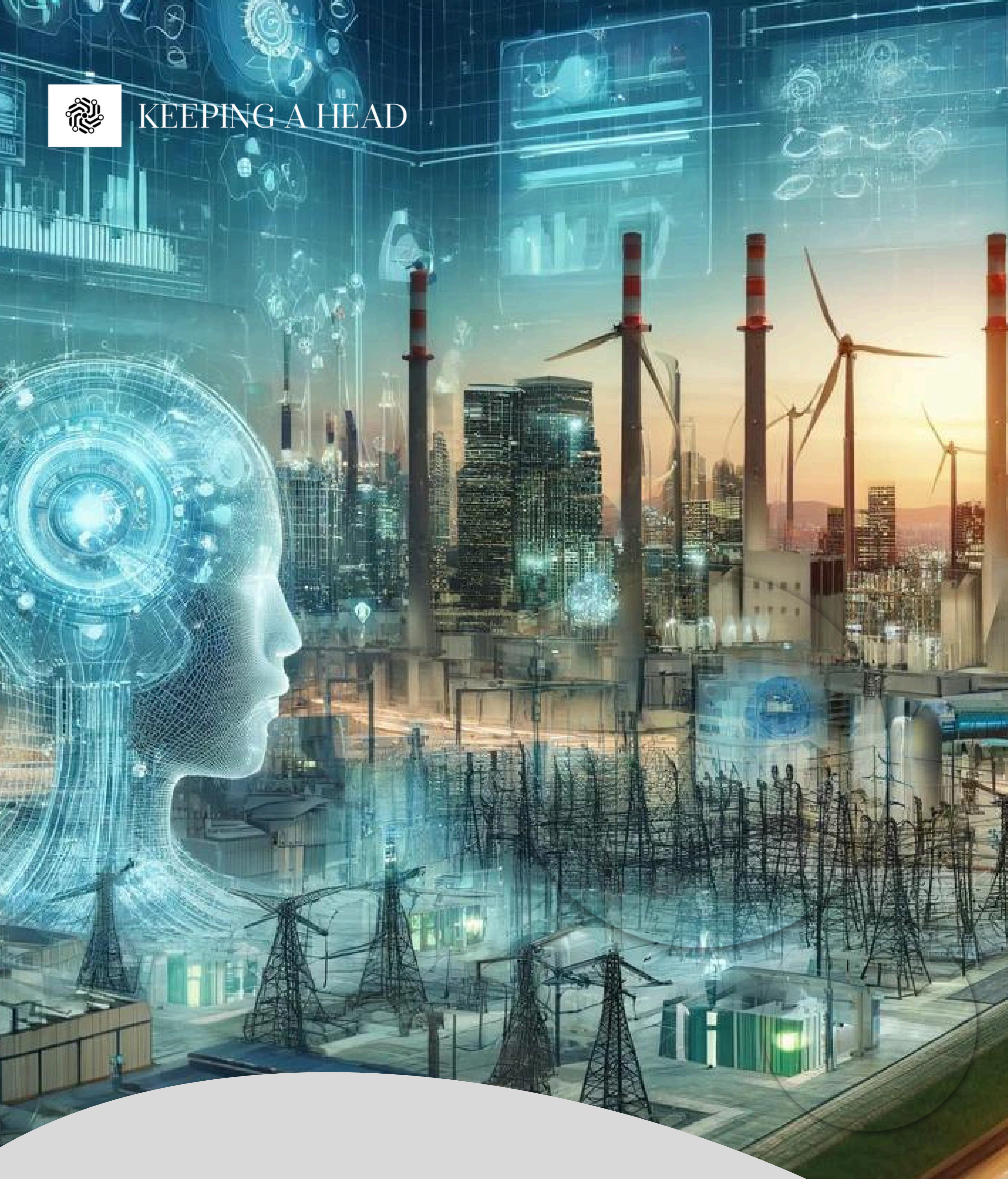
KEEPING A HEAD



# TRANSFORMING POWER SYSTEMS WITH AI:

# The Integration of AI in Modern Power Systems

Power systems are becoming vastly more complex as electricity demand grows and decarbonisation efforts intensify. Traditionally, energy was directed from centralised power stations, but today's power systems must support multi-directional flows of electricity between distributed generators, the grid, and users. The proliferation of grid-connected devices, such as electric vehicle (EV) charging stations and residential solar installations, has made these flows less predictable. Concurrently, the power system is becoming increasingly intertwined with the transportation, industrial, and building sectors. This evolution demands a greater exchange of information and more advanced tools to plan and operate power systems effectively.

**Advancements in AI and Its Role in Energy Systems**

The rapid advancement of artificial intelligence (AI) technology aligns perfectly with the evolving needs of power systems. Machine learning models have become significantly more sophisticated, with the computational power required to develop them doubling approximately every five to six months since 2010.

AI can now reliably perform tasks such as language and image recognition, transform audio into analysable data, power chatbots, and automate routine tasks. By mimicking aspects of human intelligence, AI analyses data and inputs to generate outputs far more quickly and in greater volume than human operators. The energy sector is increasingly leveraging AI to enhance efficiency and drive innovation.

Smart grids and the massive data they generate are prime beneficiaries of AI. Smart meters, for example, produce and transmit thousands of times more data points to utilities compared to their analogue predecessors. New monitoring devices also funnel exponentially more data to grid operators. The global fleet of wind turbines alone is estimated to produce over 400 billion data points annually.

# AI Applications in Forecasting and Predictive Maintenance

One of the most prominent uses of AI in the energy sector is improving predictions of supply and demand. Understanding when renewable power is available and when it’s needed is critical for next-generation power systems.

Machine learning helps match variable supply with fluctuating demand, maximising the financial value of renewable energy and facilitating its integration into the grid.
For instance, Google and its AI subsidiary DeepMind developed a neural network in 2019 to enhance the accuracy of forecasts for its 700 MW renewable fleet. This network, based on historical data, predicts future output up to 36 hours in advance with greater precision than previous methods. This increased accuracy allows Google to sell its power in advance rather than in real-time, improving the financial value of its wind power by 20%.

AI is also pivotal in predictive maintenance, where energy assets are continuously monitored and analysed to identify potential faults before they occur. This approach is more efficient than the conventional schedule-based maintenance, which can be either premature or delayed. E.ON, for example, uses a machine learning algorithm to predict when medium voltage cables need replacement, reducing grid outages by up to 30%. Similarly, Enel employs machine learning to monitor power line vibrations, reducing outages by 15%.
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# Future Potential and Challenges of AI in Energy Systems

AI’s potential uses in power systems are expected to grow substantially. Beyond forecasting supply and demand and predictive maintenance, AI applications may include:

- **Grid Management and Control:** Utilising data from sensors, smart meters, and other IoT devices to manage power flows within the network, especially at the distribution level.
- **Demand Response Facilitation:** Forecasting electricity prices, scheduling response loads, and setting dynamic pricing.
- **Enhanced Consumer Services:** Improving billing experiences and customer service through AI-driven apps and chatbots, as explored by firms like Octopus Energy and Oracle Utilities.

**Addressing the Risks and Challenges of AI Implementation**

Despite its benefits, AI implementation in the energy sector comes with risks that must be managed. These include cybersecurity threats, data privacy issues, and the potential for biases or errors in data leading to incorrect correlations. The energy sector faces a significant challenge in recruiting AI specialists, with a global shortage of skilled professionals. In June 2022, there were only 22,000 AI specialists globally, and 61% of large firms in the UK and US reported a lack of sufficient AI expertise.

AI’s high energy consumption is another critical consideration. Training a single AI model can use more electricity than 100 US homes in a year. Therefore, the most efficient computing infrastructure and algorithms should be prioritised to avoid negating the efficiency gains AI aims to provide.

Additionally, the use of automated and self-learning software raises accountability issues, especially when decision-making is based on models that operators do not fully understand. Clear national, regional, and international frameworks are necessary to guide AI’s development and use in the energy sector. The OECD AI Principles and the European Union’s AI Act are steps towards ensuring that AI development aligns with human-centric and environmental goals.

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Our website www.keepingahead.co.uk

Our e-mail louize@keepingahead.co.uk