



**WORLD FUTURE
ENERGY SUMMIT**

AN EXCLUSIVE REPORT FOR THE WORLD FUTURE ENERGY SUMMIT BY

F R O S T & S U L L I V A N

THE AI-ENERGY NEXUS - HOW AI IS TRANSFORMING THE GLOBAL ENERGY LANDSCAPE

AUTHORED BY:

Heena Juneja

Industry Principal

Soumyadeep Roy Chowdhury

Senior Industry Analyst,
TechVision Growth Analytics

Built by



In the business of
building businesses

Contents

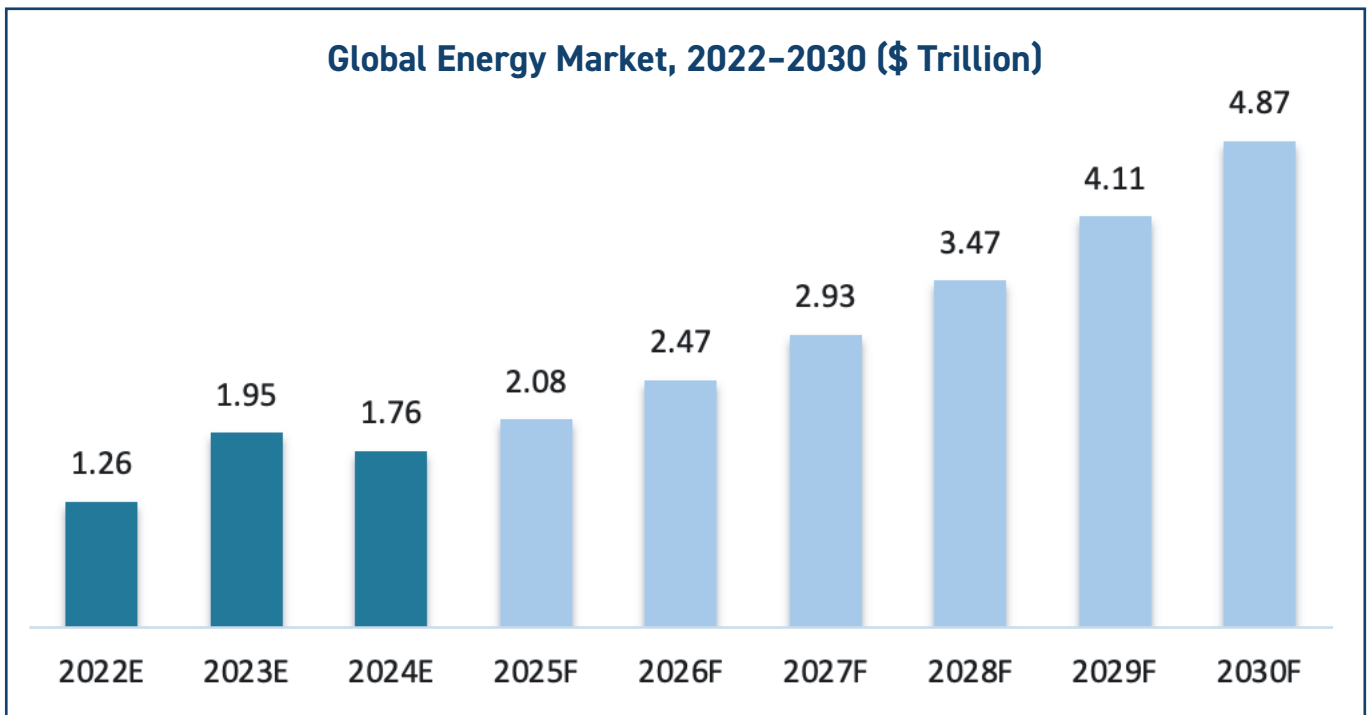
THE AI-ENERGY NEXUS - HOW AI IS TRANSFORMING THE GLOBAL ENERGY LANDSCAPE	1
GLOBAL ENERGY MARKET LANDSCAPE	3
RECENT DEVELOPMENTS & KEY DRIVERS OF AI ADOPTION	4
AI TECHNOLOGIES IMPACTING ENERGY OPERATIONS	5
REGIONAL INSIGHTS	6
USE CASES	8
GLOBAL POLICY FRAMEWORKS AND AI INTEGRATION	9
CHALLENGES AND OPPORTUNITIES	9
CONCLUSION	10
DISCLAIMER	12
ABOUT FROST & SULLIVAN	12
ABOUT THE WORLD FUTURE ENERGY SUMMIT	12
GROWTH PIPELINE ENGINE™	12
REFERENCES	12

Global Energy Market Landscape

The global energy market remains one of the world's largest industrial ecosystems. As per Frost & Sullivan's analysis, market estimates indicate a revenue valuation of around \$1.7 trillion in 2024, with projections suggesting growth to nearly \$4.9 trillion by 2030.

The market has been expanding even during the current periods of volatility, primarily driven by increasing electricity demand, rapid industrialization, urban expansion, and the rising energy needs of digital infrastructure. Energy demand reached nearly 650 exajoules globally in 2024, and the market is backed by more than \$3 trillion in year-on-year investments, particularly in power generation, grids, and downstream services.

Illustration 1: Global Energy Market (2022-2030)



Source: Frost & Sullivan

In 2024, global energy investment was estimated to have exceeded \$3 trillion for the first time, continuing an upward trend from previous years.² Approximately, two-thirds of this spending goes toward clean energy technologies and infrastructure, including renewables, transmission and distribution grids, energy storage, nuclear, low-carbon fuels, and efficiency upgrades. Investment in fossil fuel production and power remains significant, but the balance of global capital has steadily shifted toward clean energy over the past few years.



AI represents one of the fastest-growing technological segments in energy. The demand is driven by applications such as predictive maintenance, renewable energy forecasting, grid optimization, digital twins, and intelligent trading systems, along with increasing use of generative AI for engineering and field-support knowledge.

Recent Developments & Key Drivers Of AI Adoption

Use of AI has considerably increased energy consumption by 10-fold, for e.g. using Large Language Models (LLMs) requires 10 times the power of a normal Google search query. However, AI also brings the solution to this increased power consumption.

AI adoption in the global energy sector is shaped by three dominant developments that are influencing both current operations and future strategic directions. These reflect the broader shift toward smarter infrastructure, proactive decision-making, and low-carbon transformation.

1: AI for Predictive Operations and Reliability Engineering

- Energy companies are increasingly shifting from scheduled maintenance to predictive and condition-based maintenance supported by AI. Machine learning models analyze sensor data, historical failure patterns, and live equipment performance to anticipate faults before they lead to breakdowns.
- Predictive operations are reshaping budget allocation in utilities and oil and gas companies, moving investment toward digital monitoring and away from reactive maintenance. OPEX reductions, efficiency gains, and fewer safety incidents have made AI one of the strongest contributors to operational resilience.
- Up to 40% lower maintenance costs, 50% lower unplanned downtime, and 55% higher maintenance staff productivity were reported by clients after introducing AI-enabled predictive maintenance, as reported by Siemens (The True Cost of Downtime 2024)

2: Generative AI (Gen AI) and Workforce Enablement

- Gen AI interfaces are being introduced across engineering, documentation, training, and process compliance. They consolidate technical manuals, operational history, logs, and regulatory data into conversational search experiences that significantly reduce time spent on information retrieval.
- Gen AI is reducing dependency on unrecorded work techniques and workflow restricted to experts in the field (tribal knowledge) and is closing skill gaps caused by retirement and rapid digitalization. It is also enabling a new operating model where workers interact with AI copilots and receive instant decision support rather than relying solely on legacy systems and manual reference material.



By leveraging generative AI to provide real-time, expert-level support, we are empowering our technicians with the tools they need to improve reliability and efficiency within our fleet.

- Pedro Azagra, CEO, Avangrid



3: Autonomous and Self-Optimizing Energy Systems

- Advanced AI models, combined with IoT and robotics, are paving the way for autonomous asset management. This ranges from autonomous drilling and automated plant inspections to algorithms that balance supply and demand across smart grids in real time.
- Autonomous energy systems are gradually shifting the sector from human-supervised automation to true machine-driven optimization. Operators can now rely on continuous feedback loops, real-time sensing, and automated control actions to improve yield, safety, and sustainability without constant manual intervention.
- In a recent 2025 case, a major transmission operator (a utility in Brazil) announced a partnership to deploy AI across its grid infrastructure; the goal was real-time monitoring and faster correction of failures, enhancing grid resilience and reliability. ⁴

AI Technologies Impacting Energy Operations

Artificial intelligence (AI) is not a single technology but a collection of complementary capabilities that optimize the energy value chain at different levels. Some models focus on improving engineering insight, while others enable autonomous decision-making, real-time simulation, or large-scale pattern recognition. When combined with Internet-of-Things (IoT), Supervisory Control and Data Acquisition (SCADA), and modern control systems, these AI technologies reshape how energy is generated, distributed, stored, and consumed. Some of the key technologies include,

Machine Learning and Advanced Analytics: These technologies help in processing historical and real-time data from sensors, meters, and control systems to forecast demand, detect anomalies, estimate remaining useful life of assets, and optimize dispatch decisions. Machine learning has become the primary engine driving predictive and data-driven decision-making in energy operations.

Real-Life Application: Several utilities like PG&E (US), DEWA (UAE), Enel (Italy)) now use ML-driven grid forecasting tools to anticipate peak demand hours and adjust load distribution across substations, reducing stress on overloaded equipment.

- PG&E used ML-enabled grid forecasting within its ADMS to anticipate future constraints and overload risks, improving grid reliability and operational safety during peak demand periods.
- DEWA applied AI and machine-learning models to forecast peak loads and optimize load distribution, delivering around 20% cost savings while improving energy efficiency and emissions performance.
- Enel leveraged machine-learning forecasting for renewable generation and market bidding, achieving an estimated 5% annual reduction in imbalance costs and more stable grid operations.

Digital Twins: It creates live digital replicas of physical assets like turbines, substations, drilling rigs, and refining units. These models simulate real behaviors to help plan interventions before problems occur. Digital twins help organizations make changes virtually before touching physical equipment, which lowers operational risk and cost.

Real-Life Application: Power-plant operators like Engie (France), GE (Global), KEPCO (South Korea) are using digital twins to test how a turbine will perform under different temperatures or load scenarios before adjusting real-world settings.

Agentic AI Systems: These systems support decision-automation and continuous control of equipment, often without step-by-step human intervention. These also evaluate conditions and take corrective action in real time. Autonomous systems are changing the traditional operator-machine relationship by enabling machines to act on insights directly rather than waiting for instructions.

Real-Life Application: In a drilling operation, agent-based models can optimize bit pressure, mud flow rate, and directional adjustments autonomously to maximize drilling speed and precision.⁵

- SLB & Equinor employed Autonomous 'agent-like' drilling control that delivered 99% autonomous control on a 2.6 km section of operation and achieved a 60% increase in rate of penetration, speeding well delivery while cutting cost and carbon emissions.⁶

Across utilities, renewables, oil and gas, and industrial energy consumers, these AI technologies function together rather than in isolation. Machine learning delivers insight; digital twins provide simulation, generative AI delivers accessible knowledge, and autonomous agents execute decisions at machine speed. Combined, they are accelerating the transition from traditional manual operations to intelligent, self-correcting, and highly efficient energy systems.

Regional Insights

The Middle East has moved from being primarily a resource supplier to becoming one of the most assertive adopters of AI in the energy sector. National strategies in countries such as the UAE and Saudi Arabia place digitalization, AI, and advanced analytics at the center of long-term energy transition and economic diversification plans, e.g. UAE National Strategy for Artificial Intelligence 2031, Vision 2030 (Saudi Arabia), National Strategy for Data and AI (NSDAI) led by SDAIA. Large national oil companies and utilities are investing in AI for production optimization, grid modernization, and integrated planning across their portfolios.

In this region, AI is often deployed at a scale rather than through small pilots - for example, large upstream operators use AI for reservoir modelling, production forecasting, and remote asset management across entire fields.

- ADNOC's Panorama Digital Command Center aggregated real-time operational data across its subsidiaries and used AI analytics to generate recommendations, reporting over \$1 billion in value generated since launch.⁷
- Aramco, at Khurais, deployed 40,000 sensors to monitor 500+ wells and applies big data analytics and machine learning to improve field operations.⁸

Power and water utilities apply AI for demand forecasting, outage prevention, and intelligent control of desalination and generation assets.

- UAE's DEWA applies AI and machine learning through its Distribution Network Smart Centre, processing 15M+ data points daily, to enable proactive maintenance and reliability improvements, helping Dubai achieve 0.94 electricity customer minutes lost per customer in 2024, which is much below leading European utility averages.⁹

Strong state backing, centralized decision making, and access to capital allow these initiatives to move from concept to full deployment relatively quickly. **When compared with other energy-rich and technology-advanced regions, some clear contrasts emerge:**

North America

- North American energy companies are present at the forefront of advanced technology developments such as AI driven energy trading, complex grid analytics, and large digital twin platforms for refineries and pipelines.
- However, projects in this region are tightly shaped by investor expectations, regulatory requirements, & shareholder scrutiny.
- The pace of deployment can be more cautious, with strong emphasis on cybersecurity, governance, and demonstrable financial return, in the region.

Europe

- European energy companies, especially in the North Sea region, combine strong offshore engineering experience with ambitious decarbonization targets.
- Policy frameworks, including climate targets and AI regulation, encourage responsible use of AI but also increase compliance complexity.
- Adoption is focused on optimization, safety, and emissions reduction rather than sheer volume of output.

Asia

- Among key Asian markets, China positions AI as a core enabler for industrial and energy transition, integrating AI with manufacturing, industrial, and large utility networks.
- AI adoption is often coordinated at a national or provincial level, which supports fast scaling once technology is proven.
- In other Asian markets such as South Korea and Japan, AI will be supporting high reliability grids, advanced industrial energy efficiency, and complex urban energy systems where space and reliability are both critical.

Overall, the Middle East is evolving from a follower to a reference region for large scale AI deployment in energy. Its experience in running national scale AI projects (UAE – ADNOC + AIQ, ADES, MBZUAI; Saudi Arabia - Aramco, Vision 2030 AI integration), often across both legacy and new energy assets, will increasingly influence global best practice and partnership models in the coming years.



Use Cases

ADNOC, United Arab Emirates

AI Enabled Command Centers and Energy Efficiency

- ADNOC uses two major AI hubs, the Panorama Digital Command Center and the Thamama subsurface center, to integrate sensor data, optimize operations, and support real-time decision making across its value chain.
- These AI deployments have delivered significant value, including energy savings, faster operational insights, and hundreds of millions of dollars in efficiency gains.
- The company reports material reductions in emissions and improved asset performance through more than 30 scaled AI applications.

ENGIE, France

AI for Renewables Siting, Asset Knowledge, and Load Forecasting

- ENGIE has applied AI to optimize renewables siting, digitize complex industrial assets, and forecast energy demand with high precision.
- Using AI for climate and weather analysis accelerates site selection process for wind and solar projects, while 3D asset modelling improves documentation and maintenance planning across gas storage sites.
- AI-enabled forecasting also strengthens system balancing and renewable integration, improving both operational efficiency and reliability.

SHELL, United Kingdom

Scaling Predictive Maintenance Across 10k Assets

- Shell implemented AI-driven predictive maintenance across more than 10,000 critical equipment units globally, enabling early detection of issues such as degrading control valves.
- This program has helped the company reduce unplanned downtime, cut maintenance costs, and improve safety by preventing sudden equipment failures.

SLB, United States

Autonomous Drilling and Performance Optimization

- SLB uses AI-driven drilling systems such as DrillOps and Neuro to optimize drilling parameters in real time and automate key operational decisions.
- In collaboration with operators like Eni, these tools have achieved record drilling speeds, reduced non-productive time by more than half, and improved overall positive delivery consistency.

These implementations reflect a consistent pattern, and AI is no longer a peripheral tool but a central driver of operational excellence and decarbonization. As more operators scale similar capabilities, AI will define how modern energy systems are planned, operated, and continuously improved.

Global Policy Frameworks and AI Integration

Public policy is now a major force in shaping how AI is integrated into energy systems. Governments are trying to balance three pressures at once: decarbonization, energy security, and the rapid growth of AI workloads themselves. As a result, policy frameworks are increasingly designed around two ideas: using AI to modernize energy systems and ensuring that the growing energy demand from AI remains compatible with climate and security goals.

Across regions, there is no single global template for regulating AI in the energy sector. The European Union relies on comprehensive AI regulations with specific obligations for critical infrastructure. The United States and China use sectoral programs and strategic plans that heavily involve public research institutions and infrastructure planning. The Middle East embeds AI in national visions for diversification and energy leadership. India, Japan and South Korea link AI to smart grids and energy transition priorities.

For energy companies, the common signal is clear: policy is moving toward deeper alignment of AI deployment with energy security, climate goals, and infrastructure resilience. Any serious AI strategy in the sector must therefore be designed with policy and regulation as a core design constraint, not an afterthought.

Challenges and Opportunities

Although the energy sector is rapidly adopting AI, several practical gaps continue to slow down scale, consistency, and full-funnel value realization. These challenges vary across geographies and subsectors, but the underlying patterns are similar.

The biggest challenges today sit at the intersection of people, data, and systems, rather than technology alone. Many organizations operate with legacy systems that are not built for real-time data exchange. Data quality and governance vary between facilities. The workforce requires greater AI proficiency, and cybersecurity remains a priority concern. Capital requirements for digital upgrades can also be substantial. The biggest challenges today sit at the intersection of people, data, and systems, rather than technology alone.

These challenges exist alongside major opportunities:

- AI opens new frontiers of efficiency in the energy sector by improving grid stability, forecasting renewable variability, and helping operators extract more value from existing infrastructure rather than relying on costly physical expansion.
- At the same time, AI-driven knowledge tools are strengthening the workforce by closing expertise gaps, improving safety, and accelerating skills development across field and control-room operations.
- These foundations are enabling the gradual emergence of autonomous, self-managing energy systems that can balance supply, optimize assets, and correct operational deviations in real time.

Together, these shifts point toward a future where continuous intelligence underpins both decarbonization and long-term system reliability. This raises the question of whether we will be able to reduce global emissions by 43% by 2030, as forecasted by United Nations' Intergovernmental Panel on Climate Change (IPCC).



There is no doubt that the benefits of AI will transform the way the grid operates. Although it is not a silver bullet to all our challenges, it is a critical piece of the puzzle. The path of least risk for the industry is to invest in AI-ready infrastructure and determine how to leverage AI to achieve a clean and reliable energy transition.

- Marissa Hummon, CEO, Utilidata ¹⁰



Organizations that build strong data foundations, modernize operational practices, and invest in digital skills will be positioned to extract the deepest value from AI. As energy markets continue to decentralize, electrify, and transition toward low-carbon systems, AI will become increasingly central to operational reliability and economic advantage. The direction of travel is clear: the companies that treat AI as a core part of their operating model, rather than a collection of experimental tools, will define the next era of global energy leadership.

Conclusion

There is a clear shift in the energy sector from traditional, labor-intensive and reactive operations toward intelligence-driven, highly optimized and increasingly autonomous systems. AI has evolved from a supportive digital capability to a structural enabler for energy reliability, decarbonization, and economic resilience. Organizations that have already embedded AI into their operating models are seeing measurable results, lower unplanned downtime, improved workforce productivity, enhanced grid stability, more efficient planning, and reduced emissions. The next phase of value will come from moving beyond pilot deployments to enterprise-wide adoption supported by strong governance, digital foundations, and skilled teams.

Strategic Recommendations and Way Forward

Building Strong Data Foundations for Scalability:

- The long-term success of AI depends on the quality, accessibility, and interoperability of industrial data. Siloed OT and IT systems would make AI deployment a labor-intensive integration effort, hence focus should be on,
 - Standardizing data architectures, asset taxonomies & metadata models across facilities
 - Securing operational data lakes & repositories
- Middle East operators can leverage their large, centrally managed asset bases to standardize data architecture across fields, plants, and grids, enabling AI models to scale rapidly beyond pilots.
 - National digital mandates and sovereign-backed platforms provide a strong foundation to integrate OT, IT, and cloud data securely at enterprise and national levels.
- Overall, this approach reduces duplication of effort, speeds up future AI deployment, and ensures that insights can be scaled rather than recreated at each site.

Prioritizing Outcome-Driven Use Cases:

- Instead of spreading investment across many small AI pilots, companies should identify and scale use cases that deliver measurable operational and sustainability benefits, such as,
 - Predictive and condition-based maintenance
 - Grid forecasting and renewable scheduling
 - Autonomous drilling optimization
 - Digital twins for performance and downtime reduction
- This focused approach enables faster payback, builds internal confidence, and creates a repeatable scaling model.

With strong capital availability and national energy-transition goals, Middle East organizations are well positioned to focus AI investments on high-impact use cases such as production optimization, grid reliability, and energy efficiency.

Investing in Workforce Enablement Tools and Digital Culture:

- The transition to AI-supported energy systems is as much about people as it is about algorithms. Workforce enablement requires digital upskilling for technicians, engineers, and staff, decision-support tools and revamped workflows for AI-driven operations.
- Energy leaders in the Middle East can use AI copilots and decision-support tools to bridge experience gaps, support localization of expertise, and upskill a growing digital-native workforce.
- Building the culture of acceptance for these changes and AI systems themselves helps avoid resistance and better focus on operational efficiencies & growth acceleration.

Additional focus areas relevant for Energy Businesses in the Middle East:

- **Generative AI for forecasting:** Countries in the Middle East can use AI-driven hyperlocal weather and generation forecasting to better balance renewables and reduce dependence on backup power. This directly improves grid stability and asset utilization but requires high-quality meteorological and generation data to avoid forecast-driven operational risk.
- **Agentic AI for autonomous grid operations:** Energy providers in the Middle East can deploy agent-based AI to enable self-healing grids and autonomous optimization at scale. The main benefit to gain will be faster fault resolution and lower OPEX, though clear human-override frameworks are essential for critical infrastructure safety.
- **AI-driven demand management:** AI-controlled buildings, cooling systems, and EV charging can help Gulf utilities smooth peak demand and improve efficiency under extreme climate conditions. This can shift investment away from peak-capacity buildout toward smarter consumption, but success would depend on consumer participation and regulatory alignment.
- **AI-enabled policy and planning with explainability:** Middle East governments can apply explainable AI to model energy and climate scenarios, enabling transparent policy decisions and coordinated regional energy strategies. Explainability builds trust across regulators and operators, but model assumptions must be continuously reviewed to prevent policy lock-in due to outdated data.

The direction of the energy sector is unambiguous; grid and asset complexity will continue to rise as electrification accelerates, renewable penetration increases, and demand from digital infrastructure grows. AI provides one of the most scalable ways to manage these complexities without compromising reliability, safety, or sustainability. The convergence of AI and energy is no longer a distant vision; it is the foundation on which the next era of global energy leadership and competitiveness is being built.

About Frost & Sullivan

YOUR TRANSFORMATIONAL GROWTH JOURNEY STARTS HERE

Frost & Sullivan's Growth Pipeline Engine, transformational strategies and best-practice models drive the generation, evaluation, and implementation of powerful growth opportunities. Is your company prepared to survive and thrive through the coming transformation?

To get in touch with our Growth Advisory Experts, e-mail: nimisha.iyer@frost.com

Frost & Sullivan's Growth Pipeline Engine™ supports clients through all 5 phases of growth: from developing, evaluating, and prioritizing opportunities to building and implementing go-to-market strategies and optimizing opportunities. The objective of this study is to be a client's first step on a growth journey.

Frost & Sullivan's Growth Pipeline Engine™



About the World Future Energy Summit

The World Future Energy Summit is the leading global event for clean energy and sustainability, bringing together innovators, business leaders, policymakers, and investors to turn ambition into action.

Over three days, the international exhibition and conference addresses the most pressing challenges of our time—clean energy, climate change, sustainable cities, water security, waste management, green finance, and the transformative power of artificial intelligence.

By uniting almost 42,000 attendees from public, private, and non-profit sectors, it serves as a critical bridge between bold policy and real-world solutions.

worldfutureenergysummit.com

[YouTube](#) [in](#) [Instagram](#) [X](#) [Facebook](#) @worldfutureenergysummit

Disclaimer

Frost & Sullivan is not responsible for any incorrect information supplied by companies or users. Quantitative market information is based primarily on interviews and therefore is subject to fluctuation. Frost & Sullivan research services are limited publications containing valuable market information provided to a select group of customers. Customers acknowledge, when ordering or downloading, that Frost & Sullivan research services are for internal use and not for general publication or disclosure to third parties. No part of this research service may be given, lent, resold, or disclosed to noncustomers without written permission. Furthermore, no part may be reproduced, stored in a retrieval system, or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the permission of the publisher.

References

¹ International Energy Agency (France) <https://www.iea.org/reports/global-energy-review-2025/global-trends>

² The International Energy Agency's (IEA) report:

<https://www.iea.org/reports/world-energy-investment-2024/overview-and-key-findings>

³ Electric Perspectives: <https://www.electricperspectives.com/avangrid-ai-wind-first-time-right/>

⁴ <https://www.reuters.com/business/energy/eletrobras-partners-with-c3-ai-modernize-brazils-power-grid-2025-08-18/>

⁵ <https://www.slb.com/news-and-insights/newsroom/press-release/2024/slb-and-equinor-drill-most-autonomous-well-section-to-date>

⁶ <https://www.slb.com/resource-library/case-study-with-navigation/di/unlocking-potential-equinors-journey-to-autonomous-well-delivery-in-the-peregrino-field>

⁷ <https://www.adnoc.ae/en/news-and-media/press-releases/2020/adnoc-panorama-digital-command-center-generates-over-1-billion-in-value/>

⁸ <https://www.aramco.com/en/what-we-do/energy-innovation/digitalization/ai-and-big-data>

⁹ <https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2025/07/dewa-deploys-ai-in-energy-distribution-to-enhance-network-efficiency-and-service-reliability>

¹⁰ <https://gridforward.org/early-ai-use-cases-and-lessons-for-utilities-grid-operators-and-regulators/>