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Comparative Study on the Development of Non-Conventional Energy Usage: Kerala and Tamil Nadu (2020–2025)

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Abstract

Kerala and Tamil Nadu have been identified as key points of reference for the transition to the use of renewable energy (RE) in the period 2020-2025 and for the two different models of RE integration; Tamil Nadu as a case study of how the state can use its large landmass and wind resources to emerge as a leader in wind and solar energy, while Kerala is the only state that is dominant in rooftop solar and has developed innovative floating photovoltaic (FPV) technology to help the state develop its RE capacity. Tamil Nadu and Kerala are ranked at the top of the Sustainable Development Goals (SDG) and have leveraged the strength of their social welfare system and healthcare system to create an environment conducive to energy innovation. The progress of Tamil Nadu in the solar sector has also been quite strong, and it has remained in the top four consistently during the 2020-2025 period.17 By March 2025, the solar installed capacity touched 10,153 MW. On track to reach 100% RE by 2040, with a focus on 4 GW of storage and a thriving green hydrogen ecosystem. Poised to be a global hub for offshore wind, targeting a 50% RE share in its energy mix by 2030 and the repowering of over 10 GW of legacy wind assets

Key words

Renewable Energy, Windmill, Solar Energy, floating solar

Introduction

In the Indian context, the move towards the use of renewable energy sources has progressed from being a small policy consideration to being one of the key bases of economic and environmental sustainability. Kerala and Tamil Nadu have been identified as key points of reference for the transition to the use of renewable energy (RE) in the period 2020-2025 and for the two different models of RE integration; Tamil Nadu as a case study of how the state can use its large landmass and wind resources to emerge as a leader in wind and solar energy, while Kerala is the only state that is dominant in rooftop solar and has developed innovative floating photovoltaic (FPV) technology to help the state develop its RE capacity. This comparative study will examine the technology, policy, and socio-economic developments in these two states over the next five years, as well as the national achievements that have been made during this period, such as the achievement of 100 GW solar and 50 GW wind cumulative installed capacity by early 2025.

Macro-Economic Drivers and National Alignment

The efforts put forth for the development of non-conventional energy sources in Kerala and Tamil Nadu have to be evaluated in the light of the "Panchamrit" targets set by India to achieve a cumulative capacity of 500 GW of non-fossil fuel energy by the year 2030.1 As of March 31, 2025, the total installed electric capacity in India is 475.21 GW, registering an increase of 72.18% over 2014-15.[8] Approximately 46.32% of the total electricity capacity is produced by using renewable energy sources (excluding large hydro).[8] During the period 2020-2025, there has been a substantial decoupling of economic growth and greenhouse gas emissions, with the average annual growth rate of renewable electric capacities touching 15.50% and that of non-renewable capacities registering a meager 1.5%.[8]

Tamil Nadu and Kerala are ranked at the top of the Sustainable Development Goals (SDG) and have leveraged the strength of their social welfare system and healthcare system to create an environment conducive to energy innovation.[9] The use of renewable energy (RE) in these two states has a direct bearing on GDP growth, as it has been established that a 1% increase in RE production would result in GDP growth ranging between 0.04% and 0.18% in India.[10]

National Renewable Energy Capacity Trends (2020–2025)

Financial Year	Solar Power (MW)	Wind Power (MW)	Total RE (MW)*
2020-21	5,628.8	1,503.3	7,548.1
2021-22	12,760.5	1,110.5	14,082.0
2022-23	12,783.8	2,275.6	15,274.4
2023-24	15,033.2	3,253.4	18,484.7
2024-25	23,832.9	4,151.3	28,723.7
Cumulative (31.12.2025)	135,809.9	54,510.9	207,093.4

*Excludes large hydro power.[11]

The figures point to a radical acceleration of capacity addition towards the end of the 2020-2025 period. Solar power has been identified as the major driver, contributing 81% to the total RE capacity addition in the 2024-25 fiscal year.4 Tamil Nadu, a top three performer, and Kerala, a top performer in distributed solar, have been the major contributors to this national momentum.[4]

The Tamil Nadu Model: Utility-Scale Mastery and Grid Integration

The period between 2020 and 2025 is characterized by the transformation of Tamil Nadu from a wind power leader to a renewable energy hub. The state has always been at the forefront of wind power in India, contributing about 25% of the country’s total wind power capacity.[2] As of early 2025, the total RE capacity in Tamil Nadu stood at

25.2 GW, with wind energy accounting for 11.7 GW and solar energy exceeding 10 GW.[4]

The Wind Energy Paradigm: Repowering and Offshore Ambitions

One of the key issues that Tamil Nadu was facing during this period was that its wind power generation stations were outdated (although they had already surpassed their 20-year life span). Also, the majority of the wind turbines installed during the period of 1980 to 2000 had a capacity of only 55 kW. Therefore, in 2024, the State Government of Tamil Nadu introduced the Modified Repowering Policy for the State to replace all of the older, smaller wind generation stations with new ones, typically ranging between 2 and 5.2 MW. This impacted the cost structure of the State, and instead of being calculated based on the total capacity, the development charges, which were ₹3 million/MW, would now only be imposed on the new capacity addition.

Apart from the developments achieved onshore by repowering, Tamil Nadu has also made substantial progress in the area of offshore wind power. The government called for a 4,000 MW tender for offshore wind energy, along with a viability gap funding scheme of ₹74.53 billion, in the early months of 2024. The offshore wind resource potential for the State has been estimated to be 91,000 MW with capacity utilization factors (CUF) of 45% to 50%, which is almost twice the CUF achieved from onshore wind. This transition from onshore to offshore generation capacity is essential for the Resource Adequacy Plan (RAP) submitted by the State to satisfy the projected peak demand in the year 2035 of 35,500 MW.

Solar Expansion and the Industrial Open Access Shift

The progress of Tamil Nadu in the solar sector has also been quite strong, and it has remained in the top four consistently during the 2020-2025 period.17 By March 2025, the solar installed capacity touched 10,153 MW, which is an increase of 24% from the previous year.[4] One of the major reasons for this increase is the Green Energy Open Access (GEOA) Regulations 2025, which reduced the threshold limit for industrial consumers to 50 kW, enabling them to buy renewable energy directly from third-party producers.[19]

Tamil Nadu RE Installed Capacity (MW) 2020–2025

Category	March 2020	March 2022	March 2024	March 2025
Wind Power	9,304	9,867	10,603	11,760
Solar (Utility + RTS)	3,916	5,145	8,210	10,153
Biopower	950	980	1,005	1,020
Small Hydro	123	123	123	123
Total RE (excl. Large Hydro)	14,293	16,115	19,941	23,056

The data shows that, although wind continues to be the bedrock of Tamil Nadu's energy mix, solar energy has grown at a faster rate, bridging the gap in the overall capacity in the state.[4] Nevertheless, fossil fuels continued to account for an average of 52% of the procurement of the state-owned distribution utility, TANGEDCO, between 2018 and 2024.[20]

The Kerala Model: Distributed Innovation and Land-Neutral Energy

The Kerala model of non-conventional energy is a distinct reaction to the geomorphological limitations of the state. Kerala has a dense population and "wastelands" are not abundant in the state. Kerala has not been able to emulate the massive solar power parks of either Rajasthan or Tamil Nadu.[3]

The Rooftop Solar Leadership

Kerala is currently the leading state in the country in rooftop solar installations, with an impressive 106,925 installations by June 2025. During the same time, Tamil Nadu has managed only 31,620 installations. Kerala has high literacy levels, and the state's nodal agency, ANERT, has been actively implementing the PM Surya Ghar Yojana, thus contributing greatly to this success. The total installed capacity of solar power in Kerala increased from 1.02 GW during the 2023-2024 period to 1.54 GW during the 2024-25 period, a 50% increase in one year. The Draft Kerala Power Policy 2025 marks a transition from a growth strategy based on incentives to a growth strategy based on mandates (for new commercial buildings above 100 m2 to install rooftop solar). Furthermore, the state is developing two new "Virtual Net Metering" and peer-to-peer trading systems for citizens who lack sufficient roof space to invest in shared solar projects.

Floating Solar: Utilizing Water Bodies for Energy

To overcome the issue of land availability, Kerala has developed a unique “floating solar photovoltaic” system. The NTPC Kayamkulam project, with a capacity of 92 MW, was the second-largest FPV system in the country by 2025.[25] These projects have a number of technical advantages, such as an increase in efficiency of 15% due to the cooling effect of water and the albedo effect of water-reflected sunlight.[25] The Kerala State Electricity Regulatory Commission (KSERC) has declared a tariff order for FSPV projects at a levelized cost of ₹3.11 per unit, which is an attractive option compared to land-based generation.[26]

Kerala RE Installed Capacity (MW) 2020–2025

Category	March 2020	March 2022	March 2024	March 2025
Solar Power	226	512	1,020	1,540
Wind Power	70	70	70	100
Small Hydro	212	224	245	300
Biopower	2	2	2	5
Total RE (excl. Large Hydro)	510	808	1,337	1,945

Kerala’s wind potential, while limited, has seen niche developments in areas like Walayar, where around 1,500 MW could theoretically be generated.[26] Small hydro also remains a significant component, with the state maintaining a top-tier national rank in the segment.[4]

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Infrastructure, Grid Stability, and Storage Solutions

The rapid integration of variable renewable energy (VRE) has created significant technical challenges for grid managers in both states. By 2025, both Kerala and Tamil Nadu identified energy storage as the "linchpin" for the next phase of their transitions.[12]

Grid Evacuation and Curtailment in Tamil Nadu

During the period of peak winds, Tamil Nadu is normally faced with the challenge of grid pressure. In May 2025, unseasonal rainfall and lower-than-expected demand led to curtailment of 70 million units of renewable energy in one week.[28] The producers stated that the grid manager for Tamil Nadu, TANTRANSCO, curtails the intake of power for three to five hours a day at substations situated in Theni and Tirunelveli to achieve this.[28] The dependence on coal and nuclear for base load generation in Tamil Nadu leads to a "must-run" conflict because of the need to curtail renewable energy to maintain the integrity of the thermal stations.[28]

The Storage Pivot: BESS and Pumped Hydro

For meeting curtailment and evening peak shortages, Tamil Nadu has set a target of 11.7 GW of energy storage capacity by 2035.[12] This includes 1.4 GW of Battery Energy Storage Systems (BESS) and more than 4 GW of pumped hydro storage (PHS) at Kundah, Vellimalai, and Aliyar.[12] The 500 MW Kundah project is expected to be commissioned by April 2026.[12]

Kerala, on the other hand, marked a historic milestone in April 2025 by signing an MoU for its first grid-scale BESS at Mylatty, Kasaragod.[27] This 125 MW/500 MWh project, developed through a PPP model with Solar Energy Corporation of India (SECI) and JSW Neo Energy, was expected to be completed in a record nine months.[27] The Mylatty project is of utmost importance to Kerala for storing midday solar surpluses and releasing them during the evening peak hours, which may help mitigate Kerala's large dependence on energy imports, currently meeting 65% of its demand.[3]

Regulatory Frameworks and Policy Innovation

The 2020–2025 period saw a convergence in long-term goals both states aiming for net-zero emissions but a divergence in regulatory mechanisms.

Renewable Purchase Obligations (RPO) and Net Metering

TNERC in Tamil Nadu has prescribed a new RPO target that will increase from 29.91% in 2024-25 to 43.33% in 2029-30.[17] The state’s 2025 regulations brought in flexibility, where surpluses in wind or hydro can be used to meet deficits in other sources.[17] In the case of distributed renewable energy (DRE), the state of Tamil Nadu has a 4 kWh/day multiplier for RPO compliance in case of missing generation data.[32]

The state of Kerala’s 2025 regulations were centered on “Energy Banking” for prosumers, ensuring that citizens who invest in rooftop solar can receive their power back from the grid for the duration of the project.[24] However, the state was experiencing regulatory hurdles; the Domestic On-Grid Solar Power Prosumers Forum challenged the 2025 regulations in court, claiming that KSERC was being pressured by the state utility KSEB to restrict net metering to 3 kW and charge exorbitant export tariffs.[34]

Green Hydrogen: The Next Frontier

Both states had formulated ambitious Green Hydrogen policies by 2025. Kerala aims to be a 100% green hydrogen/ammonia-consuming state by 2040, with an annual domestic demand of 0.155 million tons.[35] The state's "Hydrogen Valley" project, extending from Thiruvananthapuram to Kochi, plans to mix 10% hydrogen with natural gas by 2030.[35]

Tamil Nadu has concentrated on green hydrogen's integration with its industrial hubs, with the government approving 500 MW of offshore wind power capacity exclusively for the development of hydrogen production hubs.[4]

Socio-Economic Impact and the Private Sector Role

The transition to non-conventional energy has had deep socio-economic repercussions, particularly in the creation of a "green economy."

Employment and Skill Development

In Tamil Nadu, the development of the wind and solar industries has led to formal employment growth of 6.7% on average.[36] The state's "Naan Mudhalvan" initiative has emphasized the need to skill the renewable energy industry, particularly the emerging offshore wind and EV sectors.[37] The fact that there are more than 1,500 members in the Indian Wind Power Association (IWPA) in the state indicates the level of engagement of the private sector.[38]

The influence of Kerala is evident through its adoption rate of electric vehicles. As of March 2025, Kerala had 241,000 electric vehicles, with electric vehicles constituting 13% of the total two-wheeler registrations.[4] This transition has been facilitated by KSEB's initiatives to set up solar-powered rapid charging stations, such as the Kaloor charging station in Kochi.[39]

Private Investment and FDI Trends (2020–2025)

The private investors are growing with the innovative ideas of investment in the renewable energy sector. The companies are coming forward due to the social commitment and sustainable profit making opportunity. The major investors are focusing on Tamil Nadu for the investment in the offshore windmill energy production and the key players are Suzlon, Adani, Tata Power and JSW energy. While in Kerala the priority is given for the rooftop photovoltaic solar panel installation and Green Hydrogen. The major players are JSWNeo Energy, INKEL and CIAL.

The Indian renewable energy industry registered a massive 420% YoY increase in capacity addition in June 2025, which indicates increasing global investor confidence.[40] Tamil Nadu alone attracted ₹3,000 crore of new investments for grid and storage augmentation in early 2025.10 In Kerala, the INKEL (a PPP venture) launched the state's first group captive solar project—a 23.3 MW project in Malappuram—indicating a new approach to industrial adoption of renewable energy.[22]

Challenges and Future Outlook

However, despite the remarkable progress, some structural issues are still to be addressed. Land availability is still a constraint for Kerala, requiring more investment in costly floating or rooftop structures.[21] In Tamil Nadu, the financial position of TANGEDCO is still a concern for the project developers, with irregular payments being cited by the local bodies such as the Odanthurai Panchayat, which runs its own windmill.1[4]

The Roadmap to 2030 and 2040

The comparative analysis reveals that by 2025, both states have successfully moved beyond the "demonstration" phase of non-conventional energy into the "integration" phase.

1. **Kerala:** On track to reach 100% RE by 2040, with a focus on 4 GW of storage and a thriving green hydrogen ecosystem.[3]
2. **Tamil Nadu:** Poised to be a global hub for offshore wind, targeting a 50% RE share in its energy mix by 2030 and the repowering of over 10 GW of legacy wind assets.[16]
   The current decade of 2020-2025 has only reaffirmed that, despite the different technologies of choice—wind and utility-scale solar for Tamil Nadu, as opposed to rooftop and floating solar for Kerala—the key to success remains the same: strong state policies, supportive nodal agencies (ANERT and TEDA), and the capacity to attract private investment through innovative PPP structures. As these states move towards 2030, the complementarity between their different models will be critical to the country's national vision of achieving 500 GW and a net-zero economy by 2070.

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