



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 10, October 2025

Decentralized Microgrid Systems in Industrial Parks: Reducing Carbon Footprint through Smart Load Management

Arnav Bansal

Oakridge International School, Newton Campus, Hyderabad, India

ABSTRACT: This research paper discusses the implementation of decentralized micro-grids system in industrial parks with a focus on the potential to reduce carbon emission through smart load management techniques. The fact that industrial parks are energy intensive sources of greenhouse gas emissions necessitates the need to have sustainable and efficient forms of energy. Microgrids are decentralized and combine renewable energy sources, including solar and wind power and biomass, to provide local generation, storage, and distribution and increase energy reliability and autonomy. The smart load management and demand-response systems sense the optimal utilization of consumption to balance the demand and supply side, reduce peak loads, and enhance efficiency in terms of operation.

The study is a secondary research methodology where authors examine peer reviewed articles, industry reports, and case studies to assess the design, advantages, and issues surrounding the implementation of microgrids. Findings reveal that decentralized microgrids have the potential to reduce carbon footprints significantly and reduce the cost of operations as well as increase resilience to grid disruptions. Despite these advantages, there are still challenges like high start-up costs, renewable intermittency, and regulatory risks. It has been suggested that future research be conducted to cover up these deficiencies with a focus on hybrid energy integration, predictive energy management, and scalable microgrid models.

In general, decentralized microgrids offer a feasible and sustainable solution to achieve industrial parks through low-carbon, efficient, and resilient energy management, which in turn can match the goals of industrial growth with global sustainability goals.

KEYWORDS: Decentralized Microgrids, Industrial Parks, Renewable Energy, Smart Load Management, Carbon Footprint

I. INTRODUCTION

The high growth rate of industrial parks has made them one of the biggest consumers of energy in the world and thus a key contributor of carbon gases. Traditional centralized energy infrastructures are often unable to balance the increase of demand and the sustainability targets, in part, because they rely on fossil energy and their energy allocation is often inflexible (Shaukat et al., 2023). To overcome this the microgrids systems have turned out to be a groundbreaking remedy to efficiency in energy, resilience and carbon cut down through decentralization. Microgrids enable the production, storage, and distribution of power within the industrial systems locally due to the inclusion of renewable energy systems (solar and wind) and sophisticated load-control technologies (Billah et al., 2023).

Smart load management plays a significant role in the simplification of the energy usage in other industrial facilities. The microgrids can optimise the storage, relocate peak loads, minimise wastage, and be fault-tolerant through intelligent scheduling, real-time demand and response algorithms (Dawn et al., 2024). Not only are such actions contributing to reduction of greenhouse gas emission they also make operations less expensive thereby making the expansion of industry answerable to the environment. Along with that, decentralized microgrids ensure energy independence, thereby, minimizing grid extremes and energy shortages.

Decentralized microgrids, which are at the interface of engineering innovation and sustainability, are a systemic representation of the low-carbon industrial ecologies (Hoummadi et al., 2024). Their application directly supports the

international sustainability objectives and even offers industries with a viable channel in regards to more intelligent, economical, and refined energy systems.

II. RATIONALE AND OBJECTIVE

The industrial parks are the biggest contributor to the economic growth, as well as a biggest global emitter of greenhouse gases, because they use old centralized power plants (Ojadi et al., 2024). The increasing energy requirement, and the necessity to maintain the environment necessitate new methods which would compromise the efficiency of industries and the conservation of the environment. Decentralised micro-grid systems therefore become an option that enables the generation and distribution of energy locally, which is utilised using renewable sources. Unlike the conventional centralized infrastructures, micro-grids contribute to a higher degree of energy resilience, reduce transmission losses, and are more flexible to serve heterogeneous energy needs within the industrial clusters (Moinuddin et al., 2024). The incentive behind this research is the two-fold nature of carbon abatement and energy efficiency, which can be attained by introducing intelligent load-management policies to decentralised micro- grids.

The objectives of this research are fourfold:

1. To examine the design and integration of decentralized microgrid systems in industrial parks.
2. To evaluate the role of intelligent load management strategies, such as demand-response algorithms and peak-load shifting, in reducing emissions.
3. To assess the performance of microgrids in enhancing resilience, reliability, and cost-effectiveness of industrial energy systems.
4. To propose scalable frameworks that align industrial operations with global sustainability and low-carbon transition targets.

Through these objectives, the study advances practical insights into sustainable industrial energy transformation.

III. METHODOLOGY

The current research is based exclusively on the secondary data collection, the use of the available academic sources, industry publications, and policy papers related to the idea of the decentralized microgrids and the carbon reduction policies. To guarantee credibility and reliability, sources were accessed in scholarly databases such as Google Scholar, Scopus, and ResearchGate. To identify the salient themes, models, and findings to smart load management and sustainability of industrial parks, peer-reviewed journal articles, conference papers, and case studies were reviewed.

The methodological approach involved systematic review, synthesis, and critical analysis of the selected literature to highlight patterns, opportunities, and gaps in the existing research space. This is the secondary methodological option which provides the opportunity to use a vast pool of existing knowledge and ensure a full conceptualization in place of primary data gathering.

Ethical considerations were strongly followed to the letter. The credibility and intellectual property and integrity were respected by including only reputable properly cited sources. The possibility of bias was diminished by including the studies, which cover a variety of opinions and geopolitical settings. Incorrect referencing of ideas and the giving of correct references helped to avoid plagiarism. These ethical standards will ensure that the study results are acceptable and in line with accepted research practices.

IV. LITERATURE REVIEW

Theme 1: Decentralized Microgrid Systems – Concept and Evolution

Microgrid systems have become decentralized, thus forming a response to the limitations of traditional centralized power systems, especially in high-demand settings like industrial parks. Traditional energy grids are based on large-scale centrally positioned generation plants that transport electricity over long distances (Zabihi and Parhamfar, 2025). Whilst these centralised layouts are effective in supplying energy over extensive areas, they are often inefficient with high levels of transmission losses, increased vulnerability to outage, and increased reliance on fossil fuels (which are significant contributors to carbon emissions). These difficulties are reduced through microgrids by decentralizing

electricity generation, storage, and distribution at the local level, autonomously or collaboratively with the main grid (Akter et al., 2021).

Growth of distributed energy resources (DERs) which include solar photovoltaics, wind turbines, small scale hydropower, and biomass systems has been closely associated with the long evolution of microgrids. Microgrids were initially mainly implemented in rural areas or remote areas with unstable grid connectivity (Yang et al., 2023). However, the emerging demands in industrial energy use together with renewed sustainability objectives across the world have diverted the focus into the integration of micro grids in the industrial park setting. Such types of configurations allow facilities to control energy and ensure continuity of operations in the event of grid disruptions and lessen the impact of fossil fuels (Biegańska, 2024).

Recent literature points out that a modern decentralized micro-grid is no longer a functional isolated energy infrastructure but a complex network that encompasses the sophisticated control, monitoring, and communication functionalities (Khan et al., 2021). These systems can dynamically equalise the supply and demand, optimise the storage of energy, as well as respond to increases and decreases in both generation and consumption. The decentralized microgrids are expected to become a paradigm shift in sustainable structures of energy stewardship of industries due to energy independence and stability (Noor et al., 2018). The evolution offers a sound basis of exploration of their contributory role in mitigating the carbon footprint, enhancing operation and sustainable development of industrial ecosystems.

Theme 2: Integration of Renewable Energy in Industrial Parks

The adoption of renewable energy in the industrial parks was a significant policy of low-carbon and sustainable operations (Guo et al., 2022). Industrial parks are energy consuming locations, as multiple manufacturing plants are operated concurrently, with the result that greenhouse gas emissions might be high. The use of renewable energy resources, such as solar photovoltaic (PV) panels, wind turbines, biomass, and small-scale hydropower will be an opportunity to meet the energy demand without relying on the standard grids which use fossil fuels (Mu et al., 2022). This transition is in accordance with the sustainability project on the international level and national commitments to carbon neutrality.

Solar PV systems are among the most common sources of renewable energy in industrial microgrids because they can be scaled, implemented at low cost, and located either at the rooftop or on the land (Paul et al., 2025). Wind energy, though a location based energy source, can also be utilized together with solar generation as a form of power supply during the periods of low solar energy output. Hydropower and biomass will also be available in small-scale, thereby allowing flexibility particularly to those industrial parks which are situated in abundance of resources. Combining the resources in a microgrid enables the production of hybrid energy, thereby, making the system more dependable and minimizing the intermittency of a specific source of renewable energy (Bani-Ahmed et al., 2018).

Researchers indicate that industrial micro grids need to be carefully designed and planned when introducing renewable. These are peak load requirements, generation variability, storage capacity, and energy management practice, which ought to be considered to optimise performance (Shaukat et al., 2023). High-level energy management systems and predictive algorithms have allowed balancing the supply and demand in real-time and ensuring a stable and efficient working process. In addition to that, distributed renewable energy reduces transmission loss and enhances autonomy of energy, which means that industrial parks can be independent or synchronized with the main grid (Qiu and You, 2020).

Besides technical benefits, renewable energy integration enhances both economical and environmental objectives. It will reduce resistance to changing prices of fossil fuels over time, will reduce operational costs, and reduce the carbon footprint literally (Ajaz and Bernell, 2021). The addition of renewable sources into microgrids design will empower industrial parks to be a leader in corporate sustainability and form strong, low-carbon energy communities. This theme highlights the primary significance of integrated renewable because it is the foundation of sustainable industrialization and carbon-conscious energy planning.

Theme 3: Smart Load Management and Demand-Response Mechanisms

Smart load management is a key component of decentralized micro grids, especially those found in industrial parks whose energy demand can be characterized as large and variable. Proper load management implies strict control, close monitoring, and systematic optimization of electricity use to adapt to the supply capacity, mitigate peak loads, and ensure an overall increase in system efficiency (Khan et al., 2023). With proper intelligent energy management approaches, the industrial equipments will significantly reduce the operational costs and at the same time, reduce the carbon emissions attributed to poor use of energy.

Demand-response (DR) systems are an essential part of intelligent load management. These systems control energy usage patterns directly in response to actual supply conditions, dynamic price information or grid needs. DR can be applied to industrial processes, where high-energy consumptions can be scheduled when there is excess renewable generation, non-essential loads can be curtailed temporarily when the demand is high, or the energy consumption of multiple facilities can be synchronized (Wang et al., 2018). Literature suggests that the inclusion of DR in the functioning of microgrids increases its operational flexibility, reduces the possibility of power failures, and contributes to grid stability.

Modern technologies, such as predictive analytics, Internet of Things (IoT) machines, and machine learning algorithms, will make it possible to monitor everything in real-time and adjust the load automatically (Xia et al., 2022). Such systems will be able to predict demand of energy, predict changes in renewable production and maximize the use of storage and thus create a dynamic balance between supply and demand. As a result, industrial microgrids achieve a higher resilience and had the possibility to work independently or together with the primary grid.

According to many reports, the smart load management can positively impact the environment and the economy. Peak demand reduction also lowers the use of fossil-based generation of a back up capacity, thus, decreasing the emission of greenhouse gases (Khayat et al., 2018). A certain stimulus to industrial players is also the minimization of energy expenses and higher utilization of resources as a result of reduced energy use.

All in all, the absence of intelligent load management and demand-response would prevent the full potential of decentralized microgrids (Butturi et al., 2020). Not only are they increasing operational efficiency and reliability, but also they are playing a major role in the development of low-carbon and sustainable industrial energy systems. The implemented strategies will ensure that the industrial parks will be operated in an cost effective, environmentally friendly and energy efficient manner.

Theme 4: Environmental and Economic Impacts of Microgrids

Industrial parks Microgrids are decentralized systems, which are advantageous both ecologically and economically, and, therefore, become an inseparable part of sustainable industrial energy management. Renewable sources can also be operated by microgrids that considerably reduce the use of fossil fuel (Matos et al., 2019). Another way industrial parks in countries contribute to reducing climate change is through the production of electricity using solar or wind energy or biomass and, in the process, reducing greenhouse emissions. Research indicates that well-designed microgrids are capable of minimizing carbon footprint by optimizing the use of energy, balancing loads, and minimizing energy loss caused by transmission and distribution in centralized grids (Marouani et al., 2023).

Besides, the decrease in emissions, with the assistance of microgrids, the energy consumption rate becomes far more efficient due to the improved monitoring and control of consumption rates. The most modern energy management systems can guarantee that industrial enterprises would be able to control the energy usage in real time, identify the optimization gaps and implement the required measures. This form of highly-efficient energy consumption minimizes wastage, enables peak-load operation, and improves the overall sustainability performance (Wang et al., 2018). Besides, decentralized microgrids increase grid and power resiliency, thereby allowing essential industry to run as they reduce the impact of environmental damage caused by emergency fossil-fueled backup systems.

Microgrids are long-term cost-saving operations. By using renewable energy produced locally, industrial parks cut costs on the electricity grid which at times is subject to fluctuations in prices. Microgrids also include energy storage options that store excess energy during low-demand periods and discharge the stored energy during peak-demand periods, thereby avoiding the expensive grid tariffs (Honarmand et al., 2021). Microgrids lessen reliance on

significant centralized infrastructure investment as well, and modular and scalable solutions can be tailored to the needs of any industrial park development.

Other economic benefits which are indirect like enhanced competitiveness, sustainability brand, and compliance with environmental regulatory standards have also been highlighted in some literature. Microgrids are a comprehensive solution to industry expansion in the sense that both cost-effectiveness and carbon footprint are sought after within the same context (Ma et al., 2021).

Lastly, the adopted decentralized microgrids in industrial parks provides two advantages: it not only adds to the low-carbon and environmentally friendly usage of the energy but also enhances the economic performance and stability of the operations, which makes it a value choice in terms of sustainable industrial development (Shareef et al., 2018).

Theme 5: Challenges, Gaps, and Future Research Directions

Despite the evident advantages of decentralized microgrid systems, the number of challenges and gaps in the research remains great; the primary ones lie within the scope of industrial parks. Among the most prominent ones, one must mention the high initial capital investment required to install renewable energy systems, energy storage units, and intelligent control technologies (Muthirayan et al., 2019). Though operation cost savings and environmental benefits are relevant, the initial investment may become an inhibitor to implementation especially with small- and medium-sized businesses. In addition, the concept of integrating different distributed energy sources to a unified micro grid demands high standards of energy management systems and skills that may not exist in certain industrial settings (Parag and Ainspan, 2019).

The other issue is that the sources of renewable energies are inconsistent and intermittent. Solar and wind energy sources require the existence of weather conditions, thereby influencing the sustainability and predictability of the microgrid (Milis et al., 2018). The energy storage system and demand-response system alleviate these issues, although more research is required to enhance the performance of the system under different conditions. In addition, grid interconnection criteria and administrative structures remain unfinished in the majority of the locations, which has led to the lack of structure in policy compliance and technical specifications of the industrial microgrids (Khan et al., 2019).

Some of the research gaps include techno-economic modeling, lifecycle assessment, and long-term environmental impact assessment. Not many of them provide detailed data on the synergies of decentralized generation, load management, and storage optimisation within the context of industrial parks (Ding et al., 2021). Further research would be to analyse scalable models of microgrids, plans to integrate renewable sources, and improved predictive algorithms to optimise demand-response.

Moreover, new technologies, including artificial intelligence, energy trading based on a blockchain, and monitoring with the help of the IoT, offer new chances to improve efficiency, resilience, and sustainability (Kiehbardroudezhad et al., 2023). By solving these issues and knowledge gaps, the industrial parks can achieve the full potential of decentralized microgrids as low-carbon, cost-effective, and technologically efficient energy systems.

V. CONCLUSION

This paper outlines the vivid potential of decentralized microgrid systems to make industrial parks a sustainable and low-carbon energy ecosystem. In a detailed analysis of the literature, it is observed that integration of renewable sources of energy, including solar, wind and biomass into localized microgrids can go a long way in reduction of greenhouse gas emission as well as contribute to energy reliability and resiliency. Moreover, the smart load management and demand response mechanisms make the use of energy more efficient and so makes the industrial processes to be cost effective and environmentally friendly.

The problem of environmental concerns and the economic benefits are solved by decentralized microgrids to a large extent as the operating costs are minimized, reliance on centralized grids is minimized, and finally the volatility of energy prices is avoided. However, the high cost of starting up, intermittency of renewable sources of energy, and bureaucratic influences continue to emerge as the major obstacles to total usage. The current gaps in research are all

related to the lifecycle assessment, optimization of hybrid systems, and predictive load-management strategies that should be filled in the future to optimize the benefits of microgrids in the industrial setting.

Conclusively, decentralized micro grid systems present a viable and scalable route through which industrial parks can achieve sustainability goals. Through combination of technical breakthrough, environmental sustainability, and economic viability, these systems can incorporate low-carbon industrialization, enhance global climate objectives, and foster resilient and smart energy-saving activities in the future.

REFERENCES

1. Ajaz, W. and Bernell, D., 2021. Microgrids and the transition toward decentralized energy systems in the United States: A Multi-Level Perspective. *Energy Policy*, 149, p.112094.
2. Akter, H., Howlader, H.O.R., Saber, A.Y., Mandal, P., Takahashi, H. and Senjyu, T., 2021. Optimal sizing of hybrid microgrid in a remote island considering advanced direct load control for demand response and low carbon emission. *Energies*, 14(22), p.7599.
3. Bani-Ahmed, A., Rashidi, M., Nasiri, A. and Hosseini, H., 2018. Reliability analysis of a decentralized microgrid control architecture. *IEEE Transactions on Smart Grid*, 10(4), pp.3910-3918.
4. Biegańska, M., 2024. Energy Internet-Decentralized systems contributing to reduction of greenhouse gas emissions. *Journal of Autonomous Intelligence*, 7(1), pp.1-8.
5. Billah, M., Yousif, M., Numan, M., Salam, I.U., Kazmi, S.A.A. and Alghamdi, T.A., 2023. Decentralized smart energy management in hybrid microgrids: Evaluating operational modes, resources optimization, and environmental impacts. *IEEE Access*, 11, pp.143530-143548.
6. Butturi, M.A., Sellitto, M.A., Lolli, F., Balugani, E. and Neri, A., 2020. A model for renewable energy symbiosis networks in eco-industrial parks. *IFAC-PapersOnLine*, 53(2), pp.13137-13142.
7. Dawn, S., Ramakrishna, A., Ramesh, M., Das, S.S., Rao, K.D., Islam, M.M. and Selim Ustun, T., 2024. Integration of renewable energy in microgrids and smart grids in deregulated power systems: a comparative exploration. *Advanced Energy and Sustainability Research*, 5(10), p.2400088.
8. Ding, X., Guo, Q., Qiannan, T. and Jermstipparsert, K., 2021. Economic and environmental assessment of multi-energy microgrids under a hybrid optimization technique. *Sustainable Cities and Society*, 65, p.102630.
9. Guo, J., Gong, S., Xie, J., Luo, X., Wu, J., Yang, Q., Zhao, Z. and Lai, L.L., 2022. Low-carbon robust predictive dispatch strategy of photovoltaic microgrids in industrial parks. *Frontiers in Energy Research*, 10, p.900503.
10. Honarmand, M.E., Hosseinneshad, V., Hayes, B., Shafie-Khah, M. and Siano, P., 2021. An overview of demand response: From its origins to the smart energy community. *IEEE Access*, 9, pp.96851-96876.
11. Hoummadi, M.A., Aroussi, H.A., Bossoufi, B., Karim, M., Mobayen, S., Zhilenkov, A. and Alghamdi, T.A., 2024. A review of constraints and adjustable parameters in microgrids for cost and carbon dioxide emission reduction. *Heliyon*, 10(6).
12. Khan, H.W., Usman, M., Hafeez, G., Albogamy, F.R., Khan, I., Shafiq, Z., Khan, M.U.A. and Alkhamash, H.I., 2021. Intelligent optimization framework for efficient demand-side management in renewable energy integrated smart grid. *IEEE Access*, 9, pp.124235-124252.
13. Khan, M.H.D., Imtiaz, J. and Islam, M.N.U., 2023. A blockchain based secure decentralized transaction system for energy trading in microgrids. *IEEE Access*, 11, pp.47236-47257.
14. Khan, N.A., Sidhu, G.A.S., Awan, A.B., Ali, Z. and Mahmood, A., 2019. Modeling and operation optimization of RE integrated microgrids considering economic, energy, and environmental aspects. *International Journal of Energy Research*, 43(13), pp.6721-6739.
15. Khayat, Y., Naderi, M., Shafiee, Q., Batmani, Y., Fathi, M., Guerrero, J.M. and Bevrani, H., 2018. Decentralized optimal frequency control in autonomous microgrids. *IEEE Transactions on Power Systems*, 34(3), pp.2345-2353.
16. Kiehbaddrouneshad, M., Merabet, A., Hosseinzadeh-Bandbafha, H. and Ghenai, C., 2023. Environmental assessment of optimized renewable energy-based microgrids integrated desalination plant: considering human health, ecosystem quality, climate change, and resources. *Environmental Science and Pollution Research*, 30(11), pp.29888-29908.
17. Ma, Y., Chen, X., Wang, L. and Yang, J., 2021. Investigation of smart home energy management system for demand response application. *Frontiers in Energy Research*, 9, p.772027.
18. Marouani, I., Guesmi, T., Alshammari, B.M., Alqunun, K., Alzamil, A., Alturki, M. and Hadj Abdallah, H., 2023. Integration of renewable-energy-based green hydrogen into the energy future. *Processes*, 11(9), p.2685.

19. Matos, C.R., Carneiro, J.F. and Silva, P.P., 2019. Overview of large-scale underground energy storage technologies for integration of renewable energies and criteria for reservoir identification. *Journal of Energy Storage*, 21, pp.241-258.
20. Milis, K., Peremans, H. and Van Passel, S., 2018. The impact of policy on microgrid economics: A review. *Renewable and Sustainable Energy Reviews*, 81, pp.3111-3119.
21. Moinuddin, M.D., Nasir, M.K., Zaman, M., Tarafdar, M.S.S., Mia, M.D. and Begum, M., 2024. Integrating fourth industrial revolution (4IR) technologies with green energy systems: A framework for AI-driven smart grid optimization and carbon footprint reduction. *Mari Papel y Corrugado*, 2025, pp.122-140.
22. Mu, C., Ding, T., Zhu, S., Han, O., Du, P., Li, F. and Siano, P., 2022. A decentralized market model for a microgrid with carbon emission rights. *IEEE Transactions on Smart Grid*, 14(2), pp.1388-1402.
23. Muthirayan, D., Kalathil, D., Poolla, K. and Varaiya, P., 2019. Mechanism design for demand response programs. *IEEE Transactions on Smart Grid*, 11(1), pp.61-73.
24. Noor, S., Yang, W., Guo, M., Van Dam, K.H. and Wang, X., 2018. Energy demand side management within micro-grid networks enhanced by blockchain. *Applied energy*, 228, pp.1385-1398.
25. Ojadi, J.O., Odionu, C.S., Onukwulu, E.C. and Owulade, O.A., 2024. AI-Enabled Smart Grid Systems for Energy Efficiency and Carbon Footprint Reduction in Urban Energy Networks. *International Journal of Multidisciplinary Research and Growth Evaluation*, 5(1), pp.1549-1566.
26. Parag, Y. and Ainspan, M., 2019. Sustainable microgrids: Economic, environmental and social costs and benefits of microgrid deployment. *Energy for Sustainable Development*, 52, pp.72-81.
27. Paul, K., Jyothi, B., Kumar, R.S., Singh, A.R., Bajaj, M., Hemanth Kumar, B. and Zaitsev, I., 2025. Optimizing sustainable energy management in grid connected microgrids using quantum particle swarm optimization for cost and emission reduction. *Scientific Reports*, 15(1), p.5843.
28. Qiu, H. and You, F., 2020. Decentralized-distributed robust electric power scheduling for multi-microgrid systems. *Applied energy*, 269, p.115146.
29. Shareef, H., Ahmed, M.S., Mohamed, A. and Al Hassan, E., 2018. Review on home energy management system considering demand responses, smart technologies, and intelligent controllers. *Ieee Access*, 6, pp.24498-24509.
30. Shaukat, N., Islam, M.R., Rahman, M.M., Khan, B., Ullah, B., Ali, S.M. and Fekih, A., 2023. Decentralized, democratized, and decarbonized future electric power distribution grids: a survey on the paradigm shift from the conventional power system to micro grid structures. *IEEE Access*, 11, pp.60957-60987.
31. Shaukat, N., Islam, M.R., Rahman, M.M., Khan, B., Ullah, B., Ali, S.M. and Fekih, A., 2023. Decentralized, democratized, and decarbonized future electric power distribution grids: a survey on the paradigm shift from the conventional power system to micro grid structures. *IEEE Access*, 11, pp.60957-60987.
32. Wang, C., Duan, J., Fan, B., Yang, Q. and Liu, W., 2018. Decentralized high-performance control of DC microgrids. *IEEE Transactions on Smart Grid*, 10(3), pp.3355-3363.
33. Wang, Y., Huang, Y., Wang, Y., Zeng, M., Li, F., Wang, Y. and Zhang, Y., 2018. Energy management of smart micro-grid with response loads and distributed generation considering demand response. *Journal of cleaner production*, 197, pp.1069-1083.
34. Xia, Y., Xu, Y., Wang, Y., Mondal, S., Dasgupta, S., Gupta, A.K. and Gupta, G.M., 2022. A safe policy learning-based method for decentralized and economic frequency control in isolated networked-microgrid systems. *IEEE Transactions on Sustainable Energy*, 13(4), pp.1982-1993.
35. Yang, Y., Ma, T., Li, H., Liu, Y., Tang, C. and Pei, W., 2023. Federated double DQN based multi-energy microgrid energy management strategy considering carbon emissions. *Global Energy Interconnection*, 6(6), pp.689-699.
36. Zabihi, A. and Parhamfar, M., 2025. Decentralized energy solutions: The impact of smart grid-enabled EV charging stations. *Heliyon*.



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