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Indian States' Electricity Transition (SET): 2024

Evaluating the preparedness of 21 Indian states to walk the electricity transition pathway

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Contents

Figures and Tables

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Key Findings

Karnataka and Gujarat, the top performers in SET 2023, were again exhibiting strength in 2024's assessment parameters. These states have effectively integrated renewable energy sources into their power sectors, making big strides in decarbonisation, and are adequately prepared to accelerate the transition with robust market enablers facilitating future growth.

Odisha exhibits preparedness to embrace electricity transition through the readiness of its market enablers. However, it struggles with the actual decarbonisation of its power systems.

Kerala, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh and Maharashtra all showed strong progress in one or more of the three dimensions: Decarbonisation, Readiness and Performance of the Power Ecosystem and Market Enablers. But they were also significantly slower in one of the three dimensions.

Jharkhand, Bihar, West Bengal and Uttar Pradesh move slowly than others again in SET 2024, despite the changes to our assessment parameters. There is a need to prioritise comprehensive strategies and interventions to foster sustainable growth and transition in their power sectors.

Executive Summary

The 2024 Indian States' Electricity Transition (SET) report finds that Gujarat and Karnataka have effectively integrated renewable energy into their power sectors, shown adequate preparedness to further the electricity transition and have robust market enablers to facilitate future growth of clean electricity. The two states' consistent performance over several different parameters across two iterations of our report highlights their strength when it comes to electricity transition. States such as Haryana, Andhra Pradesh, Punjab and Rajasthan exhibited considerable progress in certain aspects but the progress has not been consistent across all the dimensions. At the same time, Jharkhand, Bihar, West Bengal and Uttar Pradesh move more slowly than others again this year, despite the changes to our assessment parameters. They need to prioritise comprehensive strategies and interventions to foster sustainable growth and transition in their power sectors. We recommend the strengthening of state-level regulatory frameworks and prioritising state-level transition plans and trajectories for broad-based progress towards electricity transition at a subnational level.

India's economic growth is fuelling a surge in electricity demand. Last year, with a 6.7% growth in gross domestic product (GDP), India's electricity demand rose by a similar 7%.[1] Demand is likely to grow at a similar pace of 6.5% from 2024 to 2026, according to the International Energy Agency.

Given that electricity generation continues to account for nearly half of India's annual carbon dioxide (CO_2) emissions (1.18 gigatonnes in 2023),[2] accelerating the transition to cleaner generation sources is imperative for the country to meet both its developmental and climate goals.

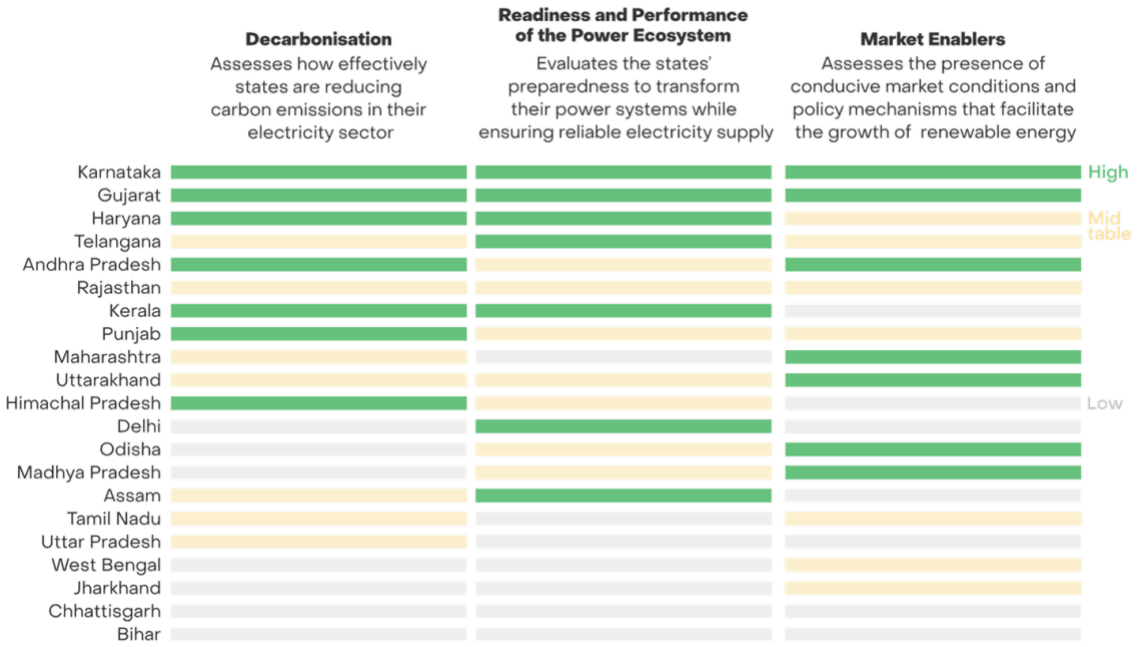
While the central government has already taken several policy measures to foster the electricity transition, states also need to move in the right direction since they have considerable control over regulations and policies.

The first edition of the Institute for Energy Economics and Financial Analysis (IEEFA) and Ember's State Electricity Transition (SET) report in 2023 analysed 16 Indian states to help identify the areas that require action and attention at the state level. This year's report builds on that work by expanding the scope to 21 states. The dimensions and parameters for assessing states have also been refined to reflect the relevance of the parameters to the status of states' electricity transition progress, feedback from stakeholders and data availability.

[1] International Energy Agency (IEA). Electricity 2024. January 2024. Page 17.
[2] Ember. India Electricity Data (State-level).

The exercise helped us identify some of the consistently top-performing states and those exhibiting signs of structural challenges when it comes to electricity transition.

Figure 1: Macro Performance of 21 States on Electricity Transition Dimensions



Source: IEEFA and Ember analysis

Gujarat and Karnataka are two states that have been the top performers across both iterations of the report despite a number of changes to the parameters this year. Specifically, in this year's analysis, the states show that they have effectively integrated renewable energy into their power sectors, have adequate preparedness to further the electricity transition, and have robust market enablers to facilitate the future growth of clean electricity.

On the flipside, states such as Jharkhand, Bihar, West Bengal and Uttar Pradesh have showcased slower progress than others in most parameters across both iterations of the SET report. Although these states are early in their electricity transition journey, comparatively low performance across several parameters over two iterations of this report suggests structural challenges.

This year we noticed that these states were grappling with challenges to decarbonise their electricity systems, which were inadequately prepared to embrace the electricity transition. These states also need to improve their policies and market-enabling mechanisms to help pave the way for a clean future for their electricity sector.

One of the striking findings from our analysis for the 2024 report was that several states are exhibiting preparedness to embrace electricity transition, whether through the readiness of their

power systems or having in place the right market enablers. However, they still struggle when it comes to the actual decarbonisation of their power systems.

Delhi and Odisha were the two notable examples in this regard. Despite significant strides in renewable energy infrastructure, Odisha struggles to make gains in decarbonisation. Similarly, Delhi too has a power system primed and ready for the electricity transition but requires better strategies to translate this strength into decarbonisation gains.

Another key theme emerging from the analysis is that several states have made uneven progress towards the electricity transition. While some lack the right market enablers, others struggle with the readiness of their power ecosystems.

Kerala, Haryana, Andhra Pradesh, Punjab and Maharashtra all exhibited considerable progress in certain aspects but also a significantly slower transition in other aspects. For example, Kerala and Punjab exhibit subpar performance in terms of market enablers for decarbonisation, while Andhra Pradesh and Maharashtra struggle with the readiness of their power ecosystems. Despite achieving relative success in decarbonising the sector thus far, states must address deficiencies in readiness and market enablers to sustain their momentum.

> **Overall, while recognising the considerable efforts states are making towards transitioning to clean electricity, we recommend the strengthening of state-level regulatory ecosystems.**

Overall, while recognising the considerable efforts states are making towards transitioning to clean electricity, we recommend the strengthening of state-level regulatory ecosystems. This not only ensures compliance but also promotes growth, data tracking and monitoring, and a conducive environment for business. India has formulated many central and state-level policy schemes to reinforce its goal of energy independence by supporting various reforms and regulatory interventions across the value chain. However, actual implementation has not been adequate and transparent.

Further, there is also a need to shift focus from national-level to state-level studies to understand the nuances of electricity transition in India fully.

Each state presents unique challenges, resources and policies influencing the adoption of renewable energy sources. There is a need to develop state-level transition plans and trajectories, delve into state-level dynamics, and identify specific barriers and facilitators to provide a holistic view of the transition landscape.

Introduction

In the year since the Institute for Energy Economics and Financial Analysis (IEEFA) and Ember jointly released the first edition of the Indian States' Electricity Transition (SET) report, the decarbonisation targets for the country have only become more ambitious.

While hosting the G20 Presidency for the first time, India championed a climate change-focused agenda, marked by getting the group of countries to agree to tripling global renewable energy capacity by 2030.[3] India reiterated these commitments at COP28 in Dubai, where it also agreed to double energy efficiency by 2030.

Yet, as it strives to meet its developmental goals by powering economic growth, emissions are rising. Although India was the fastest-growing G20 economy, clocking a 6.7% growth rate of gross domestic product (GDP) in 2023, its carbon dioxide (CO_2) emissions also grew at a rapid pace of 7% to reach 2.8 gigatonnes (Gt).[4]

Electricity generation remains the country's largest emitter by far, contributing to nearly half of India's annual CO_2 emissions, with 1.18Gt in 2023.[5]

Transitioning to clean sources of generation can help meet both India's developmental and climate goals. According to the International Energy Agency (IEA), 60% of India's electricity emissions increase in 2023 was because of cyclical weather-related events such as harsh summers and weak monsoons.[6] This year, too, a harsh summer is likely to push India's peak power demand to a record high of 260 gigawatts (GW).[7] But a harsh summer means more sunny days and an opportunity for increased use of solar power.

Utilising more solar power and, more broadly, clean electricity requires efforts both at the central and state levels. India's federal structure puts electricity under the jurisdiction of both the centre and states, which have considerable authority over energy production, distribution and regulation. As a result, states' involvement is essential for achieving the electricity transition.

To be sure, the central government has taken key policy decisions that can accelerate the electricity transition. Investments in key transmission projects to evacuate renewable energy,[8] new regulations that aim to improve clean energy integration in the electricity grid,[9] and reforms in the electricity markets[10] aim to support India's ambitious non-fossil fuel-based capacity addition targets as part

[3] Ministry of External Affairs, India. G20 New Delhi Leaders' Declaration. Page 14. 9 September 2023.
[4] IEA. CO2 Emissions in 2023. Page 17. March 2024.
[5] Ember. India Electricity Data (State-level).
[6] IEA. CO2 Emissions in 2023. Page 18. March 2024.
[7] The Economic Times. Power ministry prepares for the summer. 2 April 2024.
[8] Press Information Bureau, India. Cabinet approves Green Energy Corridor (GEC) Phase-II – Inter-State Transmission System (ISTS) for 13 GW Renewable Energy Project in Ladakh. 18 October 2023.
[9] ETEnergyWorld. Why it is the beginning of a new era for the Indian power system. 9 October 2023.
[10] Press Information Bureau, India. Central Government launches High Price Day Ahead Market and Surplus Power Portal (PUShP). 10 March 2023.

of its National Determined Contributions.[11] Concurrently, the central government has implemented several energy efficiency initiatives aimed at various sectors, including appliances, buildings and industries.[12]

The progress of states in the electricity transition is far more uneven. Some states have developed progressive steps, such as boosting decentralised renewable energy deployment, promoting solar pumps for agricultural needs, and enhancing storage solutions to ensure more renewable energy in their electricity systems.

Haryana, for instance, plans to skyrocket its solar energy capacity by 22 times, installing 6,000 megawatts (MW) by 2030.[13] States such as Uttar Pradesh,[14] Rajasthan[15] and Andhra Pradesh[16] are the only ones with notified green hydrogen policies. Gujarat was set to unveil its green hydrogen policy last year, but it is still in the draft stages.[17] Additionally, the Karnataka Energy Department has launched the state's ambitious plan to transition millions of irrigation pumps to solar energy to save substantial amounts of money spent as a subsidy every year.[18]

But, as this year's SET report finds, several other states, such as Jharkhand, West Bengal, Bihar and Odisha, need to do much more.

> **Gauging India's progress towards electricity transition requires constant monitoring of several parameters at state level.**

Gauging India's progress towards electricity transition requires constant monitoring of several parameters at state level. A purely national overview can often overshadow subtle intricacies at state level that may stymie the country's electricity transition.

IEEFA and Ember launched the SET report last year to track states' progress towards electricity transition, and help identify areas that need remedy. This year's report builds on the previous edition with more states and even more refined dimensions and parameters to map state-level electricity transition nuances. The objective of the SET report remains unchanged, which is to provide the progress and performance of Indian states on various aspects of the clean electricity transition to help policymakers make more informed decisions.

[11] As per the NDC, India is committed to increasing the share of non-fossil fuel-based electricity sources to half of the total installed capacity by 2030.
[12] Ministry of Power (MoP). The Energy Conservation (Amendment) Act, 2022. 29 December 2022.
[13] The Times Of India. Plants to pumps: Haryana sets sight on 6,000 MW solar power by 2030. 23 February 2024.
[14] The Economic Times. Uttar Pradesh Cabinet approves green hydrogen policy. 5 March 2024.
[15] ET Energy World. Rajasthan govt approves hydrogen policy. 18 September 2023.
[16] Government of Andhra Pradesh. Andhra Pradesh Green Hydrogen & Green Ammonia Policy 2023. 20 June 2023.
[17] Mint. Gujarat's draft green hydrogen policy to be ready in 2 months. 26 May 2023.
[18] The New India Express. Karnataka kickstarts ambitious plan to migrate lakhs of irrigation pumps to solar power. 30 October 2023.

Methodology

As mentioned earlier, this report builds on the previous edition, where we tracked 16 states on 17 parameters grouped under four dimensions.[19]

This year, the report tracks 21 states that collectively contributed to about 95% of India's annual power demand in the past seven financial years (FY) 2018 to 2024 (up to November).[20] The new states on the list are Kerala, Uttarakhand, Himachal Pradesh, Assam and Jharkhand.

This year's report also uses a more refined methodology, which affects both the dimensions and their parameters. We made the changes based on the relevance to the status of states' electricity transition progress, feedback from stakeholders and data availability.

New Dimensions

Based on stakeholder feedback, this year's report merges last year's Dimension 2 (Performance of the Power System) and Dimension 3 (Readiness of the Power Ecosystem). We also revised last year's Dimension 4: Policies and Political Commitments to include market enablers capturing both supply-side and demand-side interventions.

As a result, the new dimensions for this year's report are:

- **Dimension 1: Decarbonisation** – This dimension assesses how effectively states are reducing carbon emissions in their electricity sector.
- **Dimension 2: Readiness and Performance of Power Ecosystem** – This dimension evaluates the states' preparedness to transform their power systems while ensuring reliable electricity supply.
- **Dimension 3: Market Enablers** – This dimension assesses the presence of conducive market conditions and policy mechanisms that facilitate the growth of renewable energy.

Refer to **Annexure 1** for more details on the changes between the dimensions from last year and this year. **Annexure 2** elucidates the rationale behind each dimension's role in the electricity transition.

New Parameters

Extensive discussions with sectoral experts from organisations, including the Energy and Resources Institute (TERI), Grid-India, EY-Parthenon and others, helped us refine the parameters for each of the three dimensions.

[19] IEEFA. Indian States' Electricity Transition. February 2023.
[20] Central Electricity Authority. Monthly Power Supply Data. Accessed on 14 December 2023.

The changes were based on relevance to the three dimensions, feedback from experts after the launch of last year's report, and the availability of data from reliable sources.

In addition to modifying old parameters and adding new ones, we also revised the mode of measurement for a few parameters. **Annexure 1** provides details of the changes.

Refer to the **2023 report** for details on the selection of weightages, the scale used for scoring, and data collection methods, which remain the same.

We relied on qualitative data alongside quantitative data for the third dimension, Market Enablers. To ensure uniformity in analysis, the report relied on data for FY2023 wherever possible. In cases where data for FY2023 was unavailable, we used the latest available data for all the parameters. Sectoral experts vetted the data used in this report.

Similar to last year, there were challenges obtaining data for a few states in certain parameters. Refer to **Annexure 2** for a full list of data-related challenges and assumptions.

Table 1 provides details on the parameters, the metrics used for different parameters, the type of indicator, weightages and data sources for SET 2024.

Table 1: Parameters, Descriptions, Weightages and Data Sources

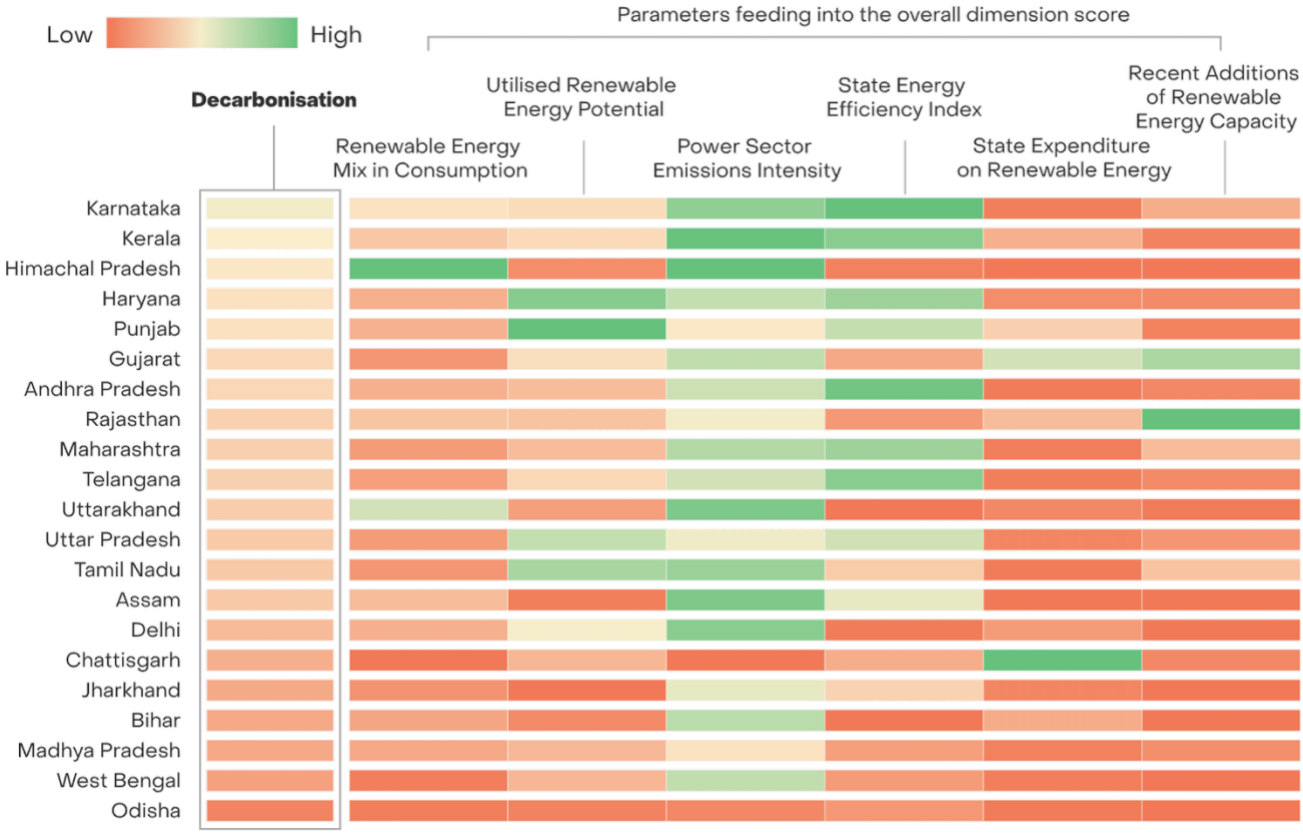
Parameters	*Weightage*	*Parameter type*	*Description*	*Data Source*
Dimension 1: Decarbonisation				
Renewable Energy Mix in Consumption	30	Progressive	Provides insight into the portion of renewable energy sources within the overall electricity consumption of a specific state, highlighting the extent to which renewable sources are integrated into the state's electricity consumption mix	Central Electricity Authority (CEA) and India Climate & Energy Dashboard
Utilised Renewable Energy Potential	10	Progressive	Evaluates the extent to which states facilitate the build-up of renewable energy capacity relative to their renewable energy potential	Ministry of New and Renewable Energy (MNRE) and Ministry of Statistics and Programme Implementation (MoSPI)
Power Sector Emissions Intensity	15	Regressive	Highlights how decoupled a state's economic growth is with its power sector emissions	Ember, Reserve Bank of India (RBI) and India Climate & Energy Dashboard
State Energy Efficiency Index	20	Progressive	An assessment of energy efficiency improvements within Indian states and Union Territories (UTs)	State Energy Efficiency Index 2023
State Expenditure on Renewable Energy	15	Progressive	Gauges how well states are utilising public funds to accelerate energy transition. It measures the percentage of public funds spent on: (a) power (also taking into account the infrastructural development common to both conventional and non-conventional sources of energy); (b) new and renewable energy and; (c) capital spent in building new renewable energy capacity	Comptroller and Auditor General of India (CAG) – State Accounts Report
Recent Additions of Renewable Energy Capacity	10	Progressive	Considers recent additions (2020-March 2024) of solar, wind, biomass and small hydro as a parameter for energy transition, and provides an assessment of the uptake of renewable energy sources, aiding in gauging progress and informing strategic decisions for accelerating sustainable energy adoption	MNRE and Ember India dashboard
Dimension 2: Readiness and Performance of the Power Ecosystem				
DISCOM Performance	25	Progressive	Provides a comprehensive assessment of the financial and operational performance of distribution utilities (DISCOMs)	Power Finance Corporation (PFC)
Short-term Market Participation	15	Progressive	Captures the level of participation in the short-term electricity market. A short-term electricity market facilitates nationwide power sharing and provides vital price signals essential for the strategic development of the transmission, storage and generation infrastructure. This enhances efficiency and augments system flexibility.	Central Electricity Regulatory Commission (CERC)

MNRE State Level Renewable Energy Target Achieved	20	Progressive	An assessment of a state's ability to achieve targets by the MNRE	MNRE from sources one and two
Adequacy of Power Supply	15	Regressive	Gauges a state's capability to fulfil its energy demand reliably. As variable renewable energy (VRE) increases in the energy mix, balancing supply and demand becomes more challenging. Effective management of this balance indicates a state's readiness for transition.	Grid-India
Uptake of Distributed Solar Energy	15	Progressive	Assesses the state's ability to leverage distributed renewable energy (rooftop solar and solar pumps) to increase renewable energy uptake	MNRE
Electricity Intensity of GDP	10	Regressive	Reflects the electricity use per unit of GDP among Indian states and indicates efficiency.	Reserve Bank of India (RBI) Data Source from Energy Intensity
Dimension 3: Market Enablers				
Development of EV Ecosystem	10	Progressive	An indicator of both the electric vehicle adoption and the effectiveness of EV policy implementation at state level	Eyatra, OMI Foundation and state EV policies
Availability and Attractiveness of Green Tariff	20	Regressive	Assesses the presence and attractiveness of green tariffs in different states	Council on Energy, Environment and Water (CEEW)
Storage Capacity Addition	10	Progressive	Evaluates the progress made by Indian states in facilitating the build-up of storage capacity within the state, which is crucial for peak power management and facilitating the integration of intermittent renewable energy sources into the power grid	CEA (Pumped Storage), JMK Research and Analytics and CEA (Peak Power Supply Position)
Renewable Energy Policy Landscape	20	Progressive	Indicates the presence of policies for capacity addition in a state by analysing the existence of state government targets for renewable capacity	MNRE
Codes/ Regulations for Distribution System	15	Progressive	Maps the state-specific implementation of codes and regulations that significantly affect the operation of the distribution system.	DSO White Paper 2023
Adoption of Green Open Access Rules	25	Progressive	Indicates if states have announced the adoption of Green Open Access Rules (GOAR) issued by the MoP	State Electricity Regulatory Commission (SERC) websites

Dimension 1: Decarbonisation

This dimension offers a holistic perspective on states' decarbonisation efforts, covering pivotal elements such as transitioning to renewable electricity, maximising renewable energy potential and decoupling economic growth from emissions. It also focuses on integrating energy efficiency into state-level policies. Furthermore, it evaluates state governments' investments in renewable energy projects, and tracks the annual additions of renewable energy capacity in recent years. Together, these parameters provide a comprehensive understanding of states' progress towards a low-carbon power system.

Figure 2: Dimension 1 (Decarbonisation) Analysis



Source: IEEFA and Ember Analysis; Note: Dimension scores are based on weighted averages. See Methodology section for details.

Karnataka stands out as the top performer in this dimension due to its strong performance across various parameters, particularly faring well in the State Energy Efficiency Index (SEEI). Despite a lower share of renewable energy consumption compared with hydro-dominant states such as Uttarakhand and Himachal Pradesh, Karnataka's share of renewable energy consumption in the total electricity consumption within the state accounted for approximately 37%. Consequently, the state also has a relatively low power sector emission intensity. Moreover, Karnataka has also added significant renewable energy capacity, emerging as the fifth-largest contributor from 2020

to February 2024, representing about 7% (~3.4GW) of the total renewable energy capacity addition (excluding large hydro) by 21 states.

Kerala stands out for its high renewable energy consumption share (29%), the fourth highest among states in this dimension, despite its relatively lower renewable energy potential. Additionally, Kerala has the third-highest score in SEEI, which may also partially explain the second-lowest power sector emission intensity in the country, indicating its efficient utilisation of electricity in various sectors.

Himachal Pradesh stands out for its strong performance in this dimension due to its historically heavy reliance on hydroelectric power, which sets it apart from other states. This enables it to consume a significant amount of renewable energy, particularly from hydro sources (almost 70% of the total power purchase). Similarly, Uttarakhand also performed well because of its focus on hydroelectric power (~47% of the total power purchase). This may be partly due to their geographical location, but it has helped these states perform well in terms of a lower emissions intensity.

Haryana's renewable energy installation is high compared with its potential, which has significantly contributed to its performance in this dimension. Most of these installations have occurred in recent years, with approximately 1.1GW added from 2019 to February 2024. Moreover, it holds the fifth-highest rank in the SEEI.

Punjab has performed well in this dimension due to its strong performance in specific parameters. It has excelled in utilising its renewable energy potential. Additionally, almost a quarter of Punjab's consumption is from renewable energy, ranking seventh-highest in the country in renewable energy consumption. Moreover, the state performs relatively well in energy efficiency (seventh-highest in the states considered here) and investments in renewable energy.

Despite contributing almost a quarter of India's total renewable energy capacity addition since 2020, Gujarat's share of renewable energy consumption within the state is relatively lower than the top-performing states (it still consumes ~17% from renewable energy). One reason for this is the low Renewable Purchase Obligation (RPO) target set by the Gujarat State Electricity Commission, which was 17%,[21] a target Gujarat achieved. This target was lower than the recommended RPO target of approximately 25%[22] for FY2022-23 set by the MoP. Additionally, the SEEI performance is modest compared with top-performing states. However, Gujarat still performs well overall in this dimension due to its renewable energy capacity addition (~12GW since 2019), significant investment in renewable energy infrastructure and expenditure within the state.

Andhra Pradesh has contributed a substantial portion to India's renewable energy capacity, and was one of the top performers in SEEI, resulting in its strong showing in this dimension.

Rajasthan consumes a significant portion of its total electricity from renewable energy sources, approximately 28%, making it one of the top performers in this assessment. Additionally, between

[21] Gujarat Electricity Regulatory Commission. Gujarat Electricity Regulatory Commission (Procurement of Energy from Renewable Sources) Regulations. 2022.
[22] MoP. Renewable Purchase Obligation (RPO) and Energy Storage Obligation till 2029-30. 22 July 2022.

2019 to February 2024, Rajasthan added approximately 16GW of renewable energy capacity, accounting for about 31% of the total installed capacity of renewable energy by the 21 states (excluding large hydro) during this period, making it the highest contributor amongst the considered states. Despite these achievements, Rajasthan's performance was mid-table in the decarbonisation dimension. A relatively higher power sector emissions intensity and lower SEEI score affected its overall performance.

Similar to Rajasthan, Tamil Nadu exhibits a significant contribution to renewable energy generation within the state, accounting for 9% of the total capacity addition by the 21 states over the past four years. However, unlike Rajasthan, Tamil Nadu has one of the lowest shares of renewable energy consumption in the country. Despite this, it boasts one of the lowest power sector emission intensities. Nonetheless, Tamil Nadu faces challenges in other parameters, which results in its dimension-level performance being slower than Rajasthan.

Similarly, Telangana and Maharashtra, despite having added a significant percentage of the country's renewable energy capacity in recent years, are not among the top-performing states due to their relatively lower share in renewable energy consumption (a parameter of significant weightage in this dimension). Eastern states such as Odisha, West Bengal, Jharkhand and Bihar are in the early stages of their decarbonisation journeys, resulting in their low scores in this dimension. While the share of renewable consumption is lower in these states, it is gradually increasing. For instance, despite its low score in this dimension, more than 16% of Jharkhand's total electricity consumption is from renewable energy sources. However, the limited resource potential for solar and wind has constrained the capacity addition within these states. Despite this, some of these states are expected to perform well in the near future, with Odisha, for instance, attracting significant investments in renewable energy,[23] green hydrogen[24] and solar cell manufacturing[25] in recent times.

Changes Compared with SET 2023

This year, the dimension incorporates changes to ensure a more comprehensive assessment of state efforts. One significant alteration is the consideration of the share of total consumption of renewable energy, regardless of the source state. This adjustment aims to capture states' endeavours in purchasing renewable energy, even if they lack abundant solar and wind resources. Consequently, the parameter of the renewable energy mix in the power supply is now based on consumption, reflecting the share of total consumption generated from renewable sources.

Additionally, to account for states' progress in adding renewable energy capacity, we evaluate their advancements between 2019 and February 2024. Moreover, this year the dimension includes the public expenditure on renewable energy by state governments, providing insight into states' efforts towards decarbonisation. These new parameters, along with existing metrics such as the utilisation

[23] MoneyControl. Odisha gets investment proposals worth Rs 4,940 crore in wind energy sector. 4 November 2023.
[24] ETEnergyWorld. Odisha approves 12 projects with investment of INR 84,918 crore. 27 November 2023.
[25] Mercom India. Jupiter to set up 1.2GW solar cell manufacturing facility in Odisha. 26 February 2024.

of renewable energy potential, power sector emission density and the SEEI, constitute a more robust assessment of states' progress towards decarbonising the power sector.

Despite these changes, Karnataka maintains its position as the top performer in this dimension, showcasing consistent leadership in decarbonisation efforts. The relatively lower performance of states such as Jharkhand, Bihar and West Bengal remains unchanged in comparison with the previous assessment.

Despite these changes, Karnataka maintains its position as the top performer in this dimension, showcasing consistent leadership in decarbonisation efforts.

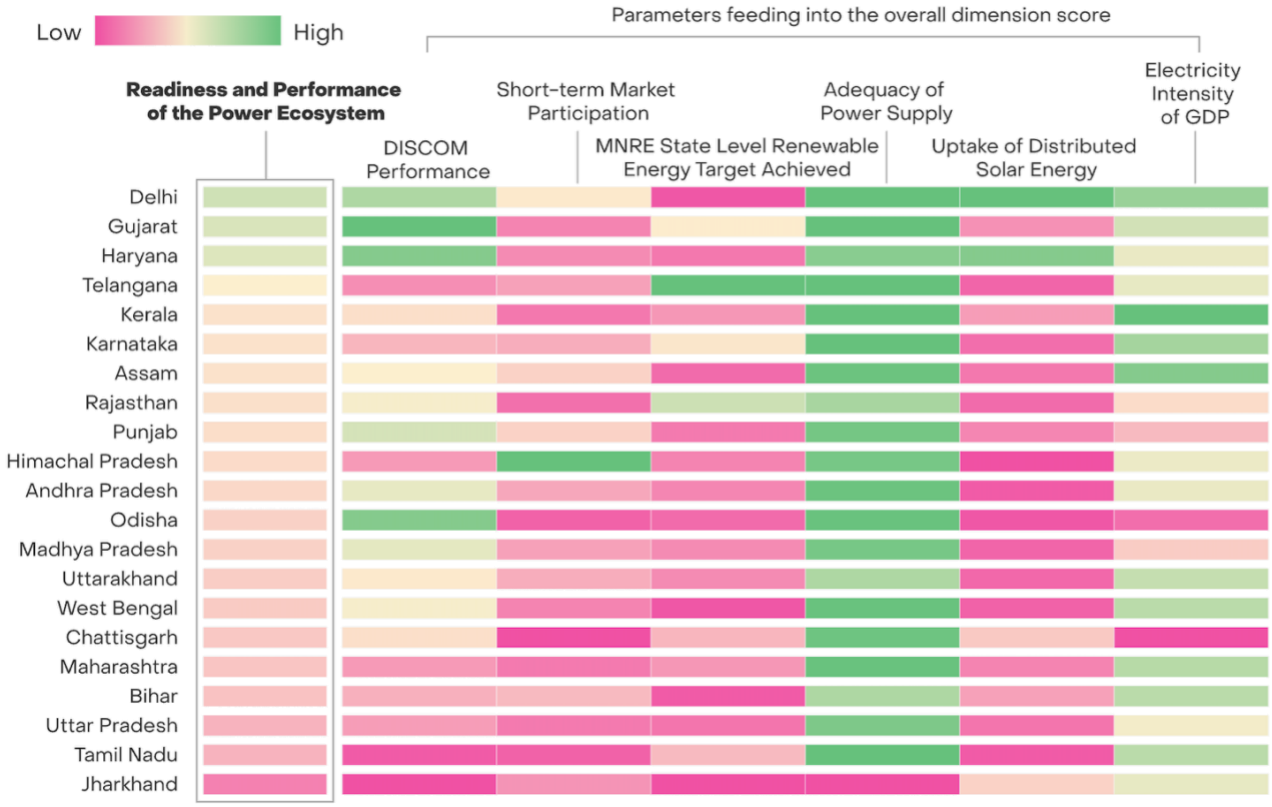
However, Rajasthan's performance has declined significantly, primarily due to a substantial reduction in its score in the new SEEI, down 46.5 points, primarily attributed to the lack of reported data. Similarly, Tamil Nadu has experienced a significant decline in performance, largely due to changes in our assessment methodologies that now include state-level renewable energy consumption. Despite its notable capacity additions, only 16% of Tamil Nadu's total consumption is from renewable energy sources, one of the lowest percentages in the country, excluding eastern states.

Conversely, Chhattisgarh's performance has improved notably. This improvement is largely because of the addition of the parameter on state expenditure in renewable energy and an improvement in the SEEI. The inclusion of these factors has lifted Chhattisgarh's overall score, reflecting its increased efforts and effectiveness in decarbonisation initiatives.

Dimension 2: Readiness and Performance of the Power Ecosystem

Alongside green electricity generation and consumption, the preparedness of the power ecosystem holds paramount importance in facilitating the energy transition of states. A well-prepared power system serves as a foundational pillar for transition, as it facilitates the integration of renewable energy sources and infrastructure. This readiness enhances grid efficiency, reliability and competitiveness, laying the groundwork for sustainable and resilient energy frameworks.

Figure 3: Dimension 2 (Readiness and Performance of the Power Ecosystem) Analysis



Source: IEEFA and Ember Analysis; Note: Dimension scores are based on weighted averages. See Methodology section for details.

States such as Delhi, Gujarat, Haryana and Telangana performed well across all the parameters. Conversely, Jharkhand, Chhattisgarh, Bihar, Tamil Nadu and Uttar Pradesh scored low on most parameters.

Delhi stands out as the top performer across five out of six parameters, particularly faring well

in the uptake of distributed solar energy. Rooftop and off-grid solar contributes to 71% of its total renewable installed capacity, the highest of all states as of 29 February 2024.[26] The state aims to generate 4,500MW or about a quarter of its total power supply through solar energy by 2027.[27] Despite high solar penetration, the state had only met 12% of the MNRE's renewable energy target by February 2024. Delhi's DISCOMs have improved their performance,[28] according to the Power Finance Corporation's (PFC) ranking[29] for FY2023. Moreover, Delhi had the highest short-term market participation in FY2023, with 34% of its total power purchase and captive generation volume traded in the short-term electricity market and 2% (~276 million units (MUs)) in the Green Day Ahead Market (GDAM). In addition, the state ensures a reliable electricity supply, facing only a shortage of 2MUs to meet the power requirement in FY2023.

Gujarat, too, shines in this dimension, boasting the highest DISCOM rating by the PFC. The state ensured reliable electricity supply, with just a 0.03% (40MUs) power shortage in FY2023. Gujarat has also built about 30% more (~5081MW) renewable capacity as of February 2024 over the MNRE suggested state target for December 2022. With only 15% of its renewable energy capacity allocated to distributed solar, Gujarat holds substantial potential for expansion in this sector. Moreover, utilising just 12% of its renewable energy potential, there is ample room for further growth. Leveraging the short-term electricity market for increased participation in GDAM beyond its current 1.8% can enhance accessibility. The state government recently signed an MoU with PFC to bolster the infrastructure of key power utilities in Gujarat.[30]

Haryana and Telangana were the other frontrunners. Haryana has the highest solar penetration after Delhi, approximately 64% as of February 2024. The state now aims to increase its solar energy capacity 22 times by installing 6,000MW by 2030.[31] Telangana achieved the highest compliance rate of 258% for MNRE's state-level renewable energy targets. Moreover, it effectively addresses power shortages, boasting the lowest shortfall of only 1MU in power requirement for FY2023. Recently, the state has also proposed the implementation of open access for power consumers, signalling a significant shift in the energy landscape.[32]

Lower DISCOM ratings led to a mid-table scoring for Karnataka and Rajasthan despite achieving high scores in Dimension 1. Karnataka scores well in MNRE's state-level renewable energy target achieved, experiences fewer power shortages, and maintains lower electricity intensity. However, its overall performance is affected as Bangalore Electricity Supply Company Limited (BESCOM), a prominent DISCOM in Karnataka responsible for nearly 47% of total power purchases, received the second lowest rating by the PFC of all DISCOMs in the state. Furthermore, the state has only about 7% (~1,592MW) of its renewable energy installed capacity as distributed solar energy.

[26] Ministry of New and Renewable Energy (MNRE). State-wise installed capacity of Renewable Power including Off-grid. 29 February 2024.
[27] The Hindustan Times. Delhi Budget: Solar is govt's new mantra for cheaper, reliable power. 5 March 2024.
[28] The Economic Times. Delhi discoms, UP's NPCL top performance ratings of power distribution companies. 20 January 2024.
[29] PFC. Annual Integrated Rating & Ranking. March 2024.
[30] ETEnergyWorld. PFC and Gujarat govt sign ₹25,000 crore MoU to boost state's power infrastructure. 4 January 2024.
[31] The Times of India. Plants to pumps: Haryana sets sight on 6,000 MW solar power by 2030. 23 February 2024.
[32] Construction World. Telangana Proposes Open Access for Power Consumers. 28 March 2024.

On the other hand, Rajasthan's performance in short-term market participation remains limited, with only 14% (~104,830MUs) of its total power purchase and captive generation traded in the short-term electricity market in FY2023. Of this, a mere 0.4% (~59MUs) is traded in the GDAM. The state also faces significant power shortages, amounting to approximately 1.6% (1,611MUs) in FY2023. Additionally, Rajasthan exhibits a lower uptake of distributed solar energy, with about 6.4% compared with the total installed renewable energy capacity as of February 2024.

Similarly, Maharashtra, despite performing well in Dimension 1, scores low in Dimension 2 due to its subpar performance in DISCOM performance, short-term market participation and uptake of distributed solar energy. Maharashtra State Electricity Distribution Company Limited (MSEDCL), one of Maharashtra's major DISCOMs responsible for approximately 90% of total power purchased by DISCOMs in the state, scored low in the PFC rating, thus lowering the state's overall score. In terms of short-term market participation, 13% (~165,190MUs) of the total power purchase and captive generation is being traded in the short-term electricity market, with only about 4% (~735MUs) of it traded in GDAM. Additionally, the state has only about 12% (~2,033MW) of its renewable energy installed capacity in the distributed solar energy category.

> **Jharkhand scores were low across all the parameters.**

Jharkhand scores were low across all the parameters. With the lowest DISCOM performance rating by PFC, the state has only achieved 7% (~142MW) of its MNRE renewable energy target of 2,005MW, indicating the potential for expansion. Additionally, it faces the lowest adequacy of power supply, experiencing a shortage of 863MUs against a requirement of 12,183MUs in FY2023, resulting in a 7% deficit.

Surprisingly, Tamil Nadu's overall score was only better than that of one state. This was primarily due to the bad performance of its DISCOMs and lower than expected distributed solar uptake (2%). The state should focus on strengthening the penetration of rooftop solar and solar pumps along with utility-scale projects. The state DISCOM registered a loss of Rs91.92 billion (US$1.1 billion) for FY2023, Rs600 million (US$7.2 million) more than the previous year, despite a tariff hike.[33] The state's short-term market participation stands at 11% (~112,817MUs) of total power purchase and captive generation. There is an opportunity to increase participation further, particularly in the GDAM, where only 0.7% (~87MU) of the traded volume lies.

Changes Compared with SET 2023

Dimension 2 has undergone revisions to provide a more holistic view of states' readiness for the electricity transition. One notable change involves merging Dimension 2 (Performance of Power System) and Dimension 3 (Readiness of the Power Ecosystem) from the SET 2023 report. This modification aims to strengthen the interlinkages between a strong distribution and transition infrastructure, and the efficient use of each electron.

[33] The Times of India. Tangedco losses cross ₹9K crore despite tariff hikes. 28 January 2024.

Consequently, we widened the parameter assessing the states' green market participation to capture their participation in short-term electricity markets, facilitating efficient power sharing and system flexibility. Another addition was to capture the penetration of distributed solar energy. This reflects states' efforts towards diversifying the energy mix and ensuring energy access across diverse regions. We also removed parameters such as feeder segregation and smart metering due to the lack of data available.

As a result of the changes, the performance of Karnataka and Andhra Pradesh, which topped Dimension 2 and Dimension 3 last year, suffered a setback in 2024. On the other hand, Delhi, Haryana and Telangana outperformed from last year in strengthening their readiness.

> **Delhi, Haryana and Telangana outperformed from last year in strengthening their readiness.**

Last year, Karnataka's strong performance was due to its high electricity generation volumes, robust green market participation and successful attainment of renewable energy targets, highlighting its proactive approach to electricity transition. However, this year the relatively lower DISCOM performance, short-term market participation and the removal of parameters, such as feeder segregation and smart metering, affected its overall performance in the dimension.

Delhi's performance improved this year due to its better DISCOM rating, short-term market participation and the uptake of decentralised solar energy.

Gujarat continued to be a strong performer this year, too, despite the changes in the parameters. Conversely, states such as Uttar Pradesh and Bihar were low performers across both years, with lower readiness levels in terms of short-term market participation, meeting renewable energy targets and DISCOM rating.

Dimension 3: Market Enablers

The Market Enablers dimension underscores a critical aspect in assessing energy transition by focusing on both supply-side initiatives to boost renewable energy capacity, and demand-side measures to facilitate increased renewable purchases. Parameters such as green tariff adoption, electric vehicle (EV) adoption rates, storage capacity at state level, state policy targets, regulatory frameworks and green open access rules are integral components within this dimension.

Figure 4: Dimension 3 (Market Enablers) Analysis

Source: IEEFA and Ember Analysis; Note: Dimension scores are based on weighted averages. See Methodology section for details.

Odisha emerges as the top-performing state with the lowest incremental green tariff rate of Rs0.25/kWh (US$0.003/kWh) compared with other states. With a robust state-specific renewable energy policy[34] and green open access rules[35] in place, the state has strengthened its policy ecosystem. Furthermore, Odisha demonstrates significant progress in the EV sector, fostering an enabling environment for development through the right policy signals, including fiscal and non-fiscal incentives, subsidies for charging infrastructure, investments in manufacturing and skills development, and innovative EV tariff and battery-swapping policies. Additionally, Odisha has

[34] Government of Odisha. Odisha Renewable Energy Policy, 2022. 30 November 2022.
[35] Odisha Electricity Regulatory Commission. Promotion of Renewable Energy through Green Energy Open Access) Regulations. 2023.

successfully implemented eight out of 14 codes/regulations set by state regulators to strengthen the operation of its distribution system as per the Distribution System Operators (DSOs) white paper 2023.[36] Even though Odisha does not have any installed pumped hydro storage or battery energy storage system (BESS) capacity, the state has invited tenders for 500MW of energy storage capacity with five hours of peak support for a period of five years.[37]

Karnataka excels not only in Dimension 1 but also in Dimension 3, with a competitive incremental green tariff rate of Rs0.5/kWh (US0.6¢/kWh), existing renewable energy policy applicable until 2027 and adoption of green open access rules. In the EV sector, the state leads with a high number of EV public charging stations, with one station per 62 EV's as of January 2024. The state surpassed Delhi and Maharashtra with 5,059 public EV charging stations.[38] Karnataka has also implemented various codes/regulations emphasising its commitment to regulatory excellence in the distribution system.

Maharashtra, Gujarat and Uttarakhand were other frontrunners with functional state renewable energy policies and successfully adopted Green Open Access Rules (GOAR). Maharashtra boasts an incremental green tariff rate of Rs0.66/kWh (US¢0.8/kWh) and Uttarakhand has a rate of Rs0.26/kWh (US¢0.3/kWh), the second-lowest after Odisha. However, Gujarat's green tariff rate is the highest of the states at Rs1.5/kWh (US¢1.8/kWh) and thus holds great potential to perform better in this area. In terms of storage capacity, Maharashtra and Gujarat have pumped hydro storage capacities of 400MW and 1,440MW, respectively. Gujarat also has 6MW of BESS storage. Although there are a number of other storage tenders (round-the-clock, BESS and grid-scale storage), most have not yet been commissioned.[39]

Rajasthan and Punjab were mid-table in this dimension. Rajasthan's lack of green tariff and limited focus on scaling storage options affected its score. On the other hand, Punjab's absence of a renewable energy policy and target led to low scores.

Without these market enablers, the widespread adoption of renewable-based electricity faces challenges, slowing down the transition towards sustainable energy sources.

Bihar, Kerala, Assam, Delhi and Himachal Pradesh need to intensify their efforts to promote renewable energy uptake as they scored low across the parameters. The absence of a EV ecosystem and non-adoption of GOARs and an EV ecosystem affected the scoring of Himachal Pradesh. On the other hand, the absence of a green tariff and the non-implementation of GOARs affected the score of Delhi, Assam and Bihar, limiting opportunities for renewable energy procurement. Moreover, Kerala and Bihar's lack of renewable energy policy exacerbates these challenges, hindering efforts

[36] IIT Delhi, TERI and IIT Kanpur. Distribution System Operators (DSOs): Need, Frameworks, and Regulatory Considerations. 2023.
[37] Emerging Technology News. Odisha launches tender for 500 MW / 2,500 MWh energy storage systems. 27 March 2024.
[38] Swarajya. Karnataka leads the way in EV infrastructure with most public charging stations, surpasses Maharashtra, Delhi; Here's all about it. 15 February 2024.
[39] IEEFA and JMK Research. Energy Storage: Connecting India to Clean Power on Demand. December 2023.

to encourage renewable energy adoption. However, the Kerala state government recently constituted a panel to draft its comprehensive energy policy.[40]

On the other hand, despite Delhi's exemplary EV ecosystem, its overall performance in this dimension is affected by other factors such as the absence of green tariffs and green open access rules. It needs to address these policy gaps and enhance their renewable energy frameworks to facilitate a smoother transition towards sustainable energy sources and achieve their renewable energy goals.

Additionally, the absence of a defined renewable energy policy target further complicates Bihar's journey towards renewable energy adoption. The state's renewable energy sector remains underdeveloped due to inadequate policy support and infrastructure. Bihar's renewable energy target and policy framework have not been updated since 2017. Despite setting a target of 3433MW of power from renewable sources, Bihar had only achieved 420MW by February 2024.[41]

Changes Compared with SET 2023

This dimension underwent an exhaustive transformation from last year, including the name change to Market Enablers from Policies and Political Commitments. Through the changes, the dimension now evaluates market enablers and readiness indicators necessary for accelerating the electricity transition. This shift led to a complete change at the parameter level, with the addition of new parameters that capture necessary market enablers. It continues to track some policy developments through parameters such as the renewable energy policy landscape and the adoption of GOARs and codes/regulations for the distribution system.

Although a direct comparison cannot be drawn between the past two years, it is interesting to see how Odisha emerges as a frontrunner this year due to its low incremental green tariff rate and robust renewable energy policy framework. The state's focus on fostering the EV ecosystem through policy incentives and infrastructure development further strengthens its position. Last year, it scored lowly in almost all parameters, including low per capita e-waste and battery recycling capacity, coal capacity in under-construction and pre-construction stages and lack of BESS projects in the pipeline.

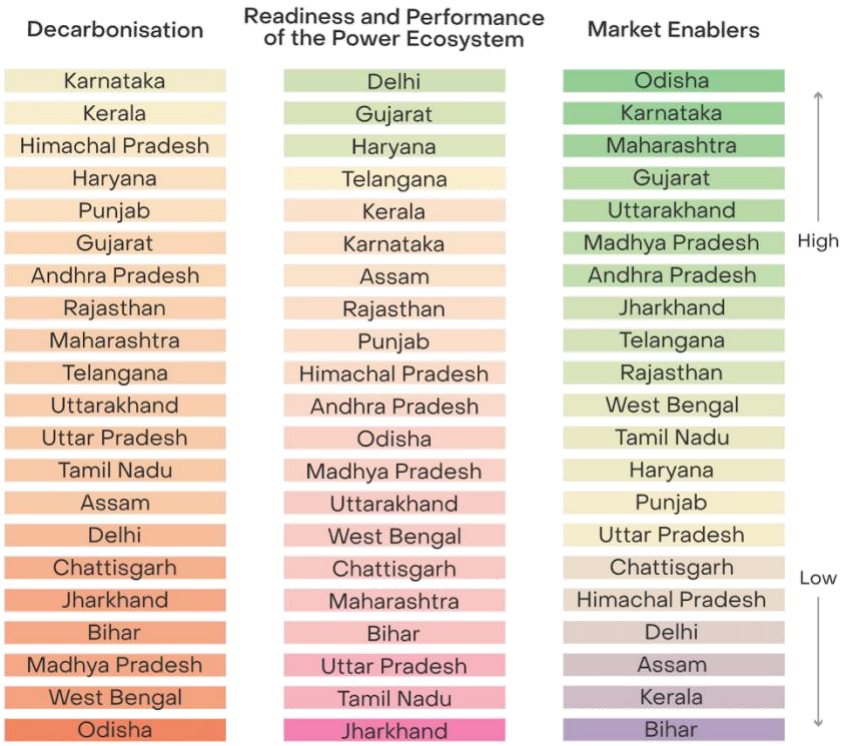
The broad comparison also reveals distinct trends and challenges across states in their readiness for the energy transition. While last year focused on the policy landscape and political commitments towards sustainability, this year's report puts emphasis on market enablers such as green tariff adoption and EV infrastructure. Gujarat and Karnataka showcase comprehensive strategies encompassing both reports, while others struggle to bridge these gaps and align market enablers with robust policy frameworks.

[40] The Hindu. State government constitutes panel for drafting comprehensive energy policy for Kerala. 1 January 2024.
[41] MNRE. State-wise installed capacity of Renewable Power including Off-grid. 29 February 2024.

Conclusion

The report acknowledges the tremendous efforts undertaken by some of the states towards electricity transition. Figure 4 summarises where the states stand regarding their progress across different parameters and dimensions of this transition.

Figure 5: Dimension-level Categorisation



Source: IEEFA and Ember Analysis; Note: Dimension scores are based on weighted averages. See Methodology section for details.

Consistent Performers

Karnataka and Gujarat exemplify strong performance across dimensions, integrating renewables with prepared power systems and robust market enablers. These states have effectively integrated renewable energy sources into their power sectors, making strong strides in decarbonisation. Moreover, their power systems are adequately prepared to further transition towards decarbonisation, complemented by robust market enablers facilitating future growth. However, states still have significant work to do in strengthening decentralised renewable energy (DRE) penetration and short-term market participation.

Interestingly, these two states were also the top performers in last year's report. Their continued strong performance, despite the numerous changes in parameters this year, indicates they are structurally strong when it comes to electricity transition.

Uneven Progress in Electricity Transition

Our analysis also found that several states demonstrate significant progress in two dimensions but face challenges in others. While some lag in Market Enablers, others struggle in the Readiness and Performance of the Power Ecosystem. To sustain progress, addressing these gaps is crucial.

Kerala, Haryana, Andhra Pradesh and Punjab also emerge as frontrunners, demonstrating commendable progress in two of the three dimensions. However, closer analysis reveals the shortcomings within each state's performance. For instance, Kerala and Punjab exhibit subpar performance in terms of market enablers for decarbonisation, while Andhra Pradesh and Maharashtra struggle with the readiness of their power ecosystems.

Himachal Pradesh, historically reliant on hydropower, has also performed well in decarbonisation, leveraging its robust hydropower infrastructure to drive progress, but it lacks progress across the other two dimensions. Despite achieving relative success in decarbonising the sector thus far, states must address deficiencies in readiness and market enablers to sustain their momentum.

Struggling to Decarbonise

Despite strong progress in power sector readiness and market enablers, some states struggle to translate these gains into effective decarbonisation efforts, highlighting the need for comprehensive strategies tailored to each state's unique energy landscape.

Notably, Delhi and Odisha excel in their power sector readiness and market enablers, respectively, yet their performance in decarbonisation lags others. While Odisha has made significant strides in renewable energy infrastructure, translating these efforts into tangible decarbonisation gains remains a challenge. Similarly, Delhi and Assam boast highly prepared systems for decarbonisation, yet they lack the necessary enablers to further enhance performance in this area. This discrepancy may stem from inherent state-specific characteristics, such as limited renewable energy potential.

Deep-rooted Challenges

States encountering challenges in multiple dimensions must prioritise comprehensive strategies and interventions to foster sustainable growth and transition in the power sector.

For states grappling with challenges across all dimensions, implementing comprehensive strategies and significant interventions becomes paramount. By prioritising initiatives to enhance decarbonisation performance, improve power system readiness and fortify market enablers, states can pave the way for sustainable growth and transition within the power sector.

Jharkhand, Bihar, West Bengal and Uttar Pradesh have showcased slower progress in most of the parameters last year and this year. These states are early in their electricity transition journey, but low performance across several parameters over two iterations of this report suggests structural challenges.

Recommendations

Based on our analysis, we make the following recommendations to accelerate the subnational electricity transition:

1. **Strengthen State-Level Regulatory Ecosystem**

   Strengthening the regulatory framework not only ensures compliance but also promotes growth, data tracking and monitoring, and fosters a conducive environment for business. India has formulated many central and state-level policy schemes to reinforce its goal of energy independence by supporting various reforms and regulatory interventions across the value chain. However, actual implementation has not been adequate, transparent and just. A poorly planned transition can disrupt the social economic development of a state. Hence, states need to step up efforts to mobilise additional public revenue, build state capacity in leveraging green financing instruments, and develop a just transition expenditure framework to help prioritise public investment in emerging sectors where it creates maximum impact.

   Ensure robust state-level planning: The recent MoP directive to all states and UTs emphasises the need for compliance with the Resource Adequacy Guidelines,[42] and is a welcome step to meet the surging power demand. These guidelines require DISCOMs to prepare a resource adequacy plan for a 10-year horizon on a rolling basis, covering the period from FY2025 to FY2034, to meet their peak and energy requirements. As of now, only Maharashtra,[43] Punjab[44] and Madhya Pradesh[45] have notified such plans. States should also ensure alignment of the guidelines with the Indian Electricity Grid Code (IEGC) 2023[46] to maintain adequate reserves to handle variability of renewable energy resources.

   Expand the boundaries of power market: The MoP has directed the Central Electricity Regulatory Commission (CERC) to initiate the market-coupling process across multiple electricity exchanges to enhance liquidity in the wholesale spot market.[47] Coupling presents a unique opportunity to form a bigger, connected, liquid and efficient marketplace to overcome the limitations of a fragmented market that has only 7% liquidity, multiple segments, a low-price cap and aggressive bidding by the supply in the face of unfulfilled demand. In addition, states should focus on robust implementation of Scheduling,

[42] MoP. Guideline for Resource Adequacy Planning Framework. 28 June 2023.
[43] Maharashtra Electricity Regulatory Commission. Draft Maharashtra Electricity Regulatory Commission (Framework for Resource Adequacy) Regulations. March 2024.
[44] Punjab State Electricity Regulatory Commission. Punjab State Electricity Regulatory Commission (Framework for Resource Adequacy) Regulations. 2024.
[45] Madhya Pradesh Electricity Regulatory Commission. Draft Madhya Pradesh Electricity Regulatory Commission (Framework for Resource Adequacy) Regulations. 2023.
[46] Central Electricity Regulatory Commission. Indian Electricity Grid Code Regulations, 2023. 29 May 2023
[47] IEEFA. Implementation of Market Coupling in India: Recommendations to the Central Electricity Regulatory Commission. 1 November 2023.

Accounting, Metering and Settlement of Transactions in Electricity (SAMAST) to ensure market readiness of interstate entities.

Update and implement cross sectoral policies for renewable energy uptake: Chhattisgarh, Telangana and Kerala still lack renewable energy policies. On the other hand, Bihar, Haryana and West Bengal need to revise their renewable energy policies, which lapsed in 2022. Even though most states now have an EV policy in place, Madhya Pradesh and Kerala still lack one. Another area that needs strengthening is state-level green hydrogen policies. Only Uttar Pradesh,[48] Rajasthan[49] and Andhra Pradesh[50] have notified green hydrogen policies. In addition, integration of storage with all future renewable energy projects will help create reserves for peak load management.

Focused compliance of national targets: A welcome step was the introduction of the new Distributed Renewable Energy (DRE) segment, allowing renewable energy projects with a capacity of less than 10MW to qualify for RPO for distribution companies and open-access consumers. Tracking and monitoring progress on the same would be crucial to ensure effective penetration of decentralised renewable energy solutions. In addition, states might also need similar focus push to strengthen their storage capacity.

2. Prioritise State-Level Studies

There is a need to shift focus towards state-level studies to comprehensively understand the nuances of electricity transition in India. Each state presents unique challenges, resources and policies influencing the adoption of renewable energy sources. There is a need to develop state-level transition plans and trajectories, delve into state-level dynamics and identify specific barriers and facilitators to provide a holistic view of the transition landscape.

Systematic and timely sharing of accurate data is the key to optimal transmission planning and development of transmission infrastructure. The absence of long-term planning for renewable energy integration, green hydrogen production hubs and reactive power planning will hamper the effective utilisation of renewable energy resources. Hence, there is a need to introduce transmission planning regulations at the state level that are aligned with CERC's transmission planning regulations.

In addition, capacity building of state transmission utilities (STUs) on the regulatory framework is required. A platform for STUs to share knowledge on innovative solutions and best practices needs to be formed.

[48] The Economic Times. Uttar Pradesh Cabinet approves green hydrogen policy. 5 March 2024.
[49] ET Energy World. Rajasthan govt approves hydrogen policy. 18 September 2023.
[50] Government of Andhra Pradesh. Andhra Pradesh Green Hydrogen & Green Ammonia Policy 2023. 20 June 2023.

3. Enhance State-Level Data Availability and Transparency

Comprehensive and transparent data collection and dissemination are essential for conducting effective state-level studies, enabling informed decision-making and policy formulation. Access to reliable public data at state level was a challenge throughout the study.

There is a need to strengthen efforts to enhance data availability and transparency at state level. While initiatives such as the India Climate & Energy Dashboard[51] have improved accessibility, there remains a significant data gap, especially for data on state-level energy consumption, transmission and market participation.

We could not consider several parameters, such as state-level STU readiness, green term ahead market (GTAM), electricity quantum exchange through open access, smart metering and storage tenders, as part of the analysis due to a lack of state-level data. Capacity building of state authorities should be done to capture, analyse and transfer the data efficiently and accurately.

These integrated recommendations emphasise the importance of prioritising state-level studies, ensuring data availability and transparency, and addressing national-level oversights to facilitate a successful transition to renewable energy in India.

[51] Vasudha Foundation. India Climate & Energy Dashboard (ICED).

Annexure 1: Changes in Dimension, Parameters and Mode of Measurement

Table 2: Comprehensive List of Changes in SET 2024 Compared with SET 2023

Parameters	2023	2024	Update name of parameter in SET 2024 (if included in SET 2024)	Mode of Measurement	Change in mode of measurement (if applicable)
Renewable Energy Mix in State's Power Supply	Yes	Yes	Renewable Energy Mix in Consumption	Renewable consumption/Total consumption (Consumption has been computed by adding total power purchase by DISCOMs and captive generation)	Yes
Renewable Energy Potential Utilised by the States	Yes	Yes	Utilised Renewable Energy Potential	Renewable energy installed capacity (as of February 2024; excluding large hydro)/Renewable energy potential as estimated on 31 March 2022	No
Old Coal Power Capacity in Operation	Yes	No	-	-	-
Power Sector Emissions Intensity (gCO2e/GDP)	Yes	Yes	Power Sector Emissions Intensity	FY2023 power sector emissions/FY2023 GDP	No
State Energy Efficiency index (SEEI)	Yes	Yes	State Energy Efficiency Index	SEEI 2023	No
State Expenditure on Renewable Energy	No	Yes	-	Data taken from states' finance accounts. Years: Average for values from FY20-FY23 Weighted average of: 1) Capital expenditure on new and renewable energy/total expenditure on new and renewable energy 2) Total expenditure on new and renewable energy/total expenditure on energy 3) Total expenditure on energy/total consolidated fund expenditure Here, total expenditure = capital expenditure + revenue expenditure	-
Recent Additions of Renewable Energy Capacity	No	Yes	-	Total MW capacity added in 2020,2021,2022,2023, up to March 2024	-
DISCOM Performance Rating	Yes	Yes	DISCOM Performance	MoP 12th Annual Integrated Rating and Ranking of Power Distribution Utilities (State-level scoring derived by weighted average method based on power purchase at DISCOM level in that particular state out of total power purchase of all DISCOMs in the state)	Yes
Percentage of Outstanding Payments of DISCOMs to Power Generators	Yes	No	-	-	-
GDAM Participation	Yes	Yes	Short-term Market Participation	Weighted average of: 1) Sum of total sales and purchases of electricity through short-term contracts/total of power purchase and captive generation 2) Sum of sales and purchases on GDAM /sum of sales and purchases of electricity through short-term contracts in electricity market	Yes
Subnational	Yes	Yes	MNRE State Level	Capacity installed within the state boundary (excluding	No

Renewable Energy Targets vs Achieved (to end of 2022)			Renewable Energy Target Achieved	large hydro)/ statewise breakup of 175GW target	
Quality of Supply/Power Shortages	Yes	Yes	Adequacy of Power Supply	Shortage (MU)/Power Requirement (MU)	No
Feeder Segregation	Yes	No	-	-	-
Smart Metering	Yes	No	-	-	-
Electricity Intensity of GDP (kWh/US$GDP)	Yes	Yes	Electricity Intensity of GDP	Total power purchase by distribution utilities (GWh) in FY22-23 (MU + To) + captive generation in FY22/FY22-23 GDP (Rs trillion) (constant prices FY12)	Yes
Uptake of Distributed Solar Energy	No	Yes	-	Rooftop solar installed capacity + off-grid solar installed capacity/total installed capacity as of 29 February 2024 (incl large hydro)	-
Avoiding Coal Power Lock-In	Yes	No	-	-	-
Flexibility – Battery Policy	Yes	Yes	Storage Capacity Addition	Total storage capacity (pumped hydro storage + BESS)/Peak demand	Yes
Circular Economy	Yes	No	-	-	-
Banking Restrictions	Yes	No	-	-	-
Development of EV Ecosystem	No	Yes	-	Weighted average of: 1) FY22-23 EV Adoption rate (EV sales vs Total Vehicles) 2) EV Vehicles as on Jan 2024/No. Of Public Charging Stations State's EV policies	-
Availability and Attractiveness of Green Tariff	No	Yes	-	Incremental green tariff (assumed/actual/kWh)	-
Renewable Energy Policy Landscape	No	Yes	-	Qualitative categorisation of states on the basis of existence of statewise renewable energy target	-
Codes/Regulations for Distribution System	No	Yes	-	Qualitative categorisation of states on the basis of codes/regulations to strengthen distribution system	-
Adoption of Green Open Access Rules	No	Yes	-	Qualitative categorisation of states on the basis of applicability of Green Open Access Rules	-

Note: Methodology details remain the same as in the previous report. Refer to Annexure 1 of SET 2023.[52]

[52] IEEFA. Indian States' Electricity Transition. February 2023.

Annexure 2: Rationale for Dimensions and Parameters and Data-related Challenges and Assumptions

Table 3: Dimensions, Parameters and the Data-related Challenges and Assumptions

Parameter	Rationale	Challenges	Assumptions
Dimension 1: Decarbonisation – *Collectively, the parameters of this dimension offer a comprehensive perspective on states' advancement towards decarbonisation, which includes transitioning to renewable electricity, realising renewable energy potential, analysing economic growth in terms of power sector emissions, integrating energy efficiency into state-level policy adoption, tracking state expenditure on renewable energy and increment in renewable energy capacity.*			
Renewable Energy Mix in Consumption	This parameter provides insight into the portion of renewable energy sources, such as solar, wind, hydro and biomass, within the overall electricity consumption of a specific state. It quantifies the contribution of renewable energy in meeting the state's total electricity consumption, highlighting the extent to which renewable sources are integrated into the state's electricity mix. This is a direct indicator of a state's progress in decarbonisation. The higher the proportion of renewable energy in the energy mix in consumption, the higher the state's efforts in diversifying its energy mix.	State-level renewable energy consumption data was not available for all states for FY23. We used FY21 data for those states. Similarly, captive consumption data was only available for FY21.	For consumption, the aggregate of captive power generation within a state and power purchase by the DISCOMs of the states are taken into consideration. Direct data collection from source and analysis.
Utilised Renewable Energy Potential	Evaluates the extent to which states facilitate the build-up of renewable energy capacity relative to their renewable energy potential. It measures the percentage of installed renewable energy capacity comparison with the estimated potential within each state. A higher percentage signifies the state's market conduciveness for utilisation of its renewable energy potential.	The 2022 estimates of renewable energy potential for different states were not publicly available. The latest available data on the renewable energy potential of states is from MoSPI's Energy Statistic 2022 report pertaining to potentials as of April 2021. We used this data as a proxy for potential estimates in 2022.	Direct data collection from source and analysis. We used the 2021 data as a proxy for potential estimates in 2022.
Power Sector Emissions Intensity	Gives us a sense how decoupled a state's economic growth is – or isn't – with its power sector emissions. Given that power sector emissions constitute a significant portion of the energy emissions, this parameter serves as a proxy measure. A lower emissions intensity of GSDP indicates reduced reliance on fossil fuel-based generation to drive economic growth, aligning with decarbonisation objectives and indicating readiness for transition towards cleaner energy sources.	While calculating the emissions intensity of GSDP, FY22 GSDP data was unavailable for Maharashtra, Gujarat, Chhattisgarh and West Bengal in the RBI database. Therefore, our FY22 estimates are based on FY21 GSDP data, assuming an 8.7% real GDP growth rate (national average) for FY22.	Emissions intensity factors have been assumed per Ember's Global Electricity Review 2022, based on IPCC 5th Assessment Report Annex- 3.
State Energy Efficiency Index	The SEEI gauges energy efficiency initiatives within Indian states and UTs. It offers a comprehensive assessment of state-level policies, implementation effectiveness and monitoring mechanisms related to energy efficiency. Coupling energy efficiency with renewable energy will help states cater to growing consumer aspirations while ensuring affordable energy access and reducing energy and emission intensity. The SEEI provides insights into states' efforts to improve energy efficiency, which complements renewable energy deployment in achieving clean electricity transition goals. The higher the score of the state, the better the state's performance in terms of energy efficiency.	-	The SEEI is the best proxy source to capture energy efficiency progress at the state level.

State Expenditure on Renewable Energy	Gauges how well states are utilising public funds to accelerate energy transition. It measures the percentage of public funds spent on (a) power (also taking into account the infrastructural development, which are common for both conventional and non-conventional sources of energy); (b) new and renewable energy and; (c) capital spent in building new renewable energy capacity. A higher weighted average percentage (of a, b and c) signifies greater flow of funds into renewable energy development facilitating the transition towards cleaner energy sources and contributing to achieving renewable energy targets.	-	A state investing more public funds in developing its renewable energy ecosystem will be able to accelerate its transition more.
Recent Additions of Renewable Energy Capacity	Assesses how well states have performed in building solar and wind capacity In recent years i.e. from 2019 to Feb 2024 It serves as a pivotal supply-side indicator, showcasing the states' proficiency in bolstering renewable energy capacity, a crucial aspect of decarbonisation efforts.	-	Direct data collection from source and analysis.
Dimension 2: Readiness and Performance of Power Ecosystem – *This dimension is crucial as it evaluates the state-level readiness as well as performance, for transitioning the power system towards cleaner and more sustainable energy sources. The parameters considered for this dimension are selected to provide a comprehensive assessment of various aspects of the power system's performance and preparedness.*			
DISCOM Performance	The financial and operational performance of distribution utilities is fundamental to the transition of the power system. It reflects the efficiency and effectiveness of electricity distribution, which is essential for ensuring reliable and uninterrupted power supply during the transition to cleaner energy sources. The PFC's Annual Integrated Ratings and Ranking of Power Distribution Utilities report,[53] which looks at DISCOMs' performance parameter consisting of 15 base metrics[54] and nine specific disincentives,[55] forms the basis for this score. The higher the score, the better the state's power sector is placed to transition to clean power.	Due to the lack of credible and consistent data for all the states, we used the PFC's 2023 Annual Integrated Ratings and Ranking of Power Distribution Utilities for DISCOM-level integrated scores. For cumulative data at state level, weighted averages based on DISCOM consumption data were calculated.	Due to the lack of credible and consistent data from some states, we used the PFC's 2023 Annual Integrated Ratings and Ranking of Power Distribution Utilities report for DISCOM performance as a proxy.
Short-term Market Participation	Participation in short-term electricity markets facilitates efficient power sharing and enhances system flexibility. It provides essential price signals that drive strategic development of infrastructure, promoting efficiency and resilience in the power system. In addition, higher participation in the green market mechanism indicates higher possibility to unlock untapped renewable energy potential.	Tracking states' performance in the short-term market is also crucial along with Green Day Ahead Market (GDAM). Due to a lack of available data on state-level GDAM performance, this report could not capture it.	Total volumes (quantum inclusive of buy and sell) through the short-term market and then GDAM participation shall give a good understanding of states' participation in green markets.

[53] PFC. 12th Annual Integrated Rating & Ranking of Power Distribution Utilities. March 2024.
[54] Fifteen base metrics considered in DISCOM rating: ACS – ARR gap (cash adjusted); days receivable; days payable to GenCos & TransCos; adjusted quick ratio; debt service coverage ratio (cash adjusted); leverage (debt/EBITDA) (cash adjusted); billing efficiency; collection efficiency; distribution loss (SERC approved); corporate governance; subsidy realised (past three FYs); loss takeover by state government; government dues (past three FYs); tariff-cycle timelines and; auto pass-through of fuel costs.
[55] Nine specific disincentives in DISCOM rating: auditor's adverse opinion; availability of audited accounts; default to banks/FIs; audit qualifications; governance (audit committee, exclusive MD & DF, quarterly accounts); tariff-cycle delays; tariff independent of subsidy; uncovered revenue gap (current year) and; regulatory assets.

MNRE State Level Renewable Energy Target Achieved	Achievement of MNRE renewable energy targets indicates a state's capacity to harness renewable resources effectively. It reflects the state's commitment to fostering an ecosystem conducive to renewable energy development and its ability to meet overall clean energy goals. Thus, the higher the percentage of target achieved, the better the state's efforts towards renewable energy utilisation.	Revised MNRE's state-level renewable energy targets beyond 2022 were not available.	MNRE's state-level renewable energy target December 2022 taken as proxy for 2023 target
Adequacy of Power Supply	Reliable power supply is critical for supporting economic growth and meeting energy demand. The ability to manage power shortages and maintain quality of supply is indicative of a state's readiness to balance supply and demand effectively, especially with increasing integration of variable renewable energy sources. The lower the percentage of power shortage compared with the state's power requirement, the more reliable the state's power sector.	-	Direct data collection from source and analysis
Uptake of Distributed Solar Energy	Decentralised renewable energy (DRE) systems play a vital role in promoting resilience and inclusivity in the energy transition. The penetration of distributed solar energy reflects the state's efforts towards diversifying the energy mix and ensuring energy access and energy security across diverse regions and communities. The higher the distributed solar energy penetration, the better the state's resilience and inclusiveness in the transition to renewable energy.	Distributed energy data concerning all sources of energy were not available.	Distributed solar energy installed capacity taken as proxy to access decentralised electricity penetration in a state
Electricity Intensity of GDP	Efficiency in electricity use relative to economic output is essential for optimising resource utilisation and reducing environmental impact. Higher electricity intensity indicates less efficient energy use, highlighting the need for improvements to support a sustainable transition.		The sectoral split in terms of electricity consumption is same for all states. Latest data on statewise sectoral power consumption was not publicly available.
Dimension 3: Market Enablers – *This dimension focuses on facilitating both the supply-side and demand-side aspects of transitioning towards renewable energy sources. It also emphasises measures to reduce emissions through electrification, particularly in sectors such as transportation.*			
Development of EV Ecosystem	The EV sector presents an upcoming demand for electricity that is vital for energy transition. This parameter reflects EV adoption and related policy at state level. The higher the adoption rate and installation of public charging stations along with policy mandates and incentives, the better the preparedness of the state to accelerate EV uptake.	-	-
Availability and Attractiveness of Green Tariff	Green tariffs serve as a mechanism to procure renewable energy, offering consumers the option to support clean energy sources. In India, green tariffs are typically incremental, meaning they are priced higher than conventional electricity tariffs. Despite this, green tariffs can still drive demand for renewable energy purchase at state level, particularly for consumers committed to reducing their emissions footprint. The availability of green tariffs sends a clear market signal to investors and developers about the demand for renewable energy. The lower the green tariff, the higher the market pull for consumers to increase their renewable energy purchase.	Incremental green tariff data was not available for all states.	The highest incremental tariff for states that don't have a green tariff is a good proxy.

Storage Capacity Addition	Storage capacity vs peak demand indicates the state's preparedness to move to a flexible clean power system. BESS provides the flexibility and agility to better integrate intermittent solar and wind energy resources into India's electric grid, and ensure high-quality power for consumers thus accelerating the electricity transition. In addition, pumped hydro storage provides much needed flexibility. The higher the score, the better the state's storage capacity to deal with its peak demand.	State-specific data on RTC tenders was not available.	States with higher storage capacity (pumped hydro + BESS) will be better equipped to handle higher renewable energy penetration along with meeting their peak demands. Projects in the pipeline were not considered.
Renewable Energy Policy Landscape	Renewable energy policy target contributes as a market enabler by providing clarity and direction to investors, signalling government commitment to renewable energy, and creating a stable regulatory environment. This fosters investor confidence, attracts necessary investment and streamlines project development, accelerating the transition to clean energy sources by stimulating market growth and driving renewable energy deployment. Thus, presence of a renewable energy policy by the government is necessary to accelerate renewable energy uptake.	Updated data on MNRE renewable energy target beyond 2022 was not available.	States without a target beyond 2024 were not considered.
Codes/ Regulations for Distribution System	A conducive regulatory environment is essential to foster stability, encourage fair competition and align industries with broader policy objectives. The parameter maps the state-specific implementation of codes and regulations that significantly influence the operation of the distribution system. The codes/regulation we considered are: state grid code; distribution code; supply code and related matters; metering code; conditions of supply; standard of performance for distribution licensee regulations, smart grid regulations; grid-interactive solar PV system regulations; micro/mini grid renewable energy generation and supply regulations; demand-side management regulations; forecasting, scheduling deviation settlement and related matters of solar and wind generation sources, regulations; power system management standards; load forecast regulations and; power quality regulations. A higher score signifies a state's commitment to multiple regulations, creating a favourable environment for efficiently discharging transmission and distribution functions within the state.	-	States with robust regulatory guidelines and frameworks in place can better track the transition.
State's Green Open Access regulation	The implementation of Green Open Access Rules (GOAR) by states strengthens market enablers by allowing consumers to access renewable energy and simplifying approval processes. By ensuring transparency in cost structures, the regulation incentivises consumer participation, fostering growth in the renewable energy market. Thus, GOARs facilitate access to renewable energy.	-	States that are not under various stages of implementation of Green Open Access Rules are not given a score.

Note: State-level progress on parameters such as open access, green energy corridors and transmission infrastructure could not be included as part of this study due to a lack of available data.

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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Ember is an independent energy think tank that aims to accelerate the clean energy transition with data and policy. It creates targeted data insights to advance policies that urgently shift the world to a clean, electrified energy future. ember-climate.org

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