AI’s Role in Transforming the Power Grid

Insights Powered by ***Cognito: PTR Expert Network***

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Who We Are

Built by PTR, Powered by Experts

Enabling proactive decision making by empowering businesses with tools and information based on transparent methodologies

PTR Inc. is committed to being your **Strategic Growth Partner** in the Electrical Infrastructure Manufacturing Sector. Leveraging our unparalleled expertise and diverse capabilities, we deliver tailored solutions and strategic insights to empower your growth and business development efforts. Through collaborative service offerings, we drive sustainable growth and ensure long-term success for our valued clients.

Market Research

- Bespoke and syndicated market intelligence reports.
- Extensive datasets and reports covering over 40 countries worldwide.
- In-depth research methodology backed by data accuracy & transparency.

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PTR Expert Network offers its clients a diverse panel of industry experts spanning multiple sectors across the energy value chain, delivering:

- Broad Industry Coverage
- Expertise Across Hierarchies
- Global Reach

Advisory

Strategic growth partners for businesses, governments, and investors, specializing in:

- Commercial advisory
- Go-to-Market Strategy
- Opportunity Assessment
- New Market Entry
- Market Access and Policy
- Pricing Strategy and more..

Marketing Support Services

Content Creation, syndication, and marketing advisory services aimed at promoting cutting-edge technologies, products, and services for our clients across the energy value chain via content collaborations on:

- Whitepapers
- Webinars
- and more..

Matos AI

- Industry Agnostic data automation tool.
- Data acquisition and AI-powered market research:
  - Bulk download options
  - Real-time data streams
  - Data outputs in several forms

Cognito: PTR Expert Network

Offering unmatched value

About Us

For senior market analysts in the technology sector seeking crucial insights and B2B consultations, Cognito, a venture by PTR Inc., offers primary data collection through surveys and one-on-one interviews with experts belonging to the power grid and new energy sector.

Our Mission

Our mission is to swiftly connect clients with the right expert, fostering knowledge sharing through a secure channel for unparalleled efficiency and confidentiality.

Our Distinctive Expertise

In today's fast-paced industry landscape, saturated with convoluted information and noise, Cognito stands out with its ability to synthesize diverse research findings into cohesive and actionable insights, providing unmatched value in driving strategic growth.

Seamless Collaboration

At Cognito, collaboration is effortless with tailored expert matching and streamlined communication channels. We ensure a seamless experience, for successful project outcomes.

Cognito Services

What services can Cognito offer you?

Expert Consultation

Access an extensive global network of experts, professionals, and specialists. Directly consult with these experts to gain valuable insights and guidance for your projects.

Survey Services

Seamlessly collect data and opinions through our B2B survey services. Leverage our platform to gather responses, ensuring a comprehensive understanding of your target audience.

Event Intelligence

This feature allows clients to gather actionable insights directly from conferences, trade fairs, and industry events worldwide. Leveraging our extensive network of analysts and researchers, we ensure on-ground intelligence collection that answers your specific business questions, enabling strategic decision-making without requiring your physical presence at these events.

Analyst Support

Explore our professional analyst support for survey and questionnaire design tailored to your research needs. Additionally, benefit from our assistance during expert consultations. As part of analyst support, we also offer a comprehensive solution by synthesizing your research, ensuring a complete and cohesive outcome.

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02

The Case for AI in Grid Operations

Power Grid Today – Challenges and Complexity

Why Grid Modernization is a need

Aging Infrastructure

Legacy grid assets are nearing end-of-life, increasing the risk of failures and blackouts.

01

Rising Renewable Integration

Intermittent solar and wind generation strain grid stability and forecasting.

02

Grid Decentralization

The shift to distributed energy resources challenges centralized control models.

03

Real-Time Data Surge

Massive real-time data flows overwhelm traditional grid management systems.

04

Electrification & Demand Surges

Accelerating electrification is creating unpredictable and peak-heavy load patterns.

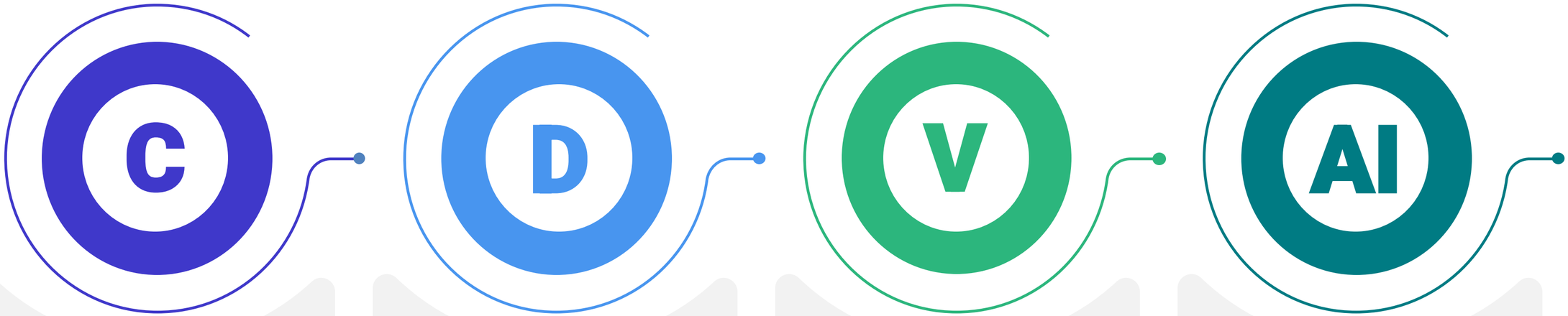
05

Digitalization in Grid

Grid transformation over the years

1980 - 2020

2020 Onwards



Conventional

- Poor scalability
- Low situational awareness
- High operational and maintenance costs
- Delayed fault detection and resolution

Digital

- Adoption of IEDs for real-time data collection, and analysis
- Integration of ADMS and DERMS for smarter grid operations
- Strengthened cybersecurity

Virtualization

- Edge computing and cloud-based SCADA
- Virtual Protection & Control (P&C) systems using software-defined architectures
- Digital twins for real-time simulation

Artificial Intelligence

- AI/ML algorithms for demand forecasting, predictive analytics, and anomaly detection
- Better equipment monitoring
- Assistance in decision making

What AI Enables in the Power Grid

Modern Grid Needs and AI-Based Solutions

AI in the power grid means applying machine learning to real-time grid data to predict faults, optimize flows, and automate decisions across the network.

Why the grid needs AI today:

- **Rising complexity** demands systems that adapt in real time
- **Legacy tools** struggle to handle volatility and distributed assets
- **AI learns continuously**, enabling predictive maintenance and self-optimization
- **Faster, smarter decisions** at machine speed improve reliability and resilience

Features	Traditional Automation	AI-Based Intelligence
Rule Based Logic	Fixed, preprogramed	Learns and adopts dynamically
Responsiveness	Reactive	Predictive and proactive
Scalability with Data	Limited	Scales with large datasets
Decision- Making	Human-defined thresholds	Data-driven and optimized

Key Applications of AI in Power Grid

AI in Power Grid today

Consumption Pattern Analysis & Demand Response

AI enables utilities to analyze complex consumption patterns in real time, allowing for smarter demand response strategies that balance grid load, reduce peak demand, and enhance overall energy efficiency.

Grid Cybersecurity & Anomaly Detection

Analyze vast data streams to identify anomalies and potential cyber-attacks in real-time, enhancing grid security.

Load Forecasting, Voltage Regulation & Fault Detection

AI-enhanced voltage regulation can improve power quality ensuring more stable electricity delivery.

Project Approval & Decision Making

AI technologies are being deployed to expedite the connection of new electricity supplies to the power grid, aiming to reduce delays and improve efficiency in project approvals.

Equipment Health Monitoring

AI-based equipment health monitoring and prediction systems save time and expense by eliminating equipment failure and downtime, leading to significant cost savings.

03

Industry Pulse (Cognito Survey)

Cognito Snapshot: Expert Voices Behind the Data

Expert's Input on AI Use Cases

To understand how AI is being applied across the power grid, we conducted a short industry pulse survey in May 2025 with over 50 power-sector experts, including professionals from utilities, OEMs, consultants, and system integrators. This was followed by 5 in-depth expert interviews to enrich the survey findings with real-world context and firsthand experience.

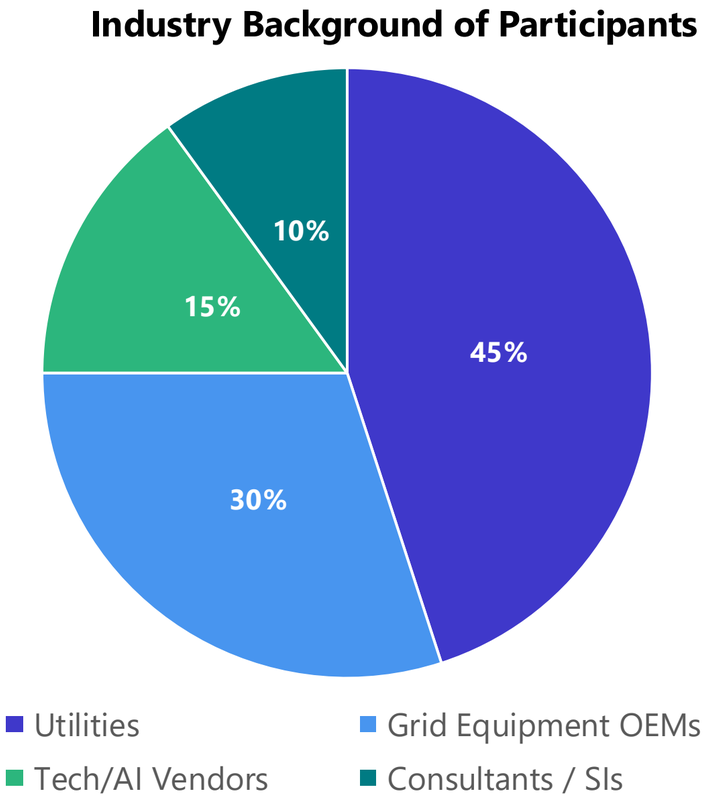
Who We Surveyed:

50+ experts from the Cognito network

7+ years avg. domain experience

Focus areas:

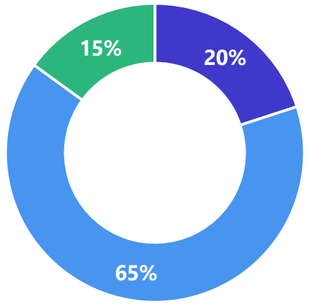
- Grid automation
- Digital substations
- Grid operations
- Asset intelligence
- R&D and Innovation



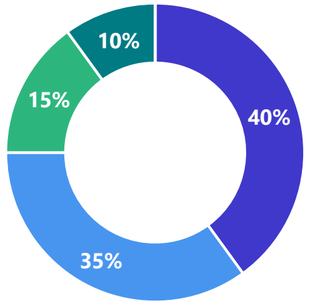
Industry Pulse on “AI in Power Grid”

Expert’s Opinion on AI Use Cases

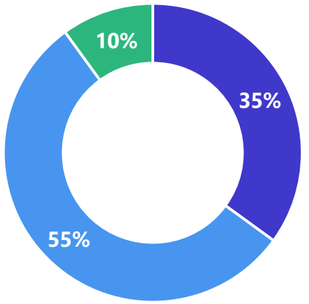
1. How significant will **AI-driven consumption analytics** (e.g., automated demand-response) be for improving grid efficiency?



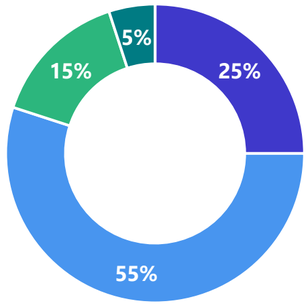
2. How significant will **AI-enhanced real-time load forecasting, voltage regulation, and fault detection** be for reducing energy losses and operational costs?



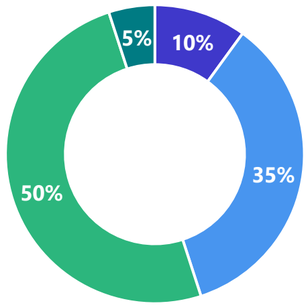
3. How significant will **machine–learning–based equipment condition monitoring and failure-prediction** models be for improving grid reliability?



4. How significant will AI-based **anomaly detection and cyber-threat prevention** be for securing critical grid infrastructure?



5. How significant do you believe AI-powered **project-approval workflows and decision-support tools** will be for speeding up grid modernization initiatives?



Very High Impact High Impact Moderate Impact Slight Impact No Impact

Analyzing Load Patterns using AI

Prediction of pricing according to the demand

1. Consumption Pattern Analysis & Demand Response

A utility-led program that rewards customers for reducing energy use during peak demand, helping balance the grid and avoid costly, seldom-used power plants.

PG&E (USA): Uses AI for short-term demand forecasting and real-time pricing to shift usage to off-peak hours, easing grid load.

Tata Power (India): Tata Power to deployed an AI-driven smart energy management system in Mumbai. The program targets 75 MW peak load reduction in 6 months (Feb 2023 launch) and aims for 200 MW by 2025.

> *Our Distribution System Operator (DSO) team extensively uses machine learning and AI algorithms for forecasting and making operational decisions.*
>
> **Innovation Projects Manager**
> **UK**

65% Responses Say:

High Impact

Industry Pulse

Pinpoint Fault Location and Restoration

Easy to determine fault location increasing response time

2. Load Forecasting, Voltage Regulation & Fault Detection

Predicts future electricity demand to ensure optimal generation and grid reliability. AI helps in maintaining stable voltage levels across the grid to ensure efficient and safe power delivery. Quickly identifies and locates faults to minimize downtime and enhance grid resilience.

40% Responses Say:

Very high impact

Industry Pulse

NESO National Energy System Operator

The National Energy System Operator (NESO) partnered with Open Climate Fix to develop a solar "nowcasting" service using machine learning.

> *With the rise of distributed energy sources like solar and wind and more consumers becoming prosumers, AI enables real-time analysis, accurate forecasting, and proactive grid management. It's not just emerging; it's essential.*
>
> **Electrical Engineer, Substation Control & Automation Expert**
> **India**

> *We've also used AI for fault management through satellite imaging, detecting issues like trees encroaching on overhead lines.*
>
> **Innovation Projects Manager**
> **UK**

Healthy Equipment, Better Sustainability at Grid

AI based assets management ensures long life of equipment

3. Equipment Health Monitoring

AI enhances equipment health monitoring in the grid by enabling real-time diagnostics and predictive maintenance through advanced data analytics.

Duke Energy employs a hybrid model combining engineered analytics and machine learning to monitor transformer health and optimize maintenance schedules.

TenneT utilizes Kafka platform for real-time data streaming, enabling continuous monitoring of the grid.

> *We also monitor several core metrics mandated by Ofgem, including Customer Minutes Lost (CML), Customer Interruptions (CI), and asset health.*
>
> **Innovation Projects Manage**
> **UK**

55% Responses Say:

High impact

Industry Pulse

Finding Potential Glitches in Data

Evicting unwanted data is a key feature of AI

4. Grid Cybersecurity & Anomaly Detection

Grid Cybersecurity & Anomaly Detection is used to protect the grid from cyber threats by monitoring, detecting, and responding to unusual activities in real time.

Pacific Northwest National Laboratory (PNNL) developed an ML algorithm to monitor SCADA logs and detect irregularities that may precede grid disruption.

55% Responses Say:

High impact

Industry Pulse

Black-box AI models used for anomaly detection or pattern recognition lack transparency, making it difficult for power engineers to explain or justify their decisions posing regulatory challenges.

Electrical Engineer, Substation Control & Automation Expert
India

Since we manage critical infrastructure, the approach is to rely on a layered suite of solutions never just a single line of defense that, if breached, compromises the entire system.

AI Expert DNO
UK

Decision Making Process Enhanced

Helping find out hurdles in making decisions

4. Project Approval & Decision Making

AI streamlines project approval and decision-making in the grid by providing data-driven insights, predictive analytics, and scenario simulations for faster, more informed outcomes.
In the U.S., AI tools used by grid operators like PJM and MISO have dramatically speed up renewable energy project approvals:

Midcontinent Independent System Operator (MISO) cut connection studies from 686 days to 10, and SPP cleared three years of backlogs in one year targeting approval times of 1–2 years by 2026.

50% Responses Say:

Moderate impact

Industry Pulse

> *TenneT in the Netherlands and Germany uses digital twins to enhance offshore wind integration, reduce curtailment, and manage balancing costs.*
>
> **Electrical Engineer, Substation Control & Automation Expert**
> **India**

> *The key concern, besides data quality, is trust in AI decision-making. Unlike deterministic systems with predictable outcomes, AI must be robust and include fail-safes to prevent harmful actions, reverting to safe defaults if needed.*
>
> **Innovation Projects Manager**
> **India**

Artificial Intelligence (AI) Beyond Grid

AI is supporting utilities beyond grid related issues

Customer in need Identification

Finding Who Needs Help: UKPN under project “Spotlight” is using AI to find people who might need extra support during power cuts like elderly or disabled customers by looking at data for each home, not just whole neighborhoods.

Wildfire Intelligence

PG&E aims to experience AI-driven wildfire risk modeling to predict and prevent utility-caused fires, enhancing grid safety and enabling proactive power shutoffs. This technology helps protect communities and minimize wildfire-related outages.

Siemens Energy and NVIDIA are developing precise 3D AI models of electrical grids, enabling utilities to optimize operations, maintenance, and planning.

Grid Assets Monitoring

Project “Satelline” by UKPN uses satellite imagery and AI for vegetation management near overhead power lines. Enables frequent monitoring to identify fast-growing vegetation and optimize trimming schedules.

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04

Challenges and Recommendations

Challenges and Bottlenecks

Key Barriers to Scalable AI in the Power Grid

Data Quality & Availability

- Inconsistent, incomplete, or siloed data across utilities.
- Lack of standardized data formats.

Cybersecurity & Privacy Concerns

- Increased attack surface due to connected AI systems.
- Utilities are cautious about deploying AI without robust security protocols.

Workforce Readiness

- Skill gaps in AI, data science, and digital infrastructure among utility staff.
- Resistance to change and lack of training slows AI adoption.

Increasing IT load

- Data centers requirement
- Grid for AI and AI for Grid

Key Recommendations

Conclusion

1. Prioritize Use Cases with Proven Value

- Demand Forecasting & Curtailment Optimization: Improve grid balancing and DER integration using ML algorithms that adapt to seasonal, behavioral, and system visibility patterns.

2. Invest in High-Quality, Granular Data Infrastructure

- Replace outdated infrastructure and digitize legacy records to reduce data inconsistency.
- Develop internal frameworks for data governance and quality control to minimize the “garbage in, garbage out” effect.

3. Implement AI with Robust Fail-Safes and Human Oversight

- Avoid full autonomy ensure that AI acts as a decision support system, not a replacement for human judgment.

4. Strengthen Internal Capability and Upskill Workforce

- Adopt a "train-the-trainer" model to propagate AI literacy within utilities and ensure consistent knowledge transfer.

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Join our network and share your expertise

Partner with Cognito for expert insights

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