The Road Ahead for Rooftop Solar in India

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White Paper, Version: March 13, 2020

Indicus Foundation, New Delhi

Abstract

Today India is the cheapest producer of solar-generated electricity, but ironically only 23.1 per cent of its power installed capacity comes from renewable sources. The Indian government has been aggressively setting targets in accordance with the Paris Agreement under the United Nations Framework Convention on Climate Change 2015. While solar power generation has taken off rooftop solar has not. Despite changes in government policies, subsidies, widespread recognition of the many benefits including employment generation, growth has been slow.

This white paper studies the hurdles and challenges faced by the various stakeholders for rooftop solar generation and provides shot-term and long-term policy solutions.

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The authors would like to thank participants of IDEA roundtable discussion, Rooftop Solar Power held on 10th August 2019, some of whom also later shared their views electronically. This white paper includes insights from that discussion and views of the authors. The authors can be contacted at laveesh@indicus.org. We are grateful for the support of Climate Trends, India. All errors are ours.

	Issues	Solutions
Utilities/DISCOMS		
High-end Customers	1. Fear of loss of revenue and profits as higher end customers most likely to switch to solar. 2. Utilities required to upgrade at least some infrastructure, further adding to their financial stress 3. Large number of residential customers, especially households do not have access to adequate roof space in apartments.	1. Set up a dedicated fund by utilities for investments in infrastructure, systems and training specific to rooftop solar. **[Utilities+ Regulator]** 2. Pilot projects using RESCO model with low paying consumer rooftop capacities by the utilities and inviting bids for the same. **[MNRE+DISCOM]** 3. Find commercially feasible ways of scaling up the conversion of small users who need to be cross-subsidized by government or utility. Those funds can then be used to compensate the DISCOM. **[MNRE+ MoF+ DISCOM**]
Long-Term Contracts	1. Long term power supply agreements in place. 2. Renewable Purchase Obligations mandate DISCOMS and large power consumers to purchase electricity generated by specified green sources (or buy renewable energy certificates from the market.)	1. Relook at such legacy contracts; suggestions include shorter contract duration, introducing some flexibility for cheap solar power, and seasonal PPA's can be experimented with. **[MNRE+ PSEs+ Regulator]** 2. Solar rooftop generation counts as greater value compared to ground-mounted solar in terms of solar RPO compliance. **[MNRE]**
Benefits to DISCOMS	1. The power produced from conventional sources incur large T&D losses but minimal in rooftop solar. 2. DISCOMS suffer from having to purchase of high cost power to meet peak demand; this is most experienced in the summer months in the afternoon and late evenings.	1. Transmission and distribution losses are reduced to a bare minimum with rooftop solar power as the consumer is at the shortest possible distance to the power producing source. 2. Solar produced power is available at cheaper rates and in abundance during the day especially in summers. 3. DISCOMS need to initiate pilot projects using RESCO model with low paying consumers' rooftop capacities.

Infrastructure Hurdles	1. Incorporation of solar power has technical and operational challenges for the existing power grid, billing systems, coordination amongst MNRE, state governments involved and lack of skilled manpower. 2. Another technical challenge is deliberate Islanding that restricts take up of solar plants in areas with significant power cuts from the grid. 3. Currently, many solar plant applications are rejected due to distribution transfer (DT) capacity in the neighbourhood. 4. There is lack of data generation through real-time monitoring & forecasting of solar rooftop generation.	1. Design features such as On Load tap Changer for Medium Voltage/Low Voltage transformer, booster transformers along long feeders, reactive power support through Static Volt-Ampere Reactive Compensators and revised protection settings for bi-directional flows etc. need to be incorporated in new design criteria. **[Regulator+ Utilities]** 2. Develop systems that can safely allow deliberate islanding and specify necessary standards. **[Regulator+ Utilities]** 3. Distribution Transfer (DT) capacity be increased to avoid denial of permission for setting up RTS on this ground. **[Regulator+ Utilities]** 4. Implement mechanism for data collection of solar power generation at a real time basis, which allows for monitoring and forecasting of power generation patterns. **[Regulator+ Utilities]** 5. Capacity building or training programs for DISCOMS personnel **[Regulator]** 6. Better coordination between multiple implementing agencies. **[MNRE]**

Metering Mechanisms	1. Net metering policy is still non-operational in many states. 2. The decision to choose which metering mechanism is adopted has been left on the state board as per the second phase of solar policy but net metering is pro consumer approach and needs to be encouraged. 3. Lack of data on applications, delays & refusals for net metering. 4. High cost of bi-directional meters	1. Enforce net metering policies in all states. **[MNRE+ Niti Aayog]** 2. Introduce a medium-term grid services charge on new net metered rooftop consumers OR add that component to subsidy for solar rooftop. **[MNRE+ MoF]** 3. R&D to make bi-directional meters cheaper or equivalent to unidirectional meters. **[MNRE+ Niti Aayog]** 4. State net metering regulations should allow energy banking of 100% of consumption calculated over a year **[State Governments]**
Customers or Prosumers		
Awareness	1. Lack of awareness of benefits, procedures and guidelines for rooftop installation. 2. Lowered incentives for take up of solar amongst residential consumers due to subsidized electricity.	1. Consumer Awareness Programmes to be conducted at housing society level **[NitiAayog+ MNRE+ DISCOM]** 2. Change form to subsidy to cash disbursal to low consumption household rather than charging less; this enables customers to benefit additionally from putting up rooftop solar **[State Government]**
Incentives and Lock-in Period	1. CAPEX model required significant one-time investment and maintenance costs. RESCO model has 25-year lock -in period making it difficult for prosumers to commit such long-term agreements.	1. Shorter lock-in period for RESCO model enables RSP provider to shift panel infrastructure to another location. **[MNRE+ Regulator]**
Credibility	1. Lack of quality standards assurance amongst solar panel manufacturers 2. Absence of a reliable body for providing solutions on all aspects like installation, maintenance and up-gradation.	1. Procedures like bank guarantee or bonds signed by the solar manufacturer to ensure quality of solar panels. **[Regulator]** 2. The utilities have been handed this task in the second phase of the solar policy, but close monitoring for course correction is required.**[Regulator]**

Reducing Peaked-ness	1. There are two slots of peak demand currently being experienced: Daytime & Evening Peak but solar power missing in evening peaks.	1. Residential solar power can also be stored in batteries including those in household inverters for evening supply provided greater prices paid for it. **[Regulator+ Utility]** 2. Awareness and education on superior household practices to smoothen the peak and reduce household demand. **[Regulator+ Utility+ MNRE]**
Multiple Bottlenecks	1. The current solar policy restricts the capacity of solar panel installation to not exceed 100% of the current connected load of a consumer. 2. There are no solutions for consumers without roof or those unable to provide roof rights.	1. Restrictions on supply of power should be phased out, with surplus saleable at a price that reflects the avoided cost of energy for the DISCOM. **[Regulator+ MNRE]** 2. Remove quantitative limits on supply of rooftop solar power. **[Regulator+ MNRE]**
Solar Panel Manufacturers		
Transaction Costs	The second phase of solar policy bestows the utilities with the responsibility of empaneling the solar vendors, however it is not clear how different vendors using very different methods and technologies and materials can be rated.	Develop a framework for ratings of developers and empaneling them by the utilities. This will create competition, ensure quality & build consumer confidence for these manufacturers/developers. **[NitiAayog+ MNRE+ Regulator]**
Delays and Insensitivity	1. The first phase of solar policy displayed frequent delays in subsidy payment by the government to the vendors. 2. How will the prosumer be protected against poor responsiveness of DISCOMs? State Electricity Boards?	1. Streamline process for subsidy disbursement, requirement for written explanation for delays more than a specified time period. Make concerned departments and officers liable in case of delayed payment. [**Regulator]** 2. Close monitoring, and fining of poor customer redressal practices of DISCOMs [**Regulator]**

Optimal use of Rooftop Space	1. Constraints on minimum roof space eligible for rooftop solar and restrictions on amount of energy generated by rooftop solar installations. 2. Absence of building norms to encourage maximum roof space for solar.	1. Allow the use of smaller roof sizes thru Demand aggregation by the utility. **[MNRE+ Regulator]** 2. Building codes should mandate rooftop solar in new buildings. **[MoUD+ ULBs]**

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Contents

CAPEX	Capital Expenditure Model
DISCOMS	Distribution Company in India
DT	Distribution Transfer
GW	Gigawatt
kWh	Kilowatt-hour
MNRE	Ministry of New and Renewable Energy
MoF	Ministry of Finance
MoUD	Ministry of Urban Development
MW	Megawatt
PPAs	Power Purchase Agreements
PSEs	Public Sector Enterprises
RESCO	Renewable Energy Service Company
RPO	Renewable Purchase Obligations
RTS	Rooftop Solar
T&DL	Transmission and Distribution Losses
ULBs	Urban Local Bodies

1. Background

India's dream of a shift from a primarily thermal-based power generator to renewably sourced power is rapidly becoming a reality. India has an installed power capacity of 367 GW as of 30th December 2019.[2] The per capita gross electricity consumption recorded for 2018-19 was 1181 kWh, roughly double that from the 559 kWh recorded in 2002.[3] It is generally accepted that the government has played a significant role and that India's recent achievement of 100 per cent electrification under *Pradhan Mantri Sahaj Bijli Har Ghar Yojana Saubhagya* has been one of the major drivers of electricity demand including the take-up of solar energy.[4] Additionally, Indians are demanding more power due to factors such as frequent heat waves, urbanization, the rise of incomes and number of people in the middle and affluent classes, and increased access to electricity. This demand has further accelerated due to the availability of cheap and free power by various governments to woo their voters.

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Take Delhi for instance, the city recorded a power demand of 7408MW on 2nd July 2019.[5] Whereas as per 2016-17 data an average Delhi household consumed 250-270kWh of electricity monthly as compared to the national average of 90 kWh.[6] The major drivers have been income growth, improved quality of supply, increasing ownership of air conditioners and also relatively cheap electricity. Since these factors are expected to remain, it is likely that household demand for electricity will continue to grow in the near future. Moreover, economic growth and greater production bring greater demand from not only manufacturing but also agriculture and services sectors, of which the latter accounts for the bulk of the Indian economy.

Along with the increased demand for electricity nationwide, India is targeting to be a front runner in the renewable energy market. India has set a goal of producing 40 per cent of its electricity capacity from cleaner sources by 2030 as a commitment for the Paris Agreement. In other words, it needs to generate 175 GW of electricity using renewable sources by 2022, out of this 100 GW will come from solar including 40GW of Rooftop Solar as per the government's estimate.[7] However, according to MNRE data

[2]Executive Summary on Power Sector, Central Electricity Authority, December 2019,http://cea.nic.in/reports/monthly/executivesummary/2019/exe_summary-12.pdf

[3]Growth of Electricity Sector in India From 1947-2019, *Growth of Electricity Sector in India from 1947-2019, Central Electricity Authority, Government of India,* May 2019, http://www.cea.nic.in/reports/others/planning/pdm/growth_2019.pdf

[4]https://powermin.nic.in/sites/default/files/webform/notices/OM_SAUBHAGYA_SIGNED_COPY.pdf

[5]Delhi's power demand touches record 7,409 MW on Tuesday, LiveMint, https://www.livemint.com/industry/energy/delhi-s-power-demand-touches-record-high-of-7-409-mw-on-tuesday-1562073004123.html

[6]Trends in India's Residential Electricity Consumption, Centre for Policy Research and Prayas Energy Group, November 2017,https://www.cprindia.org/news/6519

[7] Year End Review 2018 – MNRE, Ministry of New and Renewable Energy, Press Information Bureau, Government of India, retrieved on 19-01-2020,https://pib.gov.in/newsite/PrintRelease.aspx?relid=186228

on January 2020 only 2.376 GW capacity of the roof top solar has been installed so far.[8] There are multiple factors which require attention, let us begin by inspecting each of the players involved in the rooftop solar market.

Table 1: Installed Power Capacity in India

Fuel	MW	% of Total
Total Thermal	2,30,701	62.8%
Coal	1,98,495	54.2%
Lignite	6,760	1.7%
Gas	24,937	6.9%
Diesel	510	0.1%
Hydro (Renewable)	45,399	12.4%
Nuclear	6,780	1.9%
RES* (MNRE)	84,400	23.1%
Total	**367,281**	

* Installed capacity in respect of RES (MNRE) as on 30.11.2019.
RES (Renewable Energy Sources) include Small Hydro Project, Biomass Gasifier, Biomass Power, Urban & Industrial Waste Power, Solar and Wind Energy.

Source: Power Sector at a Glance All India, Ministry of Power, Government of India, Retrieved on 22-01-2020 from *https://powermin.nic.in/en/content/power-sector-glance-all-india*

Before we look deeply into each stakeholder's challenges, Table 1 above explains the current power mix. As per the data from the MNRE, 62.8 per cent of total installed capacity is comprised of thermal power plants that are coal, gas, diesel and lignite power plants. The share of renewable stands at 23.1 per cent, hydro at 12.4 per cent and nuclear power at 1.9 per cent. Table 1 shows the share of the power mix as per 30th November 2019.

In other words, while India has a significant share of its capacities devoted to renewables, much more is required, especially since demand is growing rapidly and is expected to continue rising.

[8] Ministry of New and Renewable Energy, Programme/Scheme wise Physical Progress in 2019-20 and Cumulative up to January 2020, retrieved on 19-02-2020 fromhttps://mnre.gov.in/physical-progress-achievements

Therefore, rooftop solar achieves great significance. Next, we consider the growth trends in renewable energy from 2007-2019.[9]

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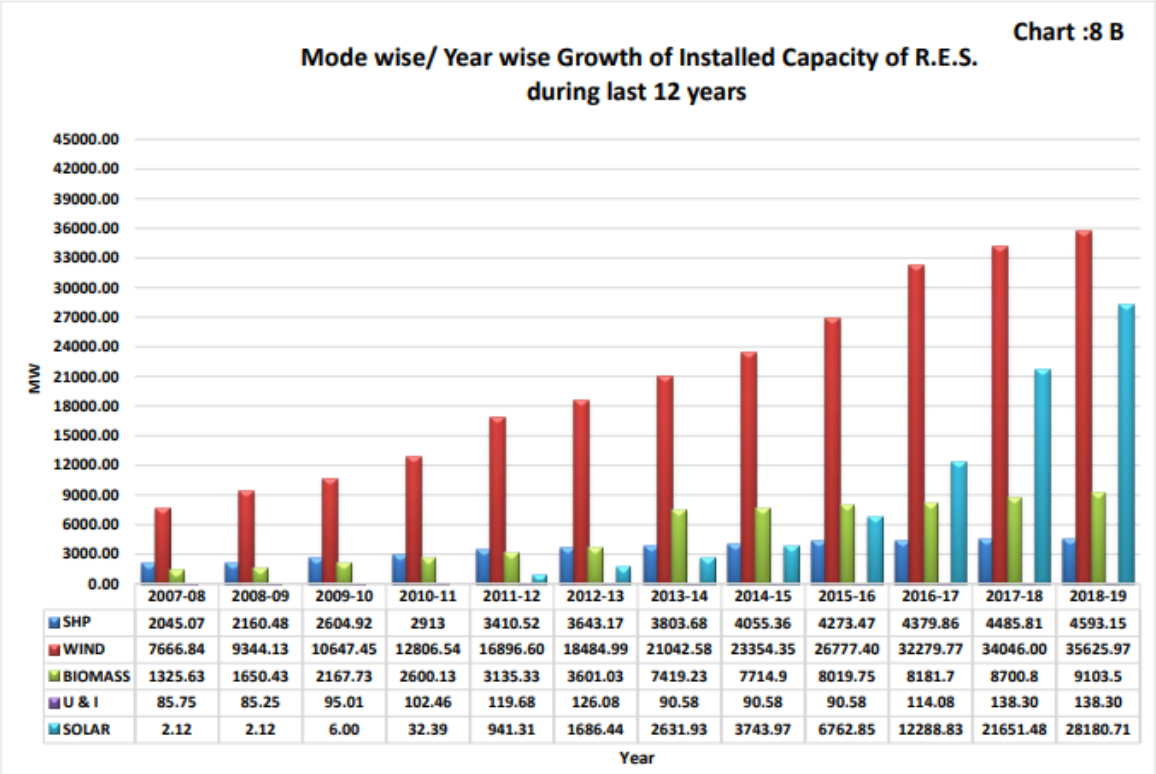
Table 2: Growth Trends in Renewable Energy from 2007 to 2019



	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
SHP	2045.07	2160.48	2604.92	2913	3410.52	3643.17	3803.68	4055.36	4273.47	4379.86	4485.81	4593.15
WIND	7666.84	9344.13	10647.45	12806.54	16896.60	18484.99	21042.58	23354.35	26777.40	32279.77	34046.00	35625.97
BIOMASS	1325.63	1650.43	2167.73	2600.13	3135.33	3601.03	7419.23	7714.9	8019.75	8181.7	8700.8	9103.5
U & I	85.75	85.25	95.01	102.46	119.68	126.08	90.58	90.58	90.58	114.08	138.30	138.30
SOLAR	2.12	2.12	6.00	32.39	941.31	1686.44	2631.93	3743.97	6762.85	12288.83	21651.48	28180.71

Source: Growth of Electricity Sector in India from 1947-2019, Central Electricity Authority, Government of India, May 2019

As can be seen, solar generation has increased from 2.12 MW in 2007-08 to 28,180 MW in 12 years for 2018-19. The rooftop solar capacity in India as on 31st January 2020 stands at 2.38 GW; while the target set for 2022 is 40 GW of Rooftop solar while the solar segment including ground-mounted and rooftop has grown at a CAGR of 137 per cent. The high growth rate is

[9] Growth of Electricity Sector in India from 1947-2019, Central Electricity Authority, Government of India, May 2019, http://www.cea.nic.in/reports/others/planning/pdm/growth_2019.pdf

largely on account of a low base and will be difficult to maintain without fairly proactive involvement of the utilities. The power distribution companies will play a pivotal role in accelerating the growth of renewable-based power especially rooftop solar, this is discussed next.

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2. DISCOMS/Utilities[10]

Rooftop solar has not had the growth rates expected by the government when the target for 40GW was set for the year 2022. There are a multitude of reasons for the slow growth. The key ones are discussed here.

2.1 Loss of High-End Customers

Industrial users, higher income and higher consumption residential consumers have been the first to move to rooftop solar installation. Each rooftop solar installation naturally leads to a reduction in sales of electricity from the utilities to the high-end or industrial customers. These customers, namely industry and high-income households, also help utilities cross-subsidize their sales to low income households who pay less. And therefore, installation of solar power by an industrial unit or high-income households represents one less contributor to the cross subsidy of low-end customers who pay less than the average cost. Such customers include those involved in agriculture and middle-income and low-income residential users. These forces work as a disincentive for utilities to push for greater rooftop solar power.

> *Installation of solar power by an industrial unit or high-income households represents one less contributor to the cross subsidy of low-end customers who pay less than the average cost.*

Most electricity distribution utilities suffer from sustained financial distress due to political pressures to keep tariffs low. Moreover, periodically large segments are provided with free electricity by various state governments. To add to this, utilities need to invest to upgrade their billing systems to incorporate net metering, grid infrastructure, administrative upgrades etc. But lack of fund availability has limited their technological upgradation. No doubt there are

[10] **DISCOMS/Utilities** signifies distribution companies that supply power to consumer. They can be a private or a government company.

selected electricity distribution companies in the private sector that are regulated, but they are limited in number and also suffer from political and regulatory pressure to work on low margins and therefore tend to have under-invested in technology.

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2.2 Long-Term Contracts

Another hindrance is that coal-based power plants continue to be the primary suppliers of power to the DISCOMS and they have long term legacy contracts in place. To elaborate, the power sector has mainly been driven under long term twenty-five year PPAs between power generators and DISCOMS, legally binding the DISCOMS to pay a fixed lump sum annual amount for fixed costs and a per unit tariff for the variable costs and the power generators to supply the agreed capacity for the entire term of the PPA. The tariffs at which distribution companies sell power to consumers is determined by the respective state regulatory commissions. With the advent of renewable's cheaper tariffs there is a need to shift towards medium and short-term contracts. Long term PPAs typically are for 25 years but can be reduced to a range of 7-10 years or even shorter terms ranging from 1,3and 5-year options.

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Moreover, most PPAs provide similar treatment to steady and intermittently available power, be it renewable or non-renewable. This provides little or no incentive for flexible options or power storage which is a key input for solar power. Apart from factoring storage costs separately, a superior system would be where utilities and power generating companies can undertake seasonal PPAs that factor in the renewable power supply available and allow flexibility and shorter time durations.

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The second phase of the solar policy mandates the DISCOMS on the initial achievement 18000 MW of rooftop solar.[11] This may drive growth of rooftop solar through the DISCOMS, however such mandates are difficult to sustain. Especially since many DISCOMS are endemically loss making.

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Additionally, the new guidelines perceive DISCOMS to be the frontrunners in the growth of rooftop solar by treating them as the key vehicle through which various models like Capital expenditure model (CAPEX), Renewable energy source company (RESCO) model, rent a roof/lease model, community model, utility model, through a solar photovoltaic (SPV) having share of utility, plug-in rooftop solar (RTS) etc. can be experimented with. While top-down policy and top-down regulation can have some impact in the short run, it will be difficult to sustain if the ecosystem is unable to provide adequate returns to DISCOMS.

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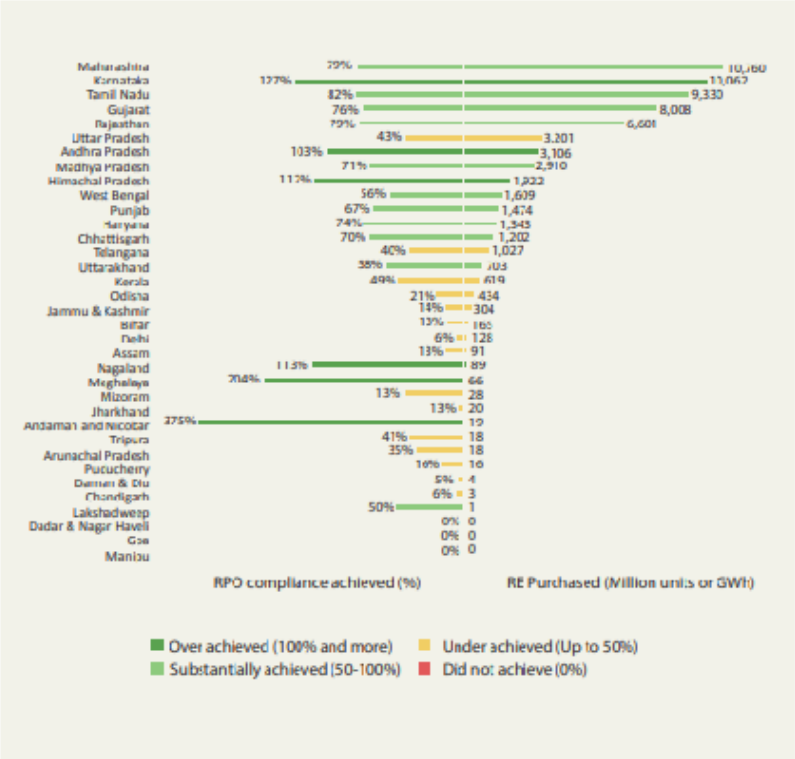
[11]Grid Connected Rooftop Office Memorandum, Ministry of New and Renewable Energy, August 2019, https://mnre.gov.in/sites/default/files/schemes/Notification-20082019-184419.pdf

Table 3: State-wise RPO Targets and Compliance for 2015-16



Source: MNRE (MNRE, 2017c, p. 69).
Note: For Gujarat the MNRE note seems to have considered the 2016-17 RPO as the one for 2015-16. Similarly for Tamil Nadu, the TNERC amendment on 7th March, 2016 has fixed the RPO at 9% and 0.5% for non-solar and solar respectively (TNERC, 2016)

The renewable purchase obligations (RPO's) initiated by the Electricity Act 2003, mandate DISCOMS and large power consumers to purchase electricity generated by specified green sources or buy renewable energy certificates from the market.[12] For the financial year 2018-19 the solar purchase obligations were set for 6.75 per cent and non-solar at 10.25 per cent. The ministry has further mandated these figures to be increased to 21 per cent by FY22 from the current 17 per cent in FY19.[13] The main goal for such obligations is to drive demand for renewable power, however the current status indicates state RPO targets are severely lagging in the targets set compared with those set under the National Action Plan for Climate Change and some states are unable to meet the lower targets as well.

This only highlights the fact that simply mandating targets without working on the financials can only work for a limited time, if at all**.** Additionally, there is lack of effective monitoring and enforcements by the various state electricity commissions. This is clearly depicted by the

[12] **Renewable Purchase Obligation** refers to the **obligation** imposed by law on some entities to either buy electricity generated by specified 'green' sources, or buy, in lieu of that, '**renewable** energy certificates (RECs)' from the market.

[13] Renewable Energy Certificate Mechanism in India: Key Learnings, Data Analysis and Way Forward, Power System Operation Corporation Limited, https://posoco.in/wp-content/uploads/2018/08/REC_REPORT_17082018_fPRINT.pdf

mounting penalties due to non-compliance of RPO, estimated at INR 42.34 billion as per CAG Audit Estimates 2015.[14] The RPO can be an effective tool to increase renewable power generation.

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The net result of all this, is that not only are utilities not incentivized enough to push rooftop solar among their high-end customers, they are also unable to invest in technologies that can help them invest in technologies that enable both sale and purchase of electricity from their customers. While this is a problem, the presence of certain industry dynamics as well as government policy does provide some reason that works towards greater uptake of rooftop solar.

2.3 Long-Term Benefits to DISCOMS

Adoption of rooftop solar does bring some important benefits for the utilities in the long run; and these benefits can also outweigh the losses under certain conditions. The first is the gain from significantly reduced T&D (transmission and distribution) losses, as rooftop solar power is consumed at its point of generation itself. T&D losses can account for a large share of electricity generated, being as much as 21 per cent in traditional grids as per 2017-18 provisional figures.[15] Second, a cheap supply of power to meet the day time peak demand does work in the utility's interest who otherwise need to purchase peak power at higher rates. And third, meeting the renewable purchase obligations (of new and renewable energy) by the utilities also requires them to access rooftop power. Moreover, if utilities could figure out a low-cost method of enabling household rooftop solar power for small residential customers, they could reduce the demand for electricity from subsidized households, and therefore reduce the share of non-customers or low-paying customers.

Adoption of rooftop solar does bring some important benefits for the utilities in the long run; and these benefits can also outweigh the losses under certain conditions.

[14] Report of the Comptroller and Auditor General of India on Renewable Energy Sector in India, Ministry of New and Renewable Energy, 2015, https://cag.gov.in/sites/default/files/audit_report_files/Union_Civil_Performance_Renewable_Energy_Report_34_2015.pdf

[15] Executive Summary on the Power Sector, Central Electricity Authority, December2019,http://cea.nic.in/reports/monthly/executivesummary/2019/exe_summary-12.pdf

2.4 Infrastructure Hurdles

The growing rooftop solar industry brings technical and operational challenges for the existing power grid, billing systems, coordination amongst MNRE, state governments involved and lack of skilled manpower. We begin with looking at the technical challenges associated with increased solar power generation, the major being the ability of the grid to handle a bi-directional flow of power from a consumer. Secondly, solar power is solely dependent on sun which may witness a sudden drop in power generation due to prolonged weather conditions owing to climate change. The grid must be capable of handling such situations.

Design features such as On Load Tap Changer for Medium Voltage/Low Voltage Transformer, Booster Transformers along Long Feeders, Reactive Power Support through Static Volt-Ampere Reactive Compensators and Revised Protection Settings for Bi-directional Flows will need to be incorporated in new design criteria. Thirdly, in the current system there is a provision for deliberate islanding which shuts down power supply in case of a power failure to safeguard the utility workers. However, this also shuts down any supply from the solar panels and can be challenge for areas with high frequency of power outages. There is a need for systems that can safely allow deliberate islanding and specify necessary standards. Fourthly, the distribution transfer (DT) capacity in the neighborhood is also considered for connection approvals. Many connections are not approved due to low DT capacity. DT capacity must be increased to avoid denial of permission for setting up RTS on this ground. Lastly, there is an urgent need for a mechanism for data collection of solar power generation at a real time basis, which allows for monitoring and forecasting of power generation patterns, thereby improving the system.

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2.5 Metering Mechanisms

Traditionally, electricity distribution and production has been uni-directional in nature of our power grid, that is top-down approach of receiving power from the generators and supplying it to the consumers and no provision is made for receiving power from the consumers, as will be the case with renewable solutions like rooftop solar. Two-way metering or net metering allows for flow of electricity in both directions, in case of surplus production by consumer, it flows back to the grid and in case the consumer consumes more electricity than they produce, the

power flows from the grid to the consumer. Currently across states, most rooftop solar systems are using gross metering, where the electricity produced by the rooftop solar is directly supplied to the grid and the consumer is supplied electricity from the grid and the tariffs for the solar generated electricity is lower than the tariffs for electricity supplied by the grid and the difference of the two is what the consumer pays or gets paid for . This is a more complex method for the consumer to understand and pro DISCOMS hence, fails to appeal to the consumers as is possible with net metering. Net metering is the key to the success of rooftop solar in the current Indian solar scenario.

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There is lack of push from the regulator towards net metering. Net metering is more transparent, easy to understand, pro-consumer and is a key element in providing RTS the push required to reach the 40GW goal by 2022. At present, there are no guidelines for implementation of the net metering regulations such that timely approvals and installation of net metering connections can occur. Solutions like collection of transparent data on applications, interconnection times, refusals, transformer loading, single window clearances, monitored timelines for new connections need to be adopted.

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3. Prosumers- The Producers cum Consumers

The new consumer can also be a producer of electricity and therefore the term ‘prosumer’ is increasingly being used. Given highly subsidized electricity tariffs, potential producers prefer to remain in the consumer space due to little or no incentive to choose rooftop solar electricity, as discussed previously. Moreover, there is lack of awareness on the part of prosumers about the procedures, guidelines and the benefits from solar panel installation, additionally there is a perceived performance risk of solar generation and concerns towards building strength and effect of wind on solar panels etc.

3.1 Education and Awareness Building

This can be addressed with educational material and tools to educate and generate awareness amongst the citizens about solar energy and about its benefits as a provider of renewable source of electricity, but such educational efforts are limited as of now. Credible resources could be utilized to educate people about the common misconceptions in regards to solar panels, strength of the building, weight of solar panels etc. This content would also need to be developed for both online and offline types of advertising as well as shared on social networks.

Content would also need to be developed for both online and offline types of advertising as well as shared on social networks.

Under the second phase of rooftop solar a fund of INR 66 crores has been set up to conduct awareness campaigns in association with the resident welfare associations and central group housing societies to educate the residents about the economic and environmental benefits of installing rooftop solar panels for electricity generation. These awareness campaigns identify the concerns of the residents.

3.2 The Incentive Model and Lock-in Period

Solar rooftop is primarily offered under two regimes in India - CAPEX & RESCO Model. The capital expenditure model or commonly known as CAPEX model is the most prevalent model in the Indian market so far with majority projects under this model itself. The model rests on rooftop owner procuring the rooftop solar system thereby taking the full risk on their shoulders. Firstly, in the CAPEX model there is huge one-time investment and regular maintenance costs making it unviable for a large segment of society. Secondly, the solar equipment has zero resale value further increasing the risks. In addition to these, there is reluctance from the banking sector despite solar loans being added to the priority sector.
The second business model available in India is the RESCO model where a renewable service provider acts as a third party between the roof-top owner and the distribution utility. The risks shift on to the renewable service provider but they benefit by selling power at higher than cost of solar but lower than the grid tariff and any surplus remaining, to other consumers. However, the RESCO model typically has a 25-year lock-in period whereas the service provider recovers his/ her costs in 10-12 years but the rooftop owner continues buys solar electricity as per a pre tariff agreement fixed for 10-25 years PPA's. There is a critical need for shorter lock-in periods to facilitate take up of this model.

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3.3 The Need for Credibility

The RTS sector being at a very nascent stage faces the need for a reliable body for providing solutions on all aspects like installation, maintenance & up-gradation. The rooftop owners need a trusted body to answer to all their queries to develop faith in the solar equipment provider and enabling the rooftop owner to take the final step towards installing RTS. The industry currently suffers from unreliable developers offering low product quality and no after-sales services. The second phase of RTS places the DISCOMS as the enablers for take up of rooftop solar by residents. In addition, a bond or bank guarantee procedure can be followed by the solar panel manufacturers to ensure quality and replacement of panels in case of any manufacturing defects. These changes have been in the right direction. Such steps are expected to build trust in the minds of the residents and are more likely to install rooftop solar panels, however they need to be sustained as the journey from awareness to active operationalization does take time.

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3.4 Reducing Peaked-ness

A rough analysis of the urban electricity consumer shows increased demand for electricity and an increased peaking demand during the afternoon and evening in the summers particularly due to air cooling demand. Although the daytime peak coincides with increased solar power generation but the evening peak does not have a similar power source. Solar power has proven to be beneficial in balancing the load in the daytime peak and could reduce or delay the need for grid up-gradation in many places. However, it fails to provide any support in the night time peak.

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A smoothening of the curve is required by way of consumer awareness and sensitization programs to bring about a change in the consumer behavior. Another method is to mandate building codes to maximize cooling techniques for any new building, thereby reducing the peaking of demand during summer months. There are many solutions that can prevent the buildup of heat islands and reduce the need for nighttime cooling. The solutions are well known, and building codes are required that (a) mandate rooftop solar (b) use of trees and greens and (c) optimize building design for lower cooling needs.

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3.5 Removing Multiple Bottlenecks

Discussions reveal a few other constraints that by themselves are not significant, but taken together act as a significant barrier to enabling higher rooftop solar power.

a) The current solar policy restricts the capacity of solar panel installation to not exceed 100 per cent of the current connected load of a consumer. This restricts the possible production of electricity through solar panels where there is roof space for further solar panel installation.
b) Additionally, the distribution transfer (DT) capacity in the neighborhood is also considered for connection approvals. Many connections are not approved due to low DT capacity. This DT capacity must be increased to avoid denial of permission for setting up RTS on this ground.
c) A hiccup in solar rooftop has been the lack of robust insurance schemes offered by the private sector, as only a handful of companies are offering insurance of solar equipment.
d) There is demand for rooftop solar by commercial and industrial consumers due to consistent rise of grid tariff's over the last many years but the adoption is low in residential users as the tariff gap are not huge enough to drive demand.

e) The policy also needs to factor in consumers without rooftop access and those unable to provide roof rights for 25 years, flexible solutions need to be developed to capture such potential buyers of RTS.

4. Solar Panel Vendors

Solar panel vendors in the first phase of solar policy acted as agents who facilitated the paperwork, subsidies and the installation process between the government, solar panel manufacturer and the electricity prosumer. As solar power generation is a nascent market, there are no standard mechanisms to assess the quality of the solar aggregators, and neither was market reputation well-developed in the nascent phase.

The second phase of the solar policy assigns most of the coordination role to the utilities/DISCOMS making the process much simpler. Some regulatory and policy changes can however improve the ecosystem.

4.1 Reducing Transactions Costs

A framework to rate the solar vendors on a list of defined parameters, publicly available on an online portal and which is periodically updated will be beneficial for the consumers in choosing the right solar vendor. Another step that has been incorporated in the second phase of the solar policy is empaneling the solar vendors by the DISCOMS/utilities.

The second phase channels the entire rooftop solar panel process through the DISCOMS, by setting up a window dedicated for new rooftop solar connections at each DISCOM office. Since electricity users have a long term and arguably trusted relationship with their respective DISCOMS, it is expected that the two parties would be better able to transact.

A framework to rate the solar vendors on a list of defined parameters, publicly available on an online portal and which is periodically updated will be beneficial for the consumers in choosing the right solar vendor.

4.2 Government Delays and Insensitivity

Solar vendors however face significant delays in release of subsidy offered by the central government. This leads to a financial crunch for many of the players as the installations pile up but no payment is released by the concerned department. Since the investment costs are borne by the vendors, delays effectively act as market destroying mechanism. There is therefore an

urgent need to streamline the process of subsidy disbursement and define a procedure in place.

Post implementation of the second phase, the DISCOMS will be responsible for any delays and they would need to provide an explanation for any such delay within a specific time period. However, a mechanism that simply loads all the risks on the vendor and absolves both the government and the prosumer from accountability will only lead to disinterest by the most important link in the chain. Policy needs to motivate and reward the vendor highly.

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4.3 Optimal use of Rooftop Space

The most crucial component for a solar panel installation is the availability of minimum roof space for the required number of solar panels. There is an untapped potential where roof areas could be clubbed to meet the minimum required area. In such a scheme the DISCOMS would be the perfect supervisor, to ensure adequate safeguards to both the solar vendors and the consumers. However, the solar policy currently restricts the capacity of solar panel installation as a percentage of the existing connection load, this restricts potential roofs with space for more than the allowed limit.

There is an untapped potential where roof areas could be clubbed to meet the minimum required area.

Second, there is no provision in the policy on making rooftop solar mandatory for new buildings. Third, currently there is no mandate to ensure maximum utilization of the roof for solar power generation. Fourth, there are stamp duty charges on roof lease agreements which only hamper the use of roof for sustainable solutions like the installation of rooftop solar panels. Stamp duties not only increase the costs, they also reduce the incentive for short term contracts in this space.

Finally, by having a holistic approach, the government can drive growth in the industry by waiving off stamp duty charges for the registration if roof lease agreements solely for

installation of rooftop solar panels. While the direction has been right, certain cracks and gaps in policies are preventing the full benefits from accruing to the society and economy.

5. Concluding Note

This monograph identifies the various forces that are operating on the three key players in the solar rooftop space – the prosumer (consumer and producer), the DISCOM (Utility or Distributor) and the solar power vendor. Beneficent policy and regulation have been the key forces that have pushed the rooftop solar space in the past. However, fine tuning and removal of some cracks and gaps can further speed up its uptake. Key changes have been discussed and identified in the relevant sections and also summarized in the summary table.

However, there is one issue that remains, that of coordination, and coherence within the various arms of the government and between the government and the regulators. There are multiple standards and policies on rooftop solar across the states, creating confusion in the minds of the consumers and making nationwide data incomparable. The government must work towards harmonizing the policies across states with minor variations to suit the consumer mix of the respective states. Secondly, the government must set an example by initializing installation of rooftop solar systems on government owned buildings. These actions will create a positive outlook in the minds of the consumers towards the government and the rooftop solar technology. Further, as there are multiple agencies involved there needs to be a platform for all of them to transverse and gain from each other's experiences and knowledge. In this regard, the government must look into a series of training programs for the regulators, utilities and the private sector related to the industry. Lastly, the various state electricity boards must work towards assigning a tariff of electricity which truly reflective of the cost of electricity, so as to reduce cross subsidies.

There are other deeper issues as well, while subsidies help a new industry in its early days but they also distort market forces and adversely affect industrial competitiveness. Therefore, all subsidies and help should be time-bound and removed over a period of time in a transparent manner. A related matter is that rooftop solar, RE and power sector in general will not be able to progress much till DISCOMS recover from financial difficulties and compensate them in a timely and fair manner. New technologies such as smart-meters, IoT technologies, blockchain, and drones can also help improve revenue, operations as well as efficient power trading etc. Institutional and technology issues such as (a) small term PPAs (b) Renewable Purchase Obligations (RPAs) and (c) battery storage also need to be embraced wholeheartedly by the various arms of the government.

Finally, key changes have taken place in the recent past and the second phase has set the stage for a tremendous increase in rooftop solar. While that has not occurred yet, there is always some time lag between policy and its impact. During this intervening period some changes can still be done that would further accelerate the beneficial impact of solar power.