Utilities report 2024
White Paper

The "energy trilemma" calls for unique solutions and a holistic approach

Data collection and analysis by

451 Research
S&P Global
Market Intelligence

EATON
Powering Business Worldwide

Introduction

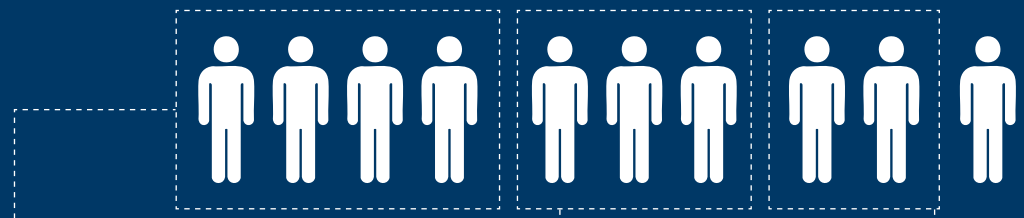
Each country has its unique culture, natural resources and energy mix. Yet, utilities around the globe face the same **trilemma**:

Ensuring energy security through reliable and resilient supply systems

Unlocking energy security and affordability

Advancing environmental sustainability by ensuring clean air and water

Globally, utilities are challenged with making energy more sustainable while accommodating growing demand as we progress toward an all-electric society. In the course of this progression, over the next 5-10 years:



4 out of 10 utilities expect that load demand will grow by up to

24%

3 out of 10 utilities think demand will grow between

25%-49%

2 out of 10 utilities expect demand growth of

50%-74%

The primary drivers of demand growth vary across countries and place strain on different parts of the grid.

These are key takeaways from a survey commissioned by Eaton and conducted by 451 Research among 250 employees of small, midsize and large utilities. All respondents are involved in their organizations' digital transformation efforts, and the respondent companies are based in 14 countries across North America, Europe, the Middle East and Asia.

The Take

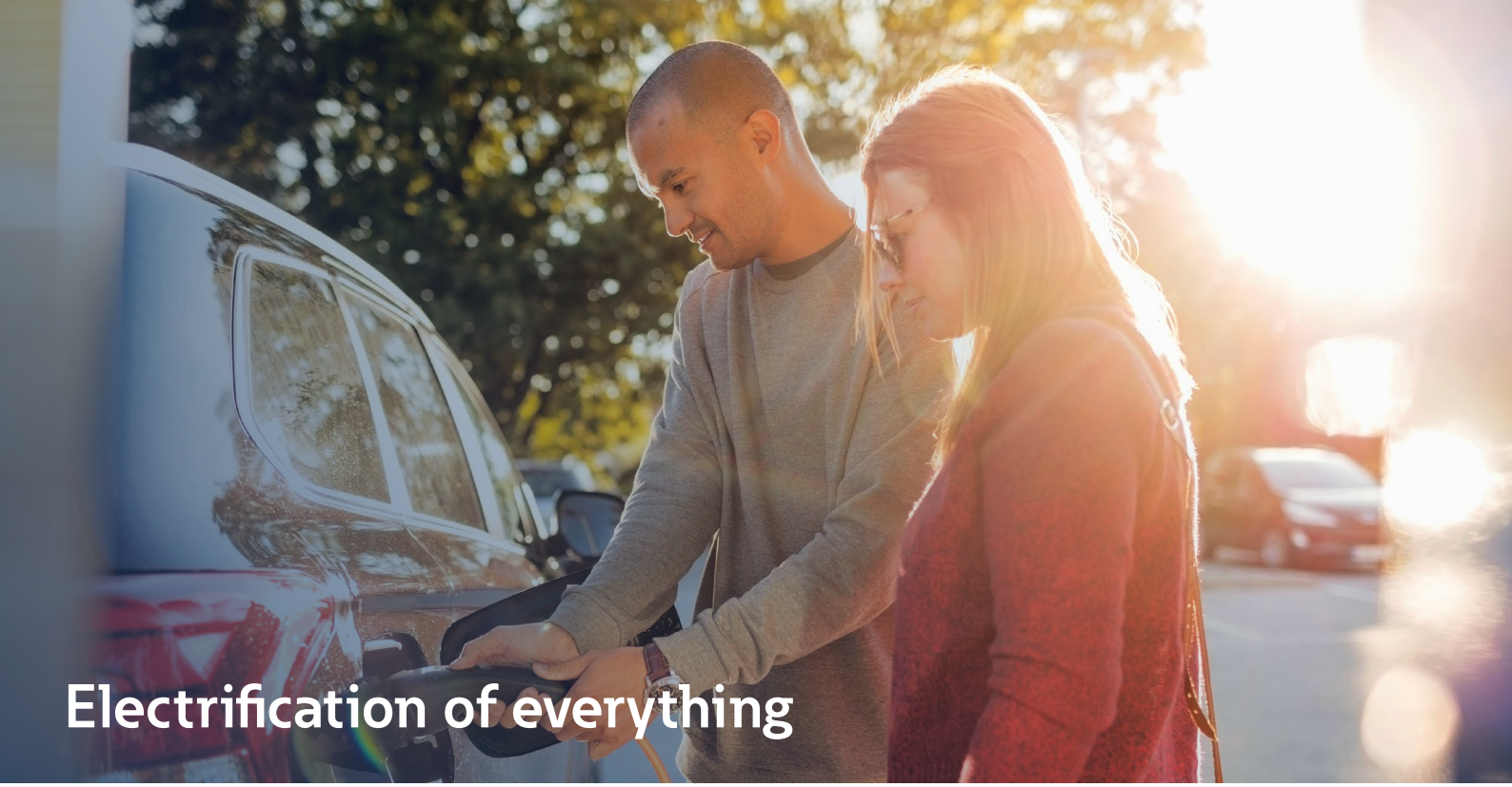
The interrelated challenges of the electrification of everything, decarbonization and resilience require a holistic approach from utilities. As the demand for electricity continues to grow, utilities must modernize their infrastructure and embrace digitalization to optimize energy distribution and enhance grid stability. Decarbonization efforts must focus on increasing renewable energy integration while addressing the limitations posed by intermittent sources. Additionally, improving resilience is critical for ensuring continuity of power supply in the face of climate change and other crises. Addressing the energy trilemma requires strategic investments alongside careful planning to meet evolving regulatory, economic and societal standards while maintaining cost-effectiveness and reliability.

The evolution of the smart grid

The electricity grid has undergone a significant transformation over the past few decades, evolving from a one-directional system to a bidirectional energy ecosystem. Initially designed to transmit power solely from centralized plants to consumers, the rise of Distributed Energy Resources (DERs) such as rooftop solar panels, wind turbines and electric vehicles has enabled consumers to generate electricity and feed it back into the grid. This shift requires utilities to modernize their infrastructure with smart grid technologies, including advanced metering and real-time monitoring, to manage the complex two-way flow of electricity and data. As a result, balancing supply and demand has become more complex, necessitating improved forecasting, increased grid flexibility and effective energy storage solutions. Traditional utility business models are evolving toward grid management and energy-as-a-service frameworks, with new rate structures that encourage grid customers to act as both producers and consumers of electricity.

The evolution of the energy ecosystem parallels these changes to the grid, involving various stakeholders that contribute uniquely to energy delivery. While traditional generation facilities remain significant, the emergence of DERs has allowed smaller companies to enter the market. Transmission and distribution companies play critical roles in managing high-, medium- and low-voltage networks and integrating local storage and smart meters. Additionally, energy retailers offer bundled services that complicate demand-side management. However, grid modernization faces challenges in coordinating diverse stakeholders with distinct regulatory environments.

Integrating new technologies with aging infrastructure requires substantial investment, while managing vast amounts of data raises cybersecurity concerns. Collaboration among stakeholders is essential to ensure that modernization efforts meet the needs of a decentralized, sustainable energy future. Meanwhile, changes in power flows and the evolution of the energy landscape are creating an increasingly complex, interconnected ecosystem in which every change leads to another. The total picture of grid modernization and expanding generation capacity to accommodate load growth presents an end-to-end challenge that requires a holistic approach.



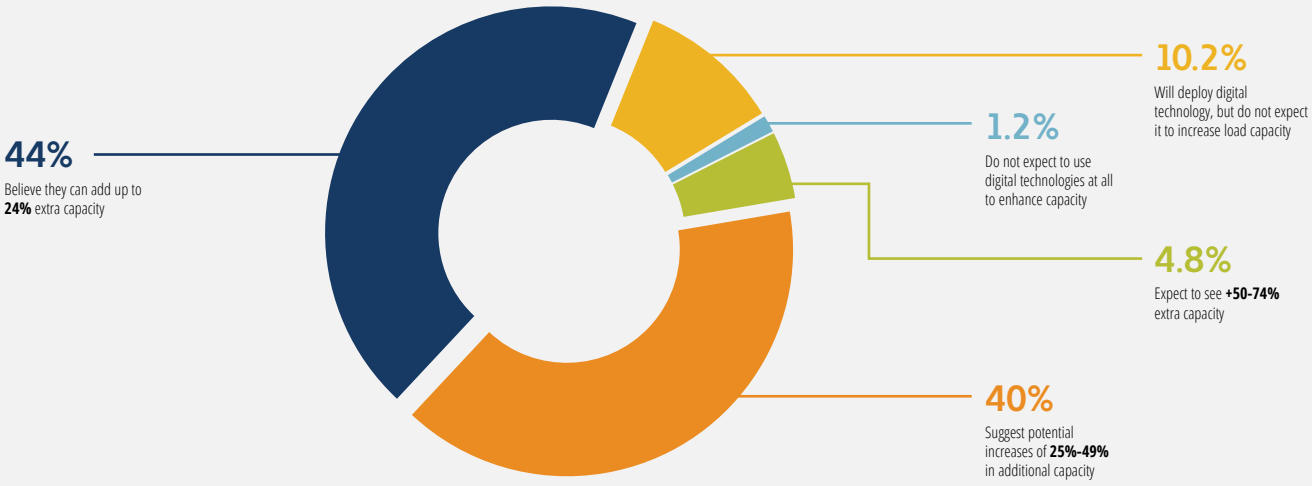
Electrification of everything

The electrification of everything refers to the increasing demand for electricity across sectors, including residential, commercial, transportation and industrial. According to our survey, utilities anticipate that organic load growth across the business will be the primary driver (38%), followed by the electrification of transport (32%) and electrification of industry (25%). One industry in particular — data centers — is significantly spiking energy demand as computing and power demands climb due to the explosive growth of generative AI. Given the scope and variety of demand drivers and difficulties, simply adding capacity is not a sufficient solution.

Outdated infrastructure poses a significant challenge in this transition. Utility respondents cite insufficient or outdated infrastructure (44%) as a significant challenge in delivering power service to customers, along with maintaining grid stability (36%). To address these issues, grid modernization is essential, along with more efficient management of existing assets. Digitalization plays a crucial role in this process, improving coordination control and freeing up capacity on the existing grid. By optimizing current assets via digitalization, 44% of utilities believe they can add up to 24% extra capacity, with another 40% suggesting potential increases of 25%-49% (see Figure 1).

Anticipated additional capacity due to digitalization

Figure 1: Digitalization can free up significant grid capacity to offset growing demand



Q. Utilities can add additional load capacity by building new plants or optimizing existing plants. How much increased capacity do you expect to gain specifically via the implementation of digital technologies?

Base: Utility respondents (n=335).
Source: S&P Global and Eaton Digital Transformation Survey 2024.

To effectively manage the transition toward an all-electric society, utilities must embrace innovative solutions that enhance grid performance and reliability. This includes adopting advanced metering infrastructure, real-time monitoring systems and predictive analytics to optimize energy distribution. By leveraging digital technologies, utilities can better balance supply and demand, allowing for more efficient use of existing resources while accommodating the influx of DERs.

Sustainability

Sustainability is a critical goal for utilities as they strive to reduce greenhouse gas emissions. The most straightforward path to sustainability involves increasing the share of renewable energy resources and decommissioning fossil fuel-based plants. In addition to adding DERs, old coal plants are retired and replaced by synchronous condensers. However, the intermittent nature of renewable energy sources presents challenges, particularly in terms of grid stability and reliability.

A significant concern identified in our survey is **load shedding due to excess renewable energy availability, with 37% of utilities recognizing this as a challenge.** While demand management tools, demand response programs and enhanced forecasting can support utilities in balancing demand and supply, there are inherent limitations. Reliance on DERs does not provide the necessary inertia for frequency reserves (i.e., resistance to sudden frequency changes in the power system), which is crucial for maintaining grid stability.

To address these challenges, technology must play a pivotal role in driving down the required inertia percentage for frequency reserves. Digital innovations, such as transitioning from grid-following to grid-forming inverters, can enhance grid responsiveness and stability. By enabling a smarter grid, utilities can effectively integrate a higher percentage of renewable energy while ensuring reliable power supply.

Reliability and resilience

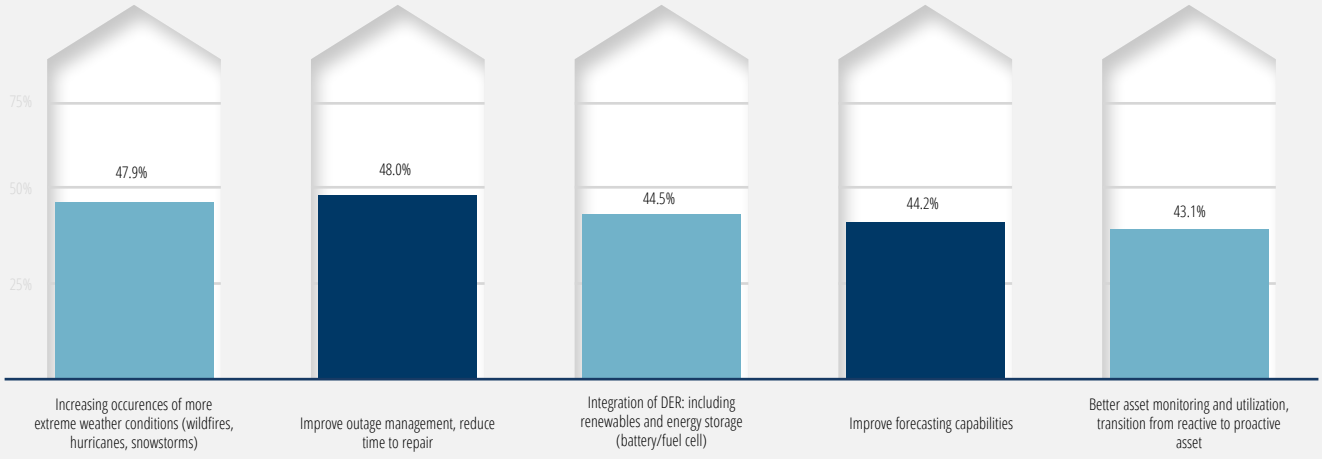
The reliability and resilience of the power supply is threatened by an increase in extreme weather events. Utilities must prioritize the continuity of power supply to mitigate the impacts of these events, as well as other crises such as global pandemics and geopolitical conflicts that contribute to market volatility. According to our survey, managing extreme weather (50%) and improving outage management/reducing repair times (48%) are the primary drivers for grid modernization projects (see Figure 2).

To enhance reliability and resilience, utilities can implement strategies including distribution automation, feeder automation, storm hardening, fire mitigation and undergrounding. Additionally, high-impedance fault detection, line swing management and vegetation management are essential components of a resilient grid. Using data analytics and AI can further drive insights, enabling utilities to anticipate and respond to potential disruptions more effectively.

Investing in resilience not only improves the reliability of power supply but also enhances the overall efficiency of grid operations. By modernizing infrastructure and adopting advanced technologies, utilities can create a more robust energy system capable of withstanding the challenges posed by climate change and other external factors.

Top drivers of grid modernization

Figure 2: Preparing for extreme weather and reducing outages drives grid modernization



Q. Which of the following are drivers for the modernization and digitization of your organization's operations?

Base: Utility respondents (n=346).
Source: S&P Global and Eaton Digital Transformation Survey 2024.

Conclusion

While the mission remains largely the same for utilities worldwide, the particular obstacles and solutions can vary by country or even by individual utility. The survey reflects these variations.

58%

respondents cite the medium-voltage grid as the portion of their network that presents the most challenges followed by

41%

saying that it's the low-voltage grid.

In the US, UK, Mexico and Italy underground cabling comes in third among key challenge areas.

In certain other countries, it is the high-voltage network that comes in third.

The task of increasing capacity and resilience while reducing emissions presents a complex puzzle that needs a holistic approach to balance hardware and software solutions.

Smaller utilities, in particular, could benefit from the support of an end-to-end partnership to address these issues, versus implementing point solutions to address individual improvements.

About the author

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Rich Karpinski is principal analyst and channel lead for the 451 Research Internet of Things and Applied Infrastructure & DevOps channels within S&P Global Market Intelligence. Rich tracks, analyses and anticipates the pace and direction of IoT adoption, as well as the use of IoT to enable vertical industry transformation. As part of that work, he oversees a quarterly survey of IoT adopters and a twice annual survey of operations technology (OT) professionals. Rich's recent areas of concentration include IoT connectivity and managed platform services, IoT edge computing, IT/OT collaboration, IoT market sizing and data flow analysis, IoT digital maturity analysis, and the adoption of IoT use cases across a variety of sectors. Before joining 451 Research (acquired by S&P Global Market Intelligence in 2019), Rich was mobile services analyst for Yankee Group and a technology editor for a range of industry publications in both telecom and enterprise IT. Rich holds a Bachelor of Arts degree from the University of Illinois and a Master of Science degree from Syracuse University.

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Johan Vermij is a senior research analyst for the Internet of Things practice at S&P Global Market Intelligence 451 Research. He covers the digital transformation of the energy sector. His smart energy research covers power and utilities, and oil and gas, as well as distributed energy resources, vehicle-to-grid integration and sustainability. Secondary research areas include operational technology security, the private spaceflight sector and autonomous robotics.

As a Cambridge Institute of Sustainable Leadership (CISL) alumnus, he has a special interest in the role technology plays in sustainable innovation. Prior to joining S&P Global Market Intelligence, he worked as an IoT and security practitioner, managing innovation projects across multiple sectors including aerospace, government and finance.

Learn more at
Eaton.com/utilities

Methodology

This report is based on a commissioned web survey conducted in March/April 2024. The respondents were qualified based on their responsibilities in their organization's operational digital transformation and their influence on the purchase of technology solutions enabling it. Respondent companies were from diverse industries and company sizes of 100+ full-time employees. Total sample size for the study is 1,381 (US, n=300; Canada, n=120; Mexico, n=120; UK, n=120; France, n=120; Germany, n=120; The Netherlands, n=120; Italy, n=120; Denmark, n=44; Finland, n=42; Switzerland, n=34; UAE, n=66; Saudi Arabia, n=55). Roles of the respondents fit into one of four eligible industry sectors: building/facilities services; data center owner/provider (including colocation and edge); manufacturing/industrial; and utilities. Survey respondents were at the director level and above in IT, operational technology, facilities management and energy/sustainability roles. Respondents were screened to be purchase decision-makers for embedded operations technology, having some sort of responsibility or connection in their role to operations technology for the site/facility. Their connection to operations technology could be either for IT or other mechanical ops. The survey was executed blindly — i.e., the survey sponsor's name was not revealed to the participants at any stage of the project.

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Printed in USA
Publication No. WP083057EN
February 2025

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