The Imperative for Solar Energy in Rural Bihar: A Comparative Analysis with Other Indian States

Ram Rahul Kumar, Rishav Kumar Singh, Er. Murari Kumar
Member, Ganga Global Institute of Management Studies, Begusarai

Abstract— **Rural Bihar faces significant energy poverty, with low electrification rates and reliance on unsustainable fuels like kerosene and biomass. This article examines the critical need for solar energy in Bihar's villages, highlighting its potential to address energy access, economic development, and environmental sustainability. A comparative analysis with states like Karnataka, Andhra Pradesh, and Rajasthan reveals Bihar's lag in renewable energy adoption despite its high solar potential. The study includes a block diagram of a typical solar home system and figures comparing renewable energy capacities. Policy recommendations emphasize decentralized solar solutions, community ownership, and women-led initiatives to bridge the energy gap.**

Index Terms— **Solar energy, Rural Bihar, comparison, Analysis**

I. INTRODUCTION

Bihar, one of India's most populous states, grapples with severe energy poverty, particularly in its rural areas. With a per capita electricity consumption of 332 kWh—far below the national average of 717 kWh—rural households often rely on kerosene and biomass for lighting and cooking, posing health and environmental risks (Kumar, 2021). Solar energy, leveraging Bihar's abundant solar insolation (4–7 kWh/m²/day), offers a sustainable solution to electrify villages, enhance livelihoods, and reduce carbon emissions (MNRE, 2025). This article explores the need for solar energy in Bihar's villages, compares its progress with other states, and proposes actionable strategies.

II. NEED FOR SOLAR ENERGY IN RURAL BIHAR

2.1 Energy Poverty and Its Impacts

Approximately 25% of Bihar's rural population lacks access to electricity, and even electrified households face unreliable supply (Borah et al., 2015). Kerosene, used by 95% of rural households for lighting, contributes to indoor air pollution, causing respiratory ailments (J-PAL, 2025). The absence of reliable electricity hampers education, healthcare, and economic activities, perpetuating poverty cycles.

2.2 Solar Energy as a Solution

Bihar receives 4–7 kWh/m²/day of solar insolation, comparable to states like Rajasthan (MNRE, 2025). Decentralized solar solutions, such as solar home systems (SHS), microgrids, and solar lanterns, can provide cost-effective, reliable power. For instance, the Dharnai village solar microgrid project, initiated in 2014, powered 450 homes and 60 streetlights, demonstrating solar's transformative potential (Ram, 2018). Solar energy also supports agricultural productivity through solar-powered pumps and fosters women-led enterprises, as seen in the Bolega Bihar campaign (Ghosh, 2023).

2.3 Social and Economic Benefits

Solar electrification reduces drudgery for women, who spend hours collecting fuelwood, and improves health by minimizing exposure to kerosene fumes (MNRE, 2025). It enables extended study hours for children, enhances healthcare delivery, and supports small businesses, boosting local economies. A 2015 study in Purnia, Bihar, found that 81% of SHS beneficiaries were willing to pay more for higher-capacity systems, indicating strong demand (Borah et al., 2015).

III. COMPARATIVE ANALYSIS WITH OTHER STATES

Bihar lags behind states like Karnataka, Andhra Pradesh, and Rajasthan in renewable energy adoption, particularly solar. Table 1 compares installed renewable energy capacities as of 2023.

Table 1: Installed Renewable Energy Capacity (MW) in Selected States (2023)

State	Solar	Wind	Biomass	Total RE
Bihar	218	0	126	344
Karnataka	7,500	5,200	1,800	14,500
Andhra Pradesh	4,200	8,100	400	12,700
Rajasthan	10,500	4,300	120	14,920

Source: Elavarasan et al. (2020); Earth Journalism Network (2024)

3.1 Karnataka

Karnataka leads in renewable energy with 14,500 MW, driven by favorable policies and public-private partnerships. The state's collaboration with farmers to lease land for solar farms has boosted capacity (Elavarasan et al., 2020). Karnataka's Green Energy Fund supports project financing, a model Bihar could emulate.

3.2 Andhra Pradesh

Andhra Pradesh's 12,700 MW renewable capacity includes 4,200 MW from solar. The state's PM Surya Ghar and PM-Kusum schemes promote rooftop solar and solar villages, with five model solar villages planned per district (Raghavendra, 2025). Bihar's floating solar plants in Supaul and Darbhanga indicate similar potential (Earth Journalism Network, 2024).

3.3 Rajasthan

Rajasthan, with 14,920 MW, leverages its high solar insolation for large-scale solar parks. Its Renewable Purchase Obligation (RPO) targets are more aggressive than Bihar's, ensuring higher solar adoption (Kulkarni & Virulkar, 2013). Bihar's RPO compliance is weak, contributing to its low solar capacity.

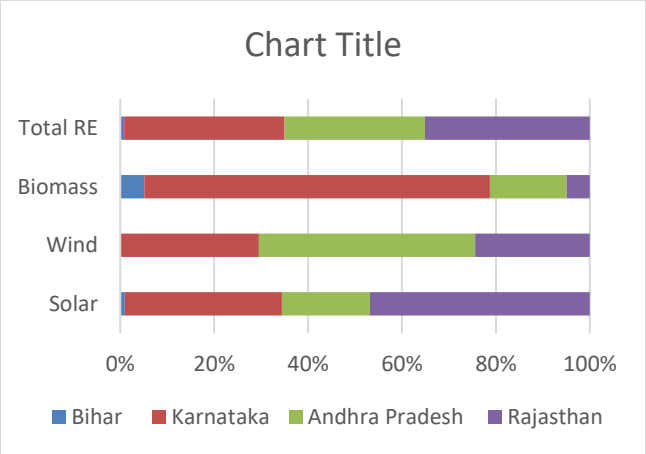

Figure 1: Comparison of Renewable Energy Capacity Across States (2023)

IV. TECHNICAL FRAMEWORK: SOLAR HOME SYSTEM

A typical solar home system (SHS) for rural Bihar includes a photovoltaic (PV) module, battery, charge controller, inverter, and load (e.g., LED lights, mobile charger). Figure 2 illustrates the block diagram.

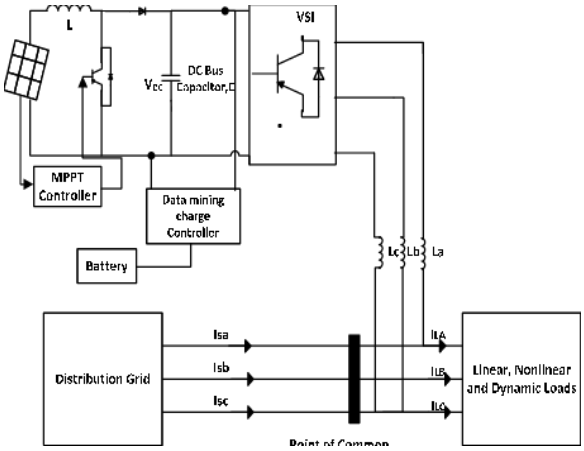

Figure 2: Block Diagram of a Solar Home System

The PV module converts sunlight into DC electricity, stored in the battery via the charge controller, which prevents overcharging. The inverter converts DC to AC for household appliances. This system is scalable and suitable for off-grid villages (Kulkarni & Virulkar, 2024).

V. CHALLENGES AND POLICY RECOMMENDATIONS

5.1 Challenges

Land Constraints: High land costs and limited availability hinder large-scale solar projects (Kumar, 2021).

Maintenance Issues: Defunct solar streetlights in Gehlaur village highlight maintenance challenges (Kumar, 2021).

Awareness and Financing: Low awareness and high upfront costs deter adoption (Ghosh, 2023).

5.2 Policy Recommendations

-Decentralized Models: Promote SHS and microgrids through subsidies and microfinance, as seen in the LaBL program (Borah et al., 2015).

-Women-Led Initiatives: Expand programs like Bolega Bihar to train women as solar entrepreneurs (Ghosh, 2023).

Strengthen RPO Compliance: Enforce stricter RPO targets to boost solar adoption (Kulkarni & Virulkar, 2013).

Maintenance Frameworks: Establish village-level maintenance units to ensure system longevity.

VII. CONCLUSION

Solar energy is pivotal for addressing Bihar's rural energy crisis, offering environmental, social, and economic benefits. While states like Karnataka and Rajasthan lead in renewable energy, Bihar's progress is hampered by policy and infrastructural challenges. By adopting decentralized solar solutions, fostering community ownership, and leveraging women-led initiatives, Bihar can bridge its energy gap and align with India's 450 GW renewable energy target by 2030 (Earth Journalism Network, 2024).

REFERENCES

[1]. Borah, R. R., Palit, D., & Mahapatra, S. (2015). Solar lighting for rural households: A case of innovative model in Bihar, India. *Energy Procedia, 54*, 680–689. https://www.researchgate.net

[2]. Earth Journalism Network. (2024). Bihar aims to be in India's top 10 green energy states by 2030. https://earthjournalism.net

[3]. Elavarasan, R. M., et al. (2020). A comprehensive review on renewable energy development, challenges, and policies of leading Indian states. *IEEE Access*. https://www.researchgate.net

[4]. Ghosh, S. (2023). In Bihar, women entrepreneurs are bringing solar energy to villages. *Mint*. https://www.livemint.com

[5]. J-PAL. (2025). Welfare benefits of decentralized solar energy for the rural poor in India. https://www.povertyactionlab.org

[6]. Kulkarni, N. G., & Virulkar, V. B. (2013). Development of solar electricity supply system in India: An overview. *Journal of Renewable Energy*. https://www.hindawi.com

[7]. Kulkarni, N. G., & Virulkar, V. B. (2024). Power electronics and its application to solar photovoltaic systems in India. *Journal of Renewable Energy*. https://www.researchgate.net

[8]. Kumar, M. (2021). To boost its slow progress on clean energy, Bihar looks at floating and rooftop solar alternatives. *Mongabay-India*. https://india.mongabay.com

[9]. MNRE. (2025). Solar overview. https://mnre.gov.in

[10]. Raghavendra, V. (2025). Every district in Andhra Pradesh to have five model solar villages. *The Hindu*. https://www.thehindu.com

[11]. Ram, M. (2018). How Dharnai, a village in Bihar became India's first solar powered village? *EQ International*. https://www.eqmagpro.com