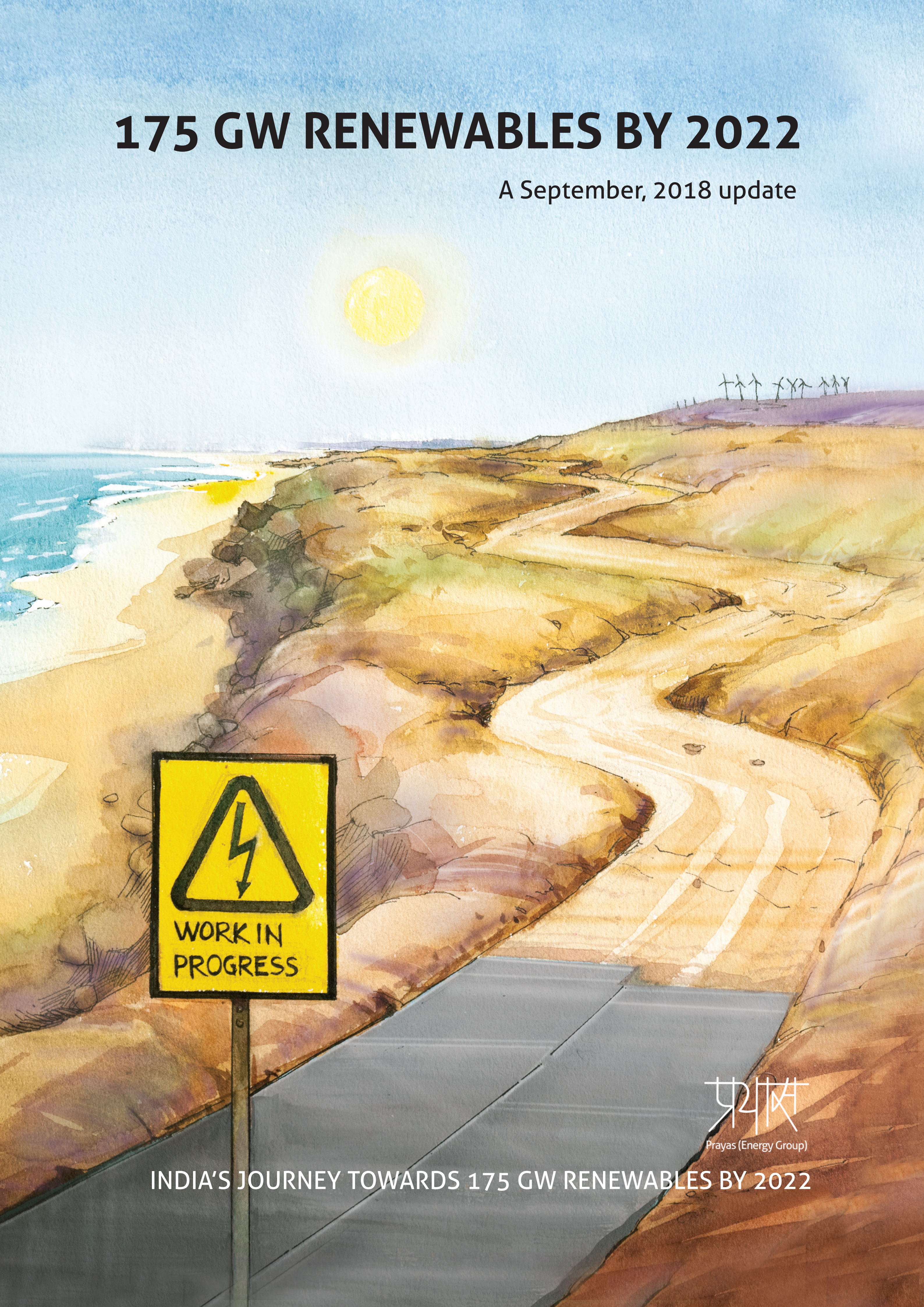
175 GW RENEWABLES BY 2022

A September, 2018 update



Prayas (Energy Group)

INDIA'S JOURNEY TOWARDS 175 GW RENEWABLES BY 2022

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Renewables by 2022

A September 2018 Update

Shiv Vembadi | Nikita Das | Ashwin Gambhir

December, 2018

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 public interest in general and interests of the disadvantaged sections of the society in particular. Prayas (Energy Group) works on theoretical and conceptual regulatory and policy issues in energy and electricity sectors. Our activities cover research and intervention in policy and regulatory areas as well as training, awareness building, and supporting civil society groups. Prayas (Energy Group) has contributed to policy development in the energy sector as part of several official committees constituted by ministries of the central government and of state governments and the Planning Commission. Prayas is registered as a scientific and industrial research organization (SIRO) with the Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India.

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Summary

The contribution of renewable energy (RE) to India's electricity mix continued to grow over the last financial year and marked an important milestone when the absolute growth in RE capacity outpaced that of conventional capacity for the first time. Notwithstanding these developments, the sector stands at crossroads. Many challenges need to be addressed, including the impending disruption of the Discom's business model, insufficient transmission infrastructure and reforms in net metering.

Policy and regulatory support: The central government continues to support the growth of RE through a number of key policy and regulatory measures. During the last financial year, these included notification of renewable purchase obligation (RPO) targets, waiver of inter-state transmission system (ISTS) charges and losses, strengthening of the ISTS under the 'Green Energy Corridor' programme and amendment to the captive generating plant rules to provide more clarity and promote serious long-term investments in the segment. The government has also proposed significant reforms for renewables under the proposed amendment to the Electricity Act.

Growth of renewable energy capacity and generation: In the last financial year, while solar capacity addition showed strong growth (in fact, it was the only source of energy to grow in terms of capacity addition), wind installations slowed down substantially. Wind capacity addition will pick up again from all the large auctions since the introduction of competitive bidding in the sector in December 2017. Solar capacity addition in the present financial year is expected to decline because of the continuing uncertainty surrounding duties. The safeguard duty remains subject to judicial processes, and developers who have been awarded solar projects are concerned about their being compensated adequately and in time, as assured, if the duty is finally levied. Lastly, while cumulative ground-mounted solar and wind power installed capacities are in line with the targets set in 2015, only 10% of the rooftop solar cumulative target had been achieved by March 2018.

Compliance with renewable purchase obligation: States differ widely in the targets they have set with respect to the new guidelines set by the Ministry of Power (MoP). Only a few states have set high enough targets for solar and non-solar energy. Of the fifteen states analysed in this report, seven have set such targets for non-solar power and only five for solar power. Further, the existing process of verifying whether RPO have been honoured continues to be weak and varies a great deal between states. A broader discussion is needed on this centre–state mismatch with respect to the target of 175 GW by 2022, because in the future, states will play a more decisive role in the growth of RE.

Renewable energy certificates: Since trading began in 2011, it has not been an easy journey for the renewable energy certificate (REC) market. More recently, the fall in RE prices below the national average power purchase cost has resulted in a distortion in the REC market. However, REC trading showed encouraging signs in the past one year, a result of increasing pressure to comply with RPO. From March 2017 to March 2018, the unsold stock of non-solar RECs decreased from 12.9 million to 1.5 million, while the traded volume (in the monthly trading sessions) increased from 0.9 million to 2.8 million. In this, Discoms have been the biggest buyers among the obligated entities. However, more attention needs to be paid to the other obligated entities (captive and

open access consumers). The role of RECs in the overall RE market is expected to decrease in the future. Currently, the capacity registered under the REC mechanism is 7% of the total RE capacity. This share will decrease as RE grows strongly and, with the auctioning of large ISTS-connected projects across the country, will help to overcome the uneven distribution of RE resources across the country.

Tenders and auctions: Competitive bidding in solar starting in 2010 and more recently for wind, starting in 2017, has helped to make RE competitive with conventional sources of energy. In the case of solar, between 2012 and 2018, solar tariffs discovered through competitive bidding have fallen by roughly 75%. In case of wind power, after the first competitive bidding in February 2017, the prices of wind power also dropped quickly to match those of solar power. Going ahead, the Ministry of New and Renewable Energy (MNRE) has set tender targets of 20 GW for solar power and 10 GW for wind power for FY 2018-19. This also includes tendering of a large capacity linked with manufacturing capacity to help create an entire domestic supply chain. However, the duties, and worries about insufficient transmission infrastructure to evacuate the power, have put the central government's tendering plans under question.

Rooftop solar: Rooftop solar is the only RE segment that lags behind markedly in achieving the targets set by the central government. By August 2018, only 1.2 GW of the 40 GW target by 2022 had been achieved, according to the MNRE. Similarly, the target for 2018-19 is 1000 MW whereas in the original announcement in 2015, it was 10,000 MW. Two missing pieces in rooftop solar are the residential segment and the Discoms. The residential segment faces a few problems including low awareness, availability of and delays in subsidies and a variety of issues pertaining to user interface and consumer experience with Discoms. On the other hand, Discoms, who have an important role to play, have not been particularly encouraging towards their consumers shifting to rooftop solar because the Discoms stand to lose revenues from such a movement. To expedite the growth of rooftop solar, the challenges facing the rooftop solar need to be addressed and a major policy and regulatory shift is needed to make the net metering rules more balanced for all stakeholders.

Open access: Open access (OA) has major implications for Discoms in the future. With their deteriorating financial health, Discoms must take steps to reenvision their business model. One such step is to take cognisance of the inevitable sales migration by ensuring that all migration, be it captive or OA, happens for the long term, i.e. permanently. Majority of OA is currently short term. One way to ensure such migration is to provide certainty in the medium term with regard to the charges for OA. Further, the Discoms need to bring down their rising average cost of supply.

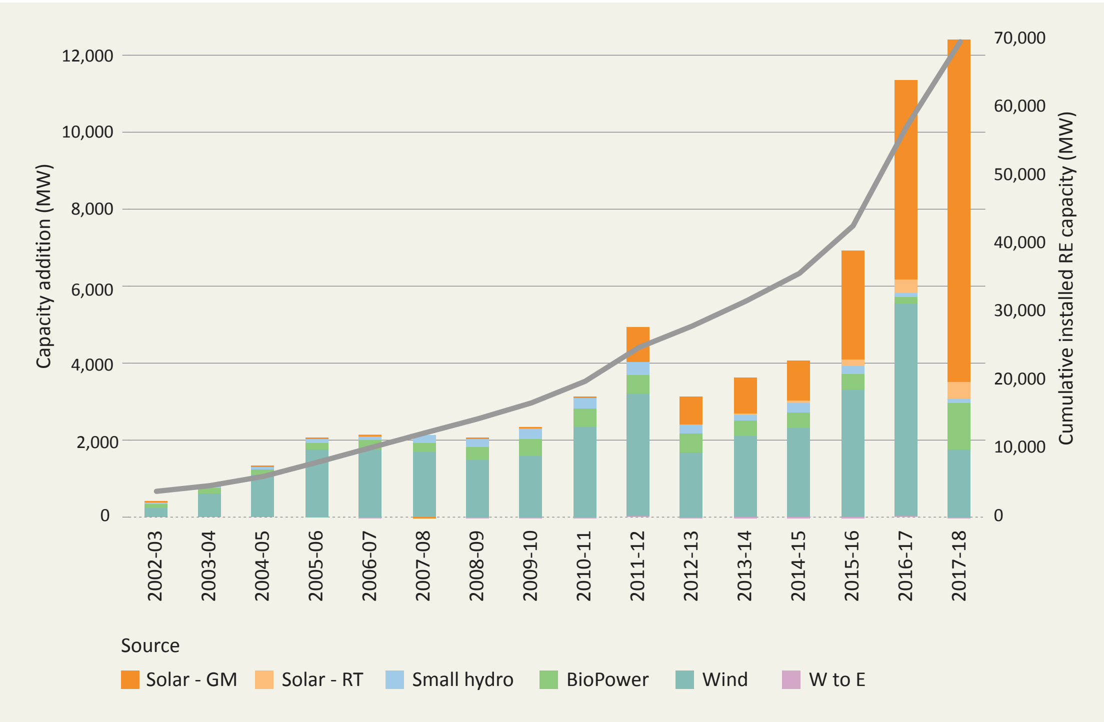
Grid integration of renewables: Reliable grid integration is one of the most, if not the most, important technical issue in the future. Various initiatives are under way to ease the hurdles to such integration. These initiatives include new regulations for transmission connectivity for RE, making the supply more flexible by introducing primary, secondary and tertiary reserves and proposal for newer ancillary services such as voltage control and black start. Greater regional cooperation among states can help reduce integration costs by reducing balancing requirements. In this regard, the Forum of Regulators subcommittee has recommended moving away from the present practice of energy banking between states and moving towards a pool-based auction mechanism. Periodic amendments to state grid codes remain a priority. Finally, increasing complexity of grid operation and tariff and commercial settlement methods will need advanced modelling tools by stakeholders to understand potential stress points and intervention areas for highest leverage.

Solar power in agriculture: The drop in solar prices coupled with its modularity makes it an excellent choice for powering pump-sets to irrigate crops. Building on the success of the off-grid pump programme, the MNRE has proposed an ambitious programme, namely Kisan Urja Evam Utthan Mahayojna (KUSUM), which is targeting close to 30 GW of capacity for solar pumps and decentralised solar plants. The state governments are also experimenting with various innovative programmes. While Gujarat and Karnataka are incentivising grid-tied AC pump-sets with capital subsidies and a high buy-back rate for power fed into the grid, Andhra Pradesh is promoting DC pumps that cannot use power from the centralised grid but can feed back into the grid as needed. Delhi is starting a unique programme of promoting solar plants on farm lands. Solar power from these plants will be procured by various departments of the Delhi government. Farmers will be assured of rents for their land as well as some free power. Finally, Maharashtra is innovating with a solar agriculture feeder programme with dedicated tail-end grid-connected solar plants exclusively for agriculture. This programme not only does not need any subsidies but also has the potential to lower agriculture subsidies from the electricity sector.

1. Introduction

This report is the third in our series of yearly reports tracking the growth of renewable energy (RE) in the electricity sector in India. Although RE continued to grow apace in the financial year (FY) 2017-18 (Figure 1.1), the solar power sector also faced major headwinds owing to uncertainties such as those in the imposition of duties. The growth in RE is underscored by the fact that 2017-18 was the first year in which capacity addition in RE outpaced that in conventional power—and by a wide margin: 12.5 GW of RE compared to 6.1 GW of conventional capacity. Another landmark in 2017 was that in the electricity sector, investments in RE surpassed those in conventional sources of energy, as reported in the International Energy Agency's World Energy Investment 2018, published in July 2018 (ET, 2018g). Recently, the first wind project connected to the inter-state transmission system (ISTS) was commissioned in Gujarat (ET Energy World, 2018b). This project was awarded in February 2017 by Solar Energy Corporation of India (SECI) as part of the first ever auction in the wind sector.

Figure 1.1. Grid-connected RE capacity addition and the growth in cumulative RE capacity.



Source: MNRE

Since the publication of the second edition of this report last year, in September 2017 (PEG, 2017d), the RE policy landscape has changed significantly. Changes such as amendments to the solar and wind bidding guidelines and the national trajectory of renewable purchase obligation (RPO) coupled with emphasis on compliance with those obligations and removal of concessions in open access (OA) charges by some states including Tamil Nadu and Maharashtra served to make the future of the sector more certain. At the same time, the sector was plagued by other uncertainties. The investigation around anti-dumping duty, port duty and safeguard duty left the solar industry in a flux. Concerns of developers over lack of adequate transmission capacity led to a poor response to several tenders, resulting in them being cancelled or modified. However, despite these recent hiccups, the Ministry of New and Renewable Energy (MNRE) is confident of achieving the target of 175 GW by 2022 in time and has chalked out a trajectory for wind and solar power tenders up to 2019-20 for the purpose. More recently, the ministry has even suggested that the target may be exceeded by 50 GW (ET, 2018c).

However, many challenges need to be overcome before the committed targets can be delivered upon[1]. The first and foremost is the slow deployment in the rooftop solar segment, which is unlikely to change its course dramatically unless an innovative option is found to meaningfully bring the distribution companies (Discoms) on board. Secondly, transmission planning and installation of new lines will need to be ratcheted up to keep pace with the deployment of RE. Grid operation with increased share of renewables, considering their diurnal and seasonal variations, needs to be quickly modernised, beginning with the implementation of the forecasting, scheduling and deviation settlement mechanism (DSM) in all the states. Finally, the country needs to take a balanced view of encouraging RE manufacturing and the levying of various duties, which will discourage imports or make them costlier in the short run.

We are exactly at the midpoint of the seven-year period beginning February 2015 when the target of 175 GW by 2022 was announced. Unless we urgently take steps to learn from the past and make appropriate amendments for the future, we are likely to miss the target.

Broad Outline of the report: Prayas's two earlier reports with the same title were published in October 2016 (PEG, 2016a) and September 2017 (PEG, 2017d). This report continues to survey the progress towards 175 GW and takes the story forward. Although the present report covers the period from September 2017 to September 2018, it should be read along with the first two reports. The report begins with a summary, which highlights the learnings from all the subsequent chapters. After the context-setting introduction, the second chapter details various changes in the policy and regulatory landscape during the past one year. The next three chapters chronicle the growth in RE capacity, deployment, actual generation and the contribution of enforcing compliance with RPO including that of renewable energy certificates (REC). The sixth chapter looks at price discovery in wind and solar tenders and critically notes various amendments to the bidding guidelines for these technologies. This is followed by a very short update on the rooftop solar and OA segment. Finally, we have a detailed write-up on various aspects of grid integration of renewables, a crucial variable for increasing the share of RE.

A note on data used in this report: Data reported in this edition of the report are up to September 2018, unless specified otherwise. Publications and information included are also as of September 2018. Starting from this edition, the report is being structured so as to be read in conjunction with the Renewable Energy Data Portal (REDP), which is hosted on our website and contains all the RE illustrations. The portal is an effort by Prayas (Energy Group) to collate all the important data, already available in the public domain, at one place and present them to highlight the rapidly expanding role of RE in the electricity system. Another feature of this effort is the interactive nature of the portal, which allows users to look at specific bits of information across RE sources, across different states in India and over time. All the visuals can be downloaded. The portal was inaugurated in December 2016, revised first in November 2017, and revised again in June 2018 to include more data and to offer better infographics.

1 Very recently, Wood Mackenzie forecast that India will only meet 76% of its 175 GW target (GTM, 2018).

2. National and State Policy and Regulatory Updates

A number of key policy and regulatory announcements have been made by the central government as well as various state governments since the previous edition of this report. Some of the important updates are discussed below.

2.1 Central Government

Draft amendment to the Electricity Act, 2003: In September 2018, the Ministry of Power (MoP) issued draft amendments to the Electricity Act, 2003, for public consultation. Some of the important provisions with regard to renewables were as follows. Firstly, the act mandates the central government, in consultation with state governments, to come out with a new national renewable energy policy. Secondly, although the act has entrusted the state electricity regulatory commissions (SERC) with the additional responsibility of promoting net metering, it has divested them of the powers to specify RPOs, giving those powers to the central government instead. Some of these newer provisions are critically analysed here.

Generation and supply based on renewable energy: Proviso 18 of Section 14 of the draft amendment specifies that any persons generating and supplying electricity from RE sources do not require a licence for these activities. Since such persons are authorised to supply electricity under Section 42 (7) of the draft amendment, consumers may not need to apply for OA to obtain electricity from these suppliers. It is thus possible for a generator to apply for OA and pay the applicable transmission and wheeling charges for the use of wires to supply electricity to a customer. Because such customers are not OA consumers, they need not pay the cross-subsidy surcharge (CSS) or its equivalent as specified in Section 42 (6) of the draft amendment. Interpreted thus, the provision can increase sales migration significantly and will broaden and deepen market operations substantially. However, it is not clear whether the provision was intended for such large-scale adoption of RE-based generation and supply services or merely as a measure to make it easy to sell renewable power generated from a small area (e.g. rooftop solar PV) to a small number of consumers by a third party such as a renewable energy service company as defined in Section 2 (57B) of the draft amendment. If the MoP intends to facilitate transactions on a much larger scale, it will be necessary to install a special energy meter at every point from which such supply is drawn and to make the supply subject to an appropriate balancing and settlement mechanism. State regulatory commissions should also be mandated to draft appropriate regulations and to ensure that due processes are in place to facilitate energy accounting, metering and balancing with respect to such supply arrangements.

Penalties for non-compliance with renewable purchase obligation: The proposed Section 57 (1A) of the amendment stipulates that in case of non-compliance with RPO by the licensee, the regulatory commission may impose a penalty ranging from ₹1 to ₹5 for every unit (kWh) by which the licensee falls short of the obligation specified by the commission. Although the principle and the need to specify a penalty per unit to ensure better compliance are commendable, it is desirable that the actual value of the penalty for non-compliance be specified by the appropriate commission in its regulations instead of leaving it to the act to do so. Further, such penalties should be imposed not only on licensees but also on all obligated entities, including captive and OA consumers, to whom the RPO is applicable. To operationalise this, the penalty specified by the respective state commissions can be based on or linked to the average cost of RE generation and applied on the total quantum of the shortfall.

Section 7 of the draft amendment specifies an obligation to generate a minimum quantity of RE, or the renewable-energy generation obligation (RGO), on part of new thermal generation plants or any planned expansions of existing plants. This renewable power can be sold bundled with thermal power, to be counted towards the RPO compliance of the procurer. Stiffer penalties for non-compliance and a push to facilitate OA coupled with doing away with the requirement to obtain a license for generating and supplying RE power will contribute a great deal to adding RE capacity: these measures make any additional instruments such as RGO redundant. Those instruments that force thermal power plants to add RE capacity will only make energy accounting, scheduling etc. more complicated, and it is best to leave it to the obligated entities to choose the means through which to meet their RPO—so long as the means are within the provisions of the act and the regulatory framework.

Wind–Solar hybrid policy: In May 2018, the central government finalised the new wind–solar hybrid policy (MNRE, 2018h), which was based on the draft policy released for public consultation in June 2016. Wind and solar power, being variable, makes grid planning and operation more complex. But the two sources complement each other and can be used to reduce the overall variability. The proposed policy framework will guide the development of wind–solar hybrid projects that have moderate to high potential for both the sources of energy. Further, hybridisation will allow land and transmission infrastructure to be used more efficiently. In June 2018, SECI released a tender for 2500 MW of such hybrid capacity, but the lukewarm response from developers has cast some doubt on the success of the proposed auction.

Kisan Urja Evam Utthan Mahayojna (KUSUM): The central government has proposed a new scheme (which, literally, means a grand plan for promoting energy for farmers) to promote the use of solar power in agriculture. The scheme was announced by the union finance minister in his speech before the parliament to present the annual budget for 2018-19 (MNRE, 2018d). The scheme has set an ambitious target of 28,250 MW of solar PV, to be achieved in four components. The first component intends to achieve 10,000 MW from decentralised, ground-mounted, grid-connected solar power plants with capacities ranging from 0.5 MW to 2 MW. The next two components intend to achieve 8250 MW by setting up 17.5 lakh stand-alone solar pumps (of capacities up to 7.5 hp) and 7500 MW by setting up 10 lakh grid-connected solar pumps (of capacities up to 5 hp). The grid-connected pumps would be owned by farmers, who would be allowed to sell any surplus energy to the grid, thereby providing them with an additional source of income. The final component intends to achieve 2500 MW by powering 50,000 grid-connected tube-wells, lift irrigation schemes, and projects to supply drinking water with large (50 hp) pumps operated by the departments of state governments (Standing Committee on Energy (Sixteenth Lok Sabha), 2018). The entire scheme is likely to require a support of ₹1.44 lakh crore; however, it is yet to be approved by the Ministry of Finance (MoF) (Business Standard, 2018).

National Energy Storage Mission: Akin to the National Solar Mission, the central government is in the process of finalising the National Energy Storage Mission. In February 2018, the MNRE constituted an expert committee on energy storage to propose a draft for the mission (PIB, 2018). The committee has 'proposed a draft NESM with objective to strive for leadership in energy storage sector by creating an enabling policy and regulatory framework that encourages manufacturing, deployment, innovation and further cost reduction.' Energy storage will be critical to India's future plans for electric mobility and integration of a greater share of RE into the grid.

Captive Generation Plant Rules (draft): The central Ministry of Power has released draft amendments to the provisions relating to group captive generating plants in Electricity Rules, 2005. The first draft was released in October 2016 to invite comments and suggestions from stakeholders and, based on the comments received, a revised draft was released in May 2018 (MoP, 2018e). These changes seek to make the rules more flexible and to encourage serious long-term investments in captive generating plants. A critical proposed amendment is to disallow the ownership of such plants through preference share capital for a group captive consumer. For a captive generating plant, the captive users will invest a minimum of 26% of the equity share capital with proportional voting rights. Also, the captive users will consume a minimum of 51% of electricity generated annually: if any of the captive user does not consume the quantum of electricity in proportion to his or her share in the ownership, with a permissible variation of 15% in general and up to 30% for solar and wind plants as stipulated in the provisions, the captive status of the generating plant will be taken away as a whole. Currently, a 10% variation is allowed; the proposed amendment thus makes the consumption requirement more flexible. The proposed amendments also bring in more clarity with respect to group captive plants (crucial for renewables), verification of consumption data of the group captive consumers and changes in shareholding patterns. However, even greater clarity is needed and some provisions need to be spelt out in greater detail (PEG, 2018a).

Solar PV anti-dumping and safeguard duty: The last year saw some uncertainty about duties strongly affecting the confidence of the sector, leading to a slowdown in tendering for capacity and a slight rise in solar tariffs. In July 2017, the Directorate General of Anti-Dumping (DGAD) initiated an investigation into anti-dumping duty on the import of solar cells and modules based on a petition filed by solar manufacturers; however, they withdrew the petition (LiveMint, 2018a; Mercom India, 2017a). Domestic manufacturers are expected to file a fresh petition based on the current market situation. The investigation is expected to continue through FY 2018-19. This is the second time an antidumping duty is being investigated; the first case was spread over 2009–14 but no duty was imposed in the end.

Further, an investigation on safeguard duty on imported solar cells and modules has put the industry in a flux since December 2017 (Renewable Watch, 2018d). Following preliminary findings, hearings, court cases and a final detailed submission by the Directorate General of Trade Remedies, the MoF finally announced a levy of 25%, effective July 30, 2018, for one year, reducing to zero by the end of the second year. Soon after the announcement, Odisha High Court stayed the MoF order, which was later overruled by a Supreme Court directive in September 2018. With this final decision on the levying of safeguard duty, an important question remains: What happens to projects for which the bidding process has been completed? A duty of 25% on solar cells and modules can increase tariffs by more than 30 paise per unit (EQI, 2018a). This possibility led the MNRE to clarify, in April 2018 (MNRE, 2018f), that any imposition of duty after the submission of a bid will be considered as a change in law under the guidelines for competitive bidding (Chapter 5 has more information on these guidelines), and the solar developer will be entitled to a compensation. However, even if the developers are allowed to pass on the duty to the procuring Discoms, the industry is sceptical of the Discoms's ability to bear the extra costs and of the pass-through being approved quickly enough by the Central Electricity Regulatory Commission (CERC) or by the SERC in response to a petition by the solar developers. Only a few tenders in recent past (such as the successful tendering of 200 MW by the Grid Corporation of Orissa in July (Mercom India, 2018g) have clear provisions for passing on such a duty. In August 2018, the MoP wrote to the CERC to expedite the hearing of the petitions on the pass-through of duty to avoid financial stress to solar power developers (MoP, 2018g), and the MNRE also recently wrote to the MoF (ET, 2018h) that the already-awarded projects be exempted from any duty. However, there has been no notification from the MoF on this issue.

Waiver of inter-state transmission system charges and losses: To promote further rapid growth in RE capacity, the MoP, in February 2018, extended the waiver of inter-state transmission charges and losses for transmission through the ISTS for wind and solar projects commissioned up to March 31, 2022 (MoP, 2018d). Prior to the notification announcing this extension, the exemption was available for solar projects commissioned up to the end of 2019 and for wind projects commissioned up to the end of March 2019 as per the provisions in the CERC (Sharing of Inter-State Transmission Charges and Losses) (Fifth Amendment) Regulations, 2017.

National trajectory for renewable purchase obligation: In June 2018, the MoP issued guidelines raising the RPO to 21% by 2022, divided equally between solar and non-solar power; in other words, 10.5% of the total consumption of electricity, excluding that met from hydro sources, should be met from solar power and 10.5%, from non-solar sources.

Off-grid and decentralised solar PV application programme: Further in decentralised solar energy, the central government approved Phase 3 of the Off-grid and Decentralised Solar PV Application Programme (CCEA, 2018). The programme aims to create additional 118 MWp capacity by 2020, through 3 lakh solar street lights, stand-alone solar power plants adding up to 100 MWp and 25 lakh solar study lamps. By July 2018, 761 MW of off-grid solar PV systems had been set up (MNRE, 2018k). The programme is estimated to benefit 40 lakh households in rural areas where grid power has either not reached so far or is not reliable.

2.2 State Governments

Uttar Pradesh and Goa solar policies: Since the release of the previous edition of this report, new solar energy policies have been announced in Goa and in Uttar Pradesh. The new solar policy in Uttar Pradesh (UPNEDA, 2018), released in December 2017, exempts the sale of solar power within the state from transmission and wheeling charges; inter-state sale of solar power to a third party is also exempt from both CSS and wheeling and transmission charges up to points within the state. In December 2017, the Government of Goa approved the draft solar policy that had been released in July 2017 (GEDA, 2017). The policy, which will be in force for 7 years, states that for plants up to 100 kW, the rooftop solar plant owner or the developer will receive financial assistance up to 50% of the benchmark cost provided by the MNRE or up to 50% of the capital cost, whichever is lower.

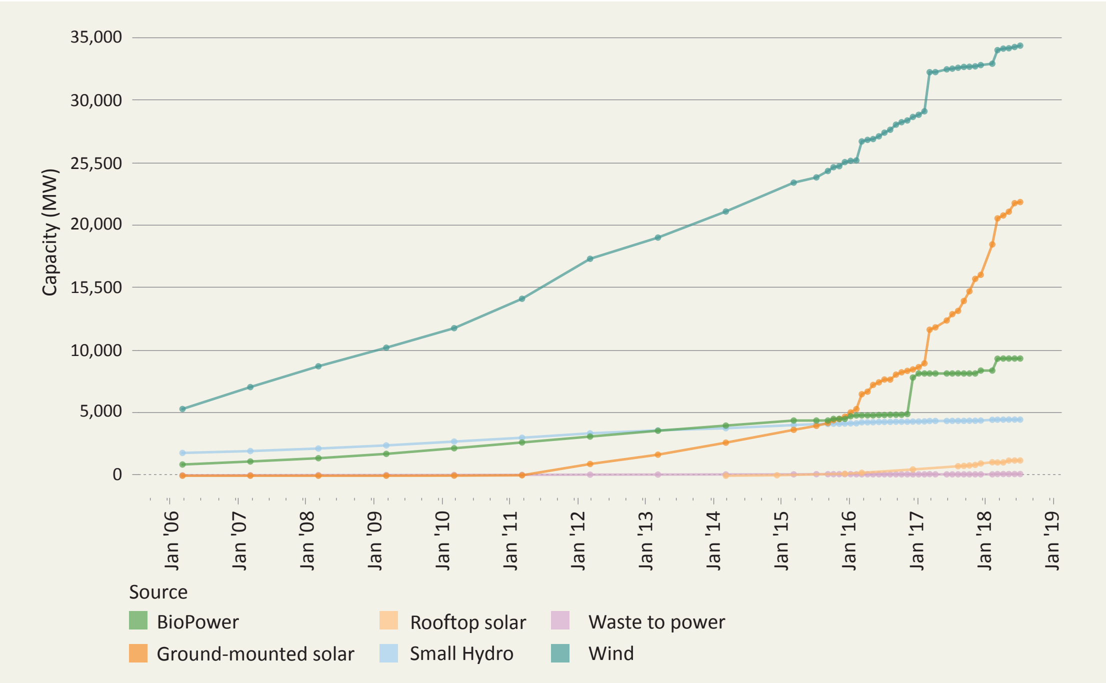
Solar power for agriculture: In yet another positive development for RE is the scheme to use solar power specifically for irrigating farm lands launched in June 2017 by Maharashtra as the Mukhyamantri Agricultural Solar Feeder Scheme, which was amended in March 2018 to remove some operational difficulties (GoM, 2018b). The policy envisages setting up distributed tail-end grid-connected solar PV plants (2–10 MW), which would be connected to the 11/33 kV substations and used for meeting irrigation needs on separate agricultural feeders. Unlike the Maharashtra model, other states including Rajasthan (GoR Directorate of Horticulture, 2017), Chhattisgarh (CREDA, 2018) and Tamil Nadu (The Hindu, 2018) have major schemes to provide solar pumps at subsidised rates or to provide additional subsidy beyond the central financial assistance (CFA).

3. Renewable Energy Capacity and Generation

The rapid rise in RE capacity continued in FY 2017-18, increasing from 57.2 GW to 69.7 GW, a growth of 12.5 GW, or 21.7%. Figure 3.1 shows the source-wise growth in cumulative installed capacity since 2006. During the same period, conventional capacity increased from 318.4 GW to 324.5 GW, a gain of 6.1 GW. (These figures take into account both utility capacity and captive conventional capacity; the sources for these are further elaborated in REDP.) Thus FY 2017-18 was the first year in which the growth in RE capacity outpaced that of conventional sources—and by a significant margin. In the previous financial year, RE, by registering a growth of 11.3 GW[2], or 24.7%, had come close to conventional capacity addition of 12.3 GW.

The share of RE capacity in total installed electricity capacity (both utility capacity and captive capacity) increased from 15.4% to 17.7% by the end of March 2018 (Figure 3.2). Much of the RE capacity addition came from the growth in solar power, which contributed 8.9 GW, or 71.8%, of the total addition. Moreover, solar was the only energy source to grow year on year. As illustrated in Figure 3.3, from FY 2016-17 to FY 2017-18, solar capacity addition increased from 5.5 GW to 8.9 GW whereas that in the case of wind decreased from 5.5 GW to 1.8 GW and that in the case of utility coal decreased from 7.0 GW to 5.0 GW.

Figure 3.1. Growth in cumulative capacity of different RE sources. Data till July 2018 has been plotted. Refer to REDP for more details and future updates.

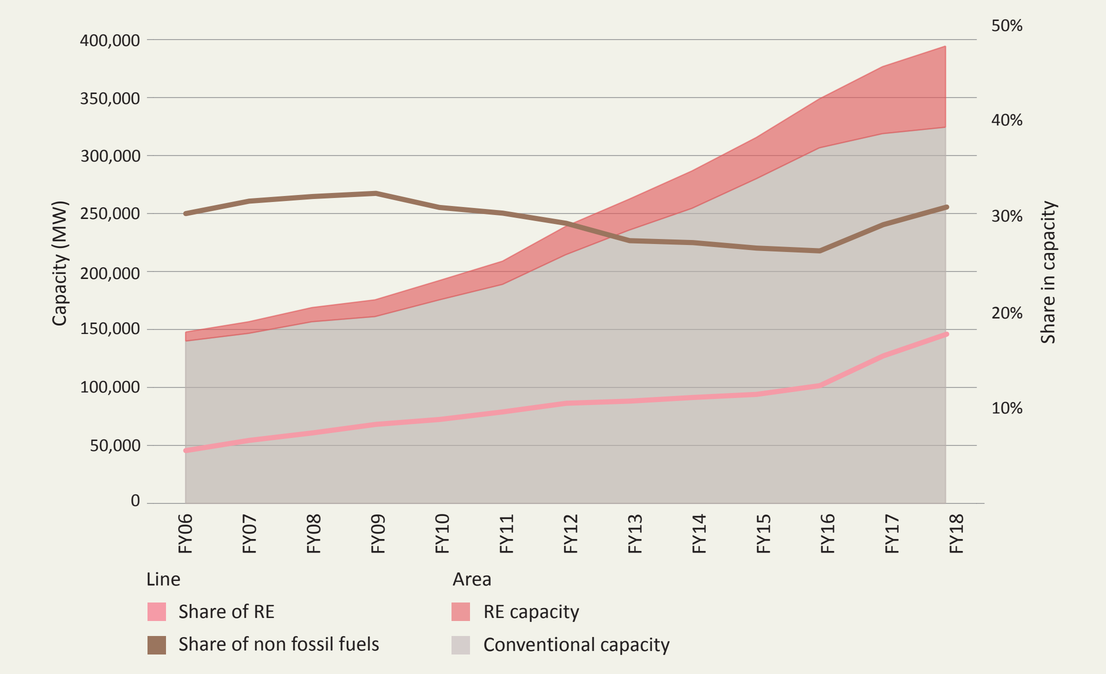


Source: MNRE

Notes: Data up to July 2018. Data from March 2006 to March 2015 are yearly, but are available for shorter intervals from March 2015. Data on rooftop capacity, taken from the MNRE, include capacity added under the central government's Grid Connected Rooftop and Small Solar Power Plants Programme. These figures are much lower than the market estimates. Refer to REDP for more details and future updates.

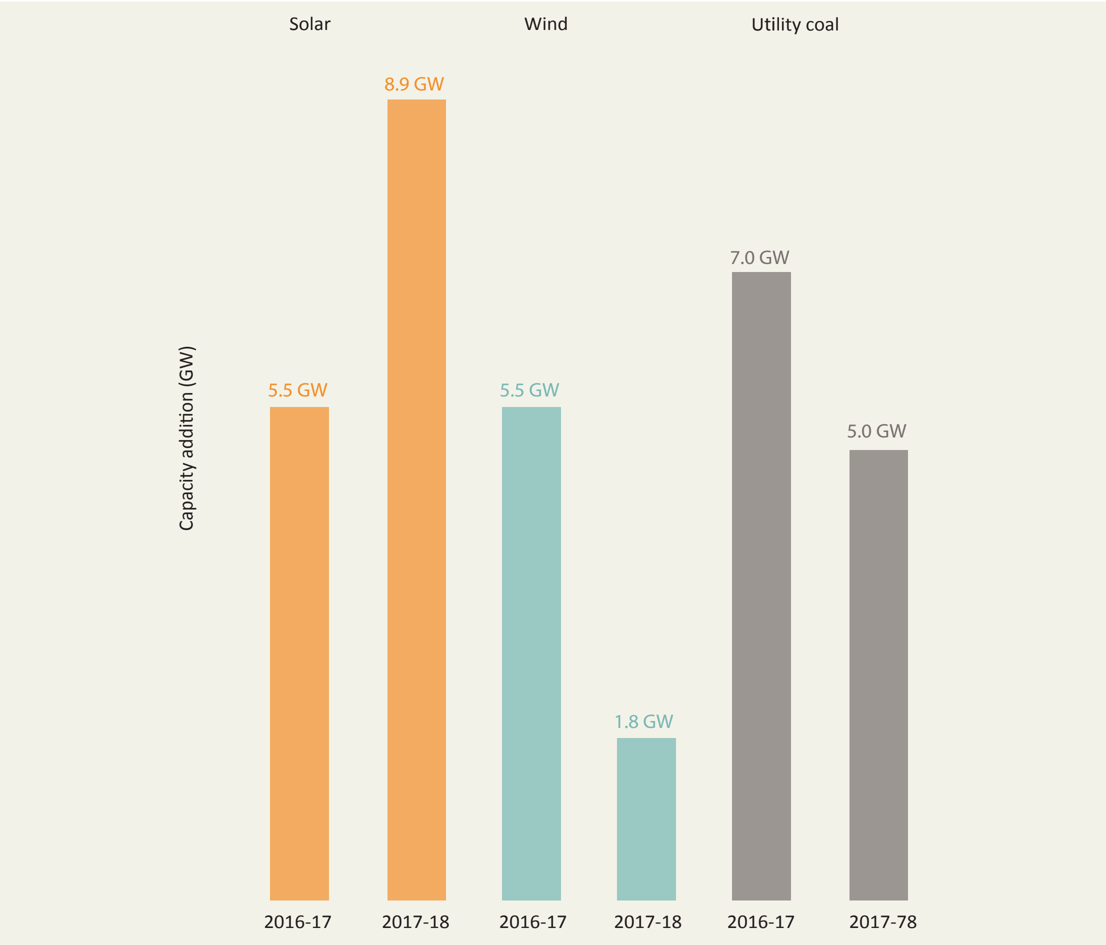
2. As was detailed in the previous edition of the report, the 11.3 GW growth is after adjusting for corrections in biopower capacity data made by MNRE.

Figure 3.2. Changing RE and conventional capacity mix over time. Refer to REDP for more details and future updates.



Source: MNRE, CEA, MoSPI

Figure 3.3: Capacity addition across solar energy, wind energy and utility coal.



Source: MNRE, CEA

Apart from the figures above, other infographics on RE capacity data in REDP include distribution of RE capacity by state, performance with respect to RE targets up to 2021-22 and installed electricity capacity (by five-year plans: past data from the end of the 9th Five-Year Plan and future capacity up to the end of the 14th Five-Year Plan).

The drastic fall in wind installation activity occurred along with the introduction of competitive bidding in the sector. The first wind project was auctioned in February 2017 by SECI (SECI, 2017a), and thereafter the tariffs fell quickly, with ₹2.43/kWh being discovered in December 2017 in the auctioning of 500 MW by Gujarat Urja Vikas Nigam Ltd (GUVNL) (Mercom India, 2017b). This is one paisa lower than even the lowest solar tariff ever discovered. A total of 4.4 GW of wind capacity was auctioned during FY 2017-18, out of which 3 GW was by SECI. Most of this capacity is slated to come online in 2019-20. On the other hand, a slowdown in tendering activity owing to various uncertainties facing the solar sector such as import duties and lack of transmission capacity (see Chapter 5) saw only 4.5 GW of utility-scale solar capacity being auctioned in 2017-18, and FY 2018-19 is expected to see a similarly trailing capacity addition once again in the case of wind power (LiveMint, 2018d) and a decline in the case of solar power.

The highest solar capacity was added in Karnataka (4.1 GW) followed by Telangana (BTI, 2018b). With this, Karnataka, at 5.2 GW, became the leading state in installed solar capacity by the end of March 2018, followed by Telangana (3.2 GW), Rajasthan (2.3 GW), Andhra Pradesh (2.6 GW), Tamil Nadu (1.6 GW) and Gujarat (1.4 GW). The graphs on REDP show installed solar (as well as other RE sources) capacity by state. At the end of March 2017, the leading states in installed solar capacity were Andhra Pradesh (1.9 GW), Rajasthan (1.8 GW), Tamil Nadu (1.7 GW), Telangana (1.3 GW) and Gujarat (1.2 GW). Karnataka went from being sixth in terms of capacity (1 GW) at the end of 2016-17 to being the leading state at the end of 2017-18 aided by a favourable OA market under its solar policy.

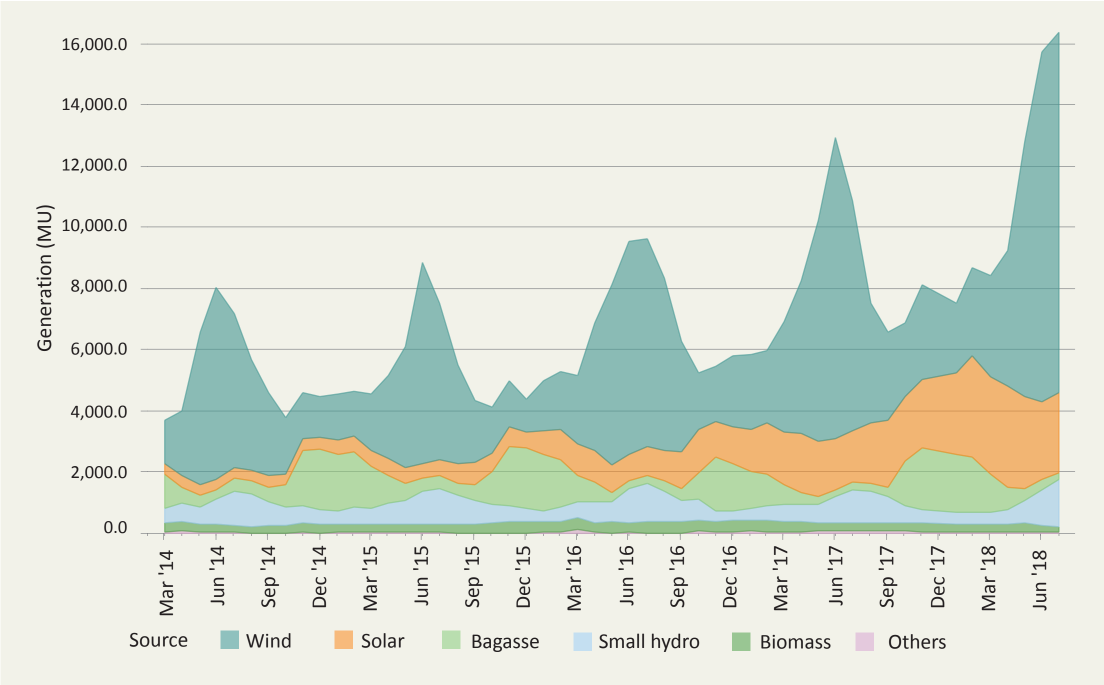
In November 2017, the Minister for Power and Renewable Energy laid down tender targets up to FY 2019-20, which are summarised in Table 3.1. The central government planned to invite bids for a total of 70 GW of solar power and 32 GW of wind power in three years (FY 2017-18 to FY 2019-20). Together with installed capacity as on March 2017, the total capacity comes to 142.6 GW; adding the capacity of 14 GW in the pipeline as of March 2017, the total capacity increases to 157 GW, very close to the target of 160 GW solar and wind power by 2022. It remains to be seen whether such rapid increase in capacity addition will be sustained, especially given the broader problems in the power sector of surplus capacity in states and the poor financial health of Discoms. (Reaching the RE targets would mean adding on average about 30 GW each year from 2019 to 2022 compared to 12.4 GW added in the last financial year, the highest so far.)

Table 3.1.Tender targets (GW) for solar and wind power.

Source	Installed capacity as on March 31, 2017	Tender target for FY 2017-18	Tender target for FY 2018-19	Tender target for FY 2019-20
Solar	12.3	20	20	30
Wind	32.3	8	10	10

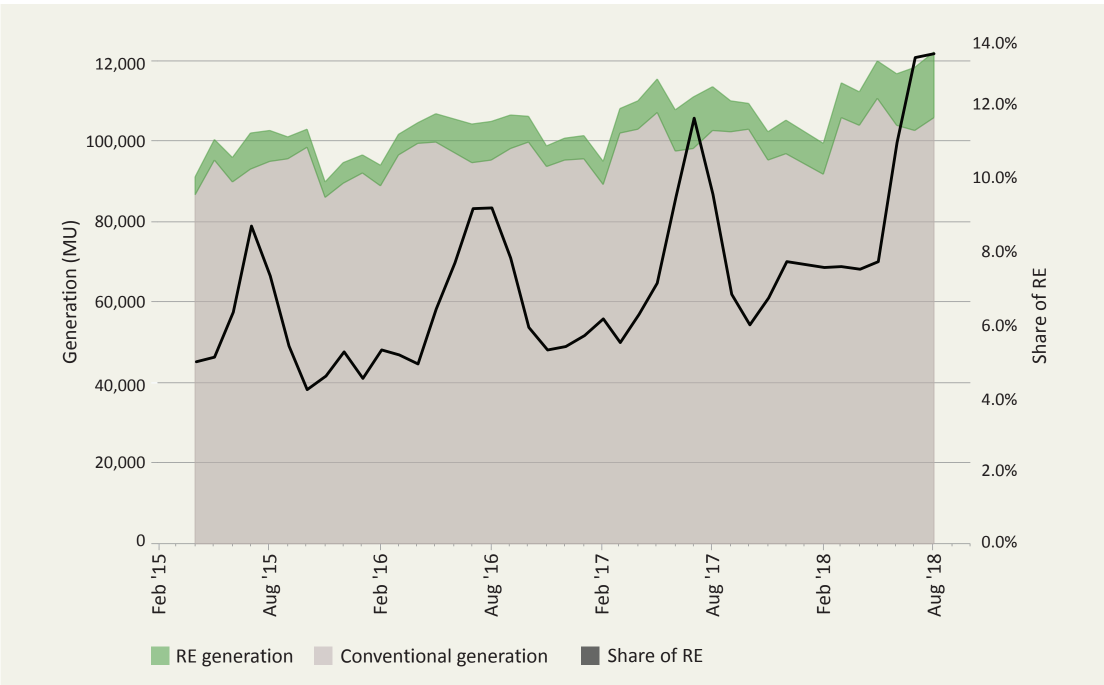
With the addition of 12.4 GW of RE, RE generation in FY 2017-18 increased to 93.5 billion units (BUs), compared to 81.3 BUs in FY 2016-17, an increase of 15%. Generation data by month and by source are shown in Figure 3.4. Further, over the same period, the share (annual average) of RE in total electricity generation increased from 6.6% to 7.9% (Figure 3.5).

Figure 3.4. All-India month-wise generation of RE. Data till August 2018 has been plotted. Refer to REDP for more details and future updates.



Source: CEA

Figure 3.5. Changing share of conventional and RE generation. Data till August 2018 has been plotted. Refer to REDP for more details and future updates.



Source: CEA

In FY 2017-18, the top RE-generating states were Tamil Nadu (15.4 BUs), Karnataka (12.4 BUs), Gujarat (11.1 BUs), Maharashtra (10.9 BUs), Andhra Pradesh (9.9 BUs) and Rajasthan (8.9 BUs). The portal gives generation data by state from FY 2014-15.

4. Renewable Purchase Obligations: Targets and Compliance

Pursuant to the amended National Tariff Policy (NTP) notified on January 28, 2016 (MoP, 2016b), the MoP, in July 2016, published the guidelines notifying the trajectory for RPO from FY 2016-17 to FY 2018-19 to be applicable uniformly to all states and union territories (UTs). The guidelines clarified that the obligations are to be calculated based on total consumption of electricity, excluding hydro power and also specified that cogeneration from sources other than RE is not to be excluded from the applicability of RPOs.

In June 2018, the MoP issued guidelines for subsequent years, setting a target of 21% RPO by 2022, divided equally between solar power and non-solar power. The trajectory is shown year by year in Table 4.1. In the previous edition of this report, Prayas (Energy Group) had suggested revising the earlier solar RPO target of 8% by 2022 given in the NTP, 2016, to 10.3% so as to be in line with the target of 100 GW by 2022. The new MoP mandate is in line with the target of 175 GW of RE. In addition, the new guidelines allow for fungibility between compliance with solar and non-solar RPO if a minimum of 85% of the obligations are met from the required source.

Table 4.1: Long-term growth trajectory of solar and non-solar renewable purchase obligations from FY 2016-17 to FY 2021-22 as issued by MoP.

Source	2016-17	2017-18	2018-19	2019-20	2020-2021	2021-22
Non-solar (%)	8.75	9.50	10.25	10.25	10.25	10.50
Solar (%)	2.75	4.75	6.75	7.25	8.75	10.50
Total	11.50	14.25	17.00	17.50	19.00	21.00

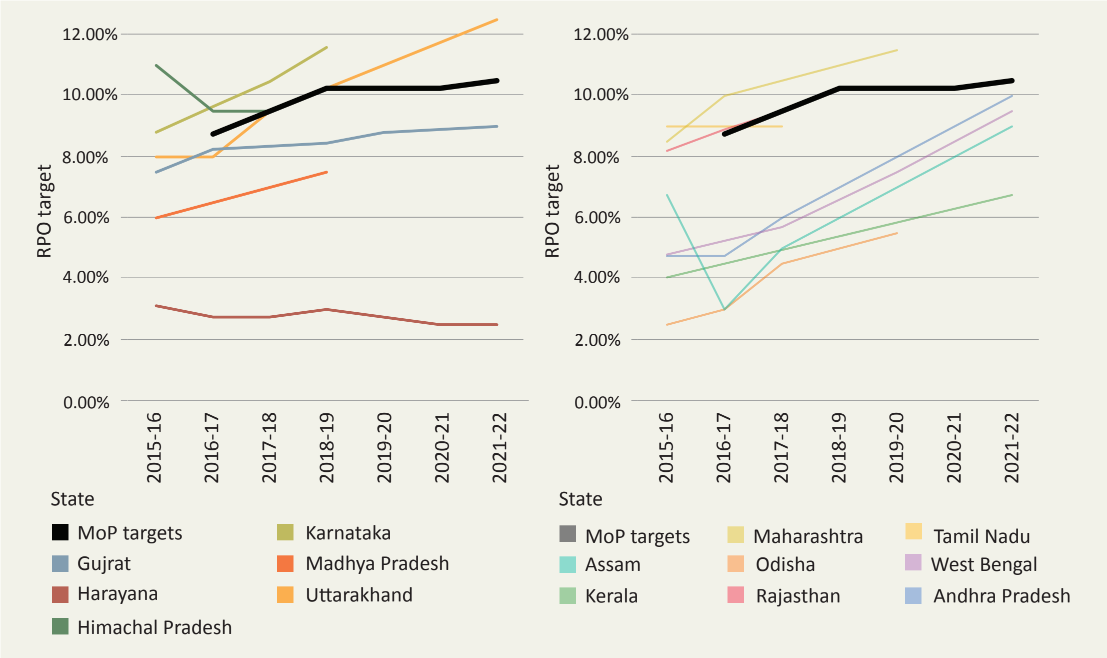
This notification by the MoP was always understood as a guideline for states, and the SERC were within their rights to set RPO targets for their respective states depending on local conditions. However, a draft amendment to the NTP, 2016, released in May 2018 (MoP, 2018f), inviting comments from stakeholders, made a stronger pitch by revising the text to add that *'all SERCs will adopt the RPO trajectory issued by the Central Government.'* At the time of writing this report, the draft amendment is yet to be finalised. Further, the proposed amendment to the Electricity Act suggests that henceforth, RPOs will be prescribed by the central government and not by the SERCs (MoP, 2018h).

As expected, not all states have published or drafted amendments to their RPO regulations to bring them in line with the recent MoP order on long-term RPOs; of the states that have done so, some have set weaker guidelines. Only a few, including Karnataka and Madhya Pradesh, have modified the definition of RPO to exclude consumption met from hydro sources from the base consumption. Figure 4.1 and Figure 4.2 illustrate this in the case of 15 states. (The data are plotted in two groups to avoid clutter.) In Karnataka, each of the five Discoms has a separate RPO target, which is why a weighted average of these targets, weighted by the Discoms's power purchase as approved by the state ERC in the annual performance review for each Discom for FY 2016-17 (KERC, 2018a), is used for arriving at a single non-solar and solar RPO target for Karnataka. A summary of these revisions in the 15 states is as follows.

- By 2017, nine states had issued final amendments to the existing RPO regulations after taking into account the RPO trajectory issued by the MoP in 2016.
    - o Andhra Pradesh (RPOs from FY 2017-18 to FY 2021-22)
    - o Gujarat (RPOs from FY 2017-18 to FY 2021-22)
    - o Haryana (RPOs from FY 2016-17 to FY 2021-22)
    - o Himachal Pradesh (RPOs from FY 2016-17 to FY 2018-19)
    - o Karnataka (RPOs from FY 2015-16 to FY 2018-19)
    - o Maharashtra (RPOs from FY 2016-17 to FY 2019-20)
    - o Madhya Pradesh (RPOs from FY 2016-17 to FY 2018-19)
    - o Rajasthan (RPOs from FY 2017-18 and FY 2018-19)
    - o Uttarakhand (RPOs from FY 2013-14 to FY 2018-19) (a draft amendment was notified in in April 2018 setting RPOs from FY 2019-20 to FY 2021-22, which are also considered in the figures below).
- Four states, namely Kerala, Maharashtra, Tamil Nadu and West Bengal, issued no amendments. Odisha released a draft amendment in 2016 to bring the RPOs in line with the MoP guidelines, but the draft is yet to be finalised. Telangana issued draft regulations in 2018 but, pending their finalisation, is currently following the regulations of Andhra Pradesh.
- Six states, namely Andhra Pradesh, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh and Rajasthan, modified the definition of RPO to exclude consumption of electricity from hydro sources for the years for which RPOs targets had been issued in those amendments. In Uttarakhand, consumption from hydro sources was excluded only from FY 2017-18. Maharashtra and Gujarat are two of the nine states with new amendments that did not modify the definition of RPO in their amendments.
- Of those nine states, seven have set ambitious non-solar RPO targets in comparison with the MoP guidelines: Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Rajasthan and Uttarakhand. And, only five states have solar RPO targets that are ambitious enough: Andhra Pradesh, Gujarat, Karnataka, Rajasthan and Uttarakhand.

Thus, out of the fifteen states analysed, nine have amended the existing regulations, and two more have issued draft amendments or regulations (but not finalised them yet). Of these nine states, seven have modified the definition of RPO to be in line with central guidelines; seven have set high enough targets for procurement of electricity from non-solar sources, and only five have done so for solar sources.

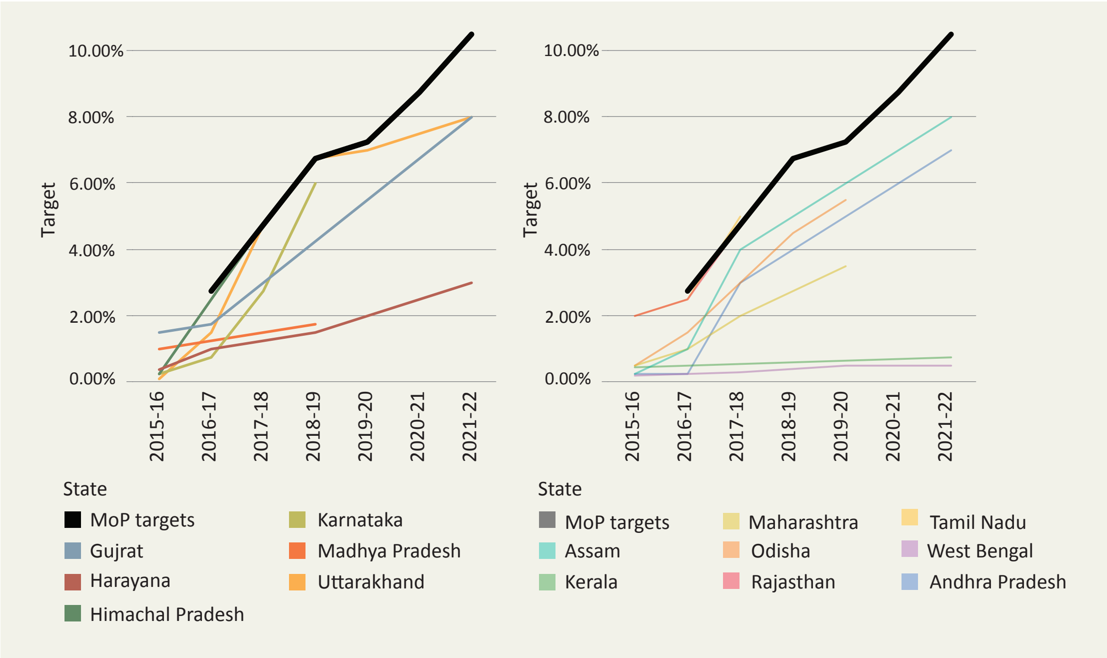
Figure 4.1. Current mandated non-solar RPO trajectory in fifteen states in comparison with the MoP guidelines, for the financial years 2015-16 to 2021-22.



Source: State ERC regulations on RPO

Note: Out of the 14 states shown in the figure, only Andhra Pradesh, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Uttarakhand have modified the definition of RPO to exclude consumption of electricity from hydro sources. Additionally, Telangana is currently following the existing RPO-related regulations of Andhra Pradesh.

Figure 4.2. Current mandated solar RPO trajectory in fifteen states in comparison with the MoP guidelines, for the financial years 2015-16 to 2021-22.



Source: State ERC regulations on RPO

Note: Out of the 14 states shown in the figure, only Andhra Pradesh, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Uttarakhand have modified the definition of RPO to exclude consumption of electricity from hydro sources. Additionally, Telangana is currently following the existing RPO-related regulations of Andhra Pradesh.

Although the MoP guideline raising the RPO to 21% of total consumption by 2021-22 is uniformly applicable to all states, some states including Rajasthan and West Bengal have reserved their right to set their own targets after considering their power supply situation and the financial condition of their Discoms (Business Line, 2018b) (LiveMint, 2018b). This stance highlights the centre–state differences on ways to achieve the goal of 175 GW and the need for building a consensus.

Table 4.2 shows the share of RE generation in different states and UTs in FY 2016-17 to facilitate a rough comparison with the central and the state guidelines on RPO and to set it in context. Generation in a state includes gross generation from all plants within the boundaries of the state or UT. Only those states in which the total generation (conventional and RE) was greater than 500 MUs are considered.

It is to be noted in Table 4.2 that the MoP guideline of 11.50% excludes hydro consumption to arrive at the base consumption, whereas the RE share calculated for the states is based on total generation including large hydro. For example, in Himachal Pradesh, although the share of RE is 5.43%, that after excluding hydro consumption rises to as high as 92.56%—because hydro, at 36,477 MUs, or 99.54%, accounts for virtually the entire conventional generation in the state (whereas for the state Discom HPSEBL, since it meets part of its requirements from power plants in other states, the actual share of hydro in conventional power is about 80%.) Other hydro-rich states such as Kerala and Uttarakhand will likewise find it easier than other states to meet the MoP guideline.

Table 4.2: Share of renewable energy in total generation in states in FY 2016-17.

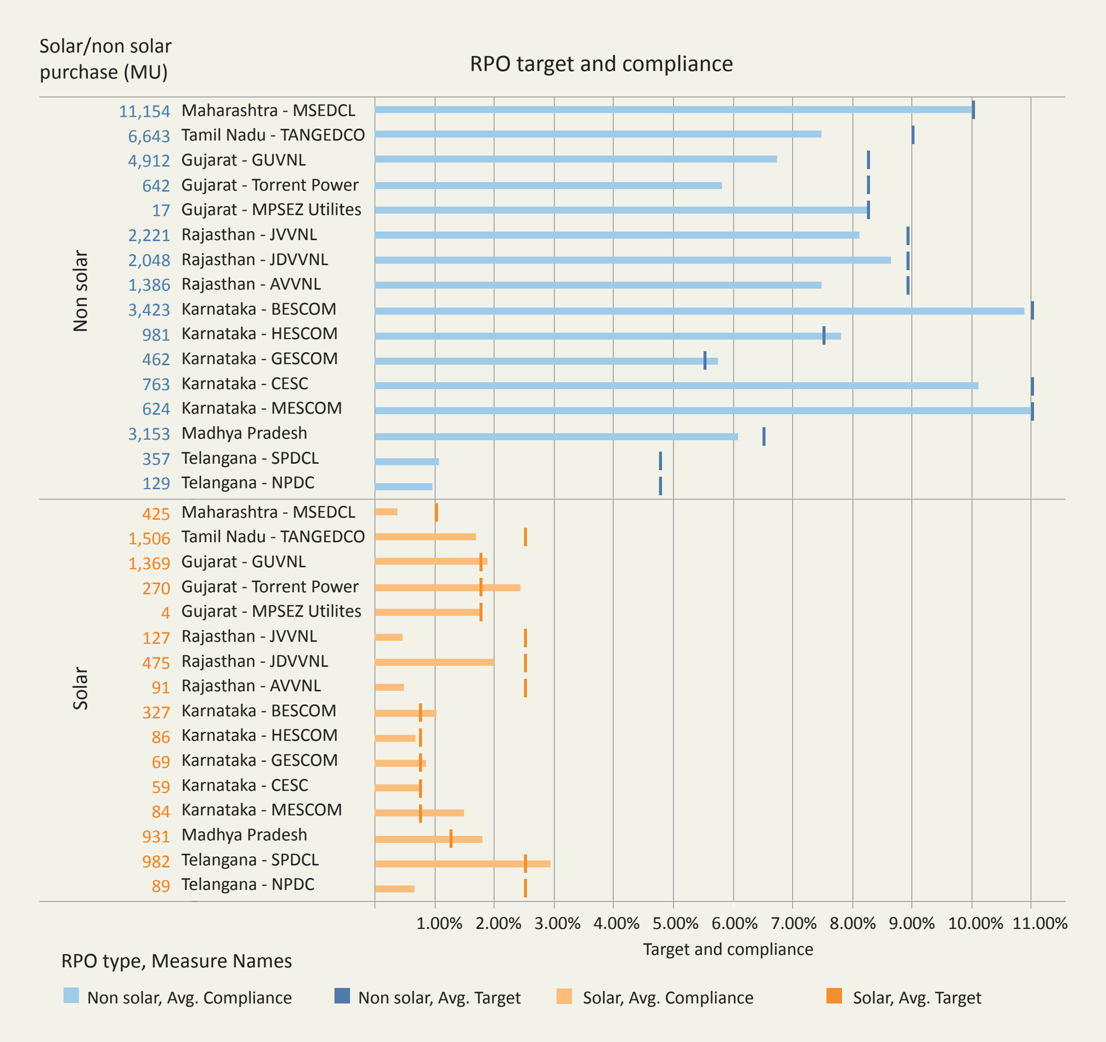
State	RE generation (MUs)	RE share (%)
MoP guideline	–	11.50
Tamil Nadu	15,154	13.80
Karnataka	9675	13.31
Rajasthan	7974	11.18
Kerala	562	9.66
Maharashtra	11,293	8.20
Andhra Pradesh	5483	6.96
Gujarat	9498	6.71
Punjab	2126	6.54
Uttarakhand	913	5.49
Himachal Pradesh	2111	5.43
Madhya Pradesh	5492	5.00
Meghalaya	59	4.95
Telangana	2000	4.03
Uttar Pradesh	3716	2.72
Jammu & Kashmir	392	2.48
Delhi	145	2.26
Assam	166	2.20
Haryana	452	2.20
West Bengal	1570	1.98
Arunachal Pradesh	17	1.35

Bihar	283	1.12
Chhattisgarh	1446	1.10
Tripura	46	0.78
Sikkim	31	0.71
Odisha	503	0.54
Jharkhand	37	0.11
Manipur	0	0.00

Note: For calculating the share of RE, data on conventional generation (utility) for each state were taken from CEA's power supply reports. The conventional (captive) generation for each state is based on the latest available breakdown of captive generation by state for FY 2015-16 in CEA's All India Electricity Statistics – General Review 2017. The data available for FY 2015-16 are used along with the all-India captive generation data in Energy Statistics 2018 published by MoSPI to estimate captive generation for each state for 2016-17. For more details, see REDP.

We also analysed the compliance with RPO of some Discoms in FY 2016-17 by going through the respective tariff orders, the agregate revenue requirement (ARR) filings and compliance reports. The solar and non-solar RE purchased by the discoms and the compliance are presented in Figure 4.3.

Figure 4.3. Prayas (Energy Group) analysis of compliance with renewable purchase obligation of various state Discoms in FY 2016-17. Refer to REDP for further updates.



The data on compliance presented in Figure 4.3 should be seen in the context of the process of monitoring compliance with RPO as followed in the respective states, as discussed below.

- Maharashtra (MSEDCL): Maharashtra Energy Development Agency (MEDA) is designated as the state agency to verify RPO compliance of obligated entities in the state. Accordingly, data on RPO settlement for 2016-17 for the Discom MSEDCL were submitted by MEDA to the MERC in November 2017. The Discom met its overall non-solar RPO including through the purchase of non-solar RECs (in the latest regulations in Maharashtra, part of the non-solar RPO is reserved for purchase of electricity from micro and mini hydel projects; see REDP for more details), but faced a shortfall of 61.9% in solar RPO. The reason provided by MSEDCL for the shortfall was the suspension of solar REC trading by the Supreme Court in May 2017 (see Chapter 5). In an order passed in July 2018 (MERC, 2018), the MERC directed the Discom to meet this shortfall by March 2019, although the Discom had requested for time up to March 2020.
- Tamil Nadu (TANGEDCO): The true-up exercise for the Discom for 2016-17 has not been carried out so far. However, in the order on Generation and Transmission Tariff for FY 2017-18 and ARR for 2016-17 (TERC, 2017), 2017-18 and 2018-19, the Discom provided actual figures for 2016-17 up to January 2017. The approved power purchase for 2016-17 has been used for estimating the extent of compliance with the solar and non-solar RPO and in doing so, only the RE bought as part of a power purchase agreement (PPA) and as banked energy has been considered.
- Gujarat (multiple Discoms): Gujarat Energy Development Agency (GEDA) provides compliance reports for the Discoms GUVNL, MPSEZ Utilities Ltd., Torrent Power Ltd. (Ahmedabad and Surat) and Torrent Power Ltd. (Dahej) annually on its website. In the data in Figure 4.3, the compliance of Torrent Power Ltd. has been considered as a whole and the purchase of RECs has been taken into account.
- Rajasthan (multiple Discoms): In Rajasthan, the three Discoms's compliance data is based on the true-up petition submitted for 2016-17 and only the RE bought as part of a PPA has been taken into account.
- Karnataka (multiple Discoms): In the case of Karnataka, compliance with the RPO is verified and reported in the yearly tariff order itself: that for 2016-17 has been verified in the respective tariff orders for 2018-19 for the Discoms (KERC, 2018a), taking into account RE bought in the form of PPAs, RECs, as short-term purchase and as banked energy. All the five Discoms in the state were compliant and have been allowed by the KERC to carry forward to the next financial year any shortfall in the RPO after adjusting for any excess RE bought from solar sources as applicable and as allowed under existing regulations.
- Madhya Pradesh (multiple Discoms): Collective RPO for all the four Discoms in the state has been estimated based on actual power purchases in 2016-17 as given in the ARR and tariff petition for FY 2018-19 submitted by the Discoms. Only the RE bought as part of a PPA has been considered.
- Telangana (multiple Discoms): Compliance of the Discoms has been estimated based on the provisional true-up of RE electricity bought (as a whole) for 2016-17 provided in the tariff order for 2017-18. The split between solar and non-solar RE is based on ARR filings of the Discoms for 2018-19. Only the RE bought as part of a PPA has been considered.

In Andhra Pradesh, which is not included in Figure 4.3, Discoms have requested the ERC to file for a separate true-up petition for 2016-17 in their tariff petition for 2018-19. However, no such petition had been filed as of September 2018.

In the previous edition of this report, it was noted that the stipulation to have separate RPO for solar and non-solar power is not relevant anymore with the decline in solar prices over the last five years and the stabilising of wind and solar prices at similar levels (see Chapter 5). Merger of the separate solar and non-solar RPOs into a single total RPO will allow greater flexibility to obligated entities to meet their targets of procuring RE. The debate on this issue has continued since the last report. In the conference of power and RE ministers of states and UTs held in December 2017 (MoP, 2017c), the MNRE and a few other states including Rajasthan and Uttar Pradesh suggested combining solar and non-solar into a single RPO. In Maharashtra, MSEDCL filed a petition before the MERC requesting for a single RPO target. However, in an order passed in December 2017, the MERC rejected the request, citing the special provisions to promote solar and non-solar RE sources in the state in its RPO regulations and the NTP. Similarly, the Telangana ERC, in its RPO regulations issued in April 2018 (TSERC, 2018a), refused to notify such a combined RPO, stating that it would result in only solar power being procured.

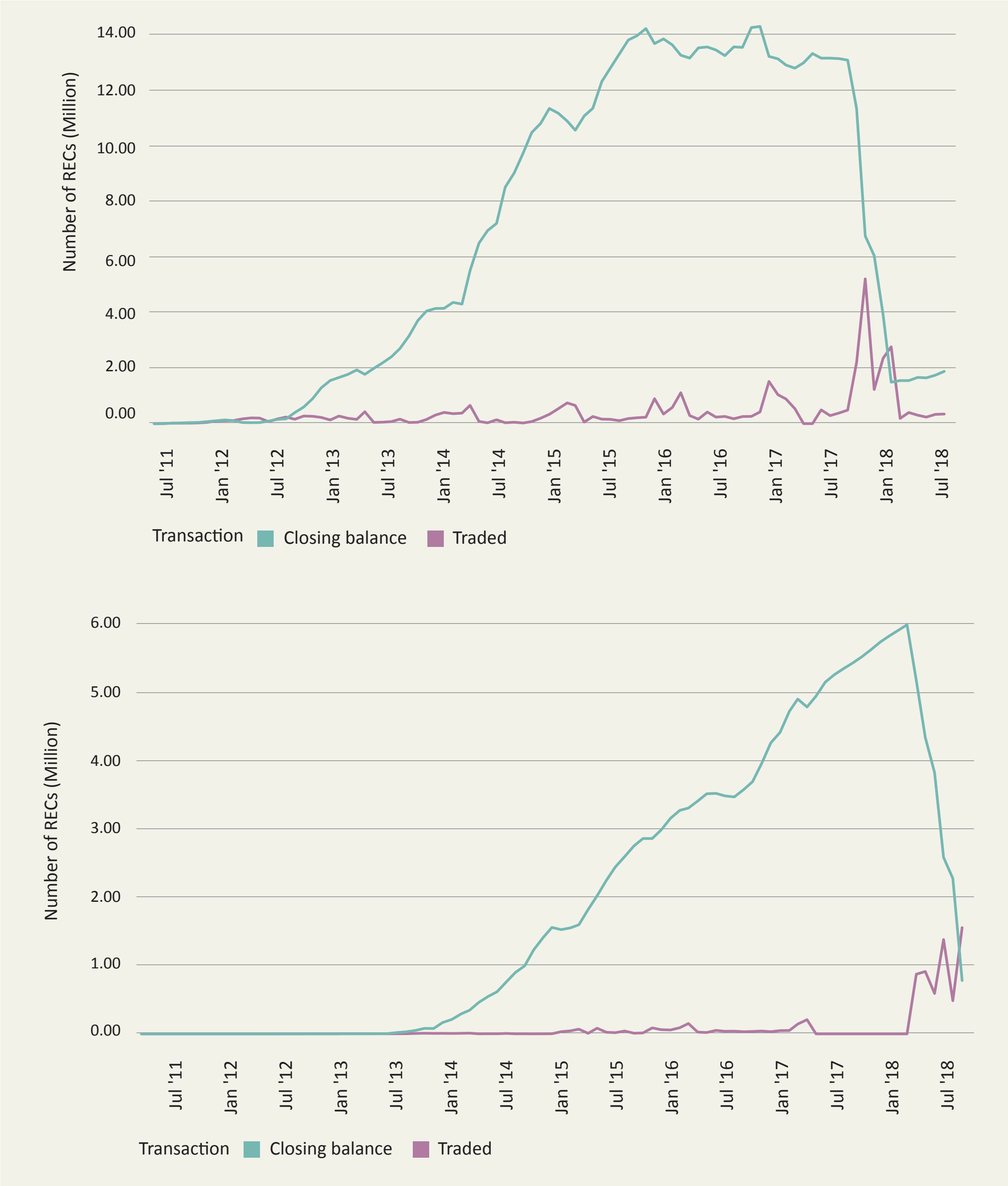
5. Renewable Energy Certificate Mechanism

As elaborated in more detail in the first edition of this report, trading of renewable-energy certificates (RECs) is necessitated by RPO of states and the non-uniform spread of RE resources across the country. In this regard, a CERC order of 14 January 2010, namely 'Terms and Conditions for Recognition and Issuance of RECs for Renewable Energy Generation Regulations, 2010' (referred to as REC Regulations in the rest of the chapter), is particularly relevant. Apart from laying down the process for registering and issuing RECs, these regulations provide for setting floor and forbearance prices by the CERC from time to time. In March 2011, RECs began trading in two power exchanges (Indian Energy Exchange, IEX, and Power Exchange India Ltd., PXIL), and the REC market has faced several challenges since then (detailed in 'Many Sparks but Little Light' (PEG, 2017c, pp. 151-154). A couple of important challenges are as follows.

- Captive generators that did not avail concessional wheeling or transmission charges and banking facilities were allowed to register under the REC mechanism through the first amendment to the REC regulations in September 2010 (CERC, 2010). This gave the generators an advantage over other REC generators that took the OA route or sold their power to utilities at the average power purchase cost (APPC) instead. Since captive generators are usually industrial or commercial consumers, the avoided tariffs for procuring power from Discoms for these captive generators (without considering the compensation from selling RECs) are already greater than the compensation available to REC generators taking the APPC route. This skewed compensation for captive generators meant that a large number of them registered for RECs for the additional compensation. This group also included captive plants that had been commissioned before the REC Regulations were put in place. Along with weak enforcement of RPO, this led to a ballooning of unsold RECs over the years (Figure 5.1). For example, in May 2015, 41% of the projects registered under the REC framework were under the captive route and 51% of these had been commissioned before the REC Regulations (CERC, 2015). Such anomalies weakened the purpose of the REC framework, which was to attract fresh investments to the RE sector rather than to make the existing projects more profitable.
- More recently, the average price of RE (in case of solar and wind power) of about ₹2.5–3/kWh discovered through competitive bidding (see Chapter 6 for more details) has dropped below the national APPC. As a result, new REC projects may potentially be entitled to compensation (APPC plus the REC floor price) at rates much higher than the market price of RE. The pricing band for REC is based on the assumption that RE price is higher than the APPC, and that the floor price for RECs as decided by the CERC from time to time bridges that gap. In the current situation, the original intention of RECs as a market instrument cannot be achieved—which is why the regulations need an urgent relook.

Due to the challenges highlighted above, the REC market has been bearish since its start, with very low clearing ratios (i.e., the ratio of RECs sold in a monthly trading session to the opening balance of RECs before the start of the trading session) and, correspondingly, faces a rising REC inventory. The closing balance (after each monthly trading session) and REC volumes traded over time are shown in Figure 5.1. As is clear from the figure, the traded volumes of both solar and non-solar RECs continue to be only a small fraction of the inventory for the large part, except very recently.

Figure 5.1. Closing balance and traded volumes for non-solar (top) and solar RECs. Refer to REDP for interactive versions of these graphs.



Source: REC Registry

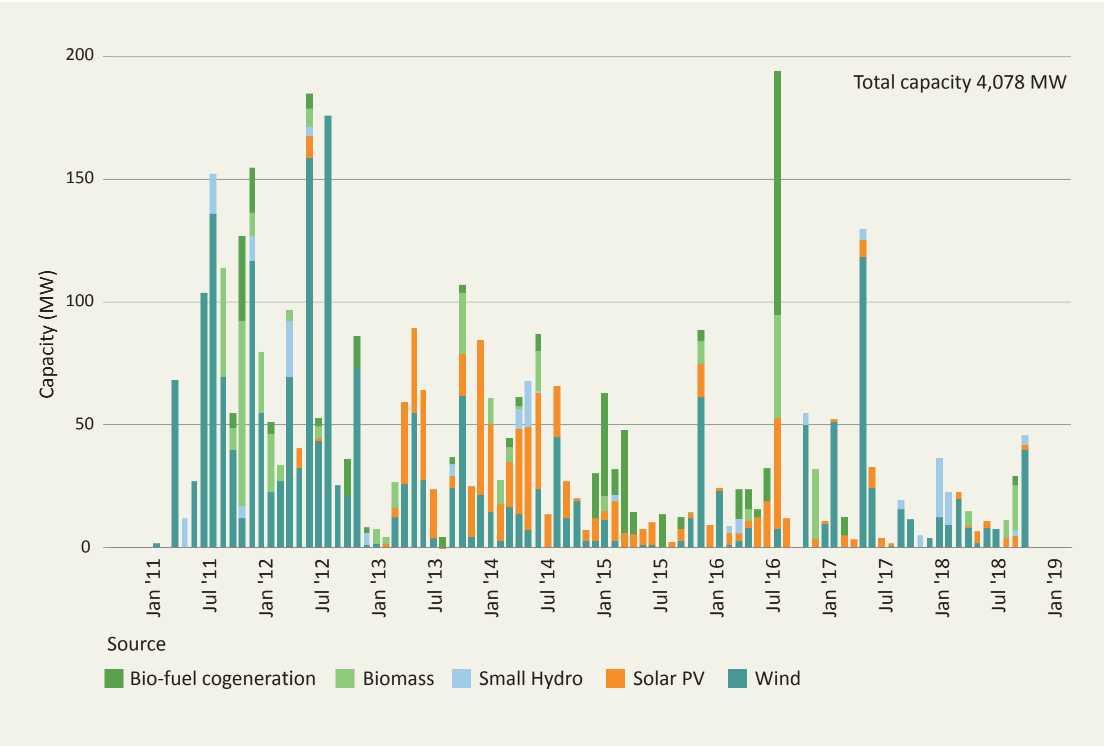
Note: Closing balance is the unsold REC stock after the closing of each monthly trading session. Refer to REDP for interactive versions of these graphs.

The market challenges were addressed by four amendments to the REC Regulations over the years. The fourth amendment, through a CERC order in March 2016 (CERC, 2016), disallowed registration and issuance of certificates, to the extent of self-consumption of the captive RE, that were commissioned before September 29, 2010 or after March 31, 2011. Further, the order stipulated that RE generators selling power through OA and availing themselves of promotional or concessional transmission or wheeling charges and/or banking facilities will not be eligible under the mechanism.

In April 2018, APTEL concluded an arbitration arising out of the CERC order issued in March 2017 (APTEL, 2017). The order had reduced the floor price for solar and non-solar RECs to ₹1000/MWh and the forbearance price to ₹2500/MWh and ₹2900/MWh, respectively, to align them with market dynamics. The order also removed the existing vintage multiplier for solar generators. Subsequent to appeals by RE producers, the Supreme Court put a halt on the trading of solar RECs, although the non-solar RECs continued to be traded at their previous floor price. This case is given in greater detail in the previous edition of this report. The order by APTEL dismissed these appeals, thereby withholding the new floor and forbearance price and paved the way to resume from April 2018, the trading of solar RECs that had stopped in May 2017.

The above developments are also reflected in Figure 5.2, which shows the registration of capacity under the REC mechanism over time. With inventories continuing to rise sharply (as can be seen from Figure 5.1), there was a fall in registration in 2015. The fourth amendment in March 2016, which disallowed captive RE from coming under the mechanism, led to a rise in registration of capacity. The March 2017 CERC order, which lowered the floor price available to solar and non-solar RECs, led to a fall in registrations of new capacity under the mechanism.

Figure 5.2: Capacity registered under the REC mechanism, source wise, over time. Refer to REDP for more details and future updates.

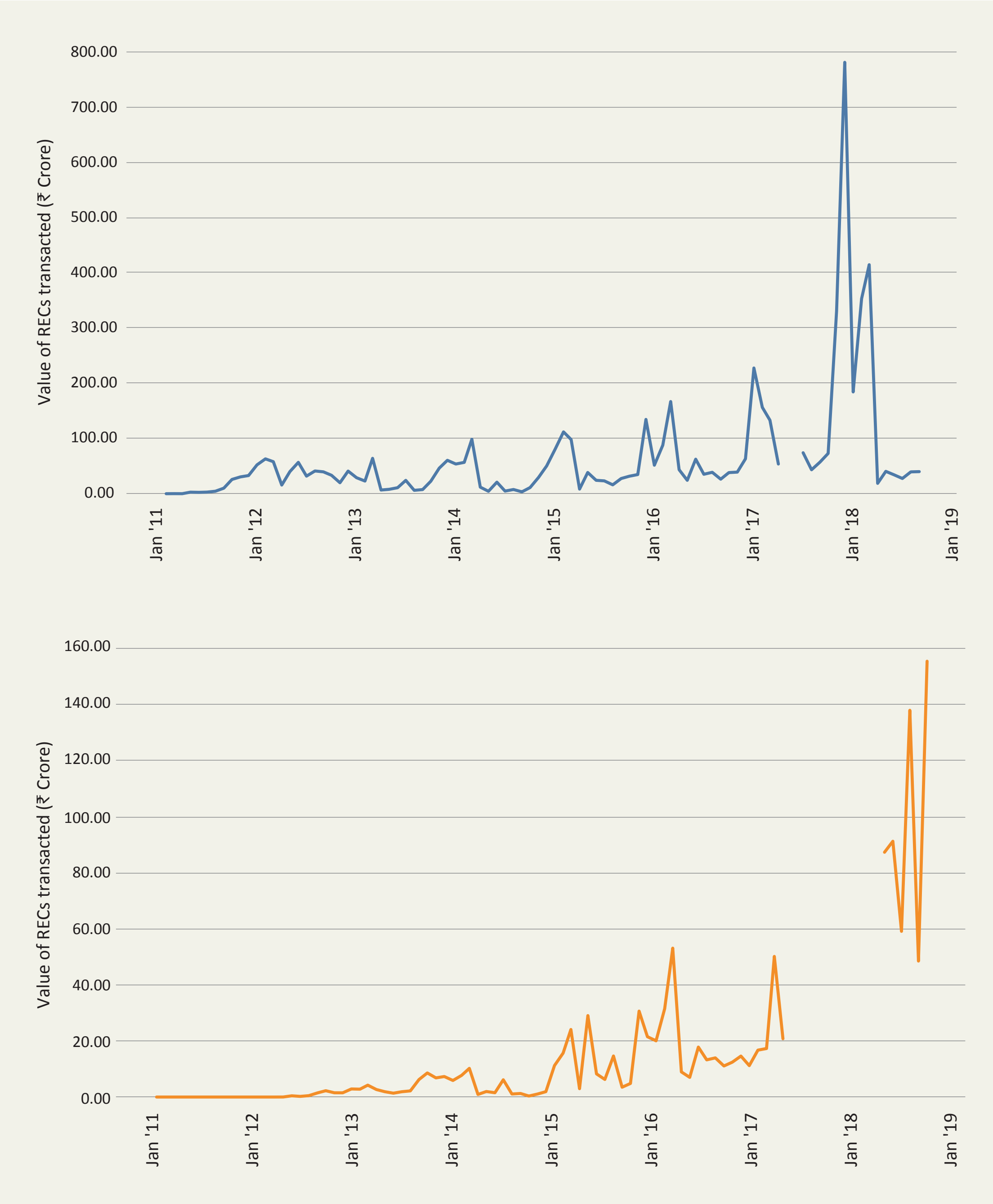


Source: REC Registry

Note: For a project that is re-registered after expiry of previous registration, the date of first registration is considered. Data up to August 2018. Projects for which registration was revoked have been excluded from data. Refer to REDP for details and future updates.

Notwithstanding the historical challenges and the more recent issue related to the fall in RE prices, the REC market has shown very encouraging signs recently: showing that the MNRE's persistent efforts in following up with the state ERCs and the increasingly stricter stance of SERCs that the RPOs be honoured by Discoms is bearing results. Figure 5.3 shows a dramatic increase in the trading of solar and non-solar RECs since November 2017. For comparison, in March 2017, the closing balance, traded volume and the corresponding clearing ratio for non-solar RECs stood at 12.9 million, 0.9 million and 6.8% respectively; a year later, in March 2018, the corresponding figures were 1.5 million, 2.8 million and 70.7%. It is to be seen if this sharp decrease in the inventory will spur more registrations under the mechanism in the coming months.

Figure 5.3: Value of trade in non-solar (above) and solar RECs.



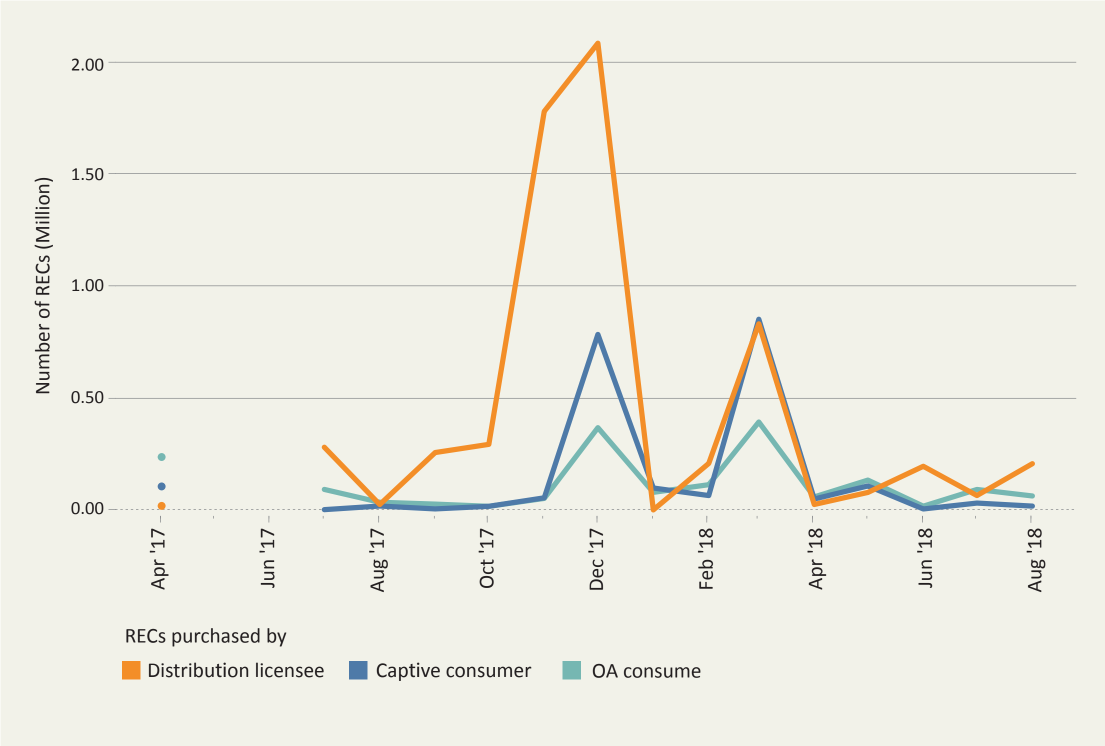
Source: IEX, PXIL

Note: There was a stay on trading of non-solar RECs from June to July 2017 and on solar RECs from June 2017 to March 2018.

More illustrations of the trading price, buy bids and sell bids at the two exchanges are available at REDP. Two noteworthy recent trends can be seen. Since May 2018, non-solar RECs have been trading above the floor price in the both the power exchanges, after the sharp drop in inventories in the previous financial year. Historically, the trading has mostly been at the floor price. Further, there have been more buy bids than sell bids in the exchanges for non-solar RECs since April 2018. Historically, buy bids have been lower than sell bids.

In the recent upsurge in REC trading, Discoms have been the biggest buyers amongst the obligated entities (Figure 5.4) following the emphasis on compliance with RPO by SERC. Going forward, more importance should also be given to compliance by those OA and captive consumers who are obligated entities.

Figure 5.4: Non-solar RECs purchase by the different obligated entities during the period from April 2017 to August 2018 in IEX. No trading took place in May and June 2017.



Source: IEX

To assess the REC market and suggest ways to overcome the existing challenges, an expert committee was formed by the MNRE towards the end of 2017, with members representing Power System Operation Corporation Ltd. (POSOCO), MoP, Indian Renewable Energy Development Agency (IREDA) and Discoms. The deliberations of the committee included the issue of RE prices discovered in competitive bidding being lower than the national APPC, issuance of RECs to captive and open access RE generators, applicability of GST on RECs and an alternative to the existing REC mechanism. The committee finalised its recommendation in January 2018. An important recommendation related to the existing mechanism was to continue it for the time being without any modifications given the recent success in ensuring compliance with RPO. Further, the fixing of a floor price for REC trading was to create a fair market for REC generators and avoid undue speculation. With renewables achieving grid parity, the concept of the floor price needs serious reconsideration.

Going forward, the role of the REC market in the overall RE scenario (the REC market stands at 5 GW whereas the cumulative RE capacity has crossed 70 GW and is rapidly growing) is expected to decrease. With the auctioning of large ISTS-connected projects across the country by agencies such as SECI and NTPC, the obligated entities will have an additional means of discharging their RPO.

Two other developments important for the existing REC mechanism are briefly discussed below.

- The finance ministry notified that a goods and services tax of 12% would be levied on RECs. After the initial lack of clarity on the tax rate applicable, a circular in June 2018 finally confirmed the 12% GST on RECs (MoF, 2018). This is expected to impact the market negatively.
- In line with the fourth amendment to the REC Regulations, the CERC released model guidelines for accreditation of RE projects and distribution licensees under the REC mechanism (CERC, 2018a). Discoms can get RECs issued for excess RE purchased or generated over and above their RPO. The state agency as designated by the respective state ERCs can accredit RE projects that have a minimum of six months until the proposed date for commercial operation, and Discoms that procured RE at tariffs determined through Section 62 or 63 of the Electricity Act in the previous financial year. The accreditation once granted shall be valid for five years. These new guidelines can incentivise Discoms to buy more RE, thereby ensuring compliance with their RPOs and provide a source of non-tariff income for Discoms.

6. Tenders and Auctions for Renewable Energy

6.1 Tenders, Auctions and Cancellations

In November 2017, the MNRE set a target to tender 20 GW of ground-mounted solar power and 10 GW of wind power in FY 2017-18. Out of the 20 GW of solar power, 3 GW each was to be tendered in December and January, 5 GW in February and 6 GW in March. However, with lingering apprehensions at the time over safeguards and anti-dumping duties, the implementing agencies lagged behind the targets significantly, managing to invite bids for only 3 GW in February and 3.5 GW in March (Mercom India, 2018c). Similarly, during the last quarter of the financial year, uncertainty around duties forced the implementing agencies in Maharashtra, Karnataka and Bihar to extend the deadlines for submitting the bids several times, amounting to more than 2.2 GW of projects (ET, 2018a).

Further, at the time of writing, two major auctions have been cancelled by the implementing agencies in 2018: the auction of 500 MW of solar power by GUVNL in March and the auction of 1000 MW (also for solar power) by Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) in July. In the case of GUVNL, the lowest tariff was ₹2.98/kWh; in that of UPNEDA, it was ₹3.48/kWh. In another case, in July 2018, a large part of the auctioning of ISTS-connected 3000 MW of solar power by SECI was affected because allotment of 2400 MW was annulled. The cancelled bid in this case was even lower: ₹2.54/kWh. In all these cases, the implementing agencies considered the tariffs to be higher than expected and not in the best interests of consumers.

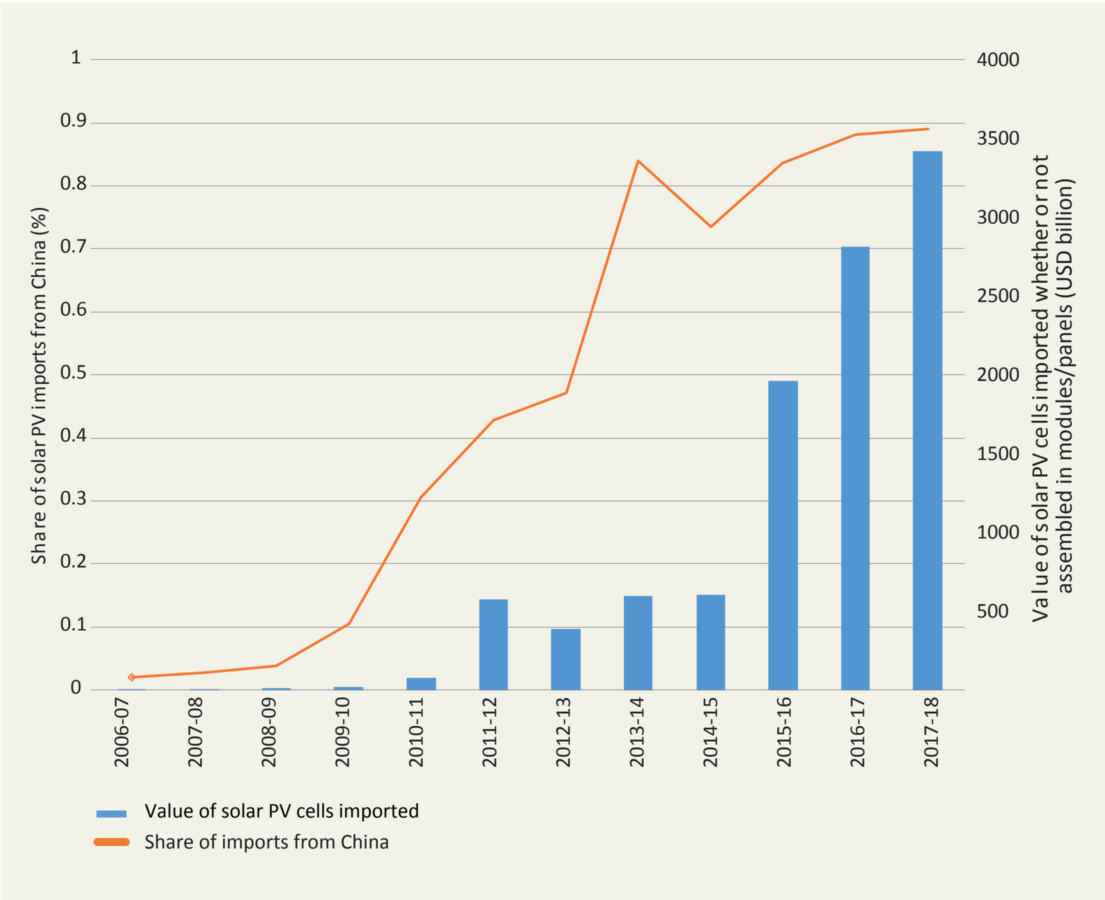
Despite these setbacks, the MNRE is confident that the country will not only meet the 175 GW target but may even surpass it and reach a much higher share of RE in the long run (ET, 2018e; ET,2018f).

6.2 Manufacturing of Solar PV

With solar power likely to become one of the most dominant sources of RE in the future, the central government is now seriously focusing on the need to create a domestic supply chain for the solar industry. Although India has a significant manufacturing base of close to 10 GW a year of wind turbines, it relies significantly on imports of solar PV cells and panels. Figure 6.1 shows the value of solar PV imports from China over the last ten years. Annual growth in the value of solar PV imports from China during this period was close to a 100%, culminating with about US $ 3.4 billion worth of imports in FY 2017-18. This represents about 90% of India's solar PV imports, underscoring the dominant role of large-scale Chinese solar manufacturing in the Indian solar story. To strengthen solar PV and electric battery storage manufacturing in India, the central government plans to introduce large-scale solar PV deployment tenders, which will mandate setting up solar PV and storage battery manufacturing in the country on a given scale. At the end of FY 2017-18, India's solar module capacity was greater than 8 GW and solar cell capacity was greater than 3 GW (Chaturvedi, 2018).

In December 2017, SECI invited expressions of interest (EOI) (SECI, 2017b) in tendering 20 GW of solar capacity from prospective and existing solar manufacturers to set up integrated manufacturing facilities (from polysilicon to module). The facilities could, in turn, supply modules for setting up the tendered capacity. This was designed to meet a majority of the module requirements to achieve the MNRE's target of tendering 70 GW of solar in total from FY 2017-18 to FY 2019-20. Thereafter, in May 2018, SECI released a tender document (SECI, 2018c) for tariff-based bidding for an aggregate of 10 GW of solar capacity (instead of the earlier plan for 20 GW), to be linked with an annual manufacturing capacity of 5 GW. Further, as opposed to the original call for EOI in December, the condition for manufacturing was relaxed to allow import of polysilicon. The tender was modified yet again in September 2018 to lower the stipulated annual manufacturing capacity to 3 GW and to cap the tariff at ₹2.75/kWh. The response has been tepid so far, with the deadline to submit the bids being extended twice during 2018, first from August to September and then from September to October. Especially, major changes in solar pricing policy introduced by China in June (Merchant, 2018) including a slashing of feed-in tariffs have affected the viability of domestic manufacturing in India. Industry expects Chinese module prices to fall by more than 30% in 2019 because of these changes in policy (Renewable Watch, 2018c).

Figure 6.1. Value (in USD millions) of solar PV imports from China and their share in total solar PV imports.



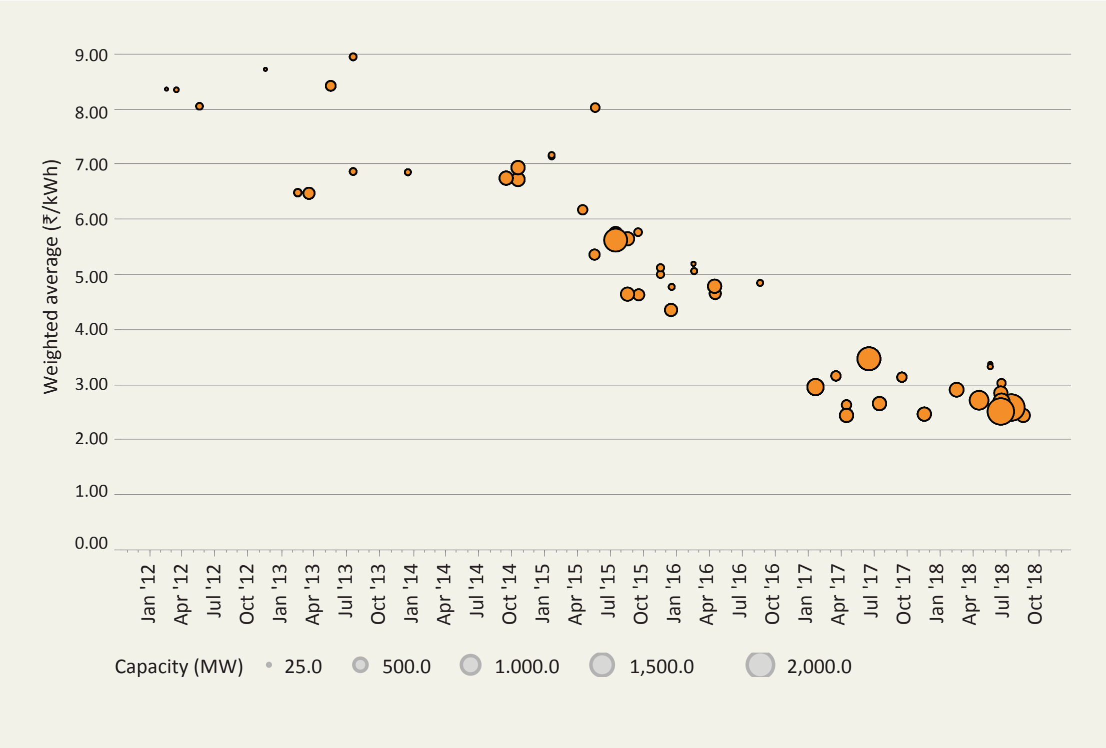
Source: Department of Commerce, Import Export Data Bank

More recently, the media reported (ET Energy World, 2018b) on a soon-to-be-unveiled ₹8000 crore scheme, under which central public sector undertakings will call for tenders, stipulating a requirement of domestic content, to set up of an aggregate capacity of 12 GW for self-consumption of the produced power. By 2022, the scheme is expected to result in setting up an additional 3 GW of solar cell manufacturing capacity. The earlier domestic content requirement scheme, the 1000 MW CPSU Programme, ended in December 2017 following a dispute at the World Trade Organization. With all the focus on state support for the domestic manufacturing industry, contrasting opinions have been voiced about its effect on the solar growth story. Some have argued strongly for creating an entire domestic supply chain (Chaturvedi, 2018), whereas others have cautioned against it, claiming that such a policy will damage the overall health of the sector in pursuit of narrower results (ET Energy World, 2018c).

6.3 Discovery of Wind and Solar Prices

Figure 6.2 and Figure 6.3 plot the solar prices discovered through competitive bidding in India. From 2012 to 2018, the discovered prices fell by about 70%, and the difference between the highest and the lowest winning tariffs narrowed from about ₹1–2/kWh to only a few paise—indicating a maturing of the sector over the last few years. All the 14.4 GW auctioned since the beginning of 2017 is priced below the national APPC; further, out of this capacity, 4.6 GW is to be connected to the ISTS.

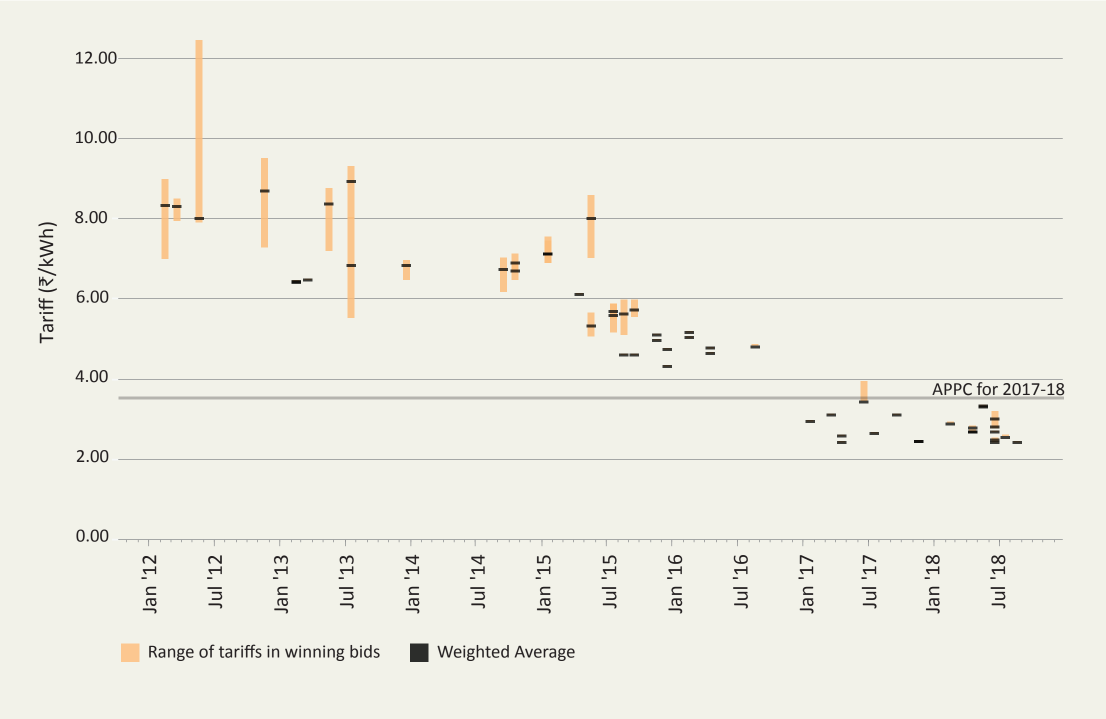
Figure 6.2. Trends in tariff and project size in competitive bidding in the solar sector.



Note: The tariffs discovered in an auction are weighted by the corresponding capacities awarded to arrive at the weighted average tariff for the auction. The bubbles are centred on the weighted average tariffs discovered in the auctions, and the bubble size corresponds to the total size of auction.

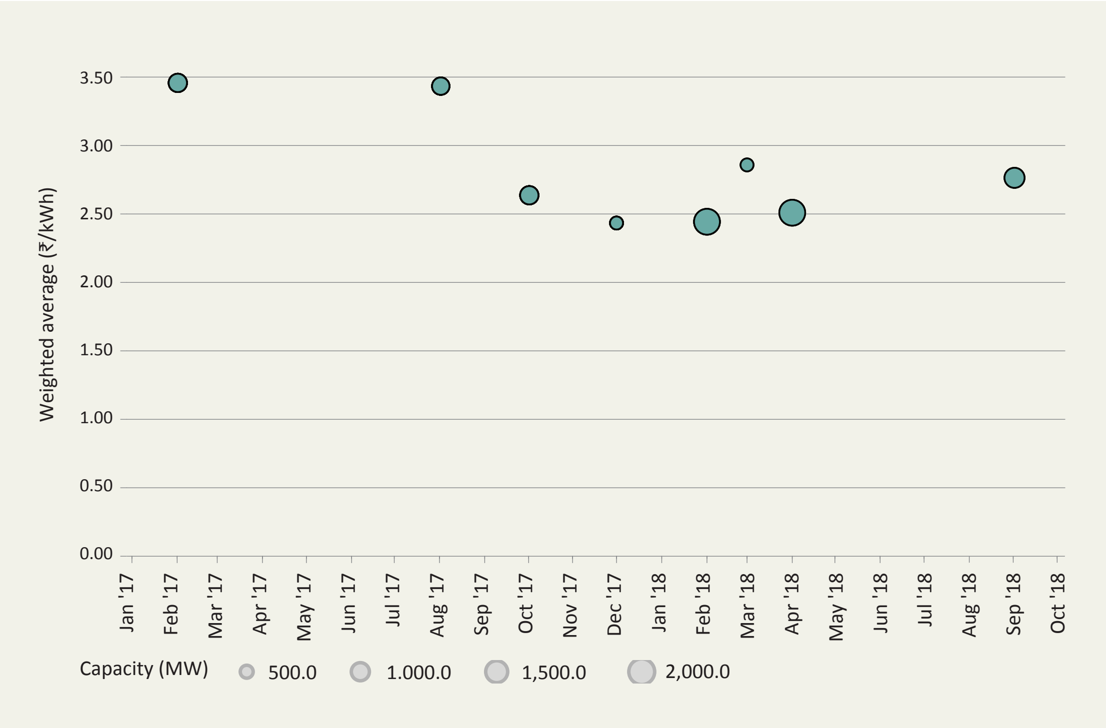
Figure 6.4 and 6.5 show the prices discovered in auctions for wind power. All of the 8.6 GW auctioned was priced below the national APPC. Most of this capacity has been auctioned by SECI and is to be connected to the ISTS. Large projects combined with large wind turbines with greater hub heights and larger rotors increased the energy output and lowered the levelised cost of energy and helped in keeping the tariffs low.

Figure 6.3. Variations in winning bids in solar auctions.



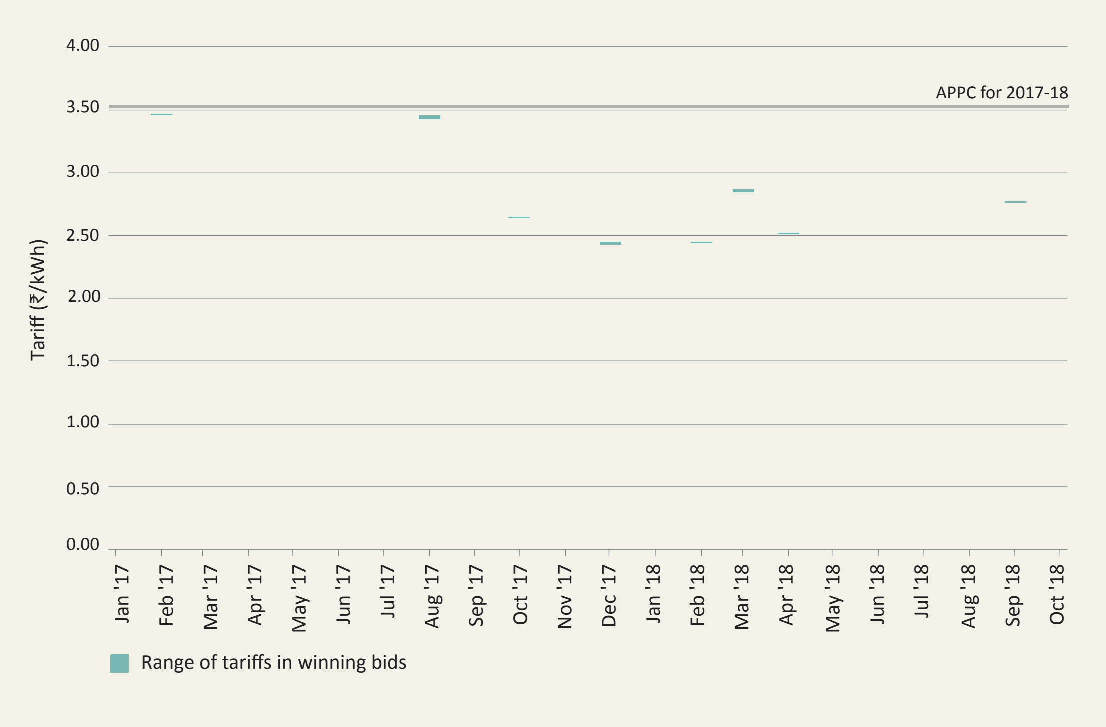
Note: The national APPC for FY 2017-18, determined by the CERC as the average of APPC of all states and union territories, weighted by volume of conventional power purchased by the respective state or UT, was ₹3.53/kWh. The black dashes represent the weighted average of the winning bids. Refer to REDP for details on these auctions and further updates.

Figure 6.4. Trends in tariff and project size in competitive bidding in the wind sector.



Note: The tariffs discovered in an auction are weighted by the corresponding capacities awarded to arrive at the weighted average tariff for the auction. The bubbles are centred on the weighted average tariffs discovered in the auctions, and the bubble size corresponds to the total size of auction.

Figure 6.5. Variation of winning bids in wind auctions.



Note: The national APPC for the FY 2017-18, determined by CERC as the average of APPC of all states and union territories, weighted by the volume of conventional power purchased by the respective state or UT, was ₹3.53/kWh. Refer to REDP for details on these auctions and further updates.

6.4 Solar + Storage and Offshore wind

The dramatic drop in storage prices, especially lithium-ion batteries, coupled with significant deployments in international markets, has led to some initial interest in solar power plus storage systems in India.

Some tenders were initiated on these lines. However, progress was slow because the tenders issued by government agencies, including NTPC, SECI and Neyveli Lignite Corporation (NLC), were delayed or had to be floated again. For example, in May 2017, NLC invited tenders for 28 MWh of storage coupled with 20 MW of solar power in the Andaman Islands – only to lower the capacity later to 8 MWh (NLC, 2018). The auctioning was finally completed in April 2018 (Mercom India, 2018d). Similarly, NTPC also invited two separate tenders in 2017, both for the Andaman Islands, for a total of 27.2 MWh of storage coupled with 25 MW of solar power; however, the deadline for submission had to be extended from July 2017 to May 2018, owing to changes in energy storage specifications (NTPC, 2018). Lastly, SECI invited two tenders totalling to a capacity of 3 MWh of storage and 5 MW of solar power in July 2018 (SECI, 2018d) and also invited tenders for a 160 MW wind-solar hybrid with 20 MWh of storage in August 2018 (SECI, 2018e).

In the nascent offshore wind industry, the National Institute of Wind Energy (NIWE), in April 2018, invited EOI to develop 1000 MW of offshore wind (MNRE, 2018g). Based on the response from both Indian and international project developers, a tender document is being prepared inviting bids to set up 1000 MW of offshore wind over 400 km^2 in the Gulf of Khambhat, Gujarat (NIWE, 2018).

6.5 Bidding Guidelines

Under provisions of Section 63 of the Electricity Act, the MoP, in August 2017, notified a set of guidelines, namely the 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Solar PV Power Projects' (MNRE, 2017a), for long-term procurement of electricity from solar PV projects of capacity 5 MW or above. Although competitive bidding for solar energy has been going on since 2010, the guidelines were designed to help tariff-based bidding for utility-scale solar PV by

- improving the transparency and fairness in the procurement process, while protecting consumer interests,
- standardising the processes to generate more confidence in the sector, and
- providing a framework for risk-sharing between the generator and the procurer—including a mechanism to ensure security of payment and compensation to protect against off-take risks and against termination in a default event.

Under these guidelines, the 'procurer' of electricity from a solar power generator can be a distribution licensee or an intermediary procurer. An intermediary procurer such as SECI may be required either to aggregate power from different solar power generators and sell it to one or more distribution licensees, or to enhance the credit profile and improve investor confidence.

In June 2018, the MoP amended the bidding guidelines (MNRE, 2018f). Along with these amendments, the tariff-based competitive bidding guidelines include the following provisions:

- The duration of a PPA will be at least 25 years from the scheduled date of commissioning.
- The solar power generator will provide two bank guarantees to the procurer: an earnest money deposit (EMD) at the time of submitting a request for selection (RfS) and a performance bank guarantee (PBG) at the time of signing the PPA.
- The generator shall be fully compensated, based on deemed generation, if no power is evacuated owing to non-availability of transmission (for reasons not attributable to the generator) and compensated 50%, based on deemed generation, if the generator is directed to backdown, notwithstanding the 'must-run' status encouraged for renewables by the Indian Electricity Grid Code (IEGC).
- If a generator fails to commission the plant within the stipulated time or repudiates the PPA, the generator is liable to pay damages as detailed in the PPA as well as forfeiture of the bank guarantee, if any; in addition, the lenders have the right to substitute the generator, failing which the procurer can acquire the generator's assets. In the event of a default on the procurer side, such as failure to make monthly payments, the procurer can transfer the PPA to a third party if acceptable to the generator; if not, the generator is entitled to a termination compensation or damages.
- The procurer shall provide a payment security though a revolving line of credit as well as a payment security fund to protect the solar generator against delayed payment.
- In case of a change in law (such as enactment of any new law or any change in the rate of any taxes) results in financial loss to solar power generators or procurers, they will be entitled to a compensation from the other party.
- The power purchase agreement will be signed within 150 days from the date of issue of the RfS; the solar power generator shall acquire the land within 12 months from the

signing of the PPA; the generator will attain financial closure within 12 months of signing the PPA, failing which the PBG will be encashed; and the project will be commissioned within 21 months from the date of execution of the PPA (within 24 months for projects of 250 MW or higher developed outside a solar park).

- The responsibility of constructing a pooling substation (if required) and a transmission system up to a transmission substation will be clearly specified in the bidding document. Depending on whether the project site is specified by the procurer, and whether it is within a solar park, the responsibility can lie either with the generator or with the procurer.

The first competitive bidding in wind was in February 2017, invited by SECI, after about a decade and a half of growth aided by a preferential tariff regime and such incentives as accelerated depreciation. To streamline the process, the central government, in December 2017, notified a set of guidelines, namely 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects (MNRE, 2017b). Some points of difference between the two sets (solar and wind) are as follows.

- In the case of wind power, the minimum project size for bidding for projects within a state is 25 MW; for inter-state projects, the size is 50 MW. In the case of solar power, the minimum project size is 50 MW (taking into account the availability of land and transmission infrastructure, the projects may be smaller).
- The annual capacity utilization factor (CUF) to be declared by a wind power generator will not be less than 22%; no such limit is stipulated for solar projects in the guidelines. If the energy generated annually by a wind project is less than that corresponding to the lower limit of the allowed variation in CUF as defined in the RfS, the generator will pay a penalty of at least 75% of the cost of this shortfall, calculated on the basis of the tariff specified in the PPA; for solar projects, the penalty will be at least 25%. If the energy generated is more than the upper limit of the allowed variation, the generator is allowed to sell the surplus power to a third party, given that the right of first refusal lies with the procurer. If the procurer decides to buy the power, the rate will be 75% of that stipulated in the PPA.
- Unlike the solar guidelines, the wind guidelines specify no generation compensation if there are offtake constraints because of unpreparedness of transmission infrastructure for reasons not connected with the generator.
- As to the timelines, the PPA is to be signed 105 days (as opposed to 150 days in the solar guidelines) from the date of issue of RfS, and land is to be acquired within 7 months (as opposed to 12 months) from the date of signing the PPA.

6.6 Guidelines for Wind–Solar Hybrid Projects

In May 2018, the central government announced a scheme (MNRE, 2018i) to tender for 2500 MW of ISTS-connected wind–solar hybrid projects to be developed across the country. The nodal agency for implementing the scheme is SECI, and the intermediary procurer of power from the projects is to be chosen on the basis of techno-commercial bidding followed by an e-reverse auction. The scheme document also contained guidelines for transparent competitive bidding for implementing the scheme. The tender was issued in the second half of June with a bid submission deadline of August 8, 2018 (Mercom India, 2018f). However, the response to the tender has not been encouraging so far.

The differences in the guidelines for competitive bidding between solar power and wind–solar hybrid projects are as follows.

- For utility-scale solar, the normative CUF is 19%, whereas the CUF to be declared by the hybrid project developer at the time of signing of the auction will not be less than 40%.
- To incentivise the development of hybrid projects, the guidelines also provide for buying any excess generation over the declared CUF at the tariff stipulated in the PPA. However, the developer is liable to compensate the buyer in case of a shortfall in generation below the lower limit of the declared annual CUF.
- The wind–solar hybrid project will be commissioned within 18 months of issuing the letter of award and the period cannot extend beyond 27 months.

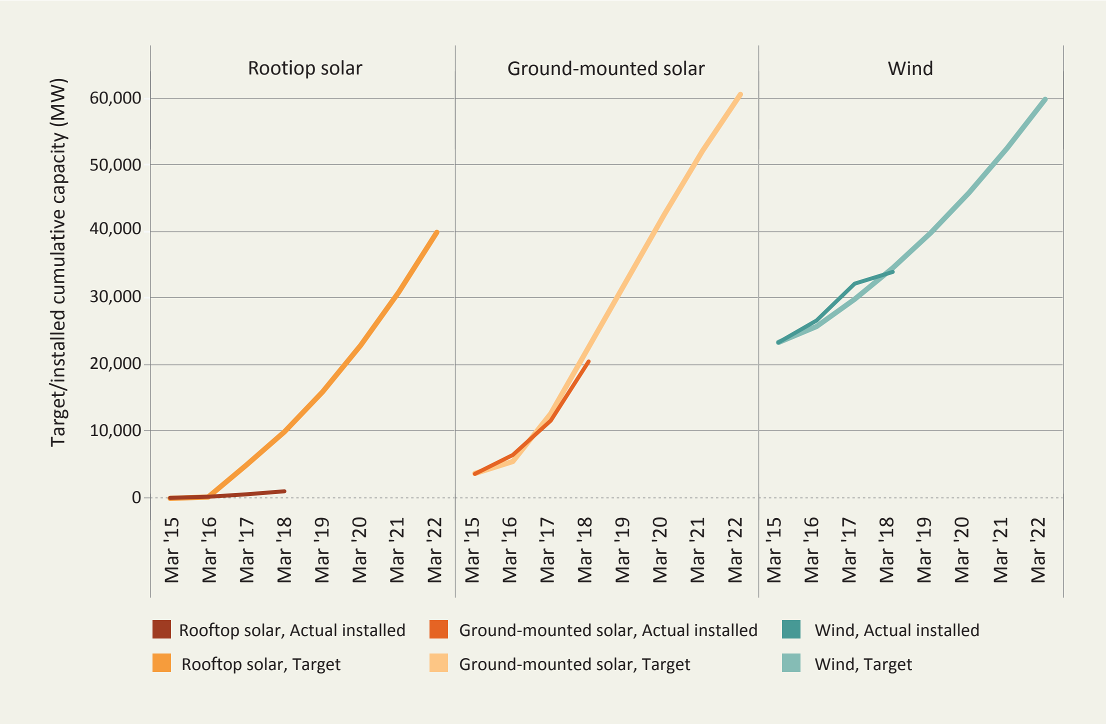
6.7 Regulations for Connectivity for ISTS-connected Projects

Lastly, In May 2018, the CERC released the final regulations (CERC, 2018d) for the procedure for granting medium- and long-term access to the ISTS for RE projects (with or without storage). Under these regulations, namely 'CERC (Grant of Connectivity, Long-term Access and Medium-term Open Access in inter-State Transmission and Related Matters) Regulations, 2009', any RE project of 50 MW or above will be granted connectivity in two stages. An entity is eligible for stage 2 connectivity if it has been selected by a central or state agency through competitive bidding for developing an RE project or establishes ownership or lease rights or land use rights for 50% of the land required for the capacity stipulated for stage 2 connectivity and has achieved financial closure.

7. Rooftop Solar

With addition of 458 MW during FY 2017-18, the cumulative rooftop solar capacity now stands at 1064 MW, which is far behind the trajectory of capacity addition required for achieving the target of 40 GW of rooftop solar by 2022, unlike ground-mounted solar and wind, which are on track (Figure 7.1). These rooftop solar figures are based on the data provided by the MNRE: the market estimates for capacity addition in 2017-18 are much higher, at 1142 MW, taking the cumulative capacity to 2538 MW (BTI, 2018c). Further, the targeted capacity addition for rooftop solar for 2017-18 as stated by the MNRE is 1000 MW (MNRE, 2018), much below the target, set in 2015, of 10,000 MW annually.

Figure 7.1: Comparision of installed cumulative capacity with the targets under 175 GW RE by 2022. Refer to REDP for more details and future updates.



Source: MNRE

Within rooftop solar, the government, industrial and commercial segments have been the most active owing to economies of scale and higher savings whereas the residential segment is yet in a nascent state. This disparity is highlighted in the case of Delhi, which released its solar energy policy in September 2016 to offer a substantial incentive to that segment. Among other incentives, the policy provided ₹2/kWh as a generation-based incentive (GBI) for three years to residential consumers installing rooftop solar plants. However, as the figures released by the Delhi government (ET Energy World, 2018a) show, in FY 2017-18, only about 300 residents used the GBI (and 31 residents had done so before that): the disbursed incentive amounted to about a crore compared to ₹20 crore budgeted for in 2017-18. The reasons for poor performance include low awareness, lack of space and structural problems with roofs, high up-front capital costs, delays in disbursing the CFA and poor implementation of net metering.

Discoms have an important role if the rooftop solar segment is to grow rapidly. They are connected to the end consumer, manage the distribution systems and are responsible for approving rooftop solar plants. However, because they stand to lose a part of their revenue as the segment grows, they are unenthusiastic about it and in some cases have been dissuading consumers from installing rooftop solar plants. For example, Maharashtra's Discom MSEDCL recently proposed a specific surcharge on consumers with rooftop solar (ET Energy World, 2018a).

Given the current status and the need for a policy shift to promote rapid growth of rooftop solar, the central government has been making efforts to provide a policy impetus: in December 2017, it issued a concept note on a scheme to promote rooftop solar, namely SRISTI, short for 'Sustainable Rooftop Implementation of Solar Transfiguration of India' (MNRE, 2017c), as part of Phase 2 of the current Grid Connected Rooftop and Small Solar Power Plants Programme (the programme will continue up to 2019-20). The scheme mainly aims to bring Discoms to the forefront by providing a financial incentive for adding rooftop solar (including for residential sector) in their distribution areas. Further, a 30% CFA will now be available only for projects in the residential sector, with a limit of 5 kWp. Financial outlay for the scheme is ₹23,400 crore. However, the scheme is yet to be officially notified.

To smoothen the development of rooftop solar, the MNRE issued a stringent directive to all implementing agencies to adhere strictly to the Grid Connected Rooftop and Small Scale Rooftop Solar Programme (Mercom India, 2018e), because disbursement of the CFA was being delayed owing to the implementation agencies not abiding by the provisions made in the programme.

Some other relevant and important policy changes and regulatory judgements are as follows.

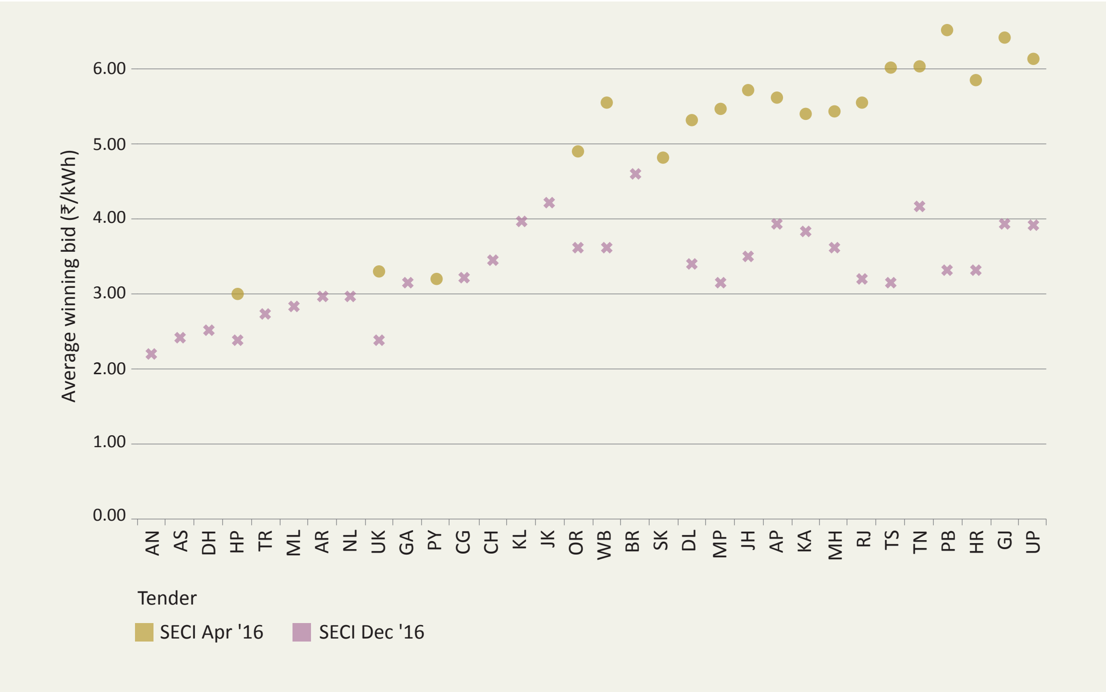
- A draft of new regulations for net and gross metering for rooftop solar was introduced in Bihar.
- Effective November 23, 2017, the MNRE discontinued the empanelment of channel partners under its Grid Connected and Small Solar Power Plants Programme.
- In most cases, net metering is applicable to grid-connected solar power plants up to 1 MW. However, this restriction has now been eased in some cases. In the new textile policy released by the Government of Maharashtra in February 2018 (GoM, 2018a), this limit has been removed, and textile plants wanting to use solar and wind power have also been offered other incentives . Similarly, in an order passed by the Odisha ERC in February 2018, the limit has been done away with. On the other hand, the MERC dismissed a petition by Bharat Electronics Ltd. (BEL) to allow net metering for a 3 MW grid-connected solar plant at an ordnance factory (MERC, 2018). In its petition, BEL had noted that under the same scheme, the UPERC had approved net metering for solar power projects greater than 1 MW at two ordnance factories. In an earlier order in January 2018, the MERC also refused to relax the 1 MW limit for Maharashtra Metro Rail Corporation Ltd.
- In an important ruling, the MERC did not allow net metering for a 991 kWp rooftop solar plant to an eligible consumer who had also been granted partial OA for 3000 kVA. (MERC, 2018). In its order, the MERC noted that net metering and OA cannot be combined, because of problems related to grid security, billing and security. The regulations related to net metering and OA have also been framed to avoid such a mix.

Rooftop Prices

Despite dim on-the-ground realities, the economic viability of rooftop solar remains high, as shown by the results of two large-scale tenders by SECI (Figure 7.2). These include results from the 500 MW grid-connected rooftop solar PV system scheme under CAPEX and RESCO models tendered in April 2016 (results declared in September 2017) and the 500 MW Phase 1 of its 1000 MW grid-connected rooftop solar PV system scheme for government buildings under CAPEX and OPEX models tendered in December 2016 (results declared in December 2017). In both these auctions, the low discovered tariffs in special category states such as the North Eastern states, Sikkim and Uttarakhand, were due to the higher CFA of 70% of benchmark costs to those states. The December 2017 auction saw significantly lower tariffs, wherein the installation was on government buildings. For example, the average winning bid in Maharashtra was ₹5.5/kWh in the September 2017 auction but ₹3.6/kWh in the December 2017 auction, a drop of ₹2/kWh in such a short time. In Telangana, the price dropped from ₹6.6/kWh to ₹3.1/kWh. In these two states, the REDP illustrates how a majority of the respective Discoms's sales are priced above these low discovered tariffs, indicative of the threat to these Discoms from rooftop solar.

More recently, in August 2018, a tender by Madhya Pradesh Urja Vikas Nigam Ltd. (MPUVNL) for 35 MW of grid-connected rooftop solar under the RESCO model saw the lowest ever tariff of ₹1.58/kWh (EQI, 2018b). This is the first-year tariff, which will rise by 3% every year, which converts to a levellised tariff of ₹2.01/kWh at a discount rate of 10%. The low tariff discovered in the tender is partly due to the additional 20% subsidy available from the state government. And, in July 2018, a tariff of ₹3.64/kWh was discovered in the auctioning of 15 MW of rooftop solar by the New and Renewable Energy Development Corporation of Andhra Pradesh Ltd (NREDCAP) for government-owned buildings (Mercom India, 2018h).

Figure 7.2: State-wise winning RESCO bids in SECI tender for the implementation of 1000 MW grid-connected rooftop solar PV system scheme for government buildings in different states/union territories of India under CAPEX/RESCO model (500 MW capacity phase I). Refer to REDP for more details and further updates..



Source: SECI, CERC, CEA

8. Open Access

The Electricity Act, by enshrining open access, or the *'the non-discriminatory provision for the use of transmission lines or distribution system or associated facilities with such lines or system by any licensee or consumer or a person engaged in generation,'* had hoped that it will lead to competition, choice and higher efficiency in the sector. However, implementing OA in general and with RE in particular (RE-OA), has proved challenging. Although third-party sale and captive consumption of RE have been in vogue for a very long time, it is only in the recent past, with its growing scale, that RE-OA has been identified as a distinct entity with its own unique features that make it different from OA based on conventional sources. These features pertain to the variable and intermittent nature and low CUFs of RE.

Our previous report on this topic, namely 'Choosing Green: The Status and Challenges of Renewable Energy based Open Access,' published in November 2017 (PEG, 2017e), noted that such RE-rich states as Gujarat, Madhya Pradesh, Andhra Pradesh and Telangana have witnessed an increase in the quantum of RE-OA in the last couple of years. The report also pointed out various regulatory and operational challenges with regard to the current OA framework in the country. These challenges include the lack of coherent data to understand the progress of RE-OA, lack of medium-term certainty in levying OA charges, absence of a pre-defined trajectory for withdrawing concessions and lack of standardised gradation of penalties for deviation settlement for different types of OA transactions. The operational challenges include delay in issuance of no-objection certificates by utilities and state load dispatch centres (SLDC) and denial of OA permission to applicants by utilities on account of various reasons. Moreover, OA charges are considerably high in many states, which defeats the purpose of competition in the sector.

Given the inherent seasonal and diurnal variation in RE generation, RE-OA is quite unviable at present without some form of a banking framework. The report suggested a new energy banking framework for valuation of banked and unbanked energy, which linked the banking charge to merit order dispatch of Discoms. Such a mechanism will do away with the usual practice of charging for the banking facility in kind. The framework comprises a yearly banking mechanism to take into account the difference between power purchase cost at the time of banking of energy and its drawal. This will ensure revenue neutrality for utilities and consumers eligible for banking.

The report also made the following suggestions for improving the OA framework in the country.

- Ensure medium- to long-term certainty, especially in the most significant charge, namely CSS, to encourage consumers to move towards medium- or long-term OA and avoid the problem of frequent switching between a Discom and market supply: set CSS at a level that does not deter competition through OA.
- Relieve Discoms of the burden of concessions or waivers given to RE-OA and their consumers. If at all concessions are to be provided, the state government can bear the burden through Direct Benefit Transfers (DBTs).
- Establish data centres similar to NOAR (National Open Access Registry) across all states to address the issue of lack of detailed data on RE-OA.
- Use ring fencing and strengthen the SLDCs to remove operational hurdles.

Regulatory Updates

RE-OA has increased primarily for two reasons: (1) the relative viability of RE-OA compared to conventional OA due to low RE market prices coupled with various concessions or waivers in charges and (2) delay in payments by loss-making distribution utilities to independent power producers (IPPs) selling renewable electricity to Discoms[3] (Renewable Watch, 2017a; Renewable Watch, 2017b).

One of the drivers for greater uptake of RE-OA is regulatory support in the form of promotional concessions and waivers in OA charges. Our report 'Choosing Green' lists these concessional OA charges for a few states—and many more have further proposed similar concessions since the publication of that report. In its draft OA regulations, the Assam ERC offered a 50% concession on bank guarantee for application of RE-OA transactions. The draft also stated that highest priority for energy drawal by OA customers would be given to RE generation (AERC, 2018). The Bihar ERC too proposed waivers in the form of exemptions for solar and wind power projects from transmission charges for OA (BERC, 2018). In 2017, the Uttar Pradesh ERC also introduced such a promotional measure: a state that has little to no solar OA has introduced waivers in various OA charges (BTI, 2018a). In its first amendment to the Captive and Renewable Energy Regulations, 2014, Uttar Pradesh ERC stated that it would exempt all inter-state transactions of solar developers opting for captive and/or OA from paying transmission and wheeling charges and CSS. A 50% exemption was also announced in transmission and wheeling charges for all intra-state OA and captive transactions of large-scale stand-alone solar projects (UPERC, 2018). Recently, the Haryana ERC also announced concessions and the facility of banking for all OA consumers who opt for solar power generated from ground-mounted and rooftop solar plants commissioned in the control period from 2017-18 to 2020-21 and located within the state. These provisions would also be applicable to captive solar projects for self-consumption. The concessions entail complete waiver of CSS, transmission and wheeling charges and additional surcharge (AS). With regard to banking, availing the facility will draw a charge of 5% on banked energy, in kind. Consumers can bank solar energy monthly throughout the year. However, the banked energy cannot be drawn during the peak season, peak load hours and certain time-of-day tariff periods. The order will be applicable for ten years from the date of commissioning of plants or the date of notification (whichever is later). The Haryana ERC also added a proviso stating that these concessions would continue until the state attains 500 MW installed solar capacity; thereafter, the commission would review the need for these concessions and the banking facility (HERC, 2018).

While Uttar Pradesh and Haryana have opened their gates to OA, some states removed such concessions in 2017. In 2016, the MERC announced removal of the 75% concession on CSS for RE OA consumers from FY 2017-18 (MERC, 2016). More recently, in 2018, the Tamil Nadu ERC also reduced concessions on OA charges in its recent solar and wind tariff orders. The new tariff orders reduced the concession on transmission and wheeling charges from 70% to 60% for solar power and from 60% to 50% for wind power. The concession on CSS too was reduced from 50% to 40%. As to banking facility, it is not available for solar projects so far, and charges for it in the case of wind power, payable in kind, were increased from 12% to 14% for all existing projects commissioned before April 1, 2018. For projects commissioned on or after that date, the Tamil Nadu ERC has allowed energy banking only for one month, and without any charges, but

3. This can also be corroborated indicatively by the fact that 66 out of a total 345 RE-related cases (19%) that were heard in the judicial and quasi-judicial courts of Maharashtra between the 2010 to 2018 were about delays in payments of energy purchase agreements. Based on Prayas (Energy Group) analysis.

only for captive and REC projects and not for projects in which power is bought from a third party. Specifically, 'the purchase of excess generation/unutilised banked energy shall be at 75% of respective wind energy tariff for normal wind energy captive users and 75% of Pooled cost of power purchase as notified in the orders of the Commission from time to time for captive generators under REC scheme at the end of the month. As and when the Commission's DSM regulations come into force, the adjustments of energy will be as per the said regulations/orders of the Commission.' (TNERC, 2018b; TNERC, 2018c).

Most recently, the Karnataka ERC reduced the concessions for all new wind and mini hydel projects and removed all concessions for new solar projects commissioned on or after April 1, 2018. For wind and mini hydel projects, the concession was reduced from 95% to 75% for transmission and wheeling charges. For new solar projects, normal OA charges are applicable. The banking charge, fixed at 2% of banked energy (and thus payable in kind) is applicable to all RE projects. The order also retroactively reduced concessions for solar, wind and mini hydel projects that were commissioned during specified periods before April 1, 2018: all wind projects commissioned between 10 October 2013 and 3 September 2017 and mini hydel projects commissioned between 1 January 2015 and 31 March 2018, are now required to pay 25% (compared to 5% earlier) of the normal transmission and wheeling charges.

For solar projects commissioned on or before 31 March 2017, the earlier concessions and exemptions will continue (KERC, 2018b; KERC, 2014). Nearly 1 GW of OA-based solar capacity was commissioned in the first three months of 2018 alone (Business Today, 2018). One of the main reasons for this spike was the impending expiry of concessions on 31 March 2018, as mentioned in the earlier order. However, it appears that for solar projects commissioned between April 1, 2017 and March 31, 2018, the reduction in concessions applies retrospectively. Such retrospective removal of concessions does create uncertainty, and the need to re-negotiate existing contracts can slow down future uptake significantly (Financial Express, 2018b). Aggrieved by the commission's order, writ petitions were filed by RE project developers including Avaada Energy, Prestige Group and Embassy Group: in response, Karnataka High Court issued an interim stay (ET, 2018b).

Figure 8.1 illustrates the landed price of solar and coal-based OA to an industrial consumer connected at a voltage level of 33 kV and within the supply area of BESCOM who obtains power from a plant commissioned during different periods. The base power purchase rate is assumed to be ₹3.50/kWh and ₹3.00/kWh for coal- and solar-based OA respectively. The landed price of coal includes the cost of complying with the RPO at the floor price of RECs. The landed price for solar includes the effective banking charge, for which it is assumed that 30%[4] of the energy generated is banked. It is charged in kind and valued at the landed cost of solar power (without banking charge).

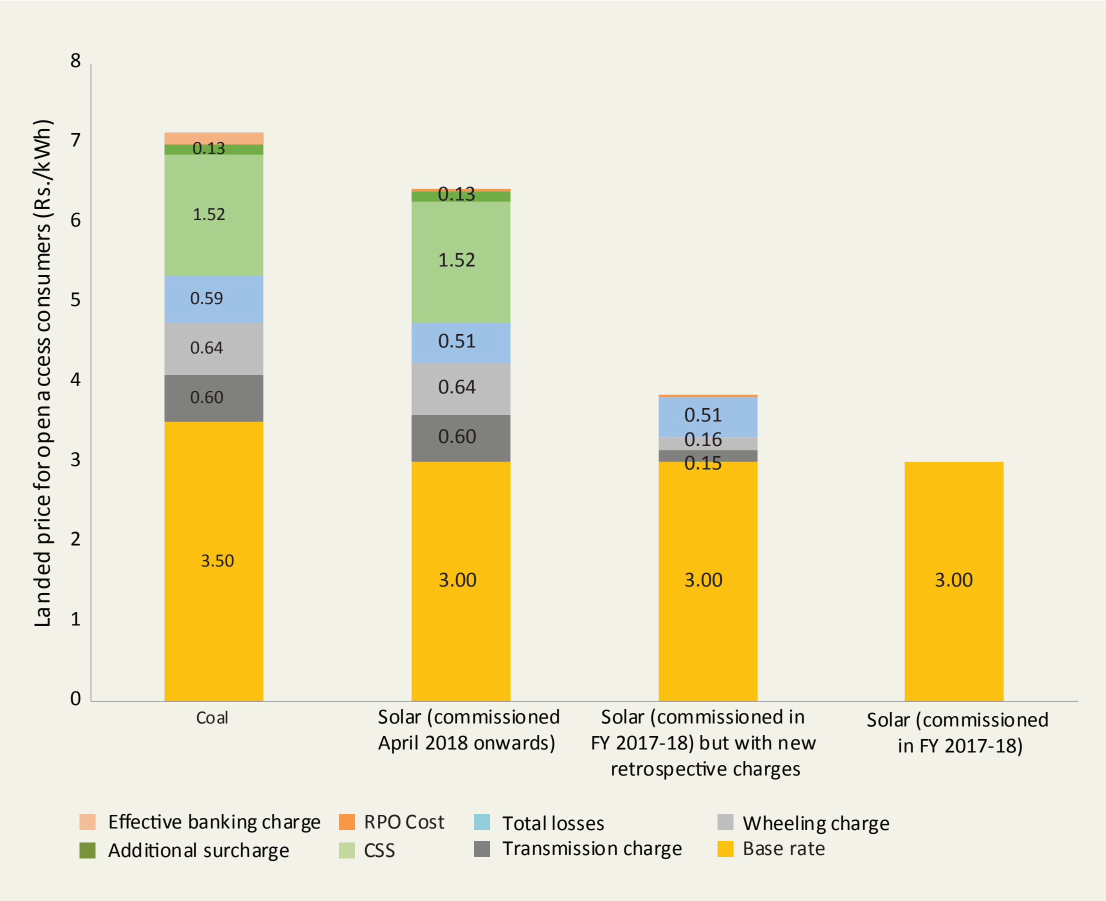
As the figure shows, for all those solar projects commissioned in FY 2017-18, the retrospective changes in concessions result in a landed price of ₹3.85–4.06/kWh[5] instead of ₹3/kWh—the landed price had the earlier concessions been upheld. This translates to a 28%–35% increase in price, thereby affecting existing contractual obligations. However, these prices are still significantly competitive compared to coal-based OA procurement.

4. Assumed for indicative analysis; it accounts for ₹0.03/kWh of the total landed price.

5. Range based on corresponding wheeling charges and losses for BESCOM, MESCOM, CESC, HESCOM and GESCOM.

All OA consumers who procure power from new solar projects commissioned on or after April 1, 2018, will now have to pay a landed price of ₹6.43/kWh because all concessions have been withdrawn. Although the price continues to be competitive compared to coal-based OA (₹7.13/kWh) and the basic energy charge for an HT 2 A industrial consumer in Karnataka (₹6.8/kWh), the difference has reduced sharply. Unless a well-defined medium-term concession trajectory with a sunset clause is announced with policy certainty, it could affect the growth of OA-based solar capacity addition in the state.

Figure 8.1: Landed price of solar- and coal-based OA and utility tariff in BESCOM supply area.



Source: Prayas (Energy Group) analysis based on various Karnataka ERC orders

However, in the midst of all this talk about competition and increase in the uptake of RE-OA, one cannot forget the impact of such market transitions on a key stakeholder, namely Discoms. Despite all the procedural and regulatory hurdles that can deter consumers from opting for OA, sales migration is an inevitable reality. Our analysis shows that in eight states with fairly high amounts of OA penetration, sales migration due to OA is as high as 20% of the HT sales of the respective Discoms. Captive consumption, the other of form of sales migration, has also increased steadily across many states: from FY 2014-15 to FY 2016-17, it has accounted for 20%–30% of the Discoms's sales across a few states (PEG, 2018f). This implies that while the high-tariff-paying industrial and commercial consumers move to alternative sources of supply that are cheaper, Discoms are left to serve small and subsidised consumers.

The National Tariff Policy, 2016, identified the need to balance the interests of utilities and consumers and hence the need for SERC to set charges such as CSS and AS accordingly (MoP, 2016b, p. 36) and for Discoms to rethink their business model to address this inevitable shift in market dynamics. Prayas (Energy Group) in a recent discussion paper suggested three strategies for the sector to break the vicious cycle of the Discoms's worsening financial health (PEG, 2018f, pp. 18-30). One of these is to take cognisance of the accelerating and inevitable sales migration. However, such sales migration, be it captive or OA, should only be allowed for medium- to long-term transactions. Currently, short-term transactions account for 60% of the total number of transactions in power exchanges (PEG, 2018f, p. 17). In the future, as larger consumers opt for non-Discom options, limiting short-term sales migration as mentioned above will reduce uncertainty in planning for power procurement. The other two strategies aim to reign in the rising average cost of supply by improving efficiency, by not signing long-term PPAs for base load without rigorous demand assessment and by pushing for low-cost, distributed solar supply to agriculture feeders to meet its demand, which can substantially reduce a Discom's subsidy and cross-subsidy requirements. Given these strategies, the Discoms can be better prepared to manage the disruptive forces facing the power sector. These ideas and a potential way forward for the sector are elaborated in the discussion paper noted earlier.

9. Grid Integration of Renewables

The efforts to integrate intermittent wind and solar generation in the electricity grid in India started with introduction of the Renewable Regulatory Fund (RRF) mechanism in 2010, which mandated forecasting and scheduling for both wind and solar generators. The mechanism faced a few concerns with regard to its legality, financial impact on generators, applicability etc. until 2014, which delayed its full implementation. To replace the RRF mechanism, the CERC notified the 'Framework on Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy Sources (Wind and Solar) for Wind and Solar Generators Connected to IST' in 2015. This framework was followed by 'Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generators at the State Level' of the Forum of Regulators (FoR) in the same year (PEG, 2016b)[6]. The efforts after 2015 to integrate renewables can be broadly categorised into improving grid practices and infrastructure, increasing the flexibility of the grid using technical options, and new commercial settlement mechanism and market mechanisms. This report gives updates on various interventions related to grid integration of renewables since August 2017.

9.1 Improving Grid Practices and Infrastructure

9.1.1 Transmission Connectivity of Renewable Energy

The Power Grid Corporation of India Ltd. (PGCIL), which is the Central Transmission Utility (CTU), is the nodal agency to process applications related to connectivity, and long- and medium-term access to ISTS. It filed a petition before the CERC in September 2017, seeking regulatory interventions to ensure efficient utilization and for preventing underutilization of bays for connectivity granted to wind and solar generation projects. The central commission identified seven issues with the current connectivity regulations for wind developers, the key ones of which are listed below.

- Whether the existing provisions of the connectivity regulations and the detailed procedure stipulated under those regulations are adequate to address the issues of connectivity of wind power developers and generators
- Whether the connectivity granted by the CTU has created vested rights with developers or generators who have been granted connectivity, and whether the developers or generators who have been granted connectivity but are not using it are likely to block it for potential developers or generators
- Whether the applicants who have been selected through competitive bidding for developing wind power projects should be given overriding priority in granting connectivity
- Guidelines for the CTU to process pending applications for connectivity in respect of wind power developers or generators

The commission also ordered its staff to check if amendments are needed in connectivity regulations and procedure (CERC, 2017a) and came up with 'Draft Procedure for Grant of

6. Refer to earlier editions of this report for more information on earlier developments related to grid integration of renewables in India.

Connectivity to Projects Based on Renewable Sources to Inter-State Transmission System' in April 2018, which was finalised in May 2018 after public consultation (CERC, 2018c). Despite the new procedure notified by the CERC, wind developers continue to face uncertainty in getting connectivity for projects especially in Gujarat and Tamil Nadu (Financial Express, 2018a). These are winning projects under bids which had been invited by the SECI in the last 15 months and had sought connectivity to ISTS. In this case, new substations are required to be built by the PGCIL, which would take 36–40 months. However, wind projects are required to be commissioned within 18 months of the date of award. This would result in increased interest during construction (IDC) and penalties for developers because getting access to a transmission network and connectivity are solely their responsibility (The Indian Express, 2018).

The new procedure by the CERC tried to solve the above problems by making the following changes.

- The grant of connectivity was divided into Stage 1 and Stage 2. A generator can apply for Stage 1 or for both the stages simultaneously. At Stage 1, only the location of the substation would be given to the applicant, the bay location being given only at the time of granting connectivity (Stage 2). Because an applicant for Stage 2 needs to be 'an entity which has been selected through the tariff based competitive bidding carried out by the agency designated by the Central Government or the State Government for development of RE projects including hybrid projects,' this will avoid underutilization of bays due to the connectivity grantee not winning the bid.
- The procedure tries to ensure optimal utilisation of bays and transmission lines by mandating periodic reports of utilisation to the CTU by both Stage 1 and Stage 2 grantees and allowing connectivity and dedicated transmission infrastructure to be shared with other generators of RE.
- To avoid delays in getting transmission connectivity because of the time required to build a substation and other similar problems, it was made mandatory to
    - develop the location and the capacity of various ISTS pooling stations and associated transmission facilities keeping in view the exploitable wind or solar potential of the area based on the information to be made available by the MNRE or any agency, authority, or nodal officer designated by the MNRE and
    - share information (this was the responsibility of the CTU) on available capacity bay by bay of the ISTS substation with the designated agencies as notified by the government who may consider it while inviting the bids (CERC, 2018c).

However, even after notifying the new guidelines, wind developers seem to see evacuation as a major challenge. This perception was perhaps reflected in the poor response to invitations from SECI to bid for wind power: a 2000 MW tender was cancelled and another reduced from 2500 MW to 1200 MW. Given the long time it takes to build substations compared to that to set up wind projects, even other bids in next one or two years are likely to be affected, as most of the substations in Tamil Nadu and Gujarat are already fully loaded. Shifting the bid regions to other wind-rich states like Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Madhya Pradesh through incentives could address this issue but may lead to higher tariffs (Wind Power Monthly, 2018).

Some suggestions to refine the procedure for allocation of ISTS connectivity to RE generators are as follows.

- Modify the bidding guidelines to enable the PGCIL or the state transmission utility to be party to the process with a defined level of responsibility.
- Invite parallel bids for new transmission infrastructure or for strengthening the existing infrastructure as necessitated by the bids for wind and solar generation.
- Allow developers to begin work, at their own risk, on transmission lines up to the substation even before they are granted the required connectivity.

Also, the CERC notified 'Central Electricity Regulatory Commission (Planning, Coordination and Development of Economic and Efficient Inter-State Transmission System by Central Transmission Utility and Other Related Matters) Regulations, 2018' to enunciate broad principles for efficient, coordinated, reliable and economical transmission planning and to ensure transparency and participation of stakeholders in transmission planning (CERC, 2018h).

9.1.2 Other Efforts to Improve Grid Practices and Infrastructure

A technical committee of the FoR is considering the rollout of smart meters in the future, after which dynamic pricing including time-of-day (ToD) tariffs may be introduced (FoR, 2017a). Smart meters may enable consumers to bring in newer and more flexible resources (on both demand and supply sides) for more effective operation of the system. The central government is also planning to shift all electricity connections to prepaid smart meters by 2021 (ET, 2018d). Although different government agencies in some states and UTs including Uttar Pradesh, Bihar and Chandigarh have started installing smart meters recently, only 3% of the high-paying consumers in the country had smart meters by July 2018 (Mercom India, 2018j) (TOI, 2018b) (LiveMint, 2018c). Apart from smart meters, other important initiatives in progress include setting up of renewable energy management centres (REMC) at SLDCs of seven RE-rich states (Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan) (PV Tech, 2017), three regional load dispatch centres (RLDC) and the National Load Dispatch Centre (NLDC); mandating low voltage ride through (LVRT) for wind and solar generators and strengthening and constructing transmission lines under the 'Green Corridor' project.

9.2 Increasing the Flexibility of Grid Using Technical Options

Grid flexibility can be broadly defined as the ability of the grid to respond to system changes over different time scales to maintain reliable, economic and secure operation of the system. In addition to sudden load changes and tripping of an element (a transmission line, a generation unit, etc.), intermittent RE generation–a feature of wind and solar power–increases uncertainty and needs the grid to be even more flexible. The flexibility of the grid is determined by how quickly and in what amount the generation and the demand respond to such needs. Efforts on multiple fronts are being made to make the Indian grid more flexible, and some of the important efforts are discussed in this section.

9.2.1 Reserves

Primary reserves

India has typical frequency response characteristics (FRC) of 9000 MW/Hz obtained through a mix of load response and governor response. The order of the CERC in October 2015 mandates about 4000 MW (equivalent to the loss of one ultra mega power plant (UMPP) of primary response for the Indian power system. The expert group set up by the CERC also recommends penalising the generators who provide lower than the mandated FRC (40% of the unit rating per unit change in frequency), as mentioned in the CERC Terms and Tariff Conditions, 2014, which stipulate a penalty for 1% reduction in the RoE for the period in which the restricted governor model operation (RGMO) or free governor mode operation (FGMO) is not commissioned or not working. The expert group recommends

- periodic tests for measuring the primary response of generators with a response time of 30 seconds for full response,
- gradual phase-out of the RGMO by April 1, 2018, and introduction of speed control with droop, and
- a road map in the IEGC for reducing the governor dead band.

The expert group also recommended that the Central Electricity Authority (CEA) notify a new technical standard for connectivity for RE generators, making primary frequency control from wind and solar plants mandatory (CERC, 2017b).

Secondary reserves

To review and suggest measures to bring power system operation closer to national reference frequency, the CERC constituted an expert group, which recommended automatic generation control (AGC) for wind and solar generators. The response from AGC of wind and solar generators can be used in extreme cases such as when secondary response from conventional generators is exhausted. If conventional generation is at its technical minimum and generation needs to be reduced even further, the AGC signals could help quicker curtailment of RE generation than that possible from the existing conventional methods. However, using these AGC signals for upward regulation should be deliberated with regard to capacity overloading vis-à-vis the capacity declared in the PPA (CERC, 2017b).

Apart from upward regulation, it is also important to consider other issues such as applicability, compensation for providing ancillary services until a market-based mechanism is put in place, readiness of the load dispatch centres (LDCs), integration with current scheduling and deviation settlement practices.

An update on implementation of the AGC and primary control within states reports

- a mock test of AGC-based secondary frequency control conducted successfully at NTPC, Dadri, on 29 June 2017, which yielded desired results: a petition was filed in this matter by POSOCO with the CERC to operationalise the AGC in Dadri Stage 2 units on an ongoing basis and
- a pilot project for AGC, which is already being considered for a few hydro units of KPCL in Karnataka.

The expert group also recommended implementing AGC-based secondary frequency control in a few large states if the respective SERC orders it (CERC, 2017b).

Tertiary reserves

Bringing regional merchant generators or independent power producers under ancillary services framework: At present, merchant generators sell power to multiple buyers using different types of contracts bilaterally, through a trader or at power exchange. This generation capacity of merchant plants, which is scheduled only by the RLDC, can also contribute to ancillary services, helping when all the generation available for ancillary services is already exhausted. At present, only those regional plants (except hydro) are allowed to participate in the reserves regulation ancillary services (RRAS) mechanism the tariff of which is completely determined by the CERC or adopted by it. This prohibits merchant plants from participating in the RRAS mechanism.

These merchant plants would need to provide their variable charge to the RLDC so that ancillary services can be dispatched according to the merit order. However, because their tariff is not determined or adopted by the CERC, the variable costs of these plants are not known upfront. The expert committee suggested two methods by which variable costs of merchant plants can be calculated and used in the merit order dispatch (MoD) of ancillary services, namely the regulated method and the auction method. In the regulated method, the weighted average rate of the long-term contracts entered into by the IPP/merchant power plant (MPP) or the commission may specify a rate for each plant; in the auction method, power exchanges may introduce a new segment for reserves, and the rate of each station so discovered is applicable for merit order dispatch during the next month.

Broadly, the above suggestions by the committee are expected to improve the ambit of RRAS in terms of eligible participants or generators and the type of services. Although the RRAS mechanism is expected to shift to a market-based mechanism in near future, some SLDCs have expressed concerns about losing control of such a valuable resource as RRAS.

Recommended ancillary services for the near future: The technical committee of the FoR had a mandate to develop a road map for implementing AGC and operationalisation primary reserves within states. In July 2016, POSOCO submitted its feedback to the CERC on the RRAS framework, after which the CERC decided to implement the following features[7].

- Secondary frequency control through AGC
- Fast response ancillary services (FRAS) from hydro generating stations, given their zero marginal cost but with a new commercial settlement mechanism
- Voltage control ancillary service (VCAS), although a valuation of reactive power would be essential (Suitable compensation and incentive approved by the commission are also needed so that hydro generators would deploy synchronous condenser operation voluntarily).
- System re-start ancillary services (SRAS), in case of system-wide blackouts, the black start capability of some identified generators is very important to bring the system back online. Under Clause 5.8(b) of the IEGC, mock exercises for a black start must be conducted twice a year by the identified units on demand by the system operator. These services were developed to ensure periodic testing of such generators and to incentivise them to keep the black start facilities voluntarily in a state of readiness.

9.2.2 Technical Minimum and Ramp Rates

At present, Section 6.3(b) of the IEGC mandates all central generating stations (which cover coal-based plants) to have a technical minimum equal to 55% of the installed capacity. However, most state grid codes do not mandate this minimum requirement, and the technical minimum of coal-based state generating stations (SGS) for many intra-state generations may be higher than

7. Presently, in India, primary frequency control is mandated and needs to be enforced. A pilot project for implementation of secondary frequency control has been implemented. The present ancillary services implementation falls in the category of tertiary frequency control.

55% of installed capacity. A petition filed by MSEDCL before the MERC in 2017 (MERC, 2018b) shows that the technical minimum of most SGS and IPPs is between 65% and 70% of installed capacity. Because states act as balancing areas, this higher technical minimum may limit the amount of intermittent wind and solar generation that can be absorbed in the state grid, resulting in curtailment (CERC, 2018g; MERC, 2018a). Recently, the MERC published its draft guidelines for merit order dispatch in Maharashtra. In this case, MSEDCL has agreed to compensate the generators for increase in heat rates, auxiliary consumption and the number of start and stops in line with the CERC regulations (MERC, 2018e).

Also, as is evident from monthly ancillary services (RRAS) data from the Western Regional Power Committee (WRPC), most of the new CGS have ramp rates less than 0.5% of the installed capacity per minute (WRPC, 2018). However, clause 6.4.6 of the recent CEA 'Standard Technical Features of BTG System for Supercritical 660/800 MW Thermal Units' states that the minimum ramp rate above 30% loading would be 3% of the installed capacity per minute (CEA, 2013b). Further, clause 2.1.14 of the CEA 'Standard Technical Specification for Sub-Critical Thermal Power Project - 2x (500MW or above) Main Plant Package' states that the ramp rate would be minimum 3% of the installed capacity per minute above 30% loading (CEA, 2008a). Hence, plant-specific studies need to be conducted by an independent entity to determine whether the technical minimum of SGS could be reduced further and whether an increase in the ramp rates of both CGS and SGS is possible. If such retrofitting is possible, the IEGC or state grid codes should be amended by introducing the relevant clauses, and the increase in the fixed cost incurred for such retrofitting can be passed through the Discom's ARR. Increasing the flexibility of conventional generation would certainly help not only in large-scale grid integration of renewables but also in reducing overall system operation costs.

9.3 New Commercial Settlement Mechanism and Market Mechanisms

9.3.1 CERC Consultation Paper on Terms and Conditions of Tariff Regulations

In May 2018, the CERC released a consultation paper on terms and conditions of tariff regulations for the tariff period April 1, 2019 – March 31, 2024 (CERC, 2018e). The paper uses the value chain approach to analyse each generation resource:

'In case of likely regulation of supply of the renewable generation, the entire tariff of the renewable generation (which is of the nature of fixed cost) is compared with the marginal cost of the other generation (excluding the fixed cost component), for merit order. Therefore, the tariff structure of renewable generation poses specific challenges in operation and for merit order considerations.'

The concept paper also discusses the idea of a two-part tariff for renewable generators unlike the present case whereby a levelised tariff (in rupees per kilowatt-hour) is offered to plants that generate RE. Whereas most new wind and solar plants are based on competitive bidding, having moved away from the generic feed-in tariff, the tariff remains a single figure that reflects fixed costs (mostly capital costs) as well as variable costs (payable for actual generation measured in kilowatt-hours). The consultation paper discusses the following limitations of the existing single-part tariff structure.

- If the supply of the RE is regulated, it may not be possible to compensate generators with some minimum charges.

- For merit-order operation, the entire tariff of RE generation) is to be compared with the marginal cost of other types of generation (excluding the fixed cost component).
- If RE is bundled with conventional power ex bus a generating station, it may be difficult to combine the tariff because a RE tariff is a single-part tariff whereas conventional generation has a two-part tariff (CERC, 2018f).

The consultation paper also discusses a two-part tariff for RE, covered only under Section 62 of the Act. Two alternatives are proposed for such two-part tariffs.

- A fixed component (debt service obligations and depreciation) and a variable component (equal to the marginal cost, i.e. operation and maintenance expenses and return on equity).
- A fixed component as feed-in tariff and a variable component equal to capacity augmentation such as storage or backup supply tariff.

This is a far-reaching proposed change in the tariff structure for RE. At present, under the new bidding guidelines and PPAs, backing down is set to be compensated for, partly or fully, depending on the reasons for curtailment. Essentially, this is a larger question over the value of renewables to the system, risks for developers etc. Finally, such a structure would also have to be extended to plants covered under Section 63, the tariff for which is discovered through competitive bidding.

For the integration of RE plants with coal- or lignite-based thermal power plants, the paper offers three alternatives: a) replacing the energy charge of the thermal plant with the feed-in tariff of the RE plant, b) combining the feed-in tariff of the RE plant with the fixed and variable charges of the existing thermal plant by changing the financial and operational parameters for determining the tariff for the thermal plant and c) recovering charges for the supply of power from RE plants and thermal plants separately, which may be preferred because of ease of implementation and simplicity: green accounting could be done post monthly energy accounting, avoiding the complexity of the notions of fixed and variable charges.

9.3.2 New Tariff Regime for Intra-State Hydro Generators

The total installed capacity of hydro-based power stations in India is about 45 GW with 16 GW connected to the ISTS and 29 GW connected to intra-state transmission systems. Most states do not have a two-part tariff for intra-state hydro generators. POSOCO released a report 'Operational Analysis for Optimization of Hydro Resources & facilitating Renewable Integration in India,' which observed that a) hydro CGS can provide better peaking capability than intra-state hydro plants because capacity payment is linked to flexibility services such as daily peaking capability and annual mechanical availability of hydro units and b) there is a scope for better utilisation of hydro plants and thermal load factors can be increased.

The 'Model Intra State Hydro Tariff Regulations' which proposed a two-part tariff for hydro plants were endorsed by the FoR. Similar to the CERC tariff regulations for regional hydro generators, these regulations split the annualised fixed cost of hydro plants into two equal parts for calculating the capacity charge and the energy charge (FoR, 2017a; FoR, 2017b). Hydro units with their inherent flexibility should be used to minimise the overall system operation costs. The hydro plants are operated by system operators while keeping within the constraint of not using reservoir water for electricity under specified conditions. However, in future hydro generators will be competing with such technologies as battery-based electricity storage system for providing flexibility to the grid. Hence, efforts to value flexibility should begin now and an appropriate ratio be fixed for deciding a two-part tariff for hydro. However, most SERCs are yet to change the tariff for intra-state hydro regulations based on the FoR model regulations.

9.3.3 Shifting to Five-Minute Block for Scheduling, Dispatch and Commercial Settlement

Globally, most RE-rich countries have already implemented five-minute scheduling. The subcommittee constituted by the FoR also recommended a move to five-minute scheduling from fifteen-minute scheduling for Indian grid operation and commercial settlement in future. The move will make decision making in the grid operation easier and confer many benefits, some of which are as follows.

- Increase in granularity that would optimise the cost of ancillary services dispatch and help in reducing the earliest possible implementation of ancillary services, i.e. 16 minutes
- Better economic signals to incentivise more flexible operation of resources such as conventional generators and to increase the possibility of participation of such fast-responding technologies as smart grids, storage, demand response and electric vehicles
- Secondary regulation services through AGC (expected soon, which would necessitate moving to at least 5-minute settlements)
- Better anticipation of the ramping requirement, especially short duration, by system operators
- More frequent re-dispatch of the system resulting in better grid balancing

Broadly, 5-minute scheduling can measure and value the flexibility provided by fast-responding resources in a better manner.

It is also recommended that while 5-minute scheduling be implemented first at the regional or ISTS level, the states too should consider the possibility of 5-minute scheduling. The CEA is also expected to amend the metering regulations. To assess the feasibility and the need for changes (metering, interfacing requirements or file interchange formats, data validation, reporting) in the system for shifting to 5-minute scheduling, pilot projects are planned at four or five locations in each region, and 5-minute scheduling is to be implemented at both inter-state and intra-state levels from April 1, 2020 (FoR, 2017a; FoR, 2017b).

9.3.4 Regional Co-operation for Optimum Utilisation of Generation Resources

The target of 175 GW of RE by 2022 will result in more than 80% of this capacity being installed in the Western and Southern regions of the Indian power system. At present, the balancing of power happens at the state level: the demand of each individual state is balanced with the generation available with that state. Most of the RE target comprises wind and solar power, which are intermittent sources, i.e. variable and uncertain. To integrate this capacity, generation from a state and from the CGSs contracted by the Discom would have to be more responsive. The requirement for cycling (varying the level of generation) would depend on the need for flexibility, which in turn depends on load shape, size and RE generation's diurnal and seasonal characteristics. Each state has a certain combination of coal subcritical, coal supercritical, gas-based, nuclear and hydro generators, each with its unique flexibility characteristics. Different variable costs will result in appropriate use of that flexibility at different times of the day. However, these balancing resources are not uniformly distributed across states. Additionally, the need for flexibility in one state may compliment more flexible generation or demand in another state within the same region. To use this complementary balancing of availability and needs of different states, the FoR constituted a subcommittee comprising the power committees of the Western, Northern and Southern regions to *'examine the feasibility and modality of co-operation among States in the respective regions for ensuring optimum utilization of generation resources with least cost options for balancing across the region and submit their findings before the Technical Committee.'* The major issues related to sharing of resources within a region brought before the subcommittee are as follows.

- The states have recognised the value of electricity vis-à-vis the cost of generation. Some states are unwilling to cooperate with other states in the region on 'cost' basis; for example, by valuing precious pumped hydro resources.
- Some regions are predominantly surplus in power, leaving little scope for cooperation within the region. This necessitates a national level framework or product for optimum resource utilisation.
- Inter-state transactions need to be enabled closer to real time, which will necessitate new intra-day market products at the national level.

To enable trading between states with appropriate valuation of traded power, seven options were deliberated upon: a) banking, b) a DAM (day-ahead market) price on power exchange as reference, c) a pool based on variable cost as approved by the regulator and on payment of cost, d) a pool based on variable cost as approved by the regulator and on payment of marginal cost, e) a pool based on auction for intra-day for the rest of the day, f) a pool based on auction for intra-day on hourly basis and g) a pool based on auction for intra-day on intra-hour basis, such as for every 15-min block. Although the regional power committees (RPCs) of the RE-rich regions (Northern, Southern and Western) recommended a pool based on the auction for intra-day for the rest of the day, response from other RPCs is not yet available (FoR, 2017; FoR, 2017).

Essentially, one would need a framework to capture the value of traded electricity for the seller and for the buyer along with an appropriate institutional structure and clear delineation of the roles of different stakeholders.

9.3.5 Forecasting, Scheduling and Deviation Settlement Regulations for Wind and Solar Generators

Forecasting and scheduling of such intermittent sources as wind and solar are two critical pieces in grid integration of renewables and help in better planning and operation of the grid by making the intermittent RE generation visible to system operators, i.e. the LDCs. The process of replacing the earlier scheduling regime under the RRF mechanism for wind and solar generators with new regulations began in 2015 with the CERC's 'Framework on Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy Sources (Wind and Solar) for Wind and Solar Gener ators Connected to ISTS.' This was followed by 'Model Regulations on Forecasting, Scheduling and Deviation Settlement of Wind and Solar Generators at the State Level' by the FoR in the same year. Most state ERCs have already released the draft regulations. Amongst RE-rich states, Andhra Pradesh (APERC, 2017), Telangana (TSERC, 2018b), Karnataka (KERC, 2016), Madhya Pradesh (MPERC, 2018), Rajasthan (RERC, 2017a) and Maharashtra (MERC, 2018c) have notified the final regulations whereas Tamil Nadu (TNERC, 2017a) and Gujarat are expected to notify the final regulations in the near future. The delay in implementation may be due to some issues in the proposed model regulations and draft regulations of the state ERCs. In November 2015, the FOR constituted a standing technical committee, with a member from the CERC as the chair, consisting of technical members from state ERCs of RE-rich states (Tamil Nadu, Gujarat, Rajasthan, Maharashtra, Andhra Pradesh, Karnataka and Madhya Pradesh)[8], to solve these issues. One mandate for the committee was 'Deployment and implementation of a Framework on Forecasting, Scheduling and Deviation Settlement of Wind & Solar generating stations at the State level.' The committee identified some important issues related to role of qualified coordinating agencies (QCAs), funding the deficit in the state imbalance pool, operationalisation of the virtual pool and de-pooling mechanism, metering arrangement, separate treatment of inter-state transactions of entities connected to the state network etc. (FoR, 2017a; FoR, 2017b). Some key issues that remain are as follows:

- Revision of absolute deviation penalties for intra-state transactions: For wind and solar power, the deviation penalties are higher for intra-state transactions (except in Odisha) and vary from ₹0.5/kWh to 1.5/kWh compared to those for inter-state transactions, which vary from ₹0.3/kWh to 0.9/kWh if the fixed rate is linked to recently discovered tariffs of about ₹3/kWh. In the concept paper on draft forecasting and scheduling regulations of the MERC, it was noted that deviation penalties are considered using average renewable power purchase rate of MSEDCL, which is ₹5.01/kWh, resulting in deviation penalties ranging from ₹0.5/kWh to 1.5/kWh. Hence, deviation penalties for intra-state transactions based on absolute values need careful attention and regular revision in line with the market prices of wind and solar power (PEG, 2016b). This may be done periodically, may be once a year. Ideally, having a schedule-based commercial settlement for intra-state transactions and linking deviation penalties to PPA tariffs, as in the case for inter-state transactions, will help overcome this difference in penalties between intra-state and inter-state transactions and also remove the need for constant revision of deviation penalties for intra-state transactions.
- In the Tamil Nadu ERC's 'Draft of Amendment to the Forecasting, Scheduling and Deviation Settlement and Related Matters for Solar and Wind Generation Regulations, 2017,' for inter-state transactions (TNERC, 2017a), deviation penalties are linked to a fixed rate equal to the national APPC as determined by the CERC (₹3.48/kWh for 2016-17). At present, the state has a range of solar and wind tariffs, especially considering solar PPAs signed in the earlier years (tariffs of ₹5–7/kWh). Newer wind and solar tariffs are being discovered at roughly ₹3/kWh and these tariffs for later projects are expected to fall further whereas the national APPC is very likely to rise in the coming years. Hence, newer projects with lower tariffs (lower than the APPC) will be disproportionately penalised for under-injection as compared to older projects. Additionally, using the national APPC as a fixed rate may not ensure revenue neutrality of the DSM mechanism within 10% of absolute error and may lead to some generators getting overcompensated and some getting undercompensated.
- Lack of compatible intra-state availability-based tariff (ABT): Although most RE-rich states have at least notified the draft forecasting and scheduling regulations, the states are yet to align the regulations with the model DSM regulations proposed by the FoR. In the case of Maharashtra, the MERC recently released 'Maharashtra Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations, 2018' which are in line with the FoR model DSM regulations (MERC, 2018d). Also, whereas the FoR's technical committee recommended against the net-zero-sum pool, some states including Gujarat and Maharashtra have adopted that approach to ensure that RE generators pay for their total cost of deviation.

8. West Bengal and Kerala have become permanent special invitees to the meetings.

Applicability to generators connected to the distribution network: The minimum capacity condition (5 MW or 10 MW) set by some states for applicability of forecasting and scheduling regulations may leave out small wind and solar generators that may be connected to a distribution network. Section 3.4.1 of the approach paper to draft forecasting and scheduling regulations published by the MERC notes the lack of visibility of wind and solar generators connected to the distribution level as one of the reasons given by the Maharashtra LDC for the difficulties in handling the increase in variable RE generation; the LDC specifically highlighted the need for visibility (Section 3.4.2) of open access RE generators connected to the distribution network. Finally, Section 4.1.2.3 of the approach paper states that 'relevant parameters for Stand-alone Generators not connected to the InSTS (being at the 33 kV level, such as the Videocon Solar Project) are subsumed in the demand of the Distribution Licensee (MSEDCL in this case).'

The above issues bring up the question of whether forecasting and scheduling regulations should be made applicable to generators with capacities less than1 MW (excluding rooftop solar) connected to a distribution network. The following two questions need to be answered by the MERC for deciding the matter.

- What percentage of total capacity of wind and solar generators is connected to the distribution network at present?
- What percentage of total capacity of wind and solar generators would be connected to the distribution network in the future, especially considering the potential increase in RE-based captive or OA projects? Knowing the schedules of open access RE generators will help the distribution licensee in better management of energy banking.

The deviation settlement penalties for projects connected at a distribution network for which forecasting and scheduling regulations will not be applicable will be reflected in the overall deviation penalties for the Discom, leading to further financial and operational difficulties for it.

Going forward, a uniform intra-state ABT mechanism compatible with the one existing at the regional level or is based on the FoR model regulations should be implemented across states. Simultaneously, forecasting and scheduling regulations, which have uniform deviation penalties with periodic revisions for intra-state deviation penalties, should be operationalised. Such revisions will be no longer necessary if intra-state commercial settlement shifts to a schedule-based regime in future.

9.4 Regulatory Issues Related to Grid Integration of Renewables

9.4.1 Need for Periodic Amendment of State Grid Codes

As already mentioned in Section 9.2.2, grid codes of most of the states are not updated and do not mention a technical minimum for intra-state generators. This omission is reflected in various cases filed before the state ERCs. Recently, MSEDCL filed a petition before the MERC to reduce the technical minimum of all intra-state generating plants and IPP plants to 55% to optimise the generation resources, to reduce power purchase cost and integrate more RE generation. This petition was first rejected by the MERC on the ground that the technical minimum for all the plants cannot be uniformly reduced to 55%. Although the CEA recommends a 50% technical minimum or the recommendation of the original equipment manufacturer (OEM) as an operating constraint, a unit may have different control limits than specified in the Regulations. In this case, MSEDCL also did not respond to the demand for compensation for partial heat rates existing at the regional level as mandated by the CERC. This petition was accepted on review by the MERC in an order dated March 1, 2018 (MERC, 2018a). Given the lower variable cost of the CGS as compared to those of the SGS in many cases, the SGS would be subjected to more backdown and more cycling. Thus the SGS would operate longer with partial heat rates than the CGS—hence the need for a similar compensation mechanism at the intra-state level.

The new wind and solar bidding guidelines released by the MNRE and the MoP provide for a compensation if generation is curtailed because of transmission unavailability or backdown by the procurer (but not when it is for grid security or safety of any equipment or personnel). However, there seems to be no agreed-upon definitions of different events of grid security. Some cases have been filed before SERCs and high courts for such compensation. One such case is the petition before the Rajasthan ERC filed by wind generators, in which grid conditions (such as whether all thermal plants were operating at 55% technical minimum when wind power was curtailed and backed down by the Rajasthan LDC) were questioned (RERC, 2017). Hence, this aspect needs to be deliberated upon and clear guidelines and procedures issued.

The Indian Electricity Grid Code was amended annually from 2014 to 2017 to introduce several provisions important for grid integration of RE such as a forecasting and scheduling framework for wind and solar generators (third amendment), a mechanism to compensate CGS for partial load heat rates (fourth amendment), a 55% technical minimum for CGS (fourth amendment) and an ancillary services mechanism (fifth amendment). However, most of the state grid codes have not been updated or amended in recent times. Table 9.1 shows the last year in which the grid codes were amended in a few RE-rich states.

Table 9.1: Year of latest amendment in grid code in RE-rich states.

State	Year of latest amendment
Maharashtra	2006
Gujarat	2013
Madhya Pradesh	2008
Rajasthan	2011
Tamil Nadu	2009
Andhra Pradesh	2016

Hence, state grid codes need to be revised periodically and comprehensively and relevant provisions introduced as needed for better integration of RE.

9.4.2 Need for Independent State Load Dispatch Centres

The Electricity Act envisaged the LDCs to be independent and autonomous organisations that would optimally schedule and dispatch power. Recognising the fact that some time would be required to set up such organisations, the act allowed the state or central transmission utilities to operate these bodies in the interim. Unfortunately, more than fifteen years since the act came into force, such interim arrangements continue to be the norm. Although POSOCO is no longer a subsidiary of the CTU at the state level, there has been no such move to make SLDCs independent. In the erstwhile integrated utility model, the autonomy of an LDC was not much of an issue. However, with more players entering the scene, autonomy or independence of the system operator becomes crucial and has serious implications for competition, optimum dispatch and grid stability. Already, generators, OA consumers, or both have filed many cases before the various SERCs and before the Appellate Tribunal alleging that LDCs have failed to act as independent system operators. Similarly, some SLDCs have also appealed against ambiguities and inconsistencies in regulations concerning OA, unscheduled interchange and merit order dispatch. These problems highlight the need to address the issue of autonomy and independence at the earliest, even from the perspective of RE grid integration (PEG, 2016b).

9.5 Importance of Modelling for Utility Planning and Operations in Future

The Indian power sector is going through a transformation with increasing penetration of such intermittent RE sources as wind and solar power and of such new technologies as battery-based grid-level energy storage and electric vehicles. The characteristics such as variability and uncertainty of wind and solar generation and the different type of services which the grid level battery storage can provide (fast ancillary services, black start, load and generation shifting etc.) are different from those of conventional generators or loads on the power system. Different grid operation procedures, tariffs and commercial settlement methods are therefore necessary, which will make power system operation more complex and uncertain than it is today. The interplay between these grid operation procedures and tariff or commercial settlement mechanism will decide the behaviour of these technologies and their impact on the system. For example, meeting peak load could be seen as a challenge to system operation at present whereas in future, with significant wind and solar generation, dispatch planning would increasingly have to be geared towards meeting net load with increased daily and seasonal variations. In that case, regulatory incentives would be needed to promote such flexible resources as hydro, storage and ancillary services to meet high ramps which will have diurnal and seasonal characteristics.

Modelling can equip utilities and system operators for better capacity planning and grid operation. Given the uncertainties related to generation and load profiles, the capacities and prices of wind and solar generators, the prices of coal and gas and the level of penetration of storage technologies and electric vehicles, multiple scenarios of system operation are possible in medium term or long term. Running these multiple scenarios and preparing for the worst-case scenarios would be of paramount importance in future for secure, reliable and economic operation of the power system. Although no model can predict the future accurately, models can be used for finding some key operational characteristics of the system in future. The use of modelling for medium- or long-term resource planning and short-term power system operation is already a norm in many countries.

In Indian context, modelling can be deployed in the following areas immediately:

- Approving medium- and long-term power procurement plans of Discoms by regulators.
- Choosing between bids for wind, solar and storage to minimise the cost of system operation

A good start to use modelling in decisions related to Indian power system may involve a) making stakeholders see the importance of modelling and increasing its acceptance by different entities such as regulators and regional and state power committees and b) making uniform or common good-quality granular data (generation, transmission) available to the stakeholders for modelling without compromising on data security.

10. Solar Power and Agriculture

Reliable and affordable access to energy in the agriculture sector is a critical developmental issue as it concerns livelihoods and national food security. Two-thirds of the total irrigated area in India is served by groundwater and accounts for the lion's share of energy used in agriculture, with nearly 2.1 crore grid-connected pumps sets and 0.7 crore diesel-powered pumps sets (CEA, 2017d; MoP, 2011a). In 2015-16, agriculture consumed about 173 billion kWh (about 17% of India's electricity consumption) (PEG, 2018g) and about 10 billion litres of diesel for irrigation and mechanisation[9]. This underscores the importance of electricity in the agriculture sector, especially since demand from agriculture is expected to double to 353 billion kWh by 2027 according to the 19th Electric Power Survey (CEA, 2017c).

One option for powering irrigation pump-sets, especially in areas with no or poor access to grid electricity, is solar PV pumps. A programme to encourage the use of such pumps was launched by the MNRE in 1992. As expected, uptake was slow, considering the very high prices of solar PV, associated subsidies and the relatively lower price of the other option, namely diesel pumps. With focus on solar power under the National Solar Mission, the MNRE in 2014 announced an ambitious programme to deploy 1 lakh solar pumps for irrigation and drinking water with an outlay of ₹400 crore. The sharply declining prices of solar panels and increase in the price of diesel have ensured rapid deployment of solar pumps across the country. The subsidy on capital costs provided by the MNRE certainly accelerated the uptake. In July 2017, the MNRE changed the subsidy pattern such that only 30% subsidy was available for pump-sets up to 1 hp; 25%, for those up to 3 hp and 20%, for those up to 5 hp. The latest benchmark costs (FY 2018-19) considered for subsidies in general-category states, as notified by the MNRE, were ₹77,000 – 85,000 per horsepower for DC solar pumps and ₹65,000-80,000 per horsepower for AC solar pumps (MNRE, 2018j).

Over the last four years (2014–18), 1,65,385 off-grid solar pumps have been deployed, taking the cumulative total to 1,77,011 by March 2018 (Standing Committee on Energy (Sixteenth Lok Sabha), 2018; MNRE, 2018e). By far, the largest deployment has been in Rajasthan (41,377) followed by Chhattisgarh, Andhra Pradesh and Uttar Pradesh. These four states account for roughly 56% of the total deployment. Other states include Odisha, Gujarat, Madhya Pradesh, Tamil Nadu, Karnataka and Jharkhand. For the next three years (2017–20), the MNRE has proposed a target of 1.5 lakh solar pumps. Building on this success, the MNRE is planning to scale up the use of solar PV power in agriculture significantly. Under the proposed KUSUM scheme, the ministry has proposed an ambitious solar PV target of 28,250 MW comprising four components. The first one, covering 10,000 MW, would be for decentralised ground-mounted grid-connected solar power plants with a capacity of 0.5-2 MW. The next two components involve setting up 17.5 lakh stand-alone (up to 7.5 hp, with a capacity of 8250 MW) and 10 lakh grid-connected solar pumps (up to 5 hp, with a capacity of 7500 MW). The grid-connected pumps would be owned by farmers, who would be allowed to sell surplus energy to the grid. The final component is solar powering of 50,000 grid-connected tube-wells, lift irrigation schemes and drinking water projects of up to 50 hp, operated by state government departments with a capacity of 2500 MW (Standing Committee on Energy (Sixteenth Lok Sabha), 2018).

9. Prayas (Energy Group) estimate for diesel use. KPMG (KPMG, 2014) puts the irrigation share of diesel at 4 billion liters.

The entire scheme is likely to require ₹1.44 lakh crore, with the central and state government each contributing 48,000 crore (30% of the pump cost). Financial institutions would also pitch in with another 48,000 crore, in the form of a loan for 30% of the pump cost, and the individual farmer is expected to put in the balance 10%. However, the scheme is yet to be approved by the MoF (Business Standard, 2018), and although the Parliamentary Standing Committee on Energy appreciated these efforts to empower farmers, it was concerned that *'already financially constrained Discoms may not be able to pay the farmers for the excess power supplied to the grid. The Committee are of the opinion that non-payment of dues by the Discoms will further alienate the farmers and will definitely have serious repercussions for the Government.'*

Some states have started their own schemes and programmes to encourage the use of solar power for powering irrigation in agriculture. Some of these initiatives of each state are briefly described below.

Maharashtra: The rising cost of electricity supply and the farmers's low paying ability makes electricity in agriculture a sticky problem in the electricity sector. Direct subsidies for agriculture place a significant demand on the exchequer and Discoms. E.g., agriculture received ₹6545 crore as a combination of cross subsidy and direct subsidy in 2015-16 in Maharashtra, which is about ₹15,400 per pump set per year. On the other hand, agriculture continues to get low quality, unreliable power leading to problems such as frequent burnouts of pumps and electricity supply during non-peak hours including late nights, making farmers distrustful of Discoms. To break this vicious cycle, Maharashtra is going ahead with an innovative approach that can provide reliable and daytime electricity supply to farmers at reasonable costs and thereby gradually increase mutual trust between the supplier and consumer while reducing the state's subsidy burden. In 2017, the state government launched the Chief Minister's Agricultural Solar Feeder policy, which, instead of focusing on solar pumps, aims at setting up distributed tail-end grid-connected solar PV plants (2–10 MW), which would be connected to the 11/33 kV substations and used for powering irrigation needs on separate agricultural feeders. This approach allows maximum use of solar power and is significantly more cost-effective and scalable than that of using solar pumps. Developers will be selected through competitive bidding. The price discovered in the first large tender was ₹3.1/kWh, thus saving nearly ₹2/kWh given the landed cost of supply from the grid of nearly 4.9/kWh. This approach will not only save subsidy but also ensure reliable and daytime power for agriculture. Currently, 2000–3000 MW capacity is at different stages of tendering or auctioning through MSEDCL and the generating company MahaGenco. Bids already invited, amounting to roughly 2335 MW, would generate 3653 MUs, assuming a CUF of 19%. This is equivalent to supplying power to 7.8 lakh pumps (of 5 hp each) for 1250 hours a year, or approximately 19% of all electric pumps sets in Maharashtra. This in turn would save approximately ₹343 crore in the first year in terms of subsidy support. Over the next 20 years, the net present value of the savings will be ₹3800 crore.

Gujarat: The state announced a pilot solar pump scheme in June 2018 (Business Line, 2018a), namely the 'Suryashakti Kisan Yojana' (SKY), which aims to cover 12,400 farmers across 33 districts at an estimated cost of ₹870 crore, supporting 177 MW of solar PV power. Farmers would be able to use solar power for irrigation and sell any excess electricity to the Discom at ₹7/kWh for 7 years. The funding pattern for this scheme is very similar to that of KUSUM, the only difference being 35% of the pump cost as a loan at a subsidised rate of 4.5%–6% and a 5% contribution by the farmer: 60% of the pump cost would be subsidised by the central government and the state government. A buy-back rate of ₹7/kWh split equally between the Discom (₹3.5/kWh) and the state government (₹3.5/kWh with a maximum limit of 1000 kWh a year) would be applicable for the first 7 years. This payment would be used first towards repayment of the loan (35% of the pump cost) and the balance amount would be credited directly into the farmer's bank account. For the next 18 years, the buy-back rate would be ₹3.5/kWh.

Karnataka: First announced in 2014, the 'Surya Raitha' scheme of the Government of Karnataka is being implemented through a pilot project in Ramanagara district and aims to replace electric pumps with grid-tied solar pumps. Solar pumps will be sized to 1.5 times the existing pump capacity and the surplus power will be sold back to BESCOM at ₹7.2/kWh under a net metering scheme. In the first phase of the scheme, the government successfully commissioned and connected 250 solar pump-sets to the BESCOM grid. The funding for the scheme will be sourced from soft loans from BESCOM, subsidy from the state and the central governments and a small investment by the farmer. Most of the revenue from the sale of power will go towards repaying the BESCOM loan. The cost of a 5–7 hp solar pump under this scheme is ₹7.1–9.4 lakh/pump (NIE, 2018a).

Andhra Pradesh: The state has started a pilot project with 250 solar pumps in Vizianagaram district and plans to implement the 'Grid connected Solar BLDC Pump Sets' scheme initially in Visakhapatnam, Srikakulam and Vizianagaram districts with a target of close to 75,000 pumps, which would need an investment of ₹2000–2600 crore (Krishi Jagran, 2018; NIE, 2018c). Here too, the farmers would be able to sell excess solar power to the grid and earn a potential additional income of ₹15,000 a year (NIE, 2018b). A unique aspect of this scheme is that the pumps are DC pumps, which, while being more efficient than AC pumps, will not be able to draw any power from the grid. The focus of the scheme will be for new agriculture connections, and the possible price points for solar pumps under this scheme are between ₹3.35 lakh and ₹4.29 lakh for a 3 hp and 5 hp pump respectively.

Delhi: The state government recently announced the 'Mukhyamantri Agriculture-cum-Solar Farm Program' (TOI, 2018a; Mercom India, 2018i; DTE, 2018), under which developers will install solar projects on farm land under a RESCO model with no investment from the farmer. Project developers will enter into PPAs at ₹4–5/kWh with Delhi government departments including the health department, the public works department and Delhi Jal Board, which will reduce their electricity bills. This is a form of OA aggregation being done by a state government, while attempting to increase the income of farmers at the same time. Farmers will be eligible for 1000 units of free power for each acre of land contributed to the project and will also be paid a rent of ₹1 lakh/acre, to be increased by 6% every year for 25 years.

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2017-18 witnessed impressive growth of renewable energy (RE) in the electricity sector wherein two major milestones were crossed. Annual RE capacity addition surpassed conventional capacity for the first time, with RE registering more than double the growth in conventional energy, in GW terms; and electricity sector investments in RE in 2017 were higher than that in conventional sources of energy for the first time according to IEA.

While direct electricity generation economics now consistently favour new renewable energy installations, the rapid increase in RE deployment is facing newer challenges. We seem to be entering a second phase of the energy transition, wherein wider system costs, planning and policy-regulatory environment is beginning to dictate the pace of RE deployment. These include the financial health of the DISCOMs, their existing surplus generation capacity, lack of adequate transmission infrastructure, uncertainty over duties/taxes etc. As a consequence, capacity installation in the present financial year (2018-19) may fall well short of the central targets for both wind and solar power. This report covers major policy and regulatory developments in the sector over the past year, while underscoring this transition pain. The graphs in the report are from Prayas' Renewable Energy Data Portal, which is updated on a monthly basis and can be referred to for more details.

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