Building intelligent energy utilities using AI and machine learning

The energy and utilities sectors are on the brink of massive change. Increased energy use by older facilities, depleting renewable sources, weather disruptions, and higher user demands have all pushed the utilities sector to upgrade its infrastructure. AI and machine learning (ML) are the key technologies behind this transition. They help utilities make informed decisions, increase operational efficiency, improve grid performance, and by utilising data insights and automation, lead the way in the integration of renewable energy sources. By leveraging AI, utilities operators can store massive amounts of data, make intelligent forecasts, carry out decisions automatically, as well as optimise the flow of power instantaneously.

Why do we need smart energy utilities?

Power systems were typically centralised—producing power in a few locations and serving comparatively stable demand profiles. A much wider mix of energy sources—including rooftop solar, small wind turbines, batteries, and electric cars—are now contributing to the grid. The only way to handle this complexity is with smart systems that can understand and respond to data changes. AI makes it possible for utilities to shift from merely reacting to situations, to foreseeing them and even taking control autonomously.

AI and ML in utility operations: Functional view

AI and ML algorithms allow utilities to precisely estimate the energy demand by looking into historical usage data, weather forecast, and other related inputs—leading to optimised energy generation and distribution. This predictive maintenance technology comprises collecting of sensor data which tracks the condition of the equipment and facilitating detection of possible failures in a timely way. This helps in avoiding the risk of major equipment breakdown, unplanned downtime, and higher maintenance costs.

More specifically, the use of AI for grid optimisation enables dynamic load balancing and management of distributed energy resources, which improve the power delivery reliability and efficiency. On the other hand, ML-based customer analytics help utilities gain insights into consumption habits, segment customer base, and deliver customised energy offers—thus enhancing the overall satisfaction level.

Additionally, combining DevOps with ML operations (MLOps) completely changes the way companies develop, release, and keep their ML systems. MLOps focuses on the DevOps concepts around the ML lifecycle. This enables complete automation with continuous integration and continuous delivery (CI/CD) pipelines in a DevOps sense. MLOps stresses the use of infrastructure as code (IaC) to set and control the computing resources for model and operations code, automated model testing for model validation and testing, as well as model and operations monitoring and enterprise system (logging) health assessment. This combination provides speed and better delivery of ML systems.

In the past, developing ML systems was confined to isolated areas that could only be reached after the development had progressed through multiple deployment cycles without enough version control. However, with MLOps, problems like these are mitigated through the application of DevOps concepts that address ML systems' peculiarities.

Key challenges in building intelligent energy utilities

Utilities must cyber-secure their energy data and infrastructure as reliance on AI-driven systems grows. Also, these AI solutions must be at par with the continuously changing privacy, sustainability, and safety standards. Juggling strong cybersecurity and regulatory compliance together not only helps protect sensitive data and keep up with the consumers' trust but also paves the way for the safe introduction of new technologies.

Fundamentally, making AI solutions available in utility networks that cover wide and sparsely populated areas is a major challenge that arises due to the intricacies of the fusion of AI technologies to already very varied infrastructures. These utility networks are spread out over large geographical areas, having systems that are very different from each other—some of which are so old that they use communication protocols that are no longer compatible, their hardware being unable to support modern AI workloads. The main problem is not a subsidiary issue; it is a key one. Integrating AI technologies in these systems should be regarded as the central obstacle to all other issues. Only if the integration of legacy systems is solved will data quality issues be manageable, model deployment be feasible, and operational workflows be changeable.

With utilities becoming more automated due to AI use, it is important to parallelly develop the skills of the workforce through well-specified training courses and change management programmes. These measures would help curb any irrational fears regarding being replaced by machines and give the workers a sense of accomplishment.

Business outcomes

Implementing AI-powered utility systems offers various tangible business results for organisations. One-way predictive maintenance can assist in lowering equipment breakdown is by increasing asset reliability, while cutting maintenance costs simultaneously. Forecasting demand with a high level of accuracy allows for better planning of resources and, ultimately, more efficient use of generation capacity. Detecting faults quickly and restoring services lead to minimal service disruptions and higher customer satisfaction.

Besides, AI is an integral part of properly integrating renewable energy sources as in addition to helping in generation forecasts, it plays a pivotal role in optimising energy storage and balancing supply and demand. In short, these features enable utilities to handle the fluctuations of renewable energies and improve the overall efficiency and reliability of the grid simultaneously.

How PwC can help

We design and deploy sophisticated ML systems that substantially increase demand forecasting precision, recognise equipment maintenance requirements, predict failures, and maximise the use of renewable energy to achieve both operational excellence and sustainability. Our cloud and infrastructure solutions facilitate efficient migration and allow scalable deployment of AI systems, along with real-time analytics platforms offering actionable insights.

Furthermore, we introduce new, advanced smart grid and digital twin systems enabling utilities to perform grid behaviour simulation, close asset monitoring, and operational optimisation through a proactive approach. A full range of managed services offerings involve ongoing model monitoring, retraining, performance tuning, and round-the-clock operational support to deliver sustained value.

While doing so, we make sure to prioritise regulatory compliance and cybersecurity, helping utilities cope with industry standards and risks. By fusing thorough understanding of the industry with up-to-date technical skills, we help utility firms to digitally turn around, build resilience, and flourish in a future that is more data-driven and sustainable.

Conclusion

AI and ML have real potential to change how we generate, distribute and consume energy. They can make grids smarter and more resilient. With the help of AI, utilities will have predictive maintenance, smart grid operations, and renewable energy management functionalities. Since service-based technology companies possess the required skills, tools, and ability to implement intelligent energy utilities solutions, they will play a crucial role in implementing the required solutions in legacy utility systems.

About PwC

We help you build trust so you can boldly reinvent

At PwC, we help clients build trust and reinvent so they can turn complexity into competitive advantage. We're a tech-forward, people-empowered network with more than 364,000 people in 136 countries and 137 territories. Across audit and assurance, tax and legal, deals and consulting, we help clients build, accelerate, and sustain momentum. Find out more at www.pwc.com.

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