Indian Journal of Artificial Intelligence and Neural Networking (IJAINN)
ISSN: 2582-7626 (Online), Volume-5 Issue-5, August 2025

Artificial Intelligence in Energy Research and Climate Change

S. J. Haider, Vijay Kumar Srivastava, Baleshwar Kumar, Syed Zaheer Hasan

***Abstract:** Artificial intelligence (AI) plays a pivotal role in addressing climate change by accelerating energy research and aligning with global initiatives towards a sustainable future, with a notable focus on India, the world's fourth-largest economy, which is on track to become the third-largest economy. As a developing nation struggling with energy demand and climate adaptation/resilience, India stands at the convergence of innovation and necessity. This research paper presents the integration of AI technologies in optimising energy resources and enhancing grid efficiency in relation to climate patterns. Leveraging AI-driven solutions, one can transform the Indian energy sector by predicting energy demand/consumption, managing resources, and minimising carbon footprints. AI shall / may transform energy research in the following direction.*

- *Smart grids and energy optimization*
- *Energy distribution efficiency*
- *Reducing losses through integration with clean and renewable energy resources*

India, with its continued excellence in science and technology, needs to play a leading role in global AI collaborations. This association involves the inclusion of globally renowned organisations, such as the United Nations Development Programme (UNDP), the International Energy Agency (IEA), and the Conference of the Parties (COP) under the banner of the United Nations Framework Convention on Climate Change (UNFCCC), considering all aspects that govern solutions for global climate change through AI. The methodological approach focuses on accelerating the integration of artificial intelligence in managing energy resources and addressing climate change. Last but not least, AI can be considered an effective and affordable system-based tool that, along with emerging technologies, effectively addresses the challenges of climate change mitigation plans.

***Keywords:** Climate Change, Data Modelling, Energy Efficiency, Renewable Energy, Future Prediction*

Abbreviations:
UNDP: United Nations Development Programme
COP: Conference of the Parties
IEA: International Energy Agency
UNFCCC: United Nations Framework Convention on Climate Change
AI: Artificial Intelligence
WHO: World Health Organisation
DNNs: Deep Neural Networks
RNNs: Recurrent Neural Networks

I. INTRODUCTION

In recent years, the rapid expansion of Artificial Intelligence (AI) tools has collectively raised a life-changing wave, aligning with global concerns and addressing the challenges associated with climate change, which has led to the adoption of renewable and clean energy resources. This work aims to explore the practical implications of AI adoption, including decision-making and predictive modelling, while considering the environmental and lifecycle sustainability of implementing these technologies. By analysing a vast database of climate patterns and predictions of extreme weather events, while integrating AI technologies, we can enhance our understanding to address the climate crisis. Thus, the study paves the way to tackle climate change by processing a vast amount of data, combating the industrial revolution, where AI has transformational potential. The AI encompasses the creation of machine tools that are effectively capable of creating an unexpected surge in energy demand following climate-warming greenhouse gas emissions. This includes tasks such as visual perception and language understanding. In a broader sense, it is the intelligence exhibited by machines, particularly computer systems, to perceive their environment and use that intelligence to take actions to mitigate. According to the World Health Organisation (WHO), nearly four billion people reside in areas deemed highly vulnerable to climate change. There appear to be the following different ways in which AI will play a pivotal role in tackling climate change.

- Melting of icebergs can be measured faster to understand the quantum of release of meltwater into the ocean
- Rate of deforestation and its impact through satellite imagery on an extensive area network
- Technology to support prediction on weather patterns to plan adaptation and mitigation mechanisms
- Efficient waste management averts methane generation and emission
- Surface water cleaning set-up through remotely sensed data
- Alerting to climate disasters through conditioning of air/water/soil quality data
- Improving weather forecasting to predict the renewable energy output
- Industrial decarbonization through helping companies to track,

Manuscript received on 07 July 2025 | Manuscript Accepted on 15 August 2025 | Manuscript published on 30 August 2025.
*Correspondence Author(s)
S. J. Haider*, K-10, Sector-19, Gandhinagar-382019, Gujarat, India. Email ID: sjhaider@gmail.com, ORCID ID: 0009-0000-9559-5008
Prof. Vijay Kumar Srivastava, Former Vice Chancellor, Sankalchand Patel University, Ambaji-Gandhinagar State Highway, Visnagar (Gujarat), India. Email ID: drvks9@gmail.com
Dr. Baleshwar Kumar, Former Chief Scientist, NGRI, 5 / 80-A, V. V. Nagar, Street No., Habshiguda, Hyderabad (Telangana), India. Email ID: baleshk@yahoo.com
Dr. Syed Zaheer Hasan, Gujarat Energy Research and Management Institute, First Floor, Energy Building, PDEU Campus, Raisan, Gandhinagar (Gujarat), India. Email ID: szaheerhasan2001@yahoo.com

trace and reduce their emissions

- Reforestation through drones to drop seeds in unapproachable areas

Above all, AI will contribute to climate research through accurate climate system modelling, identifying data gaps, propagating emission inventories, articulating climate scenarios, and optimising low-carbon technology deployment. In addition, AI is also being integrated into weather and climate modelling to forecast patterns with greater consistency and efficiency. Moreover, AI's increasing role in climate and energy research raises concerns about energy consumption and ethical considerations across industries, where these challenges require transparency, accountability, and fairness in AI development and implementation. More specifically, the objectives are to highlight the newly obtained knowledge that engages aspects of AI in climate change and renewable energy arenas that have remained independent over the past several years. Significantly, the application is an easy inference-driven system with continuously increasing complexity and interconnected behaviour of the world energy system, particularly in the context of climate change.

II. METHODOLOGICAL APPROACH

Undoubtedly, there has been appreciable progress in the traditional approach to optimising modelling [1]. The policy issues concerning energy transitions [2], technological learning with cost reductions [3], and the intensification of the reliability of existing energy systems [4] are all essential considerations. This leads to emission reduction [5] with a straightforward approach to renewable energy resources [6], while decarbonising the transport system [7]. There appears to be a pivotal role of AI applications in overcoming the previously unanticipated approach. A few of these approaches are computationally intensive, consuming a vast variety of computing resources and time [8]. The advantage of working with AI applications is that they lead to a significant reduction in computational burdens, while maintaining predictive accuracy. This is achieved through iterative adjustments to the algorithm's parameters, which minimise the differences between the predicted and actual outputs. This process of fine-tuning efficiently enables algorithmic optimisation through batch gradient or stochastic gradient descent, while distinguishing and predicting continuous results [9]. These variants differ mainly in how they process data and optimise model parameters, assuming sufficient time and a proper learning rate.

There are unprecedented advances in addressing challenges such as overfitting and underfitting, where the developed model memorises the data without generalising to new data. Innovations have been made to these models, including the advanced regularisation techniques with data upgradation, which improve the model's robustness and performance [10]. The utilisation of deep neural networks (DNNs) has significantly enhanced the approach, particularly in processing datasets. Convolutional neural networks (CNNs) combined with recurrent neural networks (RNNs) are used for sequential data, setting new standards in terms of accuracy and efficiency [11]. Subsequently, the apparently significant breakthroughs in neural language processing and other domains highlight the transformative potential [12].

While addressing the challenges associated with integrating renewable energy into electric grids and the need for accurate forecasting of electricity consumption [13], it is proposed to adopt a hybrid approach for efficient power forecasting. The trends in power consumption utilising renewable and non-renewable energy sources provide a thorough comparison with other prediction methods, considering variables such as loss of load probability and market fluctuations, as well as renewable energy sources [14].

The integration of AI into the energy system appears to mark a significant technological advancement, which may introduce new methodologies for managing energy, encompassing generation, distribution, and consumption. The role of AI lies in detecting climate signals through extensive simulations [15], which provides an interpretable framework for assessing climate data and the effects of various external factors. While navigating the complexities of climate research, it is essential to bridge the gap between short-term climate simulations and long-term projections to influence regional climate change [16]. By modelling this relationship through large-scale simulations, the interactions within the Earth's climate system are disentangled to aid comprehension of the impacts of different emission scenarios.

III. LIMITATIONS

The data dependency of all the proposed AI models carries significant limitations, as they are highly reliant on large, qualitative datasets. In the event of any missing data, the prediction is assumed to be unreliable to some extent. Furthermore, existing data silos limit the sharing of valuable information across different sources, which may, in turn, hinder the development of comprehensive models effectively.

Another limitation is the potential for overfitting, where a model performs well but fails to generalise to unseen or real-world data. This may be attributed to the energy systems, which have variables such as weather conditions and infrastructure changes that can drastically impact energy production and consumption patterns. Additionally, integrating AI into traditional energy infrastructures and upgrading the system can be both costly and technically challenging.

IV. CONCLUSION

Prospects for AI use in technical and energy systems highlight the effectiveness of optimisation methods in addressing the challenges, especially those associated with data instability. Existing methods, combined with high-performance computing systems and universal algorithms for optimisation, form a substantial domestic software foundation. The potential of this software, particularly in the renewable energy sector, is based on artificial intelligence that leverages improved resource management.

Furthermore, research and updates for existing approaches are essential components to optimise renewable energy sources using AI techniques.

Retrieval Number: 100.1/ijainn.E110405050825
DOI: 10.54105/ijainn.E1104.05050825
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

Finally, the methodological approach identifies AI as a key factor in the development of advanced energy systems, which are wholly data-driven. AI is becoming a tool to enhance performance and improve efficiency under various constraints, leading to efficient and technically optimal alternatives that eliminate human errors. Last but not least, it can be inferred that the energy industries will need to prioritise the integration of AI technologies into their existing technical systems. Additionally, it is essential to understand that AI can be one of the system-based, affordable, and sustainable emerging technologies that effectively address climate change mitigation plans and associated challenges.

ACKNOWLEDGEMENTS

The authors are highly indebted to all their colleagues for their guidance and technical support. The cooperation extended by the co-workers is also deeply acknowledged.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

REFERENCES

1. DeLuque and Shittu, E., 2019, Generation capacity expansion under demand, capacity factor and environmental policy uncertainties. Comput. Ind. Eng., 127 (2019), pp. 601-613, DOI: https://doi.org/10.1016/j.cie.2018.10.051
2. Pourahmadi, F., Hosseini, S. H., Dehghanian, P., Shittu, E. and Fotuhi-Firuzabad, M., 2020, Uncertainty cost of stochastic producers: Metrics and impacts on power grid flexibility. IEEE Trans. Eng. Manage, 69 (3), pp. 708-719, DOI: https://doi.org/10.1109/TEM.2020.2970729
3. Pan, W., & Shittu, E. (2023). Policies and power systems resilience under a time-based stochastic process of contingencies in networked microgrids. IEEE Trans. Eng. Manage, DOI: https://doi.org/10.1109/TEM.2023.3325188.
4. Deluque, I., Shittu, E. and Deason, J., 2018, Evaluating the reliability of efficient energy technology portfolios. EURO J. Decis. Process, 6 (1–2), pp. 115-138, DOI: https://doi.org/10.1007/s40070-018-0077-4
5. Deluque, I., Shittu, E. and Deason, J., 2018, Evaluating the reliability of efficient energy technology portfolios. EURO J. Decis. Process, 6 (1–2), pp. 115-138, DOI: https://doi.org/10.1007/s40070-018-0077-4
6. Gai, D. H. B., Ogunrinde, O. and Shittu, E., 2020. Self-reporting firms: Are emissions truly declining for improved financial performance? IEEE Eng. Manag. Rev., 48 (1), pp. 163-170, DOI: https://doi.org/10.1109/EMR.2020.2969405
7. Gai, D. H. B., Shittu, E., Attanasio, D., Weigelt, C., LeBlanc, S. and Dehghanian, P., 2021, Examining community solar programs to understand accessibility and investment: Evidence from the U.S. Energy Policy, 159, DOI: https://doi.org/10.1016/j.enpol.2021.112600
8. Wang, T., Deason, J. and Shittu, E., 2024, The interplay of incentives, electricity price and demand on transport decarbonization: the case of electric vehicles in the U.S., IEEE Eng. Manag. Rev, DOI: https://doi.org/10.1109/EMR.2023.3347147
9. Sun, S., Cao, Z., Zhu, H. and Zhao, J., 2019, A survey of optimization methods from a machine learning perspective. IEEE Trans. Cybern. 50 (8), pp. 3668-3681, DOI: https://doi.org/10.48550/arXiv.1906.06821
10. Kotsilieris, T, Anagnostopoulos, I. and Livieris, I. E., 2022, Special issue: Regularization techniques for machine learning and their applications. Electronics, 2079-9292, 11 (4), DOI: https://doi.org/10.3390/electronics11040521
11. Xin, M. and Wang, Y., 2019, Research on image classification model based on deep convolution neural network. EURASIP J. Image Video Process, (1), DOI: https://doi.org/10.1186/s13640-019-0417-8
12. Sarker, I. H., 2021, Deep learning: a comprehensive overview on techniques, taxonomy, applications and research directions. SN Comput. Sci., 2 (6), p. 420, DOI: https://doi.org/10.1007/s42979-021-00815-1
13. Khan, P. W., Byun, Y. C., Lee, S. J., Kang, D. H., Kang, J. Y. and Park, H. S., 2020, Machine learning-based approach to predict energy consumption of renewable and non-renewable power sources. Energies, 13 (18), p. 4870, Publisher: MDPI, DOI: https://doi.org/10.3390/en13184870
14. Lucas, A., Pegios, K., Kotsakis, E. and Clarke, D., 2020, Price forecasting for the balancing energy market using machine-learning regression. Energies, 13 (20), p. 5420, Publisher: MDPI, DOI: https://doi.org/10.3390/en13205420
15. Labe, Z. M. and Barnes, E. A., 2021, Detecting climate signals using explainable AI with single-forcing large ensembles—Journal of Advanced Modelling Earth System, 13 (6), DOI: https://doi.org/10.1029/2021MS002464
16. Mansfield, L. A., Nowack, P. J., Kasoar, M., Everitt, R. J., Collins, W. J. and Voulgarakis, A., 2020, Predicting global patterns of long-term climate change from short-term simulations using machine learning. Npj. Clim. Atmos. Sci., 2397-3722, 3 (1), p. 44, DOI: https://doi.org/10.1038/s41612-020-00148-5

AUTHORS' PROFILE

S. J. Haider is a senior IAS officer from the 1991 batch of the Gujarat cadre. With a strong academic background in physics and decades of dedicated service, he has been entrusted with crucial leadership roles in multiple departments. Currently, he serves as the Additional Chief Secretary of the Energy & Petrochemicals Department, Government of Gujarat. His administrative journey reflects his versatility and commitment across various industries, including education, energy, and governance. His in-depth analytical training in science refined his logical and problem-solving skills, which later enabled him to excel in administration and policy-making. His extensive service record across education, industry, energy, rural development, and transportation speaks to his administrative skills. His career is a testament to the impact that dedicated public servants can have on the development and governance. His leadership in the Energy and Petrochemicals Department is particularly significant with the growing focus on renewable energy, sustainable practices, and industrial innovation. His strategic vision ensures that the state remains at the forefront of these developments, addressing both economic and environmental priorities. He played a key role in the formulation of several government policies in Gujarat, including the IT Policy, Electronics Policy, Tourism Policy, Student Start-up & Innovation Policy 2.0, and the State Action Plan on Climate Change. Attended several International Conferences like COP-21 (Paris, 2015), COP-27 (Egypt, 2022), COP-29 (Baku, 2024), New York Climate Week (NYC, 2024), etc. He played a crucial role in organising landmark programs, including the Vibrant Gujarat Global Summit (2024), the launch of Mission LiFE (2022), and RE-Invest by the MNRE (2024), among others. He is a recipient of the Best Collector's Award, Kaushalyacharya Award, Census Medal, Award for the Promotion of Start-ups, etc.

Professor Vijay Kumar Srivastava is the former Vice Chancellor of Maharaja Sayajirao University of Baroda. Before joining MS University, he had served as Vice Chancellor of Indus University, Ahmedabad, and Sankalchand Patel University, Visnagar. He is also a member of the State Environmental Impact Assessment Authority. Dr. Srivastava has held several key positions in various universities over the years. These include the GSFC University, Vadodara, Pandit Deendayal Energy University, and other esteemed institutions. In addition to his administrative experience in educational institutions, he has authored several research papers and publications. He has expertise in wastewater treatment, solid waste management, environmental issues related to industries, and energy recovery using plasma technology.

Dr. Baleshwar Kumar has over 40 years of Research and Development Experience at National Geophysical Research Institute (NGRI), Hyderabad in Oil, Gas & Fossil Fuel Research & Development; Geochemical & Geophysical Instrumentation; Climate Change & Carbon Management; Energy Security and Sustainability; Geochemical Prospecting of Hydrocarbons; and Isotope Geology/ Geochemistry and its applications to Geohydrology, Geothermal Research, Hydrocarbon Exploration, Early Evolution of Life, Carbon Budget Changes, Event Stratigraphy and Palaeo-environmental Studies etc. Dr. Kumar has established the National Facility for Surface Geochemical and Microbial Prospecting of Hydrocarbons at NGRI with a grant of approximately Rs. 70 million from OIDB, comprising isotope mass spectrometry, Gas Chromatographs, GC-MS, and a total organic analyser, among other equipment. He led integrated geochemical surveys for Hydrocarbon Research & Exploration in frontier oil and gas offshore basins and NELP blocks of India, covering an area of 0.6×10^6 sq. km. He was a lead coordinator for the project on Geological CO_2 Sequestration in basalt formations of Western India: A Pilot Study (planned by DST, Ministry of Power, National Thermal Power Corporation, and Battelle Pacific Northwest National Laboratory, USA). He is a fellow of several national and international associations, including the American Association of Petroleum Geologists. He is a global expert in unconventional shale oil and gas research and development, as well as carbon capture and Storage (CCS). Dr Kumar has participated in Oil Shale Symposiums at the Colorado School of Mines (CSM), Golden, Colorado, USA, from 2008 to 2013, and has delivered invited talks. Dr. Kumar served as the Chairman of the Technical Committee for the organisation of the International Conference on 'Unconventional Sources of Fossil Fuel and Carbon Management', held at the Gujarat Energy Research and Management Institute, Gandhinagar, Gujarat, in February 2011. The conference was organised in association with the Colorado School of Mines in Golden, USA.

Dr. Syed Zaheer Hasan is working as Director & Scientist-H in Petroleum Research Management of Gujarat Energy Research and Management Institute, Gandhinagar, Gujarat. His research achievements are evidenced by the sanction of a postdoctoral research fellowship by the Department of Science and Technology, Government of India, under the Young Scientist Scheme, followed by research publications and active participation in conferences and seminars. Additionally, the number of R&D projects sanctioned by national and state funding agencies. He is a Fellow and a member of various national and international scientific societies. Additionally, he serves as the chief editor, a member of editorial boards, and a reviewer for multiple scientific magazines. Recently, he has been felicitated with the "Bharat Ratna Dr. Abdul Kalam Gold Medal Award" on the occasion of the 77th National Unity Conference, which was organised by the Global Economic Progress and Research Association (GEPRA) to recognise individual achievements and national development. Dr. Zaheer has two decades of research experience, is a recipient of research fellowship, post-doctoral fellowship, fellowships of the Indian Geophysical Union and Geological Society of India, having thirty-six publications in various reputed National and International journals, while contributing three book chapters and several abstracts across multiple conference proceedings, besides supervising one Ph. D. awarded during the year 2018. Considering all his achievements and outstanding contributions in the field of science and technology for community welfare, the National Environmental Science Academy (NESA) has awarded him the NESA Scientist of the Year Award 2021.