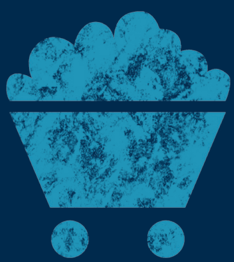
175 GW
RENEWABLES BY 2022

A July 2017 Update



₹ 4-5/kWh

₹ 3.46/kWh

₹ 2.44/kWh

Prayas (Energy Group)

INDIA'S JOURNEY TOWARDS 175 GW RENEWABLES BY 2022

175 GW
Renewables by 2022

A July 2017 Update

Nikita Das | Ashwin Gambhir | Jatin Sarode | Shantanu Dixit

July, 2017

Prayas (Energy Group)

About Prayas

Prayas (Initiatives in Health, Energy, Learning and Parenthood) is a non Governmental, non-profit organization based in Pune, India. Members of Prayas are professionals working to protect and promote the public interest in general, and interests of the disadvantaged sections of the society, in particular. Prayas (Energy Group) works on theoretical, conceptual regulatory and policy issues in the energy and electricity sectors. Our activities cover research and intervention in policy and regulatory areas, as well as training, awareness, and support to civil society groups. Prayas (Energy Group) has contributed in the energy sector policy development as part of several official committees constituted by Ministries and Planning Commission. Prayas is registered as SIRO (Scientific and Industrial Research Organization) with Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India.

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About the Cover: The cover image depicts the increasing price competitiveness of wind and solar PV in comparison with new coal power plants and is only indicative.

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1. Introduction

Two recent data points with regard to utility scale renewable energy have compelled even the most ardent sceptics to sit up and take note of renewable energy, especially wind and solar power.

First, bids for 500 MWs of solar photovoltaics (PV) in the second phase of the Bhadla Solar Park discovered a record low price of ₹ 2.44/kWh, levelised and fixed over 25 years (SECI, 2017a). Similarly, in a first ever competitive bidding based price discovery of wind power for procurement by Distribution Companies (DISCOMs), a new low for wind prices emerged, i.e. ₹ 3.46/kWh. This is much lower than the feed-in tariffs that were set by the Regulatory Commissions (SECI, 2017b). These price discoveries underscore the price-competitiveness of renewable energy, especially when contrasted with new coal capacity contracted recently by various DISCOMs which has a price range of ₹ 4-5/kWh. It is important to note that the above prices of wind and solar power are only reflective of direct costs, without valuing its various other benefits in terms of minimal environmental externalities, enhanced energy security, low gestation periods, and low price volatility due to the nature of fixed long-term price contracts. Therefore, it now appears that Renewable Energy (RE) generation prices (in simple per kWh terms) are no longer a hurdle to achieve the 175 GW national target.

Secondly, the country added about ~11.3 GW of renewable energy based power generation capacity in 2016-17, most of it from wind and solar power, which roughly matched capacity addition from thermal power (~11.5 GW) for the same period (MNRE, 2017h) (CEA, 2017a). In fact, 2016-17 was the first year in which renewables saw a double-digit capacity addition (in GW terms) on the back of 2015-16, which was a record of capacity addition at ~7 GW then. Last year, solar capacity addition (5,525 MW) very slightly out-paced wind power deployment (5,502 MW) for the first time. These trends show the increasing pace of renewable energy deployment, as is clear from Figure 1. Owing to the government support and economic trends conducive to the fast paced renewable energy capacity addition in the last year, India has been ranked as one of the top two countries for investments in renewable energy according to the renewable energy country attractiveness index (Ernst and Young, 2017, pp. 8, 9).

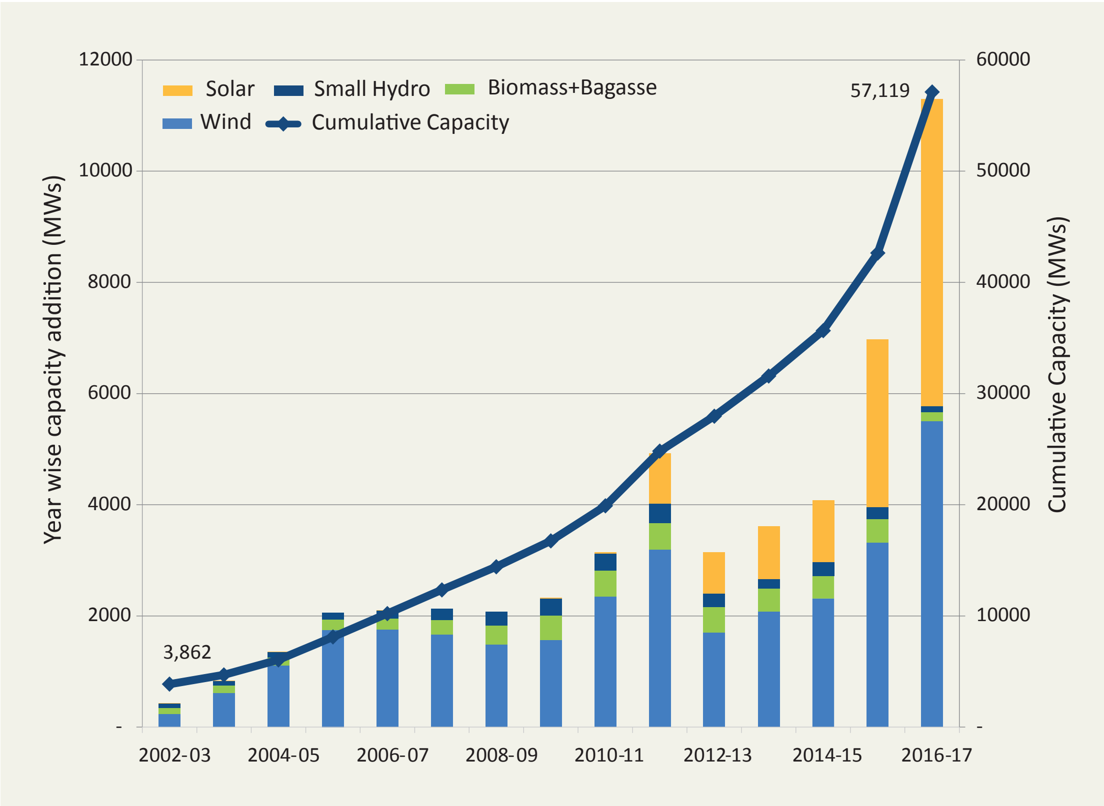
In spite of the record capacity addition and price reductions, there remain a number of areas of uncertainty within the RE sector, which if not addressed comprehensively could significantly undermine progress. The foremost issue on most people's minds is whether these low bids for wind (mostly due to higher hub heights and larger rotors) and solar PV (mostly due to drop in module prices coupled with low-cost financing) are really financially sustainable and viable in the long run. Added to this is the likely increase in tariffs due to the introduction of the Goods and Services Tax (GST), which can significantly increase indirect taxes on renewable energy. In parallel, some existing incentives for wind power, specifically the Generation Based Incentive (GBI) and Accelerated Depreciation, are to be discontinued from April 2017. Considering smaller scale rooftop solar projects, while net metering regulations for solar PV are in place in all states and a few states are even providing additional incentives[1], implementation has been very slow. There is increasing fear

1. Gujarat: subsidy of Rs 10,000/kW up to Rs 20,000, complete waiver of registration fees for rooftop installations (Source: (GEDA, 2016a) (GEDA, 2016b)); Haryana: additional incentive of 25p/kWh on solar generation.

that the 40 GW target appears quite unrealistic (Raghavan, 2017). Finally, there is the major issue of reliably integrating all this renewable energy into the national and state grid. While forecasting, scheduling and deviation settlement regulations have been put in place for projects connected to the inter-state transmission network, a similar framework is still lacking at the state level where most of the projects exist.

Hence, while the price reductions coupled with the rapid increase in pace of deployment have greatly increased solar and wind power's acceptability as mainstay generation sources for the years to come, several challenges remain. Such issues need further analysis leading to appropriate changes in policy and implementation.

Figure 1: Past growth in renewable energy generation capacity (2002-17)



Source: Prayas (Energy Group) analysis based on compilation of various Ministry of New and Renewable Energy (MNRE) reports.

Prayas' earlier report titled 'India's journey towards 175GW renewables by 2022' which critically examined the country's progress towards the 175 GW target was published last year in October 2016 (Prayas (Energy Group), 2016a). It explored the history of renewable energy development in India by detailing the policy-regulatory framework for renewables in India. This second report which surveys the progress towards 175 GW starts where the first report left off. It highlights the major sectoral developments in terms of deployment, prices, new policies and regulations since last year. It is now just over two years since the announcement of the 175 GW target (February 2015) and hence a fair enough time frame to learn from and to prepare ourselves for the next five years until 2022, the terminal year of the target. This report does not repeat the historical developments in the renewable energy sector in the country, already covered in the first report. Hence it should be read as a supplement to the first report.

Broad outline of the report

The first chapter reviews the past (1985-2017), present (2016-17) and likely future (up to 2022) RE capacity addition. The next two chapters analyse the actual electricity generation and compliance with mandatory RE purchase obligations. Chapter five focusses on rooftop solar PV (RTPV) and takes note of the various amendments in the state net-metering regulations. It also reviews the viability of RTPV in various states considering their existing costs. The next chapter is on pricing and tariffs, a very important topic considering the new lows of prices for wind and solar PV discovered through competitive bidding. Chapter seven looks at all the regulatory changes in the renewable energy certificate (REC) mechanism, especially the implications of the revision in the floor and forbearance prices for the future of this instrument. Chapter eight takes stock of the various developments linked to grid integration of renewable energy. Notable among these are the forecasting and scheduling regulations for wind and solar PV, transmission planning regulations, amendments to the Indian Electricity Grid Code (IEGC) etc. The next chapter, namely GST, as the name suggests, critically examines the implications of this new indirect tax regime on the RE sector, especially solar PV. The last chapter summarises the learnings and observations from all the previous chapters.

2. National and state policy updates

Since the publication of the 'India's journey towards 175 GW renewables by 2022' report in October 2016, a number of important policy announcements have been made by the central government as well as various state governments. Some of these key updates are highlighted below.

2.1 Central government

Policy for Repowering of the Wind Power Projects: The MNRE announced the wind repowering policy in August 2016 with the primary objective of ensuring optimum utilisation of wind energy resources. It estimates that there is close to 3,000 MW worth of wind power capacity installed prior to year 2000 on high wind resource sites with turbine rating of roughly 0.5 MW. Wind turbines of capacity 1 MW and below are eligible for repowering under this policy. All incentives available to new wind power projects will also be available for repowering projects. In addition, if financed by the Indian Renewable Energy Development Agency (IREDA), an additional interest rate rebate of 0.25% would be available over and above the interest rate rebates to new wind projects (MNRE, 2016a).

International Solar Alliance (ISA): The ISA is a treaty based inter-governmental organisation proposed by India in 2015 with the primary objective of creating a forum of solar rich countries to ensure increased utilisation and promotion of solar energy. The Framework Agreement for the ISA was signed by 19 countries in Marrakech, on the sidelines of the Marrakech Climate Change Conference in November 2016, and aims to bring together 121 countries. With the former secretary of MNRE, Upendra Tripathy, being appointed as the full-time Interim Director General of the ISA and the World Bank announcing their support for the initiative, the ISA is well poised to work towards one of its important goals of mobilising 1 trillion dollars of finance for solar energy (PIB, 2017b) (PIB, 2017a).

Solar park capacity enhancement scheme: The central government enhanced the allotted capacity for Solar Parks and Ultra Mega Solar Power Projects from 20 GW to 40 GW in March, 2017. The scheme envisages at least 50 solar parks each with a minimum of 500 MW capacity to be set up by 2019-20. A Central Financial Assistance (CFA) of ₹ 8,100 crore has been sanctioned for the scheme, and the Solar Energy Corporation of India (SECI) has been nominated as the implementing agency. The financial assistance would include ₹ 25 lakh for the preparation of the Detailed Project Report (DPR) of the solar park and up to ₹ 20 lakh per MW or 30% of the project cost, whichever is lower, subject to completion of pre-agreed milestones to be achieved by the park developer (MNRE, 2017a).

End of Domestic Content Requirement (DCR) category: India introduced a DCR category under the National Solar Mission to support its local solar cell and module manufacturing base. Citing discrimination against solar inputs from other countries, the United States formally filed a complaint with the World Trade Organisation (WTO) against this policy in 2013. In February 2016, the WTO found that India was indeed in violation of its commitments under the General Agreement on Tariffs and Trade (GATT) and Agreement on Trade Related Investment Measures (TRIMs) (Pradeep S. Mehta, 2016). This dispute has finally ended with the recent announcement on 14th June, 2017 that India and the United States have mutually agreed to put an end to the DCR procurement latest by 14th December, 2017 (Mercom Capital Group, n.d.a).

2.2 State government

Since October 2016, a number of states have come out with their new policies for renewable energy. Table 1 lists the key targets and incentives listed in these policies. While the RE policies of Odisha and Bihar have been finalised, the solar policies of Uttar Pradesh and Goa are yet to be finalised. While Uttar Pradesh has a set a very high solar target of 10,700 MW which is in line with the state targets recommended by the MNRE[2], Bihar has gone a step ahead and is targeting an installed capacity exceeding its corresponding state target.

While Maharashtra has had an official RE policy in place since 2015, recent newspaper reports mention an upcoming Mukhya Mantri Solar Energy Policy which aims to provide dedicated solar PV power to separated agriculture feeders. Projects would be undertaken under a public-and-private partnership with the government providing land on lease for 25 years. The DISCOM is likely to accrue major financial savings since the price of solar power in such projects has been discovered at ₹ 3/kWh through competitive bidding in two recent pilot projects (Indian Express, 2017).

Table 1: State policy updates

State policy	Target (MW)	Incentives	Operative period
Odisha Renewable Energy Policy, 2016 (Odisha Department of Energy, 2016)	2720 (solar-2200; wind-200; biomass and WTE-200; SHP-150)	1. Creation of an Odisha Renewable Energy Fund[#] for accelerated RE development	31st March, 2022 or until announcement of new policy
		2. Land to be made available for RE project development under the Land Bank scheme of Odisha Industrial Infrastructure Development Corporation at rates specified by Industrial Policy Resolution (IPR) 2015, with exemption from stamp duty for solar parks for government lands	
		3. Electricity duty exempted for self-consumers for next five years	
Bihar Renewable Energy Policy, 2017 (Centre for Environment and Energy Development, 2017)	3433 (solar-2969; bio-power-244; SHP -220)	1. Transmission and distribution charges to be exempted for third party and captive generators within state	Five years from date of notification
		2. Capital cost of the transmission system including all metering and protective instruments will be borne by the state government, provided generator is within 10 km from sub station	
		3. All generation, transmission and distribution of electricity from renewable energy are eligible to avail incentives under the Bihar Industrial Investment Promotion Policy, 2016	
Draft Uttar Pradesh Solar Policy 2017 (UPNEDA, 2017)	10,700 (of which 4300 - rooftop)	1. For development of public solar parks, leased land on right to use basis to be provided by state	Five years from date of notification
		2. For large scale standalone projects that sell power to Distribution Licensee, one third of cost of construction of transmission line to be borne by state government[@]	
		3. For solar generators in Open Access (OA), exemption of wheeling and transmission charges and Cross Subsidy Surcharge (CSS) at intrastate level	

2. The targets were determined by MNRE as tentative state wise source break up of Renewable Power by 2022 (MNRE, 2015b)

Draft Goa Solar Energy Policy, 2017 (Goa Energy Development Agency, 2017)	150 (solar)	1. Performance based exemption of 50% on Stamp duty (based on timely completion of project)	Up to seven years from date of notification
		2. Exemption from payment of electricity duty and cess for self-consumption, third party and sale to licensee (applicable for entire period of policy)	
		3. Building bye-laws shall not consider the height of module in the total building height, and no permission required from Urban Local Bodies or Panchayats to put up solar plants on buildings	

Source: Prayas (Energy Group) compilation based on various policy documents.

WTE – Waste to Energy; SHP - Small Hydro Power

To be funded through a payment of 5p/kWh by independent/private developers on RE sold outside the state.

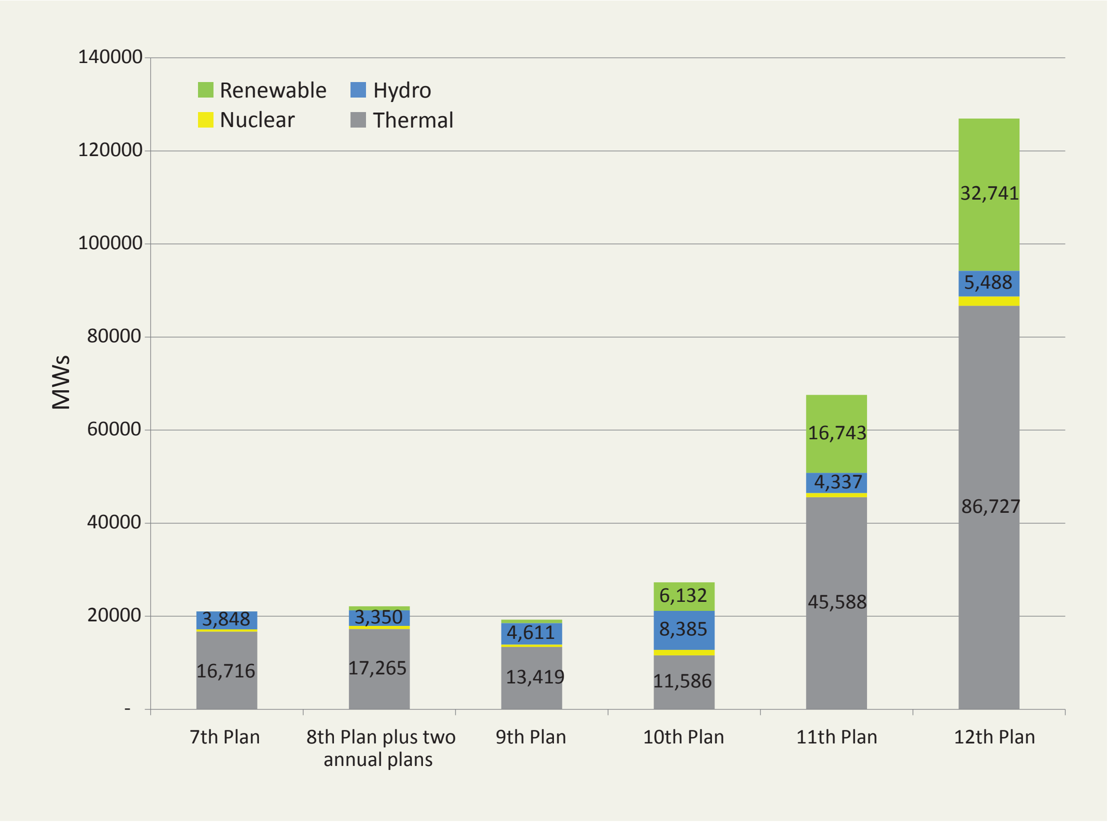
@ Provided that the line is constructed by the State Transmission Utility (STU) and is less than 15 km in length and within the Purvanchal and Bundelkhand region.

3. Renewable Energy Capacity Addition

3.1 A historical view (1985-2017)

March, 2017 was the end of the 12th five-year plan (2012-17), the last such plan exercise, since from 2017-18 the GoI plans to move away from the plan/non-plan distinction. Five-year plans are to be replaced by a fifteen year vision, seven year strategy and three year action agenda documents (NITI Aayog, 2017). If one were to take a historical view and analyse the power generation capacity addition in the last six five-year plans, it is clear that from the 7th to the 10th plan end (2002), conventional capacity addition (thermal, hydro and nuclear) remained more or less constant in absolute terms at roughly 21 GW/plan. The 9th plan saw a slightly less addition at 18.5 GW. However in the 11th and 12th plan, thermal capacity addition (45 GW and 86 GW respectively) has outpaced all others as is clear from Figure 2. Similarly, renewable capacity addition at any meaningful scale began only in the 10th plan and has grown exponentially since then. Focus on climate change mitigation and enhancing energy security ensured a supporting policy framework for renewable energy, which is seen in its growth from 7.7 GW to 57.2 GW from 2002 (beginning of the 10th plan) to 2017 (end of the 12th plan). RE capacity addition in the 11th and 12th plan was 16.7 and 32.7 GW respectively, well above the targets of 14 GW and 30 GW respectively.

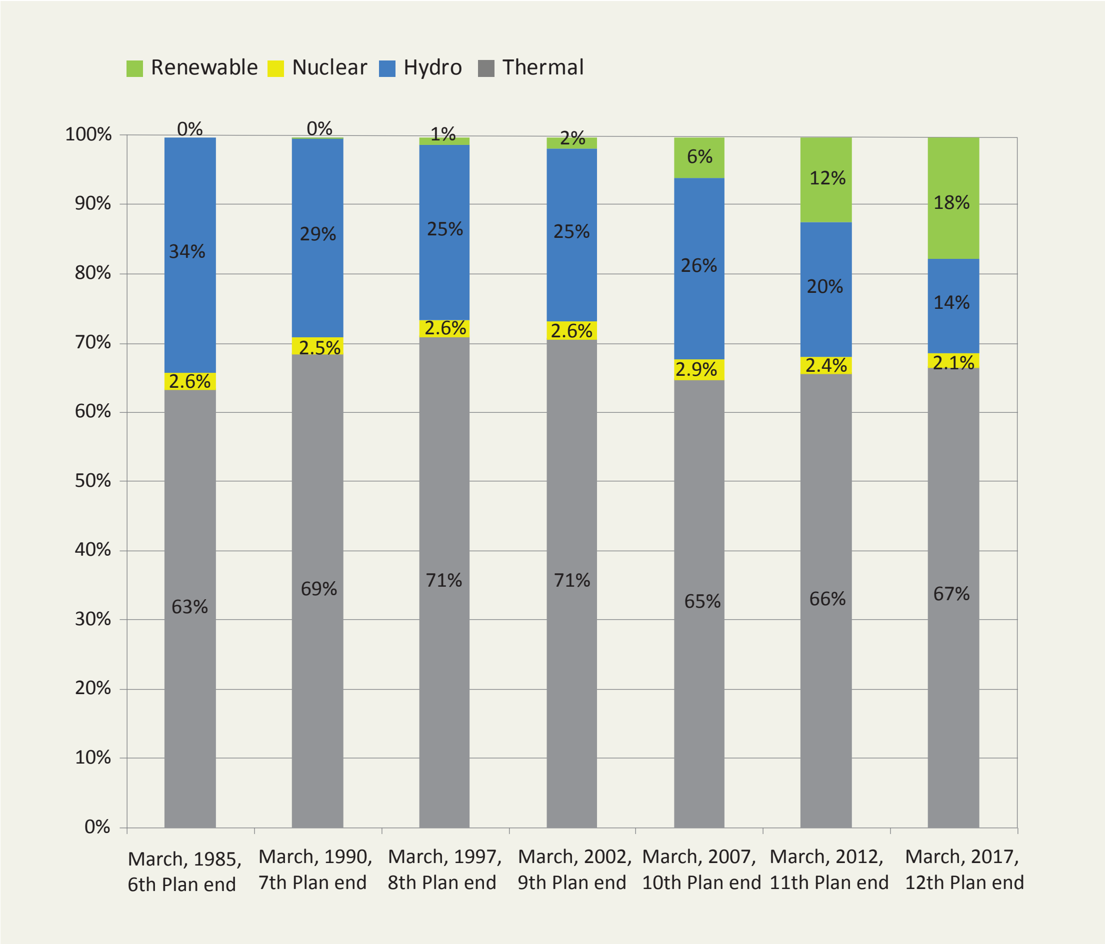
Figure 2: Capacity addition by various generation sources for 7th -12th plan



Source: Prayas (Energy Group) compilation based on various Central Electricity Authority (CEA) and MNRE reports.

In terms of the share of generation capacity, thermal sources have more or less retained their share of 65-70% over the last 32 years (last six five-year plans). Share of nuclear power has gone down marginally by half a percentage point, from 2.5% to 2%. In the same period, share of large hydro went down by 20% (from 34% to 14%), while the share of RE went up to 18% from nearly zero (see Figure 3). This transition is quite rapid considering that even at the end of the last financial year (March, 2016), the shares of RE and large hydro were equal at 14%.

Figure 3: Share of various electricity generation sources in total capacity for 1985-2017



Source: Prayas (Energy Group) compilation based on various CEA and MNRE reports.

3.2 Capacity addition in 2016–17

The total RE capacity added last year was 11.3 GW, a growth of 62% over the year before that (see Figure 1). As expected solar PV and wind power led the way with 5,525 and 5,502 MW respectively. This was the first year that solar power capacity addition exceeded that of wind power, a telling sign for the times to come. The balance was made up by bio-power (biomass & gasification and bagasse cogeneration; 162 MW), SHP (106 MW) and waste to energy (23.5 MW). The cumulative capacities of various RE sources as on 31st March, 2017 stand at 32.3 GW (wind), 12.3 (solar), 8.2 (bio-power) and 4.4 (SHP), taking the total cumulative RE capacity to 57.2 GW.

Box 1: Bio-power capacity data

The MNRE had reported the bio-power capacity at the end of March, 2016 at 4,831 MW, and given the 162 MW added in 2016-17, the cumulative capacity at the end of March 2017 should have stood at 4,993 MW and not the officially reported 8,181 MW. Upon enquiring with the MNRE as to the cause of this discrepancy, the MNRE clarified that the 4,831 MW at the end of March 2016 was only the 'Surplus Exportable Capacity (Power Supplied to Grid) of Biomass Power/Bagasse Cogeneration plants' and not the total installed capacity inclusive of the captive consumption. Out of the 162 MW added last year, 94 MW was surplus exportable to the grid. So the total surplus exportable to the grid as of 31st March, 2017 is now 4,925 MW and the balance, i.e. 8,181-4,925 = 3,256 MW is captive bio-power. The total installed bio-power capacity is 8181 MW. The sudden jump in the share of RE in the system capacity from 2016 to 2017 is mainly due to this update in the bio-power data (from 5 GW at the end of March 2016 to 8.1 GW at the end of March, 2017).

3.3 Looking back two years (2015-17) and planning for the next five (2017-22)

Looking back two years since the announcement of the 175 GW RE target, one sees that only wind power has met its annual targets. In fact, it has exceeded the two-year target (2015-2017) by 2,427 MW. All the other sources have missed their own targets. Utility scale solar and rooftop solar are nearly 1.5 GW and 4 GW below their two year target, while bio-power and SHP are 225 MW and 175 MW below theirs (see Table 2). In spite of a record renewable energy capacity addition of 18.3 GW in the last two years, there was still a slippage of 3.4 GW overall.

Table 2: Renewable energy targets and actual deployment for 2015-2017

Source/ Year	Targets/Deployment (MW)	Utility scale solar	Rooftop Solar PV	Wind	Bio-power	SHP
2015-16	Original Targets	1800	200	2400	400	250
	Actual deployment	2626	392	3325	413	219
2016-17	Original Targets	7200	4800	4000	400	250
	Actual deployment	4902	624	5502	162	106

Source: MNRE.

The record push for wind power projects in 2016-17 was amongst other reasons partly attributable to two things. Firstly, the Generation Based Incentive (GBI) is to be discontinued from April 2017, and the Accelerated Depreciation benefit has been reduced from 80% to 40% from the same date. More importantly, the low price of wind power (₹ 3.46/kWh) discovered through competitive bidding has strengthened the case for states to stop wind power procurement at higher feed-in tariffs and move completely to competitive bidding in wind power.

The 1,000 MW wind power bids which concluded in December 2016 are allowed 18 months for commissioning after issuing the Letter of Award (LoA), while the new draft bidding guidelines for wind power allow for projects to be completed in 18 months after signing the Power Purchase

Agreement (PPA). Hence none of the projects for which bidding is completed (1,000 MW) and for which bidding will be conducted this year (2017-18) will be commissioned this year. If the states refuse to allow projects at regulated feed-in-tariffs[3], wind power deployment is very likely to slow down significantly, especially in 2017-18. Deployment will largely depend on the pace at which state DISCOMs conduct wind bidding in their states, as the country transitions from regulated tariffs to market discovered prices.

NITI Aayog's draft Three Year Action Agenda document released in April 2017 has made some recommendations for renewable energy till 2020. It suggests that 100 GW of RE be installed by 2020 to contribute to the 175 GW target by 2022. Similarly, it recommends that at least 20 GW of the 40 GW rooftop solar target be met by the same date. Finally it recommends that the 5 GW by 2022 target for SHP be advanced to 2020 (NITI Aayog, 2017).

All these aspects detailed below mean that annual RE targets for the next five years need to be reworked for them to remain consistent with the 175 GW target.

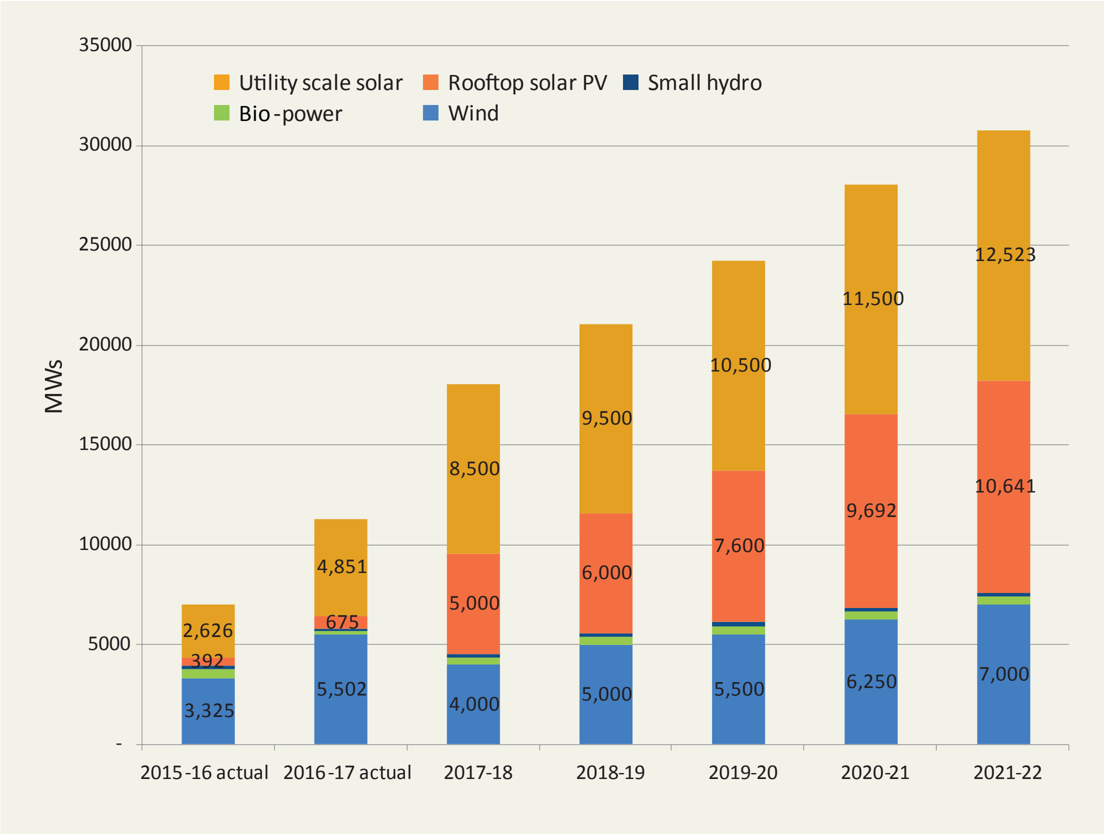
a. overachievement of wind targets and underachievement of solar, bio-power and SHP targets (2015-17),
b. likely slowdown in wind deployment in 2017-18,
c. reclassification of the bio-power cumulative capacity data which now stands at 8,181 MW (March 2017)
d. advancing of the SHP target of 5 GW to 2020 from 2022
e. 20 GW of the 40 GW[4] rooftop solar target to be achieved by 2020

We have attempted to estimate the likely revised targets for RE from 2017-18 to 2021-22 based on the above considerations. We followed the principles below in revising the targets for the next five years. The slippage in solar capacity addition from 2015-17 is taken up in 2020-2022. We also increased the rooftop deployment target for 2019-20 to meet the recommendation of the NITI Aayog to at least install 20 GW by 2020. Since wind outperformed its targets in 2015-17, we have reduced all the yearly targets to cumulatively achieve 60 GW by 2022. With regard to bio-power, we reduced future yearly targets to ~400 MW/year considering that the revised cumulative installed capacity in the country is 8,181 MW and not 4,993 MW (see box 1 on bio-power data). Finally, in light of the NITI Aayog recommendation to advance SHP targets to 2020, we have proportionately increased the yearly targets to reflect this. Our estimates for these renewable energy targets are depicted in Figure 4.

3. Recently Andhra Pradesh and Gujarat have taken such a stance.

4. The recent conference of power, new & renewable energy and mines ministers of states/UTs has resolved to reduce the solar rooftop target from 40 GW to 20 GW, while at the same time increasing the solar park target from 20 GW to 40 GW. However since no formal announcement has been made by the MNRE in this regard, we have not considered the same in our analysis (MoP, 2017b).

Figure 4: Revised year-wise and source-wise renewable energy targets as estimated by Prayas (Energy Group)



Source: Prayas (Energy Group) analysis .

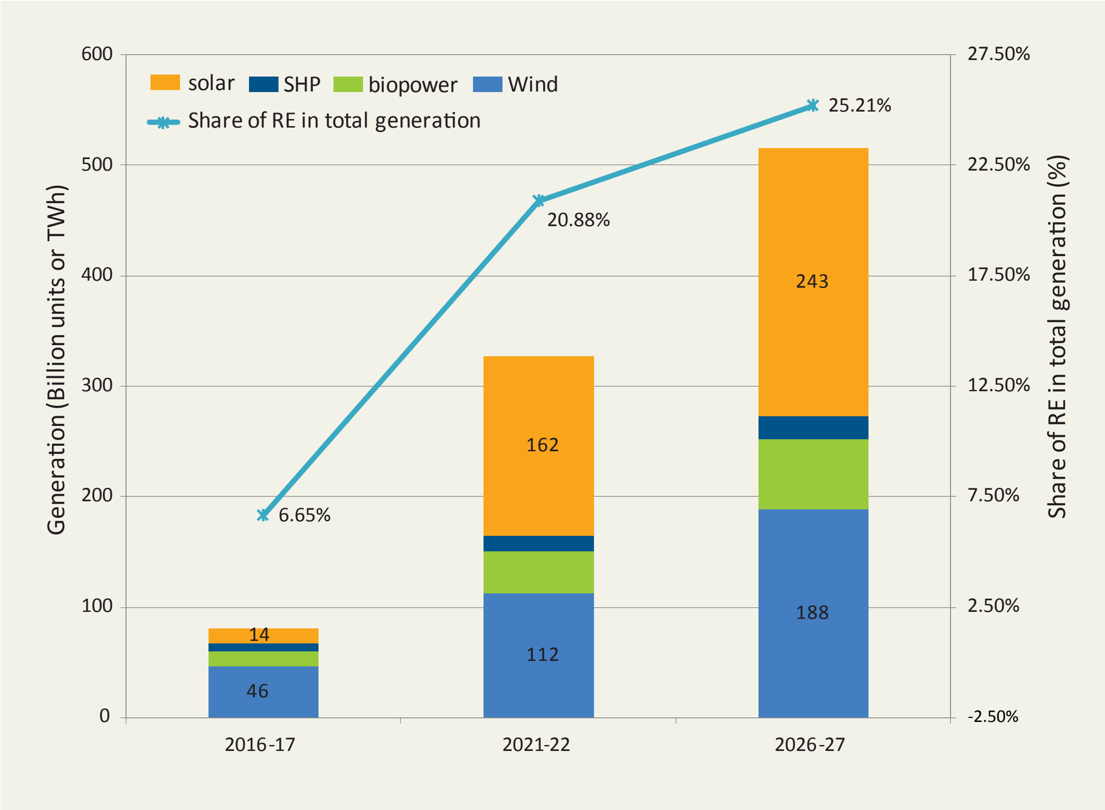
Note: For 2017-18, the MNRE has earmarked only a 10 GW target for solar power. It is unclear whether this is inclusive of the rooftop target. We have assumed a separate 5 GW rooftop solar target as before (MNRE, 2017f). However market estimates by BridgetoIndia indicate only 1.2 GW of rooftop capacity addition in 2017-18 (Bridge to India, 2017b). The Power Ministers Conference in May 2017 has resolved to add 6 GW of wind and 15 GW of solar in 2017-18, which is 50% higher than the MNRE target of 4 GW and 10 GW respectively.

As the above analysis points out, there is an urgent need to systematically revise the yearly targets for the remaining years to remain consistent with the 175 GW vision, and taking into account actual deployment performance in the last two years. Considering the rapid evolution of the RE market, the slow pace of rooftop uptake, and the situation of surplus capacity in the country, a more flexible target setting process in greater consultation with states and other stakeholders is the need of the hour.

3.4 Looking at the medium term (2022 and 2027)

The Central Electricity Authority's (CEA) draft National Electricity Plan (NEP) (generation) provides projections and scenarios of electricity demand and generation capacity (including renewable energy generation) for 2022 and 2027 (CEA, 2016b). The 19th Electric Power Survey (EPS) from CEA provides the latest demand estimates for the next ten years. Considering both these analyses, RE may contribute 33% and 43% to generation capacity and 21% and 25% to electricity demand in 2022 and 2027 respectively (see Figure 5). This assumes that the entire 175 GW will be in place by 2022 and another 100 GW would be installed from 2022-2027. This implies a 300% increase in absolute RE generation from 2017 to 2022, but only a 58% increase from 2022 to 2027. Comparing the final share of RE electricity in the total demand, there needs to be a 214% increase (from 6.6% to 20.9%) from 2017-2022, while only a 21% increase in the next five years. Clearly, the coming five years will need an ever greater focus on RE deployment.

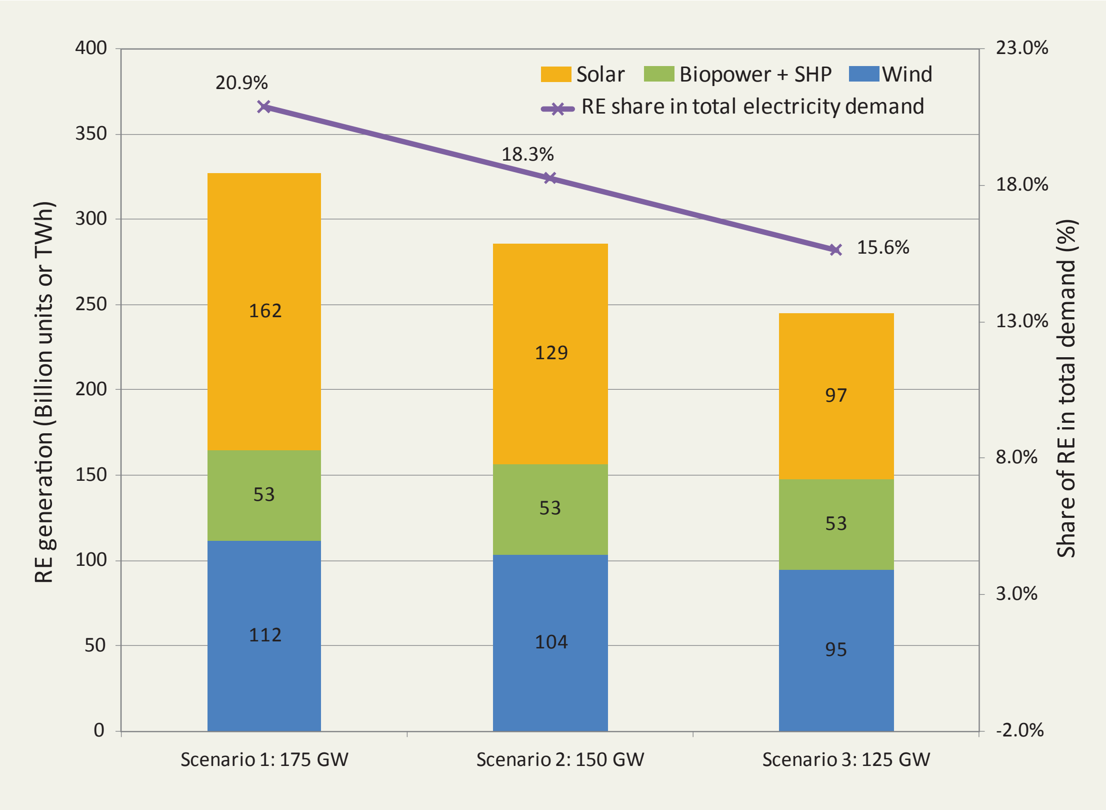
Figure 5: Source-wise renewable energy generation projections for 2022 and 2027



Source: CEA's Draft National Electricity Plan, December 2016 and 19th EPS, January 2017.

To consider various eventualities until 2022, it builds three scenarios for renewable energy as shown in Figure 6. If RE capacity addition only adds up to 150 or 125 GW, its contribution to total demand would reduce to 18.26% and 15.64% respectively.

Figure 6: Renewable Energy generation by 2022 in three scenarios and its share in the total demand

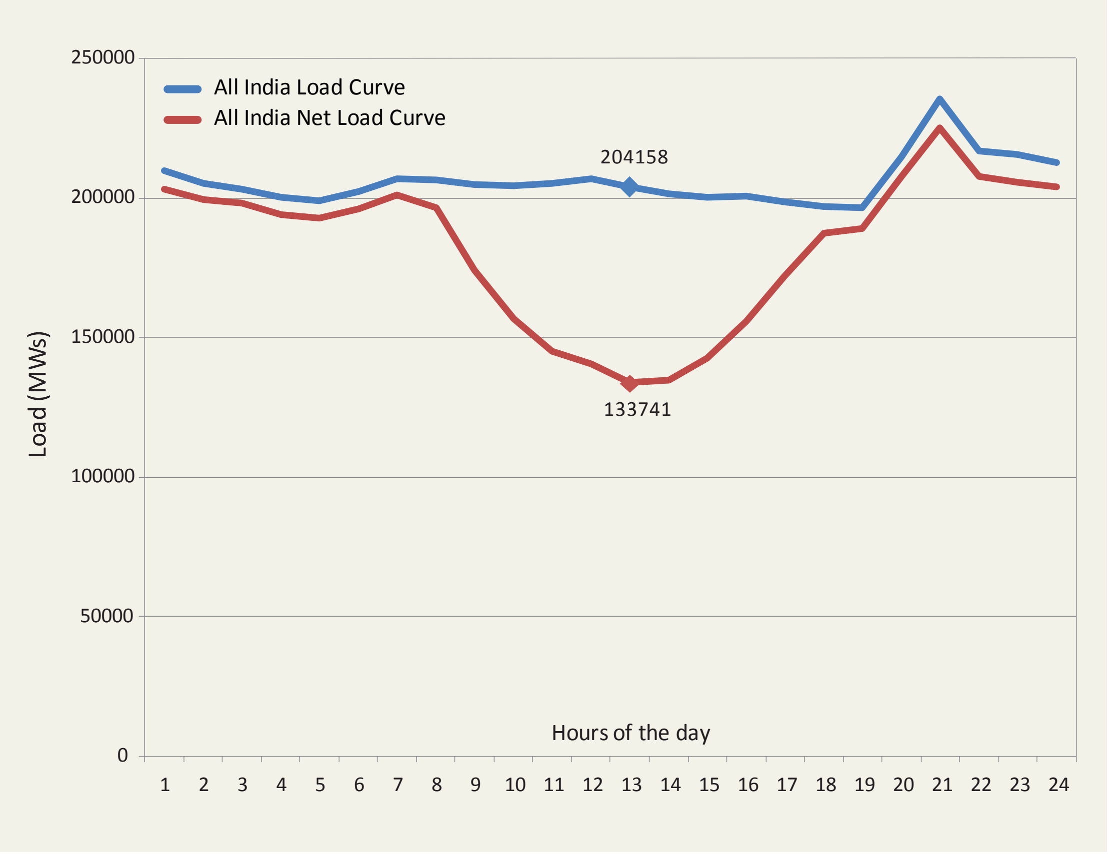


Source: CEA Draft National Electricity Plan, 2016.

Conventional generation planning studies using the software EGASS were then conducted to meet the projected demand in the year 2021-22 for these three RE scenarios. Large hydro, gas and nuclear were given a preference over coal due to their lower carbon footprint. The studies indicate that for all three RE scenarios (125, 150 and 175 GW), only 22.4 GW of conventional capacity is needed for the period 2017-22, which includes zero addition from coal. However a coal based capacity of 50,025 is already under construction and will materialise between 2017 and 2022. Given this excess generation capacity compared to the demand, coal Plant Load Factors (PLFs) are likely to come down further in the coming years. The plan estimates coal PLF to be between 48% and 53% by 2022 for the three RE scenarios. This has serious implications for the fixed costs of coal power plants and also for the practical implementation of the 'must run' status of RE plants.

The draft also estimates the all India load curve for 2022 and the all India net load curve (assuming the RE plants as must run and hence negative load). The results are shown in Figure 7. RE is expected to contribute only 10.4 GW to the peak load (at 9 pm) in spite of the 175 GW installed capacity. The difference between the load and net load curve is highest at 1 pm, roughly 70.4 GW, clearly showing the higher share of solar energy in the system generation mix. The net load curve is expected to be much peakier than the load curve, a good indication of the increased flexibility needed in the rest of the generation fleet to effectively meet demand.

Figure 7: All India load and net load curve for 2022



Source: CEA.

4. Renewable Energy Generation

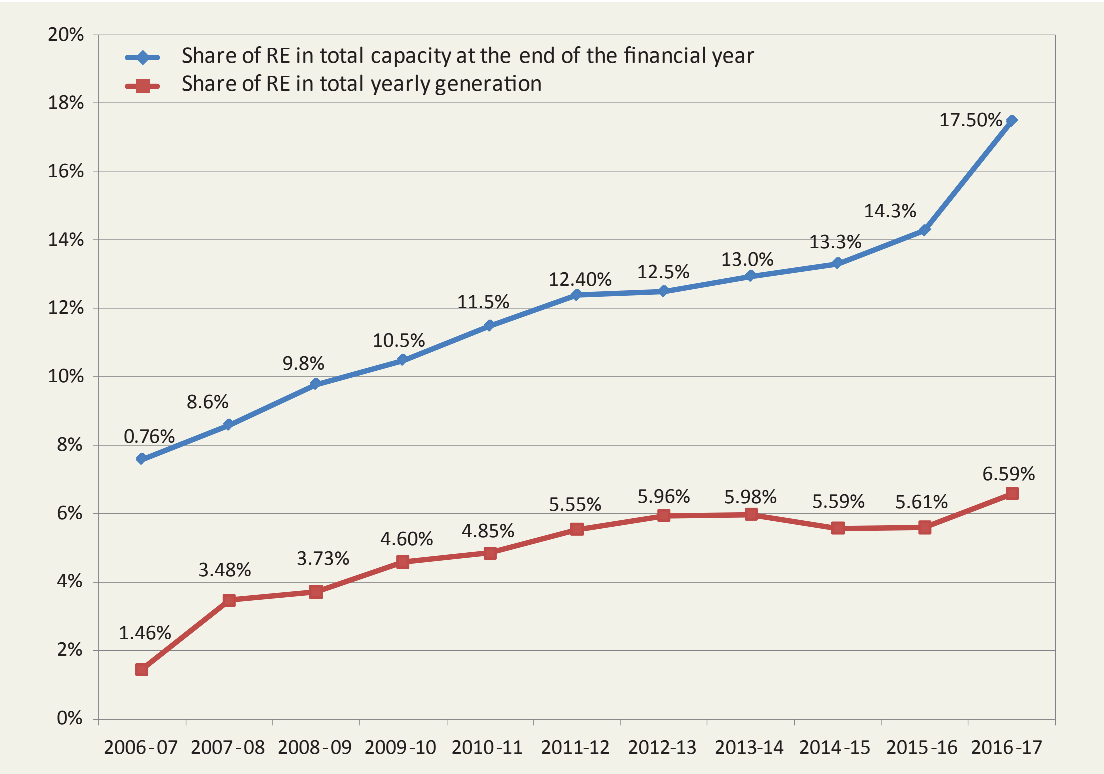
4.1 Generation in 2016–17

Renewable energy generated a total 81.8 billion units in 2016-17, contributing 6.7% of the total electricity demand in the country. More than 50% of this came from wind power (46 BU) and was followed in equal measure by solar and bio-power at 13.5 BU and 13.2 BU respectively. SHP contributed just over 8 BU in the same year. As a sectoral generation comparison, renewable energy generated roughly 2.2 and 1.7 times the generation from nuclear power and gas-based thermal power in the country in the same time period. In comparison to large hydro, RE generation is still 33% lower, but considering the rate at which RE generation is growing, it is likely to surpass large hydro in actual electricity generation in the next two-three years. This would place it firmly as the second largest source of generation behind coal power from 2020 onwards.

RE generation trends

Figure 8 shows the share of renewable energy in total generation capacity and total electricity generation from 2006-07 to 2016-17. While the share of RE in total generation capacity (excluding captive plants) has steadily increased each year from 7.6% to 17.5% in ten years, share of RE in electricity generation has been quite stagnant at roughly 5.5% from 2011-12 to 2015-16. Only in the last year did it rise to 6.6%.

Figure 8: Share of renewable energy in total system capacity and electricity generation

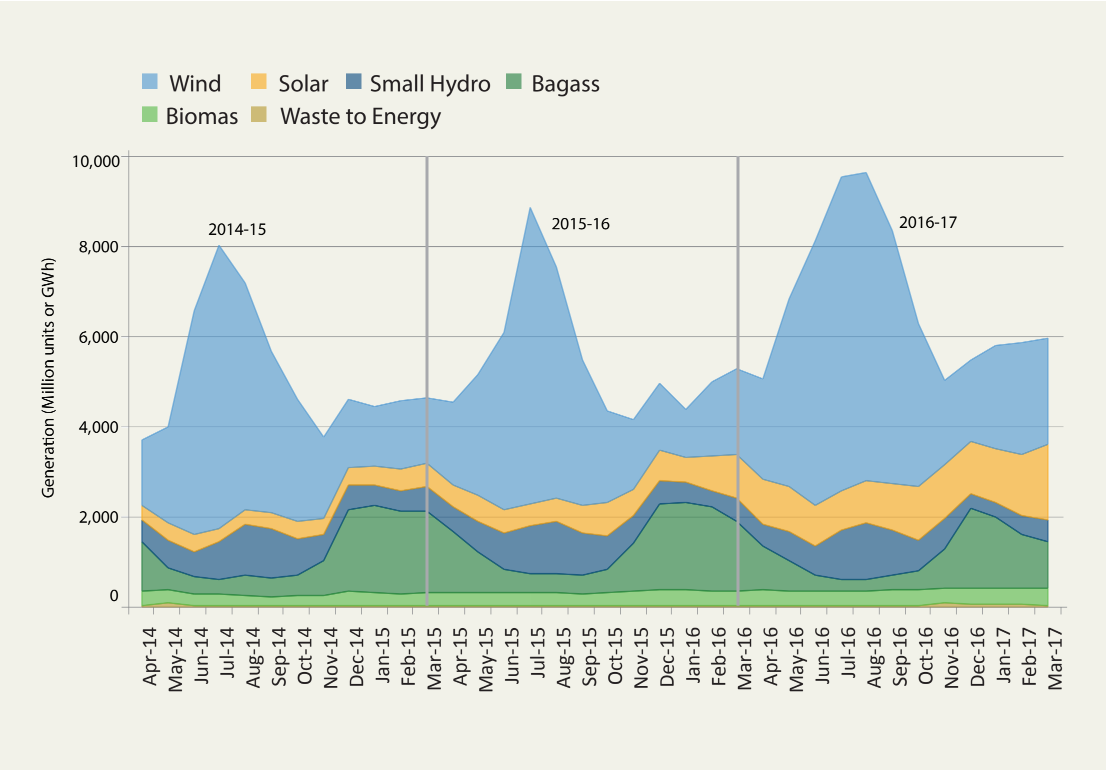


Source: Prayas (Energy Group) analysis based on various CEA and MNRE reports.

Note: The sudden jump in the share of RE in the system capacity is mainly due to an update in the bio-power data, from 5 GW to 8.1 GW at the end of March, 2017.

Figure 9 shows the month-wise and source-wise RE generation in the last three years (April 2014-March 2017). The monsoon linked seasonality of wind generation is obvious with peaks in the months of July and August. SHP and bagasse generation is also quite seasonal in nature, with SHP peaking during the monsoon months of July to October, while bagasse ramps up after the monsoon and from December to April. Year-on-year growth in biomass and SHP generation is marginal, given the negligible capacity addition from these sources. The fastest and largest growth is in solar generation, averaging nearly 72% per year over the last three years. This is expected to continue in the future reflecting the fast pace of deployment in the years to come. Unlike wind, solar generation drops during the monsoon months (June to August), due to the cloud cover. The peak monthly wind generation has grown from 6,272 MUs to 6,977 MUs over the three-year period, while the average annual growth rate was 16.7%. Figure 10 shows the month-wise share of renewable energy generated as a fraction of the total electricity generation (excluding captive plants). Conventional energy generation is the sum of generation from thermal, large hydro, and nuclear sources. The seasonal pattern of peaks and troughs is quite evident from figure 10. The high share of wind power (57% in 2016-17) in the total RE generation coupled with its seasonality ensures that the peak monthly contribution of RE occurs from July to August (9.2% in 2016-17). The months with the lowest share of RE generation are April and November (4.9% and 5.1% in 2016-17).

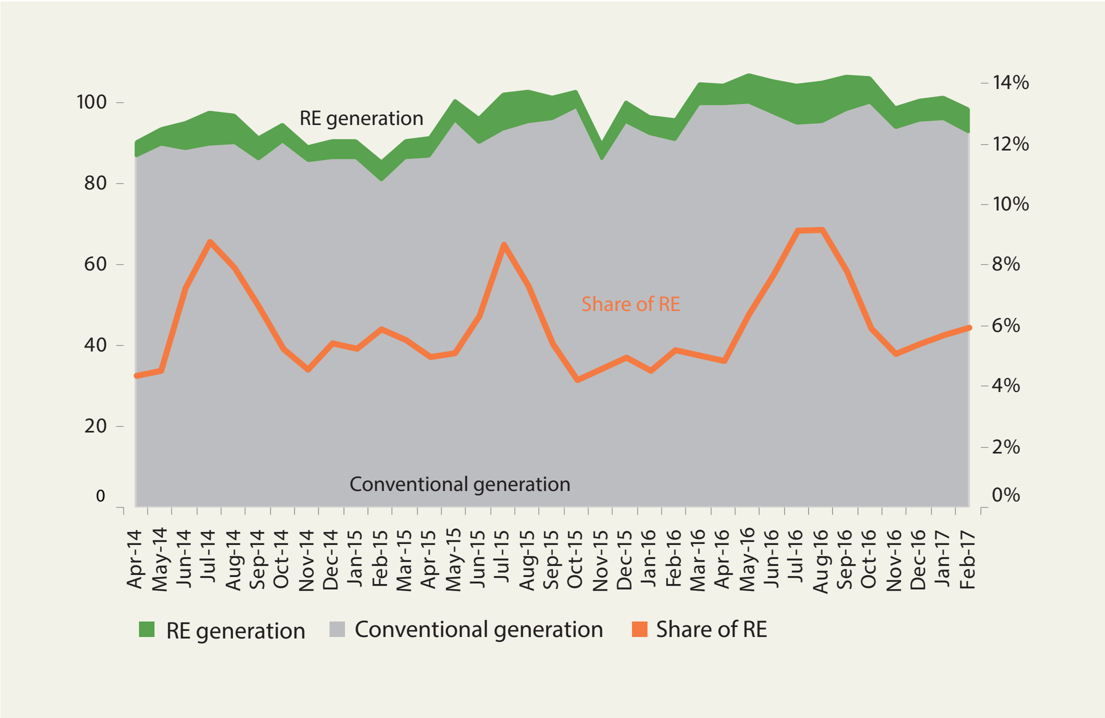
Figure 9: Monthly source-wise renewable energy generation from April 2014 to March 2017



Source: CEA.

Figure 11 shows the year-wise absolute RE generation and its share in total electricity supplied[5] in seven RE-rich states for 2014-2017. These states represent 79% of the total RE generation in 2016-17. The top three states in RE generation are Tamil Nadu (15.1 BU), Maharashtra (11.2 BU) and Karnataka (9.6 BU). With the exception of Karnataka, all states have shown growth in RE generation over the years. The highest growth over this time frame was seen in Madhya Pradesh (92%) followed by Andhra Pradesh (43%), while the lowest was seen in Karnataka (-0.5%). RE generation in Tamil Nadu experienced a 22% decline from 2014-15 to 2015-16 (thus reducing its share in total generation) but saw a surge the following year with a 62% increase.

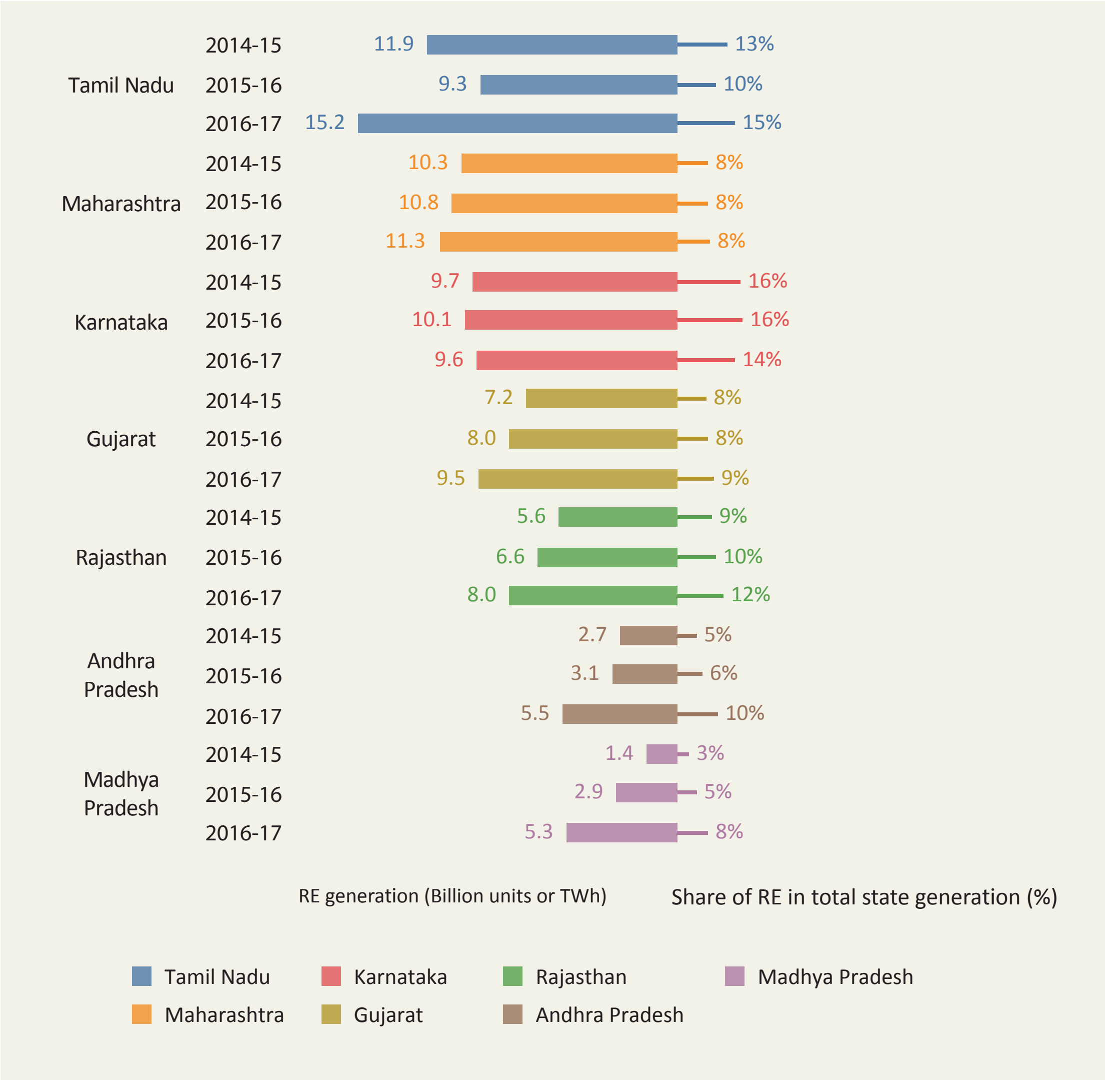
Figure 10: Month-wise share of RE generation in total from April 2014 to March 2017



Source: Prayas (Energy Group) analysis based on various CEA reports.

5. As per the power supply position data noted in the CEA monthly summary reports.

Figure 11: State-wise generation of RE electricity and share in total from 2014-15 to 2016-17 in select states



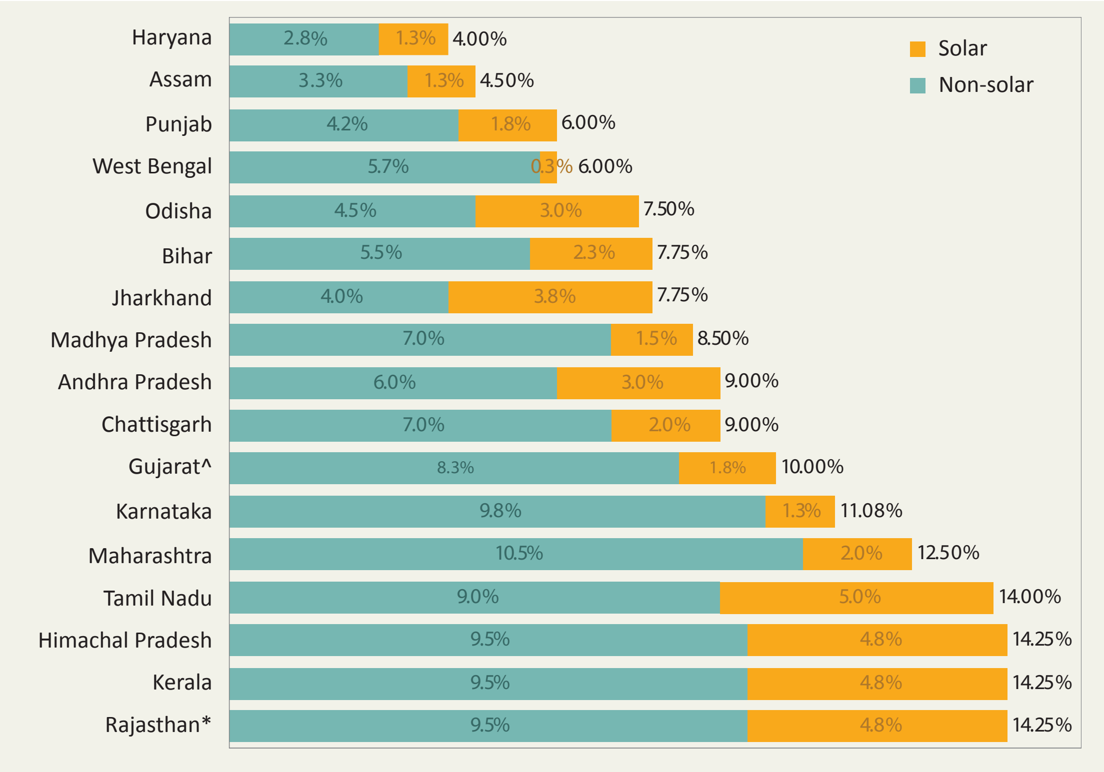
Source: Prayas (Energy Group) analysis based on various CEA reports.

5. RPOs and compliance

Renewable Purchase Obligations (RPOs) are minimum renewable energy targets which are specified in percentage terms in proportion to total electricity consumption. Such RPOs are applicable to three types of obligated entities which are DISCOMs, Open Access consumers and Captive consumers. The National Tariff Policy (NTP), 2016 amendment also made it clear that *'cogeneration from sources other than renewable sources shall not be excluded from the applicability of RPOs'* (MoP, 2016).

The State Electricity Regulatory Commissions (SERCs) are mandated to specify year-wise RPOs in accordance with section 86 (1) (e) of the Electricity Act, 2003. For the financial year 2017-18, the weighted average[6] of total (solar and non-solar) RPO targets of seventeen states is around 10.2%, considerably less than 14.25% as recommended by the Ministry of Power (MoP). This would translate to a total utility[7] renewable energy obligation of 94,763 MUs in 2017-18 in those seventeen states. The total electricity demand in these seventeen states in 2017-18 is likely to be 929 BUs (~75% of the total demand).

Figure 12: Solar and non-solar RPO targets for 2017-18 in seventeen states



Source: Prayas (Energy Group) compilation based on various ERC regulations.
Note: Rajasthan RPO target for 2017-18 is in draft stage. Data for Karnataka is an average for all DISCOMs. Gujarat RPO target for 2017-18 is assumed to be the same as 2016-17, since new targets have not yet been put in place.

6. Weighted by state-wise projected electricity consumption in 2017-18 as assessed by the CEA's Load Generation Balance Report (LGBR).

7. Utility demand as assessed by the CEA in the LGBR includes the Open Access demand but does not include captive demand.

The weighted average of non-solar RPOs of seventeen states for 2017-18 is 7.69%, implying a total utility non-solar energy obligation of 71,475 MUs in these seventeen states. Solar RPOs presently specified by SERCs are significantly lower than those expected under the MoP guidelines. Of the large states, only Rajasthan and Tamil Nadu have a sizeable solar RPO, at 4.75% and 5% respectively for 2017-18, while Gujarat is yet to specify an RPO for the same year (Figure 12). The weighted average of solar RPOs of seventeen states for 2017-18 is only 2.51%, implying a total utility solar energy obligation of 23,288 Mus in these seventeen states. This will need significant upward revision to come in line with the desired 6.75% by 2018-19 as per the MoP guidelines.

The NTP amendment in January 2016 stated that regulatory commissions should set solar RPOs so that they reach 8% of total consumption of energy, excluding hydro power, by March 2022. The MoP guidelines on RPOs issued in July 2016 (as expected under the tariff policy amendment) notified a long-term growth trajectory for RPOs so that they uniformly reach 10.25% (non-solar RPO) and 6.75% (solar RPO) by 2018-19. The MoP guideline states that, *"the obligation will be on total consumption of electricity by an obligated entity, excluding consumption met from hydro sources of power."* Table 3 lists the RPO targets for seventeen states. While, the states of Andhra Pradesh, Kerala, Madhya Pradesh, Chhattisgarh, Rajasthan, Himachal Pradesh and Uttarakhand initially proposed RPO targets in line with the MoP guidelines, only Himachal Pradesh has actually finalised the same trajectory as proposed. The final notified solar RPO targets for Andhra Pradesh, Madhya Pradesh and Chhattisgarh are actually much lower than the MoP guidelines. Kerala, Rajasthan and Uttarakhand RPO targets are still in the draft stage.

States with a high share of hydro in their total consumption will find it relatively easier to align themselves with the MoP guideline. Of the four states[8] which presently are aligned with the MoP guideline, three (Himachal Pradesh, Kerala and Uttarakhand) are having very high hydro consumption. Bihar is the only state to match the NTP guideline of 8% solar by 2022 (excluding hydro), however it has delayed the MoP guideline of 6.75% solar by 2018-19 to 2020-21. Andhra Pradesh's solar target of 7% by 2022 is just a shade lower than the MoP recommendation. However, since the RPO is defined as a percentage of total consumption (including hydro), it may turn out to be more than the 8% solar RPO (excluding hydro).

Apart from states not aligning with the MoP guidelines, there seems to be some lack of clarity in these two documents. While the NTP states that only solar RPO should be so defined as to exclude hydro power from the total consumption of energy, the MoP guideline suggests excluding hydro power from solar and non-solar RPO obligations. This divergence needs to be reconciled soon.

8. Of these states, all except Himachal Pradesh are still in draft stage.

Table 3: State-wise RPO targets for 2017-18 and beyond in comparison to MoP guidelines

Aligned with MoP guidelines	State	Definition of RPO is based on exclusion of hydro consumption	RPO targets (%)									
			2017-18		2018-19		2019-20		2020-21		2021-22	
			Solar	Non Solar	Solar	Non Solar	Solar	Non Solar	Solar	Non Solar	Solar	Non Solar
Yes	Himachal Pradesh	Yes	4.75	9.5	6.75	10.25						
	Kerala*	Yes	4.75	9.5	6.75	10.25						
	Rajasthan*	Yes	4.75	9.5	6.75	10.25						
	Uttarakhand*	Yes	4.75	9.5								
No	Andhra Pradesh	Yes	3	6	4	7	5	8	6	9	7	10
	Assam	No	1.25	4.5	1.5	5						
	Bihar	No currently (Yes, 2019-20 onwards)	2.25	7.75	3.25	9.25	4.75	11.5	6.75	14.25	8	17
	Chattisgarh	No	2	9	3.5	11	5	13	6.5	15		
	Gujarat^	No	1.75	8.25								
	Haryana	No	1.25	4	1.5	5	2	5.75	2.5	5.75	3	5.5
	Jharkhand	No	3.75	7.75	5.5	10	6.55	11.55				
	Karnataka	No	1.25	9.83	1.75	10.83	2.5	11.83				
	Madhya Pradesh	No	1.5	8.5	1.75	9.25						
	Maharashtra	No	2	12.5	2.75	13.75	3.5	15				
	Odisha	No	3	7.5	4.5	9.5	5.5	11.5				
	Tamil Nadu	No	5	9								
	West Bengal	No	0.3	5.7								

Source: Prayas (Energy Group) compilation based on various ERC regulations.

Note: * Respective state has proposed draft notifications, ^ Gujarat RPO same as for 2016-17.

Secondly, a 6.75% solar RPO by 2018-19 implies a 2% per year increase from 2016-17, while the 8% solar RPO by 2022 would imply only a 0.42% per year increase in the next three years (2019-2022). This would mean a significantly front-loaded solar deployment over the next five years, not completely in line with the year-wise targets set by the MNRE when the 175 GW target announcement was made. More so, the 8% solar RPO by 2022 (excluding hydro power) does not add up to the absolute target of 100 GW solar by 2022. As is clear from Table 4, an 8% solar RPO would imply only a 67 GW solar capacity if one were to consider the utility demand (excluding hydro) for 2021-22. It would rise to 78 GW if one were to add captive self-consumption to the utility demand. To meet the 100 GW target, the solar RPO in the NTP needs to be revised to 10.3% if one excludes hydropower from the total demand, or 9.3% if one includes hydropower in the total demand estimates.

Table 4: Solar RPOs and associated solar generation capacity by 2022

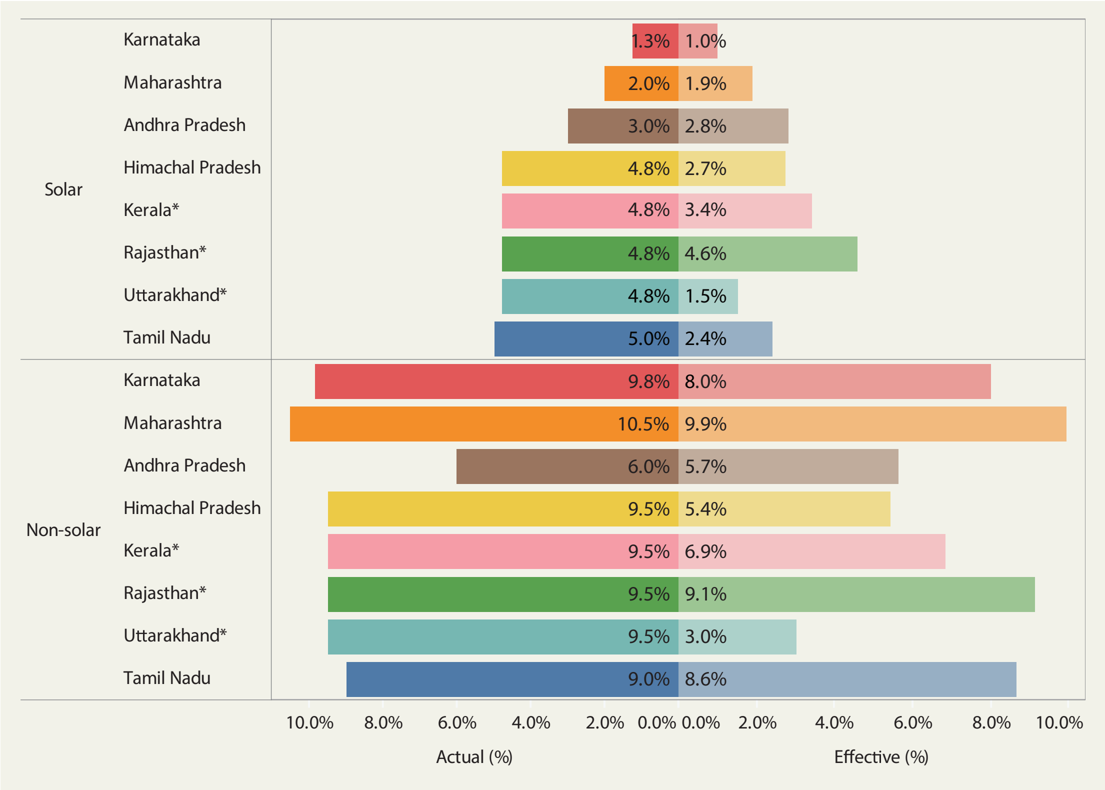
Description	Value	Units
Total utilities electricity demand in 2021-22 as per CEA's 19th EPS	1,566	BU
Total hydropower generation for 2021-22, estimated by PEG based on historical trends and additional 11.8 GW hydro addition from 2017-22, as per CEA's draft NEP	172	BU
Total demand excluding hydropower	1,394	BU
8% solar RPO; As recommended by NTP, 2016	112	BU
Solar capacity needed assuming 19% CUF	67	GW
Self-consumption of captive power in 2021-22; Estimated by PEG based on historical Captive Power Plant (CPP) generation and consumption trends from CEA's 19th EPS, assuming a 8% growth from 2014-15 to 2021-22	230	BU
Total demand excluding hydropower, but including captive self-consumption	1,624	BU
Solar capacity needed assuming 19% Capacity Utilisation Factor (CUF)	78	GW
Solar RPO (excluding hydropower from total consumption) needed by 2022 to match 100 GW target	10.3%	%
Solar RPO (including hydropower from total consumption) needed by 2022 to match 100 GW target	9.3%	%

Source: Prayas (Energy Group) analysis.

5.1 Actual and effective RPOs

Defining RPOs as percentages of demand, excluding hydropower consumption reduces the effective RPO percentage for the obligated entities by an amount proportional to the hydro consumption. Figure 13 illustrates the difference between the announced solar and non-solar RPO targets and the effective targets in different states. As expected, the difference in the actual and the effective target is more pronounced in the states with a significant quantum of hydro energy consumption. Figure 14 shows the implications of RPO targets defined in such a way, by comparing a high hydro consumption state like Himachal Pradesh and a state like Maharashtra with a comparatively lower share of hydro consumption. In 2016-17, Himachal Pradesh purchased a total of approximately 9,900 MUs , of which hydro contributed 4,403 MUs or 45% of the state's demand. In comparison, Maharashtra saw a total of 6% of the state's demand being met by hydro sources. The figure clearly shows the asymmetric fall in the effective RPO target in the case of Himachal Pradesh by a much greater rate than that of Maharashtra. Hence, hydro consumption rich states (like Himachal Pradesh, Kerala and Uttarakhand) will find it much easier to align themselves with the MoP guideline and puts these states in an advantageous position. As was noted in the earlier report, placing more variable solar generation in states with less hydro consumption makes renewable energy grid integration that much harder, as hydropower is one of the best balancing resources for short/medium term potential additional grid imbalance due to renewables.

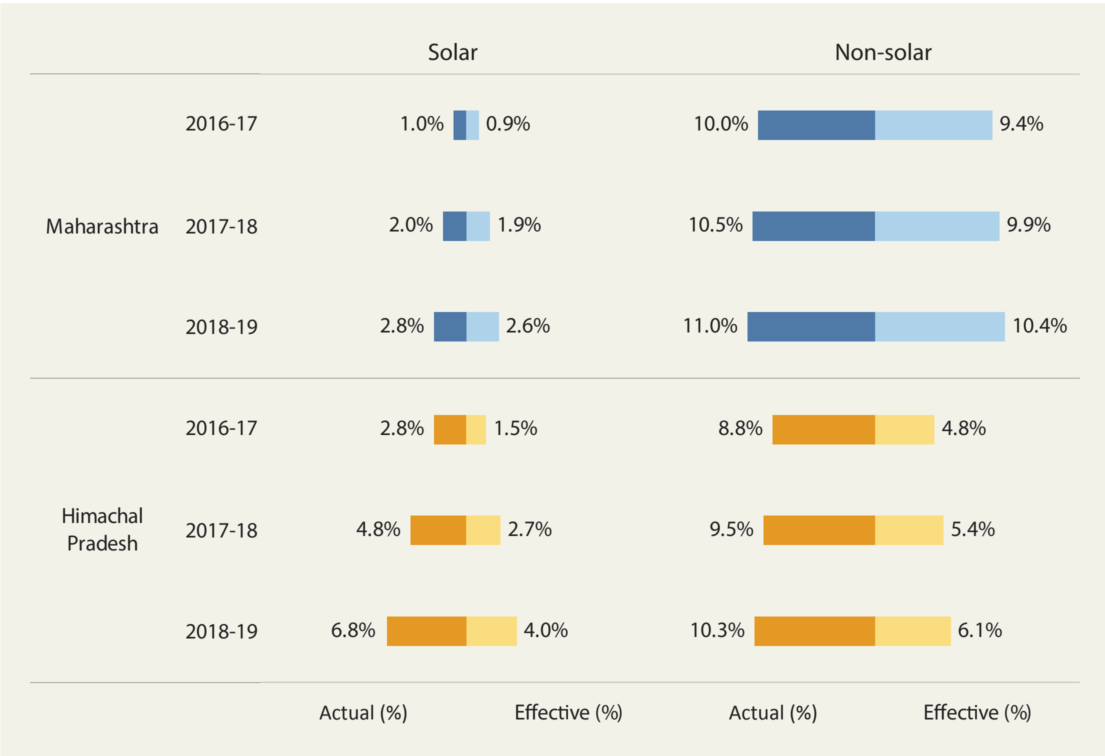
Figure 13: State-wise actual and effective solar and non-solar RPO targets in 2017-18



Source: Prayas (Energy Group) analysis based on state utility petitions and tariff orders.

Note: 1. * Respective state has proposed draft notifications 2. Karnataka data is the average RPO targets of all ESCOMs.

Figure 14: Effective and actual RPO targets in Himachal Pradesh, Maharashtra for 2016-19

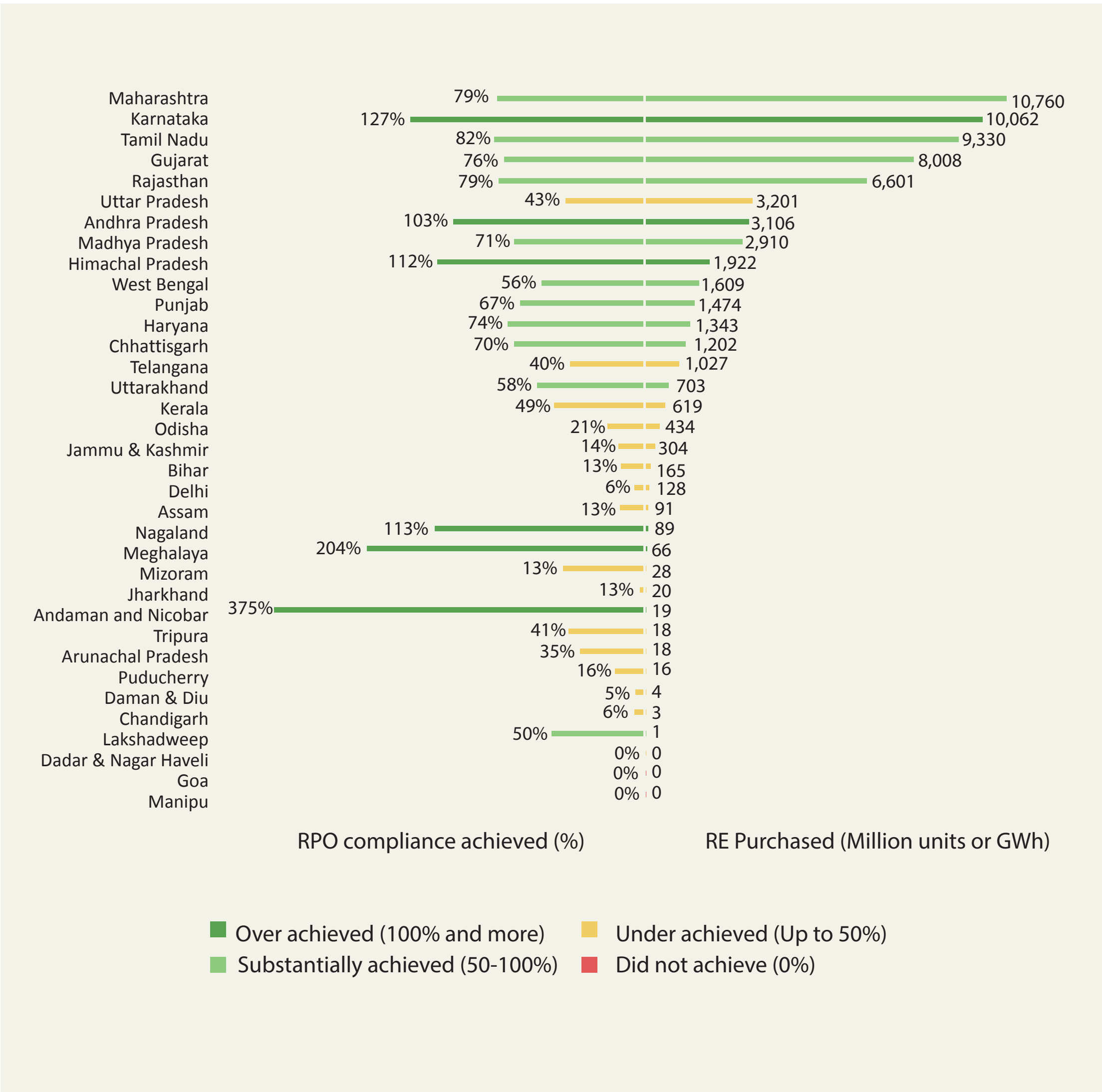


Source: Prayas (Energy Group) analysis based on DISCOM petitions and MERC/HPERC tariff orders.

5.2 RPO compliance

Monitoring and verification of RPO compliance remains a weak link in the renewable energy sector. Consolidated data on RPO compliance for all states and union territories for the year 2015-16 was recently published by the MNRE as part of the agenda note for the national review meeting of state principal secretaries and state nodal agencies of renewable energy held in January, 2017 (MNRE, 2017c, p. 69). Figure 15 illustrates that, of all the states, only a few have procured renewable energy over and above their RPO targets. Among all the five which indeed did over achieve, only Karnataka had a considerable quantum of RE procurement crossing 10,000 MUs, while the other states have a much lower absolute renewable energy target. The top five states in Figure 15 (Maharashtra, Karnataka, Tamil Nadu, Gujarat and Rajasthan) account for 69% of the total RE procurement, which adds up to nearly 45,000 MUs in 2015-16. Apart from Karnataka the other four have achieved an RPO compliance of ~80%.

Figure 15: State-wise RPO target and compliance for 2015-16

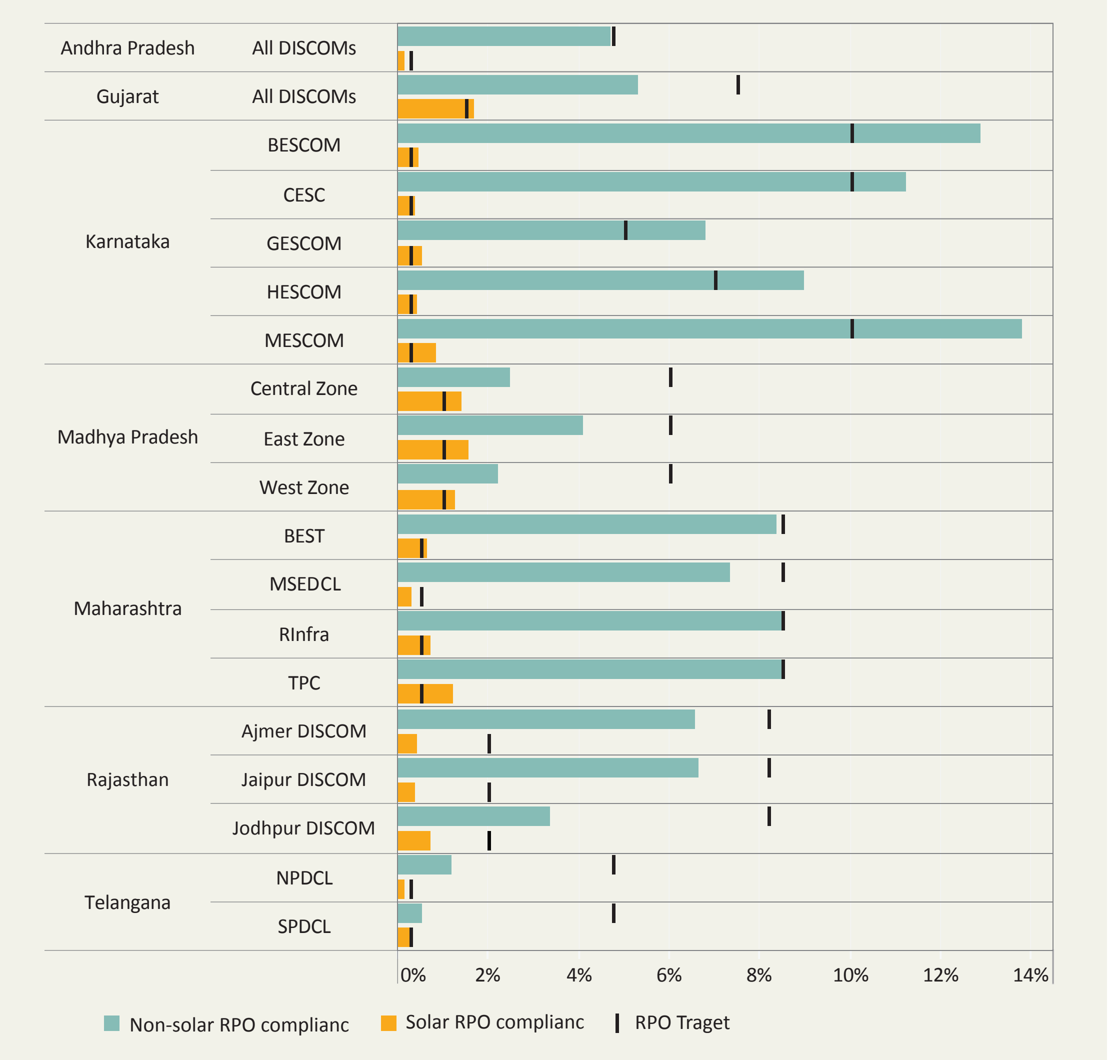


Source: MNRE (MNRE, 2017c, p. 69).
Note: For Gujarat the MNRE note seems to have considered the 2016-17 RPO as the one for 2015-16. Similarly for Tamil Nadu, the TNERC amendment on 7th March, 2016 has fixed the RPO at 9% and 0.5% for non-solar and solar respectively (TNERC, 2016).

While the above state level data is certainly useful, technically it is DISCOMs, CPP and OA consumers and not 'states' who are obligated entities when it comes to RPO compliance. It is unclear from the MNRE note whether the RPO compliance it reports is for the entire state (as an aggregate compliance for all DISCOMs, CPP and OA consumers) or only for state DISCOMs.

Figure 16 depicts the DISCOM's RPO compliance in seven large states for the year 2015-16. Karnataka DISCOMs stand out from the rest, considering their combined average solar plus non-solar RPO compliance of 131% of the target. All DISCOMs in Gujarat, Madhya Pradesh and the Telangana Southern Power Distribution Company Limited (TSSPDCL) while having achieved their solar targets, were unable to achieve their non-solar targets. Most DISCOMs from all states (except Karnataka and a few from Maharashtra) were unable to meet their non-solar RPOs, while Rajasthan is the only state in which none of the DISCOMs could achieve any of their RPO targets. Overall, there was a combined solar RPO and non-solar RPO compliance of 84% and 80% in these seven state DISCOMs. The total solar and non-solar non-compliance was 1,314 MUs (30% of target) and 8,887 MUs (24% of target), but this was offset by over-compliance by some states. It amounted to 609 MUs (14% of target) and 1,524 MUs (4% of target) in the case of solar and non-solar procurement respectively.

Figure 16: RPO compliance in 2015-16 by DISCOMs in seven states



Source: Prayas (Energy Group) analysis based on compilation from various petitions, regulations and tariff orders.

Note: For few states (Andhra Pradesh, Gujarat, Madhya Pradesh, Rajasthan and Telangana), we have estimated RPO compliance based on power procurement data. Karnataka data is from 2017 tariff orders as reported by the various DISCOMs. Our preliminary estimate for Tamil Nadu Generation and Distribution Company Limited (TANGEDCO) RPO compliance for 2015-16 is 5.38%. However we have not included our estimate in the above figure since there appears to be a considerable deviation between our and TANGEDCO's estimates on the RPO compliance data for previous years (2011-15). For more details on these deviations, please see Annexure 1.

The need and importance of granular and up-to-date renewable energy data with regard to generation capacity and actual electricity generation cannot be emphasised enough. A starting step in this regard initiated by the CEA which deserves appreciation is that it now publishes monthly, state-wise and resource-wise renewable energy generation data. At the same time, it is unclear whether rooftop solar generation and generation from older renewable energy projects connected to the 11kV or 33 kV grid (which at times is not monitored by the State Load Despatch Centres, SLDCs) is included in the total renewable energy generation data as reported by the CEA. The MoP and the CEA are taking steps to ensure better and faster data collection and have been pushing all SLDCs to set up state level generation capacity registries as well as communicating generation data in real time (CEA, 2017b). While this is a good beginning, there is still a long way to go in terms of ease in RPO compliance monitoring for which renewable energy procurement data by obligated entities would be needed.

RPO compliance for OA and CPP, a case of Maharashtra

While data on RPO compliance for DISCOMs across the countries is available to some extent, this is not true for other obligated entities like open access and captive power consumers. One of the exceptions to this near complete lack of data for the RPO compliance of OA/CPP consumers is Maharashtra. The State Nodal Agency responsible for tracking RPO compliance, the Maharashtra Energy Development Agency (MEDA) has been regularly publishing provisional data on RPO compliance for OA and CPP consumers. The MEDA has published combined data for the 2010-11 to 2013-14 period, since the Maharashtra Electricity Regulatory Commission (MERC) had allowed for cumulative RPO compliance for this four-year period. Data for 2014-15 has been published separately (MEDA, n.d.). For the 2010-11 to 2013-14 period, there were a total of 174 and 123 obligated open access and captive consumers, though only 84 and 9 of these reported their RPO compliance data to the MEDA respectively. 226 and 157 OA and CPP consumers were exempt from RPO obligation in this period. For 2014-15, 134 and 9 OA and CPP consumers reported their RPO compliance status respectively. Also, 23 and 62 OA and CPP consumers were exempt from RPO obligation respectively. Table 5 shows the solar and non-solar RPO compliance for OA and CPP consumers for these five years. As is clear from the data, compliance for solar and non-solar RPO has been very poor, significantly lower than the compliance levels of the DISCOMs in Maharashtra. This should alert the Electricity Regulatory Commissions (ERCs) to further strengthen the Monitoring and Verification (M&V) mechanism for RPO compliance for OA and CPP consumers, without which there would not be a level playing field with the DISCOMs. Without a penal mechanism, it seems unlikely that a large section of the obligated entities would strive for RPO compliance.

Looking at the year 2014-15, one sees a solar RPO compliance of 17.4% and 20.5% for CPP and OA consumers, while a non-solar RPO compliance of 28.2% and 19.3% for CPP and OA consumers respectively. However the breakup of the RPO compliance of the 9 and 127 obligated entities with data reporting is very stark. Of the 127 OA consumers, 78 have zero RPO compliance, while

39 have over 100% compliance. Similarly, of the 9 CPP consumers with data on RPO compliance, seven have only 9% RPO compliance while the remaining two have ~50% solar RPO compliance and 100% non-solar compliance. This shows the bi-modal behaviour (very low or near 100% compliance) of the obligated entities. For a detailed breakup of the OA and CPP consumers RPO compliance data, please see Annexure 2.

In terms of the implications of this level of RPO non-compliance for the Renewable Energy Certificate (REC) market, we see that the combined solar and non-solar obligation for OA and CPP consumers for the five year period was 73 and 1,486 MUs respectively. Solar and non-solar RPO compliance was only 10% and 22%, implying a huge potential of 65,847 and 1,15,3489 solar and non-solar RECs just from OA and CPP consumers in one large state.

Table 5: Solar and non-solar RPO compliance for OA and CPP obligated entities in Maharashtra from 2010-11 to 2014-15

Year	Type of obligated entity	No of Obligated entities	Average Size (MW)	Solar Target (MU)	Solar Procurement (MU)	Solar RECs	Solar RPO compliance	Non Solar Target (MU)	Non Solar Procurement (MU)	Non Solar RECs	Non Solar RPO compliance
2010-11 to 2013-14	CPP	9	31	10	0	0	0.0%	234	0	6	2.6%
	OA	90	11	37	0	2	5.5%	814	124	109	28.6%
2014-15	CPP	9	43	6	0	1	17.4%	100	0	28	28.2%
	OA	127	3	20	0	4	20.5%	338	4	61	19.3%

Source: MEDA.

Do we need separate solar and non-solar RPOs, indeed do we need RPOs at all going ahead?

The solar, non-solar RPO differentiation was institutionalised as part of the National Tariff Policy (NTP) amendment in January 2011, which required SERCs to fix a separate percentage for solar procurement. This was further adopted in the central regulatory process as part of the Renewable Energy Certificate (REC) Mechanism, which institutionalised separate solar and non-solar certificate categories from its inception. The logic behind this choice was fairly obvious. Solar tariffs were nearly three-four times the non-solar (wind, bio-power & SHP) tariffs during that time and unless a special dispensation was created for solar, no obligated entity would procure high cost solar power for a generic (non-resource specific) RPO obligation.

However, the scenario has changed dramatically in the last seven years. The lowest solar bid (₹ 2.44/kWh) presently is nearly one-third of the Central Electricity Regulatory Commission (CERC) notified feed-in tariffs for bio-power and nearly half the tariff for SHP. Similarly, the discovered tariff of wind power (₹ 3.46/kWh) is nearly half the bio-power tariffs and 50% lower than the SHP tariffs. Solar and wind power tariffs are expected to go down further in the coming years, while bio-power and SHP tariffs seem to be stable or going up slowly. Hence the price differentiation will only get more pronounced with time. Given this likely scenario, the erstwhile need to differentiate between solar and non-solar categories has vanished.

A greater focus on the RE purchases irrespective of the source could replace the existent distinguishing solar and non-solar RPOs. This would ensure that obligated entities are able to procure the cheapest form of renewables, subject to technical grid constraints and after considering the system value (distance from transmission lines, contribution to peak demand, etc.) of those renewable energy projects beyond mere generation price, further promoting a competitive spirit in the sector.

Moving beyond Renewable Purchase Obligations (RPOs) in the medium term

The need for separate RE targets (RPOs) arises as long as there is a lack of a level playing field for renewables (i.e. the cost of socio-environmental externalities of conventional power is not internalised), or till such time as there continues to be a direct price differential between RE and conventional power. One way to internalise certain externalities is to mandate stringent and time bound environmental norms (water use, air quality, etc.) for conventional power which can be further tightened over time. Such an effort has been started by the Ministry of Environment, Forest and Climate Change (MoEFCC) with regard to coal power. Another is to have an environmental tax, such as the coal cess, which now stands at ₹ 400/ton since 2016-17.

In parallel, RE prices (especially for solar PV and wind) have come down drastically, and there is an expectation of further reductions in the future. The latest solar bid (₹ 2.44/kWh) is already significantly below the cost of new coal power (₹ 4-5/kWh) and even below the cost of older depreciated conventional power plants in many cases. Hence, in the medium term, as RE and conventional power prices begin to converge, policy and regulatory officials as well as DISCOMs should begin to include renewables as an integral part of the least-cost planning exercise rather than continue with separate targets. Obviously any change in the RPO policy should be done gradually with a clear timeline for phasing it out. If solar and wind prices continue their downfall, this could actually mean far more RE procurement (to ensure least-cost) than the current or even near-future RPOs. This is especially true if open access procurement is truly streamlined while removing procedural obstacles and providing long term certainty on cross subsidy surcharge.

Obviously, RE procurement would be subject to technical grid constraints, after considering the system value (distance from transmission lines, contribution to peak demand, etc.) of the renewable energy to be procured. However, it should also consider any added differential in system integration costs (e.g. higher balancing costs) arising due to RE. Estimating and attributing such RE specific integration costs is not an easy exercise. This is especially true of the relatively weak India grid which is seeing several grid strengthening initiatives underway for effective, reliable and secure operation of the grid, which are needed irrespective of whether the grid has a high penetration of variable renewables like wind and solar or not. However, these will also help ease the integration of renewables into the grid. While calculating differential in integrating costs arising due to RE, one needs to keep in mind that the assumptions for grid reliability and functioning should be normalised in both cases.

The MNRE, MoP and the Forum of Regulators (FoR) should initiate a discussion on the above issues, namely the continued need for RPOs in the medium term (when RE prices will go below that of coal power and if and when open access procurement is truly streamlined) and the need for the continued distinction between solar and non-solar RPOs/RECs, and the possible fundamental regulatory changes needed to keep the RPO/REC framework relevant and effective if needed in the future.

6. Rooftop PV

The MNRE introduced the 'Grid Connected Rooftop and Small Solar Power Plants Programme' in 2014, which initiated the move towards battery free grid connected rooftop solar PV systems in India. This was followed by the announcement of earmarking 40 GW of the 100 GW solar target by 2022 for this sub-sector in 2015. The sector has come a long way since then. Latest market estimates suggest that the country has achieved only 1.4 GW (3% of the 2022 target) of cumulative capacity as of 31st March, 2017 (Bridge to India, 2017b). However latest official data from the MNRE suggests that the rooftop solar capacity in the country stands at 503 MW as of December, 2016 (see Table 6). This discrepancy between official data and market estimates was highlighted in our previous report as well and continues to create some level of confusion over actual deployment. It is imperative that the MNRE bring clarity on this issue as it is critical for planning future annual and state-wise targets.

Table 6: Rooftop Solar PV installations across states: Targets and achievements as of 31st December, 2016

Sr. No.	States /UTs	Target Total (MWp) by Year 2022	Approval / Sanction (MWp)	Installation (Including Installation by SECI) (MWp)
1	Andhra Pradesh	2,000	40	13
2	Bihar	1,000		1
3	Chhattisgarh	700	11	23
4	Delhi	1,100	92	36
5	Gujarat	3,200	62	49
6	Haryana	1,600	75	37
7	Himachal Pradesh	320	10	0
8	Jammu & Kashmir	450	7	1
9	Jharkhand	800	55	4
10	Karnataka	2,300	11	38
11	Kerala	800	15	4
12	Madhya Pradesh	2,200	115	5
13	Maharashtra	4,700	100	51
14	Odisha	1,000	4	2
15	Punjab	2,000	25	45
16	Rajasthan	2,300	31	19
17	Tamil Nadu	3,500	312	84
18	Telangana	2,000	74	19
19	Uttarakhand	350	51	8
20	Uttar Pradesh	4,300	7	24
21	West Bengal	2,100	7	12
22	Others	1,280	56	14
A	Total	40,000	1,160	491
B	SECI*		900	84

	Railways	503	4
C	PSUs /Govt. Depts.	482	11
	Total	3,044	506

Source: MNRE Agenda Note prepared for for National Review Meeting of State Principal Secretaries and State Nodal Agencies of Renewable Energy, 23rd and 24th January, 2017.
Note: * Capacity installed by SECI included in state-wise list.

Achievement Linked Incentive Scheme for government departments

To encourage central and state government ministries/departments and Public Sector Undertakings (PSUs) to adopt rooftop solar systems in a large way, the MNRE came up with an Achievement-Linked Incentive Scheme in 2016. Instead of paying upfront capital subsidy as it did for residential and other eligible consumers, the MNRE would fix a yearly target for interested departments/PSUs. based on their assessment of rooftop potential and financial savings. General category states would be entitled to an incentive of ₹ 18,750/kW if they achieved 80% or more of their yearly target. Special category states had a much higher incentive of ₹ 45,000/kW for 80% or more achievement. Incentives would be lower for lower achievement. For more details, please see (MNRE, 2016b).

This scheme was amended in March, 2017 with a slightly different categorisation of incentives as noted in Table 7 (MNRE, 2017e). The incentive provision has been slightly reduced (13%) and is now available as a percentage of the cost discovered through bidding under the Capital Expenditure (CAPEX) (self-ownership) model or as a percentage of the cost discovered through reverse bidding under the Renewable Energy Service Company (RESCO) (third-party ownership) model. The linking of the incentive to the cost discovered through competitive bidding is a major change compared to the 2016 scheme. The amendment has also stated timelines for project completion and release of the incentives to keep the installation plans across states in track. This scheme has the potential to quickly unlock the near 6 GW potential as assessed for government ministries/departments buildings and surplus areas available to them.

Table 7: Incentive provisions and availability under CAPEX and RESCO models under the Achievement Linked Incentive Scheme for rooftop solar for govt. entities

No.		Incentive for general category states/ UTs			Incentive for special category states/ UTs/Islands		
	Achievement within the sanctioned period vis-à-vis target	Provision (Rs/kW)	Percentage of benchmark cost or cost discovered through bidding, whichever is lower to be released under CAPEX model	Percentage of benchmark cost to be released under RESCO model	Provision (Rs/kW)	Percentage of benchmark cost or cost discovered through bidding, whichever is lower to be released under CAPEX model	Percentage of benchmark cost to be released under RESCO model
1	80% and above	16,250	25%		39,000	60%	
2	50% – 80%	9,750	15%	25%	23,400	36%	60%
3	40% – 50%	6,500	10%		15,600	24%	
4	below 40%	0			0		

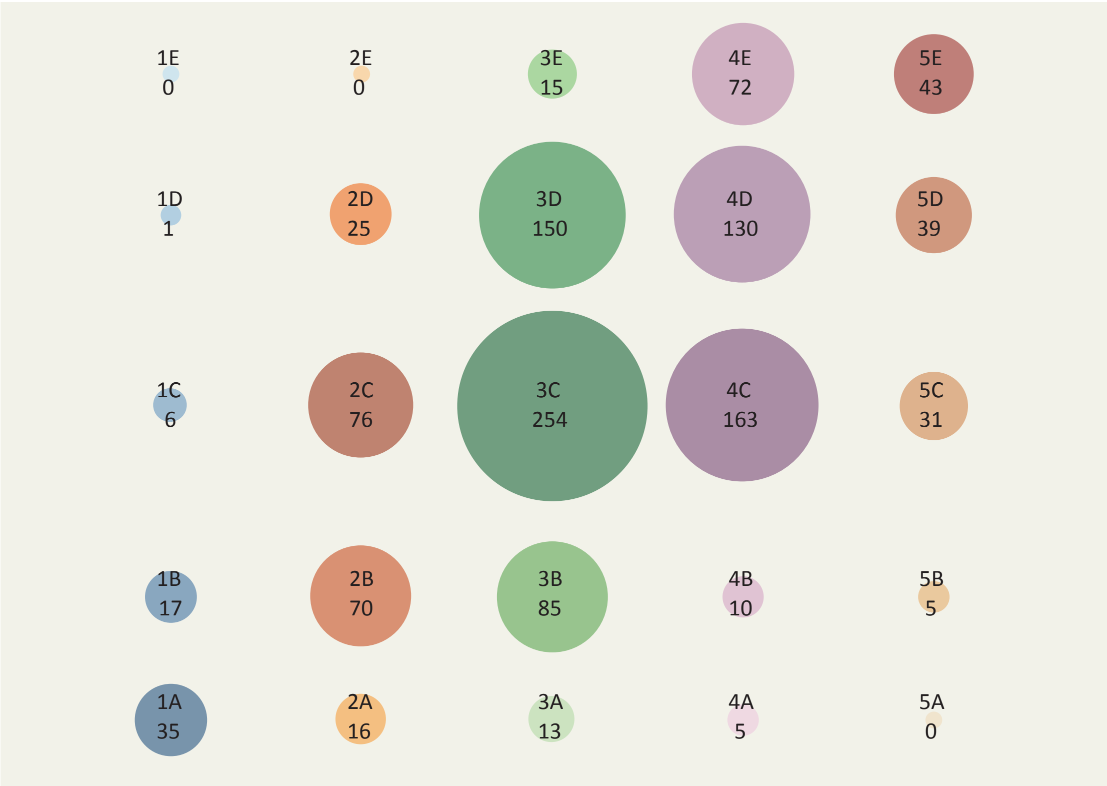
Source: MNRE.

Tools to ease rooftop solar adoption

In mid-2016, an online portal known as SPIN was launched as an e-governance initiative of the MNRE. It allows for online applications and accreditation and empanelment of channel partners (developers). Only such empanelled partners of the MNRE can avail the capital subsidy from the MNRE. Channel partners are also mandated to geo-tag their installations with relevant details and photos, which can be viewed online on a map (MNRE, n.d.a). This allows for regular and faster monitoring of deployment and subsidy usage. The SPIN portal now lists more than twelve hundred channel partners including RESCO model developers (MNRE, n.d.b). As of 1st June, 2017, the portal listed 1,262 channel partners, not including the around 700 channel partners who were new entrepreneurs.

Figure 17 shows the breakup of these 1,262 agencies empanelled with the MNRE as per their agency rating on financial and technical criteria. Technical and financial capabilities are assessed on a scale of 1 to 5 and A to E respectively, with 1 and A being the highest rating. Out of the total 1262 empanelled agencies, 3C to 3D and 4C to 4D (those with moderate technical and financial capabilities) have the largest share in the total at 32% and 23% respectively. The highest rating of 1A was achieved by 35 agencies (3%) while the second highest ratings of 1B and 2A was achieved by 17 (1.3%) and 16 (1.3%) agencies respectively. Apart from the agency rating, the MNRE is also going to conduct a regular performance and progress review[9] of these channel partners and assign them a final MNRE rating. This systematic rating and empanelment effort by the MNRE is very useful for potential customers. For more information on these aspects, please see (MNRE, 2016d).

Figure 17: Categorisation of MNRE empanelled channel partners as per their agency rating



Source: Prayas (Energy Group) analysis based on MNRE's SPIN Portal (MNRE, n.d.e).

9. Recently MNRE de-empanelled 71 agencies for not filling the details of rooftop installations on the portal. Such actions will ensure seriousness on part of the channel partners.

In addition to information on channel partners, the portal has a simple solar rooftop financial savings calculator as well as an installation interest form for potential customers (MNRE, n.d.c) (MNRE, n.d.d). The calculator allows interested customers to get a rough idea of the financial viability of installing solar rooftop systems. If they realise the financial benefit of going solar, they can fill in the interest form with details of their roof and electricity tariffs. This information would be then shared with empanelled channel partners who would contact the interested customer for taking the process forward. To further ease these two processes, a mobile application called the Atal Rooftop Solar User Navigator (ARUN) application was launched in January, 2017 with the same goals in mind. Apart from the financial calculator and interest form, the app also provides information on solar basics, installation guidelines, schemes and policies, and a list of empanelled partners (MNRE, 2017g).

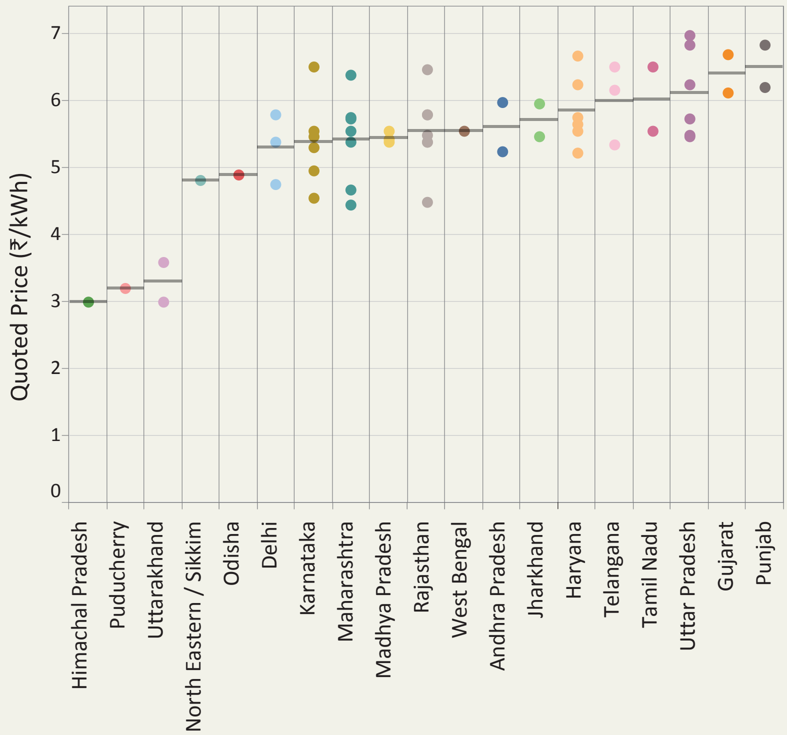
While the original rooftop and utility scale solar target for 2017-18 was 5 GW and 10 GW respectively, the latest information from the MNRE suggests only a 10 GW solar target for 2017-18. It is unclear whether the 10 GW is inclusive of the rooftop target or not. In any case market estimates have put yearly rooftop solar addition at ~1 GW in 2017-18, reaching a cumulative deployment of 13.2 GW by March 2021 (Bridge to India, 2017a). This is significantly lower than what is required to reach 40 GW by 2022. A revision in the rooftop target may be needed very soon.

6.1 Rooftop solar prices and viability

6.1.1 Rooftop solar prices

The MNRE has recently revised its benchmark cost for rooftop solar PV from ₹ 75/Wp to a lower value depending on the size of the project (MNRE, 2016c). For 2017-18, the benchmark price is now ₹ 70/Wp, ₹ 65/Wp and ₹ 60/Wp for system sizes up to 10 kW, 10–100 kW and 100–500 kW respectively (MNRE, 2017d). The last large scale (500 MW) bidding for rooftop solar conducted by the SECI for deployment across states is the most recent publicly available price benchmark to compare with the benchmark prices. Figure 18 illustrates the winning price bids in different states for SECI's 500 MW rooftop tender under the RESCO model. These bids are inclusive of the capital subsidy of 30% of benchmark cost (₹ 22.5/Wp) in the general category states and 70% of benchmark cost (₹ 52.5/Wp) for special category states. As expected, the lowest bids are for special category states, at ₹ 3/kWh (Himachal Pradesh, Uttarakhand) and ₹ 3.2/kWh (Puducherry). For general category states, the average winning bids range from just below ₹ 5/kWh in Odisha to ₹ 6.5/kWh in Punjab. For most states, the winning bids are in the ₹ 5–6/kWh range. Among all the states that have more than five participants, Karnataka has the lowest average price, at ₹ 5.39/kWh. The lowest bid amongst all general category states was in Rajasthan at ₹ 4.5/kWh. The various colours in the graph denote the different bids in those states.

Figure 18: State-wise winning bids for SECI's 500 MW rooftop tender



Average price (₹/kWh)	
Punjab	6.5
Gujarat	6.4
Uttar Pradesh	6.1
Tamil Nadu	6.0
Telangana	6.0
Haryana	5.9
Jharkhand	5.7
Andhra Pradesh	5.6
West Bengal	5.6
Rajasthan	5.5
Madhya Pradesh	5.5
Maharashtra	5.4
Karnataka	5.4
Delhi	5.3
Odisha	4.9
North Eastern / Sikkim	4.8
Uttarakhand	3.3
Puducherry	3.2
Himachal Pradesh	3.0

Source: SECI; the various colours denote the different bids in those states.

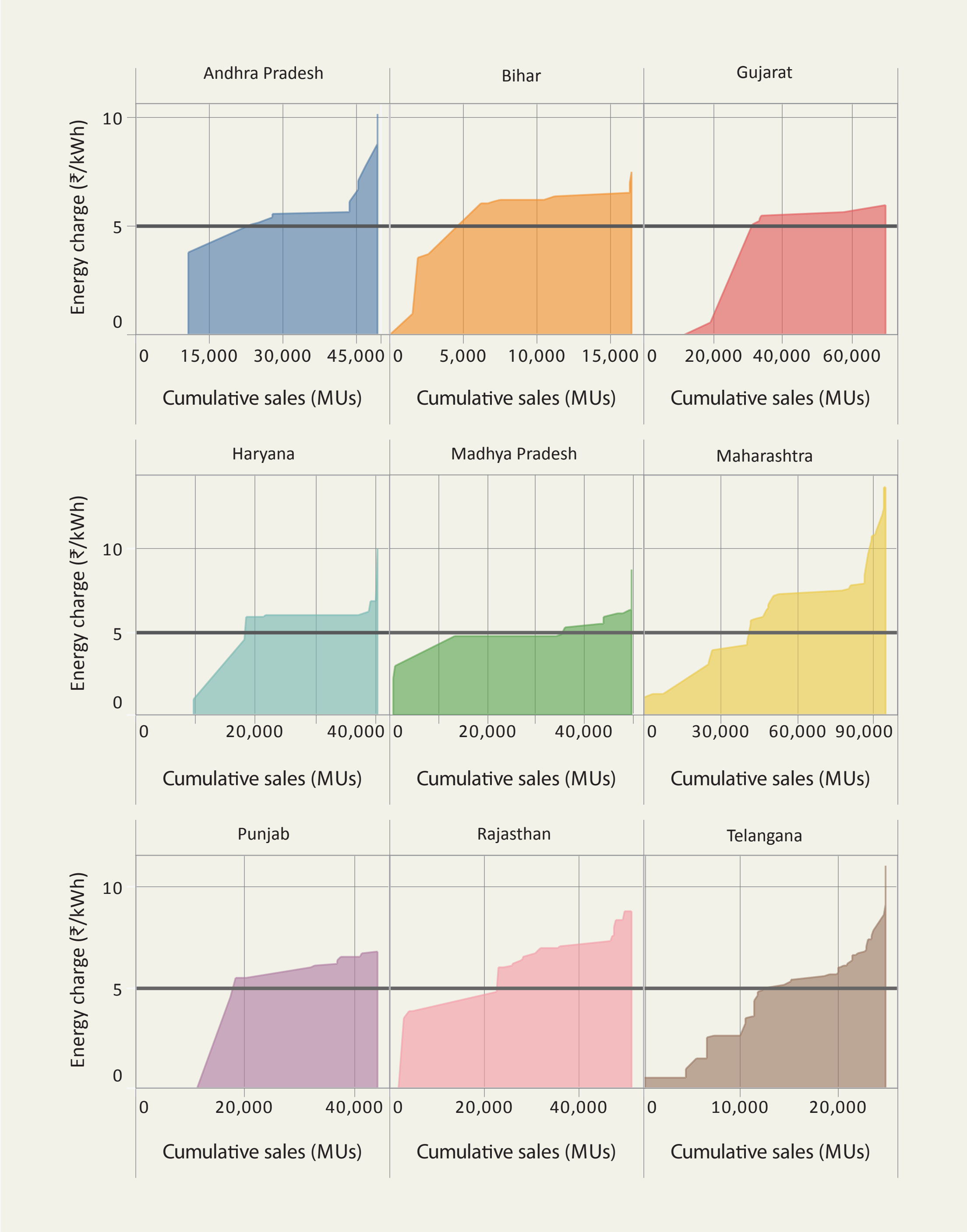
Apart from the RESCO model bids, bids for CAPEX projects were obtained for two types of project sizes, up to 25 kW and 25–500 kW. For projects up to 25 kW, average winning bids were from ₹ 65/Wp to ₹ 75/Wp, while the actual range was ₹ 57–75/Wp. For projects with size 25–500 kW, average winning bids were much lower, from ₹ 60/Wp to ₹ 75/Wp, while the actual range was ₹ 53–75/Wp. These do not include the capital subsidies available for certain consumers. For more details on the CAPEX bids, please see Annexure 3.

6.1.2 Viability of rooftop in various states

page 559 plots the cumulative electricity sales (x axis) in nine states corresponding to their variable energy charges[10] (y axis). It essentially shows the utility wide potential for customers to move cost effectively to rooftop solar PV partly or completely. Table 8 shows that if one assumes a rooftop solar price of ₹ 5/kWh, most states have more than 50% of their non-agricultural sales above this reference price. In five of the nine states, more than 70% of non-agricultural sales are above the reference price. This is true not only for industrialised states like Maharashtra and Gujarat but also for states with high shares of agriculture like Punjab and Haryana and also for relatively under-developed states like Bihar. Since solar PV prices are only expected to go further down, while DISCOM variable charges are more likely to go up, this situation seems to be only getting financially more viable for customers and in the process worse off for the DISCOM. While the potential for cost-effective sales migration through rooftop solar combined with net-metering is very high, the practical limiting factor may be the availability of shadow-free roof space or vacant space in the premises.

10. This is not the total avoided variable cost since it does not include Fuel Adjustment Cost (FAC) and Electricity Duty. Only in the case of Gujarat DISCOMs, we have included the base FAC.

Figure 19: Potential state utility sales with tariffs above rooftop solar costs



Source: Prayas (Energy Group) analysis based on regulatory tariff orders.
Note: Above data is for all public DISCOMs in those states. It does not include private DISCOMs in Maharashtra and Gujarat.

Table 8: Non-agricultural sales with variable cost more than ₹ 5/kWh in few states

State	Sales in MUs with variable tariff > Rs 5/kWh	% of non-agriculture sales with variable tariff > Rs 5/kWh
Maharashtra	52,485	75%
Punjab	26,403	80%
Madhya Pradesh	14,294	49%
Haryana	22,061	72%
Rajasthan	28,625	91%
Andhra Pradesh	25,906	67%
Telangana	12,602	61%
Gujarat	40,774	68%
Bihar	12,114	77%

Source: Prayas (Energy Group) analysis based on regulatory tariff orders.

Performance-based Incentive for DISCOMs

DISCOMs play an important role in the deployment of net-metering based rooftop solar PV systems. Since they have to provide prior approvals for setting up such systems based on certain technical criteria, they provide balancing power and energy banking services avoiding the cost of the battery for consumers. Hence for the success of the rooftop program it is essential that DISCOMs become key drivers of this process in letter and spirit and not passive indirect participants. To partly compensate for the loss of revenue from loss of sales and to compensate for the additional costs incurred for various activities and processes for net-metering, the MNRE has proposed a performance enabling financial support to accelerate deployment of rooftop solar systems within their distribution area. Such a Performance Based Incentive would be in the form of a grant up to a maximum of ₹ 37.5 lakh/MW of installed rooftop solar capacity. The MNRE has earmarked a financial support for 1,350 MW in total. The focus of the scheme will be on outcomes and performance improvements of DISCOMs through various reforms. Amongst other things, the scheme intends to *'support the DISCOMs to assess upgradation and modernisation requirements of their distribution network, facilitate demand aggregation, develop consumer awareness, develop enabling forms/processes, meter/equipment procurement, capacity development, etc.'*

To be eligible for the incentive, the DISCOMs must have regulations in place for deployment of rooftop solar systems, a well-defined and functional implementation process for rooftop solar and a dedicated Rooftop Solar Cell headed by an officer of Chief/Superintending Engineer rank. The details to be followed by the utilities are illustrated in Annexure 4. For more information on the scheme, please go through the scheme document (MNRE, 2016e).

Although the proposal has been welcomed in various quarters of the sector, some experts have stated that the financial incentive may not be a substantial amount (especially in comparison to loss of revenue) that can urge DISCOMs to become key drivers of the programme, especially as the performance indicators and eligibility criteria are extremely stringent.

6.2 Net-metering

Net-metering regulations have now been issued by all twenty-nine states and seven union territories in the country. A detailed comparison of these regulations can be accessed (Table 7) from the earlier report (Prayas (Energy Group), 2016a, p. 29).

Few states have made minor amendments in their regulations in the last few months. Most notably, though only for residential consumers, Gujarat has completely done away with the restrictive project capacity limitation, which was earlier set at less than 50% of the sanctioned load (GERC, 2017b). Assam too has relaxed its maximum project capacity from 40% of contract demand to 80% as per its draft amendment to its regulations. While it has relaxed this condition, it has introduced a much more onerous one, limiting solar rooftop deployment to only 20% of peak capacity of the distribution transformer (AERC, 2017). Maharashtra, in its first draft amendment to the net-metering regulations, has proposed to widen the scope of applicability of the regulations to all renewable energy sources including hybrid systems (MERC, 2017c).

Two states, namely Karnataka and Telangana have come out with new regulations for rooftop solar PV. Karnataka notified the Karnataka Electricity Regulatory Commission (KERC) (Implementation of solar rooftop PV plants) regulations in December 2016 and which jointly cover gross and net-metering frameworks[11]. The maximum solar capacity allowed to be connected to a distribution transformer is 80% of its rated capacity. However, only plants with size less than 50 kW are allowed for such inter-connections. All plants >50 kW have to connect only to the 11 kV system, and the total capacity in this case is restricted to 80% of the rated current capacity of that line. In another departure from usual net-metering norms, excess injection of solar power is not allowed to be carried forward to the next month. Rather, it would be compensated by the licensee at the tariff rate agreed to in the PPA (KERC, 2016b).

Telangana notified the Telangana State Electricity Regulatory Commission (Net Metering Rooftop Solar PV Grid Interactive Systems) Regulation, 2016 in November 2016. The maximum solar capacity allowed to be connected to a distribution transformer is 50% of its rated capacity and shall also not exceed 50% of the maximum load permitted on that particular feeder. All systems above a size of 75 kW are only allowed to connect to the high tension (HT) network, namely 11 kV or 33 kV, and would need to obtain a safety certificate from the Chief Electrical Inspector to the Government (CEIG). While residential consumers can size the solar system up to a maximum of 100% of their sanctioned load, industrial, commercial and other consumers are restricted to 80% of their sanctioned load / contracted demand. Finally the regulations stipulate that any unadjusted net credited units of electricity shall be settled by the licensee twice in a year, in June and December, and will be settled at its average cost of power purchase as approved by the commission for that year (TSERC, 2016).

Implementation issues

While regulations have been in place for some time now, implementation has been very sluggish, as attested by a recent survey of industry stakeholders done by the solar consultancy, Bridge to India (Bridge to India, 2016). Prayas (Energy Group's) informal interaction with various stakeholders in the rooftop solar sector in Maharashtra confirms this, though there could be variation across the state. As net-metering based systems are being implemented in the state, a number of implementation hurdles are becoming obvious. Some of these are listed below.

11. The Uttar Pradesh and Telangana rooftop solar regulations also cover gross and net-metering.

1. There is significant lack of capacity and training of field officers with regard to net-metering resulting in delays for processing and sanctioning applications. In addition, there is variation in operating practices for net-metering implementation across DISCOM circles. One example is the location where the solar rooftop output should be connected to the LT bus bar in case the building has a back-up diesel generation capability. Ideally, one would expect the solar output to be connected to the consumer's LT panel after the DG's changeover switch but before the load. This would allow solar generation to continue with the help of the DG's reference voltage when the DISCOM grid fails. Developers have pointed out that different DISCOM circles are presently adopting different practices in this regard.
2. The government of Maharashtra has also imposed electricity duty on power from renewable energy if supplied to other persons. This significantly reduces the viability of rooftop projects under the third party ownership RESCO model (MSEDCL, 2016). Also this is in stark contrast to some other states like Rajasthan which have waived off the electricity duty for rooftop solar projects (RERC, 2016).
3. Electrical inspector's permission: The notification issued by the Government of Maharashtra on 4^{th} February, 2016 states that *'the generating units having capacity to produce electricity above 200 kW from renewable or conventional sources of energy will be required to be inspected by the electrical inspector before commissioning of the unit'.* In practice however, customers having a solar rooftop system size < 200 kW are also made to seek the electrical inspector's sanction.
4. Present MERC regulations (clause 7.6) require the DISCOM to install a solar energy meter at its own cost if it desires that the solar generation be counted towards its RPO. In practice, the Maharashtra State Electricity Distribution Company Limited (MSEDCL) has been asking non-RPO obligated entities to procure the solar generation meters at their own cost.
5. Another practical implementation hurdle has been the need for a single solar energy metering point for projects which are scattered across various buildings, especially on large campuses. This necessitates significant additional wiring costs in case the buildings are far away from each other.
6. Some other issues include lack of adequate testing facilities for 0.2 S class CTs, non-clarity on whether net-metering is allowed for Open Access consumers, and the insistence of MSEDCL to locate the solar energy meter next to the net meter, which can cause high line losses if the distance between the net meter and the LT bus bar where the solar output is connected is long.

   Such issues significantly increase transaction costs and increase the time taken for deployment of rooftop systems. Unless there is significant improvement in the DISCOM capacity and processes related to net-metering to enable a much smoother consumer experience, adoption of rooftop solar systems will be much slower than official targets.

7. Pricing and tariffs

2017 has been a turning point for wind power and solar PV prices. First, bids for 500 MWs of solar PV, in the second phase of the Bhadla Solar Park discovered a record low price of ₹ 2.44/kWh, levelised and fixed over 25 years (SECI, 2017a). Similarly, in a first ever competitive bidding based price discovery of wind power for procurement by DISCOMs emerged a new low for wind prices, i.e. ₹ 3.46/kWh, much lower than the feed-in tariffs that were set by the Regulatory Commissions (SECI, 2017b). These price discoveries underscore the price-competitiveness of renewable energy, especially when contrasted with new coal capacity contracted recently by various DISCOMs which has a price range of ₹ 4-5/kWh. It is important to note that the above prices of wind and solar power are only reflective of direct costs, without valuing its various other benefits in terms of minimal environmental externalities, enhanced energy security, low price volatility due to the nature of fixed long term price contracts, etc. So it now appears that RE generation prices[12] (in simple per kWh terms) are no longer a hurdle to achieve the 175 GW national target.

From 2017-18 onwards, the CERC has stopped its usual notifying benchmark capital costs for wind and solar PV which is indicative of two aspects. One is the acceptance of the mismatch between feed-in tariffs and market discovered prices. The other is a broader macro-economic acceptance of the competitiveness of wind and solar power and their ability to compete with conventional power sources without the need for assured regulated cost-plus feed-in tariffs.

Figure 20 compares the feed-in tariffs for wind and solar PV with tariffs discovered through competitive bidding as well as the Average Power Purchase Cost (APPC) for 2016-17 in a few RE rich states. While the solar PV discovered price varies from state to state, we have used the representative price of ₹ 3.46/kWh for all states as the market wind price in the absence of state specific bidding. Andhra Pradesh, Rajasthan and Tamil Nadu stand out as the three states whose APPC is more than both the solar bids in their states and the reference SECI wind bid price. For most other states, the latest solar bid prices shown in the figure are more than a year old and not representative of the existing solar prices (₹ 2.5 – 3/kWh). Compared to these benchmarks, the APPC in all states is significantly higher. In case of wind there has only been a single bidding process (SECI 1,000 MW) as yet and projects are expected to come up mostly in Tamil Nadu and possibly in Gujarat (The Hindu, 2017b). Hence comparing the APPC from various states with the single wind discovered price may be a bit premature. However, the figure brings out the difference between the wind discovered price and the feed-in tariffs in Tamil Nadu and Gujarat.

7.1 Wind power

In early 2017, for the first time in India, we saw a competitive bidding based price discovery for wind power to be procured by DISCOMs. The bidding was conducted by SECI and the capacity of 1,000 MW was on offer. These projects were to follow the build, own and operate model and could only be inter-connected to the interstate grid, the Inter State Transmission System (ISTS). The opening of the technical bids saw an interest from thirteen companies adding up to a capacity of 2,594 MW. After opening the financial bids which ranged from ₹ 4/kWh to ₹ 4.55/kWh, a total of ten companies

12. The above generation prices do not include any potential additional costs on account of grid integration, some of which would be passed on the RE generators over time.

with a combined capacity of 2,194 MW were shortlisted for the final round of electronic- reverse auctions. Finally, five companies won the bids at a price of ₹ 3.46/kWh, while the losing bids of the remaining five companies ranged from ₹ 3.47/kWh to ₹ 3.92/kWh (SECI, 2017b). Bidding details, namely the capacities and prices are shown in Figure 21. The SECI in turn has signed agreements with six states to procure this power, namely Uttar Pradesh (449.9 MW), Bihar (200 MW), Jharkhand (200 MW), Delhi (100 MW), Assam (50 MW) and Odisha (50 MW), which will use this power to meet their non-solar RPOs. Projects are to be commissioned within 18 months of the Letter of Award to the successful wind power developers, which was completed on 5th April, 2017.

Figure 20: Comparison of state-wise feed-in tariffs, bid determined prices and APPC for solar and wind power

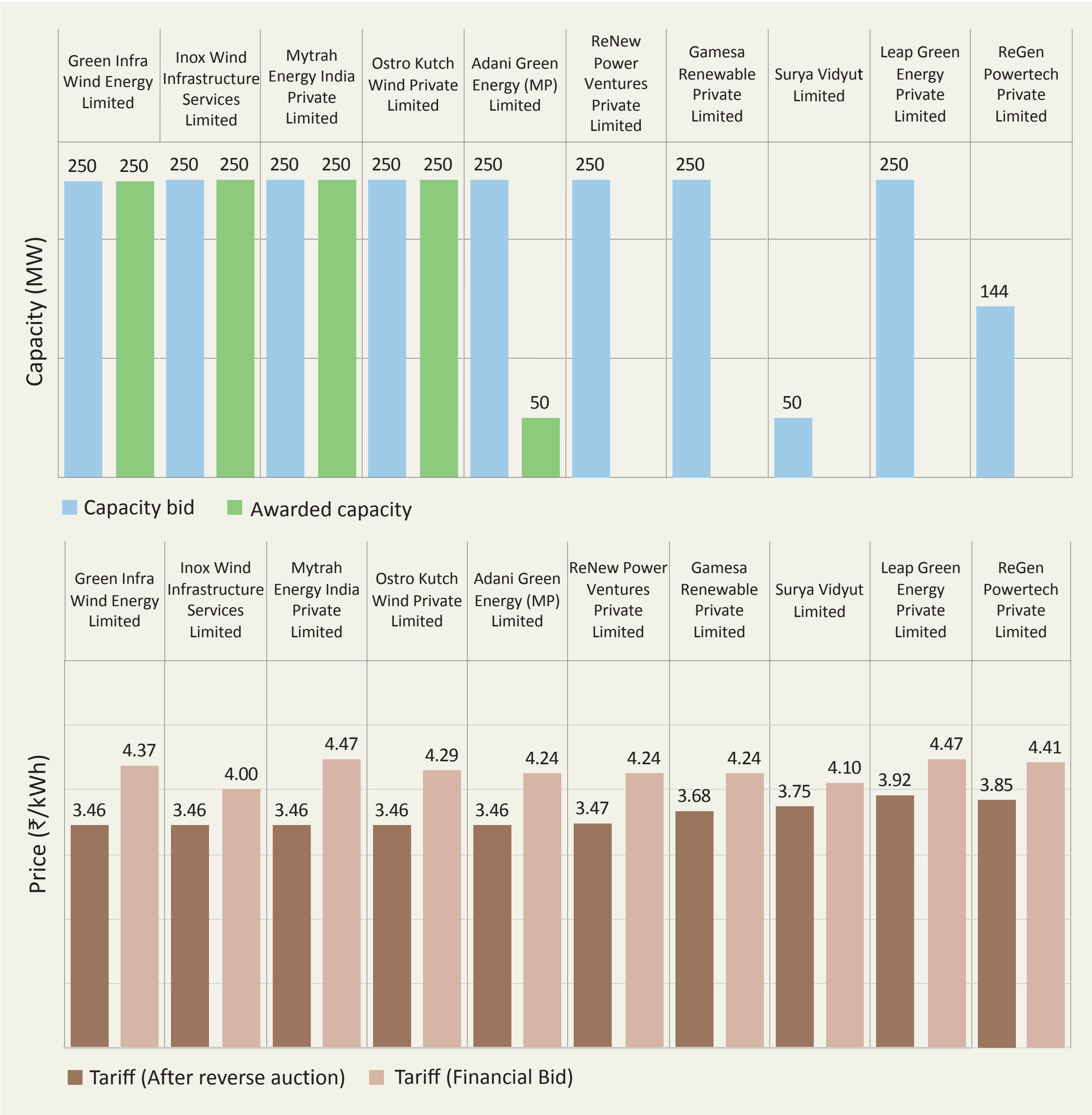
Source: Various state solar policies and final CERC REC order on determination of floor and forbearance price, 2017 (CERC, 2017f, p. 40).

Note: The wind FiTs in Andhra Pradesh, Gujarat, Rajasthan and Tamil Nadu are for the year 2016-17. For Karnataka, Madhya Pradesh and Maharashtra they are for 2017-18. The solar feed-in tariffs in Rajasthan and Tamil Nadu are for the year 2016-17 while for all other states they are for 2017-18.

The low price discovered under the competitive bidding framework has had an immediate sectoral effect with most states now unwilling to purchase wind power at the higher feed-in tariff fixed by SERCs. While DISCOMs in Andhra Pradesh are refusing to buy wind power at the regulated tariff of ₹ 4.76/kWh, some developers in Gujarat with completed projects have agreed to sell power to DISCOMs at ₹ 3.46/kWh, much lower than the feed-in tariff of ₹ 4.19/kWh (Chandrasekaran, 2017). Other states like Karnataka are also considering state specific wind bidding for further procurement (Ramesh, 2017a). Some states like Rajasthan, Gujarat and Andhra Pradesh are considering bidding for projects which are under construction or have just been completed for which PPAs have not yet been signed. This will entail significant renegotiation of agreements between developers and equipment suppliers if they have to remain competitive in today's market pricing framework. Projects where construction is not yet started may want to re-locate to locations with higher wind resource quality or newer turbines with higher Capacity Utilisation Factors (CUFs), lowering their cost of generation (Mayank Aggarwal, 2017). This essentially is the end of the feed-in-tariff regime for wind power in India.

Tamil Nadu Generation and Distribution Company Limited (TANGEDCO) has already filed a petition with the Tamil Nadu Electricity Regulatory Commission (TNERC) to procure 500 MW of wind power through reverse bidding (Vijayakumar, 2017). Similarly, the Gujarat Urja Vikas Nigam Limited (GUVNL) has put out a tender for 500 MW of wind power to be installed across Gujarat, with a bid-submission deadline of 10th July, 2017 (Mercom Capital Group,n.d.a) (Mercom Capital Group, n.d.b). Finally, the NTPC has put out a tender for 250 MW of wind power to be developed across four states with a bid submission deadline of 4th August, 2017 (Mercom Capital Group, n.d.b) (Mercom Capital Group, n.d.c).

Figure 21: SECI wind bidding results, financial and technical bids and reverse auction



Source: SECI (SECI, 2017).

Wind bidding guidelines

The distinct decline in wind prices has resonated with the centre as a successful result. The GoI is all set to build on this success and has recently completed bidding for another 1,000 MW for wind power (Ramesh, 2017a). The MNRE has published draft guidelines (under section 63 of the Electricity Act, 2003) for procurement of power from wind projects connected to the ISTS. One of the biggest changes in these guidelines is the proposed compensation for grid unavailability and backing down. It is important to acknowledge the significance of generation compensation for off-take constraints since wind power has a single part tariff and near zero marginal costs, and hence wind projects are at a big loss due to loss of off-take. This is completely different for coal power plants which have two-part tariffs and get their fixed cost paid as per the schedule and availability, thereby completely taking care of their debt payments unlike in the case for wind power. While this is a good beginning, we believe that an improvement in the methodology to calculate compensation costs is in order. For more details on a different proposed methodology, please see (Prayas (Energy group), 2017a).

However on the issue of transmission connectivity, the guidelines do not clarify whether firm transmission connectivity is a pre-requisite for bidding. Adding it as a pre-requisite risks limiting the number of players who can participate in bidding, while not considering it a pre-requisite risks winning bids not being completed due to potential future unavailability of transmission connectivity. This is an important issue since the present CERC's Grant of Connectivity, Long-term Access and Medium-term Open Access in Inter-State Transmission and Related Matters Regulations, 2009 allows transmission connectivity to, among other players, "any company authorised by the central government as solar park developer". However it is silent on the issue of wind developers. Hence this issue needs clarification from the MNRE.

The guidelines also introduce an enhanced framework on payment security, which has been a serious issue for developers in the last few years. It proposed a three level de-risking of timely payments in the form of *a) Revolving Letter of Credit (LC) of an amount not less than 1 (one) months' average billing from the Project under consideration; AND b) Payment Security Fund, which shall be suitable to support payment for at least 3 (three) months' billing of all the Projects tied up with such a fund; c) In addition to a) and b) above, the Procurer may also choose to provide State Government Guarantee, in a legally enforceable form, ensuring that there is adequate security to the Wind Power Generator, both in terms of payment of energy charges and termination compensation if any* (MNRE, 2017f).

These changes augur well for the wind sector and are likely to further reduce wind power prices in combination with ever larger wind turbines (Upadhyay, 2017).

7.2 Solar Power

In our previous report, we had illustrated the journey of all the solar bids in India till June 2016 (Prayas (Energy Group), 2016a, p. 26). The lowest solar PV bid till then was ₹ 4.34/kWh for a 130 MW plant in Rajasthan for which bidding was conducted in June 2016. In less than a year we have seen a further 44% reduction in solar tariffs. Bids for five solar projects have been announced since June 2016. Some of the features of these projects have been analysed in Table 9. The price first went down to ₹ 3.3/kWh in the Rewa solar park followed by ₹ 3.15/kWh in the Kadapa solar park. Procurers were in for a surprise when tariff fell below ₹ 3/kWh to ₹ 2.62-2.44/kWh in the Bhadla solar park within a month of the Kadapa bid. One of the unique features of the Rewa and Bhadla bids is the strong payment security framework including a three months payment security fund and state guarantees (Rewa) and central government guarantee (Bhadla). The Rewa bid has two more unique features, namely a first inter-state Open Access consumer (Delhi Metro Railway Corporation) consuming 26% of the generation and a deemed generation compensation framework for grid unavailability to assuage the developer's off-take risk. The low price realised in the Bhadla solar park bid has prompted the Uttar Pradesh government to plan a similar 750 project in Bhadla for their own procurement (Tripathy, 2017).

The most recent bid results for projects to be set up in Tamil Nadu, saw a much higher price of ₹ 3.47/kWh for the 1,500 MW on offer. While this price is nearly a rupee lower than the last winning bid in Tamil Nadu (₹ 4.4/kWh, February, 2017), it is also a rupee higher than the Bhadla bid, mainly due to lower radiation in comparison to Rajasthan, lack of any dedicated solar park, along with the absence of any specific assurance on payment security.

Several factors have contributed to this sharp decline in solar bids within a year. The first and foremost is the crash in solar equipment prices, of nearly 30% in this time frame, coupled with expected future price decline. The strengthening of the rupee against the dollar in the last few months has further contributed to the price decline. Competition has further intensified due to the entry of new large global players coupled with the drying out of capacity being bid out (only four bids since June 2016). The high level of solar park preparedness coupled with the strong payment guarantee framework and the deemed compensation benefit (for the Rewa project) has strongly contributed to de-risking the projects, making available a large pool of low-cost debt from developed countries. Finally, the higher solar radiation in Rajasthan (in case of the Bhadla solar park) also contributed to the price reduction over the Rewa and Kadapa bids. While all procurers have ensured high level of guarantees from the winning bidders to ensure project completion, there is still a considerable amount of uncertainty amongst the power sector stakeholders over the viability of these bids, especially given the break-neck speed at which they have fallen.

Table 9: Solar PV price discovery from recent bids in 2017

Features	Rewa Ultra Mega Solar Park	Kadapa Ultra Mega Solar Park	Bhadla Solar Park Phase IV	Bhadla Solar Park Phase III	Tamil Nadu
Bidding Date	February, 2017	April, 2017	May, 2017		June, 2017
Capacity (MW)	750	250	250	500	1500
Levelised Price Discovered (₹/kWh)	3.3 (2.97 with 5p/kWh escalation for 15 years)	3.15	2.62	2.44	3.47
Winning bidder	Mahindra Renewables Pvt. Ltd., Acme Solar Holdings Pvt. Ltd. and Solenergi Power Pvt. Ltd.	Solairedirect	Phelan Energy Group, Avaada Power, SBG Cleantech	M/s ACME Solar Holdings Pvt. Ltd., SBG Cleantech	Raasi Green Earth Energy; remaining 17 winning bids have to match this price or opt out
Power Offtaker	M.P. Power Management Company Ltd., Delhi Metro Railway Corporation	NTPC	DISCOMs in Rajasthan through SECI which will procure from project developer		Tamil Nadu Generation and Distribution Company (TANGEDCO)
Solar Park Developer	RUMSL, a joint venture between SECI and MPUVNL	Andhra Pradesh Solar Power Corporation Private Limited (APSPCL), a joint venture of SECI, Andhra Pradesh Power Generation Corporation and the New & Renewable Energy Development Corporation of Andhra Pradesh Ltd.	M/s Saurya Urja Company of Rajasthan Ltd., a joint venture between the Govt. of Rajasthan and M/s IL&FS Energy Development Company Ltd.		Not located in any specific solar park

Payment Security Framework	Buyer with good credit rating; one month letter of credit from off-taker; 3 months payment security fund operated by RUMSL and a state guarantee under agreement with the project developer, MPPMCL and RUMSL	National Thermal Power Corporation's (NTPC) high credit rating, NTPC covered by the tripartite agreement (GoI, state govts. and the RBI) against defaults by state DISCOMs	Three months payment security fund from SECI;	
			SECI covered by the Tripartite Agreement (GoI, state govts. and the RBI) against defaults by state DISCOMs	

Source: Prayas (Energy Group) compilation from various news reports.

Note: SBG Cleantech is a consortium of Softbank Group, Airtel and Foxconn.

CERC new RE tariff regulations, 2017

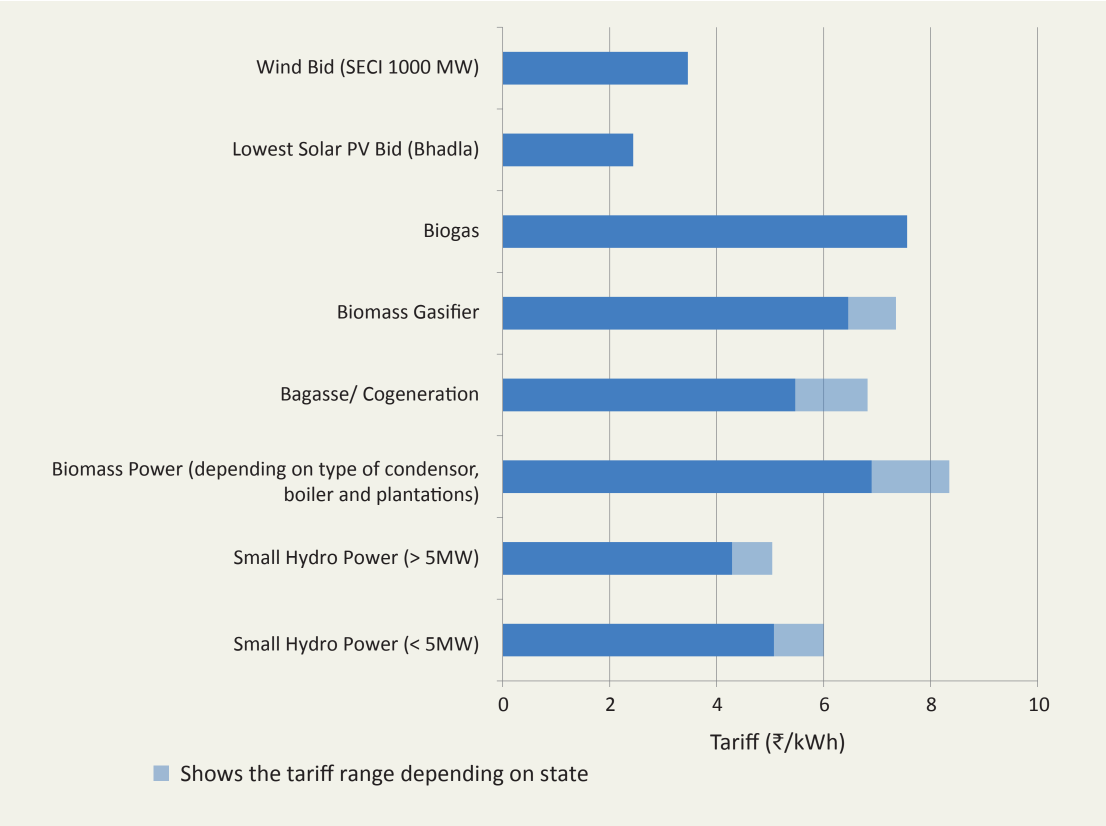
In April 2017, the Central Electricity Regulatory Commission notified its Terms and Conditions for Tariff determination from the Renewable Energy Sources Regulations, 2017. There are a considerable number of changes from the earlier regulations. The control period of these regulations has been reduced to three years from the earlier five, given the rapid developments in the renewable energy sector. The CERC has also done away with its earlier distinction between tariff period and useful life and has henceforth decided to equate the tariff /PPA period with the useful life of that technology. The CERC has changed the Return on Equity (ROE) norms from the earlier benchmark of pre-tax ROE of 20% and 24% to a new level of normative ROE at 14%, which would be grossed up by prevailing Minimum Alternate Tax (MAT).

The CERC has refrained from setting generic capital cost and Operation and Maintenance (O&M) cost assumptions for wind and solar PV. This will further signal the need to fully move towards a competitive bidding based price discovery mechanism, in line with the broader policy objective. For SHP, the capital cost norms have been significantly increased to 9–10 cr/MW in hilly regions and 7–7.8 cr/MW in other states. A similar increase is also seen in operational costs. For biomass power projects, the station heat rate has been increased as follows, a) For projects using travelling grate boilers: 4,200 kCal/kWh b) For projects using Atmospheric Fluidised Bed Combustion (AFBC) boilers: 4,125 kCal/kWh. For non-fossil fuel based cogeneration plants, the capital costs have been raised to 4.93 cr/MW for high pressure boilers.

With regard to the despatch principles for renewable energy projects, the CERC has acknowledged the issue of revenue loss for projects on account of backing down or grid unavailability. To further increase transparency in backing down instructions issued by Load Despatch Centres (LDCs), it has directed the National Load Despatch Centre (NLDC) to work with the SLDCs to evolve a framework to ensure written explanations in case of backing down due to issues other than grid security and reliability.

Based on these new regulations, the CERC came out with a tariff order in April 2017. A comparison of wind and solar prices discovered through competitive bidding with CERC determined tariffs (without accelerated depreciation) for other RE sources for 2017-18 is shown in Figure 22. The difference between wind/solar prices and the others is stark. The average bio-power tariff at ₹ 7.06/kWh is nearly three times the lowest solar bid and two times the lowest wind power bid till date. Similarly the average SHP tariff is 2.3 times and 1.6 times the lowest solar and wind bid till date. This begs the question whether policy and regulatory officials should continue to equally promote all forms of renewable energy or focus on the least-cost options. Luckily the 175 GW target has a lion's share of wind and solar power. Considering the current installed capacity of bio-power at 8.1 GW and that of SHP at 4.3 GW, a capacity addition of a little less than 3 GW is required by 2022 to meet the 175 GW sub-targets of 10 GW and 5 GW for bio-power and SHP respectively. In case of solar and wind, the capacity addition of 116 GW is needed in the 2017-2022 period.

Figure 22: Comparison of wind and solar prices discovered through bidding with CERC feed-in tariffs for other RE sources for 2017-18, without accelerated depreciation



Source: CERC determination of levelised generic tariff for RE sources 2017-18 (CERC, 2017g) and SECI.

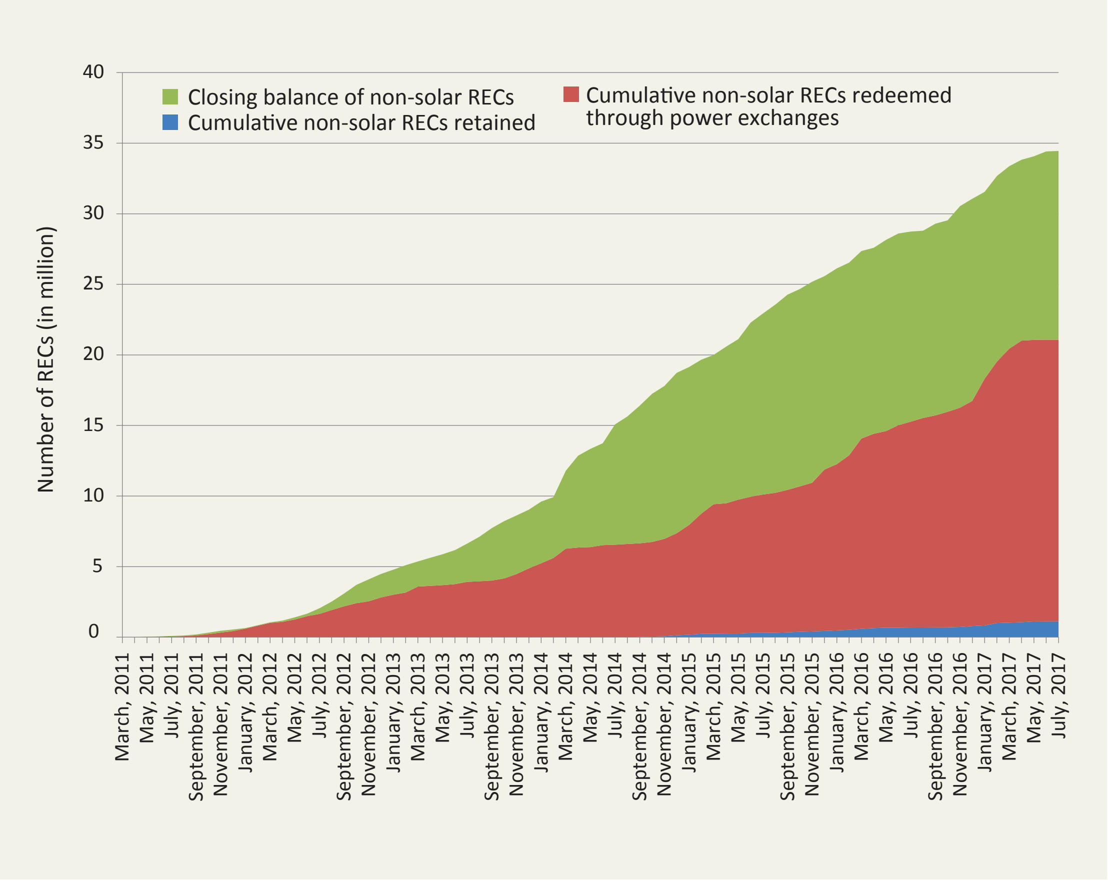
8. Renewable Energy Certificate Mechanism

The framework of the Renewable Energy Certificate mechanism and the various challenges and issues pertaining to it have been covered in the earlier report (Prayas (Energy Group), 2016a, p. 35).

A look back at the REC history

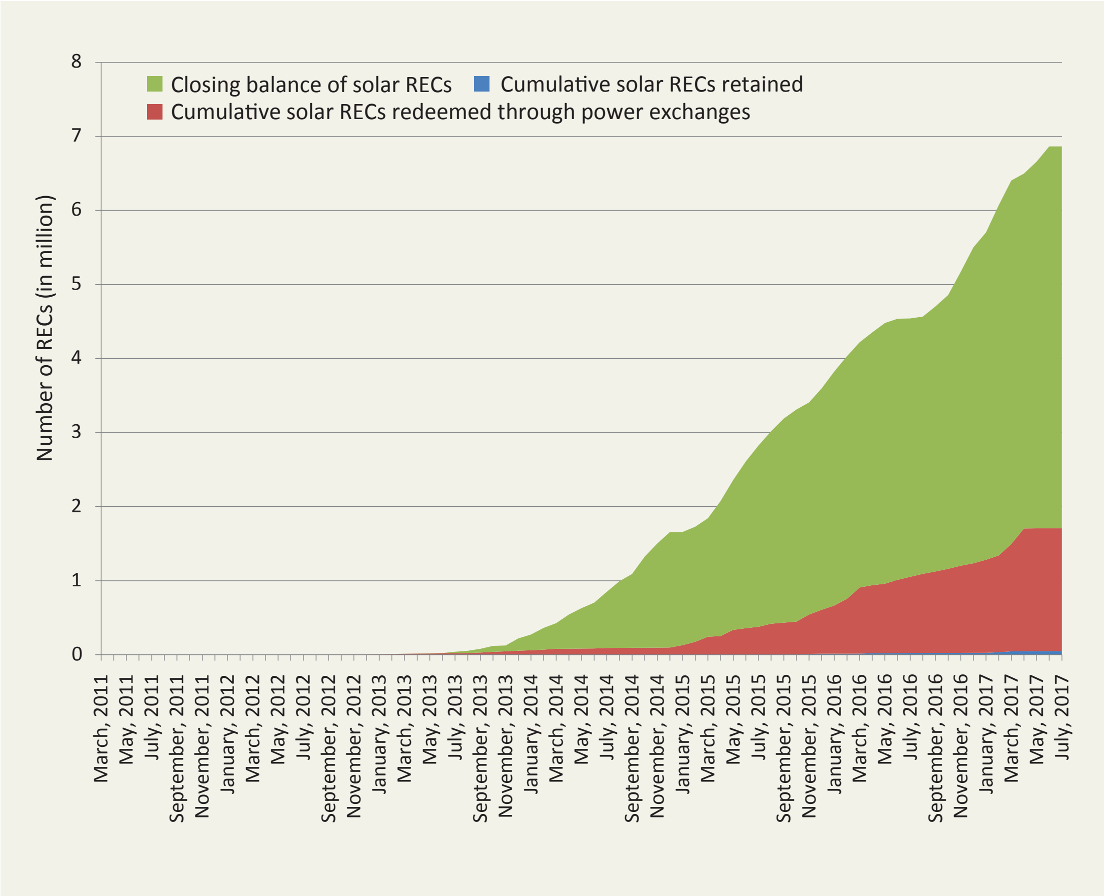
From March 2011 to July 2017, a total number of 3.44 crore non-solar RECs and 0.69 crore solar RECs have been issued (REC Registry, n.d.). Of the non-solar RECs, 57.9% were redeemed and 3.3% were retained resulting in 38.5% of the RECs remaining unsold. Similarly for solar RECs, 24.2% were redeemed and 0.7% were retained resulting in 73.7% of the RECs remaining unsold. Month-wise cumulative volume of non-solar and solar REC redeemed, retained and the closing balance are shown in Figure 23 and Figure 24.

Figure 23: Volume status of non-solar RECs for 2011-2017



Source: REC registry (REC Registry, n.d.).

Figure 24: Volume status of solar RECs for 2011-2017



Source: REC registry (REC Registry, n.d.) Source.

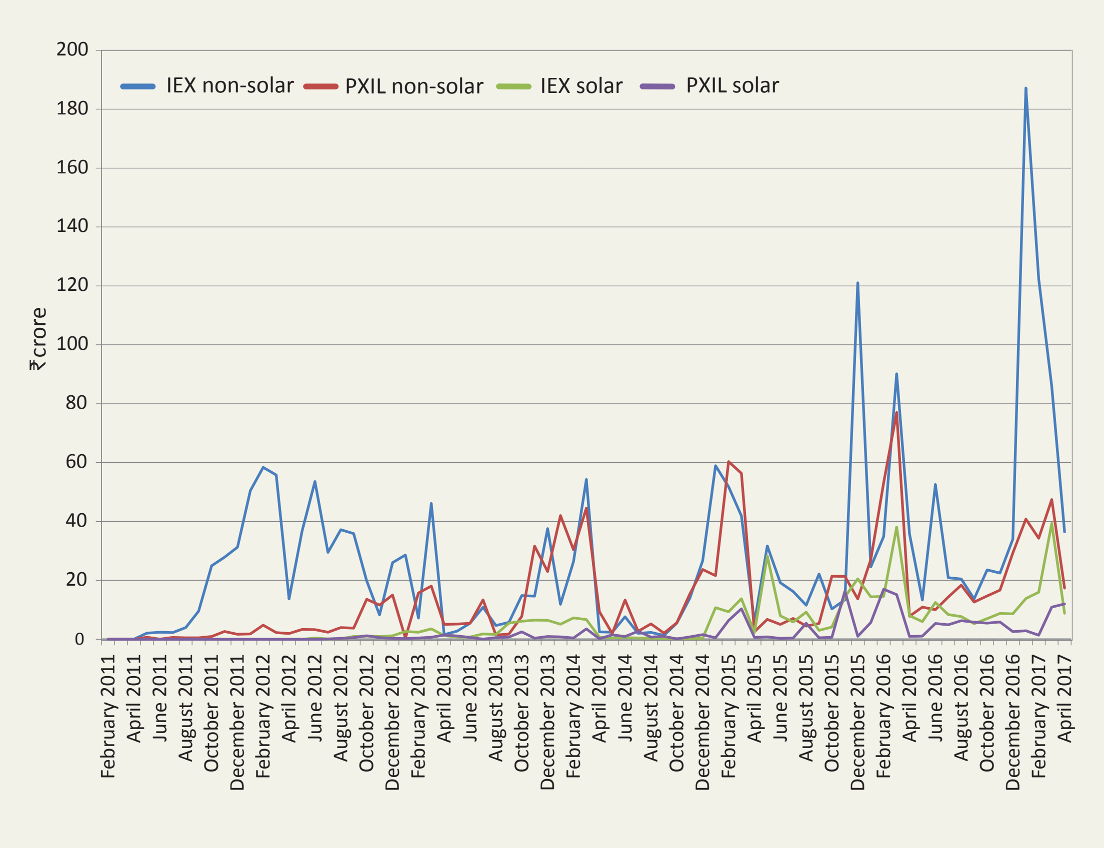
Table 10 shows the cumulative volume and value of trade of RECs across both power exchanges for the last 6 years. Volume and value of trade of the Indian Energy Exchange (IEX) has been nearly double that of Power Exchange India Limited (PXIL). Over the 75 trading sessions since February 2011, a total of nearly 2 crore non-solar RECs and 0.17 crore solar RECs have been traded. The total value of trade has been ₹ 3,148 crore and ₹ 588 crore respectively. For a month-wise value of the trade across both power exchanges, please see Figure 25.

Table 10: Volume of REC trade and value of trade of IEX and PXIL for 2011-2017

Power Exchange	IEX		PXIL		IEX+PXIL	
Type of REC	Value of trade	Volume Traded	Value of trade	Volume Traded	Total value of trade	Total volume traded
	Rs Crore	No of RECs (MWh)	Rs Crore	No of RECs (MWh)	Rs Crore	No of RECs (MWh)
Non Solar	2,089	12,902,726	1,059	7,043,280	3,148	19,946,006
Solar	414	1,122,230	174	547,645	588	1,669,875
Total	2,503	14,024,956	1,233	7,590,925	3,736	21,615,881

Source: Prayas (Energy Group) analysis based on data from IEX, PXIL.

Figure 25: Month-wise value (₹ crore) of RECs traded on IEX and PXIL for 2011-2017

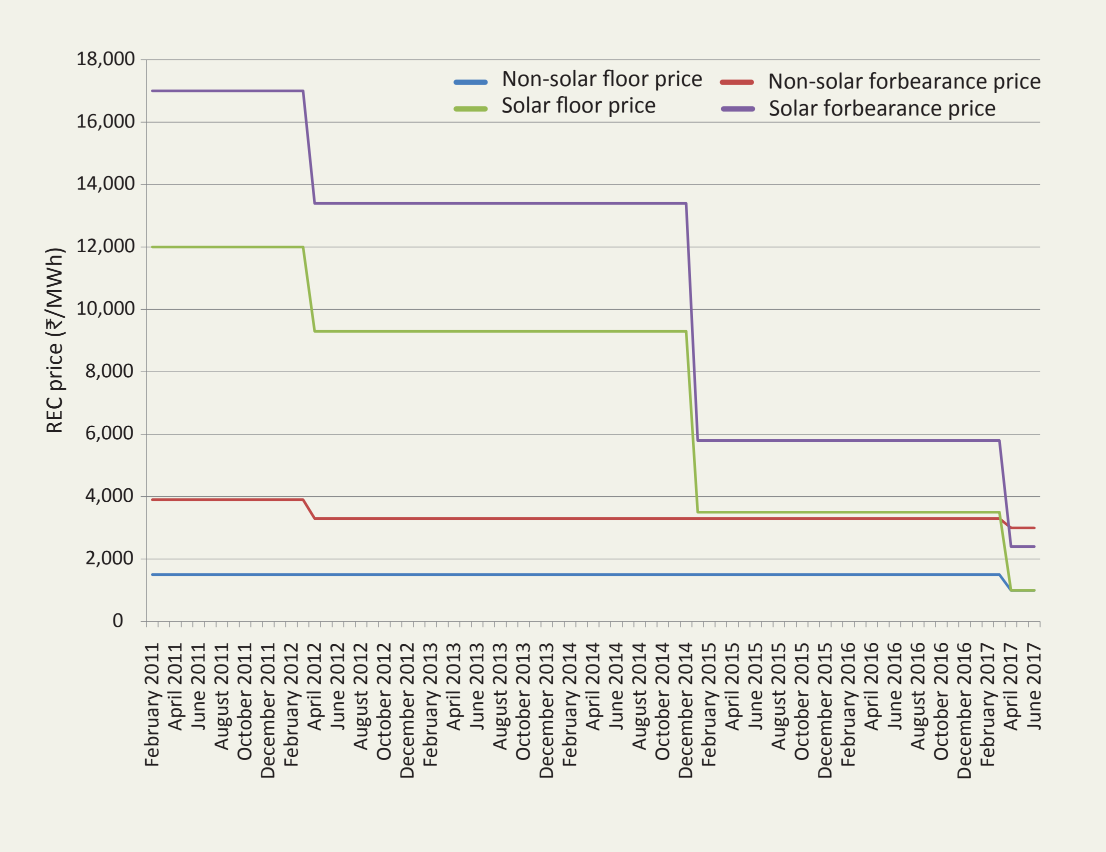


Source: IEX (IEX, n.d.), PXIL (PXIL, n.d.).

One of the largest changes in the REC mechanism since October 2016 when the last report was published is the notification of a new floor and forbearance price band by CERC, applicable from April 2017. The CERC had to essentially factor in the drastic reduction in the prices of solar PV and wind power in the last few years. As the order makes it clear, "alignment of REC prices with the market dynamics is required" (CERC, 2017f). The commission has therefore significantly reduced both the floor and forbearance prices for solar and non-solar certificates. The forbearance price of non-solar RECs is now set at ₹ 3,000/MWh and for solar RECs at ₹ 2,400/MWh, while the floor price is ₹ 1,000/MWh for both (see Figure 26). These new prices are indicative of the rising average power purchase costs of the DISCOMs as well as the significant fall in RE prices, especially of solar PV, which is now priced below wind power.

Additionally, the validity of this new price band has not been fixed for a certain number of years unlike before, but validity will remain "until further orders by the Commission". While this will allow the commission to revise these bands in a more timely manner (depending on market dynamics) going forward, it will also create uncertainty in the market.

Figure 26: Evolution of the REC price band for 2011-2017



Source: IEX, PXIL.

The expected further fall in wind and solar PV prices coupled with the rising APPC across all states will make it necessary to fundamentally relook at the existing methodology for determining floor prices. Consider the case for Rajasthan. Its APPC for 2016-17 is estimated by the CERC to be ₹ 3.39/kWh, while the tariff from the bidding for the Bhadla solar park project realised a levelised price of ₹ 2.44/kWh, thus undermining the need for any floor price. The CERC is seized of this issue fully and has taken note of it in the order as follows, "The Commission, however, directs the staff to examine the need of determining the floor price of the REC and whether going forward the floor price can be removed'.

While the validity of RECs expiring between 31st March 2017 and 30th September 2017 has been extended to 31st March 2018 by the CERC, unlike the last time when the commission reduced the solar REC price band, no vintage multiplier has been provided for older projects. This has very serious implications for solar projects under the REC mechanism since their floor price has reduced by 71%, from ₹ 3,500/MWh to ₹ 1,000/MWh. REConnect has estimated the loss for existing projects at "₹ 1,227 crore for solar projects and ₹ 646 crore for non-solar projects" (REConnect, 2017). Project developers have approached the Appellate Tribunal for Electricity (APTEL) to contest this order, seeking a vintage multiplier and considering the low floor price of ₹ 1,000/MWh. While the APTEL agreed to their demand for vintage multipliers, it did not stay trading. Aggrieved against this, developers further approached the Supreme Court which has stayed the trading as well as the new price regime introduced by the CERC (Jai, 2017). This has completely put the REC mechanism in a limbo.

Challenges going ahead

Apart from the lack of RPO enforcement leading to a poor demand for RECs and the falling forbearance and floor prices, the REC mechanism is facing a new, even greater challenge. The entire premise of the REC (of separating the power and green attribute) was to overcome the renewable energy resource mismatch across states and allow for RPO compliance without the actual trade of renewable power across states.

However with the emphasis on solar parks and large wind projects connected to the ISTS, it is now feasible to actually transmit renewable power across states, unlike the situation some years back. Competitive bidding has ensured very low generation prices in such large wind and solar PV projects. The waiver of ISTS transmission charges by the MoP and the CERC has further incentivised trade across states (MoP, 2017a). Hence it is likely that renewable energy resource poor states may prefer buying such interstate renewable power than procure RECs in the future. Secondly, the IEX has petitioned the CERC for the introduction of a green instrument Green Day Ahead Market (G-DAM) on the power exchange which will allow renewable energy specific trade of power. It would enable merchant capacity to be sold on the exchange. This would allow obligated entities to procure short term renewable power through exchanges to meet their RPO, thus further depressing the REC mechanism. For more details on G-DAM, please see section 9.3. One potential positive sign for the REC mechanism is the surplus capacity situation in many states (Prayas (Energy Group), 2017b). Such states may possibly prefer buying RECs for RPO compliance than procure further power and exacerbate the surplus situation.

Given these stark realities of the changes and upcoming challenges in the sector, the whole basis for the REC mechanism needs to be seen in this light and re-examined afresh. Unless the REC prices are truly reflective of the market prices, obligated entities are more likely to seek compliance through other means such as Open Access, Captive, Group Captive, Power Exchanges and rooftop solar net metering. Future investments in the REC mechanism will also dry up if there is a stark difference in REC and market pricing. The MNRE, MoP and FoR should initiate a discussion on the possible fundamental policy and regulatory changes needed to keep the REC framework relevant and effective if needed in the future.

9. Developments related to grid integration of renewables

In September, 2016, Prayas (Energy Group) published a report, "Grid integration of Renewables in India: An analysis of forecasting, scheduling and Deviation Settlement Regulations" (Prayas (Energy Group), 2016b). It gave an overview of the Indian power system, grid operation, especially with regard to increasing shares of variable renewables like wind and solar and also noted the ongoing grid infrastructure initiatives relevant to grid integration of renewables. At the heart of the report were the implications of the historical and ongoing regulatory reforms with regard to rules around forecasting, scheduling and deviation settlement of renewable power for intrastate and interstate transactions. This chapter takes forward this work and analyses recent developments in this space. We assume that the readers are familiar with grid planning and operation terminology. If not, please refer to the report mentioned earlier.

9.1 Forecasting and scheduling regulations for wind and solar generators

Regional Level: The CERC's 'Framework on Forecasting, Scheduling and Imbalance Handling for Wind and Solar Generators Connected to ISTS' has been in place since August 2015. Thereafter in February 2016, the Power System Operation Corporation Limited (POSOCO) proposed a draft detailed procedure to implement the framework, which was only recently approved by the CERC in March 2017 (CERC, 2017a). The procedure details out the various data requirements and formats as well as the roles and responsibilities of the various stakeholders involved. One change that has been made in the final approved procedure is the inclusion of wind parks connected at the interstate level in its scope.

State Level: After the FoR released the 'Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generators at the State Level' (referred to as the FoR model regulations in this report) in November 2015, eight states (Tamil Nadu, Karnataka, Odisha, Madhya Pradesh, Jharkhand, Chattisgarh, Andhra Pradesh and Rajasthan) had come out with their draft regulations by September 2016. The differences between these draft and the model regulations were critically analysed in our previous report. While regulations in seven states still remain in draft stage, Karnataka was the only state to notify its final regulations in May 2016. However, it subsequently deferred its implementation till June 2017 (KERC, 2016a). The Karnataka SLDC has recently started a dedicated web portal for this purpose (KPTCL, 2017).

From September 2016 till June 2017, only one additional state, Gujarat, has come out with its draft regulations in January 2017 (GERC, 2017a). Some highlights of this draft regulation are listed below.

a. Given different deviation settlement designs for interstate and intrastate transactions, the Gujarat Electricity Regulatory Commission (GERC) has mandated separate metering, accounting and settlement of the interstate and intrastate transactions behind the pooling station.

b. It mandates the state grid operator to make full use of the flexibility of conventional power plants and that the ISTS tie lines to accommodate maximum wind and solar generation in the grid without affecting its security. This would require appropriate changes such as defining a technical minimum, ramp rates, etc. in the Gujarat state grid code.

c. A lower level of absolute error is allowed without any penalties. While the FoR had suggested 10%, the GERC has proposed 8%[13] and 7% for wind and solar respectively. Additionally, it has proposed a gradual reduction of 1% per year in various absolute errors bands, both for wind and solar generators from the fourth year onwards until the eight year. A gradual tightening of the allowable absolute error bands and linked penalties is no doubt needed, especially as the share of variable RE generation increases over time. However, it should be decided on the basis of the accuracy and costs of available forecasting services. On the issue of penalties linked to deviation in various absolute error bands, it has proposed a rate which is higher for solar generators as compared to the FoR recommendation. However, with regard to wind generators, it has done the opposite.

d. The most distinguishing change proposed by the GERC is to distribute the net financial impact on the state pool due to deviations from schedule[14] by wind and solar generators among them. This is to ensure a revenue neutral state pool. However since the overall deviation penalty for any state is based on the interstate Unscheduled Interchange (UI) mechanism, the GERC's proposal indirectly links the deviation penalty for solar/wind generators to the UI mechanism. Given some level of inherent error in the forecast of state wind/solar generators and no allowable deviation band in the interstate level UI mechanism, this will lead to increase in the uncertainty of the deviation charge for wind/solar generators. Also, treating conventional and wind/solar energy generators at par with regard to the UI penalties at this stage may not be productive if the state would like to significantly increase its wind and solar capacity as envisaged under the national tariff policy. The FoR had proposed to compensate the financial burden on the state Deviation Settlement Mechanism (DSM) pool due to deviation of wind/solar generators connected to the state grid through Power System Development Fund (PSDF) or National Clean Environment Fund (NCEF).

Additionally, a new weather portal has been recently launched by the Earth System Science Organisation - India Meteorological Department (ESSO-IMD) and POSOCO with the objective of sharing weather information with power system operators for better management and analysis of the Indian power system (POSOCO and IMD India, n.d.).

Model DSM regulations by Forum of Regulators

The FoR released the 'Model DSM Regulations at State Level' in March 2017.These can be considered equivalent to the CERC DSM regulations existing at the regional level. It is applicable to "seller(s) and buyer(s) involved in the transactions facilitated through short-term open access or medium-term open access or long-term access in intrastate transmission or distribution of electricity (including interstate wheeling of power)" (FoR, 2017).

The model DSM regulations specify the forecasting and scheduling point for wind/solar generators to be on the High Voltage (HV) side of the pooling substation.

Interstate and intrastate transactions from the same pooling station are allowed only if done on separate feeders along with separate metering, accounting and deviation settlement. This is necessary since the design of deviation charges is different for interstate and intrastate transactions.

13. This is applicable only for wind projects commissioned after 30th January, 2010.

14. Below the 7% and 8% absolute error allowable without penalties for solar and wind respectively.

The regulations enable every ERC to move towards 5-minute scheduling from the present 15-minute process as has been already recommended by the Scheduling, Accounting, Metering and Settlement of Transactions in Electricity (SAMAST) report. The most important advantage of these model regulations is expected uniformity in deviation settlement regulations adopted by different states and CERC Deviation Settlement Mechanism regulations, which will allow the penalty of deviation caused to the state at state periphery to be passed to the state entity responsible for the deviation. The Madhya Pradesh Electricity Regulatory Commission (MPERC) is the first SERC to publish its draft DSM regulations on 26th May, 2017. It closely follows the model DSM regulations published by the FoR (MPERC, 2017).

Further actions needed at the state level: States should now quickly finalise both the intrastate DSM regulations as well as the forecasting, scheduling and deviation settlement regulations for wind and solar power. Past experience with the intrastate Availability Based Tariff (ABT) mechanism shows that implementation of ABT compliant meters was slow. This should not become an impediment to implementing the intrastate DSM regulations. Similarly, given the inevitable move towards a 5-mintute scheduling process in the future, care should be taken to ensure meters being compliant with such a change. Another issue which is still lacking attention in the forecasting and scheduling framework for solar and wind power is a methodology/ for distributing generation curtailment amongst member wind/solar generators connected to a pooling station. Clear criteria for such accounting would avoid disputes among the generators and the Qualified Coordinating Agency (QCA).

9.2 Transmission aspects of renewable energy

CERC Draft Transmission Planning Regulations

CERC published its draft transmission planning regulations for ISTS and Intrastate Transmission System (InSTS) in April 2017. These regulations cover the governance aspects of transmission planning and seek to ensure that it is carried out in consultation with all concerned agencies and stakeholders in a transparent manner. The regulations are applicable to the following stakeholders, namely "CEA, CTU, Inter State Transmission Licensees, SEBs/STUs, SLDC, RLDCs, NLDC, RPCs, NPC, DICs and other utilities involved in the transmission planning process". There regulations establish broad principles, criteria, methods, procedures, timelines, roles and responsibilities of various organisations for planning of ISTS and InSTS. Various committees at the national, regional and state level have been proposed to operationalise the regulations. These regulations would supplement the existing transmission planning manual which is published by the CEA.

Importantly for renewable energy, the regulations explicitly mention that one of the broad principles for transmission planning would be to 'facilitate realisation of the policy objectives for Renewable Energy Systems (RES)'. While planning transmission for renewable energy systems, the CTU and CEA would need to consider the RE capacity addition plans along with the state RPOs. A sensitivity analysis around RE capacity addition would be useful for planning. The MNRE has been tasked with identifying locations where the RE capacity is likely to come up[15] (CERC, 2017h).

15. In this regard, the MNRE has urged states to prioritise setting up solar projects near identified ISTS substations with available/spare capacity, subject to availability of the land. This data was collated by Power Grid Corporation of India Limited (PGCIL) and the MNRE has also requested the CEA to carry out a similar study for InSTS substations. This can reduce the cost and time for setting up for solar projects (MNRE, 2017b).

The draft regulations have proposed a much needed and long awaited central repository of the generators to be developed and maintained by the CEA where each project developer will have to register for setting up any new generation plant. Though the regulations do not mention the availability of such a repository in the public domain, to ensure transparency in the transmission planning it should be made public.

Compensation to wind and solar generators for grid curtailment

The importance of compensation for generation due to off-take constraints has already been emphasized in section 7.1 and 7.2. A recent news item[16] quoting a report from the ratings agency India Ratings notes that the MoP is proposing compensation against grid curtailment to all renewable energy projects which are being scheduled by the RLDC or the SLDC. The proposed compensation as detailed in Table 11 would differ depending on reasons for curtailment and the amount of curtailment (India Ratings, 2017). The ERCs will need to clearly define instances of grid security, low system demand and transmission constraints to operationalise this proposed framework.

Table 11: Proposed framework for compensation on grid curtailment

Reason for curtailment	Curtailment	Compensation
Transmission constraints	Up to 2%	Nil
	2% to 7%	50% of energy at contracted price
	>7%	50% of energy at contracted price with review from stakeholders
Grid security	Any level	Nil
Low system demand	Any level	If curtailment is done after curtailing the conventional generators to technical minimum, then 50 paise/kWh Otherwise at the power market price in that block

Source: India Ratings (India Ratings, 2017).

Green Energy Corridor and REMCs

The Green Energy Corridor as well as Renewable Energy Management Centres (REMCs) have been already covered in our previous report. Recently, in April 2017, the Ministry of Power has come out with a proposal for setting up REMCs at SLDCs of seven RE rich states (Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Madhya Pradesh, Rajasthan), three RLDCs (Southern, Western, Northern) and at POSOCO. These will assist LDCs in forecasting, scheduling and real-time management of renewable power as a part of the Green Energy Corridor (GEC) scheme. The total cost of the entire REMC project including infrastructure, training, forecasting and weather services, maintenance, etc. is around 409 crore and is completely covered by the central government (MoP, 2017c). The Power Grid Corporation of India Limited (PGCIL) has been tasked with setting up these REMCs within 15 months of award and commissioning them by 2018/19. In parallel, work has started on execution of the first green energy corridor, i.e. the 800 kV Ultrahigh-Voltage Direct Current (UHVDC) line between Raigarh and Pugalpur. The project is being executed by ABB in partnership with Bharat Heavy Electricals Limited (BHEL) (Anisha Dutta, 2017).

16. No document from MoP in this regard is available in the public domain to our knowledge as of 16th June, 2016.

Recently, the PGCIL published a report titled 'Green Energy Corridor 2, Part A – Integration of Solar Parks' as a part of the second phase of the Green Energy Corridor framework (PGCIL, 2016). This report details the grid integration plans for evacuation of power though 34 solar parks, with a capacity of 20 GW. Out of these solar parks, 13 would be connected to interstate network and 21 to the intrastate network. The report provides a detailed plan and costs of transmission capacity addition needed for each solar park. The total estimated costs of transmission schemes for all solar parks are ₹ 8,041 crore and ₹ 4,745 crore at the interstate and intrastate levels respectively. Additionally, an amount of ₹ 2,000-3,000 crore as a part of control infrastructure for intrastate transmission strengthening and large-scale energy storage projects is estimated. Acknowledging the need for system flexibility to accommodate large share of renewable energy, this report recommends developing a suitable market mechanism to *'encourage participation of flexible reserves to meet short term, medium term volatility.'* It also goes on to suggest complete allocation of existing reservoir and pumped storage hydro capacity for balancing of variable renewable generation.

9.3 Proposed Green Day Ahead Market for Green Power Trading

The Indian Energy Exchange (IEX) petitioned the CERC in September 2016 for introducing a Green Day Ahead Market (G-DAM). This would enable direct trading of green power through the exchange. The IEX expects significant advantages of such an instrument. Some of these are: i) enabling the obligated entities to procure renewable power at competitive rates and with more options at the power exchange to meet their RPOs, ii) a possibility of new RE merchant capacity enabling the GoI to achieve the target of 175 GW RE by 2022, iii) flexibility in procuring RE power without long term PPAs, iv) interstate sale of RE power from RE rich states to RE deficit states for RPO compliance.

Proposed structure of G-DAM: Only those RE generators which have scheduled an energy-based commercial settlement would be eligible to sell power through the G-DAM. The IEX proposes two types of contracts in G-DAM, namely solar and non-solar, with each having a separate uniform market clearing price. The settlement of G-DAM is expected to be done earlier than a conventional DAM to provide RE buyers and sellers with an opportunity to settle their (partially or fully) uncleared bids/offers. In case of partially or fully uncleared bids/offers, buyers and sellers can participate in the normal DAM during which the seller would sell its grey electricity at a market determined price and obtain RECs for the cleared energy.

Issues raised by system operator

While responding to the petition, POSOCO cited various issues with implementing the proposed G-DAM, which are as follows.

a. Fear of poor market participation due to lack of existing merchant power capacity connected to the ISTS

b. Need for a separate G-DAM when some RE generators are already participating in the DAM and when grid parity for solar and wind with thermal is nearly achieved.

c. Complications arising out of plants being partly merchant and partly linked to long term PPAs.

d. Shifting DAM contract timelines by 2 hours, leaving less time for contingency contract management.

e. Difficulty in implementing the deviation settlement mechanism for wind/solar generators given the lack of any fixed tariff/reference price, since market prices would change in every 15 minute block.

Instead, POSOCO proposed a Green Term Ahead Market (G-TAM) for green power contracts trading, as a G-TAM would have bilateral contracts and would require no change in the scheduling procedure. Responding to some of these concerns, the IEX noted that most of these changes could be carried out in consultation with appropriate stakeholders and would not cause any significant changes in the existing structures (CERC, 2017b).

Shifting the conventional DAM market process by 2 hours would affect the entire scheduling process carried out by all LDCs and would require appropriate amendments in the procedure of scheduling collective transactions. Similarly, two amendments will be needed in the REC regulations, namely making any RE generator who sells power in G-DAM ineligible for RECs, and any generator who sells power in DAM eligible for RECs. Finally, since only those RE generators with a scheduled generation based commercial settlement mechanism are eligible for G-DAM, this excludes most of the existing generators which are connected to the intrastate grid and have an actual generation based settlement mechanism. If such generators have to participate in G-DAM, the SERCs will have to amend their regulations (forecasting, scheduling and DSM for wind/solar) to change over to a scheduled generation based commercial settlement mechanism.

9.4 CERC Staff Paper on Energy Storage

The CERC published a staff paper on electricity storage in January 2017 (CERC, 2017c). This paper elaborates the challenges which the Indian grid may face due to a high penetration of renewables. One of the most important challenges is to address the increased variability of net load due to the intermittent (partially incontrollable and partially uncertain) nature of wind and solar generation. While traditionally gas and hydro power plants were used as load following generators, the paper introduces various applications of electricity storage technologies to address some of the upcoming challenges. Storage can help to shift generation to peak demand times, decrease intermittency of the RE generator, minimise deviation from scheduled despatch or drawal and also provide ancillary services. It also lays down various possible ownership structures and operational frameworks.

For the RE generator, storage can help increase its despatch ability. For storage combined with renewable generators, the paper discusses two types of tariff philosophies: i) combined cost approach: ii) separate tariff design for the renewable generator and storage. The paper suggests that the second approach may be more appropriate as it enables the storage owner and users to determine the true additional value of the storage system. Implementation of storage would need a separate scheduling, despatch and energy accounting framework which would take into account various storage characteristics like time of charge and discharge, capacity, efficiency, etc. For more details, please see (CERC, 2017c).

A significant amount of tendering is already under way for grid scale electric storage batteries in India. Similarly, the CEA has also been emphasising the need to utilise the existing idle pumped storage capacity and the need to augment the capacity. For more details on the existing storage projects in India, please see (CEA, 2016a).

While reduction in cost of electric storage can significantly increase its uptake and help in addressing various challenges in grid planning and operation, we need to proceed systematically.

We need to explore the possibility of using existing idle/stranded gas/coal capacity (with some retrofitting if needed) to meet the increased variability in load. This may well turn out to be a lower cost option compared to storage at this stage. Similarly a comprehensive analysis of various innovative solutions using existing infrastructure or with some modifications of existing procedures should be considered in parallel with storage.

9.5 CERC amendments to the Indian Electricity Grid Code

CERC Fourth Amendment to the IEGC and Detailed Operating Procedure for Backing down CGS or ISGS

The CERC notified its fourth amendment to the Indian Electricity Grid Code (IEGC) in April 2016, wherein it introduced the concept of technical minimum schedule for operation of central generating stations (CGSs) and interstate generating stations (ISGSs) (CERC, 2016). It set the technical minimum for all CGS or ISGS plants at 55% of the Maximum Continuous Rating (MCR) loading or installed capacity of the unit of the generating station. One of the biggest advantages of this amendment for renewable energy integration into the grid is the increased flexibility of the remaining generation fleet to effectively meet the increased variability in the net load curve. One of the first states to follow up on this is Maharashtra. The MSEDCL has petitioned the MERC to set the technical minimum of all plants with which it has PPAs at 55% to enable higher generation fleet flexibility so as to better integrate renewable energy amongst other things (MERC, 2017a).

The CERC also put in place a framework for calculating the compensation needed for such generators if they were to operate at unit loading below 85% of installed capacity. This is on account of the increase in station heat rate and auxiliary consumption from such operation. If an ISGS or CGS continues to get a schedule below the technical minimum of 55%, it has the option of going into reserve shutdown. In such a case it can get compensated for start-up fuel costs over and above seven starts or stops in a year. Compensation is linked to the size of the unit (MW) and types of start – cold, warm or hot. Any compensation so calculated "shall be borne by the entity that has caused the plant to be operated at schedule lower than corresponding to normative plant availability factor up to technical minimum". Various factors such as increasing shares of variable renewable power, enhanced energy efficiency, change in consumer behaviour, and weather patterns can affect load shapes, which in turn can affect the schedules for ISGS and CGS. DISCOMs should comprehensively study existing and future load shapes to better inform their procurement strategies and also to understand the price and value of the flexibility provided by the ISGS and the CGS.

POSOCO has come up with a procedure which details the various steps, timelines, criteria and calculations needed to operationalise technical minimum, reserve shut down, etc. (CERC, 2017d). This procedure is expected to come in force in May 2017.

CERC Fifth Amendment to the IEGC

The CERCs notified the fifth amendment to the Indian Electricity Grid Code in April 2017 (CERC, 2017e). This amendment which will come in force from May 2017 incorporates the necessary provisions to operationalise the ancillary services regulations including its commercial settlement mechanism as part of the IEGC. An important change is the revision in the definition of the spinning reserves, namely removing the necessity of only allowing part loaded generation capacity which can provide increased generation in response to a frequency drop. Streamlining ancillary services as part of the IEGC will further assist in renewable energy integration into the grid, as ancillary services would enable the system to better manage the demand-generation imbalances (CERC, 2015).

9.6 Increasing importance of renewable energy in grid planning and operation

Renewable energy already contributes 18% to total generation capacity and close to 6.5% to total electricity generation. There is a near universal acknowledgement that this share will significantly go up in the future. While no one can be certain of what the final share of renewables will be in the long run, say in 2030/2035, one could study the implications of various renewable energy penetration possibilities as part of different scenarios over the next 10–15 years. This is crucial given the long lead time needed for transmission deployment as well as considering the important issue of reliable integration of variable renewable energy such as wind and solar power into the India grid. Various Indian government agencies as well as some research organisations have undertaken planning and grid operation studies to analyse such issues. Some of the recent ones are noted below.

a. Draft National Electricity Plan (Vol-II) Transmission, 2016 published by the Central Electricity Authority: This study is a statutory requirement to be fulfilled by the CEA under section 3(4) of the Electricity Act, 2003. It estimates the requirement (both MW and cost) of the transmission system for the 13th plan using power flow analysis and with due consideration of new technologies and expected region-wise variability of wind and solar power.

b. Renewable Energy Integration-Transmission an Enabler, 2016 published by POWERGRID: The report assesses the balancing and reserve requirements and availability of the Indian power system in 15% and 30% RE penetration scenarios by 2019. The report concludes that balancing and ramping resources of the Indian power system are sufficient for the 15% penetration scenario but not for 30%. Additional resources which can provide flexibility of 5 GW are needed in the 30% scenario.

c. Techno-Economic Assessment of Integrating 175 GW of Renewable Energy into the Indian Grid by 2022 (LBNL, 2016): The study analyses the simulations of economic despatch of the Indian power system with 175 GW of renewable using PLEXOS to find the impact on power investment, operations and incremental cost of RE integration. It estimates incremental wholesale cost of electricity supply in 2022 and strategies to limit these costs under three scenarios depending on the generation mix.

d. Greening the Grid India Programme (2015-17): A team from the US Department of Energy national labs (NREL and LBNL) in collaboration with POSOCO, PGCIL, CEA and a few states has recently published a detailed study on grid integration of RE (NREL,POSOCO, Berkeley Lab, 2017). It is a joint initiative of United States Agency for International Development (USAID) and the Ministry of Power. The team has developed a unit commitment and despatch model for different renewable energy scenarios for 2022. Some of the key findings from this study are listed below.

    1. Power system balancing with 100 GW solar and 60 GW of wind power in 2022 is achievable with minimal RE curtailment and without any new fast ramping infrastructure such as combustion turbines or storage. This assumes access to the physical flexibility of the system to manage added variability and uncertainty. However, it is critical to realise

this flexibility through appropriate regulatory, market mechanisms and technological measures.

2. Reducing minimum generation levels of coal plants is the biggest driver to minimise RE curtailment. Also, ramping capability of the generation fleet is sufficient to handle system ramp requirements.
3. Increasing the balancing area from the state level to the regional or national level can reduce the cost of system operation by ₹ 6,300 crore and ₹ 7,800 crore respectively (in today's rupees).
4. Plant load factors (PLFs) of coal plants drop to 50% in 2022 with 20 GW of capacity which never starts. Retiring coal plants with PLFs < 15% (46 GW of capacity) has almost no effect on system operations as well as RE curtailment. However retirement of such plants can increase the PLF of the remaining coal fleet to 62% and avoid fixed cost payments.

10. Goods and Services Tax

The Goods and Services Tax (GST) is one of the most significant indirect tax reforms in the recent past. It amalgamates a number of existing central and state taxes into a single tax. The GST combines indirect taxes on good and services into a single framework unlike the existing separate VAT on goods and services tax. It differs from the current tax regime in two important ways, namely

a. Destination based tax system: the state in which the good or service is consumed receives the tax revenue, as opposed to the earlier origin based tax system.

b. Elimination of cascading effect: With the input tax credit feature, the existing cascading effect of taxes would be eliminated.

The GST Council has fixed a four slab structure of tax rates: 0%, 5%, 12%, 18% and 28%. A cess over the peak rate of 28% on specified luxury and sin goods has also been instituted to compensate states for any loss of tax revenue for five years. For intrastate supply of goods and services, a central GST and state GST shall be levied by the central and state government respectively, while for interstate supply of goods and services, only an integrated GST shall be levied by the central government. The Central GST Bill, 2017, Integrated GST Bill, 2017, Union Territory GST Bill, 2017 and GST (Compensation to States) Bill, 2017 were passed by parliament in March-April, 2017. With the categorisation of goods and services under different tax rates completed by the GST council, the new framework came into force from 1st of July 2017. The following existing central taxes (excise duty, sales tax, special additional duty, service tax, counter vailing duty, and surcharges and cesses) and state indirect taxes (value added tax, luxury tax, entry tax & octroi, entertainment tax, purchase tax surcharges and cesses) are to be subsumed under the GST (CBEC, 2016).

A few commodities have been excluded from the purview of the GST. Most important among these are alcoholic liquor for human consumption, five petroleum products (crude oil, petrol, diesel, natural gas and aviation turbine fuel) and electricity. These form a significant part of the state indirect tax collection. With regard to electricity, the entire value chain of power generation and distribution prior to electricity consumption is under the ambit of the GST. Hence, electricity duty levied by the state governments on consumption of electricity would be outside the purview of the GST. This essentially breaks the input tax credit chain resulting in incomplete input tax offsets and continued tax cascading (Bhandari, 2017). There has been a call by various stakeholders to bring electricity under the GST ambit (The Economic Times, 2017a).

Implications for Renewable Energy

The renewable energy sector presently benefits from a host of indirect tax concessions or waivers (MNRE, 2015a). There is a fear of renewable energy prices going up if some of these concessions are reduced and/or waivers removed. The GST council have kept "renewable energy devices and spare parts for their manufacture" under the 5% tax bracket in their rate schedule for goods (The Hindu Business Line, 2017). This is certainly good news for the renewable energy sector as it implies only a modest increase in prices for some sub-sectors.

We have done a preliminary assessment of the impact of the new GST tax rates through an example of a large scale solar PV project to be installed in Maharashtra. *The calculation is only for the purpose of illustration as it involves a number of assumptions.*

Table 12 shows the assumed breakup of the total cost of a solar PV power plant being set up in Maharashtra. It categorises the sub-units either as goods or services and whether they have been procured from within/outside the state or have been imported. The last two columns in the table depict the existing tax rates as well as those proposed under the GST. The categorisation of sub-units, their place of procurement and existing tax rates have been assumed as per the MNRE study on GST published in 2015. The GST rates have been assumed as per the rate schedule for goods as announced by the GST council. As already stated, 'renewable energy devices and spare parts for their manufacture' including 'solar power generating system' have been placed under the 5% tax bracket. However, there remains some confusion over whether this means that all goods used for a solar power project will attract a uniform 5% rate or only some select sub-components of the solar power plant. In an amendment issued by the GST council on 3rd June, 2017, it clarified that 'photo voltaic cells, whether or not assembled in modules or made up into panels' will only attract a 5% tax and not the 18% as previously mentioned (CBEC, 2017). Given this uncertainty, we have done the calculations for two scenarios, a) assuming all goods used in the solar power generating system are taxed at 5% and b) only solar PV panels are taxed at 5%, while the rest of the balance of system is taxed at 18–28%.

Four sub-units, namely land, civil and general works, preliminary, preoperative, contingency expenses and operating costs have been assumed as services with the appropriate tax rate of 12–18% (The Hindu, 2017a). Apart from this, we have assumed the capital cost of a large scale solar power plant to be ₹ 350 lakhs/MW based on market estimates. Similarly we have assumed an operating cost of ₹ 7.35 lakhs/MW/year for the year 2017-18, escalating at 4.85% per year (MERC, 2017b) (CERC, 2017g).

Based on these assumptions, we first calculated the pre-tax capital costs and operating costs. We then used the GST tax rates to arrive at capital costs and operating costs under the GST framework. For each of these four sets of capital costs and operating costs, we calculated the levelised tariffs using the Prayas RE Tariff and Financial Analysis Tool (Prayas (Energy Group), 2014). The results are detailed in Table 13. Based on these assumptions, we estimate that the tariffs for solar PV may increase between ₹ 0.12-0.21/kWh, i.e. 3.1–5.5% increase under the GST regime. Subsequently the share of indirect tax as a percentage of solar PV tariff rises from the current 4.7% to anywhere between 7.6%–9.4% depending on the scenario assumptions. Such a rise in tariff on account of 'change in law' will have to be passed on the procurers based on the terms and conditions of the PPAs. *We reiterate that these calculations are only for the purpose of illustration as they involve a number of assumptions.*

Table 12: Various assumptions used for the calculation of impact of GST on solar PV project

Total Cost breakup	Category	Share of Total Capital Cost	Import	Within State	Inter State	Existing Tax Regime[17]	GST Regime (Scenario a: all goods taxed at 5%)	GST Regime (Scenario b: only solar PV panels taxed at 5%)
PV Modules	Goods	62%	100%	0	0	Customs Duty Exempted	IGST at 5%	IGST at 5%
Land Cost	Service (as it is leased)	6%	0	100%	0	Service Tax at 15%	CGST+SGST= 12%	CGST+SGST= 12%
Civil and General Works	Installation Services	7%	0	50%	50%	Service Tax at 15%	IGST at 12%; CGST+SGST= 12%	IGST at 12%; CGST+SGST= 12%
Mounting Structures	Goods	6%	0	0	100%	Excise Duty Exempted; CST at 2% against Form C	CGST+SGST= 5%	CGST+SGST= 18%
Power Conditioning Unit	Goods	7%	0	100%	0	Excise Duty Exempted; VAT applicable at concessional rates of states	CGST+SGST= 5%	CGST+SGST= 18%
Evacuation Cost (Cables)	Goods	3.55%	0	50%	50%	Intra State= VAT applicable at concessional rates of states; Inter State= CST at 2% against Form C	IGST at 28%; CGST+SGST= 5%	IGST at 28%; CGST+SGST= 28%
Evacuation Cost (Transformers)	Goods	3.55%	0	50%	50%	Intra State= VAT applicable at concessional rates of states; Inter State= CST at 2% against Form C	IGST at 18%; CGST+SGST= 5%	IGST at 18%; CGST+SGST= 18%%
Preliminary, Preoperative Expenses \ Contingency	Services	4.9%	0	50%	50%	Service Tax at 15%	CGST+SGST= 18%	CGST+SGST= 18%
Operating Costs	Services	100.00%	0	100%	0%	VAT according to State and Service Tax of 15% on 70% of value	CGST+SGST= 18%	CGST+SGST= 18%

Source: Prayas (Energy Group) estimates based on MNRE Report, GST rate schedule, market estimates.

17. Existing tax regime mentioned here only considers the taxes that have been subsumed into the GST.

Table 13: Impact of Goods and Services Tax on solar PV tariff

Parameter	Pre tax	Post current tax regime	Post GST regime Scenario A	Post GST regime Scenario B
Capital cost (₹ Lakhs/MW)	339.24	350	361.1	370.5
Operating cost (₹ Lakhs/MW/year)	6.43	7.35	7.59	7.59
Levelised tariff (₹/kWh)	3.65	3.83	3.95	4.04
Indirect tax as a percentage of tariff		4.7%	7.6%	9.7%
Tariff increase (₹/kWh)			0.12	0.21

Source: Prayas (Energy Group) analysis.

Similar to solar power, wind turbines and coal have also been taxed at 5% under the GST regime. Price of electricity generated from coal may come down by a 6-7 p/kWh since the existing tax on coal is ~11.7% (The Economic Times, 2017b). This is in spite of the higher tax rates on steam boilers and turbines and reflects the higher weightage of fuel costs in the total tariff.

The National Clean Environment Fund was created by levying a cess on coal. It began with ₹ 50/tonne and now stands at ₹ 400/tonne. Since its inception an amount of ₹ 54,000 crore has been collected, of which only half has actually gone to the NCEF and ₹ 10,000 crore has been allocated to projects (Ramesh, 2017b). Under the GST (Compensation to States) Act, 2017, a new cess is proposed to be levied on goods and services to essentially fund any compensation to states for loss of revenue from GST. Strangely, the schedule under this Act includes the ₹ 400/tonne cess on coal which was meant only to fund the NCEF (Ministry of Law and Justice, 2017). Now the erstwhile purpose of the coal cess (namely funding clean energy) has been completely done away with and may be largely used to compensate states on account of GST. This move has been opposed by various stakeholders including states like Odisha (Dash, 2017). It can seriously limit the allocation of funds for clean energy and environment research and programmes.

11. Summary

Prices: 2017 has finally put the erstwhile question of the high cost of renewable energy behind us, hopefully once and for all. Record low prices of ₹ 2.44/kWh and ₹ 3.46/kWh for solar PV and wind power discovered through competitive bidding are extremely competitive not only with the price of coal from new plants (₹ 4–5/kWh), but also with the average power purchase costs in most states. There has been some discussion on the viability of such record low solar PV and wind tariffs and whether developers are taking undue risks. While any competitive bid involves some level of risk taking and guessing of likely future prices, what is obvious is the clear trajectory of reducing prices over time. Hence rather than focusing on the financial viability of individual case specific bids, the implications of the price competitiveness of RE with coal should be strongly debated.

The success of bidding based market price discovery essentially means the end of the feed-in-tariff regime for solar PV and wind power in India. RE generation prices (in simple per kWh terms) are no longer a hurdle to achieve the 175 GW national target. In this regard the Power Ministers conference concluded that, to further promote transparent and competitive renewable electricity procurement, standardisation and uniformity in processes along with a fair risk sharing framework between various stakeholders is necessary. It recommends that the Standard Bidding Framework being prepared by the MNRE for solar and wind power with features such as payment security mechanism, assured off-take etc. should be followed.

Capacity Addition: 2016-17 saw a record RE capacity addition (11.3 GW), nearly equal to that from thermal power. Also it was the first year when solar capacity exceeded wind capacity. This could be a telling sign for the times to come and a possible tipping point in terms of RE capacity addition going ahead. Looking back at the two years (2015-2017) since the announcement of the 175 GW target, it is clear that only wind power has met its yearly targets while all others, especially solar, in spite of its stellar growth are well behind. Considering the rapid RE market evolution, the slow pace of solar rooftop uptake, resolution to reduce the rooftop target from 40 GW to 20 GW, the situation of surplus capacity in the country and various other factors detailed in section 3.3, a more flexible target setting process, in greater consultation with states and other stakeholders is the need of the hour. There is an urgent need to systematically revise the yearly targets for the remaining years to remain consistent with the 175 GW vision. Focus on capacity addition in the next five years (2017-22) will be crucial to meet the 175 GW vision, i.e. to increase the share of RE in total demand from 6.6% (2017) to 20.9% by 2022 as per CEA's estimates. Also whether 175 GW is achieved exactly by March, 2022 should not be the narrow focus point. It would be better to focus on the pace and implementation of appropriate policy-regulatory responses to overcome emerging challenges to achieve such a significant RE target.

RPOs: For FY 2017-18, the weighted average of total (solar and non-solar) RPO targets of seventeen large states (figure 12) is around 10.24%, considerably less than 14.25% as recommended by the Ministry of Power. States with high share of hydro in their total consumption will find it relatively easier to align themselves with the MoP guideline since it defines RPO as a percentage of total demand excluding hydro consumption. Additionally, to meet the 100 GW target, the solar RPO recommended in the NTP needs to be revised to 10.3% from the current 8% (excluding hydro).

Biomass and SHP tariffs are now significantly higher than those of wind and solar power. This begs the question whether policy and regulatory officials should continue to equally promote all forms of renewable energy or focus on the least-cost options. The MNRE, MoP and FoR should initiate a discussion on the continued need for RPOs in the medium term (when RE prices will go below that of coal power) and the need for the continued distinction between solar and non-solar RPOs/RECs, and the possible fundamental regulatory changes needed to keep the RPO/REC framework relevant and effective if needed in the future. Significantly, the Minister for Power and New and Renewable Energy has recently stated that *'the MNRE may think of combining the solar and wind power RPO which at present are separate'* (MoP, 2017b).

RPO compliance: Data on RPO compliance remains a big challenge. Of the eight large RE rich states (Figure 16), our estimate is that RPO compliance by DISCOMs is roughly 80% on average. Data on RPO compliance by Open Access and CPP consumer is practically entirely missing with the possible exception of Maharashtra. As is clear from the OA and CPP data, compliance for solar and non-solar RPO has been very poor in Maharashtra. This should alert the ERCs to further strengthen the M&V mechanism for RPO compliance for these consumers, without which there would not be a level playing field with the DISCOMs. Without a penal mechanism, it seems unlikely that a large section of the obligated entities would strive for RPO compliance.

Rooftop Solar: In spite of the very high financial viability for consumers to adopt net-metering based rooftop solar PV and considering the availability of capital subsidies, awareness tools from the government (accredited channel partner database, online financial calculator, interest forms, ARUN app, etc.), actual deployment of projects have been very slow in comparison. While net-metering regulations have been in place for some time now, implementation has been very sluggish due to a variety of reasons detailed in section 6.2. Most important amongst these are lack of capacity and training of field officers, variation in operating practices across DISCOM circles, resulting in increasing transaction costs, delays for processing and sanctioning applications. Taking cognisance of this ground reality, the minister for power has directed officials, *"to reduce the target of the solar rooftop programme".* Subsequently the minutes of the Power Ministers conference (May, 2017) have resolved to reduce the rooftop target from 40 GW to 20 GW. This is much closer to the expected cumulative deployment of 13.2 GW by March 2021 as estimated by Bridge to India.

Renewable Energy Certificate Mechanism: To align REC prices with the market dynamics, the CERC recently reduced both the floor and forbearance prices for solar and non-solar certificates. The forbearance price of non-solar RECs is now set at ₹ 3,000/MWh and for solar RECs at ₹ 2,400/MWh, while the floor price is ₹ 1,000/MWh for both. Apart from the lack of RPO enforcement leading to poor demand for RECs and the falling prices, the REC mechanism is facing a new, even larger challenge. Large scale and low cost solar and wind projects connected to the ISTS make it feasible to actually transmit renewable power across states, unlike the situation few years ago. Hence it is very likely that renewable energy resource poor states may prefer buying such interstate renewable power to comply with the RPO than procure RECs in the future. The proposed Green Day Ahead Market (G-DAM) will also have the same effect. Given these stark realities, the whole basis for the REC mechanism needs to be examined afresh. Unless the REC prices are truly reflective of the market prices, obligated entities are more likely to seek compliance through other means such as Open Access, Captive, Group Captive, Power Exchanges and rooftop solar net-metering.

Grid Integration: On the issue of grid integration of RE, there is a need for state of the art modelling studies (especially at the state level) to understand the potential additional stress and complexity on system planning and operation specifically due to RE. The economic cost of this integration should be passed on to the RE sector over time. As a first step, states should now quickly finalise the long pending regulations, both the intrastate DSM regulations as well as the forecasting, scheduling and deviation settlement regulations for wind and solar power. In this regard, the Minister has remarked that the penalty on renewable rich states on account of deviation settlement mechanism (DSM) need to be relooked while states not encouraging RE need to be penalised (MoP, 2017b). Essentially a framework to equitably distribute the additional costs of grid integration due to RE among appropriate obligated entities needs to be evolved.

However equally important for RE integration is how the non-RE actors respond. Ideally, states should share resources across their boundaries and coordinate amongst themselves to further reduce the cost of system operation. Given the excess generation capacity compared to the demand, PLFs for coal plants are likely to come down further (48%–53% by 2022) depending on RE growth. The net load curve is expected to be much peakier than the load curve, a good indication of the increased flexibility needed in the rest of the generation fleet to effectively meet demand. The CERC regulated coal plants already have to meet the technical minimum norm of 55% and increasingly coal plants regulated by SERCs may also need to follow this benchmark. The must run status of the renewable energy plants, coupled with the low PLFs for coal and the flexible operation, will have implications for their fixed costs and consequently on their tariffs. Strategic retirement of excess coal generation capacity with very low PLFs may become inevitable, but such a choice should only be exercised after wider consultation with various stakeholders.

Another major challenge going ahead would be with regard to optimal generation capacity planning and appropriate system operation rules. The ERCs need to develop a framework for dealing with 'surplus' capacity while simultaneously increasing the share of RE. This needs to be supported by robust demand forecast (including seasonal and peak/off-peak variation) and capacity addition planning exercises which include RE.

Goods and Services Tax: There is a fear of prices going up if some of the existing renewable energy indirect tax concessions are reduced and/or waivers removed under the GST framework. By taxing 'renewable energy devices and spare parts for their manufacture' at 5%, the GST council has ensured only a modest increase in prices for some sub-sectors. For the highly competitive solar PV sector, we estimate tariffs to increase between ₹ 0.12–0.21/kWh, i.e. 3.1%–5.5% increase under the GST regime, depending on the scenario assumptions. Such a rise in tariff on account of 'change in law' will have to be passed on the procurers based on the terms and conditions of the PPAs.

Sectoral challenges and concurrent nature of electricity: While RE growth has been nurtured through policy-regulatory instruments like preferential tariffs, minimum purchase obligations and waiver from scheduling, until recently, RE will increasingly have to squarely confront the mainstream sectoral challenges. These include the poor financial health of DISCOMs, poor supply quality and weak grids, generation capacity 'surplus' in many states, and the need to provide 24X7 universal and affordable access. Additionally, it also has to navigate the concurrent policy-regulatory terrain of the GoI and states while keeping in mind their differing constraints and capabilities. For e.g., GoI is keen on very aggressive national RE targets since it has to deal with issues around energy security, climate change negotiations, and the current account deficit

(CAD) while the states are more concerned about rising consumer tariffs, DISCOM's financial health, subsidies for agricultural electricity, and system operation. The institutional systems and mechanisms for implementation, monitoring and verification are quite different and in many cases weaker in states in comparison with the centre.

While the high RE price barrier seems behind us, other challenges remain. To effectively deal with them, one needs an agile RE policy-regulatory framework which can proactively and quickly respond to the dynamic sectoral changes in a coordinated manner. The RE industry will also need to step up and respond to these challenges effectively. In short, planning for the RE sector needs to be even more comprehensive and consultative, and should account for wider sectoral realities failing which the RE growth may stutter in spite of the generation price advantage.

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Annexures

Annexure 1

Table 14: Deviation in Prayas (Energy Group) and TANGEDCO estimates in RPO compliance

		2011-12	2012-13	2013-14	2014-15	2015-16
Power purchase and generation	Total power purchased (MUs) (Excluding short term open access, medium term open access, trading bilateral) [A]	34,732	37,174	40,905	40,358	35,419
	Net generation by TANGEDO (MUs) [B]	25,509	22,897	26,609	32,092	29,553
	Total solar purchased (MUs) [C]	11	45	20	25	69
	Total non-solar purchased (MUs) [D]	7,644	9,508	8,316	8,461	3,427
TNERC RPO targets	Solar RPO target (%)	0.5	0.5	0.5	0.5	0.5
	Non Solar RPO target (%)	8.5	8.5	8.5	8.5	9
	Total target (%)	9	9	9	9	9.5
Prayas (Energy Group) estimates of RPO compliance	Solar RPO (%) compliance [C/(A+B)]	0.02	0.07	0.03	0.03	0.11
	Non Solar RPO (%) compliance [D/(A+B)]	12.69	15.83	12.32	11.68	5.27
	Total RPO (%) compliance [E]	12.71	15.9	12.35	11.71	5.38
As per TANGEDCO	Total RPO (%) compliance [F]	14.8	17.51	10.34	9.73	
	Deviation (%) [F-E]	2.09	1.61	-2.01	-1.98	

Source: TANGEDCO (TANGEDCO, 2017a, p. 58), (TANGEDCO, 2017b).

Annexure 2

Table 15: RPO compliance status for Open Access consumers in Maharashtra from 2010-11 to 2013-14

Total RPO Compliance Bands	No of Obligated entities	Average Size (MW)	Solar Target (MU)	Non Solar Target (MU)	Solar Procurement (MU)	Solar RECs	Non Solar Procurement (MU)	Non Solar RECs
0%-20%	72	11.7	33.6	736.8	0	0.0	17.9	1.8
20%-40%	2	15.1	1.0	21.6	0	0.0	0.0	5.6
40%-60%	1	19.7	0.1	2.7	0	0.0	1.7	0.0
60%-80%	2	20.5	0.3	5.7	0	0.3	10.3	11.8
80%-100%	9	7.5	2.0	38.8	0	1.3	77.2	73.3
>100%	4	3.3	0.5	7.9	0	0.5	16.8	16.2

Source: MEDA.

Table 16: RPO compliance status for Open Access consumers in Maharashtra for 2014-15

Total RPO Compliance Bands	No of Obligated entities	Average Size (MW)	Solar Target (MU)	Non Solar Target (MU)	Solar Procurement (MU)	Solar RECs	Non Solar Procurement (MU)	Non Solar RECs
0%-20%	78	1.8	15.9	270.9	0.0	0.0	0.0	0.0
20%-40%	1	5.0	0.1	1.7	0.0	0.0	0.0	0.5
40%-60%	2	9.6	0.3	4.4	0.0	0.2	0.0	2.3
60%-80%	1	1.5	0.0	0.8	0.0	0.0	0.0	0.5
80%-100%	6	4.6	0.3	5.5	0.0	0.4	0.0	5.1
>100%	39	5.2	3.2	54.9	0.1	3.4	4.4	52.5

Source: MEDA.

Table 17: RPO compliance status for CPP consumers in Maharashtra for 2010-11 to 2013-14

Total RPO Compliance Bands	No of Obligated entities	Average Size (MW)	Solar Target (MU)	Non Solar Target (MU)	Solar Procurement (MU)	Solar REC (MU)	Non Solar Procurement (MU)	Non Solar REC (MU)
0%-20%	8	30.1	9.0	211.2	0.0	0.0	0.0	0.0
20%-40%	1	37.5	0.8	22.5	0.0	0.0	0.0	6.1
40%-60%								
60%-80%								
80%-100%								
>100%								

Source: MEDA.

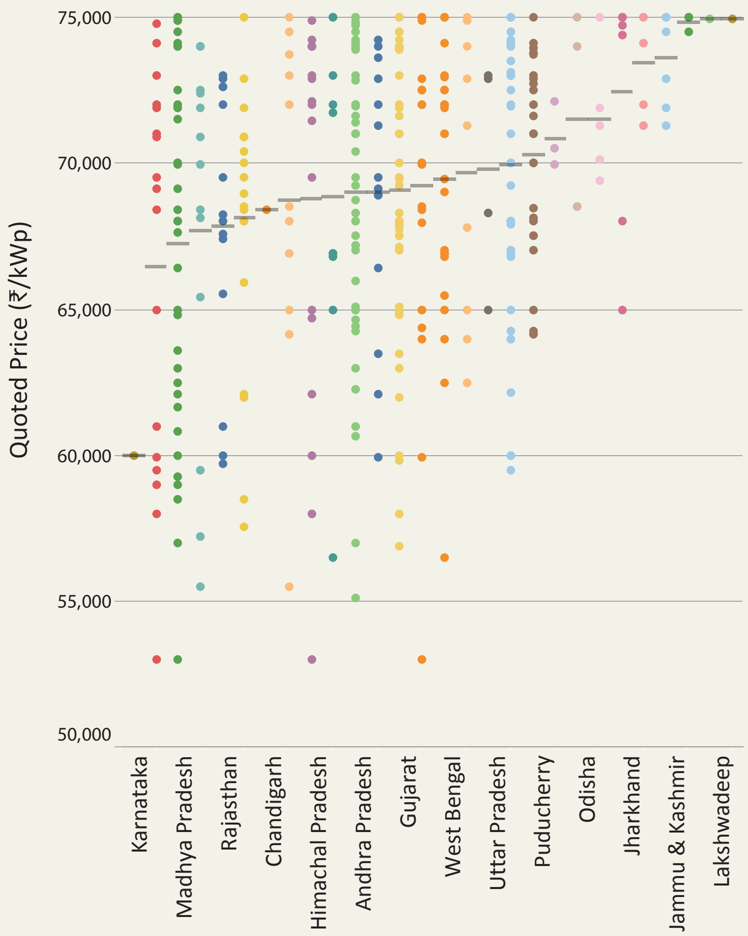
Table 18: RPO compliance status for Open Access consumers in Maharashtra for 2014-15

Total RPO Compliance Bands	No of Obligated entities	Average Size (MW)	Solar Target (MU)	Non Solar Target (MU)	Solar Procurement (MU)	Solar REC (MU)	Non Solar Procurement (MU)	Non Solar REC (MU)
0%-20%	7	44.6	4.7	79.4	0.0	0.4	0.0	7.4
20%-40%								
40%-60%								
60%-80%								
80%-100%	2	36.1	1.2	20.9	0.0	0.6	0.0	20.9
>100%								

Source: MEDA.

Annexure 3

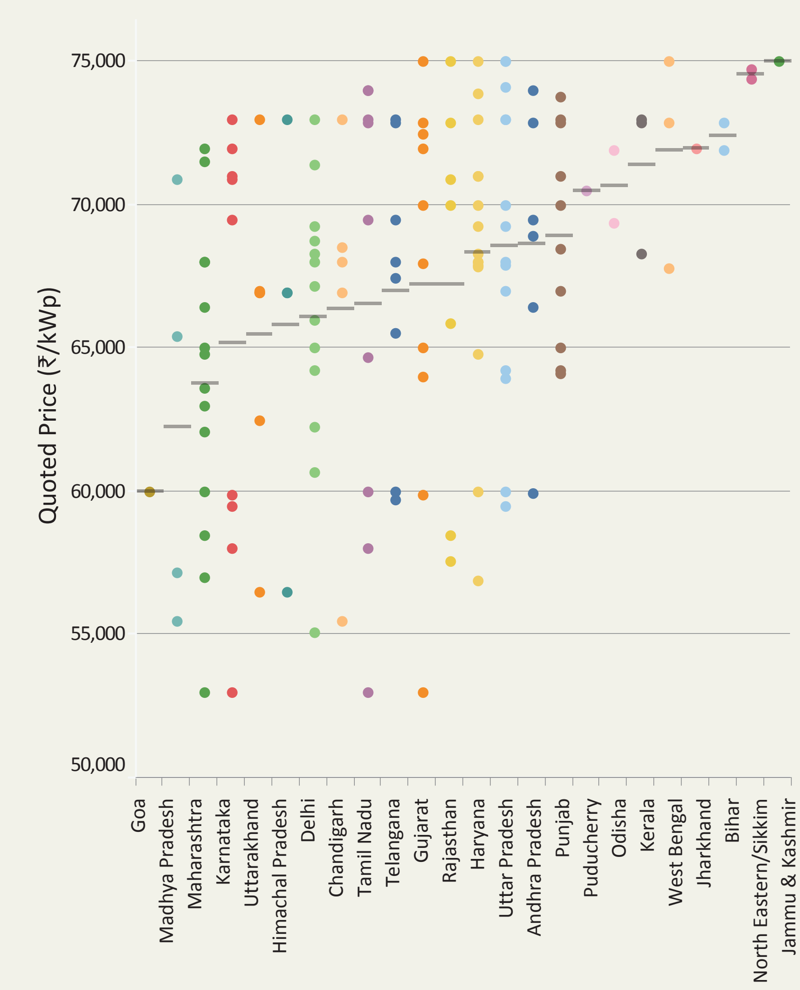
Figure 27 : State-wise quoted rates per kWp for SECI 500 MW rooftop tender of size less than 25 kWp



Average price (₹/kWp)	
Andaman & Nicobar	74,950
Lakshwadeep	74,950
Jammu & Kashmir	74,750
Bihar	74,154
Jharkhand	73,843
Odisha	72,130
North Eastern/Sikkim	71,600
Chhatisgarh	71,500
Punjab	71,272
Tamil Nadu	71,090
Puducherry	71,033
Himachal Pradesh	70,915
Gujarat	70,885
Uttar Pradesh	70,861
Uttarakhand	70,818
Chandigarh	70,722
Delhi	70,196
Madhya Pradesh	70,091
Maharashtra	69,417
Haryana	69,366
Andhra Pradesh	69,353
Telangana	69,003
West Bengal	68,612
Rajasthan	68,594
Dadra and Nagar Haveli	68,400
Karnataka	67,918
Kerala	65,000

Source: SECI; the various colours denote the different bids in those states.

Figure 28: State-wise quoted rates per kWp for SECI 500 MW rooftop tender of size 25–500 kWp



Average price (₹/kWp)	
Jammu & Kashmir	75,000
North Eastern/Sikkim	74,575
Bihar	72,400
Jharkhand	72,000
West Bengal	71,900
Kerala	71,407
Odisha	70,650
Puducherry	70,500
Punjab	68,951
Andhra Pradesh	68,613
Uttar Pradesh	68,568
Haryana	68,330
Rajasthan	67,251
Gujarat	67,228
Telangana	67,008
Tamil Nadu	66,563
Chandigarh	66,384
Delhi	66,093
Himachal Pradesh	65,838
Uttarakhand	65,475
Karnataka	65,201
Maharashtra	63,780
Madhya Pradesh	62,260
Goa	60,000

Source: SECI; the various colours denote the different bids in those states.

Annexure 4

Table 19: Criteria to be met by utilities: Performance Based Incentive Scheme for distribution companies

Mandatory Reforms		Non Mandatory Interventions
Utility Related Actions	Policy and Regulatory Actions	
Simple and effective interconnection process must be in place starting from application to screening for technical feasibility, installation of the system by the consumer and finally inspection and commissioning	PV capacity should be necessarily made equal to the contract demand of consumer	Utility based business models with direct investment in rooftop projects
Setting up timelines for completion of all consumer applications and approvals, including commissioning within 3 months	Less stringent allowance of third party investments for setting up projects	Synergy between incentives proposed by states and the targets for rooftop installations
The framework for net metering and reverse flow of current must be integrated in to the Enterprise Resource Planning System and billing software of the utilities	Increase in allowance of HT consumers to set up more rooftop installations	
Empanelment of suppliers, component vendors and RTS developers by the utility itself can fasten the pace of commissioning. Utilities must tracks all the developers to ensure maintenance of technical standards, quality control and timely grievance redressal	Broadening the scope of net metering by allowing more third party arrangements, while addressing the teething problems through introduction of new concepts like group metering and virtual metering which have already found place in certain state policies like that of Delhi	
	Banking of the solar power has to be made mandatory for all months of the year with complete waiver or exemption from banking charges. There must also be clarity on the period for which open access charges like wheeling charges, banking charges and cross subsidy surcharge are going to be exempted.	

Source: Performance Based Incentive Concept Note (MNRE, 2016e).

List of Abbreviations

ABT	-	Availability Based Tariff
APPC	-	Average Power Purchase Cost
APSPCL	-	Andhra Pradesh Solar Power Corporation Private Limited
APTEL	-	Appellate Tribunal for Electricity
BESCOM	-	Bangalore Electricity Supply Company Limited
CAPEX	-	Capital Expenditure
CEA	-	Central Electricity Authority
CERC	-	Central Electricity Regulatory Commission
CESC	-	Chamundeshwari Electricity Supply Corporation
CFA	-	Central Financial Assistance
CGS	-	Central Generating Station
CGST	-	Central Goods and Services Tax
CPP	-	Captive Power Plant
CSS	-	Cross Subsidy Surcharge
CTU	-	Central Transmission Utility
CUF	-	Capacity Utilization Factor
DAM	-	Day Ahead Market
DCR	-	Domestic Content Requirement
DIC	-	Designated Interstate Transmission System Customers
DISCOM	-	Distribution Companies
DPR	-	Detailed Project Report
DSM	-	Deviation Settlement Mechanism
EPS	-	Electric Power Survey
ERC	-	Electricity Regulatory Commission
FiT	-	Feed-in Tariff
FoR	-	Forum of Regulators
GATT	-	General Agreement on Tariffs and Trade
GBI	-	Generation Based Incentive
GEC	-	Green Energy Corridor
GERC	-	Gujarat Electricity Regulatory Commission
GESCOM	-	Gulbarga Electricity Supply Company Limited
GST	-	Goods and Services Tax
GUVNL	-	Gujarat Urja Vikas Nigam Limited
HESCOM	-	Hubli Electricity Supply Company Limited
HV	-	High Voltage
IEGC	-	Indian Electricity Grid Code

IEX	-	Indian Energy Exchange
IGST	-	Integrated Goods and Services Tax
InSTS	-	Intra-State Transmission System
IREDA	-	Indian Renewable Energy Development Agency
ISA	-	International Solar Alliance
ISGS	-	Inter-State Generating Station
ISTS	-	Inter-State Transmission System
KERC	-	Karnataka Electricity Regulatory Commission
LBNL	-	Lawrence Berkeley National Laboratory
LC	-	Letter of Credit
LDC	-	Load Despatch Centre
LGBR	-	Load Generation Balance Report
LoA	-	Letter of Award
M&V	-	Monitoring and Verification
MAT	-	Minimum Alternate Tax
MCR	-	Maximum Continuous Rating
MEDA	-	Maharashtra Energy Developement Agency
MERC	-	Maharashtra Electricity Regulatory Commission
MESCOM	-	Mangalore Electricity Supply Company Limited
MNRE	-	Ministry of New and Renewable Energy
MoEFCC	-	Ministry of Environment, Forest and Climate Change
MoP	-	Ministry of Power
MPERC	-	Madhya Pradesh Electricity Regulatory Commission
MSEDCL	-	Maharashtra State Electricity Distribution Company Limited
NCEF	-	National Clean Energy Fund
NEP	-	National Electricity Plan
NLDC	-	National Load Despatch Centre
NPC	-	National Power Committee
NREL	-	National Renewable Energy Laboratory
NTP	-	National Tariff Policy
NTPC	-	National Thermal Power Corporation
O&M	-	Operation and Maintenance
OA	-	Open Access
PGCIL	-	Power Grid Corporation of India Limited
PLF	-	Plant Load Factor
POSOCO	-	Power System Operation Corporation Limited
PPA	-	Power Purchase Agreement
PSDF	-	Power System Development Fund
PSU	-	Public Sector Undertaking
PV	-	Photovoltaic

PXIL	-	Power Exchange of India Limited
QCA	-	Qualified Coordinating Agency
RE	-	Renewable Energy
REC	-	Renewable Energy Certificate
RES	-	Renewable Energy Systems
REMC	-	Renewable Energy Management Centre
RESCO	-	Renewable Energy Service Company
ROE	-	Return on Equity
RPC	-	Regional Power Committee
RPO	-	Renewable Purchase Obligation
RTPV	-	Rooftop Solar
SAMAST	-	Scheduling, Accounting, Metering and. Settlement of Transactions in Electricity
SEB	-	State Electricity Board
SECI	-	Solar Energy Corporation of India
SERC	-	State Electricity Regulatory Commission
SGST	-	State Goods and Services Tax
SHP	-	Small Hydro Power
SLDC	-	State Load Despatch Centre
STU	-	State Transmission Utility
TANGEDCO	-	Tamil Nadu Generation and Distribution Company Limited
TAM	-	Term Ahead Market
TNERC	-	Tamil Nadu Electricity Regulatory Commission
TRIM	-	Trade Related Investment Measures
TSSPDCL	-	Telangana Southern Power Distribution Company Limited
UHVDC	-	Ultra High-Voltage Direct Current
UI	-	Unscheduled Interchange
UPNEDA	-	Uttar Pradesh New and Renewable Energy Development Agency
USAID	-	United States Agency for International Development
WTE	-	Waste to Energy
WTO	-	World Trade Organisation

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Record lows in price discovery for wind power (₹ 3.46/kWh) and solar PV (₹ 2.44/kWh) coupled with the highest ever yearly capacity addition of ~11.3 GW of renewables in 2016-17 have compelled even the most ardent sceptics to sit up and take note of renewable energy. Direct generation prices (in simple per kWh terms) no longer seem to be a hurdle to achieve the 175 GW national renewable energy target. While India has been ranked as one of the top two countries for investments in renewable energy according to a prominent country attractiveness index, several new challenges have emerged.

This report highlights the major sectoral developments in terms of deployment, prices, new policies and regulations since last year. It also analyses the major challenges and raises important questions on the future path for various policy-regulatory instruments for renewable energy as its share is set to rapidly increase. This report is an update to the first report looking at India's journey towards 175 GW renewables, published by Prayas (Energy Group) in October, 2016.

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