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GREEN FINANCING PRACTICES IN INDIA'S RENEWABLE ENERGY SECTOR: A STUDY

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Abstract:

India's goals of attaining 500 GW of renewable energy capacity by 2030, as part of its Panchamrit climate commitments, require a significant financial transformation. Addressing the projected annual funding deficit of INR 11 lakh crores (USD 170 billion) is essential for the expansion of renewable initiatives, including solar, wind, and hydro energy projects. This study examines the present state of green finance in India, highlighting the significance of instruments such as sovereign green bonds, blended finance, green banks, and crowdfunding in facilitating the growth of renewable energy. The research employs exploratory analysis of governmental data, policy documents, and multilateral sources to identify critical structural impediments, including inadequate enforcement of Renewable Purchase Obligations (RPOs), underdeveloped debt markets, minimal foreign direct investment (2.05%), and disjointed regulatory frameworks. Research indicates that while entities like IREDA and programs such as viability gap funding (VGF) have stimulated solar expansion, overarching market inefficiencies remain. Merely 34% of public sector banks actively endorse renewable energy, whereas the involvement of foreign banks is minimal. The paper additionally delineates investor engagement and quantifies sector-specific fund distributions, highlighting that solar energy commands the largest proportion (34.58%), followed by hydro and wind energy. The paper promotes enhanced adherence to RPOs, the development of innovative financing models, and the implementation of strategic de-risking mechanisms to bolster investor confidence. These initiatives are crucial for expediting India's energy transition, fulfilling Sustainable Development Goal 7, and significantly aiding global climate objectives.

Keywords: Green Finance, Blended Finance, Renewable Energy Investments, SDG 7

INTRODUCTION

The global energy transition is increasingly dependent on emerging economies, with India at the forefront due to its projected 35% surge in energy demand by 2030 (IEA, 2024). Despite remarkable progress—ranking third in solar (84.3 GW) and fourth in wind capacity (46.4 GW) globally—fossil fuels still dominate 58% of India's primary energy consumption (CEA, 2024). This paradox underscores the critical need for scalable green financing mechanisms to align with India's Panchamrit climate targets, including 500 GW of non-fossil energy capacity by 2030.

However, structural barriers impede progress, such as Capital Intensity: The renewable energy sector faces significant financial barriers due to its capital-intensive nature. As noted in the document, renewable projects require approximately 80% higher initial investments compared to conventional coal plants (Bhattacharyya & Maheswari, 2010). Private Sector Hesitation: Only 34% of public sector banks actively finance renewable energy projects, reflecting systemic risk perceptions. Only 9 of 26 public sector banks actively finance renewable projects (Sarangi, G.K.K. 2018). Policy Fragmentation: Weak enforcement of Renewable Purchase Obligations (RPOs) and an oversupply



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of Renewable Energy Certificates (RECs) distort markets. Despite Supreme Court interventions, many states fail to meet their Renewable Purchase Obligations (Khanna et al., 2022).

This study addresses the gap between green finance theory and practice by evaluating India’s hybrid financing instruments, from sovereign green bonds to blended finance models. Using ABCD analysis, we assess the feasibility of solutions like SECI’s viability gap funding (VGF) and IREDA’s masala bonds, offering actionable policy recommendations to accelerate India’s net-zero transition.

METHODS

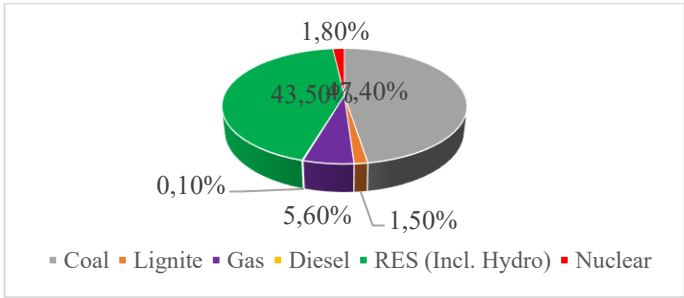
The research employs exploratory analysis of governmental data, policy documents, and multilateral sources to identify critical structural impediments, including inadequate enforcement of Renewable Purchase Obligations (RPOs), underdeveloped debt markets, minimal foreign direct investment (2.05%), and disjointed regulatory frameworks.

RESULT AND DISCUSSION

Renewable Energy Landscape in India. India established the constitutional status of energy as a concurrent item in 1950. The global oil crisis in the late 1980s marked the genesis of renewable energy development in India (Sarangi, G.K.K. 2018). Since then, the central government and state governments have formulated numerous policies and initiatives to enhance the renewable energy sector. India has various renewable energy mixes, such as solar and wind. India boasts a diverse range of renewable energy sources, including solar, wind, hydro, biomass, and clean hydrogen. However, specific policies such as the National Solar Mission (NSM) in 2010, Atal Jyoti Yojana (AJAY) in 2016, SRISTI (Rooftop Solar Initiative) in 2018, and PM-KUSUM in 2019 have prioritized solar energy in India. The wind energy projects include the National Wind Energy Mission in 2014, the Green Energy Corridor Project in 2015, the Offshore Wind Policy in 2015, the National Biofuel Policy in 2018, and the National Hydrogen Mission in 2018 have boosted the energy mix in India. It also diversified the green finance in India.

India’s energy consumption increased from 25,805 petajoules (PJ) in 2012-13 to 33,508 PJ in 2021-22, with significant growth noted during the recovery post-COVID-19. The industrial sector is the largest consumer of energy, using over 50% of total energy consumption, followed by the residential, agriculture, and transport sectors (Energy Statistics of India, 2023). The energy bill, introduced in 2003, aimed to provide power to all. However, it is difficult to reach remote locations; hence, renewable energy is the best alternative.

Furthermore, the current energy mix reflects a changing policy focus on energy generation, with an increasingly larger share of renewables in the country's energy mix. Figure 1 shows the installed capacity of the country by source.



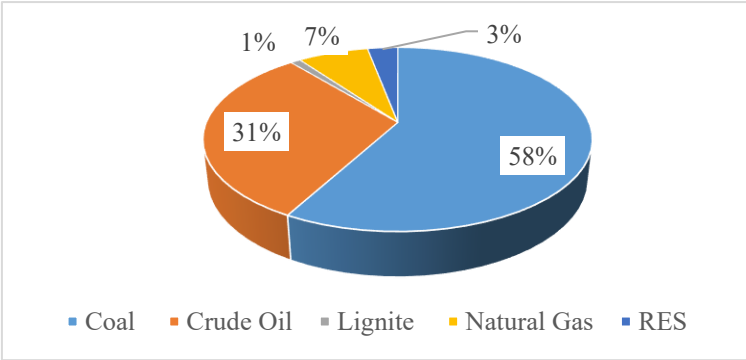
Source: CEA (2024)

Figure 1. Energy Mix by Installed Capacity in India in 2024.



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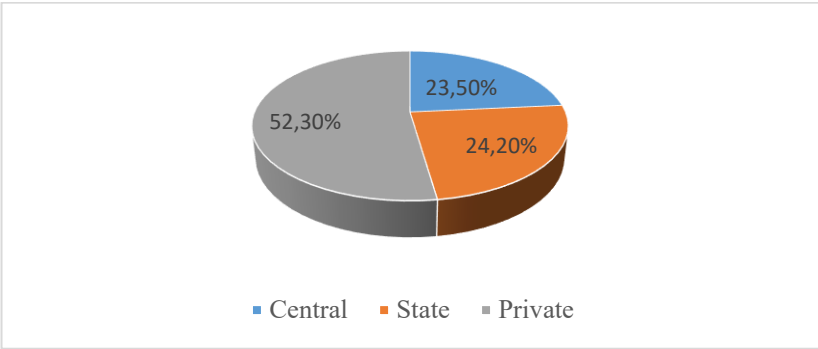
The above figure demonstrates that the country's renewable energy generation capacity has reached unprecedented heights, accounting for approximately 43.50% of the total capacity, or 193.58 GW. Further insight shows that 18.90% of renewable energy comes from solar energy, and 10.40% comes from wind energy. Large hydro accounts for 10.60%, while small hydropower projects and other waste-to-energy sources account for 1.10%. The generation of renewable energy has increased by 7.04% compared to the previous year CEA, 2024). However, the consumption of green energy is only 3%. This discrepancy highlights significant inefficiencies in grid integration, transmission infrastructure, and energy storage. Despite robust generation capacity, much of the renewable output is not optimally utilized due to technical bottlenecks, curtailments, and load balancing challenges. This contrast underscores the urgent need for investment in smart grids, storage solutions, and regulatory frameworks that can support high renewable penetration.



Source: ESI (2024)

Figure 2. Primary Energy Consumption in India in 2024 by Source

India's energy usage has grown healthily, from 26,822 petajoules (PJ) in 2013-14 to 35,159 petajoules (PJ) in 2022-2023. The overall energy consumption grew by 6.48% from 33,018 PJ in 2021-2022 to 35,159 PJ in 2022-2023. From the above Figure 2, it is evident that a large amount of energy comes from coal, which is 58%, followed by crude oil, which is 31%, natural gas, 7%, renewable energy sources (RES), 3%, and lignite, 1%. India has become the world's third-largest solar power generator, with 84.3 GW of installed solar capacity as of May 2024. 67 GW of utility-scale solar projects are under development, with large projects supported by the Ultra Mega Renewable Energy Power Parks scheme. India ranks fourth globally in onshore wind installations, with 46.4 GW as of May 2024. Wind installations have faced stagnation, but 2023/24 saw a significant recovery. The government is pushing for 10 GW annual wind capacity tenders. India's hydropower capacity is 51.9 GW, concentrated mainly in the northern and northeastern states. 104 GW of hydropower projects are in development, with pumped storage accounting for a significant portion (GEM-BRICS, 2024). This data demonstrates unequivocally that the main energy source in rural India is still fossil fuels. This indicates that India still has a long way to go before undergoing a full energy revolution. This disparity between renewable capacity and actual use suggests that India's energy system is still deeply reliant on legacy infrastructure. The high share of coal indicates the challenge in displacing entrenched sources with cleaner alternatives and points to a need for aggressive policy shifts and storage investments to improve renewable integration.



Source: CEA (2024)
Figure 3. Installed Power Generation Capacity (Sector-wise) as of 2024

Figure 3 shows that 52.30% of total power generation comes from the private sector, 24.20% from the state government sector, and 23.50% from the central government sector. This breakdown emphasizes the essential role of private capital in renewable energy development. It also highlights the importance of designing risk-mitigated financing instruments, such as green bonds and blended finance, to unlock more private investments and bridge public financing limitations in the sector’s transition.

Composition and Design of Renewable Energy Financing in India. The technological artifacts of conventional power systems and renewable energy systems differ greatly. Consequently, the cost components for both sectors also exhibit significant differences. Compared to traditional energy systems, renewable energy projects have zero fuel costs and are thus very capital-intensive (Bhattacharyya and Maheswari 2010; Hirth and Steckel 2016). These zero recurring charges positively impact the average power prices due to their less erratic nature. The ambitious goal set by the Indian government to install 500 GW of non-fossil fuel-based energy capacity and meet 50% of its energy needs from non-renewable sources is expected to require an investment of about INR 162.5 lakh crores (USD 2.5 trillion) between 2015 and 2030, or INR 11 lakh crores (USD 170 billion) annually, considering the technological characteristics of the sector (CPI, 2022).

A closer look at India's renewable energy industry structure is intriguing. The private sector has the responsibility for developing the renewable energy industry, in contrast to the traditional energy sector. The sector's next challenge is to raise private capital at a rate and speed consistent with the objectives and aims of the program. Because of the restricted public budget, this is essential. Most of the available governmental funding serves as support money, encouraging private investment in the industry. It is based on the idea that the private sector may provide funding for the sector, but the government must first establish an enabling environment (Sarangi, G.K.K. 2018). The majority of green money still comes from domestic sources, with 87% and 83% coming from domestic sources in FY2019 and FY2020, respectively. About 59% of these domestic sources, or INR 156.9 thousand crores (USD 22 billion), came from the business sector. PSUs and central and state government budgetary spending equally split public sector flows at approximately 54% and 46%, respectively (CPI, 2022). The FDI inflow in 2023 (April to June) for the same period was approximately USD 16.18 billion, increasing by about 39% year-over-year. The total FDI in 2024 (April to June) is approximately USD 22.49 billion. However, only 2.05% of the total FDI inflows into India are in sectors related to sustainable energy sources (DIIPT, 2024).

India's renewable energy financing landscape continues to be predominantly bank-driven, though the market has witnessed growing diversification of funding sources in recent years. While traditional commercial banks maintain their stronghold, the sector now attracts capital from



institutional investors, private equity firms, and development finance institutions, creating a more varied investment ecosystem. Notably, venture capital firms have emerged as important players, particularly in financing equity components of project-based developments, marking a significant evolution in funding patterns. This expanding investor base contrasts sharply with the limited participation of international banks, which remain largely absent from India's renewable energy financing space despite their potential to bring global expertise and capital. The current investment scenario reflects a transitional phase where domestic financial institutions are actively bridging funding gaps, while specialized investors increasingly support innovative clean energy ventures through alternative financing models.

Table 1. Investor’s mapping for Renewable Energy in India

Type of Investors	Category	Total Registered in India	Active in the Renewable Sector
Commercial Banks	Public Sector Banks	26	9
	Private Sector Banks	30	6
	Foreign Banks	37	0
Equity Investors	Private Equity	51	16
	Venture Capital	180	21
Institutional Investors	e.g., Insurance Funds, State-owned, and bilateral and multilateral institutions	24	11
Development Banks	Development financial institutions such as IREDA, IFCI, and SIDBI	3	3

Source: Sarangi, G.K. 2018

Table 1 illustrates the participation of various investor categories in India's renewable energy sector. While 180 venture capital firms operate nationally, only 21 actively fund renewables. Notably, foreign banks show zero engagement, whereas public sector banks (9 of 26) and private equity (16 of 51) demonstrate moderate involvement, with development banks like IREDA being fully committed.

Table 2 summarizes the commitments made by various financial institutions to renewable energy in India, along with their share of the total committed amount. Table 2 reveals that Public Sector Undertakings (PSUs) have committed 34.6% of the amount, followed by Commercial Financial Institutions at 26.76% and Union and State Government Budgets at 11.43%.

Table 2. Commitments Made by Different Financial Institutions for Renewable Energy

Funding Source	Amount (INR thousand crores)	Percentage (%)
Commercial Financial Institutions (FIs)	34,740	26.76
Public Sector Undertakings (PSUs)	44,922	34.6
Union and State Government Budgets	14,843	11.43
Bilateral Development Financial Institutions (DFIs)	2,011	1.55
Multilateral DFIs	3,616	2.79
Foreign Direct Investment (FDI)	8,978	6.92
Residential, Commercial, and Institutional Corporation	4,190	3.23
Philanthropy	16,339	12.59
	186	0.14
Total	1,29,823	100%

Source: CPI (2022)



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Table 3 illustrates the allocation of funds to the clean energy subsectors. Solar PV leads the table with 34.58%, followed by hydro at 19.95% and wind at 17.55%. This indicates investment patterns in clean energy and also shows the opportunity across the sectors.

Table 3. Financing Inflows to The Clean Energy Subsector

Sub-sector	Amount (INR thousand crores)	Percentage (%)
Solar PV	44,897	34.58
Wind - Onshore	22,787	17.55
Hydro Energy	25,899	19.95
Biofuel	973	0.75
Energy Storage	3,432	2.64
Rooftop Solar PV	9,299	7.16
Other Renewable Energy	944	0.73
Renewable Energy - Multiple	21,592	16.63
Total	1,29,823	100%

Source: CPI (2022)

Policy Levers and Financial Innovations in India’s Renewable Energy Sector through Incentives and Instruments. India’s renewable energy transition relies on a synergistic mix of policy-driven incentives and financial instruments designed to mitigate risks, attract private capital, and bridge funding gaps. This section analyzes their evolution, effectiveness, and interdependencies.

Incentives. India's renewable energy financing framework has undergone a progressive transformation, characterized by strategic policy interventions and market-driven mechanisms. The current financial ecosystem traces its origins to 1992 when the government first established dedicated institutional support, later formalized as the Ministry of New and Renewable Energy (MNRE) in 2006. This regulatory body has implemented a dynamic mix of fiscal instruments, evolving from direct subsidies to sophisticated market-based solutions. Three principal mechanisms have shaped investment patterns: (1) Accelerated Depreciation (AD), introduced in 2009, enables 40% tax deductions on renewable assets, particularly benefiting wind projects initially before expanding to solar; (2) Generation-Based Incentives (GBI), which shifted focus from installed capacity to actual energy output, successfully attracting independent power producers; and (3) Viability Gap Funding (VGF), the contemporary solution for commercially marginal but strategically vital projects. This policy evolution reflects India's adaptive approach, as renewable tariffs became competitive with conventional power (reaching grid parity in many cases), broad subsidies gave way to targeted interventions. The current framework emphasizes financial sustainability while addressing specific market barriers, demonstrating maturity in balancing public support with private sector participation in the energy transition.

Table 4. Comparison between various Incentive objectives

Incentive Type	Focus Area	Primary Beneficiaries	Key Objective
Accelerated Depreciation (AD)	Capital cost reduction	Developers of small-scale projects	Improve cash flow and reduce tax burden.
Generation-Based Incentive (GBI)	Energy output efficiency	Operators of renewable projects	Promote maximum energy generation.
Viability Gap Funding (VGF)	Project financial viability	Utility-scale developers	Bridge revenue gaps and ensure tariff affordability.



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Typically, the government issues this singular grant to boost the commercial viability of initiatives. The Solar Energy Corporation of India (SECI) has utilized the VGF system to facilitate solar energy production across the nation. Besides the previously mentioned benefits, a 10-year income tax exemption for solar installations ended in April 2017. However, a significant decline in renewable energy prices in the nation has either restructured or diminished these incentive programs. Furthermore, a variety of regulatory instruments, including renewable portfolio obligations (RPO), renewable energy certificates (REC), and feed-in-tariff (FiT) schemes, are available to promote the renewable energy sector in the country. RPO requires power distribution utilities and other obligated organizations to acquire a specified percentage of electricity from renewable energy sources. These schemes are integral to statutory mandates for transitioning to a sustainable framework in India. Nonetheless, challenges arise over the adherence to these requirements, mainly due to apprehensions concerning the fiscal stability of provincial electrical distribution utilities. This occurred despite interventions by the Supreme Court of India. This compliance issue has resulted in the accumulation of surplus renewable energy certificates (RECs).

India's renewable energy financing ecosystem relies on a robust institutional framework designed to address the sector's unique requirements. The government established the Indian Renewable Energy Development Agency (IREDA) in 1987 as a specialized financial institution under the Ministry of New and Renewable Energy (MNRE) to provide tailored financial solutions. IREDA plays a pivotal role by offering concessional loans, credit guarantees, and innovative financing mechanisms to bridge the funding gap in clean energy projects. This institutional architecture extends to other key players, including the Power Finance Corporation for large-scale projects, the Rural Electrification Corporation for decentralized solutions, and NABARD for agricultural applications. Beyond these government entities, India's financial sector has witnessed growing participation from commercial banks, private equity firms, and non-banking financial companies, all developing specialized products to support renewable energy development. The evolving landscape now features innovative financing models that combine public sector leadership with private capital mobilization, reflecting India's dynamic approach to financing its ambitious energy transition goals while addressing the sector's distinct technical and financial challenges.

Instruments. In India, funding renewable energy necessitates a variety of financial instruments to facilitate substantial investments, mitigate risk, and draw both domestic and foreign capital. The following are the principal vehicles utilized to finance renewable energy projects in India.

Green Bonds. Green bonds finance environmentally friendly projects (USAID 2017). India's green bond market, catalyzed by IREDA's USD 300 million masala bonds (2019), now includes sovereign issuances (INR 80 billion in 2023). However, liquidity constraints and high certification costs limit accessibility for small developers (Hussain & Dill, 2023). The risk holdings in the case of green bonds are similar to those of other bonds. Green bonds also have to acquire the desired credit rating to attract financial institutions (IDBI, 2018). A special type of green bond issued by IREDA in 2017 to raise 300 million USD is called Green Masala Bonds (USAID 2017). There is another type of green bond that is issued by any government, known as a Sovereign Green Bond (*Green Bonds in Europe*, 2024). Sovereign Green Bonds are backed by the creditworthiness of the issuing government, providing a sovereign guarantee. Sovereign Green Bonds generally carry lower risk due to government backing (Kaushal, T. J., 2023). India issued its first Sovereign Green Bonds in January 2023, raising INR 80 billion (approximately USD 1 billion) to support renewable energy and sustainability projects (Hussain, F. I., & Dill, H., 2023).



Green Banks. Dedicated financial institutions that leverage public funds to attract private investment for clean energy projects. They aim to reduce lending rates and provide flexible financing options (Sarangi, G.K. 2018). Green Banks utilize limited public capital to attract greater private investment, a process known as "crowding in" private capital. This approach helps to deploy commercial clean energy technologies. They employ financing techniques such as credit enhancement, co-investment, and warehousing/securitization to support renewable energy projects(Schub, 2015). It addresses the challenges of financing renewable energy projects by promoting the involvement of public financial institutions and developing green credit guarantee schemes to mitigate risks(Taghizadeh-Hesary & Yoshino, 2020). By offering green bonds and sustainability-linked loans, banks encourage businesses and individuals to adopt environmentally friendly practices(Sule et al., 2024; Khan et al., 2024). While green banks significantly contribute to renewable energy investments, challenges such as regulatory barriers and public awareness remain, necessitating ongoing efforts to enhance their effectiveness and reach.

Infrastructure Debt Bonds. These bonds are designed to finance infrastructure projects, including those focused on renewable energy, thereby supporting the transition to a sustainable energy system(Sarangi, G.K. 2018). Infrastructure projects in India have primarily relied on commercial bank loans, with bonds contributing minimally to the funding pool (Purkayastha & Iyer, 2018). The Indian government recognizes the necessity of diversifying funding sources, mainly through the bond market, to meet the projected infrastructure investment needs of approximately \$1 trillion during the Twelfth Plan period(Swamy, 2014). However, many infrastructure projects receive low investment-grade ratings, which deters bond market investments. Studies indicate that these projects exhibit lower default rates than their ratings suggest, highlighting a disconnect between perceived and actual risk; hence, the reliance on external credit ratings by investors and regulators constrains access to bond financing, necessitating reforms to improve the attractiveness of infrastructure debt bonds(Purkayastha & Iyer, 2017).

Crowdfunding. This mechanism allows individuals to invest in green projects, providing an alternative source of financing for renewable energy initiatives (Sarangi, G.K.K. 2018). Crowdfunding involves three primary participants: project owners who propose ideas, investors who provide funding, and intermediaries (crowdfunding platforms) that facilitate the connection between the two(Pouille et al., 2024). Digital platforms serve as the medium for fundraising, allowing project owners to present their initiatives and investors to contribute easily(Susanto et al., 2024). There are multiple ways of crowdfunding, but in green finance, generally, Equity crowdfunding is used in which businesses raise capital by selling a portion of ownership (equity) in the company to investors.

Blended Finance. This approach combines public and private funding to mitigate risks and attract more investment into green projects, addressing the financial challenges in the renewable energy sector (Sarangi, G.K.K. 2018). Blended finance has mobilized approximately \$171 billion towards sustainable development, primarily in developing countries("Concept note: Blended Finance Facilities for Offshore Wind & Green Hydrogen", 2022). It helps de-risk investments by providing subsidies and support, making projects more attractive to private investors(Walizai, 2023). The model encourages collaboration among public, private, and philanthropic sectors, enhancing investment in critical areas like renewable energy and infrastructure(Samans, 2016).

CONCLUSION

With solar (84.3 GW) and wind (46.4 GW) driving 43.5% of total installed capacity as of 2024, India's renewable sector has expanded. This does, however, only account for 3% of actual energy



consumption, so exposing inefficiencies in grid integration and storage (DIIPT, 2024; GEM-BRICS, 2024). Although renewables' cost parity (ESI, 2024) is reflected, Coal's ingrained 58% share reflects legacy infrastructure lock-in, hence stressing the need for faster green financing to meet India's ambitious 500 GW non-fossil fuel target by 2030. The findings show that public sector undertakings (PSUs) still contribute 34.6% of renewable energy funding, indicating a concentration of financial responsibility within government-linked entities. To rebalance this reliance and crowd in private capital, the paper recommends introducing credit guarantees that lower investment risk and encourage commercial lenders and institutional investors to enter the space.

Green bonds, among other important financing tools, have become popular; India's first Sovereign Green Bonds will bring INR 80 billion (USD 1 billion) in 2023 (Kaushal, T. J., 2023). While blended finance models have mobilized USD 171 billion globally, offering the possibility to de-risk renewable projects in India, green banks, like IREDA, are absolutely vital in leveraging public funds to attract private investment (Schub, J., 2015). For small-scale projects, crowdfunding has also become popular, although its influence is still limited (Pouille, J.-B., et al., 2024). Problems, including non-consistent adherence to Renewable Energy Certificates (RECs) and rules not regularly followed, such as the Renewable Purchase Obligations (RPOs), still exist even with these developments. Furthermore, although the private sector is involved in a considerable amount of power generation (52.30%), it is still cautious because of possible hazards, and foreign direct investment (FDI) in sustainable energy is rather low at only 2.05%.

India has to improve public-private cooperation, strengthen policy structures, and widen creative financing sources if it is to meet its targets for renewable energy. Emphasizing the need for actual implementation, Sharma, G. D., et al. (2022) stress the need to move green money from theory to practice. Reiterating RPO compliance, extending credit guarantees to reduce risk, and raising knowledge of green banking and crowdsourcing to diversify funding sources (Taghizadeh-Hesary, F., & Yoshino, N., 2020). India can hasten its renewable energy transition and fulfill its 2030 targets by tackling these obstacles and using current financing tools, so contributing to world climate goals and guaranteed sustainable economic growth. India's green finance strategy has flaws as well as promise when compared to China and Brazil. China encourages fast scaling through strong legislative mandates and state-led banking; Brazil uses development banks and blended finance for renewable energy. Mandatory ESG disclosures, regulatory rules, and blended finance models could assist India's fractured system to be more transparent, inclusive, and efficient, hence enabling its 2030 net-zero and SDG 7 targets.

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