International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 5, July-August 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Artificial Intelligence in Smart Grid

Matthew N. O. Sadiku[1], Uwakwe C. Chukwu[2], Abayomi Ajayi-Majebi[3], Sarhan M. Musa[1]

[1]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2]Department of Engineering Technology, South Carolina State University, Orangeburg, SC, USA
[3]Department of Manufacturing Engineering, Central State University, Wilberforce, OH, USA

ABSTRACT

The smart grid is an electrical power grid that is integrated with an AI-enabled, two-way communication network providing energy and information. It is a technology that enables instantaneous feedback from various sensors and devices on the operation of the power grid. Although AI is relatively new, it is poised to revolutionize the way we produce, transmit, and consume energy. AI will constitute the brain of future smart grid. The power sector has started to use AI and related technologies for communication between smart grids, smart meters, and Internet of things devices. This paper presents some applications of AI in smart grid.

KEYWORDS: *smart grid, artificial intelligence, artificial intelligence in smart grid*

How to cite this paper: Matthew N. O. Sadiku | Uwakwe C. Chukwu | Abayomi Ajayi-Majebi | Sarhan M. Musa "Artificial Intelligence in Smart Grid" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-5, August 2022, pp.770-775, URL: www.ijtsrd.com/papers/ijtsrd50563.pdf

IJTSRD50563

Copyright © 2022 by author (s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (http://creativecommons.org/licenses/by/4.0)

IJTSRD International Journal of Trend in Scientific Research and Development ISSN: 2456-6470

INTRODUCTION

We all depend on energy to do things. Electricity has been one of the most important and the most widely used forms of energy since the 19th century. The electric power has changed our society. The electric industry essentially consists of three primary functional areas: generation, transmission, and distribution. This entire structure is popularly known as the "grid." Thus, the power grid is a dynamic power system that delivers electric power from a generation system through transmission and distribution systems to end-users. The concept of smart grid is shown in Figure 1 [1].

The power infrastructure consists of a vast network of power plants, transmission lines, and distribution centers (comprising roughly 5,800 power plants and over 2.7 million miles of power lines). This deteriorating structure supports one-way power flow from centralized generation to end customers and is yet to receive a modern overhaul [2]. The energy sector worldwide faces some challenges related to rising demand of increasing global population, integration with various distributed components, efficiency, changing supply and demand patterns. These challenges are more acute in developing nations.

The word "smart" in smart grid refers to the notion of a power grid with intelligence. The main objective of the smart grid is to bring reliability, flexibility, efficiency, and robustness to the power system. Smart grid does this by introducing two-way data communications into the power grid. Thus, the smart grid consists of the power infrastructure and communication infrastructure, which correspond to the flow of power and information respectively [3]. For efficiency, a smart grid infrastructure should also include distributed generation and AI.

OVERVIEW ON ARTIFICIAL INTELLIGENCE

The term "artificial intelligence" (AI) was first used at a Dartmouth College conference in 1956. AI is now one of the most important global issues of the 21st century. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence, e.g. visual perception,

speech recognition, decision-making, and language translation. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform activities that would typically be performed by a human being. Without being taught by humans, machines use their own experience to solve a problem.

AI is stand-alone independent electronic entity that functions much like human expert. Today, AI is integrated into our daily lives in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driverless cars, companion robots, etc. AI is not a single technology but a range of computational models and algorithms.

Some forms of AI that are most commonly used in electrical and computer engineering include the following [4,5]:

- **Expert systems***:* They solve problems with an inference engine that draws from a knowledge base equipped with information about a specialized domain, mainly in the form of if-then rules. Expert systems are the earliest and most extensive, the most active and most fruitful area.
- **Fuzzy logic:** This makes it possible to create rules for how machines respond to inputs that account for a continuum of possible conditions, rather than straightforward binary.
- **Neural networks:** These are specific types of machine learning systems that consist of artificial synapses designed to imitate the structure and function of brains. They are similar to the human brain. They are made up of artificial neurons, take in multiple inputs, and produce a single output. The network observes and learns as the synapses transmit data to one another, processing information as it passes through multiple layers.
- **Machine learning:** This includes a broad range of algorithms and statistical models that make it possible for systems to find patterns, draw inferences, and learn to perform tasks without specific instructions. Machine learning is a process that involves the application of AI to automatically perform a specific task without explicitly programming it. ML techniques may result in data insights that increase production efficiency. Today, artificial intelligence is narrow and mainly based on machine learning.
- **Deep learning:** This is a form of machine learning based on artificial neural networks. Deep learning architectures are able to process hierarchies of increasingly abstract features, making them especially useful for purposes like speech and image recognition and natural language processing. Deep learning networks can deal with complex non-linear problems.
- **Natural Language Processors:** For AI to be useful to us humans, it needs to be able to communicate with us in our language. Computer programs can translate or interpret language as it is spoken by normal people.
- **Robots:** These are computer-based programmable machines that have physical manipulators and sensors. Sensors can monitor temperature, humidity, pressure, time, record data, and make critical decisions in some cases. Robots have moved from science fiction to your local hospital. In jobs with repetitive and monotonous functions they might even completely replace humans. Robotics and autonomous systems are regarded as the fourth industrial revolution.

These AI tools are illustrated in Figure 2 [6]. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. AI systems are designed to make decisions using real-time data. They have the ability to learn and adapt as they make decisions.

AI IN SMART GRID

Like other industries, the power sector has been inundated by AI-enabled technologies. To support the existing systems and to extend the flexibility and applicability of smart grids, AI has been naturally adapted. As a result, large regional grids will be replaced by microgrids that manage local energy demand.

Researchers at Argonne National Laboratory (the first US national laboratory) are developing new ways to extract insights from the massive data on the electric grid, with the intent of ensuring greater reliability, resilience, and efficiency. They are working on optimization models that use machine learning, to simulate the electric system and the severity of various problems [7].

Some of the adapted AI techniques in the smart grid include [8]:

- Managing the grid users and controllers
- System based operation strategies for the grid
- Power supply optimization
- Consensus-based intelligent distribution techniques
- Machine learning and deep learning enabled costing mechanisms

- Intelligent energy storage systems
- Intelligent voltage profile regulation techniques using smart algorithms
- Integrating privacy into the smart grid.

APPLICATIONS OF AI IN SMART GRID

Artificial Intelligence is everywhere. It is the fastest growing branch of the high-tech industry. AI's vast potential has motivated several initiatives by utilities, government agencies, and academia. The US Department of Energy (DOE) recently established a new Artificial Intelligence and Technology Office (AITO) to coordinate the agency's AI development, delivery, and adoption [6]. In September 2017, the DOE funded researchers at Stanford University to use artificial intelligence to improve grid stability. The UK's National Grid collaborated with DeepMind to add AI technology to the country's electricity system. The German government sees AI as a key strategy for mastering some of our greatest challenges such as climate change and pollution.

AI is becoming more and more important in the energy industry. Typical areas of application are autonomous grids, smart meters, energy consumption, electricity trading, failure management, and energy storage. These applications are discussed as follows [9-11].

- **Autonomous Grid:** In the US, the DOE is developing an autonomous grid using AI. With the power grids now collecting energy from different sources and the increasing decentralization of the grids, operating the grids has become more complex. This requires analyzing massive data. Artificial Intelligence helps process this data as quickly and efficiently as possible, thereby bringing stability and efficiency.
- **Smart Meters:** A smart meter is a high-tech meter that measures electricity consumption and provides additional information to the utility company unlike the conventional, analog meter. Smart meters (SMs) are essentially digital meters that read remotely over a secure wireless network. They are an important component of the smart grid system. They will be able to constantly monitor demand and supply of customers. These smart meters process information that can be related to a person and be privacy sensitive. With smart metering, one can monitor every appliance, providing the homeowner with a comprehensive picture of their energy usage [12].
- **Energy Consumption:** In addition to making the power grid smart, flexible, and autonomous, AI algorithms help utilities and energy companies understand and optimize user's behavior and manage energy consumption. In a smart networked home, the networked devices react to prices on the electricity market and adapt to household usage accordingly. By monitoring the energy consumption pattern of individuals and businesses, AI companies can offer solutions to optimize usage, save electricity, and reduce costs. For example, SmartTthermostat Nest adapts temperatures according to user behavior to reduce energy consumption.
- **Electricity Trading:** In electricity trading, AI helps improve forecasts**.** Machine Learning and Neural Networks play an important role in improving forecasts in the energy industry. *Failure management*: Without regular checks on power equipment, equipment failures are common. Using AI to observe equipment and detect failures before they happen can save money, time, and lives.
- **Energy Storage:** The Smart grid with energy storage will continuously collect massive data to make timely decisions on how best to allocate energy resources. Combined with other technologies such as big data, the cloud and the Internet of things (IoT), energy storage with AI can play an important role in power grid management. A smart grid with energy storage is able to use energy sources in the most efficient way by better integrating renewable resources.

These applications are simply a taste of what is ultimately possible. There are many more applications of AI in smart grid or energy industry such as energy management, managing electric vehicles, network planning, fraud detection, load forecasting, stability analysis, security assessment, stability assessment, fault diagnosis, fault prediction**,** and stability control in smart grids. Figure 3 shows some of the applications of AI in energy industry [10].

BENEFITS

The application of AI-based technologies to the power grid cuts energy waste, facilitates the use of clean and renewable energy sources, and improve the planning, operation, and control of the power systems. The technologies can also help improve power management, efficiency, stability. resilience. and transparency, and increase the use of renewable energy sources. Smart grid facilitates large amounts of renewable energy integration.

A major benefit of AI is the ability for the customers and the grid to be connected directly, creating win-win situation. The price of solar has come down

recently years to bolster the cost-effectiveness of renewables. This can lead to a more efficient market and more cost-effective electricity production. It is realistic to expect the smart grid system to lower electricity bills and prevent catastrophic blackouts. AI can help use less energy to accomplish more. It is also helping compress and analyze the massive amounts of data produced by energy industry. To curb data access by private companies, the European Union (EU) Commission has developed four basic ethical principles for AIs: AI should respect human autonomy, avoid social harm, be fair, and be explainable.

CHALLENGES

Smart grid faces a wide range of challenges, such as extreme weather, imperfections in the available infrastructure, reliability issues, equipment failures, gigantic customer base, decentralized generation, and decarbonizing the global economy. A major challenge is the rise of distributed generation, where individual customers generate and use their own electricity from renewable sources, such as wind and solar. The current power system was not designed to accommodate this diversification in energy sources and fluctuating supplies of renewable energy. Industry leaders in the AI energy grid industry are aware of these challenges and must address them. The use of AI in smart grid is not without risks. One risk has to do with the privacy of customer data collected by AI systems.

THE FUTURE OF AI IN SMART GRID

Artificial intelligence holds significant potential across a wide array of sectors. It is expanding its scope over tasks traditionally performed by humans. Its applications in the energy industry are helping to make the grid "smarter" or more responsive, thereby develop the smart grid of the future. AI has been regarded as the brain behind the future smart grid, enabling the real-time optimization and automation of distribution planning and operation decision. The smart grid is a dynamic system that continues to evolve as technologies are tested and perfected [13].

Although the use of AI in the smart grid faces some challenges such as insufficient reliability, imperfect infrastructure, and lack of special algorithm for power industry, AI is a powerful tool to push smart grid into the new generation of power systems. AI supports and optimizes electric networks around the world, pushing the concept closer towards a global adoption. It should be added to all levels in the energy grids, in order to enhance their development.

Although the smart is not quite here yet, it is slowly becoming a reality. It is on its way to usher the energy industry into a new era of reliability, availability, and efficiency. Significant investments in the infrastructure will be needed to help smart grids fully take off [14].

New generation of energy networks will make efficient use of renewable energy sources, support real time and efficient demand response, as well as the large-scale deployment of electric vehicles (EVs) [15]. To provide a low-cost and flexible solution for the grid-wide information exchange, wireless communications technology is expected to play the key role in the emerging smart grid applications.

CONCLUSION

The smart grid is the developmental trend of power systems. It has attracted much attention all over the world. It provides a platform for clean, sustainable, efficient and reliable energy generation, delivery, and consumption. It is inevitable that the smart grid will become part of our society. The global energy demand is expected to increase steadily in the future. Therefore, future generations should realize that AI and energy are not mutually exclusive career paths. For more information about artificial intelligence in agriculture, one should consult the books in [16,17].

REFERENCES

[1] V. Robu, " Why artificial intelligence could be key to future-proofing the grid," https://robohub.org/why-artificial-intelligence-could-be-key-to-future-proofing-the-grid/

[2] F. Wolfe, "How artificial intelligence will revolutionize the energy industry," http://sitn.hms.harvard.edu/flash/2017/artificial-intelligence-will-revolutionize-energy-industry/

[3] M.N.O. Sadiku, and S.M. Musa and S. R. Nelatury, "Smart grid – An introduction," *International Journal of Electrical Engineering & Technology,* vol. 7, no.1, Jan-Feb, 2016, pp. 45-49.

[4] M. N. O. Sadiku, Y. Zhou, and S. M. Musa, "Natural language processing in healthcare," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 8, no. 5, May 2018, pp. 39-42.

[5] "Applications of AI and machine learning in electrical and computer engineering," July, 2020, https://online.egr.msu.edu/articles/ai-machine-learning-electrical-computer-engineeringapplications/#:~:text=Machine%20learning%20and%20electrical%20engineering,can%20%E2%80%9Csee%E2%80%9D%20the%20environment.

[6] "Hype and hope: Artificial intelligence's role in the power sector," February 2020,

https://www.powermag.com/hype-and-hope-artificial-intelligences-role-in-the-power-sector/

[7] C. Nunez, "Artificial intelligence can make the U.S. electric grid smarter," June 2019, https://www.tdworld.com/grid-innovations/smartgrid/article/20972769/artificial-intelligence-can-make-the-us-electric-grid-smarter

[8] V. Sooriarachchi, "Prospect of adapting artificial intelligence in smart grids for developing countries," https://smartgrid.ieee.org/newsletters/november-2020/prospect-of-adapting-artificial-intelligence-in-smart-grids-for-developing-countries

[9] "5 Ways the energy industry is using artificial intelligence," March 2018, https://www.cbinsights.com/research/artificial-intelligence-energy-industry/

[10] "What is artificial intelligence in the energy industry?" https://www.next-kraftwerke.com/knowledge/artificial-intelligence

[11] S. Bilodeau, "Artificial intelligence in a 'no choice but to get it smart' energy industry!" April 2019, https://towardsdatascience.com/artificial-intelligence-in-a-no-choice-but-to-get-it-smart-energy-industry-1bd1396a87f8

[12] M. N. O. Sadiku, S.M. Musa, A. Omotoso, and A.E. Shadare, "A primer on smart meters," *International Journal of Trend in Research and Development,* vol. 5, no. 4, 2018, pp. 65-67.

[13] C. Frye, "4 Ways artificial intelligence is powering the energy industry," November 2018, https://www.kolabtree.com/blog/4-ways-artificial-intelligence-is-powering-the-energy-industry/

[14] M. Sulikowski, "Smart grid - AI at the service of the power distribution network," June 2019, https://naturaily.com/blog/smart-grid-ai-in-power-distribution-network#:~:text=The%20term%20%E2%80%9Csmart%20grid%E2%80%9D%20describes,faster%20restoration%20after%20power%20blackouts.

[15] N. Bassiliades and G. Chalkiadakis, "Artificial intelligence techniques for the smart grid," *Advances in Building Energy Research*, vol. 12, no. 1, 2018, pp. 1-2,

[16] L.. A. Kumar, L. S. Jayashree, and R. Manimegalai (eds.), *Proceedings of International Conference on Artificial Intelligence, Smart Grid and Smart City Applications.* Springer, 2020.

[17] S. F. Bush, *Smart Grid: Communication-Enabled Intelligence For The Electric Power Grid.* John Wiley & Sons, 2014.

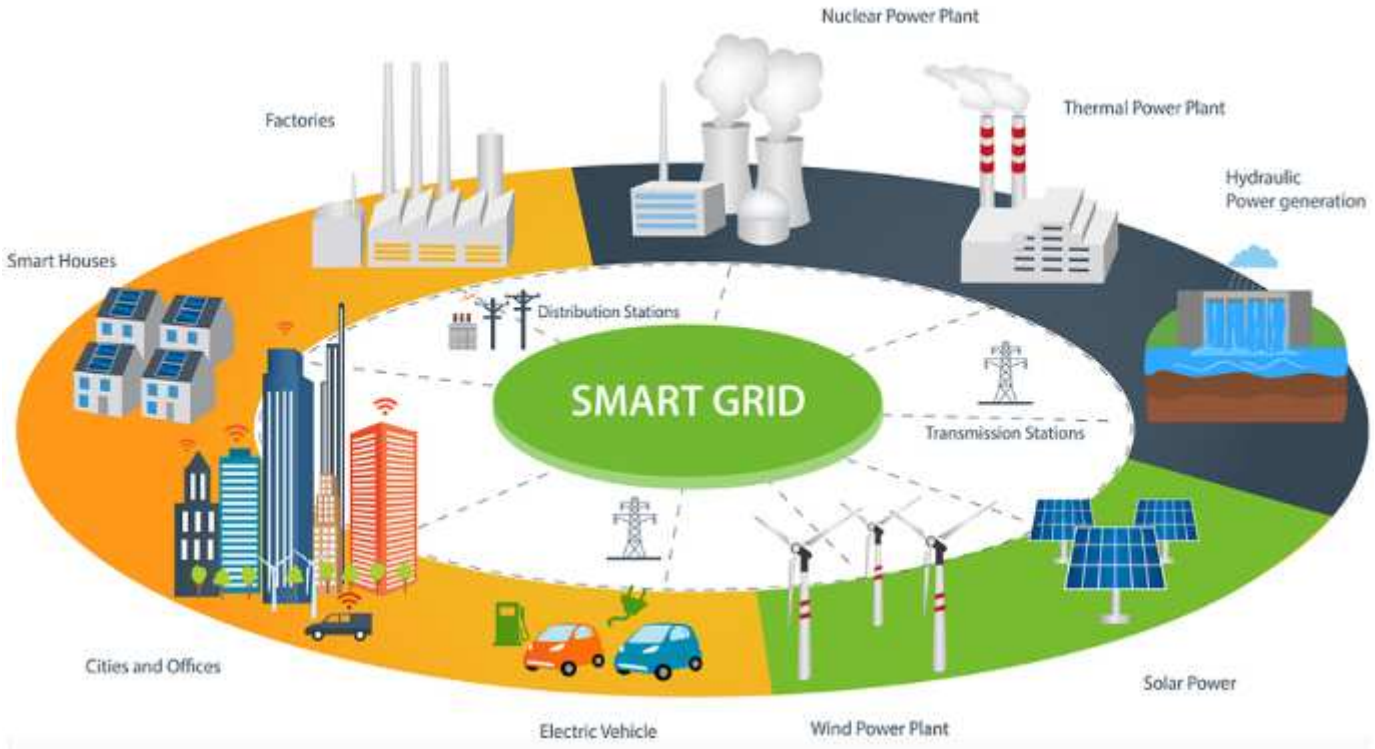

Figure 1 The concept of smart grid [1].

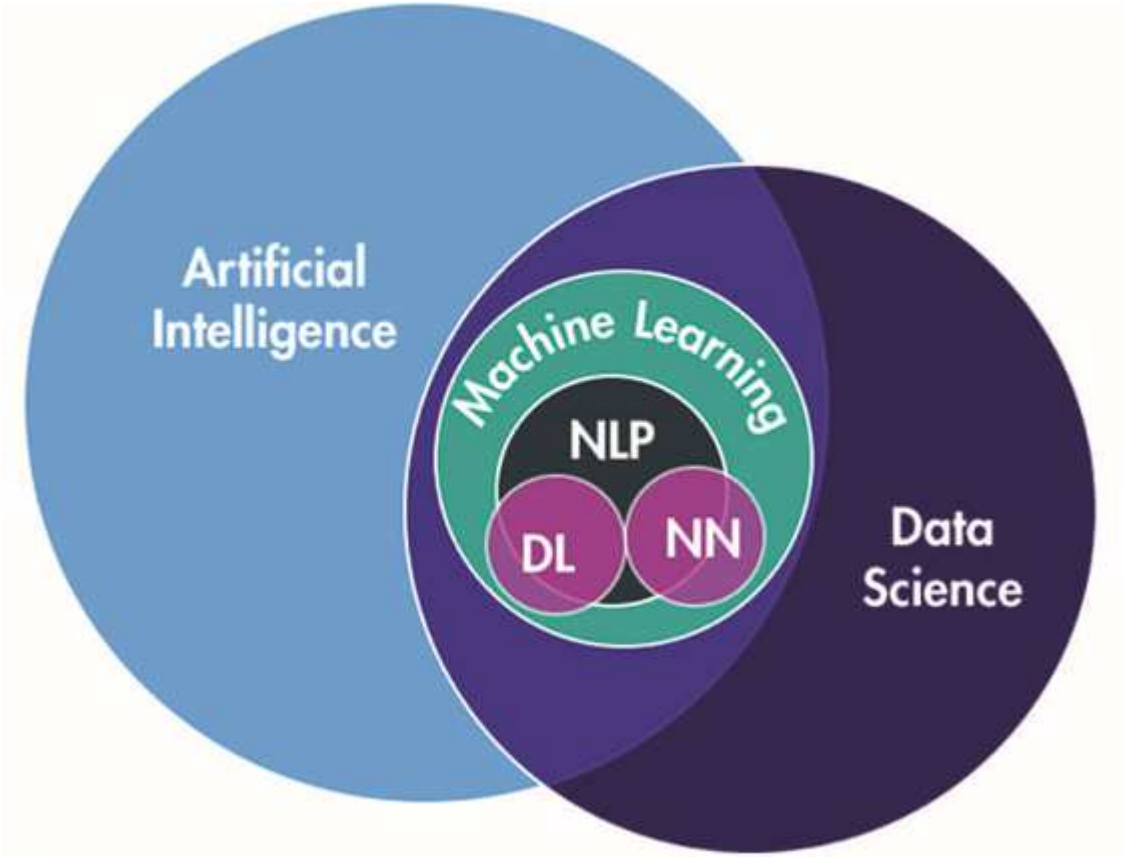

Figure 2 Artificial intelligence (AI) encapsulates several concepts including natural language processing (NLP), deep learning (DL), and neural networks (NN) [6].

Figure 3 Some applications of AI in energy industry [10]