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Energy Journal

Improvement in action: Transforming energy

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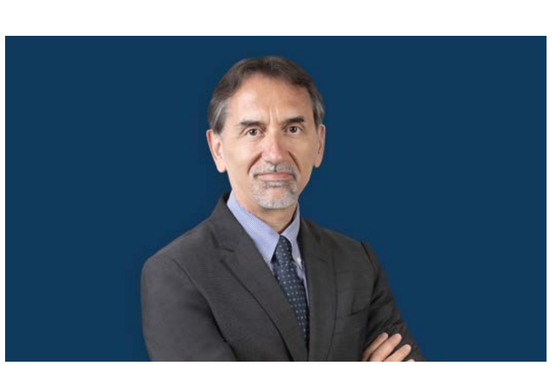
Editorial

The Energy Transition: Innovation, Resilience, and Sustainability



Paolo Chighine

Europe's energy system is undergoing a profound transformation, one that is made more complex by geopolitical challenges and infrastructure vulnerabilities. The sabotage of cables in the Baltic Sea, extreme weather events that have left entire regions without electricity, the ongoing war in Ukraine, and fluctuations in energy prices have all underscored the fragility of energy supply security. In this context, electrification is one of the key strategic pillars to make the system more independent and stable, reduce reliance on fossil fuel imports and mitigate exposure to external shocks.

However, electrification alone is not enough. We need a system that can use advanced technologies and robust infrastructure to flexibly manage energy demand and supply. "Electric grids have been the backbone of energy systems for over a century," noted Fatih Birol, Executive Director of the IEA, and they need to be reinforced to make cleaner energy sources available to all. But recent studies show that the real weak link is the system's lack of flexibility, which could undermine efficiency. Energy storage, nuclear power, pumped hydro, and digital solutions to optimise grid management are just a few of the areas where investment is needed to ensure secure and sustainable energy supplies.

At COP29, governments committed to strengthen energy storage systems and add 25 million km of power grids by 2030, which will be essential to support the global goal of tripling renewable energy capacity.

With the transition no longer optional but an imperative, a new approach to energy security is required – "Energy Security 2.0". It is not just about ensuring energy production but about developing resilient infrastructure, diversifying energy sources, strengthening cross-border interconnections and improving storage capacity. A report by Eurelectric stresses the need not only to safeguard immediate security but also to help create a cleaner, more efficient, competitive system.

The future of energy hinges on innovation, integration, and a forward-thinking approach that turns challenges into opportunities, which is why this edition of *Energy Journal* analyses the drivers for upgrading energy systems. We explore concrete solutions in key areas such as power grids, hydrogen, nuclear energy, digitalisation, and the use of artificial intelligence in energy management.

As highlighted in the *Opinions* section, artificial intelligence and machine learning will be vital to optimise energy systems, and will play a central role in demand forecasting and making grids more resilient through digitalisation. Investment in power grids is set to double in the coming years, as digitalisation and infrastructure upgrades drive the energy transition.

Further exploring the crucial role of smart grids, our *Top Story* considers extreme weather events, cyber-attacks, and infrastructure vulnerabilities – factors that create growing strains for energy systems and that highlight the urgent need for networks to be more resilient, secure, and interconnected. Recent incidents, from the flooding in Valencia to outages caused by Storm Boris and the devastating wildfires in Los Angeles, show that modern electricity networks must be able to respond swiftly to emergencies, and optimise demand-supply management to ensure stable energy supply.

CESI is a key player in the evolution of the energy landscape, developing innovative solutions to make global energy systems more resilient, secure, and efficient. As discussed in our *Future & Technology* article, our strategic projects span the digitalisation of power grids, the integration of new storage technologies and hydrogen, and the development of components for the space industry. Through our KEMA Labs unit, CESI is conducting advanced testing on SF6-free circuit breakers, next-generation batteries and smart grid management systems. We are at the forefront of designing interconnections that strengthen Europe's energy security. Projects such as the Medlink corridor, connecting Italy to Tunisia and Algeria, exemplify efforts to integrate renewables and stabilise supply chains. In Africa, CESI is working on synchronising the West Africa Power Pool and the integration of Ethiopia's and Kenya's power grids, while in Northern Europe, we are part of HVDC initiatives such as the Harmony Link interconnection between Poland and Lithuania.

We are also making a significant impact in energy storage, with projects that integrate various technologies from battery energy storage systems (BESS) to pumped hydro plants. In the hydrogen sector, the company is conducting feasibility studies to identify the best locations for green hydrogen production and storage, with a particular focus on the infrastructure needed to integrate these resources into the energy system. CESI also played an active role at COP29, contributing to international discussions on energy policies and supporting initiatives to expand renewable hydrogen supply chains.

Looking further ahead, CESI is leveraging opportunities in the space economy, establishing itself as a global leader in the production of solar cells for satellites. In a world where interconnectivity, innovation, and infrastructure security have become strategic imperatives, CESI continues to demonstrate how technological and industrial vision can transform the energy transition from a challenge into a tangible opportunity for sustainable development.

Enjoy the reading!

Paolo Chighine
CESI Group Communication and External Relations Executive Vice-President

Energy Journal can be browsed and downloaded at www.cesi.it

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«The interconnection argument around Europe is very important. We need to drive that as strongly as possible.»

***Lord Adair Turner**, Chairman of the Energy Transitions Commission*







News

Latest from CESI

Saudi Arabia

A New Step Towards Energy Innovation

CESI has signed a Memorandum of Understanding (MoU) with the Saudi Electricity Project Development Company (PDC), strengthening its commitment to the development of Saudi Arabia's energy infrastructure. The agreement was signed during a high-level roundtable held at the historic Al Ula site, in the presence of Valentino Valentini, Italy's Deputy Minister for Enterprises and Made in Italy, during Prime Minister Giorgia Meloni's recent visit to the Kingdom.
PDC, a wholly owned subsidiary of the Saudi Electricity Company, plays a pivotal role in Saudi Arabia's energy landscape, focusing on the development of large-scale projects. CESI, which has had a strong presence in the Middle East since 2012 through its Dubai office and local entity in Saudi Arabia, continues to advance its mission of fostering innovation and sustainability in the region's energy systems.

"This agreement reinforces CESI's decade-long commitment in the Middle East."

KEMA Labs Podcast

Reliability and IEC 61850 Certification

In the third episode of the KEMA Labs podcast, Antonio Boccuni, Marketing & Strategic Tools Manager at KEMA Labs, speaks with Riccardo Maria Seresini, Senior Engineer at CESI, about the importance of IEC 61850 Edition 2.1 Server certification in improving energy sector solutions.
Seresini, who joined CESI in 2008, is an expert in substation automation, distributed energy resource (DER) management, and metering solutions. His contributions to standardization include serving as Vice President of the Italian Technical Committee 57. Since 2019, he has led KEMA Labs' efforts to develop a top-tier laboratory for IEC 61850 compliance certification.
This episode explains how IEC 61850 Ed.2.1 certification ensures that manufacturers develop reliable devices that are aligned with evolving technical standards, including advanced protocol stacks, Process Bus measurements, and IPv6 communication. Certification from an accredited laboratory guarantees that devices are interoperable, strengthening market confidence and fostering effective collaboration.

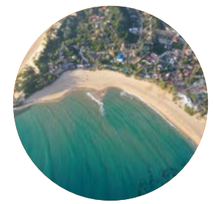
"A key certification for innovation and reliability in the energy sector."

Sicily-Malta

CESI and the New Energy Link

CESI is playing a key role in the development of the second HVAC interconnection system (IC2) between Sicily and Malta, a strategic project to increase the exchange of energy between the two islands. With a capacity of 225 MW, the IC2 connection includes a 100 km, 220 kV submarine cable, as well as 21 km of land routes in Sicily and 2 km in Malta, along with upgrades to the Ragusa and Maghtab terminal stations. The preparatory work has been carried out by a consortium led by CESI.
Within the CESI-Techfem joint venture, CESI has supported Interconnect Malta Ltd (ICM) in key phases of the project, from FEED design and the preparation of technical tender documentation, to managing permits in both Italy and Malta. The company has also assisted ICM in liaising with Italian authorities to obtain the necessary authorizations.
IC2 saw significant progress in 2024: ICM secured permits for the Maltese section, launched the tendering process, and awarded the first contracts. In December 2024, Italy's Ministry of Environment and Energy Security (MASE) granted the final authorization for the Italian section of the project.

"Energy co-operation between Italy and Malta contributes to the sustainability of electricity infrastructure."



Mozambique

CESI Supports the National Control Centre

CESI is the lead consultant for Mozambique's National Control Centre (NCC) project, a strategic initiative aimed at strengthening the country's power system. Commissioned by EDM – Electricidade De Moçambique E.P. and financed by the Swedish government through SIDA, the project has a total value of €6.59 million, with CESI overseeing activities worth €3.56 million.
The consultancy's primary goal is to ensure compliance with contractual requirements and EDM standards by supervising construction, monitoring implementation, and managing contracts to guarantee high-quality investments and timely execution. The project is assessing the interconnections between fossil fuel power generation, renewable sources, HVAC and HVDC transmission, distribution, and links to the Southern African Power Pool (SAPP).
As the lead partner in a joint venture with Decon International GmbH, CESI is involved in all project phases, from preparing tender documents and managing contract awards to supervising construction and providing post-implementation support.

"A significant step towards reliability and efficiency in Mozambique's power system."

Scenario

Electric Grids: The Key to an Effective Energy Transition

Making power grids more resilient and secure is not just environmentally vital but also an economic and social necessity. From the priorities set at COP29 to the wildfires in Los Angeles, we look at the global challenges facing electricity networks.

Italy and Albania have just agreed an ambitious project to construct a submarine power cable between the two countries. But the interconnector scheme is not an isolated development. It is part of a broader European energy transition strategy addressing a critical issue: the need to modernize and reinforce power infrastructure. The cable, with a projected capacity of over 1 GW, will play a pivotal role in ensuring the efficient and stable exchange of clean energy between the two countries. The connection will help to integrate renewables into Italy's energy mix, helping to reduce greenhouse gas emissions.

As renewable energy capacity continues to grow, and energy flows become increasingly complex and decentralized, power grids must evolve in parallel. The Italy-Albania agreement is not just a symbol of bilateral co-operation; it underscores the urgent need to invest in modern, resilient infrastructure to support a truly effective global energy transition.

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COP29: Key Priorities for a Sustainable Future

A report by the UNHCR, released during last November's COP29 climate conference in Baku, highlighted how climate shocks worsen the conditions of millions already displaced by war, violence, and persecution. Of the 120 million refugees worldwide, three quarters live in countries highly vulnerable to climate change, reinforcing the close links between climate and energy emergencies.

The COP29 Presidency, in collaboration with the International Energy Agency (IEA), identified five key priorities to accelerate the transition to a sustainable energy system. Foremost among them is strengthening power grids and energy storage systems – critical enablers of the global goal to triple renewable energy capacity by 2030. Investing in resilient grids that can support more renewable power is seen as fundamental to maximizing the benefits of the energy transition.

The Los Angeles Wildfires: A Wake-Up Call for Power Grids

Yet reality often moves faster than policy. During the wildfires that devastated Los Angeles in early 2025, concerns resurfaced that faults or malfunctions in the power grid may have played a role in sparking the fires. This echoes the tragic events of 2023 in Hawaii, where local grid failures played a part in starting the wildfires that ravaged Maui. Poor maintenance and an inability to adapt power infrastructure to extreme climate conditions were cited as aggravating factors in both cases.

In Los Angeles, ongoing investigations suggest that strong winds, combined with extremely dry vegetation from prolonged drought, fueled the flames' spread. But officials are also examining whether damaged or insufficiently insulated power lines may have triggered the initial sparks. Similar circumstances were observed in Hawaii, where failure to manage vegetation around power lines contributed to an environmental and human catastrophe.

These incidents serve as a stark reminder that modernizing power grids is essential to meeting the challenges posed by climate change. Many existing infrastructures, designed for a past era of less frequent extreme weather events, are no longer equipped to handle growing risks such as wildfires, hurricanes, and heatwaves. Introducing advanced monitoring systems – such as real-time sensors to assess grid conditions and surrounding vegetation – could significantly reduce the likelihood of failures. Similarly, undergrounding power lines in high-risk areas, while costly, remains a widely discussed option.

IEA and Deloitte Reports: The Roadmap for the Future

Recognizing the need to accelerate the modernization and expansion of power grids, the IEA stresses that grid resilience is not just an environmental concern but also a fundamental economic and social issue. Extreme weather events cause significant infrastructure damage, energy supply disruptions, and high restoration costs – impacts that ripple across entire communities.

According to Deloitte's 2024 report *Road to Scale – Expanding and Modernizing the Power Grid for a Clean Energy Transition*, global electricity demand is set to rise by 150% by 2050, driven by the increasing energy needs of emerging sectors such as data centers, artificial intelligence, and cryptocurrencies. Meanwhile, the rapid deployment of renewables and distributed energy resources is reshaping supply and demand dynamics, creating more variable and intermittent energy flows that put existing infrastructure under strain.

These changes require a radical transformation of power grids. However, the report identifies two major barriers: a projected $14.3 trillion investment shortfall by 2050 and the slow pace of grid infrastructure development. Currently, it takes seven times longer to complete grid expansion projects than to install renewable plants or electric vehicle charging stations, creating a time lag that threatens decarbonization goals.

To bridge this gap, Deloitte outlines a three-phase approach to modernizing power grids:

- **Strengthen Core Infrastructure** – upgrade existing grids with advanced technologies such as automated monitoring systems and real-time data analytics to prevent failures and enhance reliability. Energy storage solutions, including batteries and pumped hydro, are crucial to managing renewable intermittency, potentially reducing peak energy demand by up to 15%.

- **Decentralization and Resilience** – move toward a more decentralized grid, incorporating local solar panels, wind turbines, and home battery systems. By 2050, decentralized energy sources are expected to account for 45% of Australia's power capacity, while 83% of EU households could become energy "prosumers."

- **Create an Integrated Energy Ecosystem** – connect the power grid to transport and smart urban infrastructure to maximize efficiency. Technologies like vehicle-to-grid (V2G) integration will allow electric vehicles to feed energy back into the grid during peak demand, with a projected flexible capacity of 600 GW by 2030.

Without increased investment and accelerated infrastructure development, power grids risk becoming the primary bottleneck of the energy transition, Deloitte warns. However, innovative strategies, public incentives, and private-sector partnerships could help close the gap, ensuring resilient and reliable grids that support a sustainable energy future.

The UK Case: Ensuring Grid Stability and Resilience

In the UK, grid modernization is a national priority, with policies aimed both at addressing current challenges and building a more resilient system to support the rising share of renewables. Recently, the National Grid Electricity System Operator announced a temporary halt on new grid connection requests so it could implement the reforms necessary to manage the backlog of renewable energy projects and increase grid capacity.

This move reflects broader concerns over

grid stability, highlighted by recent warnings of energy shortages that raised questions about the system's ability to meet demand during periods of low renewable generation. Ambitious projects such as the £3.4 billion "electricity superhighway" between Scotland and England – designed to transmit offshore wind power southwards – underscore the urgent need to reinforce infrastructure for a secure and reliable energy transition.

The global energy transition cannot succeed without a parallel transformation of power grids – the true backbone of the energy system of the future. Investing in infrastructure, overcoming bureaucratic hurdles, and implementing innovative solutions are crucial steps to ensure that the growth of renewables is not constrained by outdated grids.

For insights into emerging technologies shaping the energy landscape, visit our *Future & Technology section*, where we explore the most innovative solutions for modern power networks.

Top Story

The Strategic Role of Smart Grids

From the Valencia floods to the devastation of Storm Boris, power grids are increasingly exposed to the impacts of climate change. Ensuring that they are resilient is crucial to delivering a secure and effective energy transition.

The fragility of today's energy systems creates growing risks to security of supply, which cleaner and more efficient networks can help to reduce. Power grids are a key element in the energy transition, as the share of renewables in electricity generation grows and the energy system becomes increasingly electrified, increasing total demand. It is no coincidence that the European Commission's Net Zero Industry Act (NZIA) identifies power grids as a strategic technology for achieving net-zero emissions by 2050. The Commission has also highlighted the critical importance of distribution networks for a functioning society and ensuring the smooth running of the economy.

Threats to the Grid

But grids face mounting threats, chief among them nature itself. The events of recent months have shown how disruptions to power supplies can have systemic and potentially uncontrollable consequences for citizens and businesses, rapidly threatening fundamental rights and upending daily life.

When extreme weather subsided in Valencia, rescue operations were hampered by downed power lines that left entire districts without electricity. The devastating floods in Spain caused by the Dana weather phenomenon are just the latest in a long series of extreme events. Over the past 30 years, 5.5 million people across Europe have been affected by such disasters, at the cost of nearly 3,000 deaths and over €170 billion in economic losses. Storm Boris, for example, struck Central Europe—including Austria, the Czech Republic, Poland, Romania, Slovakia, Germany, and Hungary—before hitting Italy's Emilia-Romagna region, leaving almost 30 casualties in its wake.

Globally, the first half of 2024 saw continued climate anomalies, particularly in temperature. May 2024 recorded an average global surface temperature of 15.9°C – 1.1°C above the 20th-century average –

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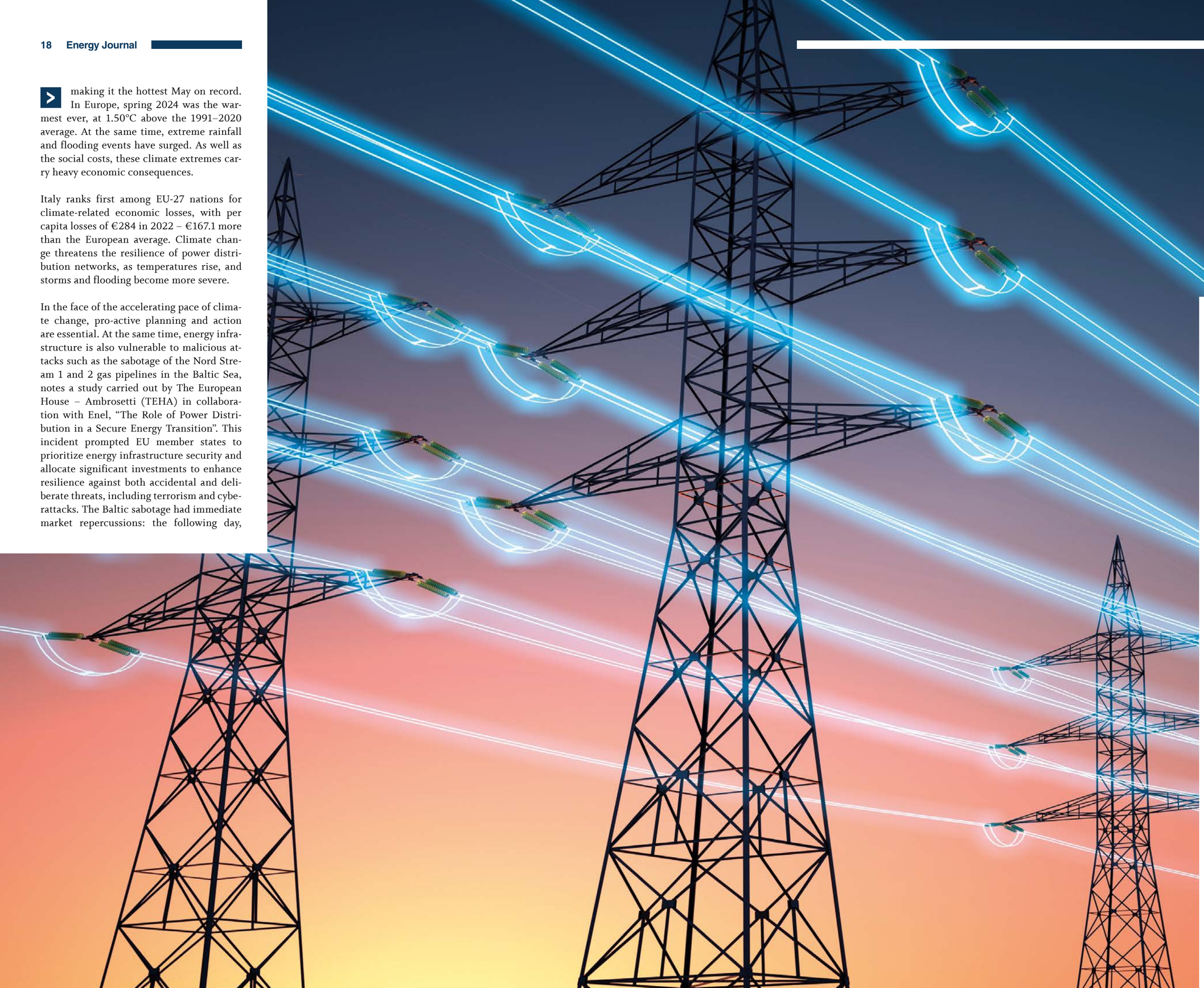
making it the hottest May on record. In Europe, spring 2024 was the warmest ever, at 1.50°C above the 1991–2020 average. At the same time, extreme rainfall and flooding events have surged. As well as the social costs, these climate extremes carry heavy economic consequences.

Italy ranks first among EU-27 nations for climate-related economic losses, with per capita losses of €284 in 2022 – €167.1 more than the European average. Climate change threatens the resilience of power distribution networks, as temperatures rise, and storms and flooding become more severe.

In the face of the accelerating pace of climate change, pro-active planning and action are essential. At the same time, energy infrastructure is also vulnerable to malicious attacks such as the sabotage of the Nord Stream 1 and 2 gas pipelines in the Baltic Sea, notes a study carried out by The European House – Ambrosetti (TEHA) in collaboration with Enel, "The Role of Power Distribution in a Secure Energy Transition". This incident prompted EU member states to prioritize energy infrastructure security and allocate significant investments to enhance resilience against both accidental and deliberate threats, including terrorism and cyberattacks. The Baltic sabotage had immediate market repercussions: the following day,



natural gas prices on the TTF market in Amsterdam surged to €200/MWh – 4.3 times the 2021 price.

Similarly, in May 2021, a cyberattack on the Colonial Pipeline – one of the largest fuel pipelines in the U.S. – by the hacker group DarkSide, led to fuel shortages across the East Coast. The attack forced the shutdown of 8,550 km of pipelines supplying nearly half of the region's fuel, causing gasoline prices to spike above $3 per gallon and prompting emergencies to be declared in several states.

In recent years cyberattacks have increased significantly, with over 1,000 incidents recorded in 2022, particularly targeting utilities.

Security and Investment

The International Energy Agency's (IEA) 2024 World Energy Outlook highlights how the growing impact of climate change, the acceleration of the energy transition, and the characteristics of clean energy technologies are reshaping how energy security is viewed. A comprehensive approach must encompass not only traditional fuels but also the secure transformation of the electricity sector and the resilience of clean energy supply chains. This shift calls for a rebalancing of energy investments.

Currently, for every dollar invested in renewable energy, only 60 cents are allocated to grid infrastructure and storage. The IEA stresses that sustained grid and storage investments are essential for the continued growth of clean energy and by 2040, investments in grids and storage are expected to match renewable energy funding. In Europe, Eurelectric estimates that

> between 2020 and 2023, investments in distribution networks increased by 24%, from €29 billion in 2020 to €36 billion in 2023. However, to address future challenges, investment in distribution grids is expected to rise by 80% between 2024 and 2050, reaching €65 billion per year over the next 27 years. To meet estimated 2050 investment needs, annual funding must nearly double compared to the 2020–2023 average.

Three Key Challenges for the Future

Despite strong momentum for clean energy, the IEA warns that the world remains off track in meeting net-zero goals. The European Commission's 2023 Action Plan for Electricity Networks outlines 14 measures to accelerate grid development by 2030 and will be crucial in enabling distribution networks to adapt to the evolving needs of the energy system.

Traditional grids relied on electricity flowing in one direction from large, remote power plants to end users. Today's networks, however, must accommodate an increasing number of distributed generation sources – many of them intermittent due to the rise of renewables – as well as a shift in consumer roles. Consumers are becoming "prosumers," feeding electricity back into the grid, which now requires energy to flow both to and from homes and businesses. Additionally, to adapt to fluctuations in solar energy production between day and night, new approaches to capacity planning and system protection are needed.

Extreme weather, infrastructure attacks, and cyber threats require both immediate responses and innovative approaches. "Patents for Power Grid Enhancement", a report by the European Patent Office and the IEA, highlights how smart grids capable of seamlessly integrating vast numbers of electrical devices have transformed networks over the past two decades. Advances in artificial intelligence and smart electric vehicle charging are further accelerating this transformation.

Power networks have been the backbone of electricity systems for over a century and will become even more critical as electricity takes a larger share of the global energy mix. However, if grids are not positioned correctly to connect supply and demand, are poorly maintained, or lack the technological capacity to meet 21st century energy needs, they risk becoming a bottleneck for economic growth and climate action.

Grid developers and policymakers face three key challenges: they must expand and reinforce physical infrastructure; enable flexible and bidirectional operations; and safeguard people, data, and the environment. Achieving these goals requires smarter grids that integrate advanced communication networks into electricity systems. These networks rely on new hardware such as sensors and switches, coupled with new data management and grid optimization software.

Smart grids enhance co-ordination among all energy stakeholders – generators, grid operators, consumers, and markets – making networks more responsive, flexible, and integrated than traditional centralized systems. Smart grid technologies also improve efficiency, reduce costs and environmental impact, and make networks more reliable and resilient. As IEA Executive Director Fatih Birol noted: "Inadequate grids hinder economic activity and energy access while making the clean energy transition more costly and complex. This study shows that innovators are rising to the challenge of more competitive and flexible grid technologies – an issue too often overlooked."

Industries & Countries

From COP29 to Global Challenges: How Power Grids and Renewables Will Shape Our Future

Between lacklustre summits, elections with weakened climate agendas, and the urgent need for concrete financial commitments, adapting global electricity grids is not just an environmental necessity but an essential strategic choice. In the European Union, the imperative to expand transmission and distribution networks is clearly understood, but the US under newly elected President Trump also faces tangible risks to competitiveness should its grid fail to keep pace.

The United Nations has described 2024 as the year with the highest number of elections in human history, with half the world's population heading to the polls across 72 countries. This exceptional event has yielded surprising results, but with one clear casualty: climate policy.

Despite devastating floods, wildfires and heatwaves affecting Europe, Asia, the United States, and Mexico, climate change remained a secondary issue in electoral campaigns. One notable exception was India, where farmers' protests—sparked by extreme weather and erratic rainfall damaging crops—framed Narendra Modi's victory for a third term as Prime Minister. In Europe, right-wing parties that dismiss climate action as costly and unnecessary made significant gains, while in the United States, Donald Trump defeated Kamala Harris after explicitly pledging to dismantle environmental regulations and abandon what he termed the 'new green scam.'

The electoral outcomes of 2024 risk entrenching policies that exacerbate climate disasters. The year culminated in a turbulent COP29 climate summit

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in Azerbaijan, overshadowed by the absence of most world leaders. Even though governments agreed the previous year to phase out fossil fuels, this conference was dominated by contentious statements and threats of withdrawal. The lack of progress on reducing emissions and providing financial support for vulnerable developing nations frustrated both activists and key policymakers.

Energy Storage and Grid Expansion Commitments

One area of tangible progress at COP29 was in the reaffirmation of a commitment to increase global energy storage capacity sixfold compared to 2022 levels, aiming to reach 1,500 GW by 2030. Participants also pledged to expand distribution capacity, with a target of adding or upgrading 25 million kilometres of grids by 2030.

The International Energy Agency (IEA) also emphasised the need to extend or modernise a further 65 million kilometres of networks by 2040 to align with the goal of net-zero emissions by 2050. Power grids and energy storage are fundamental to the concept of clean flexibility, which, explains Dave Jones, Director of the Global Insights Programme at energy think tank Ember, "is the key enabler of a renewables-dominated system. When we harness solar and wind energy, grids transport it where it is needed, while storage ensures it is available when required."

The Revival of Nuclear Energy

A growing number of countries, including Italy, are reconsidering nuclear power to address energy security and climate concerns – as well as the policy, innovation, and financial hurdles that must be overcome to seize these opportunities. With electricity demand set to surge in the coming decades, technological advancements such as the development of small modular reactors (SMRs) promise to reshape the nuclear energy landscape. The IEA report, *The Path to a New Era for Nuclear Energy*, predicts that "nuclear power is set to reach a record level of electricity production in 2025". More than 70 GW of new nuclear capacity are currently under construction – one of the highest levels in three decades – while more than 40 countries plan to expand the role of nuclear role in their energy systems.

Second only to hydropower as a global source of low-emission electricity, today nuclear energy accounts for just under 10% of global electricity production. The rapid electrification of industries, heating, electric vehicles, and data centres—accelerated by the rise of artificial intelligence—is driving energy demand at a pace six times faster than overall energy consumption growth.

Investing in Grid Efficiency

For the first time, energy storage and power grids have been officially recognised as essential components of the energy transition, providing the flexibility needed to triple renewable capacity. However, electricity grids do not experience uniform demand throughout the day. Much like motorways built to handle peak traffic but underutilised at other times, power grids are designed to meet peak consumption but often remain underused during off-peak hours. The growing penetration of variable renewable energy and the flexible management of demand could revolutionise the

way the grid is used. But for that to happen, there must be further investments in digital technologies that can adjust consumption, reduce curtailment, and make grids more efficient.

While it is crucial that nations support these commitments to enable a tripling of renewable capacity, the Global Renewables Alliance (GRA) stresses that broader participation is needed to unlock the full potential of renewables and ensure universal energy security. With COP30 approaching, industry leaders are calling for governments to approve these commitments and urgently translate them into concrete, actionable national plans.

The EU's Action Plan for Grids

If any region can claim leadership in energy networks, it is the European Union. This leadership is underpinned by a strategy focused on three key objectives: increasing the share of renewable energy in gross final consumption from 23% in 2022 to 42.5% by 2030 (rising to 45% with the RePowerEU Plan); significantly improving energy efficiency, with a 39% reduction in primary energy consumption by 2030 compared to 2007 levels; and drastically cutting greenhouse gas emissions, targeting a 55% reduction from 1990 levels by 2030.

The US After the Elections

As the world's second-largest emitter of greenhouse gases (GHGs), responsible for about 12% of global emissions (behind China's 34% as of 2023), the US plays a pivotal role in international climate efforts.

Following Donald Trump's return to office in 2025, his administration swiftly dismantled key policies supporting the energy transition and climate action. Among the first executive orders were the termination of the Green New Deal, the suspension of Inflation Reduction Act funds earmarked for electric mobility and energy transition incentives, and the repeal of federal mandates for electric vehicles. Offshore wind lease sales were halted, and the administration initiated the process to withdraw from the Paris Agreement once again.

A recent report from Grid Strategies, *Strategic Industries Surging: Driving US Power Demand*, proclaimed that "the era of flat energy demand in the United States is over," forecasting a dramatic surge in electricity demand. The study suggests that peak annual demand will rise by an average of 3% over the next five years, requiring an unprecedented acceleration in planning and constructing new generation and transmission capacity—six times the current rate.

Conclusion

The future of energy hinges on the development of modern infrastructure, resilient grids, and policies that combine vision with pragmatism to navigate the energy transition. In the face of ineffective COP summits, elections that have weakened climate agendas, and the pressing need for concrete financial commitments, the world stands at a crossroads. We need to unlock the full potential of renewable energy by adapting global electricity grids. This is not just for environmental reasons – it is also a strategic necessity to ensure security, development, and economic competitiveness around the world.

Future & Technology

The Energy of the Future: Artificial Intelligence, Hydrogen, and Nuclear Power

As the volatile geopolitical situation continues to reshape global energy markets, technological advances are paving the way for more flexible grids, more efficient storage systems, and cleaner energy sources. CESI is leading the transition with expertise and strategic vision.

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An Energy Landscape in a State of Flux

The global energy sector is undergoing profound changes, caught between the rapid development of new energy transition technologies and shifting geopolitical dynamics. The competition for control over critical raw materials – which are essential for electrification, storage, and hydrogen production – has intensified rivalries between China, the United States and Europe, with China maintaining a dominant position in the mineral supply chain and green technology development.

Despite the risks of new fractures in international trade, the energy sector is demonstrating impressive resilience. Recent crises have taught industry players to diversify supply sources and develop alternative strategies. While geopolitics continues to redefine the sector's landscape, technology is developing at a rapid pace. Next-generation nuclear power, smart grids, advanced storage systems, and green hydrogen are shaping an energy future where innovation and industrial strategy will be the key drivers of a successful energy transition.

Artificial Intelligence: A Key Driver of Change

One of the most transformative elements in the global energy sector is artificial intelligence (AI). AI-driven data sharing could revolutionise energy management, says Laura Cozzi, Head of Outlook at the International Energy Agency (IEA). "AI enables greater efficiency in energy distribution and consumption, optimising power grids and accurately forecasting demand. However, to fully harness these capabilities, international co-operation in energy data collection and analysis is essential." It is therefore critical that major global powers collaborate to overcome the challenges of the energy transition and foster a sustainable future.

Artificial intelligence and technology were also central topics in a January address by Ali Zaidi, the outgoing Biden administration's National Climate Advisor. Despite potential policy reversals under a new Trump administration, Zaidi expressed optimism about advances in clean energy technologies. He underscored the importance of diversifying energy sources to include solar,

wind, geothermal, and nuclear power. Zaidi added that further investments in AI technologies are needed to modernise the electrical grid, highlighting that the Inflation Reduction Act (IRA) has already allocated substantial resources to energy transition and decarbonisation.

Electric Grids and Storage Systems

Globally, strategies to make grids more reliable increasingly rely on advanced control technologies, proactive maintenance, and automation systems. In Italy, advanced technologies to improve grid reliability are being adopted at scale. A study by the European Patent Office (EPO) and the IEA says that Italy ranks third in the European Union for the number of patents in the smart grid sector, accounting for 1% of international patent families. While this figure is lower than Germany (11%) and France (4%), it highlights significant potential for growth. Moreover, 37% of European grid-tech startups have filed patent applications – far higher than the 6% average of other technology industries – indicating that the innovation ecosystem is expanding. On a global scale, China leads with 25% of patents in 2022, underscoring the need for Italy and Europe to accelerate research and development investments to maintain competitiveness in smart grid technology.

Batteries are also emerging as a central component of the energy transition, both for transport electrification and renewable energy storage. GlobalData projects that 13.68 million electric vehicles (EVs) will be sold in 2025, driving demand for batteries and pushing the lithium-ion battery market to an estimated value of $160 billion. Alternative battery technologies are also growing, such as lithium-iron-phosphate (LFP) batteries, which are more cost-effective and widely used in China, and sodium-ion batteries, which offer greater sustainability for short-range electric vehicles.

Beyond electric mobility, adoption is accelerating of battery energy storage systems (BESS), which play a crucial role in stabilising grids and managing renewable energy intermittency. By the end of the year, global installed BESS capacity is expected to reach 154.6 GW, a 56% increase from 2024 and a decisive step towards integrating clean energy into global power systems.

The Revival of Nuclear Power

As global energy demand surges – driven in part by the expansion of artificial intelligence and data centres – nuclear power is coming back into favour as a way to ensure reliable, low-emission energy. In 2025, nuclear energy is set to expand significantly, with more than 70 GW of new capacity currently under construction.

Political support for the nuclear industry is growing, with more countries committing to tripling global nuclear capacity by 2050, a target set at COP28. Fatih Birol, Executive Director of the IEA, says more than 40 nations are aiming to increase the role of nuclear power in their energy systems, with a particular focus on small modular reactors (SMRs). These compact reactors are seen as one of the most promising ways to deliver clean, distributed baseload power. While large-scale deployment is still in its early stages, pilot projects are under way in Argentina, China, Russia, and the United States, with countries such as the UK, Canada, and Poland also accelerating their plans for adoption.

However, SMRs still face challenges related to financing, lengthy regulatory processes, as well as costs, construction timelines, and supply chain concentration, with Russia currently controlling 40% of global uranium enrichment capacity. To ensure sustainable nuclear growth, it will be crucial to diversify supply sources and strengthen international co-operation.

In Brussels, the European Commission has launched the European Industrial Alliance on Small Modular Reactors to accelerate their deployment by the early 2030s. However, disposing of spent nuclear fuel remains a critical challenge for water-cooled reactors. A more sustainable alternative lies in fourth-generation nuclear reactors, which recycle reprocessed fuel and significantly reduce long-lived radioactive waste. Research efforts have recently focused on miniaturising these plants, which use liquid metals as coolants—a more complex but highly promising technology.

While Italy has yet to definitively decide on SMR adoption, its industrial sector

already possesses significant expertise in building reactors abroad and managing nuclear decommissioning and radioactive waste disposal—potentially offering a competitive advantage. In January 2025, the Italian government introduced a draft legislative proposal on "sustainable nuclear energy," aiming to redefine the regulatory framework and overcome restrictions imposed by referendums in 1987 and 2011. The proposed law is based on four key pillars: the final decommissioning of past nuclear plants, establishing a comprehensive regulatory framework for nuclear energy, co-ordinating with grid operators to ensure system stability, and requiring nuclear project developers to provide adequate financial and legal guarantees.

Green Hydrogen: A Driver of Decarbonisation

Hydrogen is also becoming increasingly central to the energy transition, particularly green hydrogen, which is produced via electrolysis powered by renewable sources. According to the Hydrogen Council – a consortium of 140 multinational companies spanning the entire hydrogen value chain – the cost of hydrogen production could fall by up to 60% over the next decade, as renewable energy costs fall and electrolyser production capacity expands. By 2025, global green hydrogen production capacity is expected to reach 2.76 million tonnes per year, marking a significant acceleration.

North America currently leads the market, but Europe and Australia are making strategic investments to strengthen their positions. Beyond its role as a clean fuel, hydrogen is increasingly being considered for renewable energy storage and combined heat and power generation, making it a key element in the evolution of global energy systems.

The European Union has identified green hydrogen as a cornerstone of its strategy to decarbonise hard-to-electrify sectors, with a target to produce and import a combined 20 million tonnes by 2030. However, achieving this goal remains challenging. Currently, hydrogen accounts for less than 2% of Europe's energy consumption, and 96% of it is produced from natural gas, leading to high CO_2 emissions. While the EU has allocated €18.8 billion to support hydrogen development, significant hurdles remain, including high production costs, energy losses in electrolysis, and the need for dedicated storage and transport infrastructure.

Despite these obstacles, nations such as Germany, France, and Spain are advancing ambitious hydrogen strategies. Italy, with its abundant renewable resources and hard-to-decarbonise industrial sites, is considered well positioned to produce green hydrogen. However, many experts argue that the EU's targets remain highly ambitious, requiring accelerated infrastructure investments and clearer regulatory frameworks to achieve them within the proposed timeframe.

A Balanced Energy Future Supported by CESI

As decarbonisation and electrification of final consumption reshape the entire energy system, CESI is positioned as a key player, anticipating and supporting technological innovation across the entire value chain. The sector's complexity demands an approach centred on flexibility and the integration of diverse energy sources and technologies. How effective renewable energy

sources are depends not only on the availability of primary resources such as wind, solar, and hydro but also on robust transmission and distribution networks.

CESI is operating on multiple fronts to ensure this balance. In its testing laboratories, the company explores and validates new technologies such as DC circuit breakers that will be essential for future meshed DC networks, and power cables, which are increasing in capacity and voltage while being made to work harder to greater operational stress. Additionally, CESI rigorously tests and certifies all smart grid technologies according to the latest international standards.

CESI also collaborates with investors and institutions to study and finance innovative projects, and provides engineering consultancy for the design and implementation of strategic infrastructure initiatives. Our advanced monitoring systems optimise plant operations and mitigate structural and climate-related risks. With a presence spanning Europe, Asia, the Americas, and Africa, CESI helps the exchange of best practices across highly diverse energy systems, transforming the energy transition from a challenge into a tangible opportunity.

As grid flexibility, energy storage, and interconnections become critical to system stability, CESI continues to guide the sector towards a more efficient and sustainable future. With over 60 years of experience in designing energy corridors, we are a leader in developing critical infrastructure that not only transmits energy but also connects markets and creates opportunities. However, increasing demand for network components, supply chain pressures, and the adoption of new technologies present significant challenges for reliability. High-quality materials, rigorous testing, and an integrated approach to infrastructure security are essential to ensure network resilience. CESI addresses these challenges through innovation and advanced testing, developing SF6-free circuit breakers and new transmission solutions that balance sustainability with performance.

From the South Caucasus, where we support the Green Energy Corridor for transporting wind, solar, and green hydrogen, to the Mediterranean, where we are involved in the Medlink corridor linking Italy with Tunisia and Algeria, CESI is at the forefront of establishing critical connections to accelerate Europe's decarbonisation efforts. In Africa, we are working on interconnections between Ethiopia and Kenya, and synchronising the West Africa Power Pool. Meanwhile, in the Baltic and Nordic regions, the company is part of innovative HVDC projects such as Harmony Link between Poland and Lithuania. Beyond infrastructure design, we are also strengthening the reliability of electricity networks in an era increasingly impacted by climate change. Through our KEMA Labs, we subject critical components to extreme conditions, while CESI Consulting develops feasibility studies, cost-benefit analyses, and advanced solutions to monitor infrastructure performance.

A Leading Role in Energy Storage

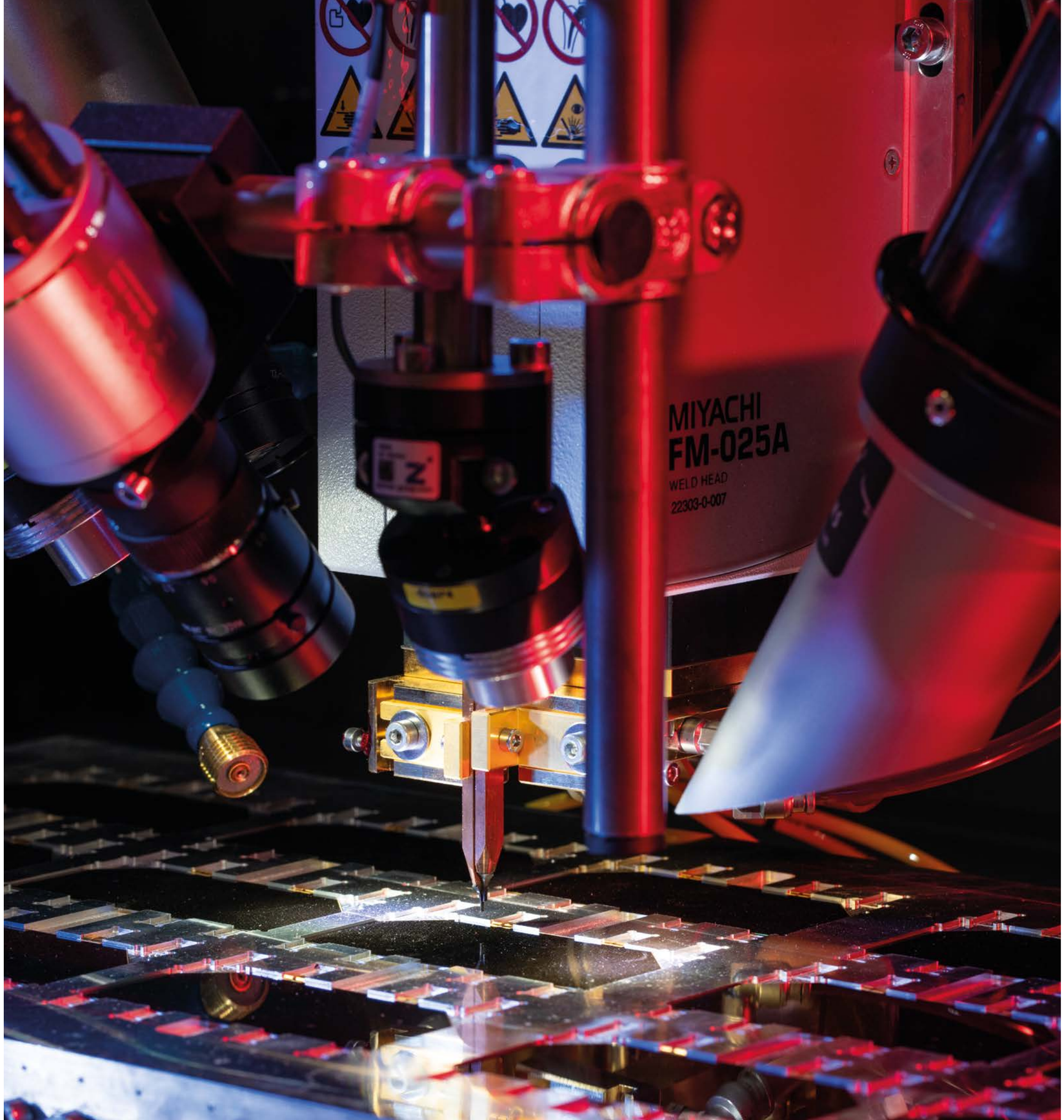
Energy storage has become a crucial part of keeping electricity grids stable and efficient, particularly in systems increasingly reliant on variable renewable sources. CESI is at the forefront of developing and integrating advanced storage solutions, combining established technologies such as

pumped hydro storage with emerging systems like Battery Energy Storage Systems (BESS), flywheels, supercapacitors, and hydrogen storage. Through feasibility studies and strategic consultancy, we help grid operators in balancing supply and demand, enhancing system flexibility.

Through our partnership with ENEL, initiated in 2021, we optimise BESS systems by evaluating their environmental and technical performance. At a global level, CESI supports the energy transition through projects in North Africa and the Middle East, helping to integrate renewables into local power systems. Across various countries, from Asia to South America, we have identified optimal solutions to incorporate solar and wind power into electrical grids while minimising curtailment risks during renewable energy surpluses. CESI updated Oman's national energy strategy by outlining the investments needed to enable the transmission network to support increased wind and solar power generation while ensuring grid stability and environmental sustainability. In the United Arab Emirates, CESI collaborated with SEWA to connect small-scale photovoltaic plants to the grid, developing safety standards and technical guidelines. Meanwhile, in Bahrain, the company helped the government formulate policies for solar energy integration.

As the energy transition accelerates, it is driving increased interaction between storage and electric mobility. EVs are evolving into decentralised storage units through bidirectional charging (vehicle-to-grid), enabling energy storage during periods of overproduction and reinjecting it into the grid when needed. With global storage capacity expected to reach 600 GW by 2030, battery systems will play a pivotal role in ensuring grid stability. However, the rising demand for critical materials such as lithium and cobalt poses challenges for resource availability and supply chain independence.

To tackle these challenges and ensure the reliability of emerging technologies, our KEMA Labs unit conducts advanced testing on batteries and EV charging systems. By simulating real-world operating conditions, CESI assesses battery performance, safety, and longevity, contributing to enhanced grid resilience. The newly established Services & Smart Technologies unit, based between Milan and Arnhem, develops advanced standards for EV batteries, offering cutting-edge testing for the secure and efficient integration of electric mobility into the global energy system.



Hydrogen and the Space Economy

Renewable hydrogen will be a key way to decarbonise high-emission sectors such as heavy transport and industry, and CESI will play an active role. We have evaluated the opportunities and challenges associated with hydrogen production, storage, and utilisation in Italy and across Gulf countries, including Qatar and Oman. One study revealed that achieving Italy's 2030 hydrogen strategy targets will require 3.6 GW of variable renewable capacity and at least 1 GW of electrolysers to power a fleet of hydrogen-fuelled heavy vehicles. The analysis identified Southern Italy, Sicily, and Sardinia as the most suitable locations for cost-competitive hydrogen production, highlighting the need to strengthen grid infrastructure to balance supply and demand while preventing congestion issues.

CESI actively contributes to international discussions on hydrogen-related energy policies. At COP29, CEO Nicola Melchiotti participated in the event "Enabling the Clean Hydrogen Economy & Developing New Supply Chains," organised in collaboration with the International Renewable Energy Agency (IRENA), to discuss hydrogen's role in achieving net-zero emissions. During the event, the Hydrogen Declaration was launched, emphasising the need for global co-operation to define certification standards, expand supply chains, and integrate renewable hydrogen into national climate strategies.

Finally, CESI has capitalised on opportunities in the space economy, establishing itself as a global leader in solar cell production for satellites. In a sector where reliability and durability are paramount, the company has developed cutting-edge technologies designed to deliver high performance in extreme conditions and operate maintenance-free for extended periods. Thanks to investments in research and development and collaborations with key players such as the Italian Space Agency, the European Space Agency, and Leonardo, CESI is now the only European-owned company capable of supplying space solar cells, meeting up to 15% of global demand. This strategic positioning not only strengthens Italy's role in the aerospace industry but also reinforces CESI's contribution to energy innovation in frontier sectors, once again demonstrating the company's ability to anticipate market trends and turn technological challenges into growth opportunities.

Opinions

Energy Systems Put to the Test by Innovation

Against a backdrop of rising electricity demand, the need to integrate renewable sources, and the emergence of new technologies, we asked a range of experts to share their insights on the urgent need to innovate and strengthen energy infrastructure. Their analyses highlight the central role of grid digitalisation and the technological support provided by artificial intelligence in strengthening energy networks.

Electricity grids, which have long been the backbone of global energy systems, are now at the heart of an epoch-defining transition. In a study conducted jointly with the International Energy Agency (IEA), the European Patent Office (EPO) highlighted Europe's significant contribution to grid transformation through digital technologies and intelligent systems. Antonio Campinos, President of the EPO, has underscored how important technological innovation and patent protection are in the electricity grid sector.

Meanwhile, IEA Executive Director Fatih Birol said that while "by 2025, nuclear power is set to generate a record level of electricity," just as important will be investment in transmission and distribution infrastructure, with grid interconnection becoming a key factor in energy security and access to electricity in emerging economies. Grids not only support economic growth, they are also crucial in integrating renewable energy sources and managing demand, he added.

Speaking at The European House – Ambrosetti Forum, *Today and Tomorrow's Competitive Strategies*, Gianni Vittorio Armani, Director of Enel Grids and Innovability, described distribution networks as the cornerstone of the energy transition. To support the increasingly electrified economy and the expansion of renewable energy, infrastructure must be improved and digitalized, he explained. Italy's electricity system will be transformed in the coming decades, with annual investment in the sector set to double in the coming decades.

Gerhard Salge, Vice-President of Hitachi Energy, recently told *Energías Renovables* that digitalization in the energy grid of tomorrow, and technologies such as artificial intelligence and machine learning "are fundamental for energy forecasting, resource management, and operational performance, providing actionable insights that drive better decision-making and greater efficiency across the grid".

Turning to security and resilience, Farshad Khorrami, a professor at NYU Tandon, explained that truly effective solutions must adapt to the complexities of cyber-physical electricity networks. "Infrastructure must provide resilient defence against a wide range of vulnerabilities and operate swiftly to detect dynamic threats."

Finally, Francisco de Leon, also a professor at NYU Tandon, examined the challenges posed by the growing adoption of electric vehicles and the increasing penetration of renewable energy. He warned that moving to a more sustainable electricity system requires costly and complex upgrades to existing infrastructure, along with new controls to manage an ever-growing number of distributed energy resources.

All of these insights underline how electricity grids are the beating heart of the energy transition. Investing in innovation, security, and interconnection will be vital to tackle global challenges and ensure a sustainable and resilient future.

Fatih Birol

Executive Director, International Energy Agency

In January 2025, presenting the report *The Path to a New Era for Nuclear Energy*, IEA Executive Director Fatih Birol expressed strong support for the revival of nuclear power:

"It's clear today that the strong comeback for nuclear energy that the IEA predicted several years ago is well underway, with nuclear set to generate a record level of electricity in 2025. In addition to this, more than 70 gigawatts of new nuclear capacity is under construction globally, one of the highest levels in the last 30 years, and more than 40 countries around the world have plans to expand nuclear's role in their energy systems. SMRs in particular offer exciting growth potential. However, governments and industry must still overcome some significant hurdles on the path to a new era for nuclear energy, starting with delivering new projects on time and on budget – but also in terms of financing and supply chains [...] Today, more than 99% of the enrichment capacity takes place in four supplier countries, with Russia accounting for 40% of global capacity, the single largest share. Highly concentrated markets for nuclear technologies, as well as for uranium production and enrichment, represent a risk factor for the future and underscore the need for greater diversity in supply chains".

At the end of 2024, Birol also stressed the crucial role of electricity grids: "Grids have been the backbone of electricity systems for more than a century, underpinning economic activity by bringing power to homes, industry and services. The role of electricity is becoming even more prominent, and the International Energy Agency has made it clear that the future of the global energy system is increasingly electric."

Without electricity networks capable of delivering new power supplies to where they are needed, economic activity could stagnate, hitting the most vulnerable in society hardest. The provision of access to energy to people in emerging and developing economies could be affected, and it would become more costly and complex to integrate new energy sources into electricity networks. To ensure the world's grids are fit for purpose we must not only build new lines but also refurbish and upgrade existing networks to get the most out of existing infrastructure.

Interconnected electricity grids are fundamental to energy security, and cross-border electricity trade in Europe is estimated to generate economic benefits of around EUR 34 billion per year. After Russia's full-scale invasion in 2022, Ukraine's electricity grid was interconnected with the continental European system in record time, and by summer 2024, exports from Europe were meeting nearly a fifth of Ukraine's peak power demand. In April 2025, the issue of electricity grids and secure power supplies will be a key part of the agenda at the International Summit on the Future of Energy Security, convened by the IEA and hosted in London by the UK government.

New approaches to grid expansion and refurbishment can boost national competitiveness, which is increasingly important to governments in the wake of a global energy crisis and a period of high prices. Technological innovation is at the heart of meeting this challenge. Innovators will accelerate progress in areas such as increasing the share of variable renewable energy like wind and solar on the grid, and improving demand-side management measures to ensure consumer participation. Governments play a crucial role in supporting innovation and encouraging grid operators to implement the latest solutions. Many countries foster domestic manufacturing of clean energy technologies and stimulate local demand. To date, these efforts have focused mainly on solutions such as solar PV, wind turbines, batteries, electric vehicles, electrolysers, and heat pumps. However, this report highlights that the quest for leadership in electricity grid innovation is intensifying, and that there is a strong case for expanding industrial strategies to include grid-related technologies.

IEA – A new era for nuclear energy beckons as projects, policies and investments increase
IEA – Patents for Enhanced Electricity Grids

Gerhard Salge

Vice President, Hitachi Energy

In a recent interview with *Energías Renovables*, Gerhard Salge, Vice-President of Hitachi Energy, discussed the future of digitalisation and the role that technologies such as artificial intelligence and machine learning will play in the energy grid of the future.

«Digitalization provides visibility of assets and systems and can efficiently harness enormous quantities of useful data. It easily integrates IT and OT information, so operators in control centers can interpret key insights from processed data in real time and take faster decisions to prevent critical failures or enhance asset management. Digitalization is the only way to manage this complexity and simplify the contextualization of the data that will be generated».

«Artificial Intelligence and Machine Learning can be leveraged to further optimize power system operations. AI and ML enhance e.g. energy forecasting, providing more accurate predictions of supply and demand, which enables optimized grid operation and minimizes energy waste. AI can also simultaneously enhance grid resilience, efficiency, and sustainability, while also ensuring reliable operations in an evolving energy landscape. These technologies are also key to energy forecasting, asset management and operational performance, delivering actionable insights that drive better decision-making and improved efficiency across the grid».

How Digitalization is Transforming the Energy Landscape: An Interview With Gerhard Salge of Hitachi Energy

António Campinos

President, European Patent Office

As recently emphasised in Mario Draghi's landmark report, taking the lead in new clean technologies and accelerating the energy transition away from fossil fuels are key conditions to secure European economic competitiveness. Significant progress has already been made: Europe is producing record levels of renewable energy, while electric vehicles and heat pumps are being deployed on a continental scale. These trends make it increasingly urgent to invest in smarter and more flexible transmission and distribution networks that can effectively balance the growing demand for power with new, variable sources of energy. In this context, producing reliable intelligence on available innovative technology options is a crucial part of the EPO's strategic commitment to sustainability and to support robust business and policy decisions.

The EPO's fourth study in collaboration with the IEA since 2020 examines innovation trends in power grids. Combining the IEA's energy expertise with the EPO's patent knowledge, it shows how digital technologies are disrupting this field and the deep transformations that are taking place in a century-old industry as a result. The study was supported by 12 patent offices involved in the EPO Observatory's energy transition activities, including Austria, Bosnia and Herzegovina, the Czech Republic, Finland, Italy, Latvia, Lithuania, Monaco, the Netherlands, Spain, Sweden, and Türkiye.

The study shows innovation within grid technologies has accelerated dramatically over the past 15 years, paving the way for a new era of power networks capable of seamlessly sensing and managing vast numbers of electrical devices. They also underscore Europe's major contribution to this transformation, highlighting the opportunities for energy transitions within European industries – both startups and large companies alike. The report also emphasizes the competitive nature of innovation in clean technologies: the global race for smarter grid technologies has accelerated in recent years, thanks to the growing impact of artificial intelligence and smart EV charging. By providing decision-makers with unparalleled insight into patenting trends, these findings offer a valuable roadmap for our transition to a new energy system.

IEA – Patents for Enhanced Electricity Grids

Farshad Khorrami

Professor in Tandon's Electrical and Computer Engineering (ECE) department

Power producers face a multitude of challenges when it comes to producing more electricity, and to ensure that power is delivered where and when it is needed. There is pressure to integrate more renewable energy resources to help meet net-zero targets and other decarbonization goals. At the same time, electrification efforts, notably from the transportation sector, are driving increased demand for electricity.

The need to upgrade aging transmission and distribution (T&D) infrastructure looms over everything—a problem exacerbated by extreme weather and other threats to the grid. Research conducted by the Tandon School of Engineering at New York University has helped identify threats to the grid, the weaknesses in the firmware used in T&D networks and what fixes could be required of T&D system software.

Farshad Khorrami, a professor in Tandon's Electrical and Computer Engineering (ECE) department, and his team of researchers developed the Digital Twin for Security and Code Verification, or DISCOVER, which helps researchers analyze and evaluate updates to software and firmware before applying them to real-world systems. The NYU project, which received a three-year $4.8 million Department of Energy grant, is an example of preventive cybersecurity, the type of infrastructure investment that is needed to ensure the resilience of America's power grid, utilities, pipelines, and renewable energy resources.

Khorrami, along with Dr. Francisco de Leon, NYU Tandon Professor of Electrical and Computer Engineering, recently talked to POWER about their work, and the challenges facing the power grid.

POWER: What are the biggest problems facing today's electricity transmission and distribution (T&D) systems?

«A crucial challenge in both transmission and distribution is the development and deployment of robust cybersecurity systems that can defend against malicious actors that seek to undermine stability or performance or cause economic impacts. Critical attack vectors include untrustworthy hardware/software supply chains and advanced persistent threats (APTs) that use social engineering and zero-day vulnerabilities to gain footholds into protected networks and laterally move to attack sensitive nodes. For example, in the context of Real Time Automation Controllers (RTACs), Remote Terminal Unit (RTUs), and protection relays, their remote reprogrammability/reconfigurability features and wide potential impact on power grid stability and performance make them likely targets for attacks. Truly effective cybersecurity solutions will need to be able to scale to the complexities of the current and evolving cyber-physical power grid, provide resilient defense against a vast array of vulnerabilities/attacks, and operate fast enough to detect dynamic threats».

The POWER Interview: Solving the Challenges Facing the Grid

Francisco de Leon

NYU Tandon Professor of Electrical and Computer Engineering

POWER: What are the biggest problems facing today's electricity transmission and distribution (T&D) systems?

«There are two challenges that distribution systems are facing. First is a high penetration of solar generation, which produces bi-directional power flows in a system that was designed solely for power to flow downstream (generator to load). The protection system needs to be updated but this is expensive and will take years (if not decades) to implement. In the meantime, utilities could be forced to curtail the amount of power generated from solar projects.

Secondly, a large number of EV [electric vehicle] charging stations can produce overloads if left uncontrolled. A low power charger (level 1, from 1 to 1.8 kW) doubles the nightly demand of a typical house. A high-power charger (level 3, from 30 to 360 kW) multiplies the demand by a factor as large as 100 (and therefore not suitable for home installation). The transformers feeding the most typical residential EV charger at level 2 (from 3 kW to 22 kW) may not be able to support two neighbors charging simultaneously. If the transformers are upgraded, the feeders may not be able to support hundreds of EVs charging uncoordinated.

The most concerning challenge that transmission systems are facing is the substitution of high-inertia traditional generation (driven by heavy steam and hydraulic turbines) by low-inertia solar and wind farms. This may produce instability problems (yielding to blackouts) if not properly addressed. A new paradigm to control power systems is approaching. Renewable resources offer better and faster controllability but the number of controllers increases dramatically, say from today at tens of thousands of controlling entities to tens of millions in the not-so-distant future. I foresee that backouts would be more frequent but their range and duration will be reduced when compared to today's conditions».

The POWER Interview: Solving the Challenges Facing the Grid

News & Events

Upcoming Energy Events

Solar Power Summit

March 26-27, 2025

Bruxelles, Belgium

www.solarpowersummit.org

What role will the EU play in a flexible solar future? Can current energy models be reimagined, and Europe's industrial strategy strengthened? Where will Europe source its solar panels?

Marking its 40th anniversary, SolarPower Europe brings industry leaders together in Brussels to shape the future of solar energy for the next five years.

Repurposing Gas Grids

March 26, 2025

Bruxelles, Belgium

www.events.euractiv.com

The EU's industrial carbon management strategy calls for the implementation of a legally binding net-zero target, with at least 50 million tonnes of CO_2 storage capacity. Achieving this will require emitters to be linked to storage sites.

This conference will explore the role of pipelines in helping the EU's to meet its decarbonisation goals.

Energy Efficiency Policy Training Week

April 7-11, 2025

Paris, France

www.iea.org

The IEA is hosting five training courses on the energy transition, combining lectures, discussions, and practical exercises. The programme includes sessions on monitoring, communication, and the socio-economic benefits of energy efficiency.

Aimed at policymakers, the courses also welcome applications from participants in industry, academia, and NGOs.

International Summit On Future Of Energy Security

April 24-25, 2025

London

www.iea.org

The IEA and the UK government host the International Energy Security Summit, which will address the geopolitical, technological, and economic challenges of energy.

The event will focus on demand, supply, the role of electricity in the energy transition, the growth of clean technologies, and the challenges around the sourcing of strategic minerals. It will offer leaders and policymakers from around the world an opportunity to examine the trends reshaping global energy security.

Offshore Technology Conference 2025

May 5-8, 2025

Houston, Texas, USA

www.2025.otcnet.org

The Offshore Technology Conference (OTC) is one of the world's leading events for the offshore energy sector.

Founded in 1969, OTC brings industry professionals together to discuss technological advancements and challenges in offshore energy.

Intersolar Europe 2025

May 7-9, 2025

Munich, Germany

www.intersolar.de

Intersolar Europe is the world's leading trade fair for the solar industry.

Covering photovoltaics, solar thermal technologies, solar power plants, and grid infrastructure, the event brings together industry professionals to discuss the latest trends and innovations in solar energy.

Shaping a Better Energy Future

CESI is a multinational Italian group headquartered in Milan. Founded in 1956, it is now one of the world's leading technical consulting and engineering firms specializing in innovation, digitalization, and testing for the electrical sector, as well as in civil and environmental engineering. Through its KEMA Labs business unit, CESI is the world's leading independent provider of Testing, Inspection, and Certification services for the electrical industry. Additionally, through its CESI Space business unit, the Group also develops and manufactures solar cells for space applications.

With nearly 70 years of expertise, CESI operates in more than 70 countries worldwide. CESI collaborates with key global players in the energy sector, including utilities, transmission system operators, distribution system operators, power generation companies, system integrators, financial investors, and manufacturers of electromechanical and electronic components. The company also works with governments and regulatory authorities, maintaining close cooperation with major international financial institutions.

CESI is a fully independent joint-stock company headquartered in Milan, Italy, with operational facilities in Arnhem (Netherlands), Berlin and Mannheim (Germany), Prague (Czech Republic), Dubai (UAE), Knoxville and Chalfont (USA), Rio de Janeiro (Brazil), and Santiago de Chile (Chile).
For more information, visit www.cesi.it

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