From Generation to Supply: New Energy Technologies (Part 5)

In the ever-evolving landscape of the energy sector, new technologies are emerging as the driving force behind a cleaner, more sustainable future.

By Guilherme Castro

8 min. read · View original

“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, transmission and distribution, system operation, supply, and regulation cycle. This is Part 5. The next and final part will appear in July, 2023.

Do you remember what the world looked like five years ago? And what about ten years ago? What were the technologies of the near future, back then? Was ChatGPT, for instance, on anyone’s radar?

When we look at the numbers, many analysts would say that the energy transition hadn’t even started then. In 2010, the total installed capacity of solar photovoltaics (PV) was only 40GW, or 3% of the current capacity. The growth of Electric Vehicles (EVs) has followed the same trend with 2022 sales hitting 14% of all cars sold across the globe, an astonishing 1400x larger market share than a decade ago. But these technologies are not new: NASA launched the first satellite equipped with a solar panel in 1958 and Henry Ford tried to produce a low-cost EV in the early 1900s. What has changed to transform these technologies and their adoption, and to democratize access to them?

The reality is that there is no single answer to this question. Public subsidies to incentivize early adoption, new materials and product improvements to make them more competitive, and growing pressure from consumers towards decarbonizing our economy are all drivers accelerating the uptake of new energy technologies. But there is another important driver in this mix: computation power and data availability. Whether we're looking at research and development processes or how these technologies are operated nowadays, the combination of data products and automation is a powerful enabler of both "0 to 1" innovations and "1 to n" scalability.

What Are New Energy Technologies?

In the ever-evolving landscape of the energy sector, new technologies are emerging as the driving force behind a cleaner, more sustainable future. Traditional technologies that have long served as the backbone of the electricity infrastructure are being challenged by a wave of innovative alternatives that represent a paradigm shift in our approach to energy generation and consumption. Battery electric vehicles, floating wind turbines, advanced battery storage systems, heat pumps, and green hydrogen are among the pioneering technologies that are driving the energy transition forward. By displacing carbon-intensive counterparts, they not only reduce harmful emissions but also offer significant economic and environmental advantages.

In addition to their own particular hardware upgrades, these emerging solutions also bring a common feature to the table: connectivity. The Internet of Things (IoT) plays a pivotal role in this ecosystem, connecting devices, sensors, and systems, and allowing for seamless communication and data exchange. IoT-enabled devices, such as smart meters, EV charging stations, and energy management systems, continuously collect and transmit data, providing real-time insights into energy consumption, production, and grid performance. This continuous stream of data empowers energy stakeholders to make informed decisions and fine-tune their operations.

AI for Accelerating New Energy Technologies

We will focus on potential use cases for four technologies powering the energy transition: electric vehicles, battery storage, heat pumps, and electrolyzers to produce green hydrogen.

Electric Vehicles (EVs)

EVs use electricity stored in batteries to power their motors, not only reducing air pollution but also paving the way for cleaner transportation and the integration of renewable energy sources into the grid. Replacing conventional internal combustion engine (ICE) cars with zero-emission alternatives, EVs are among the technologies spearheading the shift in the transportation sector.

If, earlier, cars had a single purpose of moving people and cargo around, EVs enable much else besides. From storing renewable energy generation excess to powering buildings, the vehicle-to-everything (V2X) allows an EV to perform different roles in the electricity system, depending on the utilization of the charge in their batteries.

But their widespread adoption faces challenges, such as range anxiety and limited charging infrastructure — problems that the deployment of advanced AI models aims to solve for manufacturers, charging station providers, and electricity suppliers. When trying to discover new chemical combinations for better battery performance, R&D teams can boost their processes, substituting traditional trial-and-error experiments with a combination of computational chemistry and AI. These can make processes more efficient and enhance the chances of success.

While manufacturers leverage data available to improve battery components, utilities and charging providers focus on how to anticipate where the demand for new stations is and how to offer new products to these customers. And advanced machine learning models also expand the possibility of solving one of the biggest challenges for batteries at the end of life. AI applications can increase the rate of success for the intelligent disassembly of batteries and allow the return of raw materials back to the supply chain, addressing any uncertainty about the feasibility of disassembly and related safety concerns.

Battery Storage

Beyond their use in EVs, battery storage systems also play an important role as a stand-alone technology for both small-scale (e.g. in households) and large-scale applications, like balancing grid supply and demand. In addition to its capacity to time-shift renewable energy generation to periods of high demand or low generation, the capacity of battery storage systems to help stabilize the grid is a valuable contribution to the system efficiency while also reducing the dependency on fossil fuel-based peaker plants.

A third benefit of this technology, when spread across wider areas, is avoiding losses when transporting electricity over long distances. Either aggregated or strategically displaced by TNOs and DNOs, batteries can work as the first alternative when you have power demand in a specific region before dispatching generation from further areas.

But can you imagine how time-consuming it would be to adjust your battery to recharge or discharge every 30 minutes throughout the day? Or to decide which among many electricity markets a utility should sell its stored power to, in order to increase the return on its investment? AI algorithms that can help decide when to dispatch electricity, in what quantities, and at what trading price points are essential for enabling these assets to operate optimally and competitively.

If not complex enough, all the financial decisions behind the battery operation must respect multiple hardware requirements to reduce any degradation and maintain system performance for as long as possible. And these almost real-time decisions require powerful battery management systems embedded with multiple AI models to deliver fast responses all while maintaining the equipment.

Heat Pumps

Moving from storing electricity to using it to extract heat, heat pump technology delivers a cleaner and more efficient alternative to conventional heating and cooling systems like gas boilers. The technology extracts heat from the environment and uses it to heat or cool buildings, achieving efficiencies of up to 400%.

Heating decarbonization is a challenging area due to the complex conversion of current heating systems; wider subsidies on fossil-fuel energy sources have both increased its cost-effectiveness and raised upfront costs. Still, scaling heat pumps globally has the potential to cut 500m tons in carbon emissions by 2030 — levels similar to the total annual CO2 emissions of Europe's current car fleet.

Demand flexibility is another of the values added by the use of heat pumps to decarbonize heating; and it's an area where AI plays a significant role in optimizing system operation. Electricity suppliers can deploy machine learning models to identify high-potential customers for whom switching to heat pumps would lead to savings on their electricity costs; these models can even spot customers with the technology already installed who are nevertheless not operating it to maximal performance. AI algorithms can analyze environmental conditions, building occupancy patterns, and user preferences to determine the most efficient operating modes for heat pumps. This not only reduces energy waste but also provides personalized comfort and significant cost savings for customers.

Green Hydrogen Electrolyzers

On the other side of the heat and transport decarbonization battle, green hydrogen is the contender for those who defend the idea of retrofitting the current gas distribution infrastructure and reducing heating and transportation emissions with cleaner fuel. The technology behind green hydrogen is electrolysis which uses electricity to split water into hydrogen and oxygen, producing hydrogen gas without carbon emissions.

Without taking a side, we can observe that green hydrogen's greatest value for the electricity system lies in its versatility as a clean energy carrier. The fuel can be used as a zero-emission alternative for transportation, an energy storage medium, and even in industrial processes. Its adoption can accelerate the decarbonization of sectors that have been traditionally hard to electrify, but can also enable the integration of more renewable energy generation into the grid.

Different from current battery storage technologies, green hydrogen offers the ability to store energy for longer periods, an essential benefit in the current electricity system. Co-locating electrolyzers with solar and wind plants allows developers to keep generating electricity even when the grid demand is not higher enough to consume all the power produced, avoiding the curtailment of renewable energy sources.

But to achieve the optimal design of these hybrid plants, developers can leverage machine learning models not only to combine the right capacity for each technology, but also optimize their operation based on electricity cost, efficiency, and predicted power output. Other technologies like blockchain can help regulators deploy AI models to facilitate auditing and give more transparency to green hydrogen certification, especially when electrolyzers are not physically connected to renewable generation assets.

Everyday AI for Developing New Energy Technologies

For a long-time, innovation sounded like a process restricted to scientists inside their labs experimenting with multiple materials until they finally screamed “Eureka!” The truth is that developing new technologies, or even making incremental improvements on existing ones requires a massive investment of financial and temporal resources, numerous iterative processes mixing different domain expertise, and a growing capacity to extract insights from all the data available. For energy companies and their supply chains, piggybacking on the successes of other sectors' experiences to make their innovation process even more data-driven can accelerate their digital transformation processes.

By incorporating new data sources into the innovation process, R&D teams can accelerate the development of new energy technologies while saving time and resources. These data sources can include IoT data from smart devices, weather forecasts, grid data, and customer behavior data. Platforms like Dataiku support leveraging these diverse datasets, usually spread across different silos or formats, and allow domain experts to gain deeper insights into energy consumption patterns, grid performance, and customer preferences — all of which enables them to design more efficient and tailored solutions.

Conclusion

From discovering and testing new materials to improving customer experience, the digitalization of the energy system enables the integration of advanced analytics and AI models, leveraging the vast amounts of data generated to accelerate the adoption of these new technologies. And democratizing access to these new energy technologies doesn't depend only on the innovative transformation of their hardware. The annual $4 trillion investment in clean energy required by 2030 to reach Net Zero will require energy companies to deploy part of their capital in accelerating their digital transformation and creating new data-driven solutions.

Independent of which technology becomes the winner in their sector, EVs, battery storage, heat pumps, and green hydrogen are not merely standalone solutions but interconnected elements that drive us towards a sustainable energy future. And AI has the potential to unlock these technologies' value for investors and users by optimizing performance, enhancing efficiency, and enabling cost-effective operations. Furthermore, end-to-end AI platforms like Dataiku pave the way for a more integrated and intelligent energy system, bringing us closer to a greener, cleaner, and brighter future.

In the next and final blog, we will explore the realm of electricity regulation, and how those responsible for overseeing the whole market regulatory operation can also leverage AI to improve how we generate, distribute, store, and consume electricity.