# Smart tools power UK’s shift to resilient green energy



As the global transition to renewables accelerates, traditional energy systems are struggling to manage complex, distributed assets. In response, AI, digital twins, energy management systems (EMS) and the Internet of Things (IoT) are becoming essential for improving efficiency, resilience and control across the sector.

The International Energy Agency expects solar to lead renewable power by 2029, followed by wind in 2030. Yet challenges persist, from intermittent supply and ageing infrastructure to regulatory complexity and high maintenance costs, especially offshore. For many operators, siloed data and limited asset visibility restrict predictive analytics and operational optimisation.

AI plays a central role in addressing these issues. By integrating weather forecasts, sensor data and grid demand, it enables real-time diagnostics, generation forecasting and automated dispatch. Wind farms, for example, use AI to adjust blade alignment for greater efficiency, while hydro plants integrate flow data for smarter energy delivery. These capabilities improve market performance and reduce imbalance penalties.

Major companies are investing in AI-powered energy systems. Amazon is applying machine learning to enhance battery storage and solar output, reflecting wider efforts to cut emissions from data centres and electrified transport.

Digital twins — virtual replicas of physical infrastructure — support predictive maintenance by simulating real-world wear, helping to avoid costly breakdowns. They are especially valuable for remote assets like offshore wind farms. Cities are also adopting digital twins to manage urban infrastructure and energy systems, with more than 500 expected to implement them by 2025.

At the system level, next-generation SCADA and EMS platforms are key to managing distributed resources. A tailored EMS recently delivered a 30 percent drop in energy losses for a solar operator, while halving the need for on-site technicians. Combined with IoT sensors and local data processing, these systems improve response times and allow secure, low-latency control even in remote locations.

Simulation tools help de-risk projects by testing grid integration before deployment. Meanwhile, automated compliance tools support ESG reporting and unlock access to green finance, turning regulation into a competitive advantage.

Digital transformation, however, demands customised rollouts. Many firms adopt modular approaches, beginning with predictive maintenance or reporting automation. Skills shortages can be addressed through embedded diagnostics and alert systems that support remote monitoring and reduce reliance on site-based expertise.

The UK is well placed to lead this evolution. Investments in AI, digital twins and EMS technology can enhance asset performance, ensure regulatory alignment and drive down costs. With scalable platforms and growing digital capabilities, UK energy providers can advance a smart, secure and sustainable green energy future.

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## Bibliography

1. <https://xbsoftware.com/blog/digital-tools-for-renewable-energy/> - Please view link - unable to able to access data
2. <https://www.axios.com/2024/05/21/amazon-artificial-intelligence-energy> - Amazon is leveraging artificial intelligence (AI) and machine learning to improve power efficiency and reduce emissions amid growing energy demands from data centers, electric vehicles, and electrified homes. A blog post, shared with Axios, details Amazon's effort to optimize new battery storage systems coupled with solar installations. Despite the promise of AI in enhancing battery efficiency, the surge in power demand, particularly due to new data centers for generative AI and a decarbonizing economy, poses significant challenges. Microsoft's recent sustainability report showed a 30% increase in emissions linked to its AI initiatives. Amazon, however, is focusing on developing carbon-free energy sources like nuclear, wind, and solar, and working with international partners to utilize AI for energy optimization. Chris Roe, Amazon's environment director, emphasized an "emissions-first approach" in their renewable energy strategies. AI-enabled battery storage predictive systems are among the promising technologies that could help reduce a major company's emissions.
3. <https://www.reuters.com/sustainability/climate-energy/how-ai-is-arming-cities-battle-climate-resilience-2024-05-23/> - Many cities, including Houston, Singapore, and Amsterdam, are leveraging digital twins and AI to enhance climate resilience and manage urban challenges such as flooding, air pollution, and heat islands. A digital twin is a virtual model that uses real-time data from various sources to replicate physical objects and infrastructure. By 2025, over 500 cities are expected to use digital twin technology. These tools are essential for monitoring and controlling environmental factors, optimizing energy systems, and managing waste effectively. Examples include Los Angeles' digital twin for transport management and Palermo's use for green space maintenance. Despite their benefits, the adoption of digital twins involves complex stakeholder collaboration and data privacy challenges. Previous failures in Portland and Toronto highlight the importance of transparency and robust data governance. Successful implementation of these technologies could significantly contribute to urban sustainability and resilience against climate threats.
4. <https://www.ft.com/content/b12367a3-c07c-4180-90fe-8ddf358f7952> - Sultan al-Jaber, the chief executive of Abu Dhabi's national oil company Adnoc, highlighted the significant potential for major oil companies to invest in renewable energy due to the rising energy demands of artificial intelligence (AI). This was exemplified when AI technologies like ChatGPT gained prominence about 18 months ago. Oil company executives from Shell, BP, and TotalEnergies, along with tech and finance leaders, gathered in Abu Dhabi to discuss energy solutions for AI, emphasizing the need for renewable energy and advanced battery storage. Despite recent shifts back to oil by Shell and BP, the AI surge may prompt renewed interest in renewables. Adnoc itself is advancing in AI, notably through its EnergyAI software developed with Microsoft and G42, aiming for operational improvements and carbon emission reductions. Adnoc plans significant investment in low-carbon technology, aiming to reduce emissions per barrel by 25% by 2030 and achieve net zero by 2045 for scope-one and scope-two emissions.
5. <https://time.com/7201501/ai-buildings-energy-efficiency/> - AI is being used to make buildings more energy-efficient, especially as heating and lighting account for 18% of global energy consumption. AI can help modernize outdated HVAC systems which are often inefficient. One study predicts that AI could reduce buildings' energy consumption and carbon emissions by at least 8%. A case study at 45 Broadway in Manhattan showed that AI from BrainBox AI helped reduce HVAC energy consumption by 15.8%, saving $42,000 annually and cutting 37 metric tons of carbon dioxide. AI systems optimize HVAC responses to weather and occupancy changes, with widespread deployment in various buildings globally. While AI in HVAC systems promises significant efficiency gains, there are challenges including energy usage by AI data centers and privacy concerns. Some critics argue that AI initiatives may be a form of greenwashing, as AI development itself is highly energy-intensive. Despite these concerns, experts believe the potential benefits of AI for energy efficiency and reducing carbon footprints are substantial.
6. <https://social-innovation.hitachi/en-us/think-ahead/digital/digital-twins-for-smarter-greener-energy-grid/> - Digital twins are revolutionising the management of energy grids by providing real-time insights into asset performance and enabling proactive maintenance. By continuously monitoring assets like transformers and wind turbines, digital twins detect issues early, allowing for timely interventions that prevent costly repairs and minimise downtime. This proactive approach not only extends the lifespan of critical infrastructure but also enhances grid reliability. Additionally, digital twins optimise energy storage systems by analysing real-time data to efficiently balance supply and demand, reducing reliance on fossil-fuel-based peaking plants and lowering emissions. The integration of AI with digital twins further enhances their capabilities, enabling predictive maintenance and real-time energy distribution optimisation. For example, AI-powered digital twins can analyse data from wind farms to improve remote monitoring, control, and predictive maintenance, leading to more accurate decision-making and increased operational efficiency. By harnessing these technologies, utilities and energy producers can achieve smarter, more sustainable energy systems.
7. <https://businesscasestudies.co.uk/the-role-of-ai-in-renewable-energy-optimization/> - Artificial Intelligence (AI) is transforming renewable energy optimisation by enhancing performance and predictive maintenance, particularly in wind energy. Advanced machine learning models analyse historical wind data to forecast wind speeds and directions with remarkable accuracy, enabling operators to dynamically adjust turbine settings for maximum energy capture and protection during extreme weather. AI also plays a crucial role in predictive maintenance for wind turbines by continuously monitoring performance data such as vibration levels and temperature fluctuations to identify early signs of wear or malfunction. This proactive approach allows maintenance teams to address issues before they escalate into costly repairs or unplanned outages. Additionally, AI optimises the placement of new wind farms by analysing geographical data to identify locations with the highest potential for wind energy generation, ensuring investments yield maximum returns. By integrating AI into renewable energy operations, companies can achieve significant improvements in efficiency, reliability, and profitability.