ISBN: 978-93-6773-128-4

CHAPTER 9

THE ROLE OF ARTIFICIAL INTELLIGENCE (AI) AND MACHINE LEARNING IN RENEWABLE ENERGY

DR.AKHILESH
ASSISTANT PROFESSOR, LUCKNOW PUBLIC COLLEGE OF PROFESSIONAL STUDIES

DR. AARTI RANI
ASSISTANT PROFESSOR, LUCKNOW PUBLIC COLLEGE OF PROFESSIONAL STUDIES

KEYWORDS

ARTIFICIAL INTELLIGENCE, MACHINE LEARNING (ML), RENEWABLE ENERGY, ENERGY FORECASTING, SMART GRIDS, ENERGY OPTIMIZATION, ENERGY STORAGE SYSTEMS.

ABSTRACT

The reconciliation of man-made brainpower (computer based intelligence) and AI (ML) into environmentally friendly power frameworks has altered how energy is produced, made due, and consumed. Man-made intelligence and ML advances offer imaginative answers for enhance the presentation, unwavering quality, and proficiency of environmentally friendly power sources, for example, sun oriented, wind, and hydropower. These innovations empower precise guidance of energy creation and request, dynamic lattice the board, prescient support of hardware, and further developed energy capacity frameworks. By utilizing progressed calculations, artificial intelligence and ML add to limiting energy squander, decreasing expenses, and upgrading the adaptability of sustainable power projects. Besides, they assume a urgent part in coordinating decentralized energy assets into shrewd frameworks, working with a progress to more feasible energy frameworks. This book section investigates the extraordinary effect of simulated intelligence and ML in tending to the difficulties of environmentally friendly power organization and features their capability to drive worldwide

endeavours toward a greener, more reasonable future.

9.1 INTRODUCTION

The worldwide energy scene is going through a huge change driven by the pressing need to relieve environmental change, lessen ozone depleting substance discharges, and progress toward reasonable energy frameworks. Environmentally friendly power sources, for example, sunlight based, wind, and hydropower have arisen as reasonable options in contrast to petroleum products, offering spotless, plentiful, and progressively cost-serious arrangements. Notwithstanding, the reception and versatility of environmentally friendly power face a few difficulties, remembering inconstancy for energy creation, incorporation with existing power matrices, and the productive administration of energy assets. These issues request inventive ways to deal with guarantee the dependable, effective, and monetarily reasonable utilization of environmentally friendly power frameworks. Computer based intelligence and ML have arisen as extraordinary advancements equipped for tending to these difficulties. By bridling the force of information driven bits of knowledge, high level calculations, and computerization, man-made intelligence and ML empower critical enhancements in the productivity and dependability of environmentally friendly power frameworks. These advances can anticipate energy creation in light of atmospheric conditions, upgrade energy dispersion, and work with ongoing decision-production for network the executives. Besides, simulated intelligence driven prescient upkeep lessens personal time and broadens the functional life expectancy of sustainable power framework, while ML-based improvement upgrades the exhibition of energy stockpiling frameworks, guaranteeing a consistent inventory in any event, during times of low creation.

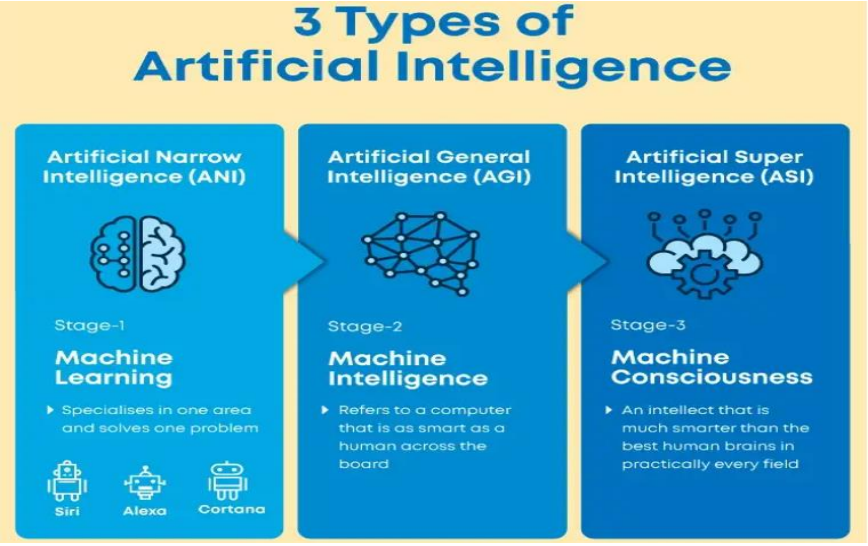
The combination of simulated intelligence and ML into environmentally friendly power frameworks has likewise opened roads for decentralization, empowering the advancement of brilliant networks that can integrate different energy sources and progressively answer changing interest designs. These capacities are basic for accomplishing energy value, lessening waste, and changing to a practical energy future. Also, computer based intelligence and ML are urgent in empowering the plan of imaginative energy arrangements, for example, virtual power plants and independent energy exchanging stages, which further speed up the reception of sustainable advancements. This book chapter digs into the diverse job of simulated intelligence and ML in progressing sustainable power, investigating their applications across anticipating, framework the board, energy capacity, and prescient support. It features the extraordinary effect of these innovations on

defeating customary boundaries and driving the broad reception of sustainable power. By looking at the open doors and difficulties related with artificial intelligence and ML in environmentally friendly power, this study expects to highlight their capability to reshape the energy area and add to a feasible future.

9.1.1 ARTIFICIAL INTELLIGENCE

Simulated intelligence is the method involved with transforming computerized PCs into utilitarian robots that can do both physical and non-actual undertakings. They can execute any appointed errand and make decisions in view of the data sources that are given to them on account of how they are planned. Since it acts and takes on a similar mindset as an individual, it has become very famous from one side of the planet to the other. Man-made brainpower can decidedly influence our lives and has the ability to modify the manner in which we currently live. Computer based intelligence endeavors to assemble machines that are equipped for thinking, learning, critical thinking, and language perception by recreating human insight. The standards of picking up, thinking, critical thinking, discernment, and language use are the groundwork of man-made brainpower. Artificial intelligence has gone through patterns of improvement, with current advances in transformer engineering and profound getting the hang of adding to a flood in the field, especially in the US.

Fig. 9.1 TYPES OF ARTIFICIAL INTELLIGENCE

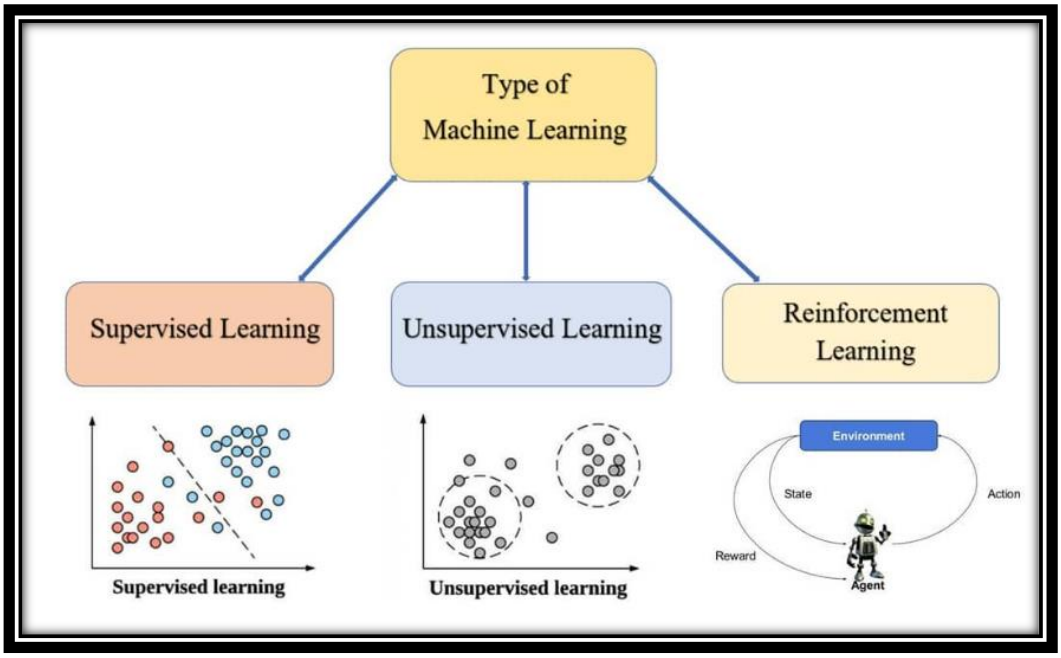


SOURCE: https://www.fossguru.com/types-of-ai-different-types-of-artificial-intelligence-systems/

9.1.2 MACHINE LEARNING

A subfield of artificial intelligence called machine learning gives algorithms the ability to find hidden patterns in datasets so they can anticipate outcomes on fresh, comparable data without needing to be explicitly programmed for every assignment. Conventional machine learning generates actionable insights by predicting outcomes using data and statistical tools. Applications using this technique can be found in a variety of domains, including recommendation systems, fraud detection, portfolio optimization, natural language processing, picture and speech recognition, and job automation.

Fig. 9.2: TYPES OF MACHINE LEARNING



SOURCE: Top 9 Essential Concept Of Supervised Learning That Will Surely Make You An Expert Instantly - InfinityCodeX

9.1.3 RENEWABLE ENERGY

One of the key components for the nation's economic growth is energy. A renewable energy source is any sustainable energy source derived from the environment. A clean substitute for fossil fuels, renewable energy is endless. Energy derived from natural processes that is constantly renewed is known as renewable energy. Geothermal heat, biomass, wind, water, sunlight, and tides are a few examples of renewable energy. Energy from renewable resources is utilized in

five key areas: transportation, electricity generation, the rural sector, and air and water cooling and heating.

FIG. 9.3: RENEWABLE ENERGY

9.2 ROLE OF AI AND ML IN RENEWABLE ENERGY

Our everyday lives depend on energy. Numerous issues are brought on by the continuous rise in global electricity consumption, which is correlated with both economic and population expansion. First of all, there is tremendous demand on the global energy industries to provide electricity in a secure and dependable manner. Furthermore, power networks may suffer from widespread grid-connected renewable energy power generation. By 2050, many countries hope to rely solely on renewable energy. The assessment and analysis of renewable energy's contribution to the attainment of sustainable development goals is inadequate, given the recent and swift growth in the usage of RE in the global energy mix and its progressive influence on the global energy sector. Wind power might be renewable. For supply-and-demand problems in smart grids, wind power forecasting is essential. One of the main problems with wind energy is that it fluctuates a lot and is intermittent, which makes forecasting challenging [1].

Sustainable power frameworks (RES) are progressively being coordinated into current power lattices because of the worldwide shift toward economical energy sources. A potential way to deal with improving these frameworks' viability, steadfastness, and financial plausibility is the helpful utilization of computerized reasoning (simulated intelligence) methods. Utilizing man-made brainpower

(computer based intelligence) approaches has made environmentally friendly power frameworks (RES) more trustworthy, productive, and practical. A developing corpus of exploration has inspected how artificial intelligence driven improvement methods could change RES in various routes lately, from asset assessment to framework upkeep and operation [2].

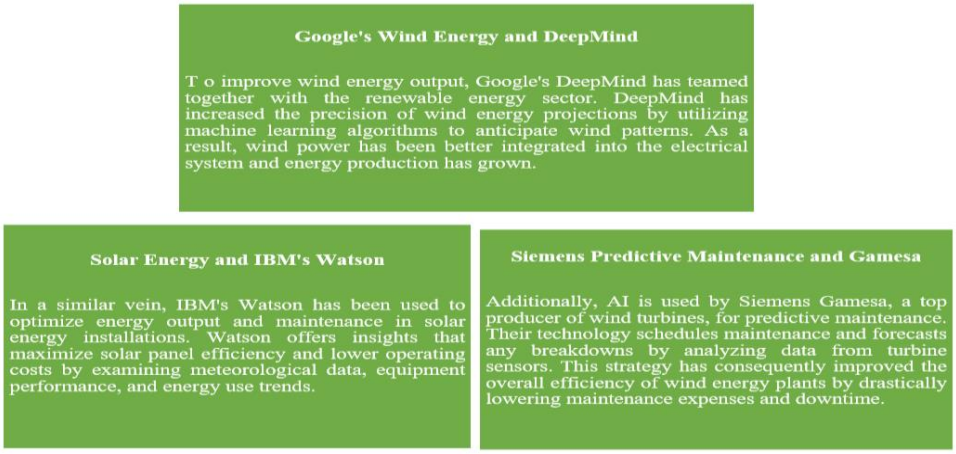
The use of AI and ML to environmentally friendly power frameworks is changing reasonable energy arrangements. Imaginative improvements in the energy area are being worked with by these advancements, which are additionally working on the steadfastness and proficiency of environmentally friendly power sources. Consequently, this part looks at how computer based intelligence and ML are reforming environmentally friendly power frameworks, impelling a future where reasonable energy is more trustworthy, proficient, and open. There are a few significant jobs of AI and ML in Sustainable power Frameworks.

Enhancing Energy Generation	In environmentally friendly power frameworks, simulated intelligence and ML calculations are totally changing the way that we boost and control energy creation. These advances offer huge experiences through the investigation of enormous volumes of information from different sources, like verifiable energy creation, weather conditions patterns, and constant sensor information. To further develop arranging and energy framework the board, prescient examination, for instance, can conjecture wind speeds and sun powered irradiance. The presentation of sunlight powered chargers, wind turbines, and other sustainable power sources is consequently significantly upgraded.
Improving the Stability of the Grid	Wind and sun oriented power are discontinuous, making it hard to keep up with framework dependability in sustainable power frameworks. Computer based intelligence controlled arrangements help by determining changes in the organic market for energy. To find patterns and irregularities, AI models inspect past information. Network administrators can now make a precaution remedial move subsequently. Thusly, it keeps a consistent energy supply, brings down the opportunity of power outages, and balances the market interest for energy.
Maintenance	For sustainable power frameworks, prescient upkeep depends

Prediction	intensely on artificial intelligence and ML. These advances recognize mileage or potential breakdowns before they occur by assessing information from sensors put in gadgets like sunlight powered chargers and wind turbines. Prescient support, accordingly, brings down fix costs and personal time by arranging upkeep assignments just when required. Thus, this delays the existence of apparatus and ensures continuous energy age.
Management of Energy Storage	Dealing with the unconventionality of sustainable power sources requires proficient energy stockpiling. By expecting energy interest and changing stockpiling levels suitably, man-made intelligence and ML calculations assume a key part in energy capacity framework enhancement. Man-made intelligence can, for instance, choose when putting away additional energy and delivery it when request is high is generally effective. This lessens reliance on petroleum products and works on the general execution of environmentally friendly power frameworks by really taking advantage of put away energy.
Systems for Intelligent Energy Management	How energy is utilized in homes and organizations is changing thanks to artificial intelligence controlled shrewd energy the executives advances. These frameworks further develop energy use by examining utilization patterns and utilizing AI calculations in view of ongoing information and client inclinations. For example, savvy lighting and indoor regulator settings can be changed to streamline energy economy without forfeiting solace. Through the joining of these frameworks with environmentally friendly power sources, buyers can additionally bring down their energy costs and carbon influence [3].

TABLE 9.1: ROLES OF AI AND ML IN RENEWABLE ENERGY SYSTEMS

FIG. 9.4 AI AND ML CASE STUDIES IN RENEWABLE ENERGY SYSTEMS



9.3 LITERATURE REVIEW

The creation and creation of sustainable power could go through an extreme change with the utilization of man-made consciousness (simulated intelligence). From site choice and plan through activity and upkeep, man-made reasoning (man-made intelligence) can be applied at many places in the sustainable power process. Engineers of environmentally friendly power tasks can augment the result and effectiveness of their ventures by using artificial intelligence calculations, which will further develop energy creation and set aside cash. Moreover, simulated intelligence can further develop energy capacity frameworks, gauge and decrease hardware breakdowns, and work with the matrix's joining of environmentally friendly power sources. Indeed, even with computer based intelligence's brilliant future in the improvement of environmentally friendly power, there are still hindrances to survive, like an absence of information, mechanical expertise, and lawful limitations [4].

A vital strategy in the worldwide work to create some distance from petroleum derivatives and toward more supportable energy sources is the utilization of AI (ML) and man-made consciousness (artificial intelligence) into environmentally friendly power frameworks. Environmentally friendly power is changing because of the consolidation of simulated intelligence and ML, which presents new opportunities for manageability and effectiveness.

Anticipating organic market is turning out to be more hard for matrix administrators because of the development of discontinuous wellsprings of energy like sun based and wind. The manner in which we saddle and utilize environmentally friendly power sources like sun based and wind is changing because of man-made intelligence and ML's ability to further develop maintainability and proficiency. A significant strategy for boosting environmentally friendly power frameworks is man-made intelligence fueled prescient upkeep. Artificial intelligence frameworks can guess when support is expected by following the condition of gadgets like sunlight based chargers and wind turbines. This assists with dragging out the life expectancy of environmentally friendly power energy resources and forestall spontaneous disappointments. This proactive technique brings down support costs and margin time, upgrading the general toughness of sustainable power frameworks [5].

Author and Year	Contribution
Singh, V., et al (2025)	The purpose of this study is to provide an overview of RE's sources, technology, and applications. This chapter describes the historical growth of different RESs, as well as their environmental and climate change-related benefits and drawbacks. This chapter suggests important actions for the best use of the sophisticated RES approaches [6].
Malkova, Y. (2025).	The authors of this study concentrated on distinguishing between sustainable and renewable power, emphasizing the former's ability to be used for an extended period of time without depleting resources. Innovation in technology, energy independence, and job development are some of the financial and environmental advantages of sustainable power [7].
Hamid, H., et al (2025)	The future of artificial intelligence (AI) and computer vision (CV) is examined in this chapter. The author reviewed recent advancements and opportunities for the use of renewable energy systems to improve their efficacy, reliability, and durability. The integration of AI and CV is critical to the future of renewable energy, since it has the ability to drastically change the field's research, development, and application. The performance and reliability of renewable energy systems can be enhanced with better monitoring, optimization, and prediction analytics made possible by contemporary technologies like artificial intelligence (AI) and CV [8].
Oral, B., et al (2025)	The author covered the use of machine learning (ML) to energy production and storage, energy forecasting and planning, and our viewpoint on the prospects and difficulties for ML's future. While there are significant obstacles to both sustainable energy supply (such as the conflict between urgent energy needs and global warming) and ML applications (such as high energy consumption in ML applications and the risk of increasing inequality among people and nations), ML has the potential to significantly contribute to sustainable energy efforts and, consequently, to the achievement of SDGs through data collection through monitoring and remote sensing, global effort planning, and the enhancement of new and more sustainable

	energy technologies[9].
Sapre, I. (2024).	Using the VOSviewer software, this study examines and reviews the application of AI and machine learning in the energy sector and suggests exciting but understudied applications for these ideas [10].
Manuel, H. N. N., et al (2024).	The revolutionary possibilities for AI in energy efficiency and its crucial role in influencing the direction of environmentally friendly building methods are highlighted in this study [11].
Ukoba, K., et al (2024).	AI-driven solutions will be included into decentralized energy systems, smart grids, and autonomous energy management systems, according to the report. Important new information about the state of AI applications in RES is provided by this inquiry [12].
Tewary, A., et al (2023).	Author present a comprehensive analysis of these computing tools in this study, along with how their integration can effectively improve our renewable energy systems and give us a strong foundation for sustainable energy management. We have also discussed the advantages and disadvantages of these contemporary methods as well as certain uses for each in the field of renewable energy [13].
Mehta, Y., et al (2023).	In this research, the precision degree of machine learning algorithms over different time periods are highlighted. This study examines the ML algorithms by outlining the process of selecting the right parameters for input for weather, locations, and complexity. Metrics like mean square error (MSE), mean absolute error (MAE), mean percentage error (MPE), and root mean square error (RMSE) are taken into consideration when adjusting the algorithm performance parameters. In most situations, the long short-term memory functioned well, according to the review's performance and findings [14].
Benti, N. E., et al (2023).	The strengths and limitations of the many models and methodologies that have been employed for projecting renewable energy are reviewed in this research. It also draws attention to the difficulties and potential avenues for future study in the area, including models' interpretability, data accessibility, and coping with the unpredictability and variable of renewable energy supply. This research article aims to

	highlight the significance of creating reliable and accurate forecasting models for renewable energy in order to promote the integration of renewable energy sources (RES) into the electrical grid and the shift to sustainable energy [15].
Rangel-Martinez, D.et al (2021)	Researchers examined the state-of-the-art in machine learning applications in manufacturing sectors that significantly affect sustainability and the environment in this paper. These sectors include smart grids, the catalysis industry, power storage and distribution, and renewable energies (solar, wind, hydropower, and biomass). The most popular methods above other machine learning algorithms are artificial neural networks due to their capacity for generalization. In the upcoming years, there will be a significant increase in demand for machine learning (ML) approaches in the energy sector due to the increased demand for academic programs connected to AI in science, math, and engineering [16].

TABLE 9.2: AUTHORS CONTRIBUTION TABLE

A few months back, two researchers from 'Thapar Institute of Engineering and Technology', India made an AI that examines solar panels at high speed and low-cost. The gadget significantly lowers the cost of energy production through improved solar power forecasting models by using machine learning and clustering-based computation for a quick inspection procedure [17].

India is generally perceived for its reception of sustainable power and its aggressive organization objectives. India's introduced breeze and sunlight based power limit are more than 35 gigawatts (GW) and 25 GW, separately, representing 60 GW of the country's 75 GW environmentally friendly power limit. In the impending years, India needs to gain significantly more headway, with an objective of 175 GW of environmentally friendly power in the electric power industry by 2022. Besides, focal government delegates as of late expressed at a meeting of the Worldwide Sustainable power Organization that the public authority needs to expand its expectation to convey 500 GW of environmentally friendly power by 2030.Artificial insight (man-made intelligence) is one innovation that India could use to build the productivity of current sun based and wind power sources and make the reception of renewables more reasonable, as indicated by a Public System for Man-made brainpower distributed by the Public Establishment for Changing

India (NITI Aayog), the public authority of India's true strategy think tank. It isn't sufficient to fault man-made intelligence for the future; to limit the decrease of environmentally friendly power and advance the productivity of the inexhaustible sources they expect to create, Indian state run administrations should start making the establishment for simulated intelligence today. Better prescient electrical network load the board and upkeep for sustainable sources can be accomplished with AI, permitting states to further develop their general energy security [18].

Microsoft says it will invest $3 billion over two years in cloud and AI infrastructure in India to boost innovation, skill development, and AI adoption.

Satya Nadella, the chairman and CEO of Microsoft, announced a US $3 billion investment in cloud and AI infrastructure in India over the next two years while on stage at the Microsoft AI Tour in Bengaluru.

Microsoft reaffirmed its commitment to working with India as it transitions to an AI-first country by revealing a detailed strategy to train and skill 10 million people by 2030.

In an innovative move to speed up the transfer from research to practical, business-useful solutions, Microsoft Research Lab established an AI Innovation Network.

Additionally, with the goal of influencing over 5,000 businesses and 10,000 entrepreneurs, Microsoft and SaaSBoomi have partnered to advance India's AI and SaaS ecosystem towards a trillion-dollar economy[19].

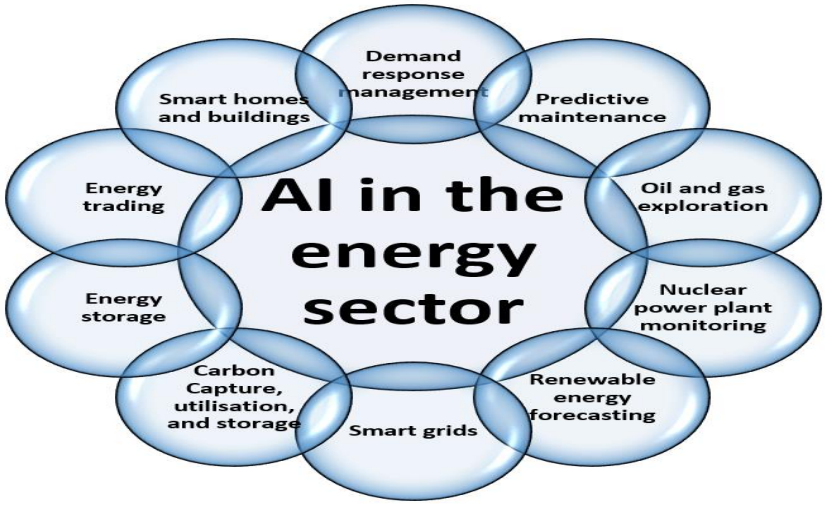
"AI is a valuable instrument that is already assisting our society in addressing climate change on a large scale and moving toward carbon-free energy," stated Kara Hurst, vice president of Worldwide Sustainability at Amazon. "As we move closer to our goal of becoming a more sustainable company, we are able to guarantee that the grid and its customers receive a consistent supply of carbon-free energy for more hours each day by combining solar projects made possible by Amazon with AI technologies powered by AWS [20]."

9.4 APPLICATIONS OF AI AND ML IN RENEWABLE ENERGY

AI and ML play an important role in managing Renewal Energy and transforming power production, distribution, and use. It provides new dimensions in renewal energy management. AI is radically altering how the energy sector functions, guiding it toward a more secure, sustainable, and efficient future in areas like smart

grid management, renewable energy forecasts, and even nuclear energy plant safety.

FIG. 9.5 EXAMPLES OF AI AND ML IN RENEWABLE ENERGY



- **Smart Grids:** With the utilization of savvy lattice advances, power from these sources might be disseminated, put away, and facilitated into a predictable and reliable stream. This is where simulated intelligence enters the image since, as per SAP, popularity strains might be anticipated and allotted to a few plants and substations utilizing prescient examination. Cloud-based man-made intelligence innovations for example, AI, information examination, and the Web of Things extend savvy lattice capacities to empower refined power appropriation and age. "The entirety of the gadgets furthermore, resources inside the lattice can convey thanks to man-made intelligence, cloud, and advanced innovations, which supports better control and self-guideline," the global programming business noted.
- **Demand Response Management:** The executives improving power utilization and keeping up with the dependability of the power framework are critical goals in the energy area. It involves answering signs from matrix administrators or energy suppliers by altering the power utilization of shoppers, frequently business and modern firms. This approach forestalls the requirement for expensive foundation extensions, helps with directing interest with supply during busy times, and starts load shedding to ease matrix strain. By empowering ongoing reactions to changes in energy interest, artificial

intelligence too assists with laying out an intelligent relationship among energy suppliers and buyers.

- **Predictive Maintenance:** Energy organizations can utilize simulated intelligence to estimate when their hardware will separate or require upkeep. To expect any breakdowns before they occur, machine gaining can examine huge volumes of information from different sources, including utilization insights, meteorological information, and past upkeep logs. This technique expands the by and large reliability of energy foundation, limits margin time, and brings down fix costs.
- **Renewable Energy Forecasting:** With regards to foreseeing the development of environmentally friendly power, simulated intelligence is fundamental. Man-made reasoning calculations look at estimates for the climate, past age information, furthermore, current circumstances for sources that are inclined to changeability, like breeze and sun based. This makes it feasible for energy suppliers to estimate how much sustainable power that will be accessible, further developing organic market balance.
- **Energy Storage:** AI makes the conveyance and capacity of fuel from sources that are sustainable more effective. Whether choosing whether to store energy, when to deliver it, and the amount to convey, AI considers various factors, including supply, demand, pricing, and grid conditions.
- **Carbon Capture, Utilisation, and Storage:** In energy exchanging, AI examinations complex market elements. It helps energy associations settle on beneficial and all around informed exchanging choices by handling continuous information on supply, request, and evaluating patterns. AI is additionally awesome in danger the executives, proactively assessing the vulnerability and unpredictability of the market. Computer based intelligence controlled algorithmic exchanging moves dangerously fast, finishing many exchanges milliseconds. Energy portfolios are enhanced, market situations are mimicked, feeling is broke down, errands are mechanized, what's more, it consistently changes with moving economic situations.
- **Smart Homes And Buildings:** Computer based intelligence is changing houses and structures into energy-productive environments, which has a significantly troublesome impact on the mission for energy productivity. Computer based intelligence teams up with IoT gadgets and shrewd meters to fabricate responsive, clever environments. These advancements permit simulated intelligence to make information driven decisions that advance energy use by ceaselessly checking energy utilization progressively.

- **Oil And Gas Exploration:** AI revolutionizing Oil and Gas Drilling Based off powerful analysis of huge amounts of geological data, AI (Artificial Intelligence) can identify potential areas for oil and gas deposits that might be otherwise missed by traditional methods. AI makes operations in the oil and gas sector safer and more efficient by allowing drilling teams to anticipate problems, improve safety protocols, and optimize drilling procedures.
- **Nuclear Power Plant Monitoring:** Nuclear continues to provide about 10% of the world's power today. Nuclear power plants, where safety is the highest priority, most need AI. These AI systems are designed to monitor all the plant processes twenty-four hours, seven days a week, without fatigue. This technology continuously analyzing data collected from multiple sensors and equipment; these systems are able to identify even the smallest irregularities or deviations from accepted safety regulations.
- **Energy Trading:** AI analyses complex market mechanisms in energy trading. By analysing real-time data on supply, demand and pricing trends, it assists energy companies in making profitable & informed trading decisions. AI is great at risk management as well, for instance by analyzing the uncertainty and volatility of the market ahead of time. Algorithmic trading powered by AI is so fast that much of it happens in milliseconds.

9.5 THE FUTURE OF AI AND ML IN RENEWABLE ENERGY SYSTEMS

As innovation grows further, it is guessed that the joining of computer based intelligence and ML into environmentally friendly power frameworks will turn out to be progressively more perplexing. Environmentally friendly power sources will turn out to be considerably more proficient and dependable in light of the facts that to advancements like constant direction, refined prescient examination, and independent energy frameworks. Considering this, the mix of simulated intelligence, ML, and sustainable power frameworks guarantees a future in which clean energy is handily integrated into our regular routines, assisting with making an additional supportable and biologically cordial world.

The energy scene is changing because of the coordination of man-made intelligence and AI standards into environmentally friendly power frameworks. These advances are expanding the productivity and steadfastness of sustainable power frameworks by overseeing energy stockpiling, refining prescient upkeep, supporting matrix steadiness, and boosting energy creation. The chance of a cleaner and more

economical energy future turns out to be increasingly more practical as we keep on embracing these turns of events.

9.6 REFERENCES

- Talaat, F. M., Kabeel, A. E., & Shaban, W. M. (2024). The role of utilizing artificial intelligence and renewable energy in reaching sustainable development goals. *Renewable Energy*, *235*, 121311.
- Ukoba, K., Olatunji, K. O., Adeoye, E., Jen, T. C., & Madyira, D. M. (2024). Optimizing renewable energy systems through artificial intelligence: Review and future prospects. *Energy & Environment*, 0958305X241256293.
- https://krce.ac.in/blog/infusion-of-artificial-intelligence-and-machine-learning-concepts-in-renewable-energy-systems/
- M. Swarnkar, M. Chopra, V. Dhote, N. Nigam, K. Upadhyaya and M. Prajapati, "Use of AI for development and generation of renewable energy," *2023 IEEE Renewable Energy and Sustainable E-Mobility Conference (RESEM)*, Bhopal, India, 2023, pp. 1-5, doi: 10.1109/RESEM57584.2023.10236136.
- https://www.linkedin.com/pulse/ai-ml-catalysts-renewable-energy-transformation-adrian-chavira-ch6yc/
- Singh, V., Prasad, M., Aswal, R. S., Shrivastava, U., Sharma, T., & Patel, N. K. (2025). An overview of renewable energy sources: technologies, applications and role of artificial intelligence. *Computer Vision and Machine Intelligence for Renewable Energy Systems*, 1-14.
- Malkova, Y. (2025). Artificial intelligence and sustainable power. In *The Sustainable Power Grid* (pp. 43-58). Elsevier.
- Hamid, H., & Samantaray, S. (2025). Future directions of computer vision and AI for renewable energy: trends and challenges in renewable energy research and applications. *Computer Vision and Machine Intelligence for Renewable Energy Systems*, 335-361.
- Oral, B., Coşgun, A., Kilic, A., Eroglu, D., Günay, M. E., & Yıldırım, R. (2025). Machine learning for a sustainable energy future. *Chemical Communications*.
- Sapre, I. (2024). The Role of Artificial Intelligence in Enhancing Renewable Energy Efficiency: A Case Study on Solar and Wind Energy

Optimization. *Intersect: The Stanford Journal of Science, Technology, and Society*, *18*(1).

- Manuel, H. N. N., Kehinde, H. M., Agupugo, C. P., & Manuel, A. C. N. (2024). The impact of AI on boosting renewable energy utilization and visual power plant efficiency in contemporary construction. *World Journal of Advanced Research and Reviews*, *23*(2), 1333-1348.
- Ukoba, K., Olatunji, K. O., Adeoye, E., Jen, T. C., & Madyira, D. M. (2024). Optimizing renewable energy systems through artificial intelligence: Review and future prospects. *Energy & Environment*, 0958305X241256293.
- Tewary, A., Upadhyay, C., & Singh, A. K. (2023). Emerging role of AI, ML and IoT in modern sustainable energy management. In *IoT and Analytics in Renewable Energy Systems (Volume 2)* (pp. 273-288). CRC Press.
- Mehta, Y., Xu, R., Lim, B., Wu, J., & Gao, J. (2023). A review for green energy machine learning and AI services. *Energies*, *16*(15), 5718.
- Benti, N. E., Chaka, M. D., & Semie, A. G. (2023). Forecasting renewable energy generation with machine learning and deep learning: Current advances and future prospects. *Sustainability*, *15*(9), 7087.
- Rangel-Martinez, D., Nigam, K. D. P., & Ricardez-Sandoval, L. A. (2021). Machine learning on sustainable energy: A review and outlook on renewable energy systems, catalysis, smart grid and energy storage. *Chemical Engineering Research and Design*, *174*, 414-441.
- https://analyticsindiamag.com/ai-features/ai-has-become-a-key-contributing-factor-in-the-renewable-energy-sector/
- Optimizing India's Electricity Grid for Renewables Using AI and Machine Learning Applications
- https://news.microsoft.com/en-in/microsoft-announces-us-3bn-investment-over-two-years-in-india-cloud-and-ai-infrastructure-to-accelerate-adoption-of-ai-skilling-and-innovation/?msockid=1e0e186f79e96642133e0cbf78ef67a4
- https://www.aboutamazon.com/news/sustainability/carbon-free-energy-projects-ai-tech