SIEMENS

SIEMENS INFRASTRUCTURE TRANSITION MONITOR 2025

Smarter grids, **smarter decisions**

Building resilient and sustainable power networks

Executive Summary

The Siemens Infrastructure Transition Monitor 2025 reveals that digitalization is rapidly reshaping global energy infrastructure, with strong momentum across industries and governments. The research finds that over 70 % of energy sector respondents agree digital technologies, particularly AI, grid software, and smart meters, are essential to enabling the energy transition.

Survey findings show that resilient energy supply has become the number one policy priority, rising sharply since 2023. Respondents also report marked progress in areas such as national energy independence, renewable energy expansion, and large-scale energy storage, indicating growing confidence in the energy transition.

There is also increased confidence in national policy, with 63 % saying their country has an effective decarbonization strategy – up from 47 % in 2023. However, challenges remain, and nearly two-thirds of respondents cite regulatory, political, and economic uncertainty as key threats to progress.

Three-quarters of respondents believe AI is already strengthening infrastructure resilience, and many organizations are investing in data integration and smarter technologies to manage rising grid complexity. Yet limited visibility (especially in low-voltage grids) and outdated regulatory models hinder progress.

Most survey participants agree that flexibility markets and autonomous grid technologies are vital for scaling transformation. A clear majority believe the benefits of autonomous systems outweigh the challenges, and over 60 % say their regions are ready to adopt them. More systematic, collaborative approaches between government, utilities, and technology providers will be essential to realize this potential.

What is the 'infrastructure transition?'

The infrastructure transition is the transformation (between 2020 and 2050) of the structures and systems that keep our world functioning, particularly in the areas of energy, industry and the built environment. The energy transition and the decarbonization of industry are the drivers of the infrastructure transition, and forward-looking technologies, policies, and leadership enable it.

The Siemens Infrastructure Transition Monitor (ITM) explores the state of the infrastructure transition, highlights its urgent priorities and lays the path ahead for business and government leaders.

The ITM 2025 is based on a global survey of 1,400 executives from a wide range of industries, complemented by in-depth interviews with leaders and experts from around the world. This chapter explores how energy infrastructure – enabled by digital systems – is evolving toward a net zero future.

1 Resilience first: Digitalization for security and stability

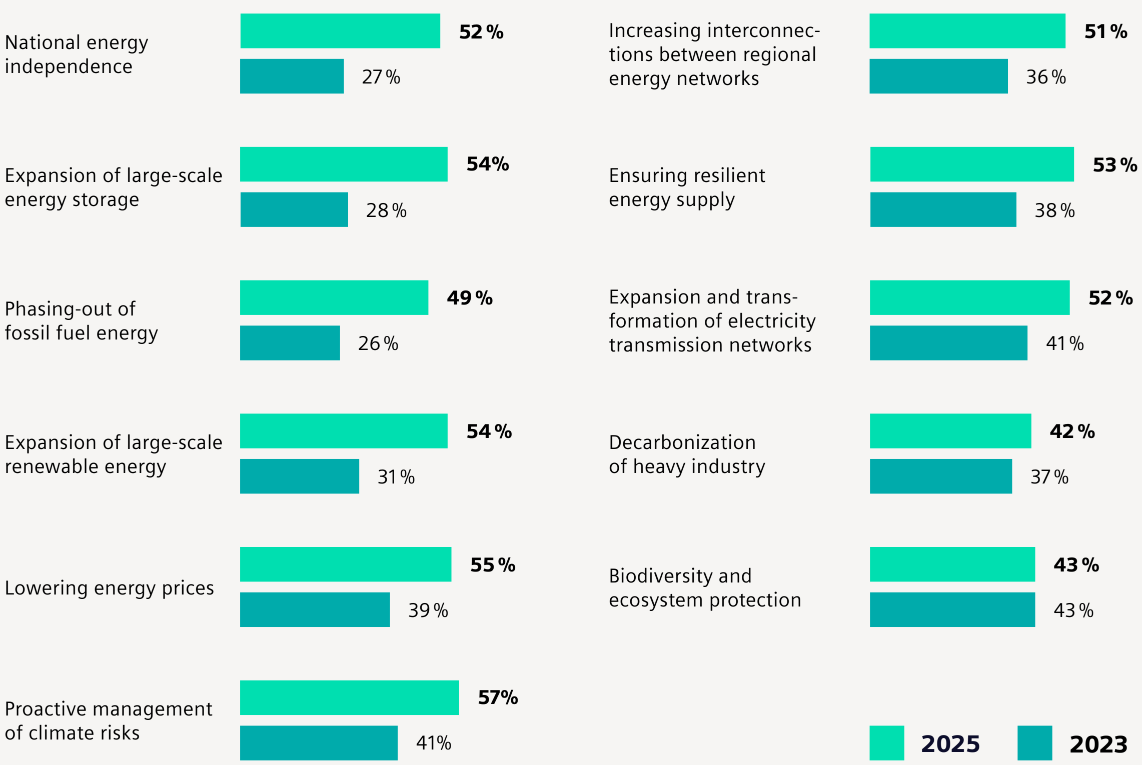
Our ITM 2023 survey found only modest progress toward most country-level infrastructure transition goals. These goals constitute a diverse set of outcomes that collectively define how the world's public and private infrastructure is evolving.

But since then, there has been significant progress. In 2025, survey respondents report that a range of important goals have moved into the mature and advanced phases – in some cases we find nearly twice as many reporting this level of progress, compared to 2023. The biggest increase are in national energy independence; the expansion of large-scale energy storage; the phase-out of fossil fuel energy; and the expansion of large-scale renewable energy.

There are still important areas that need more development. The decarbonization of heavy industry, for example, is advancing much more slowly, while biodiversity/ecosystem protection has stagnated.

Nevertheless, the fact that most indicators have progressed reflects the strong capital investment that has flowed into the energy transition over recent years. According to the International Energy Agency (IEA), global investment in clean energy – including renewable power, grids and storage, low-emissions fuels, nuclear power, and energy efficiency – has increased from US$1.9 trillion in 2023 to US$2.2 trillion in 2025. By contrast, investment in fossil fuels has declined slightly over the same period, from US$1.2 trillion to US$1.1 trillion. The fact that clean energy investment is now double that of fossil fuels is remarkable given the two were roughly on par between 2016 and 2019.

More respondents report being mature or advanced across infrastructure transition goals compared with 2023



Over the past two years, technological advancements, increased manufacturing capacity (particularly in China), and falling input costs have made clean energy technologies such as solar and battery storage more affordable and accelerated their deployment. At the same time, as shown below, the infrastructure transition is also a path to greater energy independence. In an era of increasing geopolitical uncertainty, this is ever more important.

Respondents also told us which goals should have the highest priority for governments in their region over the next three years. Resilient energy supply has risen from third in 2023 to become the top priority in 2025. Meanwhile, national energy independence and the proactive management of climate risks have seen the most significant growth in priority.

Resilient energy supply is seen as the top priority for the next three years

Priority ranking 2025		Priority ranking 2023
Ensuring resilient energy supply	1	Expansion of large-scale renewable energy
Expansion of large-scale renewable energy	2	Expansion of large-scale energy storage
Expansion of large-scale energy storage	3	Ensuring resilient energy supply
Expansion and transformation of electricity transmission networks	4	Increasing interconnections between regional energy networks
National energy independence	5	Biodiversity and ecosystem protection
Proactive management of climate risks	6	Expansion and transformation of electricity transmission networks
Phasing-out of fossil fuel energy	7	Decarbonization of heavy industry
Establishing flexibility mechanisms to balance and stabilize energy networks	8	Phasing-out of fossil fuel energy
Expansion and transformation of electricity distribution networks	9	Lowering energy prices
Biodiversity and ecosystem protection	10	National energy independence
Expasion of electric vehicle charging infrastructure	11	Proactive management of climate risks
Increasing interconnections between regional energy networks	12	
Lowering energy prices	13	
Decarbonization of heavy industry	14	

Biggest Risers Biggest Failers

As the share of renewable energy increases, grids need to stay resilient. To this end, many countries are developing strategies to improve grid stability and enhance resilience through grid interconnections. For example, the UAE is linked to the Gulf Cooperation Council (GCC) Interconnection Authority, which connects its electricity grid with those of Saudi Arabia, Kuwait, Bahrain, Qatar, and Oman. This allows for electricity exchange during peak demand or outages. Wider regional interconnections are also under discussion.

In parallel, countries are investing in advanced energy control centers to manage increasingly dynamic and decentralized energy systems. In the UAE, for instance, a new national energy control center (developed in partnership with Siemens) integrates all local utilities onto a single platform, enabling real-time coordination of renewable energy sources, enhancing load forecasting, and strengthening overall energy security.

Once a grid is sufficiently digitalized and integrated, operators can harness more advanced technologies to improve resilience. Chief among these is AI, which can be used to predict and respond to demand fluctuations, equipment failures, and extreme weather events in real time, effectively enabling faster and smarter decisions. This point is well understood among energy respondents in our survey, where 74 % say that AI is helping to make critical infrastructure more resilient.

CASE STUDY: ACEGASAPSAMGA, ITALY

Maintaining resilience as grids grow more complex

In a bold step toward grid modernization and decarbonization, Italian distribution system operator **AcegasApsAmga** is developing a digital twin of the city of Trieste's medium and low-voltage grid. This initiative leverages Siemens' Gridscale X software to provide real-time situational awareness, optimize grid operations and reduce emissions – particularly from the Port of Trieste, one of Europe's busiest cargo hubs.

The digital twin will enable **AcegasApsAmga** to simulate grid conditions, proactively manage congestion from distributed energy resources, and accurately assess the energy required to meet port demands. It can also help improve the reliability and efficiency of the grid by visualizing congestion and predicting outages using smart meter data. With Trieste's port handling millions of tons of cargo annually, ensuring stable and dependable electricity supply is essential.

As Carlo Andriolo, CEO of **AcegasApsAmga,** noted, the collaboration ensures grid reliability without compromising operations, an essential balance to keep as energy systems evolve in complexity and scale.

2 Empowering infrastructure: The key to achieving electrification goals

Electrification is widely seen as the most feasible way to decarbonize energy systems. However, progress will depend on developing transmission and distribution systems that can manage both greater demand and the new dynamics of the energy system.

As Dr. G Ganesh Das, Chief, Collaboration and Innovation at Tata Power Company puts it: "Electricity's form has not changed. Core equipment, such as transformers, has not evolved much. But demand patterns, per capita consumption, and customer expectations have changed drastically. That's encouraged utilities to adopt digital tools, optimize supply-demand gaps, and predict consumer behavior. It's a shift from being reactive to proactive."

Investments in power grids are important not only for national energy goals. Survey respondents see this as one of the top three ways to speed up their industry's transition to clean energy.

Digitalization and power grid investments among top priorities to speed up the transition to clean energy

A major challenge for distribution grids is limited visibility, a problem compounded by the rapid growth of behind-the-meter energy assets such as solar panels and electric vehicles. This lack of visibility is a challenge because it hinders the ability of grid operators to monitor, predict, and manage the flow of electricity effectively. "In low-voltage grids, there is often no visibility, no mapping, and hardly any active management," says Sabine Erlinghagen, CEO of Siemens Grid Software. "We coined the term 'Flip the Grid' to emphasize the need to manage complexity from the bottom up. We need to understand distributed energy from the consumer's end because that's where the complexity lies."

Software as a nervous system

Digital technologies are crucial to achieving this. As Erlinghagen adds, “At some point, the grid becomes so complex that software isn’t just useful – it’s essential. It becomes the nervous system of the entire energy network.” Crucially, grid software, together with emerging technologies such as AI and digital twins, can help tackle this complexity and maximize the value of existing infrastructure.

For example, smart meter data can be used to create a digital twin of the grid. This will allow utilities to anticipate energy flows, pinpoint risks, evaluate connection requests and identify where flexibility is most important.
The digital twin is important because the raw smart grid data is meaningless without context, but once it is linked to grid topology, it reveals flow patterns, asset impacts, and emerging risks. This is perhaps why 74 % of energy industry survey respondents believe that smart grids and grid software are crucial enablers of the energy transition.

But building the grid of the future is not just about technology. Power grids are regulated assets driven by market forces. However, today’s energy sector regulations, market designs and business models often fail to support goals such as greater visibility, agility and flexibility.

Erlinghagen cites three important examples of the kinds of regulatory characteristics that need to evolve: “Regulation still favors copper over software – capital over operational expenditure. Add to that the strict separation of retailers and grid operators, which prevents the grid operator from being close enough to customers to assess demand and flexibility opportunities. Plus, many markets have first-come-first-served connection queues, which means we can’t prioritize based on what’s best for the system. These regulatory lines, while well-intended, now block progress.”

The rise of flexibility markets

In addition to regulatory reforms, new market mechanisms should be nurtured, particularly those that value flexibility. According to survey respondents, establishing flexibility mechanisms to balance and stabilize energy networks is the least advanced of the national infrastructure transition goals. But this is likely to change soon, because energy respondents rate it as the fifth highest priority (out of 14) for governments in their region over the next three years.

Market-based mechanisms allow grid operators to source flexibility services from distributed energy resources in real time, from EV charging adjustments to distributed battery storage, rather than building overcapacity. They also enable cross-border collaboration, where grid services can be traded across national lines. This dynamic approach uses agile, data-driven decision-making to help maximize the value of existing physical infrastructure.

“We’re not just building infrastructure anymore. We’re building flexibility markets,” says Daniela Haldy-Sellmann, SVP and General Manager Energy and Natural Resources Industries at SAP. “That’s the only way to respond fast enough, cost-effectively, across borders.”

The value of strategic collaboration

Energy system transformation requires an integrated approach. In our survey, most respondents (62 %) believe that different parts of the energy system (e.g., electricity, gas, hydrogen, supporting infrastructure and consumers) should be managed as a single, coordinated whole. This requires greater collaboration between stakeholders, particularly between business and government, and between grid operators and energy market participants. Our survey finds that the former has improved significantly, with 59 % now agreeing that government and business collaborate closely over energy system policies – up from 40 % in 2023.

Examples of greater collaboration are emerging around the world. "We helped define India's smart grid roadmap," says Dr. Ganesh Das of Tata Power. "Through partnerships with global utilities, technology partners and institutions, we introduced two-way meters, advanced distribution management, and communications. We involved policy makers, state regulatory commissions, and ministries to build robust, intelligent frameworks. The Indian government drew on this work to develop the National Smart Grid Mission, which is now funding pilot projects and rolling out smart grids nationally. That's the power of strategic collaboration – starting with tech and ending with national transformation."

CASE STUDY: ALLIANDER, NETHERLANDS

Maximizing grid infrastructure for flexibility, utilization, and scalability

Dutch network company **Alliander,** needed to develop more flexible, intelligent grid management to address mounting congestion and support the energy transition. Serving 3.5 million customers, Alliander faces both rising energy demand and integration challenges, with some users facing up to 10-year waits for grid connections.

Alliander has partnered with Siemens to implement Gridscale X software. This technology – drawing on an open innovation ecosystem – will empower **Alliander** to boost grid utilization by up to 30 %. This is a crucial improvement amid surging adoption of renewables, which now supply over half of the Netherlands' energy.

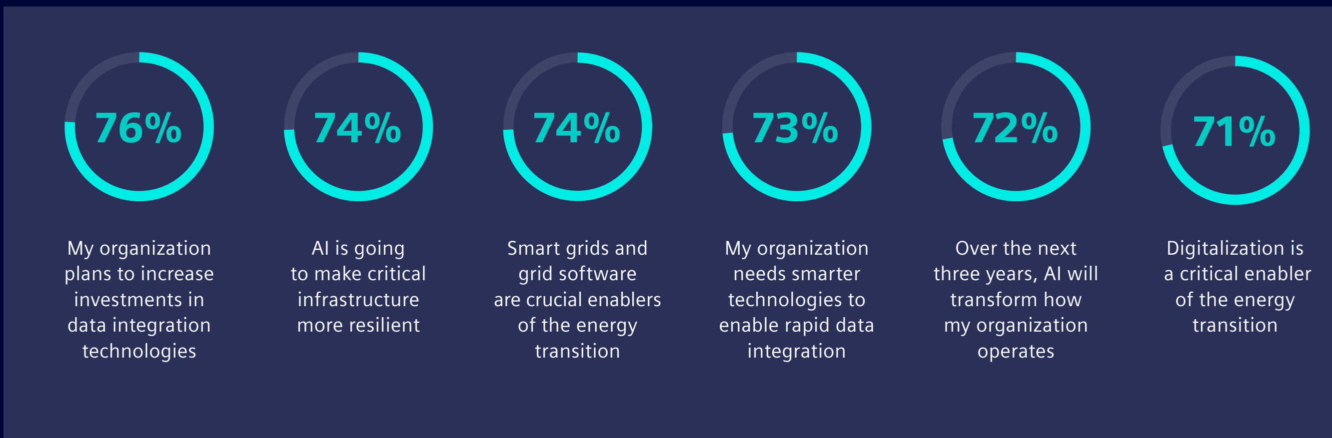
The software offers real-time visibility and actionable insights, enabled by a digital twin of the grid, allowing **Alliander** to distinguish between grid segments that require physical upgrades and those that can be optimized through flexibility. The collaboration highlights the critical role of flexibility in building sustainable and resilient energy systems and underscores the importance of interoperability and knowledge sharing in addressing large-scale energy transition challenges.

3 Autonomous grids: How smart grids are getting smarter

There is strong consensus among survey respondents that AI will significantly transform how organizations operate over the next few years, and that it is already helping to make critical infrastructure more resilient. Most also recognize the need for smarter technologies to improve data integration and are planning to increase investments in this area.

But even the most advanced, digitalized power grids are only a foundation for more transformative advances. Energy systems are growing in complexity at a rate that is outpacing the ability of human operators to manage them. From grid imbalances to extreme weather, the number of variables in play is overwhelming. The next frontier for grids is to tackle these issues with more advanced AI-enabled decision support systems and autonomous systems.

Energy respondents see digitalization, data integration, and AI as critical enablers of the energy transition

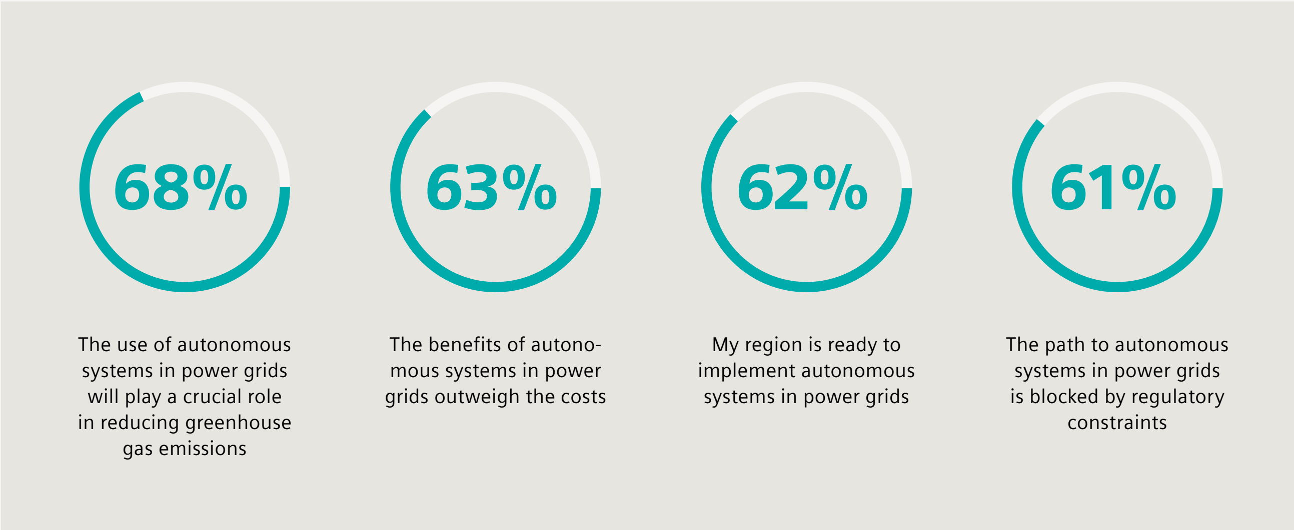


"With AI and digitalization, we can create self-healing autonomous grids that reconfigure in real time, manage storage, and optimize the value of behind-the-meter resources," says Thomas Kiessling, CTO, Siemens Smart Infrastructure. The promise of autonomous grids is already coming to life in localized deployments – so-called "autonomous zones" – where software responds to real-time inputs from distributed generation and demand-side resources.

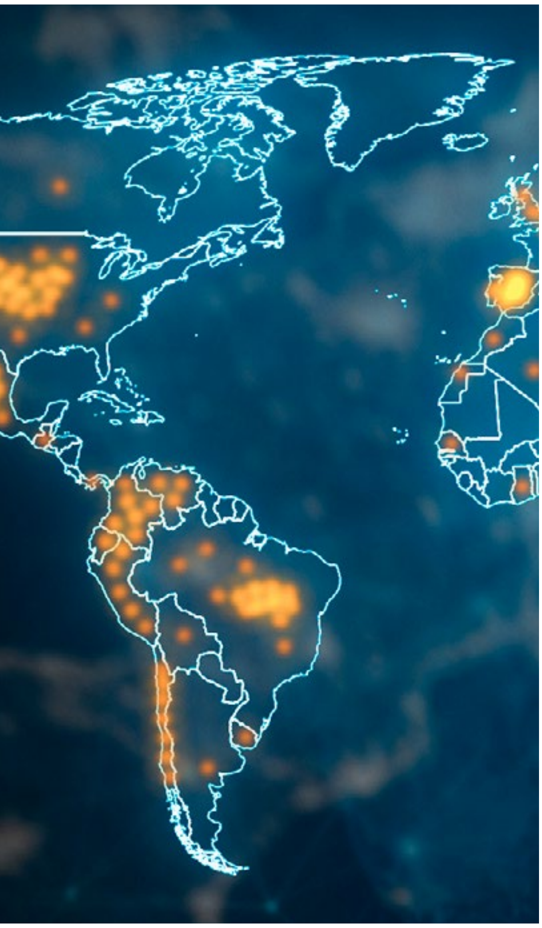
"Autonomous zones are city districts or campuses with local solar, wind, and storage. If there's no wind but plenty of sun, the system can ramp up EV charging to avoid curtailing solar. If a feeder line overloads, the system can reroute power. It's not zero human involvement – operators still approve suggestions – but this is how we make distribution grids smarter, more dynamic, and more efficient," says Kiessling.

Grids are evolving toward autonomous systems to handle the scale and speed of today's grid dynamics. Energy sector respondents in our survey believe that the most likely outcomes from increased use of autonomous systems to manage power grids are lower operating costs, increased energy efficiency, and greater reliability. Most (63%) also believe the benefits outweigh the costs, and a high proportion (62%) believe their region is ready to implement autonomous systems in power grids.

Most say the benefits of autonomous grids outweigh the costs



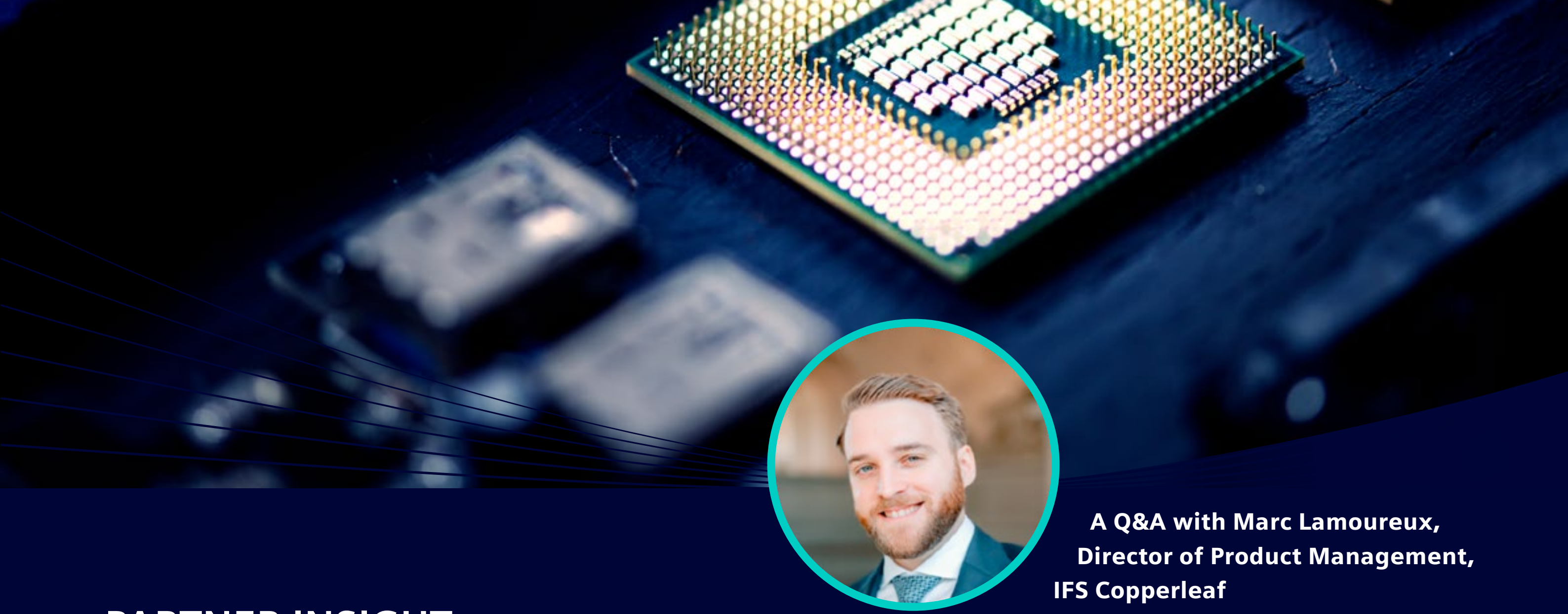
Autonomous systems: orchestrating power grid control



A major roadblock to full-scale implementation of autonomous grids remains: the fragmentation of platforms, systems, and standards. Legacy infrastructure often lacks the interoperability needed for real-time data exchange and seamless orchestration across grid layers.

"Much AI potential is wasted because utilities still use legacy systems. The data isn't clean or connected enough to support real-time intelligence," says Haldy-Sellmann, SAP. "If you want autonomous grids, the platform must support TSOs, DSOs, IT providers, and flexibility providers working together. But even more importantly, everyone needs to speak the same language: common data protocols, standardized APIs. Otherwise, you're forced into custom integration at every handover point, which is practically unscalable."

Despite these hurdles, momentum is building. In many places, AI, digital twins, and intelligent automation are already delivering measurable value – helping to balance distributed energy, improve demand forecasting and increase resilience. It is clear that the grid is no longer just a physical network, but a digitalized, smart system of systems.



A Q&A with Marc Lamoureux, Director of Product Management, IFS Copperleaf

PARTNER INSIGHT

How AI-supported decision-making is transforming utilities

What trends are you seeing in how utilities are approaching capital planning?

The latest is system or process consolidation, for example, from siloed, program-based planning to continuous integrated planning spanning commodities (electric, gas, etc.), business units (transmission, distribution, etc.), and functional groups (strategy, execution, etc.). Integrated planning enables utilities to have a consolidated picture of asset needs and create investment plans that link multi-decade strategic goals to circuit-level deployment. Enabling leadership can see the ten-year impact of today's decisions.

How can AI-powered Asset Investment Planning (AIP) solutions transform how utilities operate?

While there is an important place in AIP for deterministic tools, AI excels in complex data intensive environments within utilities. From considering all relevant context for investment creation, exploring future scenarios, to iterating tailored communication strategies for varied stakeholders, AI-powered AIP will drive a material change in the time to value and the ability to comprehensively defend decisions.

How are environmental and regulatory goals incorporated?

Our framework considers constraints and targets on a common economic scale, including emission caps, carbon budgets, and regulatory targets. This enables trading-off between investments during what-if scenario optimization and constraint sensitivity analysis, making it relatively simple to align capital allocation decisions with environmental and regulatory goals.

What measurable outcomes have utilities seen from using your platform?

Utilities typically achieve up to a 20% improvement in capital efficiency, a 25% reduction in project deferrals, a 30% faster planning cycle, and up to 15% in OPEX savings through work bundling. For example, we helped the UK's National Grid Electricity Transmission (NGET) to replace periodic, frequency-based maintenance with a continuous, risk- and value-based approach. This increased the average annual value of maintenance and modernization plans by £900 million – a 270% increase. Risk-based optimization further reduced maintenance volumes by 17%, worth £4.4 million over five years, and halved planning time.

Which technologies do you believe will have the biggest impact on decarbonization?

AI will play a critical role in enhancing process efficiency and analysis depth for the scenarios needed to model the potential pathways to achieving decarbonization objectives. Modeling and simulation platforms will have an increasing impact on defining feasible investments. While uncertainty analysis will enable organizations to perform in a variety of future scenarios, increasing the probability of achieving decarbonization goals.

Conclusion: Accelerating momentum

The building blocks of a more intelligent, flexible, and resilient energy system are already in place. But deploying them at scale and aligning them with national energy and climate ambitions will demand a radical shift in how we coordinate across the energy ecosystem.

This requires energy and tech companies, regulators, building owners, and consumers (industrial, commercial and residential) to operate as part of an integrated system of systems. Data needs to flow more freely. Markets must reward flexibility, not just capacity. And policies must reflect the distributed, digital, and dynamic nature of today's energy flows.

As Kiessling puts it, "The future is decentralized, democratized, and digital. The future is about ecosystems. Distribution operators, transmission, buildings, and industrial consumers all need to collaborate. Platforms must orchestrate this, and that requires the right policies."

Next generation energy systems will have to respond in real time to climate shocks, market volatility, and rapidly shifting demand patterns. We have the tools to build this system; it is now a question of integrating them effectively. By doing so, we will enable greater energy independence, faster decarbonization, and a more resilient energy system for future generations.

About the research

The ITM 2025 is based on a global survey of 1,400 executives from a range of sectors and countries, supplemented by in-depth interviews with senior leaders and experts. This edition builds on the inaugural ITM conducted in 2023, providing updated insights into the evolving landscape of energy infrastructure and decarbonization.

We would like to extend our sincere thanks to our interviewees and survey respondents for their time and insights in support of ITM 2025.

Interviewees

Dr. Ganesh Das
Chief – Collaboration and Innovation, Tata Power Company

Sabine Erlinghagen
CEO Grid Software, Siemens Smart Infrastructure

Jan Fassbender
Head of Global Facilities and Engineering, One Human Pharma, Boehringer Ingelheim

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Founding Director of Feilden Fowles Architects

Daniela Haldy-Sellmann
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Thomas Kiessling
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Brian Motherway
Head of Energy Efficiency and Inclusive Transitions at the International Energy Agency

Andreas Schumacher
Executive Vice-President Strategy, Mergers & Acquisitions, Infineon Technologies

Susanne Seitz
CEO Buildings, Siemens Smart Infrastructure

Dr. Sean Woolen
Assistant Professor, Department of Radiology and Biomedical Imaging, University of California, San Francisco

Survey Sample Breakdown

Organization size

50-249 employees	290
250-499 employees	290
500-999 employees	350
1000-4999 employees	270
5000+ employees	200

Seniority

C-suite executive (or equivalent)	200
Reports directly to a C-suite executive	500
Manager reports directly to a C-suite executive	700

Sector

Government	Energy	Transport	Technology	Health	Industrials	Consumers	Real estate
100	241	140	189	100	352	184	94

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We create technology to transform the everyday, for everyone. Our world is changing at an unprecedented rate. Demographic change, urbanization, glocalization, 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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