# From Generation to Supply: Electricity Generation (Part 1)

Learn how automation, AI, and machine learning are essential parts of the new energy system, helping teams and companies be more efficient & innovative.

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*"From Generation to Supply: How AI is Transforming the Energy System" is a six-part series on the many ways in which AI is helping to transform the energy sector at every stage of the generation, distribution, supply, and regulation cycle. This is Part 1. The next part will appear in March, 2023.*

## The Three D's

The alarm rings. You grab your fully charged phone, turn the lights on, and rush to the coffee machine to start your day. Sound like your routine?

Most of us go through these and other motions every day without realizing how essential electricity is to performing all of them. And if we succeed in *decarbonizing* our energy system, many more everyday activities will be powered in the same way, like driving our electric vehicles or warming up our houses with electric heaters. To put things in perspective, McKinsey expects electricity demand to triple by 2050, driven by electrification's low costs and increased reduction in $CO_2$ emissions.

Most of us don't rationally think about where the electrons powering our life are coming from. Was it generated five minutes ago, or stored in a large battery during the night? Did a wind turbine generate it, or was it a gas-fired power station? Who guaranteed that I would have power available when I flipped the light switch?

These questions illustrate the complexity of our energy system for regular customers. But things can get even more complex if you consider the significant transformations the sector is currently going through. From centralized large-scale plants to *decentralized* generation, from one-way supply to multidirectional flow of electricity, and from a few pieces of equipment to interconnected smart homes: these are just a few examples of the challenges energy companies need to keep up with while maintaining operational excellence, looking for competitive advantages, and adapting their own businesses.

Then there's the third D in the energy system transformation — *digitalization*. For a long time, energy companies have been collecting an enormous amount of data without extracting full value from it. On the one hand, the lack of data standardization is a blocker for energy companies to extract valuable information across the supply chain and occasionally even across their own siloed teams. On the other hand, processing all this data, in some cases with sub-second requirements, makes the task almost impossible for humans to perform without computing support.

Thinking about these challenges to keeping up with the digital transformation of the energy system, we decided to launch a monthly blog series: “From Generation to Supply: How AI Is Transforming the Energy System.” We will follow the flow of electricity through the cables and wires, starting with this post on Generation, and followed by five other blogs on Transmission & Distribution, System Operation, Flexibility & New Technologies, Energy Supply, and Regulation.

Let’s see how automation, AI, and machine learning are essential parts of this new energy system, helping teams and companies be more efficient and innovative.

## What is Electricity Generation?

Electricity generation refers to the process of producing electricity from various sources. The main sources of power generation include fossil fuels, nuclear energy, and renewable energy sources such as solar, wind, and hydro-electric power. Generation technologies vary depending on the source of energy used. For example, thermal power plants use fossil fuels like coal, natural gas, and oil to generate electricity, whereas nuclear power plants harness the energy produced by nuclear reactions.

Fossil fuel power generation has been the traditional form of electricity generation for over a century. However, the negative environmental impact of fossil fuel production and consumption has led to a global shift towards cleaner forms of power generation. Without relying on finite and carbon-intensive resources to produce power, renewable energy sources have experienced steep growth in recent years, already becoming more cost-effective than traditional technologies in certain countries. And this trend is only continuing upward: cleaner technologies already account for 30% of world electricity production today, and the IEA expects it to reach 60% in 2030, provided their NetZero scenarios go as planned.

In electricity generation, developers are companies responsible for building new plants. These companies can either specialize in one technology (e.g. wind) or work with multiple technologies — the combination of more than one form of generation within a single hybrid plant is becoming increasingly common. Looking at the state of things from a high-level perspective, generation companies typically go through the following steps before an asset is ready to generate electricity:

1. **Technology Selection**: Identify the type of technology or technologies (e.g. solar, wind, hydro, natural gas) to be used.
2. **Feasibility Study**: Assess the potential for the proposed plant, including site selection, resource availability, and potential environmental impacts.
3. **Development Plan**: Lay out a concrete plan for getting the plant up and running, including cost estimates, timelines, and projected energy output.
4. **Fund Raising**: Secure funding for the project through a combination of private investment and/or government incentives.
5. **Regulatory approvals**: Obtain the necessary permits and approvals from local, state, and federal authorities.
6. **Construction**: Begin construction of the plant, including any necessary infrastructure, such as transmission lines.
7. **Test and Commission**: Test, observe, and tweak the plant’s processes to ensure they operate correctly and efficiently.
8. **Operation & Maintenance:** Begin operations and monitor the plant's performance to identify any necessary adjustments or improvements.

Developers have the potential to utilize AI and machine learning models as all stages of the generation process. Still, their maturity depends directly on how much data is available, on the quality of that data, and on the company's ability to transform data into value. Use cases range from more established financial forecasting and predictive maintenance programs to innovative AI-powered land assessment and technical design.

## AI in Electricity Generation

To illustrate AI's potential to improve electricity generation development, we will focus on three potential uses at different maturity levels: land selection strategy (low maturity), design optimisation and automation (medium maturity), and predictive maintenance (high maturity).

### Land Selection Strategies

Selecting the right land for power generation projects is crucial to their success, since high-quality land can represent more energy output per area, lower costs with planning approvals, and reduce environmental impact. Until now, most developers have been developing land selection strategies with little to no technological support. Those with more advanced technological capabilities use their own land banks mapped by internal specialists or third-party real estate partners to generate insights. Integrating AI into land selection represents a game-changing opportunity for developers.

AI can analyze many of the factors relevant to land selection, such as geographical conditions, weather patterns, and the presence of natural resources, to determine the most suitable location for a power generation plant. For example, AI can analyze satellite images and topographical data to identify areas with high potential for solar or wind power generation, but also identify zones with lower natural risks (e.g. floods) or even facilitate local authorities' urban planning and development approval.

Where grid data is openly available and up-to-date, developers can identify high-potential zones for the deployment of technology development building models to rank the best sites with the lowest production costs, improving confidence in a project's viability. By using AI for land selection, electricity generation companies can save time and resources, and can increase the chances of success for their projects.

**Optimal Plant Design and Automation**

The use of software to assist design engineers is not new. The most advanced tools have the ability to identify the optimal combination of equipment size, inclination, direction, height and several other parameters required when designing a generation plant. However, relying on rigid spreadsheet models and human trial and error to run large, complex simulations devised to determined the optimal design can become time-consuming and inefficient. This process risks making the designing process a scalability bottleneck. There are also untapped opportunities for using historical data to optimize project design.

Embedding the historical performance of operating generation plants with similar characteristics into AI-powered design models helps to avoid the pitfalls of only working with theoretical energy outputs and building overconfident business cases for financial approval. AI technology enables the integration of various other factors in the analysis — such as the cost of raw materials, efficiency, and emissions — to determine the most suitable design for a power generation plant given current market conditions. By using AI to design power generation plants, developers boost team and project efficiency and reduce the costs of their projects.

**Predictive Maintenance**

A growing number of generation plants spread across long distances; an expensive business model of rotating engineers around sites at a certain frequency (preventive maintenance); and a highly competitive industry with low margins: these are the realities that most Operation & Maintenance (O&M) companies have dealt with recently in the electricity generation sector. On the other hand, these challenges are also why predictive maintenance has never been so hyped among these companies.

Due to the importance of electricity for critical operations, data collection and equipment monitoring have become industry standard practices, from the adoption of sensors with sub-second frequency levels to the use of more familiar sensors that measure current, vibration, and temperature information. And yet, several O&Ms are still early in their data journey, and are still learning to develop and use machine learning models to harness all the available historical data and predict when equipment is likely to fail.

O&Ms are starting to understand that predictive maintenance is not only crucial for ensuring the reliability and efficiency of power generation equipment but also as a cost-reduction strategy for achieving a lean operation. The potential for AI to support improved efficiency with respect to operation maintenance at generation plants also includes simpler solutions like optimized maintenance routing, spare parts shipment and stock management, and the optimal integration of different types of technology.

## Moving to Everyday AI in Power Generation

Whether by anticipating plant failure or making design engineers more efficient, AI technology will become more prevalent among generation developers as it matures. Companies that haven't yet started implementing more robust data strategies have the opportunity to leapfrog and accelerate their AI journeys with a one-stop shop platform like Dataiku. Rather than stacking up numerous solutions for each specific task in the development process, there is a unique opportunity to foster efficiency at both the company-wide and the team-specific levels, through collaboration and workforce upskilling.

Without a clear AI strategy to harness years of data and develop competitive advantages within a fast-paced industry like the energy sector, developers risk losing market share to more agile and lean companies able to diversify their offerings. On top of the hardware development business model, producing insights on electricity generation patterns is highly valuable for other electricity supply chain stakeholders. For example, power forecasting will be even more critical for the energy system, enabling utilities and grid operators to optimize their operations and reduce costs based on real-time insights from plant performance.

## Getting Energy From A to B (to C to D to E...)

Unexpected disruptions in electricity generation plants could lead to costs of US$10 billion per year in lost production. The use of AI in electricity generation has the potential to revolutionize the industry, providing new solutions to the challenges associated with producing enough power to meet the needs of a growing population while also reducing carbon emissions.

In the next part of “From Generation to Supply,” we’ll explore how AI is being used to improve the transmission and distribution networks that deliver power to our homes and businesses.