International Journal of Science, Technology and Management (IJSTM) ISSN (online): 2321-774X
Volume 11, Issue 1, 2024

A Comprehensive Review on Renewable Energy in Rural Environment

[1]Samta, [2]Vivek Kumar
[1]M.Tech Student, [2]Professor and Head
Department of Electrical Engineering, BRCM CET Bahal, Haryana

Abstract- This comprehensive review explores the current landscape of renewable energy, emphasizing its importance in mitigating climate change, enhancing energy security, and promoting sustainable development. The paper provides a detailed background on various renewable energy sources, including solar, wind, biomass, and hydropower, highlighting their technological advancements and deployment trends. A feasibility analysis assesses the economic, technical, and social aspects of renewable energy adoption, illustrating its viability and potential for large-scale implementation. The advantages of renewable energy, such as environmental benefits, job creation, and energy independence, are discussed in depth. Additionally, the paper identifies future gaps in the renewable energy sector, including the need for advanced energy storage solutions, grid infrastructure upgrades, supportive policy frameworks, and ongoing research and development.

Keywords: Renewable energy, hybrid renewable energy system (HRES), emission.

Introduction The world is facing an unprecedented energy crisis, with the increasing demand for energy outpacing the supply. This has led to a significant reliance on fossil fuels, which not only contribute to climate change but also deplete natural resources. Each of renewable sources has its own advantages and limitations, and combining them in a hybrid system can offer a more reliable and efficient energy supply. The key benefits of using a hybrid system with these renewable energy sources include improved energy reliability, increased energy independence, optimal utilization of resources, reduced grid dependency, environmental benefits, cost savings, and scalability [1-3]. Overall, the standalone HRES can integrate various combinations of these clean and abundant sources to meet the energy demands for sustainable and efficient manner. When selecting a renewable energy source for a standalone hybrid renewable energy system, several factors need to be considered. By carefully considering these factors when selecting renewable energy sources for a standalone hybrid renewable energy system, researchers and engineers can design efficient, reliable, and sustainable energy solutions tailored to specific locations and energy demands. Figure 1 represents the multiple energy sources of HRES.

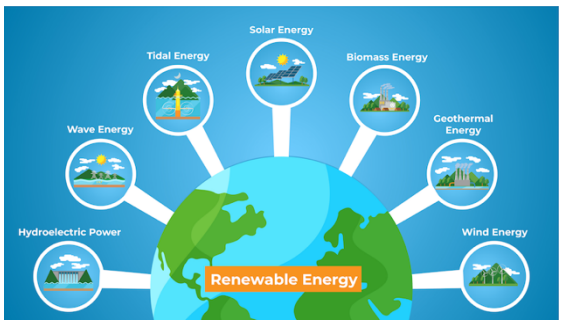

Figure 1: Representation of different renewable energy sources

This research is significant because it addresses the need for a sustainable and reliable energy supply, particularly in remote locations where traditional energy infrastructure is lacking. The contribution of this study lies in providing a thoroughly study of a standalone HRES, which can serve as a model for similar applications worldwide. Policymakers, energy planners, and industry stakeholders will find the research's conclusions helpful in making decisions on the adoption of renewable energy technologies.

Feasibility Analysis of a Standalone Hybrid System

The feasibility of standalone hybrid renewable energy systems incorporating solar, wind, and hydro components has garnered significant attention in the academic community. The competitiveness of renewable technologies still lags behind that of fossil fuels when renewable energy sources like solar, wind, and geothermal energy are contrasted with non-renewable sources. A full design and optimization of a freestanding hybrid system integrating wind turbines, solar cells, biomass, and pump-hydro storage was reported in the work given in reference [4]. The research emphasizes the importance of minimizing the energy cost value while ensuring system reliability. The potential for affordable and ecologically friendly energy solutions is highlighted by the implementation of several optimization algorithm. The author underscores the importance of hybrid renewable systems, particularly in the context of grid-connected applications and their reliability. The paper discusses the experimental verification of such systems, suggesting that hybridization could be key to overcoming the intermittency issues associated with renewable energy sources [5]. A hybrid wind-solar system with a rainwater collecting function for high-rise buildings is presented by [6], which investigates the integration of renewable technologies in urban contexts. The study's techno-economic analysis, using the life cycle cost (LCC) method, demonstrates the system's potential for energy savings and its suitability for urban applications. A detailed feasibility study on a remote island is provided by [7-9], which employs the HOMER software for simulation and techno-economic evaluation. The results of the study, which took into account several size configurations and carried out sensitivity studies on energy consumption and resource availability, show the feasibility of a solar-wind-battery hybrid system.

Advantages of Renewable Energy

1. **Environmental Benefits [10]**

Reduction in Greenhouse Gas Emissions: Renewable energy sources such as solar, wind, and hydro produce little to no greenhouse gases or pollutants during operation, significantly reducing the carbon footprint and helping combat climate change.

Improved Air Quality: By replacing fossil fuels, renewables reduce emissions of harmful pollutants like sulphur dioxide, nitrogen oxides, and particulate matter, leading to better air quality and public health.

2. **Sustainability**

Inexhaustible Sources: Renewable energy sources are virtually inexhaustible on a human timescale. Unlike fossil fuels, which are finite, sources like sunlight, wind, and biomass are continuously replenished by natural processes.

3. **Energy Security**

Diverse Supply: Using a mix of renewable energy sources diversifies the energy supply, reducing

dependency on any single source or country for energy needs.

Resilience: Decentralized energy systems based on renewables can be more resilient to disruptions, such as natural disasters or geopolitical conflicts, compared to centralized fossil fuel-based systems.

4. **Economic Benefits**

Job Creation: The renewable energy sector is labour-intensive, creating jobs in manufacturing, installation, and maintenance. For instance, solar and wind industries have seen significant employment growth.

Economic Development: Investments in renewable energy can stimulate local economies, especially in rural and underdeveloped areas, by providing new business opportunities and infrastructure development [11].

5. **Energy Access**

Electrification in Remote Areas: Renewable energy technologies, particularly solar photovoltaic (PV) systems and small-scale wind turbines, can provide electricity to remote and off-grid areas, improving access to energy and quality Including these points in your paper will provide a comprehensive overview of the advantages of renewable energy, highlighting its benefits across environmental, economic, and social dimensions.

Future Gaps in Renewable Energy

1. **Energy Storage Solutions**

Technological Advancements: Despite progress, there is still a need for more efficient, cost-effective, and scalable energy storage solutions to address the intermittent nature of renewable energy sources like solar and wind.

Grid Integration: Improved storage technologies are essential for integrating large amounts of renewable energy into the grid, ensuring stability and reliability [12-13]

2. **Grid Infrastructure**

Modernization: Existing grid infrastructure needs significant upgrades to handle the variable and distributed nature of renewable energy. Smart grids and advanced transmission technologies are crucial for efficient energy distribution.

Interconnectivity: Enhanced interconnectivity between regional and national grids can help balance supply and demand, reducing reliance on backup fossil fuel plants [14].

3. **Policy and Regulatory Frameworks**

Supportive Policies: Consistent and long-term policy support is required to encourage investment in renewable energy. Uncertainty in government policies can deter private sector investment and slow down the transition.

Regulatory Barriers: Addressing regulatory barriers that hinder the deployment of renewable energy projects, such as lengthy permitting processes and grid access issues, is crucial.

4. **Research and Development (R&D)**

Innovation: Continued R&D is needed to advance renewable energy technologies, making them more efficient, affordable, and widely accessible.

Emerging Technologies: Investment in emerging renewable technologies, such as advanced

bioenergy, ocean energy, and next-generation solar cells, can open new avenues for clean energy production.

5. **Financial Barriers**

Investment Mechanisms: Developing innovative financing mechanisms and reducing the cost of capital for renewable energy projects are essential for scaling up deployment [15-16].

Risk Mitigation: Creating financial instruments to mitigate the risks associated with renewable energy investments can attract more investors.

6. **Public Awareness and Acceptance**

Education: Increasing public awareness and understanding of the benefits and challenges of renewable energy is necessary to gain widespread support for the energy transition.

Community Engagement: Engaging local communities in the planning and development of renewable energy projects can address concerns and foster acceptance.

7. **Environmental and Social Impacts**

Sustainable Practices: Ensuring that renewable energy development adheres to sustainable practices, minimizing negative impacts on ecosystems and local communities, is critical.

Resource Management: Addressing the environmental impacts of renewable energy technologies, such as the lifecycle impacts of solar panels and wind turbines, including resource extraction and end-of-life disposal.

By addressing these future gaps, the renewable energy sector can overcome current challenges and move towards a more sustainable and resilient energy future. Including these points in your paper will provide a comprehensive analysis of the areas that need further attention and development.

Conclusion

In conclusion, renewable energy presents a viable and essential solution to the global challenges of climate change, energy security, and sustainable development. The technological advancements in solar, wind, biomass, and other renewable energy sources have significantly improved their efficiency and cost-effectiveness, making them increasingly competitive with traditional fossil fuels. The feasibility analysis underscores the economic, technical, and social benefits of renewable energy, demonstrating its potential for widespread adoption. However, several future gaps must be addressed to fully realize the potential of renewable energy. These include the development of advanced energy storage technologies, modernization of grid infrastructure, establishment of consistent and supportive policies, and continued investment in research and development.

References:

[1] Qazi, A., Hussain, F., Rahim, N., Hardaker, G., Alghazzawi, D., Shaban, K., & Haruna, K. (2019). Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions. IEEE Access, 7, 63837-63851.

[2] Destouni, G., & Frank, H. (2010). Renewable Energy. AMBIO, 39, 18-21. https://doi.org/10.1007/s13280-010-0059-7.

[3] Bull, S. (2001). Renewable energy today and tomorrow. Proc. IEEE, 89, 1216-1226. https://doi.org/10.1109/5.940290.

[4] Koroneos, C., Spachos, T., & Moussiopoulos, N. (2003). Exergy analysis of renewable energy

sources. Renewable Energy, 28, 295-310. https://doi.org/10.1016/S0960-1481(01)00125-2.

[5] Moriarty, P., & Honnery, D. (2016). Can renewable energy power the future. Energy Policy, 93, 3-7. https://doi.org/10.1016/J.ENPOL.2016.02.051.

[6] E., , M., Husin, H., , N., Zaki, M., & , M. (2021). A critical review of the integration of renewable energy sources with various technologies. Protection and Control of Modern Power Systems, 6, 1-18. https://doi.org/10.1186/s41601-021-00181-3.

[7] Niknam, T., & Firouzi, B. (2009). A practical algorithm for distribution state estimation including renewable energy sources. Renewable Energy, 34, 2309-2316. https://doi.org/10.1016/J.RENENE.2009.03.005.

[8] Parthasarathi, A. (2006). Renewable energy sources: Situation and prospects. World Affairs, 10, 112-138.

[9] Panwar, N., Kaushik, S., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. Renewable & Sustainable Energy Reviews, 15, 1513-1524. https://doi.org/10.1016/J.RSER.2010.11.037.

[10] Johansson, T., Kelly, H., Reddy, A., & Williams, R. (1993). Renewable energy : sources for fuels and electricity. . https://doi.org/10.5860/choice.31-0332.

[11] Alturki, F., & Awwad, E. (2021). Sizing and Cost Minimization of Standalone Hybrid WT/PV/Biomass/Pump-Hydro Storage-Based Energy Systems. Energies, 14, 489. https://doi.org/10.3390/EN14020489.

[12] Pérez-Navarro, Á., Alfonso, D., Ariza, H., Cárcel, J., Correcher, A., Escrivá-Escrivá, G., Hurtado, E., Ibáñez, F., Peñalvo, E., Roig, R., Roldán, C., Sánchez, C., Segura, I., & Vargas, C. (2016). Experimental verification of hybrid renewable systems as feasible energy sources. Renewable Energy, 86, 384-391. https://doi.org/10.1016/J.RENENE.2015.08.030.

[13] Chong, W., Naghavi, M., Poh, S., Mahlia, T., & Pan, K. (2011). Techno-economic analysis of a wind–solar hybrid renewable energy system with rainwater collection feature for urban high-rise application. Applied Energy, 88, 4067-4077. https://doi.org/10.1016/J.APENERGY.2011.04.042.

[14] Ma, T., Yang, H., & Lu, L. (2014). A feasibility study of a stand-alone hybrid solar–wind–battery system for a remote island. Applied Energy, 121, 149-158. https://doi.org/10.1016/J.APENERGY.2014.01.090.

[15] Al-Falahi, M., Jayasinghe, S., & Enshaei, H. (2017). A review on recent size optimization methodologies for standalone solar and wind hybrid renewable energy system. Energy Conversion and Management, 143, 252-274. https://doi.org/10.1016/J.ENCONMAN.2017.04.019.

[16] Fathabadi, H. (2017). Novel standalone hybrid solar/wind/fuel cell/battery power generation system. Energy, 140, 454-465. https://doi.org/10.1016/J.ENERGY.2017.08.098.