

# The Integration of Renewable Energy Sources into Mechanical Systems, Focusing on Efficiency and Reliability - A Case Study

Saidul Islam Khan<sup>1</sup>, Zohar Al Dodaev<sup>2</sup>, Abrarul Haque<sup>3</sup>

<sup>1</sup> Mechanical Engineering, Hubei University of Automotive Technology, China

<sup>2</sup> Department of Electrical and Electronic Engineering, Prime University, Mirpur-1, Dhaka-1216, Bangladesh

<sup>3</sup> New Generation Electronic Information, Hubei University of Automotive Technology, China

Email: <sup>1</sup> [saidulislamkhan1995@gmail.com](mailto:saidulislamkhan1995@gmail.com), <sup>2</sup> [zadodaev13@gmail.com](mailto:zadodaev13@gmail.com), <sup>3</sup> [mdabrarulhaque8@gmail.com](mailto:mdabrarulhaque8@gmail.com)

\*Corresponding Author

**Abstract**—The main objective of this review to analyze the efficiency and reliability of renewable energy technologies when integrated into mechanical infrastructure. The concerns of energy sustainability and environmental impact can be effectively addressed by incorporating renewable energy sources into mechanical systems. The use of renewable energy technology to mechanical systems is examined in this case study, with an emphasis on improving dependability and efficiency. The study explores the integration of solar, wind, and hydroelectric power generation into mechanical systems, such as HVAC (heating, ventilation, and air conditioning) systems, industrial machinery, and transportation systems, by means of a thorough analysis of a practical application. Studying the integration of solar, wind and hydroelectric thermal energy to raise building HVAC systems' dependability and efficiency are the main concern of this review. The design, implementation, and optimization of renewable energy systems are important topics covered because they optimize energy output while maintaining dependability and compatibility with the mechanical infrastructure already in place. In addition, the study assesses the technological issues, environmental advantages, and economic feasibility of integrating renewable energy sources, offering insights into successful strategies and difficulties faced. This case study is to educate decision-makers, engineers, and stakeholders about the potential and factors for sustainable energy solutions in mechanical engineering applications by examining the effectiveness and dependability of renewable energy integration in mechanical systems.

**Keywords**—Renewable Energy, Integration, Mechanical System, Efficiency, Reliability

## I. INTRODUCTION

Concerns about energy security, climate change, and environmental degradation have made it more and more necessary to switch to sustainable energy sources in recent years. As part of this shift, a viable option to lessen dependency on fossil fuels and minimize greenhouse gas emissions is through the incorporation of renewable energy sources into mechanical systems [1]. Renewable energy technologies offer practical substitutes for fossil fuel-based powering sources for mechanical systems in a variety of industries, such as manufacturing, transportation, and infrastructure construction. These include solar photovoltaics, wind turbines, hydropower generators, and biomass systems [2]. The purpose of this case study is to investigate how mechanical systems can include renewable

energy sources while maintaining a high level of efficiency and dependability. This study aims to provide light on the advantages, difficulties, and best practices related to renewable energy integration in mechanical engineering contexts by looking at actual applications and experiences. This research aims to offer insights into the design, implementation, and optimization of renewable energy systems within mechanical infrastructure through a thorough investigation of case studies and real-world examples [3].

The assimilation of sustainable renewable energy sources into mechanical systems bears noteworthy consequences for environmental preservation, economic growth, and energy sustainability [4]. Organizations can save operating costs, improve energy security, and help meet carbon emission reduction targets by using renewable energy resources to power mechanical systems. But attaining the highest levels of efficiency and dependability in the integration of renewable energy demands meticulous planning, technological innovation, and careful consideration of several variables, such as system design, site-specific conditions, and operational requirements [5].

Considering this, the following major goals are attempted to be addressed in this case study. Examine how renewable energy is currently integrated into mechanical systems in many applications and sectors. Examine how well-reliable and efficient renewable energy solutions are when combined with mechanical infrastructure. Determine the difficulties, impediments, and possibilities for maximizing the integration of renewable energy sources into mechanical systems. Provide stakeholders in mechanical engineering projects and the implementation of renewable energy with useful insights, guidance, and recommendations [6]. This case study intends to add to the expanding body of knowledge on sustainable energy solutions and inform engineering, energy policy, and environmental management decision-making processes by analyzing the junction of renewable energy and mechanical systems. This research project aims to expand our knowledge of renewable energy integration in mechanical systems and encourage the use of sustainable energy solutions in a variety of applications and sectors through a thorough examination of real-world examples and best practices [7]. Increased efficiency, lower operating costs, and a less environmental effect are just a few advantages of integrating renewable energy into mechanical systems. Under identical conditions,

air-source heat pumps can only achieve efficiencies of 175–250%, but geothermal heat pumps can reach up to 300–600% on the coldest winter nights. Reliance on traditional energy sources can be greatly decreased by using solar thermal systems, which can supply 50–70% of the energy needed for water heating. Approximately 1,400 houses may be powered by a single 2.5 MW wind turbine per year.

The integration of renewable energy sources into mechanical systems, with a specific emphasis on efficiency and reliability, makes a significant contribution to the sustainable energy landscape. This case study broadens our comprehension of the opportunities and difficulties related to renewable energy integration in mechanical engineering contexts by exploring real-world applications and experiences. The study provides useful advice for stakeholders involved in mechanical engineering projects and the deployment of renewable energy sources, in addition to assessing the dependability and efficiency of renewable energy technologies through thorough analysis and assessment. The case study aids in strategic planning and decision-making by highlighting opportunities, obstacles, and best practices. This helps to direct efforts towards improving system performance and integrating renewable energy as efficiently as possible [8]. It has been reviewed that how mechanical system efficiency is increased by integrating renewable energy sources. Prior to and following integration, track and contrast performance indicators, conversion efficiencies, and energy consumption. Calculate how much using renewable energy will save our carbon footprint and other environmental benefits.

## II. MECHANICAL SYSTEMS

Mechanical systems comprise a wide range of apparatuses, machinery, and buildings that apply mechanical concepts to carry out operations or duties. These systems are essential to many different sectors and uses, from building infrastructure and energy generation to manufacturing and transportation [9]. Mechanical systems are integral to modern society, providing essential services, facilitating economic activities, and enhancing quality of life. These systems continually evolve with advances in technology, materials, and design principles to meet the changing needs and demands of society. Here are a few typical illustrations and traits of mechanical systems:

- **Power generation systems:** these devices transform different energy sources into electricity that may be used in commercial and industrial settings. Power plants, generators, turbines, and electrical grids are examples of these systems. Fossil fuel-based systems (like coal and natural gas) and renewable energy sources (like solar, wind, and hydroelectric power) are examples of power generation technologies [10].
- **Renewable energy systems:** these energy systems use biomass, wind, water, and sunshine to create mechanical, thermal, or electrical power. Solar photovoltaic (PV) panels, wind turbines, hydroelectric generators, biomass boilers, and geothermal heat pumps are a few types of renewable energy systems. In addition to reducing climate change, these systems provide fossil fuel substitutes that are sustainable [11].

- **HVAC systems:** for homes, businesses, and automobiles to remain comfortable inside, heating, ventilation, and air conditioning (HVAC) systems are necessary [12]. In order to maintain the comfort and health of occupants, these systems control temperature, humidity, and air quality. Heating, ventilation, air conditioning, ductwork, and control systems are the usual components of HVAC systems.
- **Transportation systems:** these include the vehicles, infrastructure, and logistics networks that are used to move materials, people, and things from one place to another. Transportation networks comprise vehicles such as cars, trucks, buses, trains, aircraft, ships, and pipelines. These networks are essential for enabling communication, travel, and business.
- **Water and wastewater systems:** these systems include the facilities and methods of treatment used to manage wastewater and provide clean water to businesses and communities. Stormwater management systems, distribution networks, sewage treatment facilities, pumping stations, and water treatment plants are some examples of these systems [13]. Systems for managing water and wastewater are essential for maintaining environmental quality, public health, and sanitation [14].

## III. RENEWABLE ENERGY'S INTO MECHANICAL SYSTEMS

There are numerous alternatives available for powering mechanical equipment in a variety of sectors using renewable energy sources. When it comes to powering mechanical systems, these renewable energy sources provide environmentally acceptable and sustainable substitutes for fossil fuels [15]. The plentiful energy found in the sun, wind, water, biomass, and Earth's heat may be harnessed to power mechanical systems more effectively, cut carbon emissions, and help create a cleaner, more sustainable energy future which is shown in Fig. 1. The following are a few typical renewable energy sources that are applied to mechanical systems.

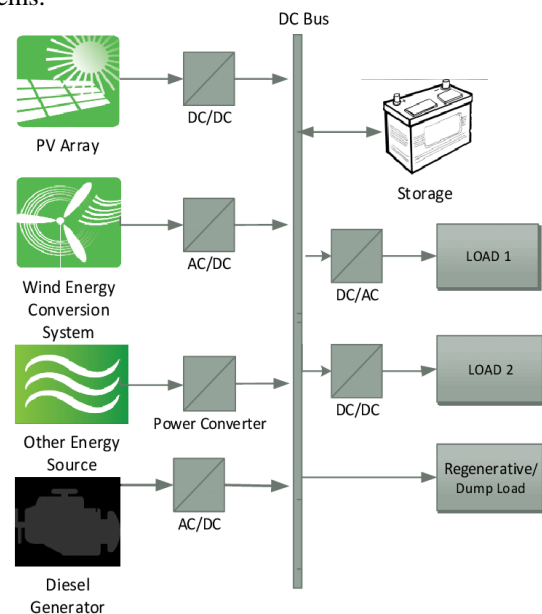


Fig. 1. Block diagram of alternative potential multi-source renewable energy ship powering network with parallel AC and DC [16]

- **Solar power:** among the most plentiful renewable energy sources accessible is solar power. It can be used to directly produce electricity from sunshine using photovoltaic (PV) panels, or it can be used to provide heat for mechanical processes using solar thermal systems. Numerous mechanical systems, such as HVAC units, industrial machinery, water pumping systems, and transportation systems, can be powered by solar energy.
- **Wind energy:** another plentiful and easily accessible renewable resource is wind energy. With the utilization of wind turbines, mechanical energy from the wind's kinetic energy can be transformed into electrical power for mechanical systems [17]. Wind energy is frequently utilized for off-grid applications in rural locations, industrial machines, and water pumping systems.
- **Hybrid systems:** to optimize energy production and dependability, hybrid renewable energy systems integrate two or more renewable energy sources. A hybrid solar-wind system, for instance, might combine wind turbines with solar PV panels to benefit from complementary energy production profiles and guarantee a steady supply of electricity [18].
- **Hydroelectric power:** hydroelectric power produces electricity by harnessing the energy of flowing water. The mechanical energy of flowing water can be converted into electrical energy by mechanical devices like water turbines and hydroelectric generators. Grid-connected power generation plants, water pumping systems, and industrial gear are frequently powered by hydroelectric power [19].
- **Biomass energy:** by using techniques like combustion, gasification, or anaerobic digestion, organic materials like wood, agricultural residues, and organic waste can be converted into biofuels or biogas. While biogas can be used for heating, producing electricity, or as a fuel for transportation, biofuels can be utilized to power combustion engines in automobiles or industrial machines.
- **Geothermal energy:** this type of energy uses the heat that is stored beneath the surface of the Earth to produce electricity or heat and cool spaces. Geothermal power stations turn turbines to produce energy by using steam or hot water from subterranean reservoirs. Geothermal heat pumps use the ground's consistent temperature to offer buildings and industrial processes with heating and cooling [20].
- **Ocean energy:** this category covers a range of technologies that use the energy of tides, waves, and currents in the ocean to produce power. Ocean energy can be converted into mechanical power to produce electricity or other uses using mechanical devices like tidal turbines, wave energy converters, and ocean thermal energy conversion (OTEC) systems.

#### IV. INTEGRATION OF RENEWABLE ENERGY INTO MECHANICAL SYSTEM

The incorporation of sustainable energy sources into mechanical systems is a crucial approach to decreasing dependency on fossil fuels and promoting sustainability. This integration entails integrating renewable energy technologies

such as biomass, solar, wind, and hydroelectric power into diverse mechanical systems used in a variety of industries.

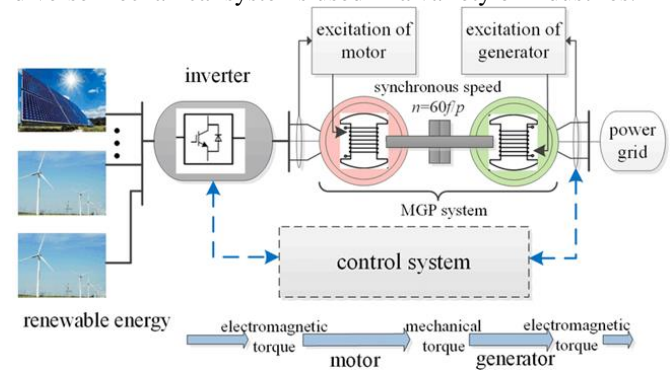


Fig. 2. Structure of renewable energy resources adopting MGP for grid-connection [21]

The incorporation of sustainable energy sources into mechanical systems is a crucial approach to decreasing dependency on fossil fuels and promoting sustainability. This integration entails integrating renewable energy technologies such as biomass, solar, wind, and hydroelectric power into diverse mechanical systems used in a variety of industries. All things considered, there are numerous advantages to integrating renewable energy sources into mechanical systems in terms of sustainability, energy security, prosperity, and environmental stewardship [22]. The shift towards cleaner and more sustainable energy can be expedited by societies through the adoption and promotion of renewable energy technology. The motor generator pair system consists of a synchronous motor and a synchronous generator whose rotors are connected to the same mechanical shaft, as shown in Fig. 2. Here are several key aspects and benefits of this integration:

- **Reduced environmental impact:** mechanical systems have the potential to drastically cut greenhouse gas emissions and pollutants linked to conventional energy generation by utilizing renewable energy sources. By producing clean energy with little to no emissions, renewable energy technologies help to slow down global warming and safeguard the quality of the air and water [23].
- **Energy efficiency:** resource utilization and energy efficiency can both be increased by integrating renewable energy sources into mechanical systems. When compared to conventional fossil fuel-based systems, renewable energy solutions frequently run more effectively, which eventually results in lower energy consumption, less waste, and cost savings.
- **Energy independence:** by diversifying energy sources and lowering reliance on imported fossil fuels, the integration of renewable energy improves energy security. Renewable energy-powered mechanical systems can function without the need for centralized power grids, increasing communities' and companies' energy autonomy and resilience against disturbances.
- **Savings:** long-term operating costs of renewable energy systems are frequently lower than those of traditional energy sources, even though the initial investment in renewable energy infrastructure may be more. Renewable energy-powered mechanical systems can have cheaper

fuel expenses, less maintenance needs, and possible income streams from surplus energy production.

- Technological innovation: the renewable energy sector is driven by technological innovation and advancement in part by the integration of renewable energy sources into mechanical systems. The goal of research and development is to increase the cost, dependability, and efficiency of renewable energy technology, which will inevitably lead to advancements and new discoveries in the area [24].
- Employment creation and economic growth: the switch to renewable energy offers chances for employment creation and economic growth, especially in sectors involved in the production, installation, upkeep, and services of renewable energy [25]. Communities may promote sustainable growth, green job creation, and local economic stimulation by investing in the integration of renewable energy.
- Resilience to climate change: by lowering susceptibility to harsh weather, interruptions in the energy supply, and geopolitical hazards related to fossil fuel dependence, the integration of renewable energy sources improves resilience to climate change. Renewable energy-powered mechanical systems can endure climate-related problems and help construct infrastructure that is resilient to climate change.
- Engagement of the community and stakeholders: the incorporation of renewable energy sources into mechanical systems promotes stakeholder participation in sustainability projects as well as community engagement. Stakeholders can establish shared advantages, encourage cooperation, and develop consensus by incorporating local businesses, institutions, and communities in renewable energy [26].

#### V. CHALLENGES OF INTEGRATION OF RENEWABLE ENERGY INTO MECHANICAL SYSTEM

Several issues need to be resolved for mechanical systems integrating renewable energy sources to function effectively and dependably. A multidisciplinary strategy including engineering, technological development, policy formulation, and stakeholder involvement is needed to address these issues [27]. To overcome these obstacles and quicken the shift to a sustainable energy future driven by renewable sources, cooperation between business, government, research institutes, and communities is crucial.

- Intermittency and variability: a lot of renewable energy sources, including wind and solar energy, are inherently intermittent and variable, which means that the amount of energy they produce varies depending on the time of day and the weather. Resolving the issue of balancing energy supply and demand as well as controlling variations in energy availability are necessary for integrating these sources into mechanical systems.
- Energy storage: systems for storing extra energy when it's available and discharging it when needed are frequently required to overcome the erratic and intermittent nature of renewable energy sources. However, incorporating energy storage increases the complexity and cost of mechanical systems, and choosing the right storage

technology necessitates taking longevity, capacity, and efficiency into account [28].

- Grid integration and stability: there are issues with power quality and grid stability when mechanical systems driven by renewable energy are connected to the electrical grid. In order to ensure dependable and stable operation, variations in the output of renewable energy might affect grid stability and necessitate coordination with grid operators. Upgrades to the grid infrastructure can also be necessary to integrate renewable energy sources.
- Technological compatibility: to guarantee compatibility and peak performance when integrating renewable energy sources into current mechanical systems, technological upgrades or adjustments may be necessary. This could entail modifying parts to accept inputs from renewable energy sources, installing new control systems, or retrofitting already-existing equipment [29].
- Cost & economics: although incorporating renewable energy sources into mechanical systems might result in large upfront expenses, they can also offer long-term cost savings and environmental benefits. One of the main challenges facing stakeholders is striking a balance between the predicted benefits and payback period and the economic viability of integrating renewable energy.
- Location and resource availability: geographical location and environmental factors influence the suitability and availability of renewable energy resources. The successful integration of renewable energy projects into mechanical systems requires the identification of appropriate sites and the evaluation of resource availability [30].
- Regulatory and policy considerations: the implementation and integration of renewable energy sources into mechanical systems are greatly influenced by regulatory frameworks, incentives, and policies. Regulatory obstacles, permission needs, and policy ambiguities that impact project development and funding might provide difficulties [31].

#### VI. DISCUSSION

One major step forward in the search for sustainable energy solutions is the incorporation of renewable energy sources into mechanical systems, with an emphasis on efficiency and dependability. This talk examines the main conclusions, ramifications, and issues that came up during the case study's examination of the integration of renewable energy in mechanical engineering settings. The case study highlights several key aspects, one of which is how crucial it is to maximize the effectiveness of renewable energy sources when integrating them with mechanical infrastructure. By utilizing renewable energy sources like solar, wind, hydroelectric power, and others, mechanical systems can lessen their need on fossil fuels and lessen their environmental effect. To achieve maximum efficiency, however, several aspects need to be carefully considered, including operational parameters, component selection, and system design. The case study illustrates methods for improving the effectiveness of renewable energy integration through in-depth analysis and evaluation, including maximizing energy capture, decreasing losses, and optimizing system layout.

Another important topic covered in the case study is reliability. For mechanical systems to perform as intended, they need to function consistently and predictably. The incorporation of renewable energy sources poses novel obstacles to system dependability, such as fluctuations in energy yield, sporadic power generation, and probable equipment malfunctions. Robust design approaches, redundancy measures, and predictive maintenance techniques must all be used to ensure dependable operation. The case study offers recommended practices, such as integrating energy storage systems, diversifying energy sources, and putting advanced control algorithms into practice, for improving the reliability of renewable energy integration. The case study also emphasizes how efficiency and dependability are related when integrating renewable energy. Mechanical systems can increase energy output while minimizing resource use and environmental effect by optimizing system efficiency. Ensuring dependability is also necessary to keep things running smoothly and avoid downtime, which can have serious operational and financial repercussions. A comprehensive strategy that considers application-specific needs, operating environment constraints, and technical, economic, and environmental aspects is needed to balance these goals. The incorporation of renewable energy sources into mechanical systems presents many issues concerning dependability and efficiency. The amount of energy generated by the sun and wind varies with the season and the weather. Systems that depend on a constant energy source may become inefficient as a result of this intermittent. Since solar panels have an efficiency of just 15–22%, a large amount of solar radiation does not get converted into electrical power. Because renewable energy sources are intermittent, there is a chance that connected mechanical systems may become unstable due to changes in grid voltage and frequency. Severe weather events (such as hurricanes and snowstorms) have the potential to interfere with the generation of renewable energy and cause system breakdowns.

The case study's conclusions have significant ramifications for those working in mechanical engineering, energy policy, and the implementation of renewable energy sources. The report provides guidance for investments in renewable energy infrastructure and enhances decision-making processes by highlighting potential for increasing efficiency and dependability. The case study also emphasizes the value of cooperation between business, academia, and government in overcoming technological obstacles, creating creative solutions, and encouraging the broad use of sustainable energy technologies. There is a lot of promise for lowering carbon emissions, improving energy security, and advancing environmental sustainability when renewable energy sources are integrated into mechanical systems.

## VII. CONCLUSION

The potential, difficulties, and best practices related to sustainable energy integration are clarified by the case study on the integration of renewable energy sources into mechanical systems, with a focus on efficiency and dependability. The report emphasizes the tremendous potential of renewable energy technologies to revolutionize mechanical infrastructure and promote energy sustainability

goals through a thorough review of real-world applications and experiences. The results of the case study emphasize how crucial it is to maximize energy output, reduce environmental effect, and guarantee the continuous operation of mechanical systems by enhancing the efficiency and reliability of renewable energy integration. Mechanical systems can boost energy resilience, lessen their dependency on fossil fuels, and reduce greenhouse gas emissions by utilizing solar, wind, hydropower, and other renewable energy sources. A approach to reaching energy sustainability targets and creating a more robust and sustainable society is the integration of renewable energy sources into mechanical systems. Stakeholders may overcome obstacles, seize opportunities, and quicken the adoption of renewable energy technology to power mechanical infrastructure in a dependable, economical, and ecologically conscious way by continuing research, ingenuity, and cooperation.

## REFERENCES

- [1] M. A. Halim, M. M. Hossain, M. J. Nahar, "Development of a Nonlinear Harvesting Mechanism from Wide Band Vibrations," *International Journal of Robotics and Control Systems*, vol. 2, no. 3, pp. 467-476, 2022, <https://doi.org/10.31763/ijrcs.v2i3.524>.
- [2] D. Hao *et al.*, "Solar energy harvesting technologies for PV self-powered applications: A comprehensive review," *Renewable Energy*, vol. 188, pp. 678-697, 2022, <https://doi.org/10.1016/j.renene.2022.02.066>.
- [3] Z. Li, S. Zhou, Z. Yang, "Recent progress on flutter-based wind energy harvesting," *International Journal of Mechanical System Dynamics*, vol. 2, no. 1, pp. 82-98, 2022, <https://doi.org/10.1002/msd2.12035>.
- [4] Z. Qin, X. Tang, Y. T. Wu, S. K. Lyu, "Advancement of Tidal Current Generation Technology in Recent Years: A Review," *Energies*, vol. 15, no. 21, p. 8042, 2022, <https://doi.org/10.3390/en15218042>.
- [5] X. Ma, S. Zhou, "A review of flow-induced vibration energy harvesters," *Energy Conversion and Management*, vol. 254, p. 115223, 2022, <https://doi.org/10.1016/j.enconman.2022.115223>.
- [6] A. Z. Arsal *et al.*, "Hydrogen energy storage integrated hybrid renewable energy systems: A review analysis for future research directions," *International Journal of Hydrogen Energy*, vol. 47, pp. 17285-17312, 2022, <https://doi.org/10.1016/j.ijhydene.2022.03.208>.
- [7] D. Roy, "Modelling an off-grid hybrid renewable energy system to deliver electricity to a remote Indian island," *Energy Conversion and Management*, vol. 281, p. 116839, 2023, <https://doi.org/10.1016/j.enconman.2023.116839>.
- [8] P. Roy, J. He, T. Zhao and Y. V. Singh, "Recent Advances of Wind-Solar Hybrid Renewable Energy Systems for Power Generation: A Review," *IEEE Open Journal of the Industrial Electronics Society*, vol. 3, pp. 81-104, 2022, <https://doi.org/10.1109/OJIES.2022.3144093>.
- [9] B. Nastasi, N. Markovska, T. Puksec, N. Duić, A. Foley, "Renewable and sustainable energy challenges to face for the achievement of Sustainable Development Goals," *Renewable and Sustainable Energy Reviews*, vol. 157, p. 112071, <https://doi.org/10.1016/j.rser.2022.112071>.
- [10] K. A. Khatri, K. B. Shah, J. Logeshwaran, A. Shrestha, "Genetic algorithm based techno-economic optimization of an isolated hybrid energy system," *ICTACT Journal on Microelectronics*, vol. 8, no. 4, pp. 1447-1450, 2023, [https://ictactjournals.in/paper/IJME\\_Vol\\_8\\_Iss\\_4\\_Paper\\_3\\_1447\\_1450.pdf](https://ictactjournals.in/paper/IJME_Vol_8_Iss_4_Paper_3_1447_1450.pdf).
- [11] S. Liaquat, M. F. Zia, M. Benbouzid, "Modeling and formulation of optimization problems for optimal scheduling of multi-generation and hybrid energy systems: Review and recommendations," *Electronics*, vol. 10, no. 14, p. 1688, <https://doi.org/10.3390/electronics10141688>.
- [12] Y. Yuan, J. Wang, X. Yan, B. Shen, T. Long, "A review of multi-energy hybrid power system for ships," *Renewable and Sustainable Energy Reviews*, vol. 132, p. 110081, 2020, <https://doi.org/10.1016/j.rser.2020.110081>.

- [13] M. R. Zaman, M. A. Halim, M. Y. A. Khan, S. Ibrahim, A. Haque, "Integrating Micro and Smart Grid-Based Renewable Energy Sources with the National Grid in Bangladesh-A Case Study," *Control Systems and Optimization Letters*, vol. 2, no. 1, pp. 75-81, 2024, <https://doi.org/10.59247/csol.v2i1.76>.
- [14] M. A. Halim, M. S. Akter, S. Biswas, M. S. Rahman, "Integration of Renewable Energy Power Plants on a Large Scale and Flexible Demand in Bangladesh's Electric Grid-A Case Study," *Control Systems and Optimization Letters*, vol. 1, no. 3, pp. 157-168, 2023, <https://doi.org/10.59247/csol.v1i3.48>.
- [15] M. S. H. Lipu *et al.*, "Artificial Intelligence Based Hybrid Forecasting Approaches for Wind Power Generation: Progress, Challenges and Prospects," *IEEE Access*, vol. 9, pp. 102460-102489, 2021, <https://doi.org/10.1109/ACCESS.2021.3097102>.
- [16] C. Ammari, D. Belatrache, B. Touhami, S. Makhloufi, "Sizing, optimization, control and energy management of hybrid renewable energy system—A review," *Energy and Built Environment*, vol. 3, no. 4, pp. 399-411, 2022, <https://doi.org/10.1016/j.enbenv.2021.04.002>.
- [17] S. Ahmed, A. Castellazzi, A. Williams, "Multi-source energy networks for cargo Vessels," *Transactions on environment and electrical engineering*, vol. 1, no. 4, pp. 37-43, 2016, <http://dx.doi.org/10.22149/teee.v1i4.52>.
- [18] W. Azam, I. Khan, S. A. Ali, "Alternative energy and natural resources in determining environmental sustainability: a look at the role of government final consumption expenditures in France," *Environmental Science and Pollution Research*, vol. 30, pp. 1949-1965, <https://doi.org/10.1007/s11356-022-22334-z>.
- [19] X. Li, C. J. Raorane, C. Xia, Y. Wu, T. K. N. Tran, T. Khademi, "Latest approaches on green hydrogen as a potential source of renewable energy towards sustainable energy: Spotlighting of recent innovations, challenges, and future insights," *Fuel*, vol. 334, p. 126684, 2023, <https://doi.org/10.1016/j.fuel.2022.126684>.
- [20] A. Kasaeian, M. Javidmehr, M. R. Mirzaie, L. Fereidooni, "Integration of solid oxide fuel cells with solar energy systems: A review," *Applied Thermal Engineering*, vol. 334, p. 120117, 2023, <https://doi.org/10.1016/j.applthermaleng.2023.120117>.
- [21] Y. S. Mohammed, B. B. Adetokun, O. Oghorada, O. Oshiga, "Techno-economic optimization of standalone hybrid power systems in context of intelligent computational multi-objective algorithms," *Energy Reports*, vol. 8, pp. 11661-11674, <https://doi.org/10.1016/j.egyr.2022.09.010>.
- [22] Q. Wu, Y. Huang, C. Li, Y. Gu, H. Zhao and Y. Zhan, "Small Signal Stability of Synchronous Motor-Generator Pair for Power System With High Penetration of Renewable Energy," *IEEE Access*, vol. 7, pp. 166964-166974, 2019, <https://doi.org/10.1109/ACCESS.2019.2953514>.
- [23] Y. Zhang, Q. Xue, D. Gao, W. Shi, W. Yu, "Two-level model predictive control energy management strategy for hybrid power ships with hybrid energy storage system," *Journal of Energy Storage*, vol. 52, p. 104763, <https://doi.org/10.1016/j.est.2022.104763>.
- [24] J. Shang, J. Gao, X. Jiang, M. Liu, D. Liu, "Optimal configuration of hybrid energy systems considering power to hydrogen and electricity-price prediction: A two-stage multi-objective bi-level framework," *Energy*, vol. 263, p. 126023, 2023, <https://doi.org/10.1016/j.energy.2022.126023>.
- [25] Z. Asghar, K. Hafeez, D. Sabir, B. Ijaz, S. S. H. Bukhari and J. Ro, "RECLAIM: Renewable Energy Based Demand-Side Management Using Machine Learning Models," *IEEE Access*, vol. 11, pp. 3846-3857, 2023, <https://doi.org/10.1109/ACCESS.2023.3235209>.
- [26] M. R. Maghami, A. G. O. Mutambara, "Challenges associated with Hybrid Energy Systems: An artificial intelligence solution," *Energy Reports*, vol. 9, pp. 924-940, 2023, <https://doi.org/10.1016/j.egyr.2022.11.195>.
- [27] M. Thirunavukkarasu, Y. Sawle, H. Lala, "A comprehensive review on optimization of hybrid renewable energy systems using various optimization techniques," *Renewable and Sustainable Energy Reviews*, vol. 176, p. 113192, <https://doi.org/10.1016/j.rser.2023.113192>.
- [28] M. R. Zaman, S. Sarker, M. A. Halim, S. Ibrahim, A. Haque, "A Comprehensive Review of Techno-Economic Perspective of AC/DC Hybrid Microgrid," *Control Systems and Optimization Letters*, vol. 2, no. 1, pp. 36-42, <https://doi.org/10.59247/csol.v2i1.72>.
- [29] A. K. Patwary, M. A. Sayem, M. A. Hossain, M. A. Halim, "A Review of Energy Storage Systems (ESS) for Integrating Renewable Energies in Microgrids," *Control Systems and Optimization Letters*, vol. 2, no. 1, pp. 103-112, <https://doi.org/10.59247/csol.v2i1.68>.
- [30] M. E. Shayan, G. Najafi, B. Ghobadian, S. Gorjian, M. Mazlan, "A novel approach of synchronization of the sustainable grid with an intelligent local hybrid renewable energy control," *International Journal of Energy and Environmental Engineering*, vol. 14, pp. 35-46, 2023, <https://doi.org/10.1007/s40095-022-00503-7>.
- [31] S. A. Omid, M. J. A. Baig, M. T. Iqbal, "Design and Implementation of Node-Red Based Open-Source SCADA Architecture for a Hybrid Power System," *Energies*, vol. 16, no. 5, p. 2092, <https://doi.org/10.3390/en16052092>.