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UTC Global Advisory Committee

Artificial Intelligence in Electric Utilities: Enhancing Safety, Efficiency, Reliability and Customer Service

July 2025

Utilities Technology Council™

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Endorsements by the three executives of UTC, UTCAL and EUTC.

"AI is no longer optional, it's a strategic imperative. For North American utilities, embracing AI with strong governance and clear business alignment is the only path to delivering safe, reliable and customer-focused service in a rapidly evolving grid environment."

Rusty Williams – President and *CEO, Utilities Technology Council (UTC)*

"In Latin America, utility companies and electric system operators are very active, deploying and/or testing AI. Legislative bodies and sector regulators are enacting laws and defining regulatory frameworks that facilitate sustainable, safe and responsible AI growth."

Dymitr Wajsman - *Executive Director, UTC América Latina (UTCAL)*

"Europe's utilities are at the forefront of digital transformation, and AI is central to building a sustainable, resilient and intelligent energy system. The time is now to operationalize AI under ethical, auditable and interoperable frameworks."

Dr. Andreas Breuer - *President, European Utilities Telecom Council (EUTC)*

Contributors:

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About the GAC

The three independent trade organizations Utilities Technology Council (UTC), Utilities Telecom & Technology Council América Latina (UTCAL) and European Utilities Telecom Council (EUTC) form the UTC Global Advisory Committee (GAC) which was formally incorporated in February 2014 and is governed by operating principles. The chairs/presidents of the respective regions lead the GAC in annual rotating succession. The GAC acts in an advisory capacity to further the knowledge and interests of the members of the independent UTC organizations.

About UTC

The Utilities Technology Council (UTC) is a global trade association dedicated to serving critical infrastructure providers. Through advocacy, education and collaboration, UTC creates a favorable business, regulatory and technology environment for our members who own or operate Information and Communication Technology (ICT) systems in support of their core business. For more information: UTC.org

About UTCAL

UTC América Latina promotes the understanding and debate of key issues for utilities telecommunications and technology in Latin America. UTCAL recognizes the increasingly decisive role that technology and telecommunications play in the security and reliability of businesses and encourages the exchange of expertise between companies with critical infrastructure, maximizing the benefits of the use of ICT. UTCAL enables a constant exchange of knowledge and information and works with regulators, supporting the interests of its members. UTCAL

About EUTC

The European Utilities Telecom Council (EUTC) fosters energy efficiency and security as well as a net zero carbon future through developments in utility telecom across Europe. EUTC promotes these objectives by advocating for its members and influencing policies to promote the use of innovative technologies, processes and business insights to support smart infrastructure and the related policy objectives. EUTC shares best practices and learnings from EUTC, UTC and UTCAL industry practitioners within the field of utilities and other critical infrastructure environments and associated stakeholders. EUTC

1. Executive Summary

This discussion paper, authored by the Utilities Technology Council (UTC), UTC América Latina (UTCAL) and the European Utilities Telecom Council (EUTC), explores the transformative potential of Artificial Intelligence (AI) in the electric utility sector. As the industry navigates complex landscape of electrification, distributed energy integration and rising customer expectations, AI emerges as a critical enabler of improved efficiency, reliability and customer engagement.

> "…AI is not merely a technical upgrade but a strategic necessity."

The paper aims to equip senior utility executives with a deep understanding of AI's current applications and future potential across business verticals, i.e., generation, transmission, distribution and within varying regulatory contexts. It argues that AI is not merely a technical upgrade but a strategic necessity. However, unlocking its benefits demands careful planning, significant investment, risk management and organizational flexibility.

This introductory analysis is the result of extensive research, industry interviews and real-world use cases that will be the springboard for deeper future exploration.

Key Conclusions

- AI as a Strategic Asset: Utilities must treat AI as a core strategic capability, not just a digital experiment.
- Purpose-Driven Deployment: Success depends on clearly defined use cases supported by high-quality utility-specific data.
- Operational Integrity: Outputs from AI systems must be auditable, secure and aligned with engineering protocols.
- Cyber Resilience: Utilities must integrate their AI initiatives into robust cybersecurity strategies.

- Workforce Alignment: Success hinges on upskilling existing staff and fostering an AI-literate culture.
- Anticipating Second-Order Effects: AI infrastructure will impact energy demand and regulatory needs.
- Equity in Restoration Logic: AI opens the door to rethinking restoration priorities with equity in mind.
- Scalability through Sharing: Shared frameworks and learnings will accelerate sector-wide transformation.

Recommendations

Short-Term (12–24 Months):

- Develop an AI Strategy: Link AI to clear business outcomes, supported by executive leadership and cross-functional governance.
- Enhance Data Readiness: Invest in data infrastructure and quality, treating data governance as foundational.
- Pilot High-Impact Projects: Focus on narrow, value-driven use cases (e.g., predictive maintenance, load forecasting).
- Build Workforce AI Literacy: Train staff across all levels to understand and interact with AI tools.
- Implement Strong AI Governance: Establish committees and frameworks to manage bias, explainability and cybersecurity.
- Create a Knowledge Library: Document lessons and build institutional memory for internal scaling and external collaboration.

Mid-Term (3–5 Years):

- Scale Proven Solutions: Expand successful pilots into enterprise-wide tools integrated into daily workflows.
- Invest in Advanced Capabilities: Explore prescriptive AI, autonomous operations and intelligent cyber defenses.

- Reassess Restoration Protocols: Use AI insights to align outage response with modern critical service priorities.
- Strengthen Partnerships: Collaborate with tech vendors, academic institutions and peer utilities to drive innovation.
- Shape Regulatory Dialogues: Proactively work with regulators to co-create ethical, explainable AI frameworks.

2. Introduction

The Utilities Technology Council (UTC), Utilities Telecom & Technologies Council América Latina (UTCAL) and European Utilities Telecom Council (EUTC) present this discussion paper on the current and future impacts and opportunities of Artificial Intelligence (AI) on the electric utility sector. From improving the safety and performance of field operations to reshaping customer engagement and accelerating regulatory processes, utilities have only begun to explore AI's potential to make operations more efficient, reliable and customer focused.

The core purpose of this paper is to move beyond generalized discussions and provide senior managers and corporate executives with a nuanced understanding of AI's current applications and future trajectory specifically within the context of sector business verticals (generation, transmission and distribution) and regional regulatory regimes. It aims to illuminate the tangible opportunities AI presents for transforming core utility operations. The central thesis posits that AI offers unprecedented potential to make these operations significantly better through enhanced efficiency, reliability and productivity; safer in terms of reducing risks for personnel and the public; and more customer-centric by enabling increased levels of personalized services and engagement. However, realizing this potential is not automatic. It demands deliberate strategic planning, significant investment in capabilities, careful management of inherent risks and a commitment to organizational flexibility and adaptation. This paper serves as an initial introduction to the state of AI in the industry and guide for navigating the coming complex but critical transition.

This paper is the culmination of extensive research, interviews with utilities and technology providers already deploying AI and dialogue between select industry professionals over the course of months. Even as such, it is only a cursory current state examination of the coming AI transition with the intent of providing an overview and high-level recommendations to senior managers and leadership regarding managing the initial transition. Coming papers will build on this foundation and provide additional depth of understanding in terms of both AI's capabilities and impact, as well as guidance regarding the associated standards and frameworks covering the safe and resilient incorporation of AI into the sectors operational verticals and backend business functions.

3. Defining the Scope of AI in Utilities

"Artificial intelligence" is a broad term referring to machines performing tasks that typically require human intelligence – such as understanding language, recognizing patterns, solving problems, or making decisions. AI is enabled by various subfields and techniques, each of which plays or will play a role in utility applications. The figure below presents the categorical inclusion that different types of AI have with one another. Please note that it is not meant to be a full "model" of AI ecosystem, it represents a few select elements/families of algorithms and methods and is not an all-encompassing overview of AI.

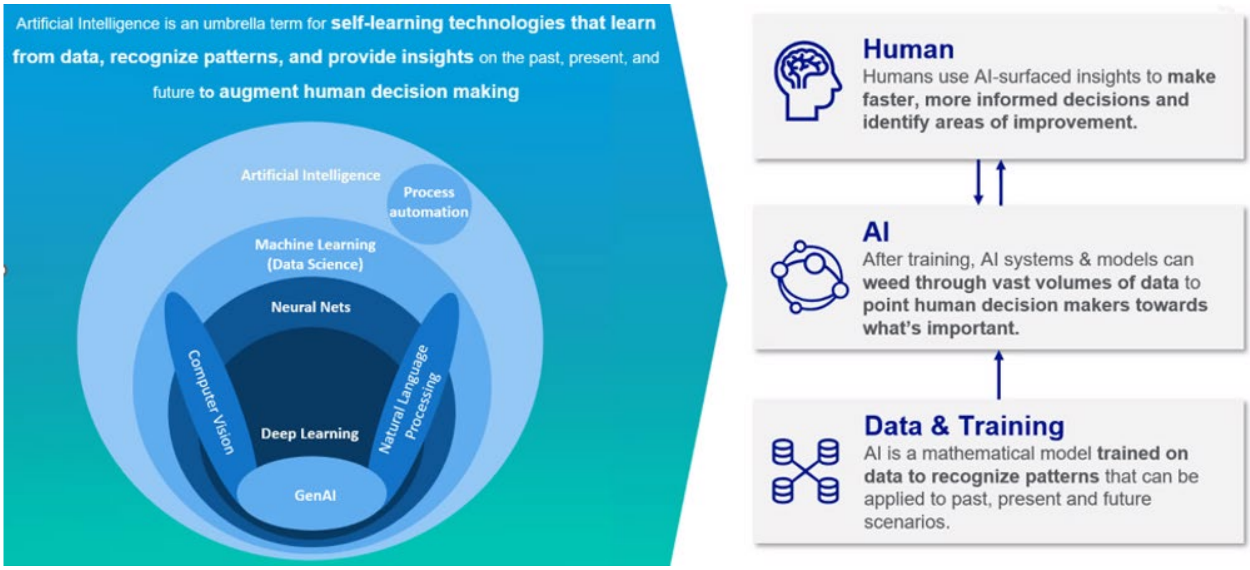

Figure 1: UTC utility member

3.1. Machine Learning (ML)

A subset of AI that enables systems to learn from data examples rather than explicit programming. ML algorithms find patterns in historical data and improve their performance over time. (Syracuse University School of Information Studies, 2025) In utilities, ML is the engine behind an increasing number of predictive analytics solutions, e.g., forecasting electricity demand or predicting equipment failures from sensor trends. Deep learning (using multi-layer neural networks) is a powerful ML approach used for complex pattern recognition, such as detecting grid disturbances or classifying imagery. These data-driven methods thrive on large datasets, which modern utilities are increasingly able to provide through IoT sensors and smart devices. Subsections of ML that could prove especially valuable for utilities are Supervised Learning which is used for predictive maintenance by training models on historical failure data; Unsupervised Learning which employs clustering algorithms for identifying consumption patterns; and Reinforcement Learning which can facilitate optimization of grid operations by continuously learning and adapting to dynamic conditions.

3.2. Natural Language Processing (NLP)

AI techniques that allow computers to interpret and generate human language. NLP powers utility chatbots and voice assistants that can understand customer queries or voice commands. NLP can also analyze unstructured text data, e.g., mining insights from maintenance logs or customer feedback comments. By understanding language input, NLP systems enable more intuitive interactions between humans and utility computer systems (e.g., allowing an operator to ask an AI assistant for the status of a substation in plain English).

3.3. Computer Vision

AI that can interpret visual information from cameras, drones, or satellite images. In the electric utility context, computer vision algorithms analyze images or video to identify objects and anomalies. This is crucial for automated asset inspections – utilities use drone cameras or aerial imagery to survey lines and equipment, and AI vision models can pinpoint problems like a cracked insulator or an encroaching tree branch without a human inspector climbing a pole (Slind, 2024). Vision-based AI is also employed in vegetation management, automatically identifying overgrown vegetation near power lines (a major cause of outages and wildfire ignition) so that crews can target high-risk areas.

3.4. Generative AI

A newer class of AI models (exemplified by GPT-4 and other large language models (LLM), as well as image generators and Generative Adversarial Networks (GANs) (Terra, 2024) that can create new content – text, images, or synthetic data – based on patterns learned from training data. While generative AI in utilities is nascent, there are emerging use cases. One example is creating synthetic training data for AI models when real data is scarce or sensitive. Utilities can generate simulated grid sensor data or failure scenarios to train predictive models. Generative AI can also help with scenario planning; for instance, producing plausible what-if scenarios for grid contingency analysis (e.g., simulating the effects of a hypothetical widespread outage or cyberattack) to improve emergency preparedness. Additionally, large language models are being experimented with for assisting employees – such as summarizing technical documents or serving as intelligent chat assistants ("co-pilots") for engineers seeking information (MIT News, 2023).

3.5. Agentic AI

Sometimes referred to as *Autonomous Agents*, these are AI systems endowed with a degree of decision-making autonomy, capable of perceiving their environment and taking independent actions toward goals. In utilities, this concept underpins the vision of self-healing grids – where intelligent control agents distributed throughout the grid automatically reconfigure circuits in response to faults, without waiting for central commands. Early steps toward this include AI-driven fault isolation and service restoration in distribution networks. Research suggests that multi-agent AI systems could coordinate in real time to optimize grid reliability (e.g., autonomously rerouting power flow around a downed line). While full autonomy in grid control is still in the future, we discuss below how some utilities take careful steps toward greater automation and smarter controls (Purdy, 2024).

3.6. Artificial General Intelligence (AGI)

This human-level, broad AI concept remains theoretical and beyond the planning horizon of the next decade. The AI applications in utilities today are examples of *narrow AI* focused on specific tasks. These can nevertheless be very powerful in their domains, and their capabilities continue to advance rapidly. In the next sections, we examine concrete use cases of these AI technologies across the value chain: generation, transmission, distribution, customer service and internal operations (Littman et al., 2021).

4. Overview of Current State of AI Adoption

Artificial Intelligence is no longer a futuristic concept for electric utilities. They are actively deploying AI across the electric sector's value chain, delivering measurable improvements in efficiency, reliability and safety. While adoption levels vary, early adopters are demonstrating significant benefits, primarily by applying AI, particularly machine learning algorithms, to optimize existing processes and leverage the growing volumes of data generated by modern grid technologies. The current landscape reveals a focus on leveraging AI for enhanced situational awareness, predictive capabilities and process automation within established operational frameworks.

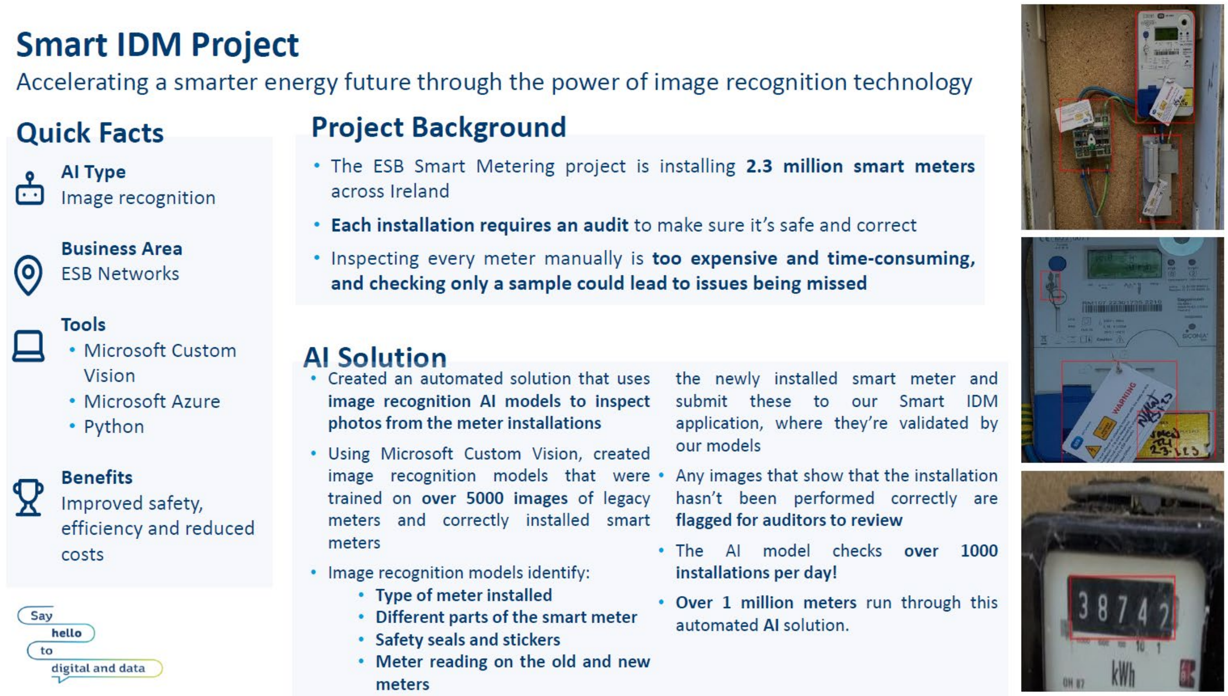

Figure 2: ESB Presentation

The primary drivers of adoption appear to be efficiency gains (reduced O&M costs, improved asset utilization), enhanced reliability (reduced outages, improved stability), customer service (faster and more accurate responses, higher customer loyalty) and improved safety. These applications, while valuable, largely represent incremental improvements. The data underpinning these systems often comes from increasingly digitized operational technology (SCADA, sensors, AMI) and enterprise systems. The concentration of AI applications in Transmission and Distribution aimed at managing grid complexity introduced by renewables and Distributed Energy Resources (DER) also highlights a shift: AI is becoming essential not just for internal efficiency, but for adapting the grid itself to the evolving energy landscape.

The table below provides a snapshot of where AI is actively contributing value. While utilities are achieving considerable progress, these areas of application largely represent the first wave of AI adoption. AI's rapid evolution promises capabilities that will fundamentally reshape utility operations and strategies.

Table 1: Summary of Key Current AI Application Areas Across Utility Value Chain

Note: Maturity Level indicates general industry adoption trends; specific utility maturity varies.

Value Chain Segment	AI Application	Primary Benefits	General Maturity Level
Generation	Predictive Maintenance (PdM)	Reduced O&M costs, Increased Availability, Extended Asset Life	Scaling/Mature
	Performance Optimization	Improved Efficiency (Heat Rate), Reduced Fuel Consumption, Emissions Reduction	Scaling
	Emissions Monitoring & Compliance	Reduced Penalties, Environmental Compliance Assurance	Pilot / Scaling
Transmission	Asset Health Monitoring	Reduced Failures, Optimized Maintenance, Improved Safety	Scaling
	Vegetation Management	Reduced Outages, Lower O&M Costs, Improved Safety	Scaling
	Grid Stability Analysis / Power Flow Opt.	Improved Reliability, Increased Renewable Integration, Reduced Congestion	Pilot / Scaling
	Dynamic Line Rating (DLR)	Increased Transmission Capacity, Reduced Congestion Costs	Scaling

Value Chain Segment	AI Application	Primary Benefits	General Maturity Level
	Fault Detection & Localization	Faster Restoration Times (Reduced SAIDI/SAIFI)	Scaling
Distribution	Advanced Load Forecasting	Improved Operational Planning, Reduced Procurement Costs, Grid Stability	Scaling/Mature
	Outage Prediction & Management	Faster Restoration (Reduced SAIDI/SAIFI), Improved CSAT, Optimized Resources	Scaling
	DER Integration & Management (incl. DERMS)	Improved Grid Stability (Voltage/Freq.), Increased Hosting Capacity	Pilot / Scaling
	AMI Data Analytics (Theft, Targeting)	Reduced Non-Technical Losses, Improved Program Effectiveness	Scaling
Cross-Cutting	Intelligent Customer Service (Chatbots)	Reduced Call Volume, Improved CSAT, 24/7 Availability	Scaling/Mature
	Cybersecurity Threat Detection & Analysis	Faster Threat Detection/Response, Reduced Risk Exposure	Scaling
	Energy Trading Optimization	Increased Trading Profitability, Reduced Risk	Pilot / Scaling
	Workforce Safety Analysis	Reduced Incident Rates, Proactive Risk Mitigation	Pilot

Figure 3: (Minerv**AI**nstitute, 2025)

5. Examination of Specific Use Cases

Before examining the various uses cases where they can use AI, it is important to note that AI is not a fix-all panacea for electric utilities. Currently, there are several aspects of integration and inherent factors within sector's ecosystem that may restrict the implementation of AI. Those challenges will be explored in a later section. Despite the potential for challenges, there are several areas in which utilities have begun piloting/using AI to optimize business processes and introduce innovation.

5.1. Grid Monitoring

Electric utilities are increasingly integrating AI into grid monitoring to enhance reliability, responsiveness and efficiency. Fault Location, Isolation and Service Restoration (FLISR) which involves the analyzing of real-time sensors and SCADA data to allow rapid identification of anomalies and potential failures, is an example of existing technology that is being enhanced by more sophisticated AI. For example:

- The European Service Oriented Grid Network of the Future (SOGNO) project (SOGNO, n.d.), coordinated by Ericsson, designed FLISR algorithms driven by machine-learning logic to improve performance. Predictive Load Management is currently leveraging deep learning models to forecast electricity demand, especially with fluctuating DERs. To support voltage and frequency regulation, some utilities are using reinforcement learning to refine the operation of control devices in real time.

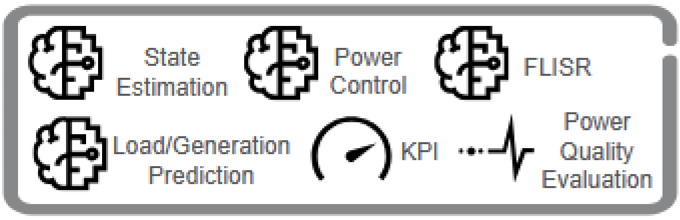

Figure 4: Services and algorithms of SOGNO reference architecture

- The European edgeFLEX project (edgeFLEX, n.d.) examined developing the concept of Virtual Power Plants (VPPs) to manage a wider range of generation and storage assets. It described the use of Artificial Neural Networks or Machine Learning tools to manage voltage control for the distribution grid. By offering a set of dynamic services, the emergence of a new market for ancillary services will be enabled. The project outlined a new architecture of VPPs with communications, supported by 5G, corresponding to multiple layers of dynamics, paving the way for a fully renewable energy system. With the expansion of the VPP concept, local energy communities can develop technical solutions linked to societal expectations of sustainability.

AI also allows for the implementation of adaptive protection schemes that can adjust to changing grid conditions, improving system resilience. As integration of DERs continue to increase, AI algorithms that coordinate DERs to maintain grid stability will become much more useful. (World Economic Forum, 2025; International Energy Agency, 2023)

5.2. Asset Management

Predictive maintenance, using AI to forecast equipment failures before they occur by analyzing sensor data, historical maintenance records, weather conditions and other relevant information, is rapidly becoming a common use case for AI within utilities. Duke Energy uses AI-driven predictive analytics to monitor the health of power transformers and other critical equipment. They employ machine learning models that analyze sensor data to predict failures, enabling proactive replacement or repair (Duke Energy, 2022). Pacific Gas and Electric (PG&E) uses AI and machine learning to identify patterns in historical data that signal potential transformer and equipment failures. This initiative is part of its broader wildfire mitigation strategy (PG&E, 2021). Exelon has implemented AI to monitor substation components and predict failures in its electric grid infrastructure. The AI models continuously learn from asset data, improving over time (Exelon, 2021).

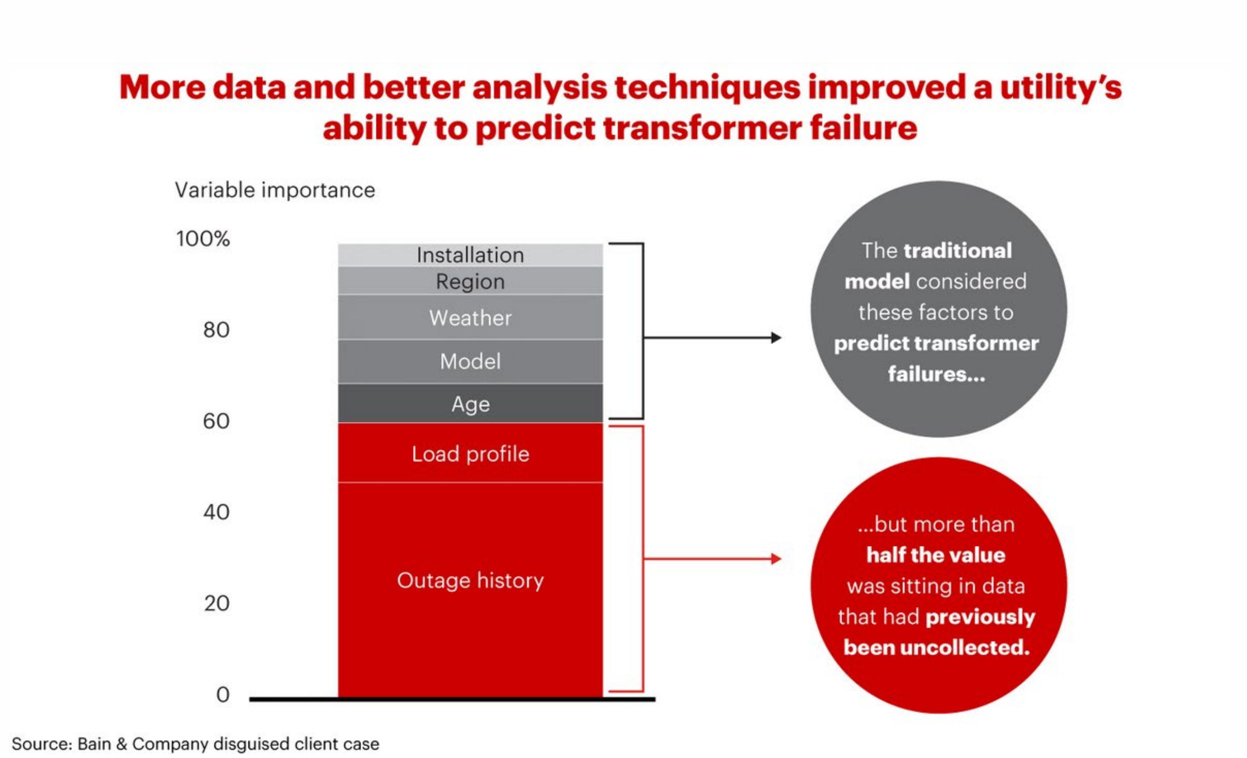

Figure 5: Bain & Company

The City of Elko's deployment of Baseform's predictive analytics platform highlights how advanced data integration and modeling can transform asset management in critical infrastructure systems. While developed for water utilities, this technology offers a compelling blueprint for electric utilities seeking to modernize their own asset management practices. By synthesizing data from sources such as SCADA systems, GIS and maintenance logs, utilities can identify emerging issues, optimize maintenance schedules and prioritize investments based on risk and performance. The success of this approach in water systems provides a valuable opportunity for electric utilities to learn from parallel industries, adapting proven methods to enhance grid reliability, extend asset life and reduce operational costs (The Shpigler Group, 2025).

Vegetation management is crucial to prevent tree limbs from interfering with power lines, a common cause of outages and wildfires. AI helps optimize this process through image recognition, satellite imagery and drone-based inspections. This is a highly active area of development with enhancements being developed to refine models to better predict vegetation growth through identification of species of plants and monitoring of the local climatic conditions to adjust growth forecasts. A further development being considered is to link the identification of the vegetation to the ownership of the vegetation and the utility's cutting rights to enable permissions to cut vegetation to be obtained more efficiently and reliably. Florida Power & Light (FPL) uses drones equipped with AI to inspect vegetation near power lines. The AI models process imagery in real-time to identify encroachments and prioritize trimming, significantly improving inspection efficiency (FPL, 2021). San Diego Gas & Electric (SDG&E) uses AI to analyze satellite imagery and LiDAR data for vegetation encroachment. The system helps prioritize risk areas and plan vegetation clearing more effectively (SDG&E, 2020). National Grid has implemented AI to automate the classification of vegetation around power lines using aerial imagery. This has reduced inspection time and increased the accuracy of vegetation threat detection (National Grid, 2020).

5.3. Forecasting

The rapid electrification utilities are experiencing makes AI increasingly vital for electric utilities in the U.S. and Canada, particularly in load forecasting and demand management. Here, AI can enhance utilities' ability to predict and manage electricity demand by analyzing very large datasets, including weather patterns, historical consumption and real-time grid conditions. This capability is crucial for EV Charging Management where AI models can forecast EV charging demand, allowing utilities to optimize charging schedules and prevent grid overloads. (IEEE, 2025). In Demand Response Programs AI can enable dynamic adjustment of electricity usage during peak periods, improving grid stability and efficiency. Ameren, Avista and PG&E are among the utilities that have implemented successful programs (Trabish, H.K., March 7, 2025).

In partnership with BluWave-ai, Hydro Ottawa launched the "EV Everywhere" pilot project, utilizing AI to manage EV charging during peak demand. The system coordinates charging schedules based on grid conditions, enhancing reliability and integrating renewable energy sources (Ontario Energy Board, 2022). PJM, the largest grid operator in the United States, collaborated with Google to implement AI technologies for accelerating the integration of new electricity supplies. The AI system automates tasks like assessing connection applications, aiming to reduce delays in connecting new energy sources (Kearney, 2025)

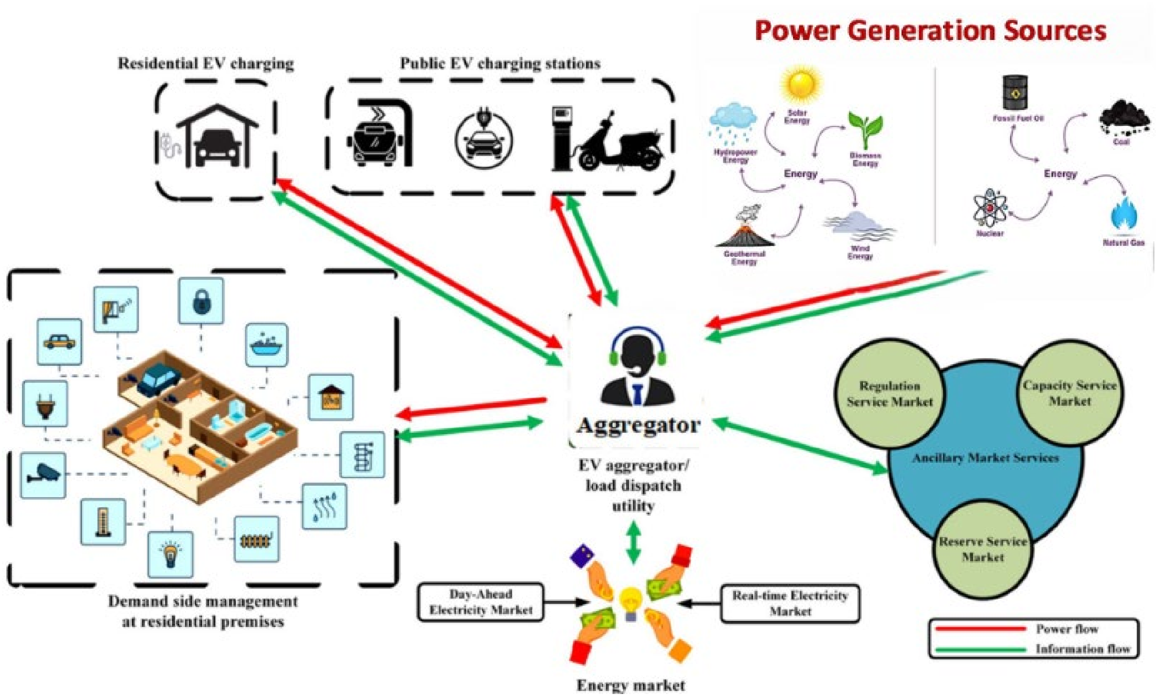

Figure 6: Schematic representation of smart grid architecture integrated with EV and DSM Programs

Source: Nature.com

AI has enormous potential in generation forecasting for electric utilities, particularly in managing distributed energy resources (DERs) and streamlining interconnection processes. Improvements in the prediction of renewable generation will allow AI models to forecast outputs from solar, wind and other renewable sources, accounting for variables like weather patterns and equipment performance. Several methods based on machine learning have been tested in the European edgeFLEX project for the wind output forecasts.

In this way, wind output forecasts are optimized for the Virtual Power Plant (VPP). By analyzing data from various DERs, AI helps balance supply and demand, ensuring efficient energy distribution. Furthermore, AI is helping to streamline the interconnection process by automating the assessment of new energy projects, reducing delays in connecting them to the grid (Trabish, H.K., April 29, 2025).

5.4. Customer Service

At first blush, Customer Service may seem like the easiest target for implementation of AI. However, electric utilities generally have specific customer care requirements while the rapid implementation of new technologies creates call volumes with very specific requirement profiles. It is thus critical for utilities to provide effective, interactive and learning-enabled AI customer care solutions. Some utilities have made investments that have shown early success.

Evergy has partnered with Interactions LLC to deploy an Intelligent Virtual Assistant (IVA) that manages over 40 types of customer inquiries, including payments, service transfers and outage reports. The IVA supports both English and Spanish, facilitating millions of self-service interactions annually. In 2024, Evergy received Chartwell's Gold Award for Excellence in Digital Experience, recognizing the IVA's success in automating more than 40,000 start or move service transactions in its first year. (Interactions, 2024)
Duke Energy introduced an AI-powered chatbot to enhance its mobile app's customer service capabilities. Within the first three months, the chatbot handled over 280,000 interactions, reducing manual feedback form submissions by 90%. This implementation has significantly improved self-service options and customer satisfaction. (Message Broadcast, 2025)

ENMAX has implemented a conversational AI virtual agent to handle high-volume customer inquiries, particularly those related to billing and payment arrangements. This AI solution allows customers to interact using natural language, enabling them to perform tasks like requesting payment extensions without the need to speak to a live agent. The deployment of this virtual agent has significantly reduced the workload on human agents, allowing them to focus on more complex customer issues. (Tata Consultancy Services, 2022).

Brazil's National Transmission Operator has devised an AI system to transcribe control room dialogues into text so that fault investigations can be carried out more efficiently and effectively. The system transcribes voice into text but has been continuously developed to improve its accuracy and value. For example, the system has been trained on the dialects of the staff and callers, resulting in more accurate transcriptions. A subsidiary benefit of this training is that the system can track the caller, so that the member of staff can be identified and all the text associated with a single caller identified to make the dialogue clearer. Punctuation is also now added to the text to make it more readable. The system has been trained on the technical terms used in control room conversations to further aid accuracy. Finally, the text is linked to the actual recorded conversation so that if an engineer is uncertain that the conversation has been accurately transcribed, they can easily and quickly refer to the original voice recording. (ONS, n.d.)

5.5. Operations

Streamlining operations for efficiency is certainly nothing new for electric utilities. AI is the impetus that opens new possibilities for improvement. Once the vast data sources of utilities have been located, organized and analyzed, previously underutilized or neglected information can play a key role in customizing new, innovative and future-oriented processes.

Duke entered into a three-year partnership with Amazon Web Services (AWS) and startup AiDash to modernize its asset inspection and monitoring. The resulting digital twin solution integrates geospatial data with network design systems and distribution management systems. This novel approach complements existing projects using AI for forecasting, safety, customer experience, reliability and efficiency. (Jenkins, 2024) Similarly, Iberdrola uses AI-powered digital twins of its networks to simulate grid conditions and test operational scenarios in real time. (Giacobone, Bianca, 2025)

Brazil's National Transmission Operator has developed an AI system to assist maintenance and repair staff to identify the correct procedures and processes for investigating faults, repairing and maintaining grid infrastructure. This codifies all their existing maintenance manuals, fault diagnosis check sheets and work instructions to guide maintenance staff to the correct procedures in order to conduct their work safely and effectively. For added safety and security, if an engineer is uncertain about the provenance of any work instruction, the AI system can call up the original document on which its advice is based for added assurance. (ONS, n.d.)

The European Union provides support for the Service Oriented Grid for the Network of the Future (SOGNO) with the charge of creating cloud services implementing next generation data-driven monitoring and control systems. The State Estimation (SE) service offers observability of an electrical network to facilitate secure, reliable and efficient grid operation. Monitoring data, combined with the output of the SE algorithm, allows the grid operator to assess the performance of their network more accurately. The operator can detect potential anomalies in the grid operation and, thus, operate the network more efficiently and reliably. The European SOGNO project implemented and tested Service Estimation based on different types of algorithms; the first one was an innovative data-driven approach based on the use of Artificial Neural Networks (ANN), while the second was a more classical Weighted Least Squares approach. The Load and Generation

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Forecasting service (LGF) predicts future electricity demands based on historical information of customers' power consumption and injection as well as future generated power in a photovoltaic system based on weather information. It enables the Distribution System Operator (DSO) to ensure stability and reliability in power grid planning and operation. The European SOGNO project developed the necessary Load Prediction and Generation Prediction services using machine learning algorithms. The SOGNO services FLISR, mentioned above, and Load Prediction and Generation Prediction services are using machine learning algorithms. (SOGNO, n.d.)

6. Implementation Challenges & Constraints

6.1. Technological

6.1.1. Legacy Data & Technology Infrastructure

Electric utilities often face substantial obstacles in managing the data needed for AI applications. Legacy systems result in fragmented data silos that hinder the integration necessary for effective AI. Inadequate data quality and lack of real-time availability further impair machine learning performance. Moreover, increased data collection raises the risk of cyber threats, demanding robust governance and cybersecurity strategies (National Renewable Energy Laboratory, 2021).

Data—the Critical Bottleneck for AI in Utilities

" Without achieving a carefully planned, targeted and comprehensive data collection, any resulting AI project would be unlikely to deliver the expected value to a utility."

Given the complexity of the grid, certain operational technologies may not be suitable use cases for some time. At the current stage of industry implementation, utilities cannot afford to risk catastrophic failures of mission-critical systems like protection systems. Some systems may never be fully transformed by AI as experience or regulation dictate that only human decisions or low-level automation should be allowed. Regulatory and compliance concerns will continue to determine the adoption of AI as compliance can be jeopardized by relying on AI-driven decisions that cannot be properly audited and lack support for critical decisions the model might have made.

Integrating AI with existing infrastructure presents significant technical challenges. Many utilities rely on outdated Supervisory Control and Data Acquisition (SCADA) systems, which are not designed to support modern AI technologies (NREL, 2021). Furthermore, achieving interoperability with tools like Geographic Information Systems (GIS), Advanced Metering Infrastructure (AMI) and distribution management systems requires substantial customization and investment.

Before AI can scale, utilities must modernize data governance and architecture.

Finding, collecting and processing the necessary huge amount of data sources necessary to properly create an AI can be quite challenging because of utility legacy systems and incomplete or inaccurate data. Without achieving a carefully planned, targeted and comprehensive data collection, any resulting AI project would be unlikely to deliver the expected value to a utility. AI use cases involving real-time grid control also require reliable access to real-time data streams. Accessing this data requires ultra-low-latency and high-reliability data streams that need powerful infrastructure that not every utility has yet deployed or will deploy in the near future. Additionally, utilities will find that cost-benefit analyses reveal that not every challenge requires an AI solution and, while technically possible, there will be AI use cases that might deliver only marginal or net negative benefits for a utility. At the same time, utilities could decide against implementing an AI use case that promises large benefits because the investment in developing or procuring an AI system is too expensive at that moment. As utilities become more familiar with AI tools, the ROI might eventually be convincing.

However, a significant practical barrier often lies in accessing, integrating and ensuring the quality of data from traditionally siloed systems. Overcoming these data challenges is often a prerequisite for unlocking the full potential of even current AI applications.

6.1.2. Cybersecurity

As utility systems become more interconnected and reliant on digital technologies, the cybersecurity threat landscape has evolved in parallel. Adversaries, potentially state-sponsored or sophisticated criminal groups, are increasingly likely to leverage AI to enhance their attack capabilities. Consequently, utilities must deploy increasingly advanced AI-driven defenses. As such, the use of AI that leverages cybersecurity tools and applications is moving beyond current anomaly detection and general intelligence sharing, including:

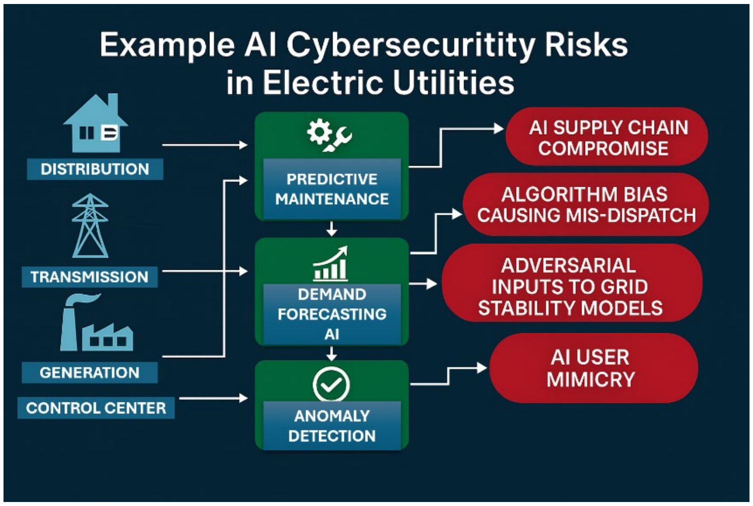

Figure 7: Example AI Cybersecurity Risks in Electric Utilities
*Source Minerv**AI**nstitute, 2025*

- Predictive Threat Intelligence: AI analyzing vast amounts of global threat data, dark web chatter and geopolitical factors to predict emerging attack vectors and campaigns targeting the energy sector.
- Automated Threat Hunting: AI agents proactively searching utility networks for subtle signs of compromise that might evade conventional detection systems.

- AI-Driven Incident Response: Automating key aspects of incident response, such as isolating affected systems, deploying countermeasures and collecting forensic evidence, to dramatically reduce reaction times.
- Self-Defending Networks: Exploring concepts where AI can dynamically reconfigure network security postures or deploy deceptive countermeasures in real-time in response to detected threats.

This escalating cyber arms race necessitates continuous investment and innovation in AI-based security tools. The deep intertwining of IT and OT systems, particularly as AI eventually begins to move toward control of physical grid assets, demands a converged cybersecurity strategy that addresses risks across both domains holistically. The required level of system integration and data sophistication is significantly higher than for most current applications. Data from previously disparate systems (OT, IT, customer, external) must flow seamlessly and be readily available for complex AI models.

Perhaps most important for the evolving utility technical ecosystem will be building trust in AI systems which will respond at the speeds necessary to parry adversary AI-enabled attacks and make time critical decisions with minimal human oversight is paramount. This requires robust validation, testing, explainability (where possible), transparent governance and strong cybersecurity measures. Furthermore, the potential for AI agents to automate complex coordination tasks implies a need to rethink traditional organizational structures and workflows, potentially leading to significant changes in roles and responsibilities within the utility workforce.

Cybersecurity: Defense to Dynamic Response

"The role of AI in cybersecurity is rapidly expanding from passive monitoring to proactive, real-time defense."

6.2. Workforce

The demand for skilled AI professionals – data scientists, machine learning engineers, data engineers – far outstrips supply across industries and the utility sector faces stiff competition for this talent. Most organizations lack data scientists and AI specialists capable of developing and maintaining such systems (Ernst & Young LLP, 2025). Resistance to change and a conservative, risk-averse culture, which is not untypical in critical infrastructure sectors, further slow AI adoption. Therefore, in addition to supplementing the workforce with new AI native developers and users, utilities will be compelled to upskill the existing workforce who in turn will need to adapt to working alongside AI systems (Hill, Emily, 2025). Utilities must adopt a multi-pronged approach to address this human capital challenge:

> **From Workforce to Work with Force-The Human Side of AI**
>
> "The future utility workforce will work with AI—not be replaced by it."

- **Attracting and Retaining AI Talent:** Creating an attractive value proposition for tech talent, which may involve competitive compensation, challenging projects, modern development environments and a culture that embraces innovation. Partnerships with universities and specialized recruitment efforts are key.
- **Upskilling and Reskilling the Existing Workforce:** Implementing comprehensive training programs to build AI literacy across the organization. This ranges from basic awareness for all employees to specialized training for engineers, operators, analysts and managers who will interact with or utilize AI tools in their daily work. Focus should be on how AI complements human expertise, enabling employees to perform higher-value tasks.
- **Capture Incumbent Knowledge:** Document veteran knowledge before automation erodes tacit expertise. Launch structured “knowledge sprints” pairing senior technicians with data engineers to document heuristics, failure cues and safety

practices into searchable repositories and model-training datasets. Require periodic expert reviews, version control and sign-off to ensure AI outputs accurately reflect evolving operational realities.

- **Adapting to AI Agents and Automation:** Proactively considering the impact of increasingly sophisticated AI agents and automation on future job roles and skill requirements. This involves planning for workforce transitions, emphasizing skills like critical thinking, complex problem-solving and collaboration with AI systems.

Figure 8 : Source LibreStream

Ignoring the human element is a recipe for failure. Technology implementation without workforce readiness leads to low adoption, resistance to change and unrealized potential. Therefore, the human resource challenge for electric utilities will consist in building awareness of and taking seriously the range of human intelligences and talents of the existing workforce while best understanding how AI can complement existing capabilities. (Baker, 2021; International Energy Agency, 2023; Gardner n.d.).

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6.3. Legal, Regulatory and Policy Landscapes

The utility sector is heavily regulated and this affects AI deployment. For instance, if an AI system recommends investment or operational decisions, regulators might ask: how do we audit this decision-making? Many oversight organizations require evidence and transparency for decisions that affect rates or reliability. A "black box" AI that utility managers cannot fully explain may not be acceptable for making grid operational decisions without human sign-off. Regulators are also concerned with fairness and bias; could an AI inadvertently bias certain customer groups (e.g., in how it recommends energy efficiency outreach)? The key is explainability. Utilities need to ensure their AI models have interpretable outputs or associated rationales. When utilities use AI for rate case preparation, they should be equipped to provide all the traditional documentation required by the regulator. Utilities should expect that the regulatory process will require a human-in-the-loop approach in which AI can assist, but accountability remains with the utility to justify its actions in human terms.

Regulation Requires Explanation

"AI won't pass regulatory scrutiny if it can't explain itself."

Looking at the transferability of AI use cases across geographic regions and international borders, such transferability is limited by both technological readiness and legal/regulatory tolerance. AI models trained in one geography may require adaptation before being deployed elsewhere due to differences in grid topology, operational practices and climate conditions. For example, vegetation management models developed in the western U.S. may be less applicable in tropical environments or where regulatory permissions for land access differ.

Utilities must also account for differences in workforce readiness and cultural adoption. Large investor-owned utilities (IOU) often have dedicated innovation teams that can integrate AI into strategic planning, while smaller utilities may have to rely more heavily on vendor partnerships or public funding. Even within a single region, what works in a large IOU may not be a good fit for a rural electric cooperative or municipality.

Despite these limitations, the core value propositions of AI; predictive accuracy, automation and operational efficiency remain transferable. Utilities that document their processes, share lessons learned and invest in scalable, explainable models will find it easier to adapt innovations across jurisdictions and grid environments.

6.3.1. Regulatory Structures Across Geographical Regions

North America

AI implementation in electric utilities is deeply influenced by both national and regional regulatory frameworks. In North America, regulation occurs at multiple layers, each imposing distinct expectations for utility operations. For transmission and generation operators, compliance with NERC-CIP (North American Electric Reliability Corporation-Critical Infrastructure Protection) standards is essential (North American Electric Reliability Corporation, n.d.). AI applications that interact with control systems or impact reliability must align with these cybersecurity and risk management rules. AI models must be auditable, traceable and secure, especially if they contribute to decisions

Center for AI Standards and Innovation (CAISI)

- The principal U.S. industry-government nexus for secure commercial AI research and deployment.
- Collaborates with NIST to craft voluntary AI security standards, guidelines.
- Conducts unclassified evaluations of cyber, bio, chemical AI security risks.
- Assesses adversary AI vulnerabilities, backdoors and malign foreign influence threats.
- Champions U.S. leadership, opposing restrictive international regulations on AI technologies.

affecting Bulk Electric System (BES) operations. The National Institute of Standards and Technology (NIST) provides valuable guidance and standards for technology integration and implantation freely available to utilities and regulators. The newly constituted Center for AI Standards and Innovation (CAISI) within NIST is a continuation of that mission.

At the distribution level, State Public Utility Commissions (PUCs) set operational expectations around reliability, customer service and efficiency. While they rarely prescribe technology use, AI adoption must prove clear benefits to ratepayers and align with approved rate cases and performance metrics. The Federal Energy Regulatory Commission (FERC) plays a regulatory role in how transmission operators recover costs and plan grid modernization. AI that supports transmission planning, congestion management, or dynamic line ratings must be incorporated into transparent planning processes and cost-allocation frameworks. Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) increasingly rely on real-time data and forecasting for market operations. AI used for generation dispatch forecasting, load balancing, or interconnection modeling must meet the technical and operational criteria laid out by these organizations.

Europe

The European Union (EU) has established a comprehensive regulatory landscape for AI, emphasizing ethical standards, data privacy and human rights. The cornerstone of this framework is the Artificial Intelligence Act (AI Act), which categorizes AI applications based on risk levels, i.e., unacceptable, high, limited and minimal, and imposes corresponding obligations on providers and users. High-risk applications, such as those used in critical infrastructure like energy, must comply with stringent requirements, including risk assessments, data governance and human oversight mechanisms. Complementing the AI Act is the Data Governance Act (DGA), which facilitates data sharing across the EU while ensuring privacy and security. The DGA aims to create a framework that encourages the reuse of certain categories of protected data held by public sector bodies, fostering innovation in sectors like energy. In the energy sector, the EU's digital strategy promotes the integration of AI to enhance grid management and support the transition to renewable energy sources. Initiatives like the Green Deal Data Space aim to aggregate environmental and energy data, enabling AI-driven solutions for sustainability challenges. European countries outside of the EU follow generally similar principles for the control and regulation of AI.

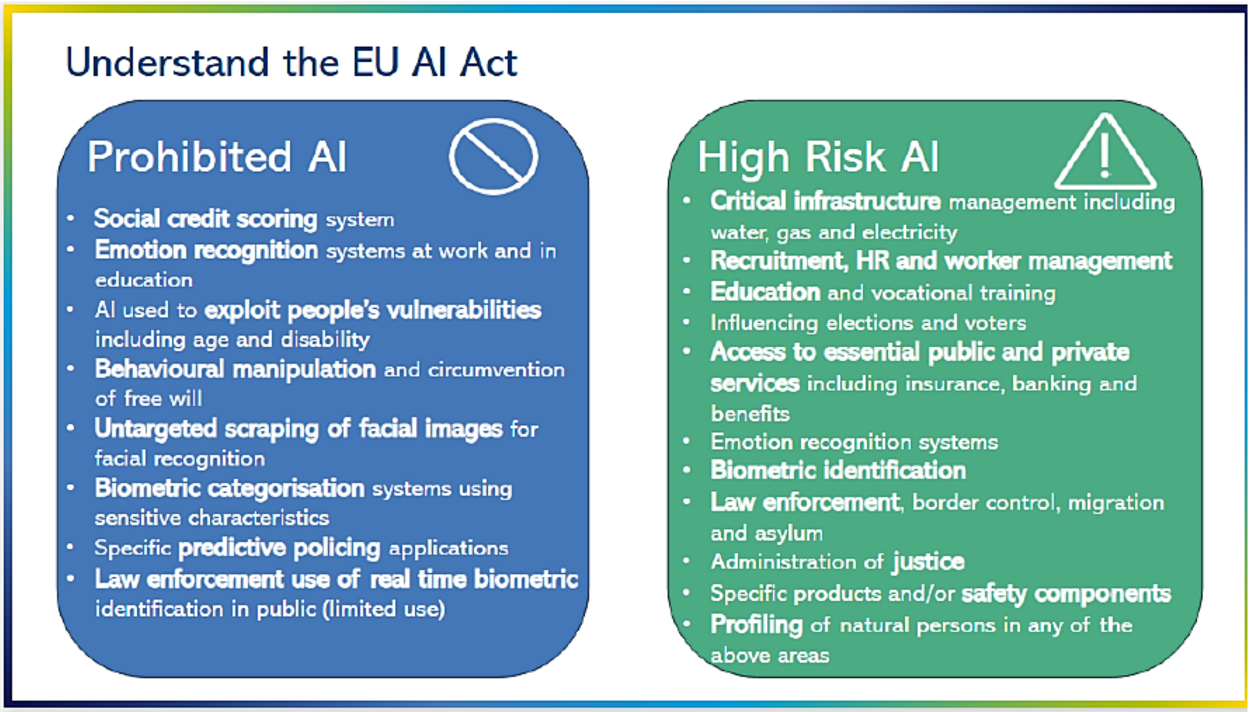

Figure 9: ESB presentation

Latin America

Latin American countries are actively developing AI regulations to promote ethical AI development, protect human rights and foster innovation.

In December 2024, the Brazilian Senate passed a Bill, which aims to regulate AI in Brazil, prioritizing human rights, democracy and technological advancement while ensuring the development and use of safe and trustworthy AI systems. The Bill is now being analyzed by the Chamber of Deputies before it can be signed into law and take effect. The Bill encompasses a definition of AI and classifies artificial intelligence systems according to their levels of risk to human life and threats to fundamental rights. It also contains detailed provisions on copyright issues in the development of artificial intelligence systems. (Chamber of Deputies, 2025; Institute for Technology and Society, 2024)

Argentina is considering a bill that defines AI terms, principles and prohibitions along with establishing a National Registry of AI Systems for impact assessments and risk classification. In February 2025, Mexico began discussing a bill for an ethical AI framework to protect human rights and personal data, with plans for a central AI policy office and national AI collaboration center. Chile's National AI Policy defines AI and sets goals, including a bill to regulate AI while respecting human rights and democracy. Peru is modeling a bill after the EU AI Act to protect rights and promote ethical AI, with plans for a national authority to oversee AI use and promotion. In addition, in 2023, Colombia established public policy guidelines for the development, use and implementation of AI.

6.3.2. Implications of Technology Maturity & Limitations

The technological maturity of AI implementation varies by region. In North America, utilities generally have access to robust IT/OT systems, advanced metering infrastructure and high data granularity, making it easier to deploy AI at scale, particularly in transmission and generation. However, legacy systems in distribution operations can slow adoption.

European utilities often benefit from widespread grid digitization efforts and strong interoperability mandates. Many utilities there have advanced their use of digital twins, grid-edge analytics and AI-integrated DER management. However, stringent regulatory oversight of data privacy and explainability can constrain the pace of deployment.

In Latin America, utilities face greater infrastructure variability. Some urban networks support modern AI integration, while rural and decentralized grids present unique data and connectivity challenges. As a result, most utilities are focusing on targeted applications such as theft detection, renewable optimization and customer segmentation rather than fully autonomous control systems. (World Bank, 2020)

6.4. Liability and Responsibility

Unlike traditional automation systems, AI-driven tools often make recommendations or trigger actions based on dynamic data inputs and probabilistic reasoning, which may be difficult to trace or explain. This creates ambiguity in assigning accountability when errors occur, especially in high-stakes environments like grid control or outage response. Utilities must contend with whether responsibility lies with the AI vendor, the operator, or the utility itself, particularly when decisions are made with limited human intervention. Regulatory frameworks have not yet fully addressed these challenges, leaving utilities to manage legal exposure in areas such as cybersecurity, data bias and system failure. Establishing clear governance structures, human-in-the-loop safeguards and audit mechanisms will be essential to ensuring both operational reliability and legal defensibility.

6.5. Investment and Rate Case Constraints

AI projects can be expensive – not just the software or cloud costs, but also the change management, training and integration effort. While big utilities have R&D budgets for innovation, smaller ones might worry about the return on investment. There is sometimes a "hype vs reality" gap with AI: vendors may overpromise, or an approach that worked in one context does not easily transfer to another. Utilities are well advised to engage in pilot programs for this innovative technology to determine the most effective use cases. Critically, utilities can identify through early pilots the appropriate use cases because not every problem needs AI, and simpler analytical methods can often yield substantial gains without adding unnecessary complexity. A cautious approach is common: start with a narrow AI application that has clear metrics (e.g., reduce transformer failures by X% with predictive maintenance) and pilot it. Quantifying the benefits (reductions in outage minutes, cost savings, etc.) helps build the business case for broader deployment. While utilities still often treat AI initiatives as experimental investments, carefully tracking outcomes, the expected successful use cases will highlight the efficiency and financial gains.

7. Conclusions

In the opinion of UTC, UTCAL and EUTC, the transformative potential of AI in the electric utility sector is both profound and far-reaching. While implementation presents significant challenges, strategic and informed deployment of AI can enable utilities to manage complexity, improve performance and build future-ready systems. For senior utility executives and corporate leadership, the key takeaway is that AI should be treated as a strategic capability to be developed, not just a one-off project or IT initiative.

1. Data Quality and Clarity of Purpose Are Non-Negotiable

AI is not a solution looking for a problem; it must be applied to clearly defined use cases. Projects that begin with specific, measurable objectives and are backed by high-quality utility-sourced data consistently yield the most reliable results. Training models on public or uncurated data introduces risks that utilities cannot afford.

2. AI Is a Direct Answer to the Data Overload Challenge

Modern utilities face a deluge of data that exceeds human and conventional analytic capacity. AI provides the automated intelligence layer needed to translate that data into actionable insights, particularly in grid operations, asset management and outage response.

3. Outputs Must Be Secure, Auditable and Interpretable

Utility environments require a high standard of operational safety. All AI-generated outputs, especially those tied to critical infrastructure, must be rigorously checked, interpretable by humans and aligned with established engineering and operational protocols. Hallucinations or black-box decisions are not acceptable in mission-critical applications.

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4. AI Implementation Must Be Paired with Cyber Resilience

As AI tools increase connectivity and control, they also expand the number of avenues of attack. UTC emphasizes the need for integrated AI, cybersecurity strategies, resilient physical networks (high-speed, low-latency, high-availability) and governance frameworks that keep AI deployment safe and verifiable.

5. Workforce Upskilling Will Define Long-Term Success

Where AI has been introduced with transparency and purpose, it is generally embraced, not feared, by utility staff. But this requires active and genuine inclusion of the workforce, deliberate training, reskilling programs and communication about AI's capabilities and limitations. Ensuring that the industry workforce understands how to work alongside AI is essential to avoiding implementation fatigue or resistance.

Strategic Adoption > Reactive Innovation

"Utilities that lead with strategy—not just tech—will shape the future grid."

6. AI Guardrails Will Vary Based on Scope

From chatbots to automated substation control, AI solutions can vary greatly in scope and complexity. Governance structures and internal approval processes must reflect this range, ensuring appropriate scrutiny and safety checks are applied.

7. Collaboration Is Crucial

AI adoption is not a journey that utilities should walk alone. Utilities, vendors, regulators and researchers must collaborate to align development with real-world needs. Shared experiences, both successes and failures, will reduce duplication, improve model generalizability and accelerate innovation across the industry.

8. Second-Order Effects Require Strategic Attention

As AI matures, it will drive new demands on infrastructure and regulation. Data centers powering AI workloads will become major energy consumers, requiring load planning and possibly dedicated rate structures. Regulatory bodies will also need to develop standards around AI decision-making, explainability and liability. Future UTC papers will explore these second-order effects in depth.

9. Restoration Priorities Must Be Examined Anew

AI can automate prioritization in outage response. However, utilities need to address an urgent question: Are we reinforcing legacy assumptions about which customers or areas get restored first? AI adoption offers utilities a chance to examine the default logic built into their systems and the associated restoration equity, reliability tiers and vulnerability considerations.

10. Sharing and Scaling Will Define the Future of AI in Utilities

Utilities should not merely adopt AI; they should help shape its development. By sharing data, model results and lessons learned, utilities can collectively advance toward a more resilient, intelligent and responsive energy system. Future UTC work will focus on frameworks for scalable AI adoption, industry-wide benchmarks and cross-jurisdictional coordination.

8. Recommendations

AI is rapidly becoming indispensable for achieving the fundamental objectives of the modern utility, i.e., ensuring the delivery of safe, reliable, affordable and increasingly clean energy while providing excellent customer service in a complex and evolving environment. Utilities that proactively embrace AI, guided by a clear strategy and a commitment to addressing the associated organizational, technical and ethical challenges, will be better positioned to thrive. Conversely, utilities that adopt a reactive or piecemeal approach risk falling behind, potentially facing higher operating costs, lower reliability, diminished customer satisfaction and challenges in meeting regulatory mandates and competitive pressures. The evidence suggests a critical sequencing is required: foundational investments in data, strategy and initial skills must precede attempts at large-scale or highly advanced deployments. Proactive and strategic adoption of AI is therefore not just an opportunity but a necessity for ensuring short-term survival and long-term success and relevance in the turbulent transition ahead.

8.1. Short-Term Recommendations (12-24 Months): Focus on Foundations and Targeted Value

The immediate focus should be on building the necessary groundwork and demonstrating value through targeted initiatives.

1. **Develop an Enterprise AI Strategy & Roadmap:** Formulate a comprehensive AI strategy explicitly linked to core business objectives (e.g., reliability improvement targets, O&M cost reduction goals, customer satisfaction metrics). Establish clear governance structures, define roles and responsibilities and create a phased roadmap outlining priority application areas and required investments. This strategy must have executive sponsorship and cross-functional buy-in.
2. **Prioritize Data Readiness:** Conduct a thorough assessment of data maturity across the organization. Invest strategically in data infrastructure modernization (e.g., data lakes, cloud platforms) and data integration capabilities. Implement robust data governance policies and processes, focusing initially on datasets critical for high-priority AI use cases. Treat data quality improvement as an ongoing process.
3. **Launch Targeted, High-Value Pilot Projects:** Initiate or expand pilot projects in areas with clear potential for significant ROI and operational improvement, leveraging existing AI capabilities. Examples include enhancing predictive maintenance programs for critical assets, improving short-term load and DER forecasting accuracy, optimizing outage prediction and crew dispatch, or implementing AI-powered customer service tools for specific high-volume interactions. Use these pilots to build internal expertise, refine methodologies and demonstrate tangible value to the business.
4. **Build Foundational Workforce AI Literacy:** Roll out training programs aimed at

increasing AI awareness and understanding among key employee groups, including executives, managers, engineers, operators and IT staff. Focus on demystifying AI, explaining its potential benefits and limitations and preparing the workforce to collaborate with AI tools.

5. **Establish Guardrail Guidance:** Develop an "AI Guardrail Playbook" translating ethics into practice. Define allowed uses; decision tiers detailing autonomy, human oversight, escalation; performance thresholds triggering rollback; change-management for data, retraining, monitoring; and incident-response integrating AI failure modes with emergency and cybersecurity plans. Guardrails empower staff, reduce regulatory risk and protect safety and service.
6. **Participate in Standards and Policy Development**
   Engage with standard setting bodies and other industry bodies shaping AI-related regulatory, technical and ethical standards with the goal to influence policies before they become enforceable and shape best practices. The expert input of utilities can offer valuable insight by offering a "birds-eye view" to policy makers and regulators.
7. **Plan for the Energy and Cost Impact of AI Infrastructure**
   As AI adoption grows, utilities may need to expand data center capacity or negotiate cloud service agreements. It is imperative for utilities to incorporate such provisions in long-term financial and power planning forecasts such as sustainability goals and potential load impact.

8.2. Mid-Term Recommendations (3-5 Years): Focus on Scaling, Integration and Transformation

Building on the foundational work, the mid-term focus should shift towards scaling successful applications, exploring more advanced capabilities and embedding AI into the organizational fabric.

1. **Scale Proven AI Applications:** Systematically roll out successful AI solutions from the

pilot phase across relevant parts of the enterprise. Integrate AI tools and insights into standard operating procedures and decision-making workflows, ensuring they become part of the regular business rhythm rather than standalone projects. Focus on realizing benefits at scale.

2. **Invest in Advanced AI Capabilities:** Begin exploring and piloting more sophisticated AI applications aligned with the future vision. This includes prescriptive analytics for grid control, AI modeling for climate resilience planning, platforms for hyper-personalized customer engagement, advanced AI for cybersecurity defense and potentially initial deployments of autonomous systems in controlled environments.
3. **Reassess restoration priorities to reflect critical service needs.** Use AI deployment as an opportunity to review outage restoration logic, ensuring it accounts for essential services and community impact, not just historical or load-based priorities.
4. **Develop Strategic Partnerships:** Actively cultivate relationships with leading technology vendors, research institutions and potentially peer utilities. Collaborate on developing or acquiring cutting-edge AI capabilities, accessing specialized talent pools and sharing knowledge and best practices to accelerate innovation.
5. **Foster an AI-Driven Culture:** Promote a culture that embraces data-driven decision-making, encourages experimentation and values continuous learning. Adapt organizational structures, roles and processes as needed to fully leverage the capabilities of AI and emerging AI agents. Ensure performance management and incentive systems align with AI adoption goals.
6. **Proactively Engage with Regulators:** Initiate and maintain an open dialogue with regulatory bodies regarding the utility's AI strategy, applications and governance practices. Educate regulators on the benefits (e.g., reliability, efficiency, customer value) and challenges of AI deployment. Collaborate on developing regulatory frameworks that support responsible innovation in the use of AI for critical infrastructure management.

The pace of AI development is rapid, meaning that continuous learning and adaptation must be central to the utility's strategy. A static plan will quickly become outdated. The recommendations provided offer a structured approach, but agility and a commitment to flexibility based on technological advancements and evolving business needs will be crucial for sustained success.

9. Next Steps

Potential Follow-On Paper Topics on AI's Impact in the Electric Power Sector

As stated at the outset, the core purpose of this paper is to move beyond generalized discussions and provide a nuanced understanding of AI's role within the context of our sector's business verticals (generation, transmission and distribution) and regional regulatory regimes.

Building on this foundation allows us to further examine both AI's capabilities and impact, as well as guidance regarding the associated standards and frameworks, as well as covering the safe and resilient incorporation of AI into the sector's operational verticals and backend business functions. Below we list select topics for further consideration:

AI-Enabled Grid Resilience - Predictive Maintenance for Generation & Transmission Assets and AI Forecasting for real-time storm impact prediction, automated restoration planning and resilience investment prioritization.

Optimizing Distributed Energy Resource (DER) Integration with AI Orchestration - AI as an enhancement to coordinating rooftop solar, battery storage and microgrids.

AI-Driven Demand Flexibility & Customer Engagement Programs - AI enabled dynamic pricing, personalized energy insights and behavioral nudges to flatten peaks and improve customer satisfaction.

AI Enabled Cybersecurity in Operational Technology (OT) - Leveraging AI to secure SCADA, substation automation and IoT edge devices.

Generative AI for Regulatory Compliance & Rate Case Preparation - Automating evidence package assembly, scenario modeling and stakeholder-ready narrative generation.

Ethical & Governance Frameworks for AI in Critical Infrastructure - Establishing transparency, accountability and risk control tailored to utility safety and reliability mandates.

Digital Twins Enhanced by AI for Asset & System Planning - Case studies on combining physics-based models with data-driven AI to simulate grid performance and investment options.

EV Charging Infrastructure Optimization via AI - Forecasting spatial/temporal charging demand, siting fast chargers and managing distribution impacts.

Workforce Transformation: Upskilling Programs for AI-Augmented Operations - Competency models, training methodology and change-management lessons from early adopter utilities.

Strategic Sourcing & Vendor Management for Utility AI Solutions - Frameworks for evaluating AI vendors, open-source options and build-versus-buy considerations.

AI Workloads Impact on Electric Demand - Assessing energy use and mitigation strategies for AI compute (data centers and edge devices).

AI for Capital Planning & Asset Investment Prioritization - Portfolio risk scoring and scenario analytics to align spending with regulatory, environmental and reliability goals.

Enhanced Communication through Generative AI Chatbots - Personalized, multilingual customer updates and self-service portals that integrate customer, operations and outage management system data.

Bi-Annual Benchmarking Global AI Adoption Trends in Electric Utilities - Comparative study of policy incentives, market structures and technology maturity across regions.

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