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Drivers in Solar deployment in India: A state-level analysis

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Headlines

- Increasing solar energy deployment is essential for India to tackle ongoing environmental challenges whilst ensuring energy security and managing a healthy economy.
- India has already achieved significant growth in solar deployment. However, its current capacity of approximately 32 GW is still far short of its 2022 target of 100 GW.
- A better understanding of the drivers of inter-state solar power deployment can help Indian policymakers reach India's solar penetration goals.
- Our findings indicate that the command and control policy *Renewable Purchase Obligation* has been effective in stimulating both large-scale and distributed solar, indicating value in its continued widespread use.
- Furthermore, we find that large-scale solar deployment is driven by the enabling policy *Solar Park Development*. Policymakers should consider duplicating such policy in similar regions.

Introduction

Solar energy deployment is a key element of India's plans to tackle environmental concerns, such as climate change and local air pollution. There are also other benefits, including energy security and some macroeconomic implications.

India has ambitious solar energy targets

India has mapped out reductions of greenhouse gas emissions in its 2030 Nationally Determined Contribution (NDC), part of India's international climate change commitments. In the NDC India pledged to derive 40% of its installed electricity general capacity from non-fossil fuel sources[1]. India's 2022 renewable energy capacity target is 175GW, of which 100 GW is expected to come from solar energy. India's NDC implies 350GW of renewable energy capacity in 2030 and Prime Minister Modi's commitment to 450GW of renewable energy[2] indicates that India's solar ambitions are on an upward trend.

Contents

Introduction 1
What role does policy play? 2
What economic and policy drivers increase solar deployment? 2
Policy Implications 3
References 3
Acknowledgements 4
About the authors 4

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India's solar power deployment targets of 100GW by 2022 includes 60GW of utility scale and 40GW of distributed solar[3].

Policy is likely to be significant

In India, solar power deployment to date has largely depended on government policies at both the central government, and state level. Renewable energy policies are based on overarching provisions of the Electricity Act 2003, the National Electricity Policy 2005 and the National Tariff Policy 2006. Central policies make provisions for optimal utilization of resources, inter-state grid connectivity, sale of energy, purchase obligations and tariffs. In addition, the Ministry for New and Renewable Energy administers programs that create demand for solar energy, such as through establishment of solar parks and mandating preferential treatments for renewable energy in public contracts. The Ministry also coordinates tax concessions to the sector and capital subsidies to individual projects which affect their economic viability. State policies focus on regulations governing implementation of purchase obligations and tariffs for transmission and distribution.

India still has a long way to go

As a result of government policies, solar deployment increased eight-fold from 2.6GW in 2014 to 22 GW in 2018[4]. (Figure 1) However, annual capacity additions have consistently stayed below annual targets. This mismatch has been attributed to a variety of institutional, infrastructural and financing constraints[4]. Resolution of some of these issues, such as lack of storage solutions and poor grid infrastructure, are long term in nature. This paper focuses on identifying factors that have driven solar deployment so far, with near-to-mid-term implications for policy design.

What role does policy play?

In this paper we present new, data-driven analysis that estimates the effect of central and state-level policies on in-state solar deployment in India.

In this econometric analysis, we exploit that fact that there is variation in solar deployment across Indian states. This variation in solar deployment can be correlated, using a time series cross sectional econometric analysis, with various state-level factors that change over time. These factors include policy, structural, and economic factors.

Our insights should be relevant to policy makers at the state and central level as well as power-sector investors.

What economic and policy drivers increase solar deployment?

Our analysis indicates that some policies have stimulated solar power deployment, but finds no evidence for the effectiveness of other policies. For instance, we found evidence that the Renewable Purchase Obligation (RPO) is a stimulus for both large-scale and distributed solar power. RPO is a state-level policy that mandates that a certain percentage of electricity generation will be procured from renewable sources by a certain year. Every percentage point of renewable purchase obligation has resulted in 42-65MW of incremental solar capacity in India, with the lower limit corresponding to distributed solar and the upper limit corresponding to large-scale solar.

The enabling policy Solar Park Development is also effective in increasing large-scale solar. Under this policy, India's Ministry of New & Renewable Energy set up 25 solar parks with a capacity of 500+ MW each since 2014[5]. In these parks, the government guarantees land availability and transmission interconnection. The presence of dedicated solar parks is highly correlated with the amount of utility scale solar in a state. This study finds that the Solar Park Development policy has influenced 39% of large-scale solar capacity in India.

However, there is no supporting evidence for proving that policies such as *Viability Gap Funding, Accelerated Depreciation, Banking of Power, Net Metering, and Grid Tariff Charges* are drivers of solar deployment in India.

Box 1: Methodological approach

Analytical framework: Solar capacity is estimated for state *i* in year *t* using a panel regression model. To account for unobserved state and year heterogeneity, state and year fixed effects are included. This approach controls for persistent differences between states in terms of solar deployment and country-wide exogenous factors. Heteroskedasticity is accounted for by employing clustered robust standard errors on the remaining error term.

Data: Data set covers 20 states carrying the majority of installed solar capacity in India over the past 10 years (2010-2019). This is the period when most of the ambitious government policies on solar deployment were introduced.

Variables: Large-scale deployed capacity (>5MW plant capacity) and distributed solar deployed capacity (<1MW plant capacity) are the two different dependent variables used for solar energy. The policy variables that were analysed are Renewable Purchase Obligation and Accelerated Depreciation in regards to large-scale and distributed solar deployment; Solar Park Development and Viability Gap Funding for large-scale solar deployment; and net metering and banking of power for distributed solar deployment. The economic variables used were GDP per capita and average retail tariff for residential customers. The structural variables used were ease of doing business, DISCOM ratings (strength of a distribution company in a state), transmission and distribution losses (another measure of DISCOM rating), net generation of electricity, renewable energy generation, and electricity consumption per capita.

These results imply that policymakers should continue using both policies that have shown success so far.

We also found that wealthier states (i.e. this with higher GDP) have more solar power of both kind, indicating a greater willingness to install expensive solar power during our period of observation. However, we did not find supporting evidence that a higher Average Retail Tariff results in higher solar deployment in the states analysed.

Only one supporting structural variable, electricity consumption per capita, was correlated with solar power deployment. Higher electricity consumption per capita resulted in both higher large-scale distributed solar capacity deployment. It might be that states that consume more power require larger capacity of all types of power, including solar. We could not find evidence of a relationship between solar power deployment and the remaining supporting structural variables.

In addition, the study found that higher transmission and distribution losses, indicating weaker state-level distribution companies, were aligned lower solar deployment levels of both large-scale and distributed solar capacity.

This finding implies that as a DISCOM becomes better functioning, there would be higher levels of solar power deployment.

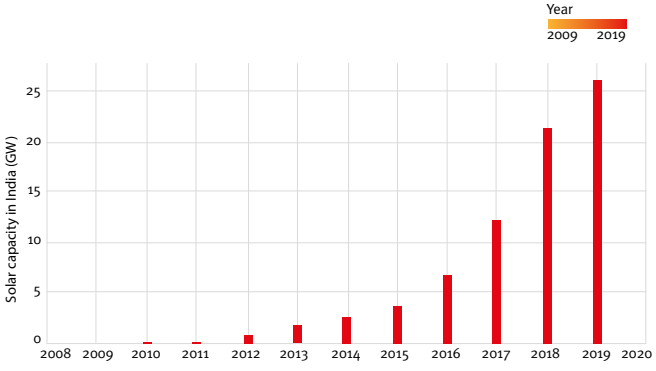

Figure 1: Large-scale solar deployment in India with 2014-19 compound annual growth rate (CAGR) of 38%

Policy Implications

This preliminary analysis, can help policy makers consider what mix of policies are most appropriate to help India reach its ambitions solar power targets (see Table 1).

These findings indicate several areas for further policy development and implementation:

- better DISCOM operations can have a positive impact on solar deployment
- policies such as the Renewable Power Obligation can be important, possibly even essential, in stimulating solar power deployment
- designation of solar power parks can help over come several well know barriers for utility scale solar projects – the availability of land in a country like India where land ownership is distributed and many times widely contested, and the ease of transmission interconnection which guarantees that solar developers feel comfortable that the generated solar power would be evacuated. The success of this policy suggests not only continued widespread use but also duplication, in particular in developing countries that may face similar issues as India.
- several policies there was no evidence of any relationship with solar power deployment. Absence of this evidence does not mean that these policies are ineffective; this absence of evidence could likely be due to lack of reliable data. Further exploration would be valuable in these cases.

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