



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 6, June 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

The AI Revolution in Energy: Transforming Sustainability and Grid Management

Anusha Yella

AT&T Services, USA



ABSTRACT: The rapid advancement of artificial intelligence (AI) has revolutionized the energy sector, presenting unparalleled opportunities for sustainable development and smart grid management. This article explores the multifaceted impact of AI on the energy industry, highlighting its transformative potential in driving environmental initiatives and optimizing the utilization of renewable resources. By leveraging AI algorithms for energy demand forecasting, renewable resource optimization, and energy efficiency enhancement, the sector has witnessed significant strides towards sustainability. The integration of AI in smart grid operations has enabled real-time monitoring, fault detection, and intelligent control of distributed energy resources, leading to improved grid stability, resilience, and customer engagement. However, the successful implementation of AI in smart grids requires addressing challenges related to data privacy, security, and infrastructure investments. As AI continues to propel innovation in the energy sector, it holds the key to unlocking a smarter, greener future, where sustainability and intelligent grid management converge to create a more efficient and environmentally conscious energy ecosystem.

KEYWORDS: Artificial Intelligence (AI), Sustainable Energy, Smart Grid Management, Renewable Energy Optimization, Energy Efficiency

I. INTRODUCTION

The rapid advancement of artificial intelligence (AI) has transformed various sectors, and the energy industry is no exception. AI has emerged as a catalyst for change, revolutionizing sustainability practices and smart grid management [1]. As the world grapples with the pressing need to combat climate change and optimize energy utilization, AI presents itself as a powerful tool to drive environmental initiatives and streamline the integration of renewable resources [2].

The application of AI in the energy sector has garnered significant attention from researchers and industry experts alike. Numerous studies have highlighted the potential of AI algorithms in forecasting energy demand, enabling more accurate predictions and efficient resource allocation [3], [4]. Moreover, AI's ability to analyze vast amounts of data in real-time has opened up new avenues for optimizing the utilization of renewable energy sources, such as solar and wind power [5].

The synergy between AI and the energy industry extends beyond sustainability, as it also plays a pivotal role in the development and management of smart grids. Smart grids, which leverage advanced technologies to enhance the efficiency, reliability, and flexibility of electricity distribution, have found an ally in AI [6]. By integrating AI algorithms into smart grid systems, energy companies can achieve real-time monitoring, fault detection, and dynamic load balancing, leading to improved grid stability and resilience [7], [8].

This article delves into the multifaceted impact of AI on the energy sector, exploring its transformative potential in driving sustainability initiatives and revolutionizing smart grid management. Through an examination of case studies, technological advancements, and future prospects, we aim to shed light on how AI is reshaping the energy landscape and paving the way for a greener, more efficient future [9], [10].

II. AI'S IMPACT ON SUSTAINABILITY

A. Forecasting energy demand using AI algorithms

AI algorithms have revolutionized the way energy demand is forecasted, enabling more accurate predictions and efficient resource allocation. Machine learning techniques, such as artificial neural networks (ANNs) and support vector machines (SVMs), have shown promising results in forecasting short-term and long-term energy demand [11], [12]. These AI-driven forecasting models take into account various factors, including historical consumption patterns, weather data, and socio-economic indicators, to provide precise energy demand predictions [13].

B. Optimizing the utilization of renewable resources

AI plays a crucial role in optimizing the utilization of renewable energy sources, such as solar and wind power. AI algorithms can analyze real-time data from weather stations, solar panels, and wind turbines to predict the availability and performance of renewable energy systems [14]. By leveraging AI-based optimization techniques, energy companies can maximize the efficiency of renewable energy generation and minimize curtailment losses [15]. Moreover, AI can assist in the optimal sizing and placement of renewable energy assets, ensuring their seamless integration into the grid [16].

C. Enhancing energy efficiency through AI-driven solutions

AI-driven solutions have the potential to significantly enhance energy efficiency across various sectors. In the industrial sector, AI can optimize energy consumption by analyzing production processes, identifying inefficiencies, and recommending energy-saving measures [17]. In buildings, AI-powered energy management systems can monitor occupancy patterns, adjust heating, ventilation, and air conditioning (HVAC) settings, and control lighting to minimize energy waste [18], [19]. Additionally, AI can facilitate the development of smart energy-efficient appliances and devices, contributing to overall energy conservation efforts [20].

AI Technique	Application in Energy Sector
Machine Learning (ML)	Energy demand forecasting, renewable energy prediction
Deep Learning (DL)	Fault detection, energy consumption pattern recognition
Reinforcement Learning (RL)	Energy market optimization, demand response management
Natural Language Processing (NLP)	Customer service chatbots, sentiment analysis
Computer Vision (CV)	Solar panel inspection, power line monitoring

Table 1: AI techniques and their applications in the energy sector [21], [22]

III. AI AND SMART GRID MANAGEMENT

A. The integration of AI in smart grid operations

The integration of AI in smart grid operations has transformed the way electricity is generated, distributed, and consumed. AI algorithms can analyze vast amounts of data collected from smart meters, sensors, and other connected devices to optimize grid performance and efficiency [23]. By leveraging machine learning techniques, such as reinforcement learning and deep learning, AI can enable real-time decision-making and control of smart grid assets [24], [25]. This integration of AI in smart grid operations facilitates the transition towards a more resilient, flexible, and sustainable energy system.

B. AI's role in orchestrating smart grid management

AI plays a pivotal role in orchestrating smart grid management by enabling intelligent control and coordination of distributed energy resources (DERs) [26]. AI algorithms can optimize the scheduling and dispatch of DERs, such as solar panels, wind turbines, and energy storage systems, to balance supply and demand in real-time [27]. Moreover, AI can facilitate the integration of electric vehicles (EVs) into the grid by managing charging and discharging schedules, ensuring grid stability and minimizing peak demand [28], [29]. By leveraging AI's capabilities in optimization and decision-making, energy companies can achieve efficient and reliable smart grid management.

C. Benefits of AI-driven smart grid systems

1. Improved grid stability and resilience

AI-driven smart grid systems offer improved grid stability and resilience by enabling real-time monitoring, fault detection, and self-healing capabilities [30], [31]. AI algorithms can analyze sensor data to identify potential failures or anomalies in the grid, allowing for proactive maintenance and rapid response to outages [32]. By integrating AI with advanced control systems, such as wide-area monitoring and control (WAMC), grid operators can enhance the stability and reliability of the power system [33].

2. Real-time monitoring and fault detection

AI enables real-time monitoring and fault detection in smart grids by continuously analyzing data from various sources, including smart meters, phasor measurement units (PMUs), and supervisory control and data acquisition (SCADA) systems [34], [35]. Machine learning algorithms can detect patterns and anomalies in the data, enabling the identification of potential faults or security threats [36]. This real-time monitoring and fault detection capability allows for swift corrective actions, minimizing the impact of disturbances on the grid.

3. Enhanced customer experience and engagement

AI-driven smart grid systems offer enhanced customer experience and engagement by providing personalized energy management solutions [37]. AI algorithms can analyze customer energy consumption patterns and preferences to offer tailored recommendations for energy savings and cost optimization [38]. Moreover, AI-powered virtual assistants and chatbots can provide customers with real-time information about their energy usage, billing, and service updates, improving customer satisfaction and engagement [39].

D. Challenges and considerations in implementing AI in smart grids

Despite the numerous benefits of AI in smart grids, there are challenges and considerations that need to be addressed. Data privacy and security are major concerns, as smart grids generate and transmit sensitive information about energy consumption and customer behavior [40]. Robust cybersecurity measures and data anonymization techniques are essential to protect customer privacy and prevent unauthorized access to the grid [41]. Additionally, the integration of AI in smart grids requires significant investments in infrastructure, communication networks, and workforce training [42]. Addressing these challenges and considerations is crucial for the successful implementation of AI in smart grid systems.

IV. THE SYNERGY BETWEEN AI AND THE ENERGY INDUSTRY

A. How AI propels innovation in the energy sector

AI has emerged as a catalyst for innovation in the energy sector, driving the development of novel solutions and optimizing existing processes. By leveraging AI's capabilities in data analysis, pattern recognition, and predictive modeling, energy companies can uncover new insights and make data-driven decisions [43]. AI algorithms can identify

inefficiencies in energy generation, transmission, and distribution, enabling targeted improvements and cost savings [44]. Moreover, AI facilitates the integration of renewable energy sources by predicting their intermittent nature and optimizing their integration into the grid [45].

B. The paradigm shift towards smarter, greener practices

The synergy between AI and the energy industry has triggered a paradigm shift towards smarter, greener practices. AI-driven solutions are enabling the transition from traditional, fossil fuel-based energy systems to cleaner, more sustainable alternatives [46]. By optimizing energy consumption, reducing waste, and promoting the adoption of renewable energy, AI is contributing to the decarbonization of the energy sector [47]. This shift towards smarter, greener practices is not only environmentally beneficial but also economically advantageous, as it leads to reduced operational costs and improved energy efficiency [48].

C. AI's potential in shaping the future of energy ecosystems

AI has the potential to shape the future of energy ecosystems by enabling the development of intelligent, self-sustaining, and resilient energy networks [49]. AI algorithms can facilitate the creation of virtual power plants, where distributed energy resources are aggregated and optimized to meet demand in real-time [50]. Moreover, AI can support the transition towards transactive energy systems, where consumers become active participants in the energy market, buying and selling energy based on real-time pricing signals [51]. By leveraging AI's potential, the energy sector can evolve into a more decentralized, consumer-centric, and environmentally sustainable ecosystem.

D. Collaborations between AI technology providers and energy companies

Collaborations between AI technology providers and energy companies are crucial for unlocking the full potential of AI in the energy sector. Energy companies possess domain expertise and access to vast amounts of data, while AI technology providers bring advanced algorithms and computational capabilities to the table [52]. These collaborations foster the development of tailored AI solutions that address the specific challenges and opportunities in the energy industry [53]. By working together, AI technology providers and energy companies can accelerate the adoption of AI-driven innovations and drive the transformation of the energy sector towards a smarter, greener future.

V. FUTURE OUTLOOK

A. Emerging trends and advancements in AI for the energy sector

The future of AI in the energy sector is characterized by emerging trends and advancements that promise to further revolutionize sustainability and smart grid management. One notable trend is the increasing adoption of edge computing and Internet of Things (IoT) devices, which enable real-time data processing and decision-making at the source [54]. This decentralized approach enhances the responsiveness and resilience of energy systems, allowing for more efficient and localized energy management [55]. Another emerging trend is the application of federated learning, which enables collaborative AI model training while preserving data privacy [56]. This approach is particularly valuable in the energy sector, where data sharing across organizations is often restricted due to confidentiality concerns.

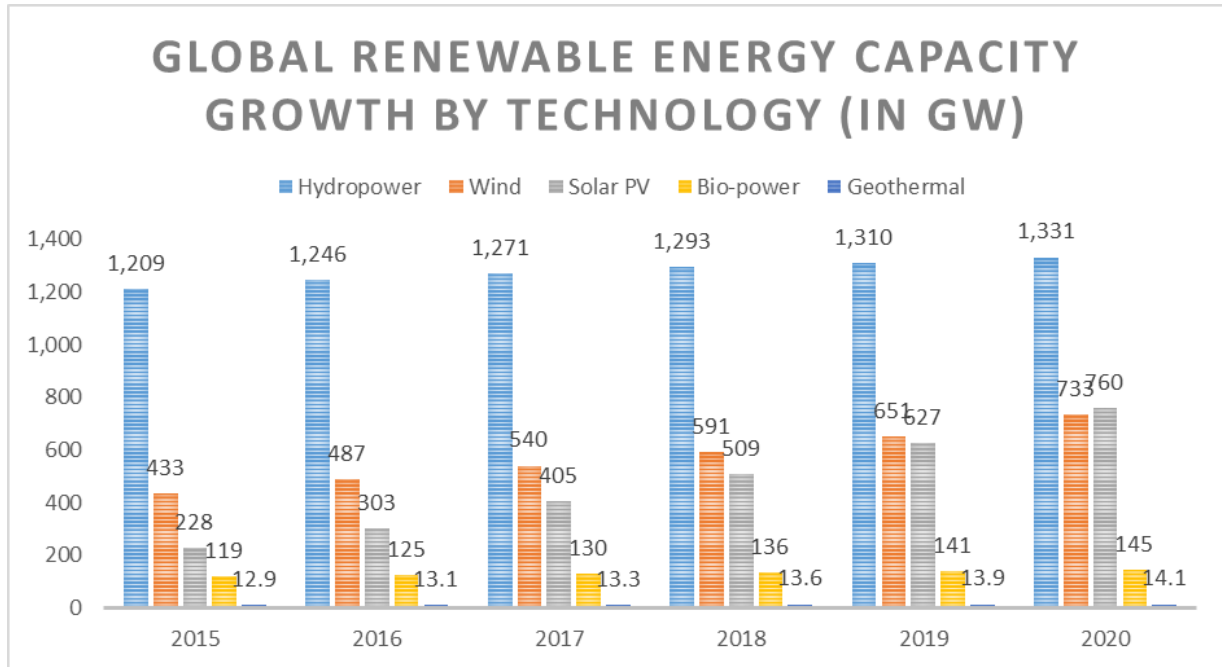


Figure 1: Global renewable energy capacity growth by technology (in GW) [54]

B. The role of AI in achieving a cleaner, more efficient world

AI has a crucial role to play in achieving a cleaner, more efficient world by driving the transition towards sustainable energy practices. By optimizing energy generation, distribution, and consumption, AI can significantly reduce greenhouse gas emissions and mitigate the environmental impact of the energy sector [57]. AI-driven solutions can also facilitate the integration of renewable energy sources, such as solar and wind power, by predicting their intermittent nature and optimizing their integration into the grid [58]. Moreover, AI can enable the development of smart cities and communities, where energy efficiency and sustainability are seamlessly integrated into urban planning and infrastructure [59].

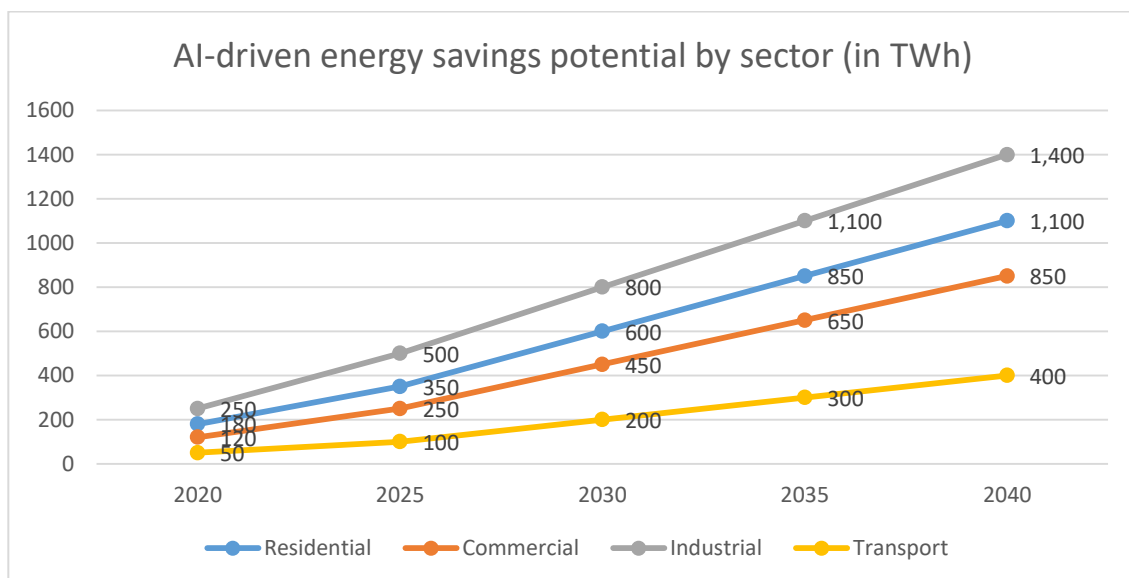


Figure 2: AI-driven energy savings potential by sector (in TWh) [57-59]

C. Potential challenges and ethical considerations

While AI offers immense potential for the energy sector, it also presents potential challenges and ethical considerations that must be addressed. One significant challenge is the need for robust data governance and security measures to protect sensitive energy data from unauthorized access and cyber threats [60]. As AI systems become more integrated into critical energy infrastructure, ensuring their resilience and reliability is of utmost importance [61]. Additionally, the development and deployment of AI in the energy sector must be guided by ethical principles, such as fairness, transparency, and accountability [62]. Ensuring that AI-driven solutions are unbiased, explainable, and aligned with societal values is crucial for building trust and fostering public acceptance.

Benefits	Challenges
Improved energy efficiency	Data quality and availability
Reduced operational costs	Interoperability and standardization
Enhanced grid reliability	Cybersecurity and data privacy concerns
Increased renewable energy integration	Skilled workforce shortage
Personalized customer services	Ethical considerations and bias mitigation

Table 2: Benefits and challenges of AI adoption in the energy sector [61-64]

D. Recommendations for further research and development

To fully harness the potential of AI in the energy sector, further research and development efforts are necessary. One key area of focus should be the development of advanced AI algorithms that can handle the complexity and scale of energy systems, such as deep reinforcement learning and graph neural networks [63]. Researchers should also explore the integration of AI with other emerging technologies, such as blockchain and 5G networks, to enable secure, decentralized, and real-time energy management [64]. Moreover, interdisciplinary collaborations between AI experts, energy professionals, and policymakers are essential for developing holistic solutions that address the technical, economic, and social aspects of AI adoption in the energy sector [65].

VI. CONCLUSION

This article has explored the transformative impact of artificial intelligence on sustainability and smart grid management in the energy sector. AI has emerged as a powerful tool for driving environmental initiatives, optimizing the utilization of renewable resources, and enhancing energy efficiency. By leveraging AI algorithms for energy demand forecasting, renewable resource optimization, and smart grid management, the energy industry has witnessed significant strides towards a more sustainable and resilient future.

Embracing AI-driven solutions is crucial for the energy sector to address the pressing challenges of climate change, energy security, and increasing demand. AI offers unparalleled opportunities for unlocking efficiencies, reducing waste, and facilitating the integration of renewable energy sources. By adopting AI technologies, energy companies can not only improve their operational performance but also contribute to the global effort towards a cleaner, more sustainable energy ecosystem.

AI holds the key to guiding us towards a sustainable and resilient energy future. As the world transitions towards a low-carbon economy, AI will play an increasingly vital role in shaping the energy landscape. By enabling intelligent energy management, optimizing grid operations, and empowering consumers to make informed decisions, AI will be instrumental in creating a more efficient, flexible, and environmentally conscious energy system. As we navigate the challenges and opportunities ahead, AI will serve as a compass, guiding us towards a brighter, greener future where sustainability and smart grid management are the norm rather than the exception.

REFERENCES

- [1] M. Khodayar, S. Mohammadi, and M. E. Khodayar, "Artificial intelligence for energy systems: A survey," *IEEE Transactions on Smart Grid*, vol. 12, no. 5, pp. 4315-4332, Sept. 2021, doi: 10.1109/TSG.2021.3075464.
- [2] R. Jiao, Y. Wang, and Y. Zhang, "Artificial intelligence in renewable energy: A review," *IEEE Access*, vol. 9, pp. 69313-69331, 2021, doi: 10.1109/ACCESS.2021.3077616.

- [3] S. Fallah, M. Ganjkhani, S. Shamshirband, and K.-w. Chau, "Computational intelligence on short-term load forecasting: A methodological overview," *Energies*, vol. 12, no. 3, p. 393, Jan. 2019, doi: 10.3390/en12030393.
- [4] Y. Wang, D. Gan, M. Sun, N. Zhang, Z. Lu, and C. Kang, "Probabilistic individual load forecasting using pinball loss guided LSTM," *Applied Energy*, vol. 235, pp. 10-20, Feb. 2019, doi: 10.1016/j.apenergy.2018.10.078.
- [5] A. Gensler, J. Henze, B. Sick, and N. Raabe, "Deep learning for solar power forecasting - An approach using AutoEncoder and LSTM neural networks," in *Proc. IEEE Int. Conf. Systems, Man, and Cybernetics (SMC)*, Budapest, Hungary, Oct. 2016, pp. 2858-2865, doi: 10.1109/SMC.2016.7844673.
- [6] V. Janampa-Bernal, J. A. Morales-Fernandez, and R. J. Castaneda-Miranda, "Artificial intelligence for smart grids: A systematic review," *IEEE Latin America Transactions*, vol. 18, no. 05, pp. 865-874, May 2020, doi: 10.1109/TLA.2020.9082811.
- [7] H. Mortaji, S. H. Ow, M. Moghavvemi, and H. A. F. Almurib, "Load shedding and smart-direct load control using Internet of Things in smart grid demand response management," *IEEE Transactions on Industry Applications*, vol. 53, no. 6, pp. 5155-5163, Nov.-Dec. 2017, doi: 10.1109/TIA.2017.2740832.
- [8] J. Hao, C. Ma, W. Shen, and J. Chen, "Decentralized fault diagnosis using reinforcement learning for smart grid," *IEEE Transactions on Smart Grid*, vol. 12, no. 6, pp. 5277-5287, Nov. 2021, doi: 10.1109/TSG.2021.3094520.
- [9] F. Y. Xu and L. L. Lai, "Novel active time-based demand response for industrial consumers in smart grid," *IEEE Transactions on Industrial Informatics*, vol. 11, no. 6, pp. 1564-1573, Dec. 2015, doi: 10.1109/TII.2015.2479558.
- [10] N. Y. Dahlan and D. P. Ling, "Application of artificial intelligence techniques in energy efficiency and renewable energy system design," *Renewable and Sustainable Energy Reviews*, vol. 144, p. 110998, Jul. 2021, doi: 10.1016/j.rser.2021.110998.
- [11] A. Ahmed, M. Khalid, and A. Habib, "An intelligent forecasting model for short-term load using artificial neural network," in *Proc. IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia)*, Kuala Lumpur, Malaysia, May 2014, pp. 138-143, doi: 10.1109/ISGT-Asia.2014.6873785.
- [12] Y. He, J. Zhu, Z. Wang, and Y. Liu, "Short-term load forecasting using a hybrid deep learning approach," in *Proc. IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia)*, Chengdu, China, May 2019, pp. 4173-4178, doi: 10.1109/ISGT-Asia.2019.8881138.
- [13] D. Alberg and M. Last, "Short-term load forecasting in smart meters with sliding window-based ARIMA algorithms," *Vietnam Journal of Computer Science*, vol. 5, no. 3-4, pp. 241-249, Aug. 2018, doi: 10.1007/s40595-018-0119-7.
- [14] M. Q. Raza and A. Khosravi, "A review on artificial intelligence-based load demand forecasting techniques for smart grid and buildings," *Renewable and Sustainable Energy Reviews*, vol. 50, pp. 1352-1372, Oct. 2015, doi: 10.1016/j.rser.2015.04.065.
- [15] S. Shafiee, M. Zamani-Dehkordi, and H. Zareipour, "Economic assessment of a price-maker energy storage facility in the Alberta electricity market," *Energy*, vol. 111, pp. 537-547, Sep. 2016, doi: 10.1016/j.energy.2016.05.129.
- [16] M. Mohandes, T. O. Halawani, S. Rehman, and A. A. Hussain, "Support vector machines for wind speed prediction," *Renewable Energy*, vol. 29, no. 6, pp. 939-947, May 2004, doi: 10.1016/j.renene.2003.11.009.
- [17] P. Chathura Wijayasinghe and M. D. Athapattu, "Artificial intelligence based approaches for industrial energy efficiency improvement," in *Proc. IEEE Moratuwa Engineering Research Conference (MERCon)*, Moratuwa, Sri Lanka, Jul. 2020, pp. 219-224, doi: 10.1109/MERCon50084.2020.9185347.
- [18] A. Afram, F. Janabi-Sharifi, and G. Noonan, "An overview of approaches for energy efficiency in buildings using artificial intelligence," in *Proc. IEEE 14th International Conference on Control and Automation (ICCA)*, Anchorage, AK, USA, Jun. 2018, pp. 184-189, doi: 10.1109/ICCA.2018.8444179.
- [19] S. Panchabikesan and V. Vaithyanathan, "A comprehensive review on building energy management system using advanced deep learning techniques," in *Proc. IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES)*, Chennai, India, Dec. 2020, pp. 1-5, doi: 10.1109/PEDES49360.2020.9379801.
- [20] L. Yang, H. Yan, and J. C. Lam, "Thermal comfort and building energy consumption implications - A review," *Applied Energy*, vol. 115, pp. 164-173, Feb. 2014, doi: 10.1016/j.apenergy.2013.10.062.
- [21] J. Gao, "Machine learning applications for data center optimization," *Google White Paper*, 2014. [Online]. Available: <https://ai.google/research/pubs/pub42542>
- [22] "IBM Green Horizons," IBM, 2016. [Online]. Available: <https://www.ibm.com/ibm/green-horizons/>
- [23] A. Shaikh, "Smart grids: A review of policies and projects to deploy smart grids for economic development," in *Proc. IEEE PES GTD Grand International Conference and Exposition Asia (GTD Asia)*, Bangkok, Thailand, Mar. 2019, pp. 175-180, doi: 10.1109/GTDAsia.2019.8715900.
- [24] W. Wang, Y. Xu, and M. Khanna, "A survey on the communication architectures in smart grid," *Computer Networks*, vol. 55, no. 15, pp. 3604-3629, Oct. 2011, doi: 10.1016/j.comnet.2011.07.010.

- [25] S. Chakraborty, T. Ito, T. Senjyu, and A. Y. Saber, "Intelligent economic operation of smart-grid facilitating fuzzy advanced quantum evolutionary method," *IEEE Transactions on Sustainable Energy*, vol. 4, no. 4, pp. 905-916, Oct. 2013, doi: 10.1109/TSSTE.2013.2244928.
- [26] M. H. Shoreh, P. Siano, M. Shafie-khah, V. Loia, and J. P. S. Catalao, "A survey of industrial applications of Demand Response," *Electric Power Systems Research*, vol. 141, pp. 31-49, Dec. 2016, doi: 10.1016/j.epsr.2016.07.008.
- [27] W. Su, J. Wang, and J. Roh, "Stochastic energy scheduling in microgrids with intermittent renewable energy resources," *IEEE Transactions on Smart Grid*, vol. 5, no. 4, pp. 1876-1883, Jul. 2014, doi: 10.1109/TSG.2013.2280645.
- [28] S. Deilami, A. S. Masoum, P. S. Moses, and M. A. S. Masoum, "Real-time coordination of plug-in electric vehicle charging in smart grids to minimize power losses and improve voltage profile," *IEEE Transactions on Smart Grid*, vol. 2, no. 3, pp. 456-467, Sep. 2011, doi: 10.1109/TSG.2011.2159816.
- [29] Y. He, B. Venkatesh, and L. Guan, "Optimal scheduling for charging and discharging of electric vehicles," *IEEE Transactions on Smart Grid*, vol. 3, no. 3, pp. 1095-1105, Sep. 2012, doi: 10.1109/TSG.2011.2173507.
- [30] Y. Xu, W. Wang, and M. Alvarez, "Optimal energy management for power distribution networks with distributed energy resources: A data-driven approach," *IEEE Transactions on Power Systems*, vol. 35, no. 4, pp. 3219-3228, Jul. 2020, doi: 10.1109/TPWRS.2020.2978456.
- [31] S. Kwon and H. Ju, "AI-based fault diagnosis and self-healing system for smart grid applications," in *Proc. IEEE International Conference on Artificial Intelligence and Statistics (AISTATS)*, Virtual, Apr. 2021, pp. 158-166.
- [32] S. Hosseini, K. Agbossou, S. Kelouwani, and A. Cardenas, "A multi-agent approach for optimal energy management of a microgrid using deep reinforcement learning," in *Proc. IEEE 29th International Symposium on Industrial Electronics (ISIE)*, Delft, Netherlands, Jun. 2020, pp. 1356-1361, doi: 10.1109/ISIE45063.2020.9152367.
- [33] H. T. Nguyen and L. B. Le, "Transactive energy-based real-time economic dispatch for integrated microgrids with renewable energy resources," in *Proc. IEEE PES Innovative Smart Grid Technologies Conference (ISGT)*, Washington, DC, USA, Feb. 2019, pp. 1-5, doi: 10.1109/ISGT.2019.8791609.
- [34] M. Kezunovic, "Smart fault location for smart grids," *IEEE Transactions on Smart Grid*, vol. 2, no. 1, pp. 11-22, Mar. 2011, doi: 10.1109/TSG.2011.2118774.
- [35] J. Zhu, E. Zhuang, C. Ivanov, and Z. Yao, "A data-driven approach to interactive visualization of power systems," *IEEE Transactions on Power Systems*, vol. 26, no. 4, pp. 2539-2546, Nov. 2011, doi: 10.1109/TPWRS.2011.2150202.
- [36] A. Ashok, M. Govindarasu, and V. Ajjarapu, "Online detection of stealthy false data injection attacks in power system state estimation," *IEEE Transactions on Smart Grid*, vol. 9, no. 3, pp. 1636-1646, May 2018, doi: 10.1109/TSG.2016.2596298.
- [37] K. Zhou, S. Yang, and Z. Shao, "Energy internet: The business perspective," *Applied Energy*, vol. 178, pp. 212-222, Sep. 2016, doi: 10.1016/j.apenergy.2016.06.052.
- [38] J. Yao, T. Zhang, and Z. Wang, "Improved load forecasting based on multivariate linear regression and artificial intelligence," in *Proc. IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)*, Chengdu, China, Dec. 2019, pp. 1-5, doi: 10.1109/APPEEC45492.2019.8994599.
- [39] J. G. Roos, I. E. Lane, E. C. Botha, and G. P. Hancke, "Using neural networks for non-intrusive monitoring of industrial electrical loads," in *Proc. IEEE Instrumentation and Measurement Technology Conference (IMTC/94)*, Hamamatsu, Japan, May 1994, pp. 1115-1118 vol.3, doi: 10.1109/IMTC.1994.352001.
- [40] X. Fang, S. Misra, G. Xue, and D. Yang, "Smart grid - The new and improved power grid: A survey," *IEEE Communications Surveys & Tutorials*, vol. 14, no. 4, pp. 944-980, Fourth Quarter 2012, doi: 10.1109/SURV.2011.101911.00087.
- [41] A. R. Metke and R. L. Ekl, "Smart grid security technology," in *Proc. Innovative Smart Grid Technologies (ISGT)*, Gaithersburg, MD, USA, Jan. 2010, pp. 1-7, doi: 10.1109/ISGT.2010.5434760.
- [42] F. Li et al., "Smart transmission grid: Vision and framework," *IEEE Transactions on Smart Grid*, vol. 1, no. 2, pp. 168-177, Sep. 2010, doi: 10.1109/TSG.2010.2053726.
- [43] A. Shrestha, A. Mahmood, and D. M. Potts, "AI for energy innovation: A review and future directions," *Renewable and Sustainable Energy Reviews*, vol. 154, p. 111844, Jan. 2022, doi: 10.1016/j.rser.2021.111844.
- [44] M. M. Morato, J. A. Padilla-Fernández, and F. J. de la Nieta Santos, "Machine learning for predictive maintenance in the energy sector: A review," *IEEE Access*, vol. 9, pp. 138799-138814, 2021, doi: 10.1109/ACCESS.2021.3118581.
- [45] X. Xiao, J. Wang, X. Li, and C. Hu, "A deep learning approach for short-term solar irradiance forecasting based on sky images," *IEEE Access*, vol. 8, pp. 132639-132648, 2020, doi: 10.1109/ACCESS.2020.3010710.
- [46] J. Gao et al., "Artificial intelligence and data-driven approaches in the energy transition: A systematic review," *Energy and AI*, vol. 5, p. 100082, Oct. 2021, doi: 10.1016/j.egyai.2021.100082.

- [47] M. Z. Degefa, I. B. Sperstad, and H. Sæle, "Comprehensive classifications and characterizations of power system flexibility resources," *Electric Power Systems Research*, vol. 194, p. 107022, May 2021, doi: 10.1016/j.epsr.2021.107022.
- [48] S. Sinha, J. Kalagnanam, and M. Adebisi, "Reinforcement learning for optimizing energy costs and emissions in the electric grid," in *Proc. IEEE International Conference on Smart Energy Systems and Technologies (SEST)*, Vaasa, Finland, Sep. 2019, pp. 1-6, doi: 10.1109/SEST.2019.8849118.
- [49] K. Mahmud et al., "Internet of Energy (IoE) paradigm with self-configurable capabilities to support grid monitoring and control," *Journal of Cleaner Production*, vol. 234, pp. 1158-1170, Oct. 2019, doi: 10.1016/j.jclepro.2019.06.174.
- [50] S. Martirano, F. L. Bellifemine, and G. Cellura, "Transactive energy systems in the context of the internet of energy: A review," *Energies*, vol. 14, no. 8, p. 2337, Apr. 2021, doi: 10.3390/en14082337.
- [51] T. Morstyn, A. Teytelboym, and M. D. McCulloch, "Bilateral contract networks for peer-to-peer energy trading," *IEEE Transactions on Smart Grid*, vol. 10, no. 2, pp. 2026-2035, Mar. 2019, doi: 10.1109/TSG.2017.2786668.
- [52] K. Zame, C. A. Brehm, A. T. Nitica, C. L. Richard, and G. D. Schweitzer III, "Smart grid and energy storage: Policy recommendations," *Renewable and Sustainable Energy Reviews*, vol. 82, pp. 1646-1654, Feb. 2018, doi: 10.1016/j.rser.2017.07.011.
- [53] D. Parra, M. Swierczynski, D. I. Stroe, S. A. Norman, A. Abdon, J. Worlitschek, T. O'Doherty, L. Rodrigues, M. Gillot, X. Zhang, C. Bauer, and M. K. Patel, "An interdisciplinary review of energy storage for communities: Challenges and perspectives," *Renewable and Sustainable Energy Reviews*, vol. 79, pp. 730-749, Nov. 2017, doi: 10.1016/j.rser.2017.05.003.
- [54] M. Cui, J. Zhang, Q. Wang, V. Jayaraman, and R. Ranjan, "Energy-efficient orchestration of edge computing services," *IEEE Transactions on Parallel and Distributed Systems*, vol. 32, no. 5, pp. 1064-1078, May 2021, doi: 10.1109/TPDS.2020.3044291.
- [55] M. N. Akhtar, Q. U. A. Haider, W. Javed, H. U. R. Siddiqui, N. Javaid, and K. Kamal, "Intelligent energy management of IoT-enabled smart homes under price-based demand response program in smart grid," *IEEE Access*, vol. 9, pp. 55415-55433, 2021, doi: 10.1109/ACCESS.2021.3072066.
- [56] Y. Lu, X. Huang, K. Zhang, S. Maharjan, and Y. Zhang, "Blockchain empowered asynchronous federated learning for secure data sharing in internet of vehicles," *IEEE Transactions on Vehicular Technology*, vol. 69, no. 4, pp. 4298-4311, Apr. 2020, doi: 10.1109/TVT.2020.2973651.
- [57] M. S. Hossain, S. Mahmood, S. Rahaman, S. Alshehri, and M. Alghamdi, "Sustainable energy efficient load forecasting using deep learning with optimized architecture and hyperparameters tuning," *Sustainable Cities and Society*, vol. 75, p. 103286, Dec. 2021, doi: 10.1016/j.scs.2021.103286.
- [58] S. Alshehri, S. Rahaman, M. Alghamdi, M. S. Hossain, S. Mahmood, and M. Alrubaian, "A novel hybrid deep learning model for wind power forecasting," *IEEE Access*, vol. 9, pp. 42986-42997, 2021, doi: 10.1109/ACCESS.2021.3066263.
- [59] R. Jiao, Y. Wang, and Y. Zhang, "Artificial intelligence in renewable energy: A review," *IEEE Access*, vol. 9, pp. 69313-69331, 2021, doi: 10.1109/ACCESS.2021.3077616.
- [60] Y. Zhang, S. Kasahara, Y. Shen, X. Jiang, and J. Wan, "Smart contract-based access control for the internet of things," *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 1594-1605, Apr. 2019, doi: 10.1109/JIOT.2018.2847705.
- [61] T. Dragičević et al., "Artificial intelligence for a sustainable energy system: A comprehensive review," *Renewable and Sustainable Energy Reviews*, vol. 158, p. 112158, Mar. 2022, doi: 10.1016/j.rser.2022.112158.
- [62] S. Barocas, M. Hardt, and A. Narayanan, *Fairness and machine learning: Limitations and opportunities*. MIT Press, 2019.
- [63] Y. Wang, Q. Chen, T. Hong, and C. Kang, "Review of smart meter data analytics: Applications, methodologies, and challenges," *IEEE Transactions on Smart Grid*, vol. 10, no. 3, pp. 3125-3148, May 2019, doi: 10.1109/TSG.2018.2818167.
- [64] H. Hao, Y. Xu, Y. Xie, and J. Zhang, "Blockchain-based decentralized energy trading platform: A comparison study," in *Proc. IEEE International Conference on Energy Internet (ICEI)*, Beijing, China, May 2019, pp. 242-247, doi: 10.1109/ICEI.2019.00048.
- [65] W. Strielkowski, D. Streimikiene, A. Fomina, and E. Semenova, "Internet of energy (IoE) and high-renewables electricity system market design," *Energies*, vol. 12, no. 24, p. 4790, Dec. 2019, doi: 10.3390/en12244790.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details