POWER CONSULTING INSIGHTS

Artificial Intelligence Enables Efficiency and Reliability for Utilities

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AI helps utilities capture opportunities in the changing energy industry.

Artificial Intelligence (AI) has been around since the mid-1950s, but with a recent boom in massive computational power, big data, and algorithms, AI has seen tremendous growth and is shaping the daily functions of the utility industry. With energy industry trends, such as renewables and the Industrial IoT, AI technologies can help utilities capture these opportunities. From the perspective of Power Consulting at ABB, AI can be implemented with daily operations, grid safety, reliability, and resilience.

Introduction

Artificial Intelligence was first coined by John McCarthy, a Stanford researcher, in 1956 who was using the words to describe 'thinking machines' in the context of computer science.[1] Today, AI has become more than just a thinking machine and is gaining a buzz because of the remarkable growth of the internet and the vast amount of accessible data. By definition, from Merriam-Webster, AI is a branch of computer science dealing with the simulation of intelligent behavior in computers and is the capability of a machine to imitate intelligent human behavior.[2] AI is based on the idea that human intelligence can be defined in set terms and that if a machine follows those terms, it can mimic a human.[3] Machines, therefore, are programmed to think like a human and mimic the way a person will act and rationalize.

There are many branches within AI, and Machine Learning is just one of the subsets.[4] Machine Learning involves teaching computers to learn for themselves. The evolution of the internet has helped with the emergence of Machine Learning as there are plentiful amounts of data being generated and stored on the internet – readily available for analysis. Researchers realized that it would be much easier to teach the machines to learn for themselves then for the researchers to program these machines themselves. The machines can learn from the data and identify patterns within the data to make decisions. The fundamental tool behind Machine Learning is the neural networks, which is a computer system that works on a system of probability that can make statements and decisions based on data that is fed to it. The neural networks can classify information using a series of binary questions or even extract a numerical value from data. Additionally, these neural networks enable learning with the addition of a feedback loop that enables the machine to recognize if its decision is correct and adjust if it's wrong.

Within Machine Learning, there is a 'deeper' subset called Deep Learning and it takes Machine Learning one step further.[5] With Deep Learning, machines can learn from their mistakes and can solve almost any problem that requires human thought. Deep Learning works similarly to Machine Learning by feeding data through neural networks, however, these neural networks become more developed and complex, which is necessary for classifying massive unstructured datasets. As the neural networks classify more and more data, it gains experience and can teach itself about the new data it receives.

Factors Driving Change

As mentioned, AI has been around for over half a century. However, three essential components of AI technology have seen significant growth over the past years, which has accelerated and expanded the uses of AI. First of which is computation power, which is crucial for AI to be massively scaled as machines need to be able to process data quickly and efficiently. Today's technology allows computers to run over ten trillion calculations per second.[6] On top of that, the training speed of deep neural networks has increased fifty times in the past year. Computational capacity is driving the capabilities of AI and allowing more industries to benefit from this technology.

Secondly, access to big data helps drive AI technologies. The world has seen tremendous growth in data and has created nine times more data than it had from the beginning of time up until 2015.[7] Accompanying this growth in data, is the endless storage accessible via the cloud. According to Microsoft, the cloud is a global network of servers that are connected to operate as a single ecosystem. These servers can store and manage data, run applications, deliver content, service office productivity software, and more.[8] AI goes hand in hand with the cloud and the Internet of Things (IoT) and is functionally necessary to connect devices online and make sense of all the data streaming from these IoT devices.[9] IoT is basically connecting any electronic device to the Internet or to one another. IoT involves sensors or devices, connectivity, data processing, and user interface for control.[10] The sensors or devices will collect data from its environment, such as the temperature of a room. Connectivity will send that piece of information, the data containing the temperature, via the internet to the cloud. Then, that data will be processed by software and lastly, this information is made useful to the end-user on an easy to read platform. AI plays a big role by being able to quickly gather insights from the gathered data.[11] This technology can create analytics, identify patterns, and detect anomalies in the data.

IoT is mainly consumer-facing, and the utility industry will primarily use the Industrial IoT, which is the application of connected sensors and other devices to machinery and vehicles in the transport, energy, and industrial sector.[12] Utilities are ideal for Industrial IoT because it's an asset-heavy sector that has many hazardous and remote work sites. However, compared to IoT, Industrial IoT has more at stake as its system failures and downtime can create high-risk situations that can be extremely risky. Globally, the IoT market for utilities is expected to exceed $15 billion by 2024, highlighting the fact that this technology will be an indispensable tool.[13]

Thirdly, algorithms have been key in the acceleration of AI technology. These algorithms are now better at finding patterns because they have more access to more data. Additionally, players such as Google, IBM, and Microsoft are making it easier and more accessible to develop applications with cloud service and products, such as IBM's Watson.[14] More investment in AI allows for more research and effort to be put into developing algorithms.

Now, while these advancements have helped jump-start the growth of AI, the value of the technology is not found in the algorithms or how fast the machine can process, but rather the ability of companies to harness the technology to help propel their businesses.

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Unique Value Proposition for Utilities

Utilities are at a crossroads and AI will be an essential part of the solution. The traditional models used by utilities are swiftly becoming outdated as more deregulated and complex models are taking form. Additionally, the energy industry is being shaped by decarbonization, decentralization, and digitalization. With decarbonization, more and more renewable forms of energy are shaking up utilities' energy mix and replacing older forms of energy generation, such as wind generation replacing coal. Moreover, not only are these new energy sources cleaner, but they have also become more decentralized on the power grid. Utilities have to handle more and more Distributed Energy Resources (DERs), like battery storage and solar panels and have to learn how to optimize the grid with these new forms of generation. Over the next six years, the global DER market size is predicted to reach over $570 billion by 2025 and expected to grow at a rate of 15% during that time period. With DERs drastically on the rise, AI can help utilities better manage and control the grid.

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AI will help utilities leverage the disruption of decarbonization, decentralization, and digitalization.

Lastly, digitalization allows utilities to make more sense of the vast amounts of data collected and enable interoperability between their physical assets and software via the cloud and the Industrial IoT. According to the World Economic Forum, the electricity sector will capture over $1.3 trillion of value from digitalization.[15]

AI will help utilities leverage the disruption of decarbonization, decentralization, and digitalization. In fact, Machine Learning technology is best suited for business problems where the decision or prediction to be made is complex, there is access to high quality, clean and recent data, and some margin of error is acceptable.[16] Utilities can check yes for all of these specifications. AI is crucial for managing and optimizing the increasingly complex infrastructure of power generation, grids, homes, and any connected devices. This technology helps make the grid smart and allows utilities to successfully manage the new decentralized system.

According to a Roland Berger study on European utilities, about 1 in 5 utility companies consider AI a high to medium priority for their business and more than 40% believe that the technology will enable new business models.[17] However, the same study also revealed that only 5% of utilities have a clear AI strategy and implementation roadmap defined. Utilities need to be proactive and utilize these technologies to their benefit before they fall behind to other energy providers. According to a Chief Digital Officer at General Electric, AI can help save over $200 billion globally for the energy industry.[18] General Electric is looking at how to use the technology to optimize electricity flow out of batteries to the points of consumption. One small technology change can unleash enormous savings for companies.

Additionally, IDC predicts that in 2019, 40% of digital transformation initiatives will use AI services and 75% of enterprise applications will use AI by 2025.[19] With the current market conditions, utility companies have much to gain by leveraging the massive computational power and speed with the uses of AI technology.

Human-to-Asset Interactions

AI helps develop human-to-asset interactions for utilities that aid in optimizing operations. The technology can help with asset management, routine operations, and even with dangerous field service operations. AI can help utility companies utilize data from their digital twins and run operations more smoothly. A digital twin is a virtual or digital representation of a physical product or asset and allows for utilities to view the conditions of a physical asset on a digital screen.[20] Computer systems monitor the performance of the asset and can compare it to what should be expected under those conditions. AI comes into play here by identifying anomalies and alerting the utilities when these detections are found. The technology can be used for predictive maintenance, which is when machines learn to monitor and maintain themselves, which allows utilities to avoid costly emergency repairs. Additionally, IDC predicts that by 2020, about 30% of Global 2000 companies will be using data from digital twins of IoT connected assets and will be able to achieve efficiency gains of up to 25%.[21] Also, according to Gartner, by 2021, more than half of large industrial companies will use digital twins and will gain a 10% improvement in effectiveness.[22]

This technology can also be applied to routine operations for utility companies to help with accuracy and efficiency. Natural Language Processing (NLP), another branch of AI, helps machines understand, interpret, and manipulate human language.[23] This allows humans to interact with machines as if they were interacting with another human and is extremely helpful for instances of maintenance and repairs. NLP sources data, records, logs, and returns relevant asset data while improving technician proficiency and reducing time and costs needed for repairs. The NLP software solutions global market is already quickly growing and is expected to grow from $136 million in 2016 to $5.4 billion by 2025.[24] A great example of NLP, is a Duke Energy pilot project that uses an NAO robot to help workers with substation transformer maintenance.[25] A physical robot helps assists a worker during a routine check, in the future, this application can be used without a physical robot, but with just a tablet or mobile phone. Using the NAO robot, the worker can ask the robot a question and it responds with the correct data.

The robot analyzes the worker's question and works to understand the grammar and context by cross-referencing the data with what it already knows. The robot can understand complex questions and evaluates possible meanings and determines what is exactly being asked. Next, the robot will present an answer based on supported evidence and quality of information found. Currently, Duke Energy's robot uses ChatBot technology and can only answer a question. In the future, the idea is to use CogniBot technology that allows the robot to answer the question in addition to giving intuition. For example, the robot will answer the worker's question and make a suggestion if it believes that if there is a foreseeable problem in the future for that particular asset.

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AI develops human-to-asset interactions to help optimize daily operations such as asset management and routine and field operations.

AI technology can also be leveraged with risky field service operations to keep workers safe and efficient. By implementing the use of drone technology and image recognition, AI can identify differences in images of service areas.[26] PwC valued the market of drone-powered solutions in the power and utility sector just slightly under $10 billion, and this number will continue to grow as the drone and AI technologies evolve.[27] Additionally, Navigant Research predicts that power grid companies will spend over $13 billion a year on drones and robotics globally by 2026, a huge increase from about $2 billion now.[28] For this technology to work, camera-enabled drones will conduct baseline aerial surveys of field service areas and capture these images. Later, during routine operations or during emergencies, such as after a hurricane, AI can compare the baseline images previously captures to the images recently captured. The technology can identify anything from missing electric poles to chemical spills. And it doesn't stop there, AI can also estimate the need for replacement poles and conductors from the service area and link to vendor databases to check on availability of parts, place orders, and prioritize which repairs need attention first.

This is everything that a human would have to do, but now it is done in a more safe and efficient manner.[29] RTE in France has been using drones for field service operations and recently tested a long-distance drone that was able to fly over 50 kilometers inspecting transmission lines. The drones were able to send back data that were useful to the technicians. RTE said that over the next two years it would be investing $6 million on drone technology. Additionally, the CEO of a drone maker, PrecisionHawk, stated that utilities can save as much as $180 for every mile of data capture than compared with traditional methods.[30] Not only is this technology safer, but it is also economically sound.

Optimizing Renewables

With more and more renewables being added to the grid, AI will assist utilities to optimize their energy resources, especially renewables, by matching supply and demand. According to BP's Energy Outlook, by 2040, renewables will make up over 20% of total global power generation, while hydro and nuclear will make up about 10% and 8%, respectively.[31] This global generation mix will be the most diversified the world has ever seen. Additionally, this growth in renewables is predominant in developed and developing countries, including OECD countries, China, and India.

To help manage the diverse generation risk and reduce curtailment from renewables, AI will decide the best source of energy at any given point in time. It can also manage DERs, like wind and battery storage, and connect electricity customers to their preferred energy source. Not only will the grid become more optimized, but utilities are able to create a more personalized experience for their consumers.

Additionally, AI can have the power grid lower the usage of fossil fuel generation if algorithms detect that renewable energy is producing a lot of electricity on a particularly sunny or windy day.[32] It also improves grid reliability by matching supply and demand on the grid in real time to ensure constant energy flow, no matter the energy source. Demand management is key for utilities to run the grid smoothly and to be constantly aware of any fluctuations in the supply or the demand. Moreover, predictive algorithms can decide when to store or release energy to balance the grid and estimate the production and consumption of consumers that both use and produce energy. The possibilities seem endless and AI can help make decisions and optimize the grid without utility companies having to think twice.

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By matching supply and demand, AI manages the diverse generation and reduces renewable curtailment.

Improve Reliability and Resiliency

With more than 99 million households worldwide forecasted to be powered by off-grid sources in the next two years, AI is utilities' solution to improve grid safety, reliability, and resilience.[33] AI can be applied to smart meters for behind and in front of the meter applications. A smart meter is installed outside of a household or building and transmits readings to the utility company in real time.[34] It can also automatically register and alert utility companies if there is an event of tampering or electricity theft and immediately notifies any power outages. Smart meters have been around for about 15 years; however, utilities are now starting to roll out a second generation of these smart meters that will be able to provide even more insights and help with energy efficiency. This second round of smart meters will grow to a $12.2 billion global market over the next decade, according to Transmission and Distribution World.[35] Globally, the smart meter market will top over $10 billion by 2022 with about 136 million smart meters deployed around the world.[36]

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AI can help mitigate issues by creating forecasts for electricty demand, generation, and weather, and predicting and managing fluctuations.

Behind-the-meter, which is consumer-facing, AI can connect in-home consumer devices and react to human preferences and energy price signals to maintain comfort and control cost.[37] With front-of-the-meter, which is utility facing, the technology works with the smart meter to help grids self-rely by automatically moving power around any damaged equipment to keep the power on for the customers. AI makes the grid smart and allows companies to focus on other pressing matters while the technology keeps the grid reliable.

AI can also help improve the reliability and resiliency of the grid by enhancing weather prediction and battery storage.[38] A major caveat of renewable energy is its inconsistency and its dependence on natural, uncontrollable factors. If it's a cloudy day or there is a windless afternoon, it will cut generation of renewables and can create power shortfalls. On the other side of things, too much energy can be generated and if there is no demand, that energy is wasted. AI can help mitigate these issues by creating forecasts for electricity demand, generation, and weather and predicting and managing fluctuations.[39] Machine Learning can collect and learn from past weather data and make predictions on future weather. Partnering AI weather predictions with battery storage will help alleviate renewable curtailment as well as prepare for renewable power shortfalls. Battery storage allows for excess wind and solar power to be stored for use during peak demand periods. According to Bloomberg New Energy Finance (BNEF), the global energy storage market will grow to 942 GW by 2040 and attracting over $1 trillion in investment over the next 22 years.[40] BNEF also predicts that by 2040, energy storage will make up about 7% of total global installed power capacity. If there is an excess of renewables, the technology optimizes the grid and automatically stores the excess energy in the batteries. When this energy is needed, because let's say it's a cloudy day, the AI technology will know to release the energy stored in the batteries to the grid.

Reshape Consumer Relationship
By providing individualized customer offerings and experiences, AI will reshape the relationship between the energy consumer and supplier. The energy management market will more than double to a $44 billion industry by 2020, and is a great opportunity for utilities to create customized experiences that consumers are now demanding.[41] Additionally, according to Accenture's New Energy Consumer Research report, about 71% of consumers are interested in an online personalized marketplace from their energy provider.[42] 78% of consumers would use more digital channels if offered a personalized experience across them and 92% of consumers said they would be more satisfied if their energy provider could personalize their entire customer experience. Consumers are demanding this personalization, and AI can help utilities easily create these experiences for their customers.

AI can learn customer preferences from consumers' energy usage and create an energy plan unique to that customer and target energy products for that specific customer. The technology can track the consumer's everyday energy use and learn that they run their dishwasher every night before they go to bed. AI also accounts for the fact that the customer prefers to use renewable energy sources. When wind energy is high, in the evening, AI technology can automatically use wind energy to run the customer's dishwasher – all without humans having to think about anything. Similarly, the technology can study the consumer's habits and offer targeted energy products they could be interested in – just how Netflix offers new shows you might be interested in, based off the ones you have already watched. The technology cross-references the consumer's habits with external data sets and trends to offer products – something a person could probably do, but Machine Learning can deliver a high degree of personalization and insights within a matter of seconds.

Another emerging trend that AI can help utilities with is Peer-to-Peer energy trading, as more and more prosumers, people or business that both produce and consume energy, pop up on the grid. According to Frost & Sullivan, there will be over 20 million prosumer households by 2020 in America alone.[43]

Additionally, from 2011 to 2016, the amount of energy fed into the grid by consumers has grown by over 500% per year, and this number is continuing to grow.[44] DERs are at the heart of the movement and according to Navigant Research, global DER capacity is expected to grow from 132 GW in 2017 to 528 GW in 2026.[45] AI can help optimize Peer-to-Peer energy trading by generating the best price to trade the electricity. Additionally, it can predict how much energy a home will need by mapping historical behavioral trends using the data from a consumer's appliance usage. Moreover, AI can use predictive algorithms to account for environmental factors and allow for adjusts on a cloudy day when solar panels aren't producing as much electricity.

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AI will reshape the relationship between the energy consumer and supplier by individualizing the customer offering and experience.

Lastly, AI can help utility companies with customer engagement. AI is the technology behind Chatbots and Smart Homes that give energy consumers the complete personalized experience. Many consumer-facing companies have already deployed Chatbot applications on their websites and use them to help with customer service, this should be no different for utility companies. These Chatbots use AI technology, NLP, to answer questions and assist consumers. Additionally, AI technology helps to create the Smart Home, a market that will grow to $40 billion in 2020.[46] The technology can integrate the smart home and smart grid, and consumers can manage their energy use via a mobile app. Utility companies can benefit by creating these mobile apps for consumers to use and helping link up their energy appliances to provide a unique energy solution. This more personalized experience is changing the energy industry and offering an opportunity for utilities to give customers the full personal experience they have been demanding for a while now.

Conclusion

The energy industry is rapidly changing as it faces disruption from decarbonization, decentralization, and digitalization. AI can help utilities successfully optimize the grid and maintain reliability and resiliency. Massive computational power, the growth of big data, and advanced algorithms have propelled AI technology to solve numerous problems in every industry. Particularly with utilities, AI can develop human-to-asset interactions that improve asset management, routine operations, and field service operations. Additionally, AI optimizes renewable resources on the grid and can improve reliability and resiliency. It also offers an opportunity for utilities to create a personalized customer experience.

To learn more about the implications and applications of AI in the energy industry, reach out to ABB Power Consulting today. We would be happy to further discuss this emerging technology.

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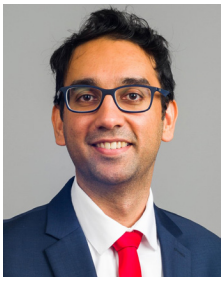

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