follows that utilities are valuing as their highest priority the use of solar — a widely accepted, proven energy source.

Reality Versus Perception

In an election year, it's easy for a politician to speak about their vision for America's future, but what about the reality of it all? Is 100 percent clean energy by 2035 even feasible? With only about a decade left until this goal, the pressure is on.

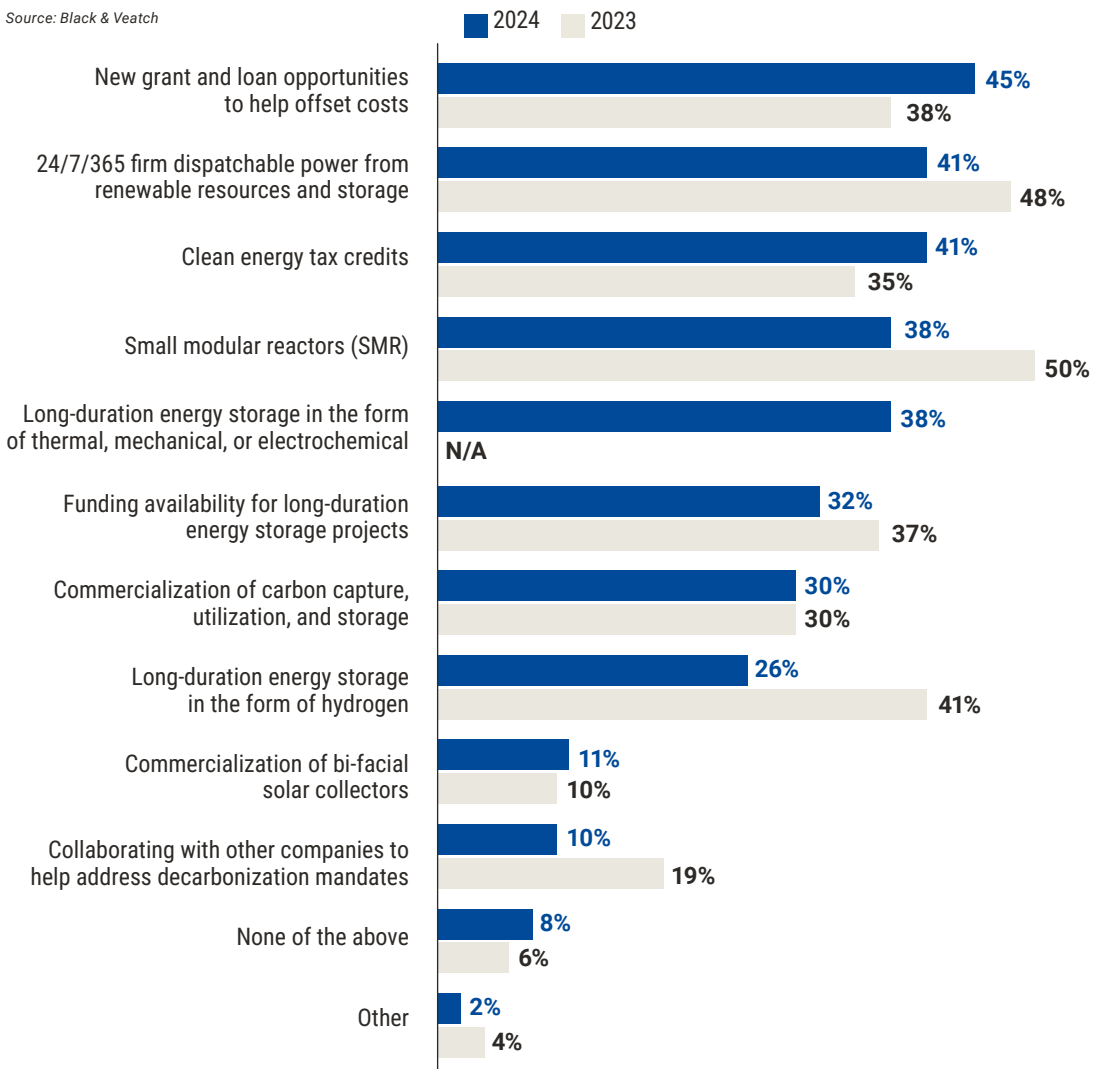So, what's the roadmap? What trends most intrigue U.S. electric sector stakeholders? Respondents weighed in, citing new grant and loan opportunities to help offset costs (45 percent) as the top trend in which they're most interested. Around-the-clock, firm dispatchable power from renewable resources and storage drew 41 percent, followed by clean energy tax credits (41 percent) *(Figure 12).* A takeaway: when two of the top three responses revolve around funding to aid utilities in decarbonization, the energy transition's fate really may come down to money.

Figure 12

In which of the following trends, if any, are you most interested in?
(Select all that apply)

Source: Black & Veatch

Legend: ■ 2024 ☐ 2023

Trend	2024	2023
New grant and loan opportunities to help offset costs	45%	38%
24/7/365 firm dispatchable power from renewable resources and storage	41%	48%
Clean energy tax credits	41%	35%
Small modular reactors (SMR)	38%	50%
Long-duration energy storage in the form of thermal, mechanical, or electrochemical	38%	N/A
Funding availability for long-duration energy storage projects	32%	37%
Commercialization of carbon capture, utilization, and storage	30%	30%
Long-duration energy storage in the form of hydrogen	26%	41%
Commercialization of bi-facial solar collectors	11%	10%
Collaborating with other companies to help address decarbonization mandates	10%	19%
None of the above	8%	6%
Other	2%	4%

At least year over year, small modular reactors (38 percent, down 12 percentage points from 2023) and long-duration energy storage involving hydrogen (26 percent, down from 41 percent) had the sharpest declines among respondents. For hydrogen energy storage, high supporting infrastructure costs and/or geologic siting requirements associated with this solution could be a driving factor in the decline. Hydrogen is difficult to move around and is one of the least efficient fuel sources when created via electrolysis from renewable sources. The deployment of hydrogen hubs that include production, storage, distribution and transportation of hydrogen could spark renewed utility interest in utilizing hydrogen for energy storage as a part of their strategy.

Energy Storage Needs

As decarbonization plans are refined annually and the energy transition becomes more of a reality for utilities, so does the need for energy storage. Not only are utilities generating different forms of energy such as solar or wind, but the intermittent nature of renewable energy requires reliable and widespread energy storage.

According to respondents, almost two-thirds (64 percent) note that they need energy storage, but no more than one week's worth, while only 6 percent report needing it for longer than a week. Since long-duration energy storage is classified as 12 hours or more, 41 percent are looking at long-duration use cases. Meanwhile, almost one-third (30 percent) report that they need less than 12 hours of energy storage. *(Figure 13)*.

Figure 13

Does your organization see a need for both medium- and long-duration energy storage? (Select one)

Source: Black & Veatch

Legend: 2024, 2023, 2022

	2024	2023	2022
Yes, but no more than 8 hours	14%	16%	12%
Yes, but no more than 12 hours	16%	10%	14%
Yes, but no more than 1 day	19%	12%	22%
Yes, but no more than 1 week	16%	24%	24%
Yes, for longer than 1 week	6%	13%	17%
No	5%	5%	2%
Not sure	24%	20%	9%
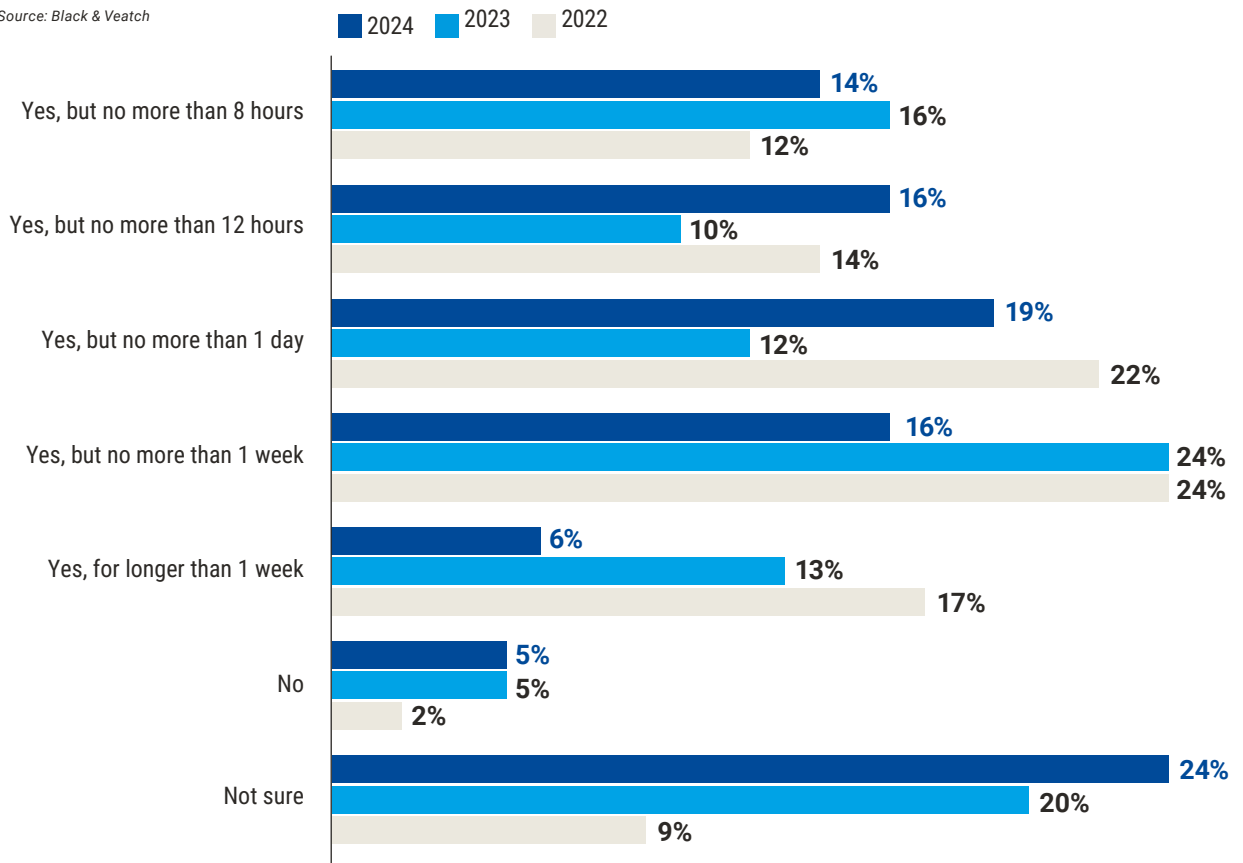
To better understand this data, it's important to understand what assets or functions the respondents are planning to replace with energy storage. As an example, to fully support solar with energy storage alone, the utility would need to replace the hours of the day that the sun doesn't shine with enough storage to fill in the nighttime capacity gap plus additional storage for low production days. On top of that, it is crucial to maintain the storage that could provide grid stability for voltage swings caused by intermittency of these systems. Respondents could be looking at medium- (12 hours or less) or long- (12 hours or more) duration energy storage for all these needs, or only a part.

As the responses shift year to year — with the most notable change being a drop from 24 percent in both 2022 and 2023 to only 16 percent now in terms of needing no more than one week of energy storage — this could mean a variety of things. It could represent refinement in decarbonization plans as emerging technologies become more or less viable as commercial options. Another factor

in storage duration difference is likely the maturity of the respondent's plan. If a utility is still working on the first couple of phases of their plan, they likely don't have as great a need for long duration energy storage yet.

Money and regulatory requirements are the driving force behind the pursuits around cleaner energy, with a critical element being the timing of funding incentives and regulations that would force compliance. Nearly one-third of respondents — 32 percent — cited a need for funding for long-duration energy storage projects as a trend of interest.

When all signs point back to funding, the message is loud and clear. Is the future of the energy transition dependent on consistent, reliable funding? That might just be so. With funding expected to accelerate in the next 12 to 18 months, this picture may look different, and the perception of what the energy industry could look like might start to meet reality.
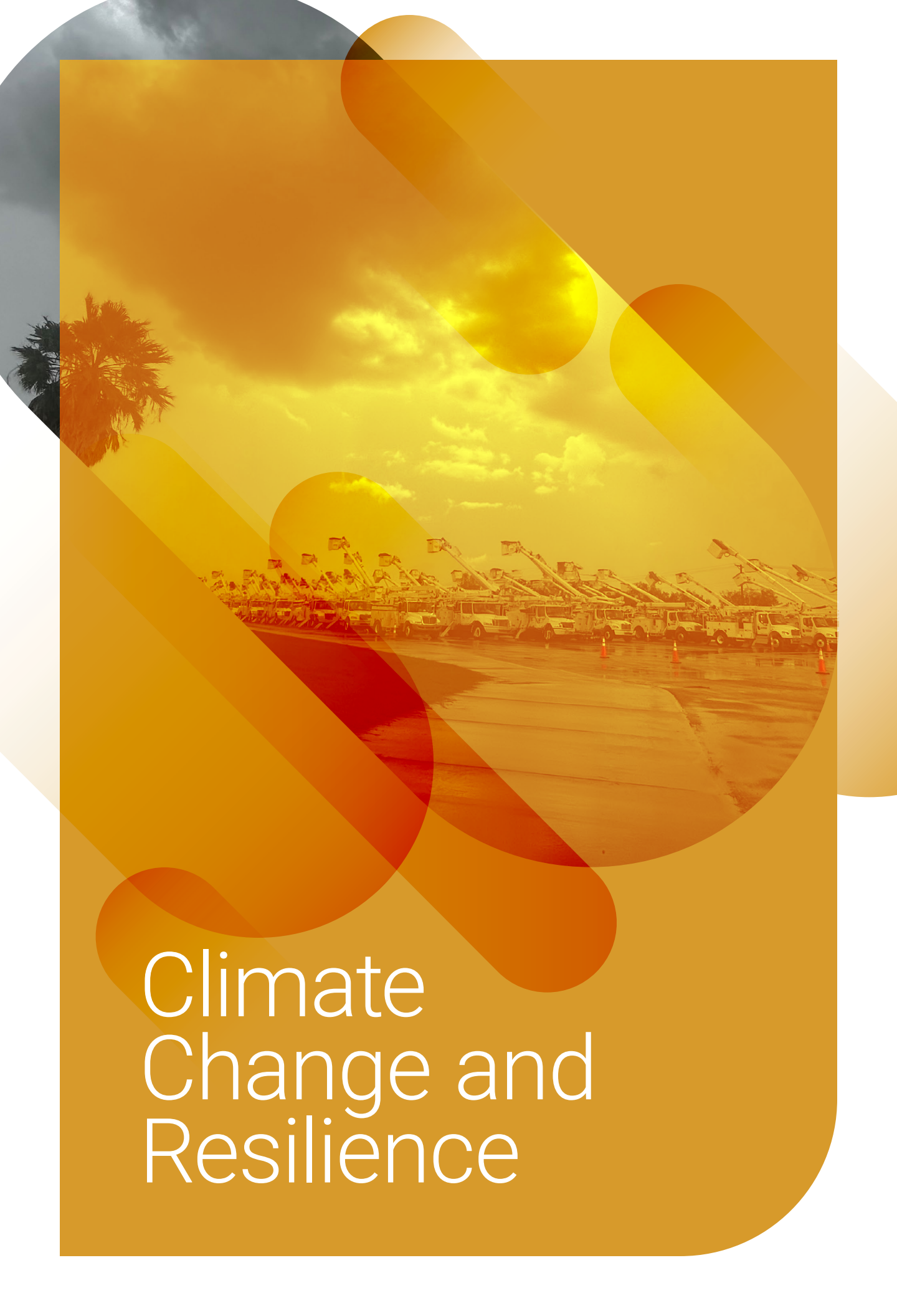
Climate Change and Resilience

Climate Concerns Intensify Nationally, But Recovery and Resiliency Vary by Region

Impacts from severe climate events are affecting utilities in all the regions of our country. While the geographical impacts vary from fire to snow, hurricanes and tornadoes, the threats remain the same in the form of outages, damaged infrastructure and widespread disruption. For this reason, large investments are required, but a one-size-fits-all approach to resiliency doesn't work due to the regional diversity of threats.

Energy utilities from regions where lower risks were reported aren't necessarily better prepared for those risks; they just have alternative threats to consider. With climate modeling data growing in accuracy,

the storm readiness and response teams of energy utilities can be a lot more strategic and effective in their tailored approach to the specific region.

According to responses from nearly 700 U.S. electric sector stakeholders for Black & Veatch's *2024 Electric Report*, cold/ice (66 percent), high wind (62 percent) and heat (49 percent) are the most common threats to system operations, and these concerns vary significantly by region. For example, wildfire is the biggest concern in the West (68 percent) while it's a lesser concern in the Midwest (20 percent) *(Figure 14)*.

Figure 14

Which climatological event(s) have affected your system operations in the past 10 years? (Select all that apply)

Source: Black & Veatch
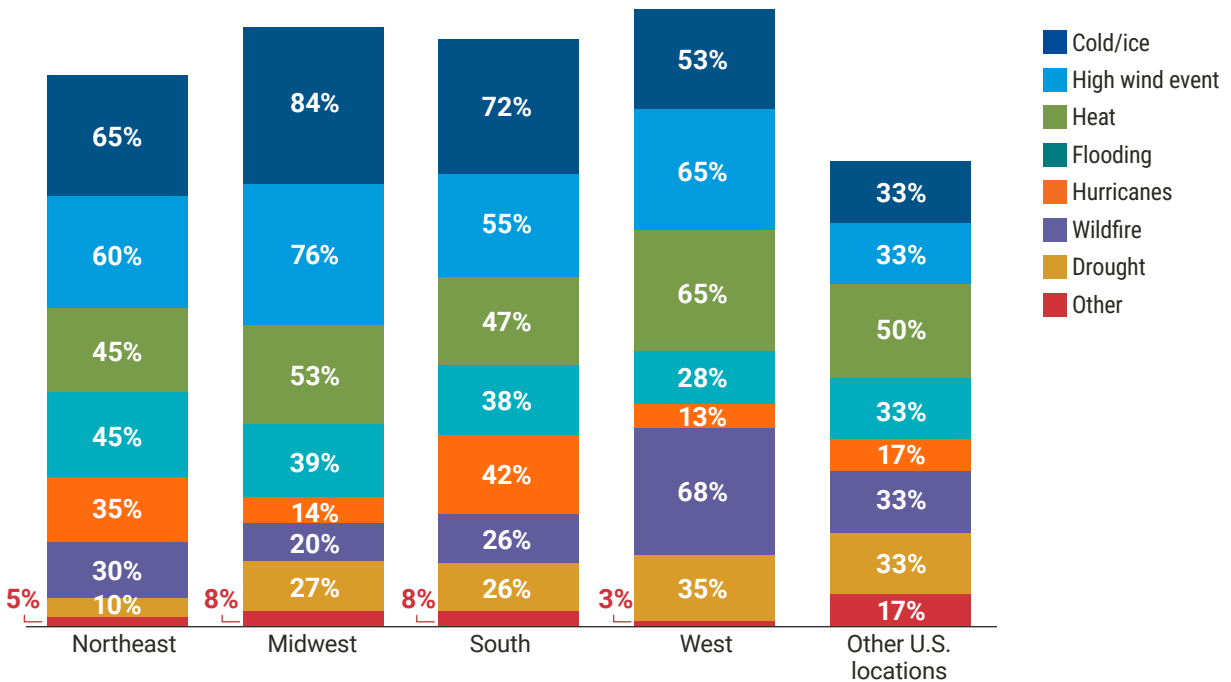
Despite these obstacles, recovery times are being optimized, and those surveyed reported that their specific utility's recovery time has improved from previous years — with 48 percent saying it's taking less time to recover from severe weather events (and just 13 percent saying it's taking more time).

This may be attributed to utilities developing more robust response plans, mutual assistance programs, system automation and improved infrastructure. Utilities also are implementing ways to isolate and address issues before the entire system is affected. Additionally, we're seeing the positive effects of resiliency investments in grid infrastructure a few years after the U.S. government's Infrastructure Investment and Grid Resiliency and Innovation Partnerships (GRIP) Program was established.

Disaster Planning Gains Momentum

Most utilities reported they are prioritizing disaster planning, regardless of regulatory requirements. Thirty-seven percent of respondents say they are motivated by regulatory requirements, while 41 percent said they would be developing disaster plans even if it wasn't regulated.

Only 12 percent responded that resiliency is "probably not" or "definitely not" being given more consideration regarding their investment decisions *(Figure 15)*.

With almost eight in 10 respondents incorporating disaster planning, it's clear that utilities are taking a proactive approach and making progress in their resiliency efforts. But are utilities effectively using data to inform further investments?

Figure 15

Is resiliency being given more consideration in your investment decision-making due to high-impact, low-frequency events (ex. wildfires, freeze events, hurricanes)?
(Select one)

Source: Black & Veatch

Definitely yes — 50%
Probably yes — 30%
Might or might not — 9%
Probably not — 10%
Definitely not — 2%
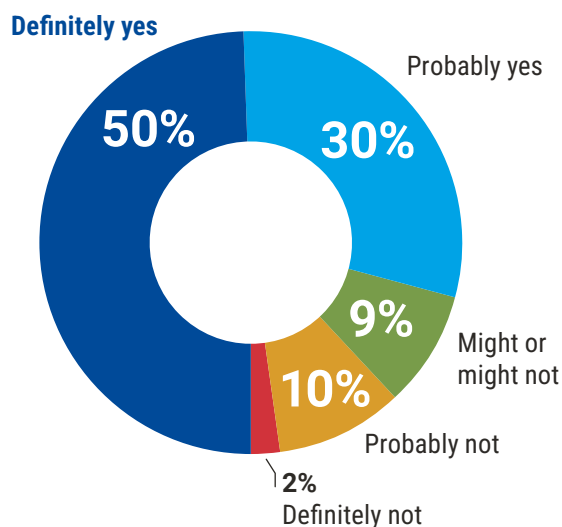
Affordability Still a Major Hurdle

Survey data revealed that the biggest hurdles to climate event mitigation include affordability (55 percent), regulatory scrutiny and rate case approval (38 percent), and difficulty in accurately modeling future events and impact (33 percent). The severity of these top three obstacles increased significantly from 2023 to 2024; conflicting priorities and internal buy-in also became a bigger problem in 2024 (29 percent, up from 22 percent) *(Figure 16)*.
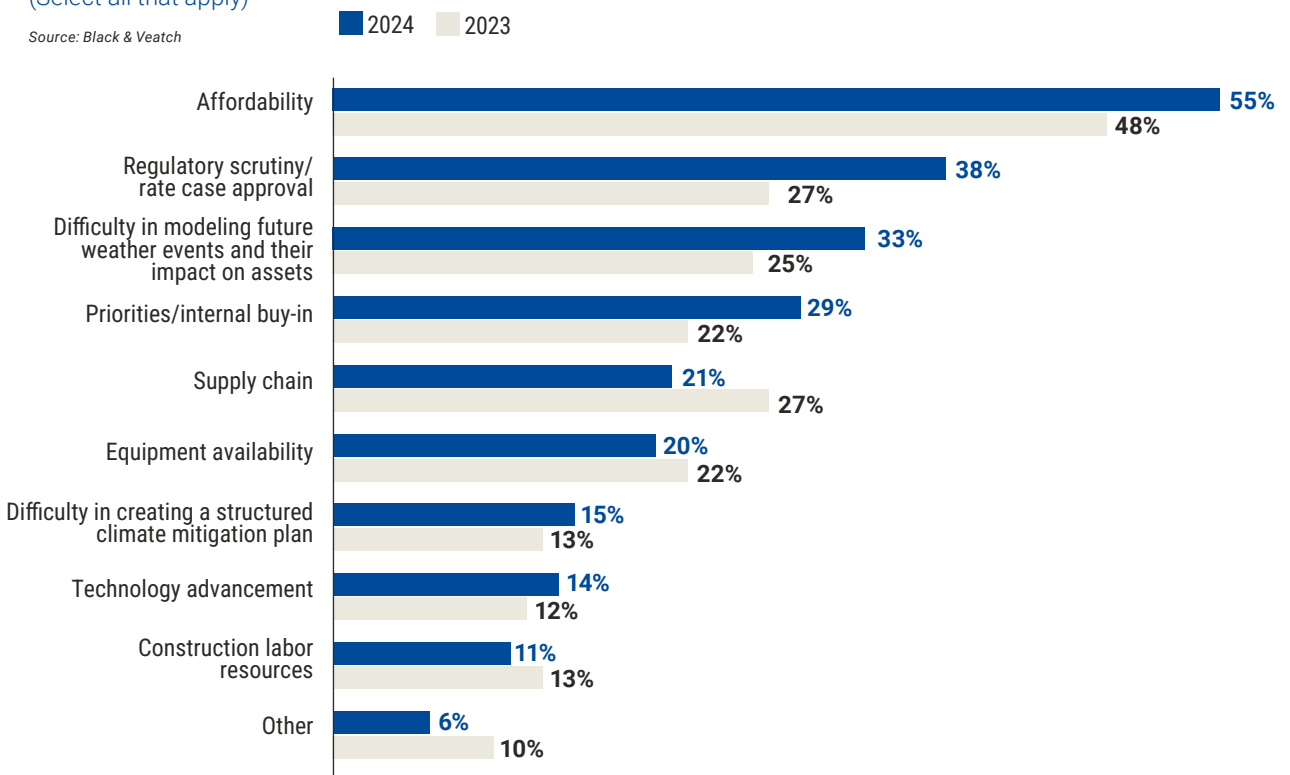
The top two hurdles — affordability and rate case approval — go hand in hand, and the sheer magnitude of investments needed is creating affordability challenges nationwide. Conversations with energy utility clients also have highlighted that more attention is necessary to unlock the power of data analytics for accurate climate modeling.

Figure 16

What are the biggest hurdles to obtaining investment in climate-related mitigation measures?

(Select all that apply)

Source: Black & Veatch

Legend: ■ 2024 □ 2023

Hurdle	2024	2023
Affordability	55%	48%
Regulatory scrutiny/ rate case approval	38%	27%
Difficulty in modeling future weather events and their impact on assets	33%	25%
Priorities/internal buy-in	29%	22%
Supply chain	21%	27%
Equipment availability	20%	22%
Difficulty in creating a structured climate mitigation plan	15%	13%
Technology advancement	14%	12%
Construction labor resources	11%	13%
Other	6%	10%

Infrastructure Investments Needed. But Where?

Despite great progress fueled by the Infrastructure Investment and Jobs Act (IIJA), industry data shows that there's still investment needed for our nation's grid infrastructure to achieve optimal resiliency and reliability. And despite widespread funding and investment, utilities still face affordability and regulatory roadblocks.

Could climate modeling and improved data analytics related to climate-based events and their direct impacts on infrastructure trigger approvals for necessary investments?

Although modeling technology has come a long way, severe weather events remain unpredictable and can, at times, feel like a guessing game, leaving energy utilities wondering where to invest.

Engineering, procurement and construction (EPC) companies such as Black & Veatch are performing studies for major energy providers that include financial models and stakeholder communications that effectively inform how to appropriately set aside money for repairs and optimizations.

Extreme weather events are increasingly frequent and — combined with large-scale energy transition — create a complex environment that requires significant investments across the electric utility sector. Utilities that are proactive in leveraging climate and risk analytics to develop data-driven strategies position themselves best for navigating the unpredictability in weather and regulations.

Cybersecurity

Cybersecurity: Not Just an IT Problem

According to [Forbes Advisor](#), there were 2,365 cyberattacks in 2023, affecting an astounding 343,338,964 people — roughly 10 million more people than the U.S. population. A [USA Today article](#) says "the cost of cybercrime would reach a massive $9.5 trillion in 2024 and exceed $10.5 trillion in 2025," and it "is estimated that attacks on businesses, consumers, governments and devices will happen every two seconds by 2031." With the average data breach costing companies $4.5 million as rapidly evolving technologies make cyber attackers more sophisticated by the day, this isn't a concern anyone has the luxury of ignoring.

Along with the crucial efforts to mitigate the effects of climate change and severe weather events, an aging infrastructure and an aging workforce, and the mandate to keep up with environmental regulations, utilities are working diligently to protect their communities from the added threat of cyberattacks. To safeguard their communities and ensure they can continue to provide essential services, utility companies are taking proactive measures to protect against these cyber threats. While addressing climate change and environmental issues remains a top priority, utilities recognize that cybersecurity is a critical component of their overall strategy.

With cyberattacks becoming increasingly sophisticated and frequent, utilities must remain vigilant in their efforts to protect their systems and data. Failure to do so could result in significant disruptions to services and potentially devastating consequences for the communities they serve.

Black & Veatch's *2024 Electric Report* illustrates the pressing need for investment in cybersecurity across both information technology (IT) and operational technology (OT).

On the IT side, seven in 10 survey respondents consider phishing attacks as their most concerning cyberthreat, followed by ransomware and malware (both at 45 percent) — three methods that tend to dominate headlines. On the OT front, malware (52 percent) and ransomware (47 percent) top the list, with cloud vulnerabilities coming in as a most concerning threat for 35 percent of respondents.

While no defense is invincible, ample solutions exist to increase agility for IT and OT defenses.

One question remains: How exactly is cybersecurity affecting OT?

Measuring Preparedness

The rate of attacks on OT is far outpacing the maturity of most industrial cybersecurity programs. As systems become more connected and automated, they become more exposed to increasingly skilled cyber attackers. Meanwhile, many OT managers don't have a comprehensive view of their networks, leaving them even more vulnerable.

This translates to the pressing dilemma: most utilities' cybersecurity protection plans are too immature to protect their OT assets from cyber threats. When asked if their utility has ever hired or consulted with an external, specialized cybersecurity firm, only one-quarter of survey respondents reported having full-time permanent staff. An additional half of those surveyed responded that they have consulted with outside cybersecurity consultants such as companies like Black & Veatch *(Figure 17)*. While that is good, that also means half have never consulted with an outside expert, leaving them and the public's access to electricity potentially vulnerable to threats.

One-fifth of respondents have never hired or consulted with grid cybersecurity specialists — a concerning number, given the gravity of the threat.

Figure 17

Has your IT or OT ever hired or consulted with a firm or consultant(s) who specializes in grid cybersecurity? (Select all that apply)
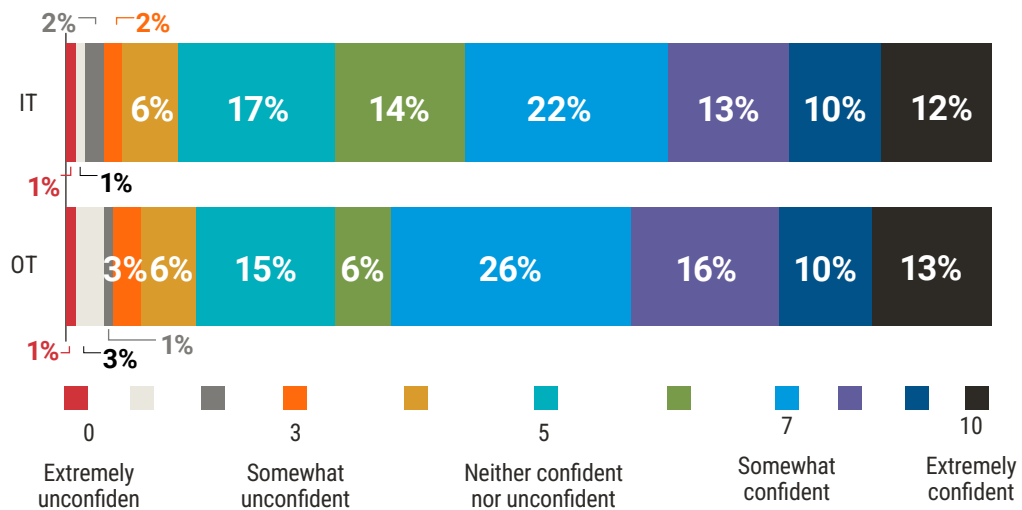
Source: Black & Veatch

Legend: IT, OT

Category	IT	OT
Yes, hired as full-time permanent staff	28%	24%
Yes, consulted with outside experts	45%	50%
Yes, hired on a contract or part-time basis	18%	17%
No	19%	20%
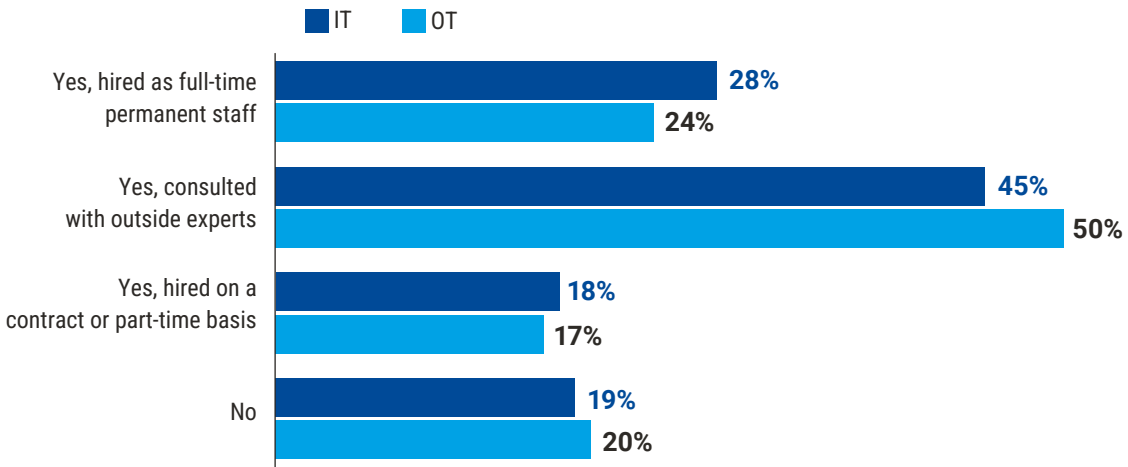
Figure 18

On a scale of one to 10, how confident are you in your utility's ability to recover from a cybersecurity attack? (Select one)

Source: Black & Veatch

The survey shows a level of confidence in resilience should an attack take place. On the IT side, seven in 10 respondents reported some level of confidence, with 12 percent casting themselves as "extremely confident." Those numbers virtually mirror the sentiment on the OT side, where 71 percent express some level of confidence and 13 percent say they're extremely confident *(Figure 18)*.

The figures at hand paint a picture of an industry ready and armed for a cyberattack, but the question remains: could they withstand just any cyberattack? Additionally, recovery might be an objective assurance, but the length at which it takes to recover becomes a subjective matter, requiring more context around the utility's specific plans.

Since the attackers are becoming more sophisticated, it is especially crucial for utilities to prepare and have a plan and resources in place for a speedy recovery that minimizes the number of households and businesses affected.

Figure 19

Which of the following efforts are needed most for your utility to mitigate cybersecurity risks?
(Select all that apply)

Source: Black & Veatch

Effort	Percent
Threat intelligence	36%
Monitoring and response	34%
Vulnerability assessment/management	31%
Incident response plan	25%
Hardening	23%
Recovery	21%
Compliance management	18%
Compliance assessments	18%
Policy development	17%
Asset inventory/management	17%
Maturity assessments	12%
Table-top exercises	11%
Red teaming	7%
Segmentation	5%
Program stand-up	3%
Other	11%
None of the above	21%

Compliance as a Starting Point

The industry is on the precipice of big changes to meet regulatory standards in the constantly evolving energy ecosystem. But compliance alone might be the go-to standard for a far greater number than the industry should feel comfortable with.

When asked to identify what efforts are needed most by their utility to better mitigate cyber risks, 36 percent pointed to threat intelligence, followed by monitoring and response (34 percent) and vulnerability assessments and management (31 percent) *(Figure 19)*.

With 18 percent of respondents under the impression that compliance is most needed for their utility, it should be clarified: compliance alone is not enough. An organization can be fully compliant and not very secure at all. By its nature, compliance is a lowest common denominator game, often casting a false sense of security. The industry is replete with stories of the fully compliant getting taken down by cyberattacks.

While mere compliance is part of the equation, for almost one-fifth of respondents to answer it as the most needed response shows a disconnect in where we are in the electric industry versus where we need to be.

In this real-life game of chess, utilities would be wise to not conflate compliance with actual security — or see it as merely a box-checking exercise. It's essential for utilities to ensure that their cyber defenses are robust, thoroughly implemented, consistently monitored, and

frequently pressure-tested and revised to remain effective. As threats evolve, so must the protections against them.

Think of it this way: In a neighborhood where most homes have a security alarm, those complemented with ample lighting, warning signs and a gated fence are less likely to be targets.

> To remain effective against cyber threats, utilities must ensure their cyber defenses are robust, thoroughly implemented and evolve as new threats arise.

Rates and Regulations

UNITED STATES
ENVIRONMENTAL
[PROT]ECTION AGENCY

Rate and Regulatory Uncertainty Permeates U.S. Electric Sector Landscape

Already grappling with fierce headwinds that include upgrading and hardening their chronically aging grids in the pressing interest of resilience, U.S. electric utilities have grown to know one of the few certainties is the uncertainty of regulation.

The sector got another jolt of that in April, when the U.S. Environmental Protection Agency unveiled four new major regulations targeting coal and natural gas plants that the EPA insisted would give "regulatory certainty" to the industry and nudge them to invest in transitioning "to a clean energy economy."

One of the measures requires that existing coal and new natural gas power plants deploy carbon capture and sequestration. The move was quickly questioned by industry groups such as the National Rural Electric Cooperative Association, whose CEO, Jim Matheson, warned that the power plant pronouncement would "limit construction of new natural gas plants just as the power sector is facing a surge in demand from factors like transportation electrification and the rapid expansion of data centers to support artificial intelligence, e-commerce and cryptocurrency."

"This barrage of new EPA rules ignores our nation's ongoing electric reliability challenges and is the wrong approach at a critical time for our nation's energy future," Matheson added.

In a heavily regulated industry with so much on its plate, this development punctuates how business-altering regulations can arise and alter market dynamics, underscoring the uncertainty reflected in Black & Veatch's *2024 Electric Report* — expert analysis of survey responses from roughly 700 U.S. electric sector stakeholders.

> U.S. electric utilities know one of the few certainties is the uncertainty of regulation.

The challenging regulatory landscape continues to stoke angst, compounded by the uncertainties that come with November's presidential election and the transformational changes reshaping the market.

The proof: More than half of respondents — 54 percent — see regulation as challenging now, with an additional 26 percent defining it as "somewhat challenging." While devoid of a crystal ball, a little more than one-third expect regulations to be challenging in three years and 36 percent anticipate it to continue to be a challenge in the next half decade.

Regulation, Grid Modernization and the Climate

In an industry where federal and state regulators hold so many cards, respondents asked to rank their challenges cited environmental regulations second only to access to capital investment, with economic regulation — rates — placing sixth, behind grid stability, reliability and the nagging challenge of dealing with an aging infrastructure.

With an evolving regulatory landscape across the United States, planning by utilities exploring needed upgrades to make grids more accommodating of surging renewable energy sources and more resilient to extreme weather events fueled by climate change has never been more challenging.

Without question, utilities appear to understand who holds the hammer, with respondents putting regulators at the top of the list of stakeholders who provide their enterprises with the most motivation to make climate change-related investments, edging out end users.

While many electric utilities see merit in bolstering their infrastructures' climate resilience, the difficulty in recovering that cost from ratepayers likely to object to the prospect of paying more for their electrons keeps such projects from being viable, no matter the utility's commitment to it.

On that front, respondents asked to identify their biggest hurdles to obtaining investment to harden their systems against climate change events put affordability (55 percent) atop the list, followed by — you guessed it — regulatory scrutiny (38 percent) and difficulty in modeling future weather events and their impact on assets (33 percent).

Looking ahead over the next three to five years, the top concern among survey respondents about grid development included 32 percent pointing to the lag in getting regulatory approvals for system changes, matching the results from last year. That only was trumped by the generation mix with fewer traditional baseload units and more utility-scale renewable sources (46 percent) and lingering post-COVID supply chain issues for equipment (36 percent).

As Black & Veatch has noted in the past, it's hard to predict the future. As the proliferation of such energy-intensive data centers accelerates, load forecasters have a burdensome job, and their predictions can drive billions of dollars in investments, resulting in changes to the electric rates paid by residential and commercial customers. 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 diverse customer profiles.

Add regulatory uncertainty to the mix, and the path forward becomes numbing in an environment in which nothing is clear or guaranteed. That might help explain why many U.S. electric utilities remain passive about investing in grid upgrades — especially those related to climate action — without clarity on how they can recover those costs.

About the Authors

About the Authors

Christian Alejandro is an operational technology (OT) cybersecurity specialist at Black & Veatch's industrial cybersecurity practice. With his technical knowledge and background in mechanical engineering, he possesses a unique skill set that allows him to support companies in their cybersecurity journey. In his previous role at ABS Group, Alejandro collaborated with clients in critical infrastructure industries such as transportation, manufacturing, oil and gas, and power to implement cybersecurity programs, achieve compliance and enhance their cybersecurity posture. He has a strong background in compliance requirements including NIST, ISA/IEC 62443 and NERC CIP, as well as in OT/ICS networks and systems. He is certified in CompTIA Security + and various SANS certifications.

Ian Bramson is vice president of Black & Veatch's global industrial cybersecurity practice, responsible for the strategy, commercialization and business growth of all the company's integrated cybersecurity solutions and capabilities. Bramson has more than 25 years of experience solving the business challenges of cybersecurity, risk management and digital transformation. Before joining Black & Veatch in early 2024, Bramson built two successful cybersecurity consulting services backed by global sales organizations and cybersecurity programs across multiple industries.

Kristen Braun is an associate vice president and nuclear business line director for Black & Veatch. She has more than 25 years of cross-functional project experience from proposal development and engineering design through construction execution and project management. In her role at Black & Veatch she is responsible for the development and execution of the global nuclear strategy. She manages relationships with nuclear customers, technology providers, and partners; working to develop innovative solutions to resolve business and project challenges.

Ann Bui is a senior managing director who leads Black & Veatch's global strategic advisory rates and regulatory market business. Besides providing clients with strategic financial management strategies, her responsibilities include driving growth and innovation to water, electric and gas utilities in financial and advisory planning, advanced metering, sustainability issues, asset integrity and enterprise risk management services. Bui has more than 30 years of experience with clients in North and South America, Europe and Asia.

Jonathan Cristiani serves as Black & Veatch's bioenergy and hydrogen technology manager with nearly two decades of experience in various renewable energy technologies. He provides insights across the global organization in low-carbon fuels, supports front-end project development/consulting assignments, and manages engineering, projects and programs. Cristiani has developed notable expertise with respect to the conversion of biogenic and anthropogenic feedstocks into energy products as well as with the production, storage and utilization of low-carbon hydrogen for a multitude of end uses.

Kristie Deiuliis is a managing director at Black & Veatch, leading decarbonization strategy and planning initiatives. With more than 30 years in the energy industry, Deiuliis leads strategic initiatives, driving the development of all economic, policy, technology, and feasibility assessments for a broad range of global top-tier clients. Her experience spans energy industry domains, including wholesale and retail (regulated and competitive) markets, distributed energy resources, market entry and expansion business cases, and investment strategies for companies seeking to pivot or accelerate specific goals.

Heather Donaldson is managing director of Black & Veatch, 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 managing director of Black & Veatch, where she leads sustainable fuels practice and Black & Veatch's Energy Market Perspective (EMP), a proprietary 25-year forecast of the electric and fuel markets in North America. Fang is an economist with over 20 years of experience providing economic, commercial, and regulatory advisory in natural gas, electricity, carbon, hydrogen/ammonia, renewable diesel and other sustainable fuels markets.

Brandon Greer is the conventional generation portfolio Leader at Black & Veatch which includes gas, nuclear, and hydropower generation. Greer has more than 30 years experience in the power industry.

Susan Herman is Black & Veatch's strategic development lead for the industrial cybersecurity practice. For more than 30 years, she has delivered digital solutions to clients across the government sector, including in the energy, water and education markets. Partnering with clients to drive best-fit digitalization efforts, Herman develops forward-looking solutions that enhance resilience, sustainability, quality, safety, security and transparency. She joined Black & Veatch in 2021 after decades of digital and automation product and service innovation at companies such as Schneider Electric, Invensys and Texas Instruments.

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.

Richard Jacober is an executive vice president and the grid solutions business director at Black & Veatch. With more than 30 years of experience, Jacober leads Black & Veatch's global grid business, which includes transmission, distribution and battery energy storage solutions. He also has joint responsibility with growing the grid self-perform construction business within Black & Veatch and oversees the company's Bird Electric construction subsidiary. His focus is on providing strong execution results while growing grid solutions globally to assist clients in meeting their needs for the energy transition, digitization and grid modernization, as well as infrastructure construction and upgrades that deliver reliable, resilient energy to customers.

Josh Johnson is the integrated solutions portfolio leader at Black & Veatch which includes teams of professionals dedicated to providing solutions and execution delivery of data center campuses and industrial manufacturing facilities. In addition to providing traditional data center planning and design solutions, Johnson's team works across the Black & Veatch enterprise to seamlessly integrate the design and construction of necessary power and water infrastructure collocated on data center campuses.

Ajay Kasarabada is a Black & Veatch associate vice president and director of environmental solutions. His team delivers positive environmental outcomes to clients by aligning with regulations and community needs for selecting optimal build sites, securing timely permits with acceptance certainty, ensuring project financing and transaction diligence, and managing risks for compliance and climate resilience. A 25-year Black & Veatch veteran, Kasarabada brings experience in air quality and greenhouse gas emissions, sustainability, distributed generation and renewable energy, electrification and decarbonization road mapping. He has helped deliver resilient, sustainable and cost-effective solutions to energy clients, water and wastewater utilities, transit districts and critical infrastructure

facilities. He is a member of the Johnson County (Kansas) Sustainability Coalition and a subcommittee chair at U.S. Commerce Department's Environmental Technology Trade Advisory Committee (ETTAC).

Sal Kutub is a managing director who leads the development of solutions and services for digital transformation in clean energy transition. With almost two decades of experience in the power industry, he has collaborated with prominent utilities both domestically and internationally, assisting them in areas such as investment strategy, grant management, transformation roadmap, and change management. Kutub has a wealth of knowledge in system implementation and digital transformation.

Kevin Ludwig is a vice president and grid portfolio 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.

Bryan Mandelbaum, as associate vice president and director of hydrogen and ammonia solutions for Black & Veatch, integrates the global breadth and depth of the company's to help clients transform their energy requirements sustainably and reliably. Mandelbaum is responsible for implementing industry-leading solutions across the full range of our project execution capabilities, from early feasibility studies and engineering through turnkey EPC and long-term O&M scopes.

Keon McEwen is the head of solutions development at Black & Veatch's industrial cybersecurity practice. His expertise includes cybersecurity, control systems, automation and data. He brings a unique combination of technical expertise and market development acumen to help companies achieve success during pivotal moments of change. He has designed, built and managed Industrial Security Operations Centers (ISOC) with international reach across critical infrastructure industries such as power, oil & gas, transportation and manufacturing. Keon has a strong knowledge in OT/ICS systems and related compliance requirements including NIST, IMO, ISO and NER CIP.

Katie Muer is the substation solution leader at Black & Veatch. She is responsible for developing substation solutions for clients' needs, ensuring resources and execution plans are strategically aligned and supportive. Muer has 18 years of experience in the power industry. She recently led efforts to scope and design HV substation solutions for data centers to design, build, own and operate. Her work is instrumental to Black & Veatch successfully supporting more than 2,000 substation projects, worth more than $420 million annually (2023).

Amanda O'Dell is the corporate sustainability manager for Black & Veatch. She leads the companies' corporate sustainability program, ensuring wthat the company is setting, tracking and meeting its environmental, social, and governance goals. She provides leadership and diverse analytical support for clients and Black & Veatch's, sustainability programs. She focuses on industry-specific approaches to implementing continuous improvement programs in support of companies' sustainability commitments.

Deepa Poduval is a senior vice president and global sustainability leader for Black & Veatch. In this role, as part of Black & Veatch's leadership team, she is responsible for building and implementing the company's sustainability strategy spanning corporate, client and community initiatives to advance environmental, social, and governance ambitions. Including through her previous role as global advisory leader for Black & Veatch, Poduval brings more than 20 years of cross-industry strategic consulting experience advising clients on multi-billion dollar sustainable infrastructure investments.

Leslie Ponder is a global solutions leader for Black & Veatch's energy and process industries market segment. She is responsible for developing industry-leading solutions through technology innovation. Ponder uses her industry experience and technical acumen to align Black & Veatch's portfolio of advanced energy storage technologies, grid modernization, IT/OT integration, renewable and distributed energy, electrification, decarbonization, and environmental and sustainability solutions for small-scale services engagements through large-scale engineering, procurement, and construction projects.

Mike Prescher is a principal network and cybersecurity architect for Black & Veatch, contributing to critical infrastructure digital modernization projects and cybersecurity strategy and planning initiatives. With more than 25 years in the packet networking and cybersecurity industry, Prescher participates in strategic initiatives, supporting development of policy, technology and feasibility assessments for a broad range of technologies and clients. His experience spans investigation and product development work for OEMs and consultancies and includes contributions to industry standards and frameworks organizations, including the NIST and NERC energy and cyber domains, as well as extensive participation in various thought leadership groups and contributions to IEEE, UTC and others.

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), CO_2 dehydration and compression, CO_2 pipeline and storage, and CO_2 utilization technologies. 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.

Jay Reeder is a Black & Veatch senior air permitting specialist. He is a meteorologist/climatologist who works with team members to deliver positive environmental solutions for clients by aligning with regulations and client needs for securing timely permits with acceptance certainty and risk management for compliance and climate resilience. A 20-year Black & Veatch veteran, Reeder brings experience in air permitting, air dispersion modeling, vapor dispersion modeling, climate studies, and greenhouse gas emission calculations. Reeder has experience helping clients to understand current and future climate solutions and has worked with clients to develop expectations of future climate conditions. He has helped develop resilient, sustainable, and cost-effective climate solutions to energy clients, utility companies, and critical infrastructure facilities.

Sam Scupham is grid execution director for the southeast United States, responsible for delivering engineering and construction projects for transmission, substation and distribution across the region. Scupham has 25 years of industry experience that also includes solar, BESS, and oil and gas.

Ken Sosnick is a managing director and the electric and gas rates and regulatory lead at Black & Veatch. With more than 20 years of experience with electric utilities, natural gas pipelines and crude/product pipelines, Sosnick serves as an expert testimony and provides advisory services for clients in matters before the Federal Energy Regulatory Commission (FERC), state regulators, civil litigation proceedings and management consulting engagements.

Rob Wilhite is a senior vice president at Black & Veatch. With four decades of experience in energy business strategy and utility operations, Wilhite served 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 and 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.

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