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Knowledge Partner

Digitalization & Smart Grid Intelligence: From Sensors to AI



AI and Digitalization are pre-requisites to address the 5 grid-modernization challenges

1

Monitoring Gap: The grid is largely invisible below transmission level

2

Data Quality, Standardization, and Interoperability challenges

3

Flexibility and Market Access: The promise largely unrealized

4

Grid Planning Under Uncertainty: Models that cannot see the future

5

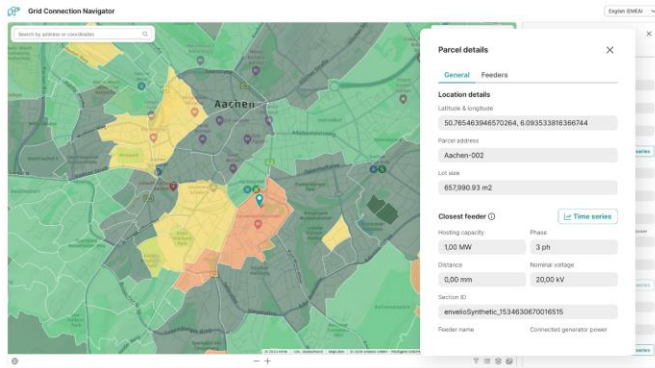
Resource Asymmetry: A Two-Speed Europe Between Large TSOs and Small DSOs

Note : MTU (Market Time Unit) is the smallest time interval used for trading, scheduling, pricing, and balancing electricity in power markets.

Source: ENTSOE ([≥](#))

Sensors, Twins, and AI: How the grid is growing a brain

Digital Twins: Germany's E.ON fully digitalized 700,000km LV/MV network using Envelio (intelligent grid platform)



- More than a third of the German distribution grid is virtually mapped
- Data from 55 million components and 180,000 measuring devices

Public reports indicate 15-20% cost reduction and around 20% of annual ROI

Source: E.ON (>>), envelio (>>), IET Smart Grid, 2025 (>>), Duestcher Presser (>>)

Notes: Hexagon AB surveyed 660 global executives, and 80% noted an increase in interest in digital twins due to AI's growing role. This rising interest is leading to real action, with 43% of companies planning to enhance their digital twins with AI-powered features in 2024.

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AI in Grids: E.ON developed an AI-based predictive maintenance system in Schleswig-Holstein Netz AG's MV grid



- 2-3x improvement in probability of predicting a defect in the grid
- Helps in early intervention

The impact is reflected in reliability with over 50% reduction in downtime

EMT simulation can address what conventional tools miss

Conventional simulation tools fail to address nonlinear loads

Case Example: The 2022 Odessa, Texas Solar Disturbance



Incident

- Routine fault on a 345 kV transmission line in West Texas triggered solar PV plants and synchronous generators to trip in waves across the ERCOT grid
- 2,555 MW of generation lost in secs, one of the largest IBR-related disturbances recorded in North America. ERCOT frequency dropped to 59.7 Hz

Why did conventional tools miss it?

- RMS models miss fast inverter dynamics
- OEM firmware settings were hidden
- Operators lacked real-time fleet risk visibility



How can EMT simulation fix it?

- Post-event EMT modelling successfully replicated the trip sequence, confirming inverter AC overvoltage protection as the root cause
- **NERC mandated that all generator owners making firmware changes submit updated EMT models to their Transmission Planner**

AI could help in addressing both existing potential of improvement and emerging scenarios across every facet of industrial asset management

						
Areas		Planning	Asset operation	Asset reliability	Field service	Safety
Need for AI	Deficiencies in human intervention	Strategies based on historical data, static schedules	Missed early signs of deterioration, human error in readings	Manual FMEA, RCA, ECA and LCC	Work order creation, dispatch scheduling, reporting	Physical inspection, monitoring and risk assessment
	Changing scenario	Complex, large-scale assets require dynamic scheduling	Dynamic optimization and real-time decision-making	Multiple failure points, and large data volume	Faster service, skill allotment and routing	Video and image analysis in real time
Future potential		Better visibility and situational awareness	Enhanced asset efficiency	Efficient maintenance and replacement	Improved resource allocation	Human and asset safety

Source: IBM →; Asset Panda →; SAP →; FMEA: Failure Mode and Effects Analysis; RCA: Root Cause Analysis; ECA: Equipment Criticality Assessment; LCC: Life-Cycle Cost;

FutureBridge's Point of View



Digitalization & Smart Grid Intelligence are indispensable for the physical grid of the 20th-century



Standardization is the key to leveraging the data and ensuring interoperability



A paradigm shift from point-to-point supply to overall system intelligence

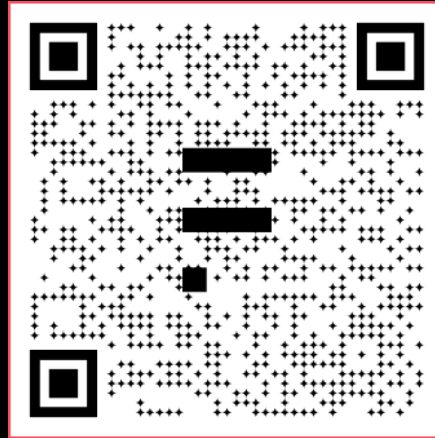


AI will emerge from being reactive to predictive to autonomous

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and market signals shaping tomorrow's power ecosystem.



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