

State-wise Review of Compliance in Renewable Purchase Obligation in India

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Abstract

Stable and clean energy is highly significant for India's development and for environmental conservation. The Electricity Act, 2003 initiated a regulation known as the Renewable Purchase Obligation (RPO), which requires specified entities to procure a minimum share of electricity from renewable sources. This paper examines state-wise RPO targets and performance using the compliance data provided by NITI Aayog for 2018–2021. The findings indicate large disparities in performance: close to half of the states achieved less than 40 percent of the required renewable purchases. Some southern states such as Karnataka, Tamil Nadu and Andhra Pradesh meet or even exceed their objectives, while many states in the East and North continue to lag. A persistent gap is also evident between solar and non-solar targets. States are fulfilling their non-solar targets (on average) at approximately 83 percent, yet their solar targets (on average) at slightly less than 41 percent. The analysis of time trends and clustering indicates changing trajectories, weak enforcement, and policy impediments that restrain RPO success. The paper also links compliance levels to renewable adoption and provides practical measures to strengthen monitoring and accelerate solar integration. These insights support more effective RPO implementation and contribute to India's renewable energy transition.

1. Introduction

The global transition toward cleaner and more sustainable energy systems has become more urgent than ever to combat climate change and ensure that we have a good amount of secure energy in the future. India is considered to be among the largest and quickest-growing consumers of energy on the planet. India currently faces two major challenges; it must generate more electricity to serve the whole population and simultaneously consume less coal and oil. Both challenges can be addressed through the expansion of renewable energy sources such as solar and wind. It is beneficial to the economy, that the air is clean and it will assist India in its strategy of being green and sustainable. The government ensured that

this occurs by making an electricity Act (2003) rule known as the Renewable Purchase Obligation (RPO). This regulation states that the generation of power by the large electricity users, power companies and the personal power makers have to acquire a portion of the electricity produced by renewable energy. Each state has its target, these targets are occasionally changed to keep up with the clean energy targets in India. To supplement the RPO structure, the Renewable Energy Certificate (REC) market enables the obliged parties to comply optimally, hence, enabling an expanded geographic and technological scope of renewables.

The RPO policy has been developed in parallel with such ambitious national targets as the attainment of 500 GW of renewable energy by 2030. The policy not only encourages states to consume more renewable energy but also assists them to develop superior power systems and energy saving. However, it is not the case in all the states. Certain states perform better as compared to others as rules are varied, the resources are not similar, and the markets are at various stages of development. Therefore, a comparative study of states in a more detailed way will be critical to determine the strengths, gaps, and the directions to improve. The paper will start with an introduction to the renewable objectives and the policy of RPO in India and then provide a literature review of the policy development and related research. It has then described data and statistical procedures. The outcomes indicate the level of RPO compliance of various states to the rules and the trends observed in various areas. The paper also discusses the difficulties in implementing the rules and the impact of the same on the utilization of renewable energy. There are examples of states that performed well and those that failed.

Although, India boasts of a good policy of Renewable Purchase Obligation (RPO) to promote the utilization of renewable energy, not all the states are following suit. Approximately fifty percent of states are not even achieving 40 percent of their targets of RPO. The inability to adhere to the rules is complicated by such issues as the poor monitoring, the slow updating of targets and the weak enforcement. Besides, there is the huge discrepancy between solar and non-solar RPO compliance demonstrating that there are problems with technologies and markets. The literature examining these disparities in detail with the help of credible state-level data is very limited. The study attempts to address that gap by verifying how each state has implemented RPO rules between 2018 and 2021, which can be used to enhance the policies.

This study adds to the existing RPO compliance literature by using a state-level dataset (NITI Aayog, 2018–2021) and applying multiple statistical approaches together rather

than relying on only descriptive comparisons. Along with summary statistics, the paper uses time-trend estimation (linear regression), regional comparison (ANOVA), clustering of states based on performance (K-means), and a compliance-gap assessment to identify leaders and laggards in a consistent manner. This combined approach helps in understanding not only which states are underperforming, but also whether there are regional patterns and recurring solar versus non-solar compliance gaps that require targeted policy action.

The 2018–2021 period was selected because it is the latest time window for which the NITI Aayog RPO compliance dataset provides consistent and comparable state-wise targets and achievement figures for both solar and non-solar categories. Using a continuous four-year window allows a like-to-like comparison across states and helps track short-term changes in compliance while keeping the data definition uniform.

2. Literature Review

The Renewable Purchase Obligation (RPO) system in India set out by the Electricity Act 2003 and national tariff policy 2006 is one of the key tools of influencing renewable energy (RE) implementation. It obliges electricity distribution companies (DISCOMs), open-access and captive consumers to purchase a certain amount of power from renewables. The framework continued being extended based on solar, non-solar, wind, and hydro sub-categories to fit the strategy of the diversification of renewables in India [1]. Though the RPO mechanism has been a major contributor to the development of RE in India, empirical studies indicate that there are large state-wise differences. States like Karnataka and Gujarat were the only ones that followed the targets regularly and surpassed the expectations, but others fulfilled less than half the expectations [1]. These loopholes are usually indicative of the disparity in endowment of renewable resources, fiscal soundness of DISCOMs, and the divergence in the state-levels of enforcement capabilities [2].

The lack of strong regulation enforcement is a thorny issue. Most State Electricity Regulatory Commissions (SERCs) have permitted RPO shortages to be carried forward without penalty, which weakens compliance credibility [3]. Further, there is the Solar vs Non-Solar compliance gap: even with drastically reduced solar tariffs, a number of states fail to meet solar RPOs because of grid integration restrictions and unavailability of bankable solar agreements [4]. The mechanism of Renewable Energy Certificate (REC) which was proposed to bring flexibility has been hampered by the

lack of consistency in enforcing it. The low level of compliance with RPO has lowered the REC demand, which results in the oversupply and poor price indicators [5]. Despite the reforms that are being implemented, there is scanty evidence that shows that REC trading is correlated to renewable capacity growth.

The literature highlights the fact that the RPO policy in India has been central in integrating renewable energy into the electricity mix of the country and in putting India on a path towards cleaner generation. The framework has developed as a compliance-based mechanism into a strategic policy tool that is consistent with the objectives of national climate and energy security. Although the experiences of implementation are different in each state, the RPO has developed the necessary regulatory base that fosters market development, facilitates the renewable energy investment, and supplements other wider programs like competitive bidding and the REC market. Altogether, these works indicate that the RPO continues to play a leading role in the energy transition in India as both an incentive in the adoption of renewables and policy consistency in the federal system of energy governance.

3. Methodology

3.1 Data Source: NITI Aayog RPO Compliance Dataset (2018-2021)

This study uses data provided by NITI Aayog that is the primary governmental institution planning the development in India. The information demonstrates the level of achieving Renewable Purchase Obligation (RPO) targets by each state during 2018-2021. It provides data about solar energy and non-solar energy on an independent basis stating the targets and actual results each state reached. These figures are derived based on State Electricity Regulatory Commissions (SERCs), power distribution companies (DISCOMs) and government reports. This, combined, provides a clear illustration of the

manner in which the various states and Union Territories have purchased renewable energy over this period. It assists in comparison of the working success of the policy both through time change and state-to-state variation. This is the primary data of the analysis in this research. It allows us to estimate the extent to which states adhere to the rules, identify local tendencies and identify unmet policy use. The graphs and basic tests on the premise of this data help the purpose of the study to comprehend the effectiveness of the RPO policy and propose methods to enhance it (Table 1).

3.2 Statistical Models and Analysis Approaches

In this study, we examine state/UT compliance with Renewable Purchase Obligation (RPO) targets from 2018 to 2021 using a combination of descriptive and inferential methods. First, descriptive statistics and visualizations summarize solar, non-solar and overall compliance levels, highlighting distributions, outliers, and year-to-year changes. Second, linear regression is used to estimate short-term trends in compliance over time. Third, regional differences are tested using ANOVA, and solar versus non-solar compliance differences are compared to highlight the solar compliance gap. Finally, cluster analysis groups states with similar compliance profiles, and a compliance-gap calculation quantifies the shortfall between targets and actual procurement. Together, these methods provide a transparent and comparable assessment of state-wise RPO performance [6].

3.3 Linear Regression

The evaluation is aimed at monitoring the compliance performance changes during the study period and finding out definite trends in time. The compliance percentages of all 50 states with RPOs in 2018 to 2021 are as per the following: assembled under solar, non-solar and general headings. Linear regression models are then used, where the compliance is used. percentage as dependent variable and year as independent variable, to estimate whether the trend

Table 1: Key Indicators for RPO Compliance Analysis.

Sr No.	Indicators	Explanation
1	State-wise RPO Targets	The lowest amount of electricity that each state should receive through renewable sources. These objectives are divided into two categories, solar and non-solar. This captures the policy objectives to be met by every state by 2018 to 2021.
2	RPO Achievement Percentages	Reflects the actual amount of renewable energy that each state reached in comparison to the targets. It assists in knowing whether the states are achieving the required compliance levels.
3	Solar and non-solar Split	Tracks performance for solar RPO and non-solar RPO separately since both grow differently and face different challenges.
4	Compliance Gap	Displays the variation between the targeted RPO and the attained one. This gap is presented as a percentage and also as energy and indicates the states that underperform or exceed expectations.
5	Temporal Trends	Looks at how the targets and the achievements have changed year by year to understand progress and improvement over time.

of each state is or not. growing, constant, or decreasing. The statistical significance of such trends is verified in order to check that they are observed. The changes are not imaginary but rather as a result of not being random. Smooth out short term can also be done by the use of moving averages. trends so that there are less trends in the long-term. This aids in demonstrating whether performance is becoming better or not, standing still or becoming worse, and it brings out a better understanding of whether the current policies are achieving or need adjustments. This model assists in gauging the orientation and intensity of change in the levels of compliance on a state-by-state basis. Since the study period includes only four annual time points (2018–2021), the regression results should be interpreted as short-term indicative trends rather than long-run patterns. With a limited time span, statistical significance is harder to establish, and the main value of the regression here is to highlight directional changes and compare states on a consistent basis.

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

The symbols used in this equation are, Y is the percentage of compliance with the RPO, X = the year, β_0 is the intercept that values are below one. the level of compliance at the beginning of the time period which is approximated, and β_1 is the slope of the line. The slope indicates the average change rate of the compliance percentage with one year passing. A positive slope shows a negative slope indicates a downward direction, an improving trend indicates an upward direction, and a slope that is near to zero indicates that compliance has. was not generally altered with time. ε is the symbol that signifies the random error or unexplainable variation of the data [7].

3.4 Analysis of Variance (ANOVA)

The analysis examines the variation in the level of compliance amongst regions and between solar and non-solar categories. In order to achieve this a one way ANOVA is carried out to test the means of the compliance rates of the varying geographical areas like the North, South, East, West and Northeast. Before interpreting ANOVA results, the key assumptions were considered. State/UT observations are treated as independent. Given that compliance distributions can be skewed, the ANOVA findings are interpreted cautiously and presented primarily as evidence of differences in mean compliance across regions, supported by descriptive comparisons and visual trends. When the ANOVA indicates that differences exist, post hoc tests assist in finding out specific regions that are different. Paired t tests are also conducted along with this and within each state to compare the solar and non-solar compliance percentages to assist

us in knowing how huge the percentage is; whether it is statistically significant and different. This method is useful for in ascertaining whether the differences are not just random but real as well and it can also aid in better and more focused policy recommendations.

$$SS_{\text{total}} = \sum (X_i - \bar{X})^2$$

3.5 Cluster Analysis

The aim of this analysis is to cluster states with similar tendencies in their RPO compliance. To do this, the data is first standardized and subsequently the K-means clustering algorithm is applied on solar compliance, non-solar compliance, and compliance as a whole as the most crucial variables. The most appropriate number of clusters is selected by the means of such methods as silhouette. score and the elbow technique so as to have a sense in grouping. Cross checking is also done by hierarchical clustering. and strengthens the results. After the formation of the clusters, the groups are then studied with the aim of gaining knowledge on the performance patterns each group has. and the particular policy issues which it has. This method is useful for in grouping the states into high, moderate and low. categories of compliance and thus, it will become simpler to create policies that suit the needs of every group [8].

3.6 Compliance Gap Computation and Analysis

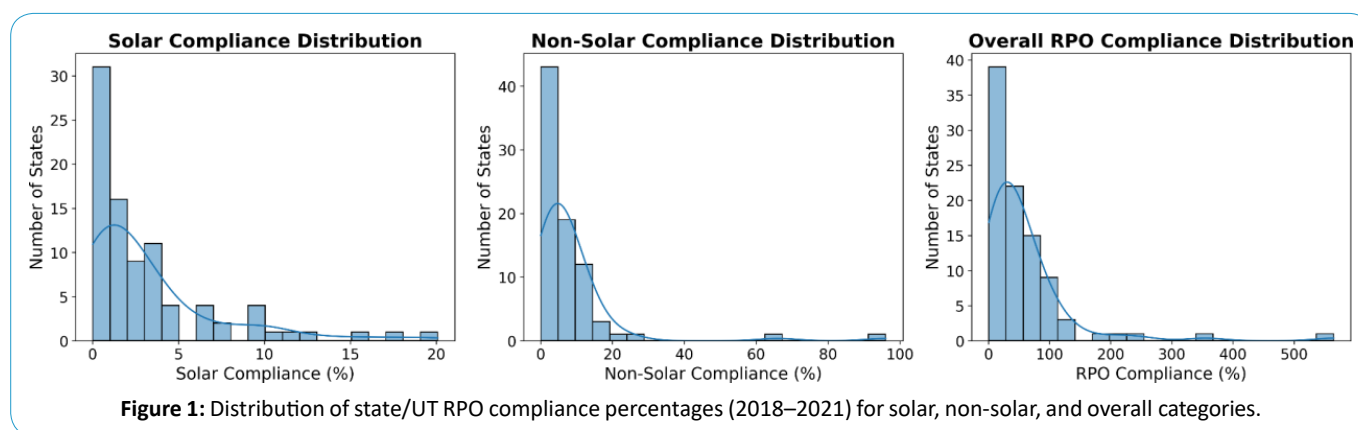
This section aims to determine the areas in which the states are failing in meeting their RPO targets and knowledge of the severity of these deficiencies. To determine the compliance gap, the difference between the target of the RPO and the actual compliance level of both the solar and non-solar groups that are available in each state is calculated. year. Such gaps are then analyzed through summary statistics and graphical representations such as geographic maps to demonstrate clearly. how the deficits are distributed to various parts. The data is also verified across years in order to determine whether these loopholes are transitory or in case some states are always unable to achieve their goals. By examining these patterns, we see better the extent of the problems, large and persistent, and this assists in seeing the whole. policy enforcement effectiveness and most needed improvements [9].

4. Results and Discussion

Temporal Trend: The solar compliance was improved by a small score of 2.44 to 3.59 (2018-19 to 2020-21). Non-solar compliance fluctuated, with a dip in 2019-20. Compliance in General: Percentages are in the 50-60% range and indicate that a significant number of states are complying with half of their. renewable energy acquisition requirements (Table 2).

Table 2: Summary of RPO Targets and Compliance (2018–2021).

Metric	Solar RPO (%)	Non-Solar RPO (%)	Overall RPO (%)
Average Target	7.63	10.25	–
Average Compliance	3.21	8.06	~50–60%
Compliance Gap (Target – Compliance)	4.42	2.19	–
Minimum Compliance	–	–	0.56
Median Compliance	–	–	35.26
Maximum Compliance	–	–	564.76
Number of Observations	94	94	94



State-Wise Performance: Himachal Pradesh, Karnataka and Andhra Pradesh have done significantly the best job and way beyond their cumulative RPO objectives. Conversely, there are still states that are lagging behind with very low progress. This demonstrates that there exist enormous regional disparities and that certain regions are experiencing difficulties in putting the plan into action.

In this dataset, RPO compliance is measured as a percentage of the annual target. Therefore, values above 100% indicate over-compliance, meaning that the state procured more renewable electricity than its obligation for that year. Very high values (e. g., above 300–500%) can occur when targets are relatively low in a given year (small denominator) or when compliance accounting includes adjustments such as carry-forward provisions, target revisions, or Renewable Energy Certificate (REC) procurement used to meet or balance obligations. These extreme values should be interpreted as accounting-year over-compliance rather than as a direct one-to-one indicator of capacity addition (Figure 1).

The above histograms show the distributions of Solar Compliance, Non-Solar Compliance and Overall. The Indian states and union territory RPO Compliance percentages (2018-2021). All three distributions are heavily right-skewed, with most states clustered at lower compliance levels and a long tail representing a few high outliers. The vast majority of

states have Solar Compliance below 5%, with very few states achieving double-digit percentages. Non-Solar Compliance shows slightly better distribution but still, most states achieve less than 10%, with rare occurrences above 60%. Overall RPO Compliance is also dominated by states below 100%, but a few exceptional states significantly exceed their targets (e. g., values above 300%), creating a pronounced long tail in the distribution. The KDE graphs show that most states have very low compliance rates, with only a few doing extremely well. This makes it clear that special policies are needed to improve the average performance and reduce the gap between states.

4.1 Time Series Analysis and Linear Regression – Key Findings (Table 3)

Overall Trends: Most regression slopes are statistically insignificant due to limited time points (2018–2021) and high data variability.

Null Hypothesis (H_0): There is no significant trend in RPO compliance over the years 2018–2021 for the state and compliance category being tested.

Alternative Hypothesis (H_1): There is a significant trend in RPO compliance over the years 2018–2021.

Interpretation: Under H_0 , the regression slope (β_1) is equal to zero, which implies no increasing or decreasing trend in

Table 3: State-wise RPO Compliance Trends (2018–2021).

State/UT	Compliance Type	Trend (Slope % per year)	Significance (p-value)	Interpretation
Andhra Pradesh	Solar	+3.79	> 0.1(Not significant)	Strong upward solar trend, not significant
Andaman & Nicobar	Solar	+2.61	> 0.1(Not significant)	Upward solar trend, but not significant
Rajasthan	Solar	> +2.0	Not reported	Progressive solar improvement
Karnataka	Solar	> +2.0	Not reported	Progressive solar improvement
Lakshadweep	Solar	-0.80	< 0.05 (Significant)	Statistically significant decline
Multiple states	Non-Solar	Small/Negligible slopes	High p-values	Mixed/weak progress in non-solar segment
Andaman & Nicobar	Overall	Large positive slope	Not significant	Upward overall trend, limited by data
Rajasthan	Overall	Large positive slope	Not significant	Upward overall trend, limited by data
Few states (unspecified)	Overall	Negative slopes	Not reported	Declining compliance over time

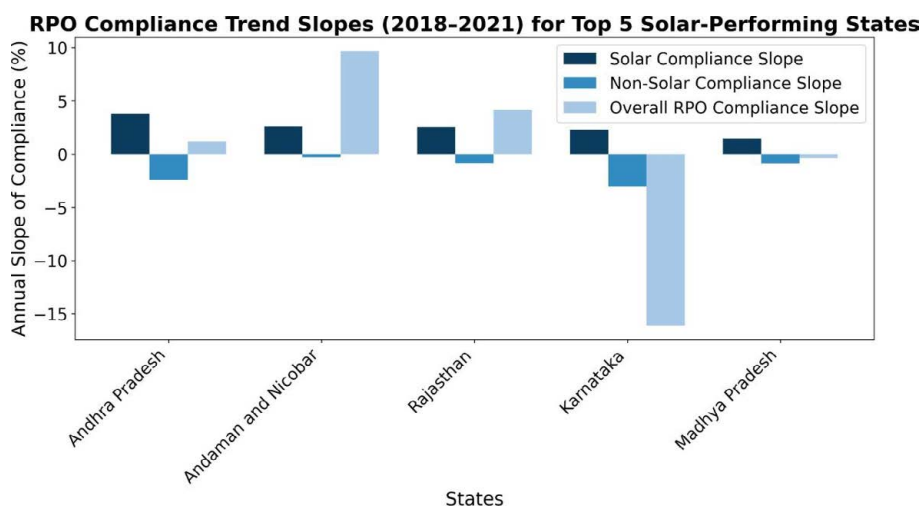


Figure 2: Annual regression slopes of RPO compliance trends (2018–2021) for five states with the highest positive solar-trend slopes.

compliance over time. Under H_1 , β_1 is significantly different from zero, which implies a statistically detectable upward or downward trend in compliance between 2018 and 2021.

Non-Solar Compliance: States demonstrate careless or ambivalent tendencies, which means that progress is in a less regular manner than in solar compliance. **General Adherence:** High variation - some states are doing better, others less so- displays inconsistent practice. **Policy Implication:** The absence of any considerable tendencies highlights the necessity to have more effective enforcement, stronger monitoring, and longer time horizons in order to be able to do reliable statistical assessment (Figure 2).

The group bar chart is a comparison of annual trend slopes of Solar Compliance, Non-Solar Compliance and Overall RPO Compliance. All the best five states with positive trends in solar compliance: Andhra Pradesh, Andaman and Nicobar, Rajasthan, Karnataka and Madhya Pradesh. Every state is embodied by three bars, presenting the direction and magnitude of change in compliance between 2018 and 2021 of each indicator.

Blue bars indicate the slopes of Solar Compliance with large positive increases observed in most of these states, especially Andhra Pradesh and

Andaman and Nicobar. The Non-Solar Compliance slopes are plotted using green bars and they are also usually low or negative and thus stagnant or reducing in non-solar renewable compliance to almost everyone. The slopes of the overall RPO compliance are displayed as orange bars, which demonstrate both significant improvements (e.g., Andaman and Nicobar, Rajasthan) and acute decreases (especially Karnataka). The different height of bars among groups focus on the heterogeneous and even divergent tendencies of the compliance groups of the same state. As indicated by the chart, when solar compliance has increased significantly, it may not necessarily imply that it is non-solar or total. The same way enhances the compliance of RPO. This points out the fact that every form of renewable energy requires its own individual policies rather than treating everyone in the same manner.

4.2 Analysis of Variance (ANOVA) – Detailed Interpretation ANOVA Test for Solar Compliance by Region:

The F-value obtained in the test was approximately 10.87 with a p-value of less than 0.000001. This implies the disparities in Indian interregional solar compliance is a fact, as opposed to mere coincidence. Differently put, certain areas are doing much better than others. Such differences can be attributed to the implementation process of policies, resources, or the degree of RPO compliance to rules in each locality. This shows that each region may need its own set of policies or stricter checks based on its local situation. The null hypothesis which assumes no difference in means between regions is decisively rejected for solar compliance.

4.2.1 ANOVA Test for Non-Solar Compliance by Region:

The F-statistic of about 2.08 and a p-value of 0.0785 indicate a weaker, statistically non-significant difference in mean non-solar compliance across regions at the conventional 0.05 level. We fail to reject the null hypothesis, which means that the available data do not provide sufficient evidence of statistically significant regional differences in mean non-solar compliance at the conventional 0.05 level. This may suggest relatively similar non-solar compliance across regions, or it may reflect high variability within regions that makes differences difficult to detect with this dataset (Figure 3).

The grouped bar chart shows and compares the mean

Solar and Non-Solar RPO compliance percentages in each geographical area of India. In all of the regions, the mean Solar RPO compliance is always lower than the mean Non-Solar RPO compliance, which is a graphical confirmation of the significant variation in the paired t-test. Both Solar and Non-Solar RPOs are most compliant in the South and other categories that are, by far, more mature than in

other regions and are indicative of improved policy execution or of good renewable circumstances. In case we consider the data, we can see that the East, North, and Northeast regions appear to be much less subjected to solar energy rules than other regions. This is what the ANOVA test revealed that there are actual differences between the areas as far as adherence to solar energy standards is concerned. The differences between bars in areas such as North and East of the Sun as to non-solar compliance are relatively small in nature, which supports the ANOVA finding that regional differences as to non-solar compliance are not as strong as the standard and statistically significant 0.05 level. There are two superficial things exhibited in the chart. Some states are not working at equal rates towards achieving their solar energy goals - some are performing well and some are losing out. Moreover, not all regions of the country have the same circumstances, and this is the reason why the RPO policy in India is not that effective. It is better, therefore, that the energy plans must be designed to suit the conditions and requirements of each region, rather than attempting to go on with a single general plan for the entire country.

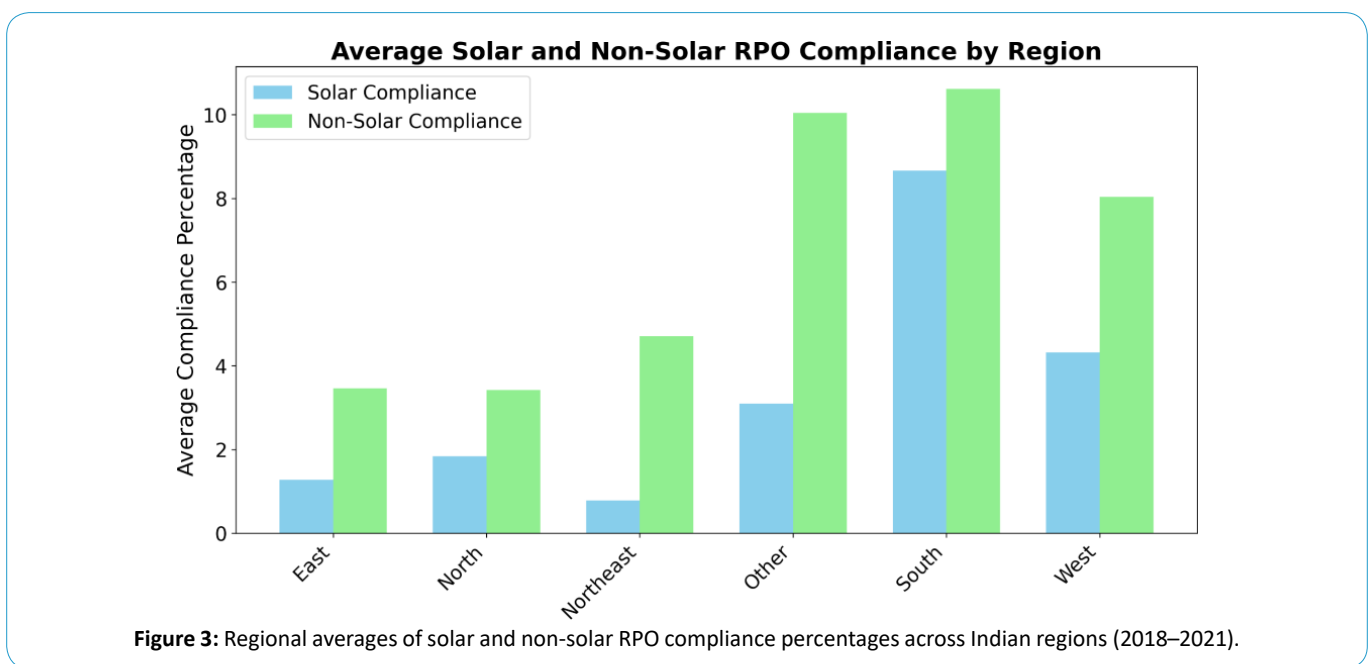


Figure 3: Regional averages of solar and non-solar RPO compliance percentages across Indian regions (2018–2021).

4.3 Cluster Analysis – Grouping States by Compliance Performance

An analysis based K-Means (3 clusters; nclusters=3) on three standardized variables, namely Solar Compliance, Non-Solar Compliance and Overall RPO Compliance during the year 2020-21. The features are standardized with the help of StandardScaler so that they have an equal impact on clustering and then cluster assignment is conducted. The findings are presented in the form of a scatter plot where Solar Compliance and Non-Solar Compliance are compared.

4.3.1 Cluster Characteristics and Interpretation:

Cluster 0 (n=20): This is the biggest group. It covers states with very low solar compliance (mostly less than 5%) and low to medium non-solar compliance. These states are in the lower-left part of the scatter plot which indicates that both solar and non-solar RPO categories continue to underperform. Examples: Assam, Bihar, Delhi, Maharashtra, Odisha, Punjab, West Bengal etc.

Policy implication: These are the priority states to build capacity, tighten enforcement and targeted actions to increase both the solar and non-solar renewable adoption.

Cluster 1 (n=7): This cluster is composed of high solar compliance (way above cluster 0), moderate-to-high non-solar compliance but less variable than cluster 2. The states of this category are more likely to show balanced RPO implementation and can be found in the higher curves of the scatter plot. Examples: Tamil Nadu, Karnataka, Andhra Pradesh, Rajasthan, Telangana, Madhya Pradesh and Andaman and Nicobar. Policy implication: These states may be termed as leaders or models of good policy where best practices may be obtained.

Cluster 2 (n=1): There is a single-state cluster that is exclusively inhabited by Himachal Pradesh and uncharacteristically high non-solar compliance (outlier of more than 60) and high overall RP compliance. This condition looks physically separated to all other conditions-outlier probably because of special local policy, surplus resources, or peculiarities of data. Policy implication: Study whether it can be replicated or is a consequence of a unique situation; outlier requires further qualitative confirmation.

Cluster Centers and Technical Findings: The cluster analysis (K-Means, n=3) indicates that there is a large cluster of low-compliance states, an intermediate cluster of high-to-moderate states, and one impressive outlier. Such segmentation enables better policy focus, benchmarking, and resource allocation- the pillars of propelling the RPO goals of India to national consistency in compliance.

4.5 Compliance Gap Computation and Analysis

The analysis of compliance gap compares the renewable purchase obligation (RPO) targets to the actual compliance percentages of solar, non-solar, and total percentages.

- A. **Descriptive Statistics:** The mean Solar Compliance Gap comes at an approximately 4.15 percentage points, which means that on average, states do not meet their solar procurement goals by this percentage. It has an average Non-Solar Compliance Gap of 3.47 percentage points implying that states are slightly better at fulfilling non-solar commitments, but they continue to experience gaps. The mean Total Compliance Gap, which is a combination of solar and non-solar, is 7.62 percentage points, which is significantly below the total RPO requirements. The differences are very varied: the standard deviations (solar: 4.25, non-solar: 8.56, overall: 10.58) and a big range indicate that there are states where it is above the targets (over-compliance) and where it is much lower.
- B. **Temporal Trends:** Average changes by year reveal that since 3.97% solar compliance gaps in 2018-19, the corresponding number in 2020-21 rose to 4.78% indicating that the solar compliance deficit is slightly expanding. Non-solar compliance gaps experience an impressive decline of 4.43 to 1.89 out of 2018-19 to 2020-21, which means that non-solar compliance obligations have improved over the last few years. The total compliance gap decreases by around 8.40 to 6.66 in 2018-19 to 2020-21 and thus can be viewed as a slight, though still substantial, decrease.
- C. **State-Level Insights:** The 10 states, which have the highest mean of overall compliance gaps, are Arunachal Pradesh (~16.95%), Manipur (~16.86%), Tripura (~16.53%), and Haryana (~15.39%), and so on. The shortfalls in these states are enormous and especially in terms of non-solar compliance (some gaps are almost 10 percentage points or even higher), which requires specific policy focus and corrective measures.
- D. **Negative Gap Values:** There are negative compliance gaps (minimum solar gap: -12.82%, non-solar gap: -55.75) which demonstrate that states have surpassed their targets (over-compliance) and this information can reflect the strength of the renewable energy markets, or intensive purchasing activities.

E. Implications for Policy: This gap analysis highlights the chronic and geographically diverse RPO under-compliance with particular reference to solar procurement, and refers to structural or enforcement barriers. The diversity of performance requires specific interventions to the specific states and groups, as well as to encourage over-compliance incentives. Temporal trends indicate that the policy ameliorations of non-solar renewable energy might be taking action, and the Solar compliance needs a new effort to bridge the broadening gap.

4.6 Policy Discussion and Implications

The statistical findings highlight that RPO compliance is not only a technical issue but also a governance and enforcement issue. The strong regional differences in solar compliance and the clustering of multiple states in the low-compliance group indicate uneven enforcement capacity and follow-through across State Electricity Regulatory Commissions (SERCs). Where monitoring is stricter and compliance shortfalls are not routinely carried forward without consequence, states are more likely to maintain stable procurement strategies and meet RPO targets. In contrast, repeated carry-forward of deficits and weak enforcement reduces the credibility of the RPO mechanism and lowers the incentive to contract new renewable power, especially solar.

Financial conditions of DISCOMs are also closely linked to compliance outcomes. States with stressed DISCOM finances can face constraints in signing new renewable power purchase agreements, making timely payments to generators, and investing in grid readiness for variable renewable energy. This can translate into lower solar compliance even when tariffs are competitive. In addition, inter-state differences in renewable resource availability, project development pipelines, and transmission capacity shape how easily states can meet obligations. These patterns suggest that improving RPO outcomes requires a combination of stronger enforcement, better compliance tracking, and differentiated support for lagging states—particularly measures that reduce procurement barriers for solar and improve grid integration.

5. Conclusion

The paper presents an in-depth discussion of the Renewable Purchase Obligation (RPO) policy in India between the year 2018 to 2021, including the differences in its implementation at state level. It starts by putting into perspective the ambitious renewable energy targets of India and the regulatory framework that is intended to facilitate the acquisition of renewable power. The analysis

of official compliance data demonstrates that there are huge discrepancies between the states, and many of them fail to meet the required targets, especially when it comes to adopting solar energy. There is more compliance in southern states as compared to eastern and northern regions. The study uses a combination of descriptive statistics, time series analysis, cluster grouping, and compliance gap

analyses to identify trends, regional trends and areas of weaknesses in enforcement. It identifies some of the major problems such as poor implementation of policies, failure to update the targets and ineffective mechanisms of monitoring which hinder successful RPO implementation. The proposed research notes a steady disparity between solar and non-solar compliance, which is attributed to technological and market issues peculiar to the integration of solar energy. The knowledge that is gained through visualizations and cluster analyses enhances the comprehension of the way states cluster based on performance and identify leaders and laggards. Policy implications are also proposed with the aim of recommending better enforcement, data transparency, and targeted support to the lagging states, particularly in order to speed up the process of solar procurement. The results underscore the need to make region-specific flexible interventions to ensure that the country realizes its ambitious renewable energy goals and climate pledges in a smooth and equal manner.

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