

INFRASTRUCTURE TRANSITION MONITOR 2025

Getting ready for an electrified world

How AI, digital twins, and software are paving the way towards autonomous grids



Power utilities at a turning point

At a glance:

48%

of power utility leaders believe that the future energy system will be less stable and reliable than it is today

62%

of power utility leaders agree that the pace of the energy transition must accelerate significantly

74%

say that digitalization is a critical enabler of the energy transition

Energy systems globally are undergoing massive transformation. As electrification accelerates across industries and distributed energy resources (DERs) grow at scale, the need for additional grid capacity is rising exponentially. Power utilities are under increasing pressure to respond – not only to the technical demands of a more complex grid – but also to evolving customer expectations and sustainability requirements.

With so much complexity at hand, it's no surprise many energy leaders warn that the energy system of the future could be less stable and reliable than the one in place today.

Existing grid infrastructure cannot keep pace with rising energy demands and consumer demands for greater reliability.

Conventional expansion strategies alone are no longer sufficient to address the multifaceted challenges ahead. Utilities must embrace innovative technologies that unlock grid capacity, modernize aging infrastructure, and advance progress towards sustainability, all while maintaining system stability and power quality.

The good news? Through digitalization, power utilities can accelerate the energy transition now. Technology like AI, digital twins, and software are enabling smarter grid management, paving the way for a more reliable, resilient, and sustainable energy future – faster than ever before.



Electrification: A challenge and an opportunity

The electrification of everything – from transport to industry to buildings – is reshaping the energy landscape. Electric vehicles, electric boilers, and heat pumps are driving exponential growth in electricity demand, pushing consumption to historic heights. Within the next decade, grid capacity will need to double in many regions to meet these new requirements.

The challenge is that most of today's networks were built decades ago for far more predictable operating conditions – where power flows followed stable, well-understood patterns from centralized generation to passive consumers. As renewable energy sources multiply and DERs expand, grids are now exposed to much greater variability and entirely new power flow patterns that differ significantly from original design assumptions. This growing variability is blurring the lines between static long-term planning and real-time operations, requiring a shift from sequential planning to integrated grid planning and algorithm-driven operations.

Together, these shifts expose two critical challenges for power utilities. First, rapid electrification and rising energy demand are straining grid capacity, making it essential to get more out of existing infrastructure. Second, the growing variability of DERs is increasing operational complexity, requiring far greater flexi-

bility and coordination to keep supply and demand in balance across a more dynamic system.

These pressures are most acute at the distribution level. As the energy mix shifts toward lower voltage and decentralized generation, networks designed for predictable, one-way power flows now face congestion, localized overloads, and reduced visibility. This intensifies the need to modernize grid planning and operations to maintain stability and reliability in an era of rapid change.

At the same time, electrification is widely regarded as the most practical way to achieve net zero, but many power utility leaders believe progress is constrained by inadequate grid infrastructure. This disconnect between ambition and capability underscores the need for new ways of planning, managing, and optimizing the grid.

Technology provides the path forward. With AI, digital twins, and grid software, utilities can transform the electrification challenge into an opportunity for lasting progress. Compared to 2023, far more utilities now see digitalization as a strong driver of multiple business goals – including decarbonization (76%, up from 43% in 2023) and energy efficiency (72%, up from 54% in 2023). And a large majority plan to increase investment in digital technologies in the year ahead.

At a glance:

66%

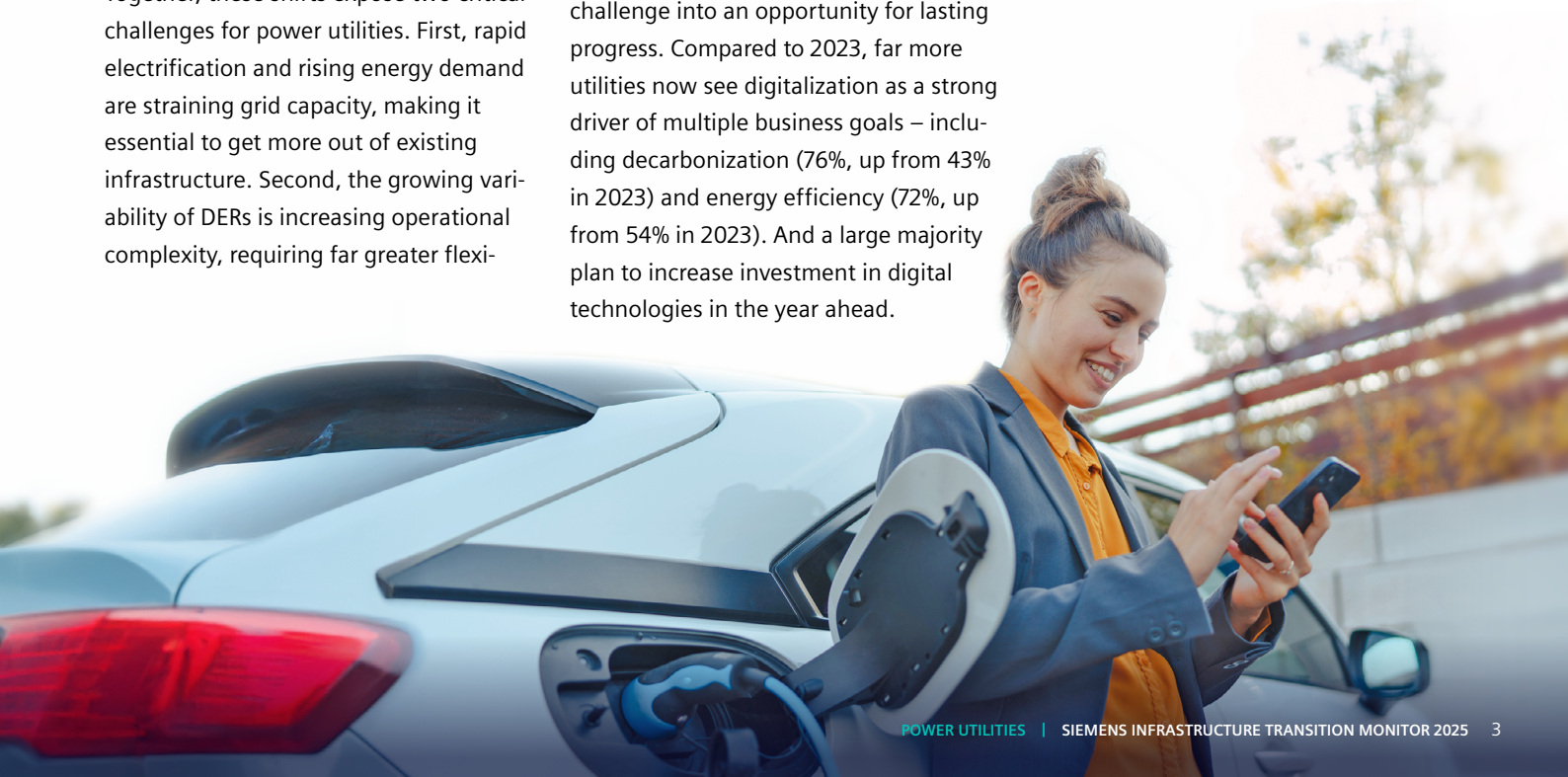
of power utility leaders say electrification is the most feasible way to achieve net zero energy systems

73%

feel that electrification is held back by inadequate grid infrastructure

65%

plan to increase investment in digital technologies in the year ahead



Digitalization and data: the backbone of a more connected, stable grid

To overcome the challenges of electrification, capacity constraints, and aging infrastructure, power utilities are increasingly turning to grid software, digital twins, and advanced data management as cornerstones of grid modernization. These technologies enable operators to visualize, model, and optimize every layer of the energy system – unlocking additional grid capacity, reducing outages, and improving planning and investment decisions. The industry consensus is clear: 72% of power utility leaders believe that smart grids and grid software are critical enablers of the energy transition.

At the heart of this transformation is the ability to connect the physical grid with its digital counterpart. Digital twins allow utilities to create real-time, data-driven models of their networks, combining information from sensors, smart meters, and control systems to provide a single source of truth for operations and planning. These models make it possible to simulate new connection requests, assess the impact of distributed energy resources, and identify bottlenecks before they occur. Two-thirds of power utility leaders rate their organization's progress on scaling digital twin technology as mature or advanced – proof that the industry is rapidly moving beyond experimentation to full-scale implementation.

Yet, digital tools are only as effective as the data that fuels them. For most utilities, managing and integrating the vast amount of grid data generated every second remains a major challenge. In fact, power utility leaders believe that “ensuring important decisions are data-driven” should be their top priority over the next three years, but only 58% consider their organization mature or advanced in this area today.

To close this gap, 74% believe they need smarter solutions to enable rapid data integration, and more than three quarters of power utility leaders plan to increase investment in data integration technologies. The message is clear: making data accessible, accurate, and actionable is no longer optional – it is essential for building a modern, flexible, autonomous grid.

Greater data sharing and interoperability across the energy ecosystem will also be key to strengthening system resilience. As generation becomes more decentralized, coordination between producers, operators, and consumers becomes critical to balance supply and demand in real time. Nearly three-quarters of power utility leaders say that increased data sharing between energy producers and consumers would make the energy system much more resilient. By embracing open data architectures and collaborative platforms, utilities can unlock the full value of their digital transformation – creating grids that are not only smarter but also more transparent, efficient, and customer-focused.

Ultimately, the smart use of data, digital twins, and grid software are transforming how utilities plan, operate, and deliver power. These technologies allow operators to extend the lifespan of existing infrastructure while creating the digital backbone needed to support the shift towards autonomous grids. Together, they represent a decisive step toward a more connected, intelligent grid – one capable of meeting the demands of a fully electrified, sustainable world.

At a glance:



66%

rate their organization's progress on scaling up advanced technologies like AI and digital twins as mature or advanced

#1

Power utility leaders believe “ensuring important decisions are data-driven” should be the top priority over the next three years

77%

say their organization plans to increase investments in data integration technologies

74%

believe increased data sharing between energy producers and consumers would make the energy system much more resilient

AI and autonomous grids: a new foundation for resilience and performance

AI is the transformative technology of our time. With the ability to analyze vast amounts of data and turn it into actionable insights, AI empowers utilities to make faster and more precise decisions in real time. For example, it can forecast demand fluctuations with greater accuracy, optimize power flows to unlock hidden grid capacity, and identify potential faults before they occur – reducing outages and maintenance costs. AI can also help operators simulate complex grid scenarios, prioritize upgrades, and allocate resources more efficiently, accelerating the modernization of aging infrastructure.

Today, most grids are operated using static safety margins that must err on the side of caution, often leaving valuable capacity untapped. AI helps utilities better understand real patterns in supply, demand, and stress points across the network – revealing where the system is approaching physical limits and where flexibility actually exists. By making these dynamics visible in real time, AI enables operators to run grids closer to their true technical capabilities without increasing risk.

As the grid grows increasingly dynamic, AI is becoming central to how utilities manage complexity, build resilience, and drive progress toward a cleaner, more autonomous energy future. In fact, a large majority of power utility leaders say AI will transform how their organization operates over the next three years, and a comparable share say AI is already helping to make critical infrastructure more resilient.

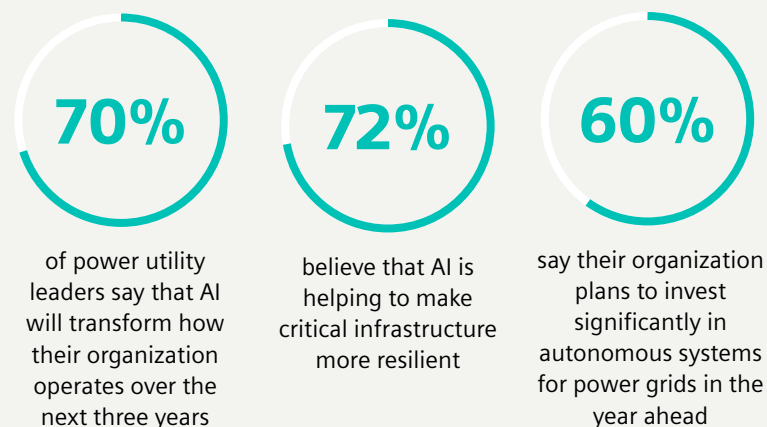
As AI capabilities continue to evolve, they are paving the way toward autonomous grids – self-optimizing, intelligent energy systems that can anticipate, adapt, and act with minimal human intervention. These next-generation grids will continuously balance supply and demand, reroute power in real time, and self-correct to prevent disruptions, enhancing grid resilience and efficiency.

The power utilities industry is already preparing for this transformation: 65% of leaders believe their region is ready to implement autonomous systems in power grids, and a similar majority says their organization plans to invest significantly in autonomous systems for power grids in the year ahead.

This growing commitment reflects confidence in both the maturity of the technology and the tangible benefits it delivers. Most power utility leaders (67%) agree that the benefits of autonomous systems in power grids outweigh the costs, as they expect lower operating costs, greater grid reliability, and improved energy efficiency.

In the future, autonomous grids will not only reduce human error and operational risk but also empower utilities to manage growing complexity, integrate renewable resources seamlessly, and maintain stability in an increasingly electrified and decentralized energy system. Together, AI and autonomous systems are redefining what is possible for the modern power grid – enabling utilities to transition from reactive grid operations to predictive, autonomous management.

At a glance:





CASE STUDY

Future-proofing distribution grid management in Norway

Elvia – Norway's largest power grid operator supplying over two million people – faced numerous challenges due to the rising demand for energy and the exponential increase in distributed energy resources. In fact, Norway has the highest penetration of heat pumps and electric vehicles sales worldwide putting increasing strain on the power grid. To increase grid capacity and gain more transparency of the low-voltage grid, Elvia turned to smart technology.

As a decisive step in its digital transformation journey, Elvia implemented Siemens' Gridscale X LV Insights to create a digital twin of its low-voltage grid. This

solution generates insights by combining data from various sources across the company and offering real-time transparency, allowing Elvia to get more usable grid capacity out of its existing infrastructure and make quicker, more accurate investment decisions.

The results are tangible: data that was once siloed in black boxes is now combined to create a digital twin of the grid. Grid stability has improved, in addition to customer satisfaction.

[Read the entire story.](#)

up to

30%

reduced outage time in low-voltage grids

up to

50%

reduction in model maintenance time

We've got you covered

At Siemens, we are empowering power utilities to build a future where power grids are smarter, cleaner, and more reliable. For this, we're leveraging digitalization and a broad range of applications, systems and services. To name just two of many offerings:

Gridscale X – paving the way for autonomous grid management

Gridscale X provides modular software that is easy to deploy and fast to integrate into any existing IT and OT landscape. It empowers grid operators to turn DERs into valuable assets, operate grids closer to their physical limits, and make well-informed CAPEX investment decisions that yield high returns.

[Learn more.](#)

Electrification X – mastering challenges of the energy transition

Electrification X is one integrated IoT suite for electrification and automation. It helps grid operators manage their energy networks, increase uptime, and improve reliability, asset utilization, cybersecurity, and energy efficiency to reach sustainability goals.

[Learn more.](#)



The rapid rise in electrification is pushing power grids to their limits, increasing both energy demand and operational complexity. To keep pace, utilities must rethink grid planning and operations in a prosumer-centric way and adopt new technologies that connect data, AI, and digital twins to enable autonomous grid management. Gridscale X and Electrification X make this possible – unlocking capacity, strengthening resilience, and securing a more reliable and sustainable electrical grid that serves people.

Franka Krimm

Industry Developer for Power Utilities, Siemens



What's next?

Let's tackle the challenges of the energy transition together. By joining forces, we can drive innovation and build a more sustainable and resilient energy future.

Talk to an expert

Interested in learning more about smart grid infrastructure for power utilities? Whatever questions or challenges you may have, our experts are here to support you.

Discover smart solutions & new opportunities

Learn more about adaptable smart grid infrastructure and technology that accelerates grid transformation, and smart energy solutions that align IT and OT.

Learn from a real case for the low-voltage grid

Elvia – Norway's largest power grid operator supplying over two million people ...

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We create technology to transform the everyday, for everyone. Our world is changing at an unprecedented rate. Demographic change, urbanization, globalization, environmental change, resource efficiency, and digitalization are presenting new challenges and opportunities.

Siemens Smart Infrastructure addresses these topics by combining the real and the digital worlds.

Our technology transforms infrastructure, across buildings, electrification, and grids, at speed and scale, enabling collaborative ecosystems to accelerate our customers digital journey to become more competitive, more resilient, and more sustainable.

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