Energizing South 2017 – 2nd edition

Economic growth: Smart-reliable-sustainable power

1–2 September 2017, Vishakhapatnam

www.pwc.in

Preamble

In the last few years, noteworthy efforts have been made by the government and private sector towards achieving the goal of 'Power for All'. The government has taken a multidimensional approach to tackle the issues of the power sector. The Ministry of Power, Coal, New and Renewable Energy and Mines, GoI, with support from state governments, is working on a far-reaching transformation of the entire sector. These efforts include: resolving the issues of fuel availability, adding new capacity with a focus on RE, improving efficiency and emissions of fossil fuel based power plants, bringing down the cost of generation from RE sources, electrifying rural areas, strengthening the inter and intrastate power evacuation system, modernising grid system operation, focusing on energy storage and reviving power distribution companies.

The southern states have a substantial share in the national power sector in terms of both power generation and consumption. While capacity addition of renewables is happening at a rapid rate, conventional power continues to be the dominant source of power. The states have to perform a balancing act while contributing towards the national target of 175 GW RE capacity addition and maintaining a healthy electricity grid. An efficient mix of conventional and renewable power along with balanced ancillary services has to be brought in to meet the current and future power requirements and thereby support our industrial, economic and social growth. On the journey to achieving these goals, we also have to focus on our responsibility towards maintaining environmental norms.

One of the areas of development—that is, large-scale RE capacity addition—is drawing attention from all quarters. This is because of its effect on the way the electricity grid has been conventionally managed thus far. While one set of discussions is centred on identifying a suitable share of RE in the power mix, the other is focused on improving grid management capabilities to allow large-scale RE integration. CTU and STUs are working in coordination to strengthen the grid infrastructure. This has also led power sector players to explore new avenues such as distributed generation, energy storage and EVs.

In line with the power and renewable agenda of the GoI, CII is organising the '2nd Edition Energizing South: Two Day Conference Southern Region' on 1–2 September 2017 at Vishakhapatnam, AP. This conference will serve as an ideal platform for participants to gain a strong understanding of the power scenario in the near future, challenges to be addressed, opportunities for industries and the role of various stakeholders.

As part of this event, an industrial survey involving about thirty companies was conducted with the aim of seeking their opinions on the current status and future course for the sector. Along with a sector snapshot covering the theme of this conference, this report captures the responses received from various Indian and multinational companies involved in the Indian power sector value chain.

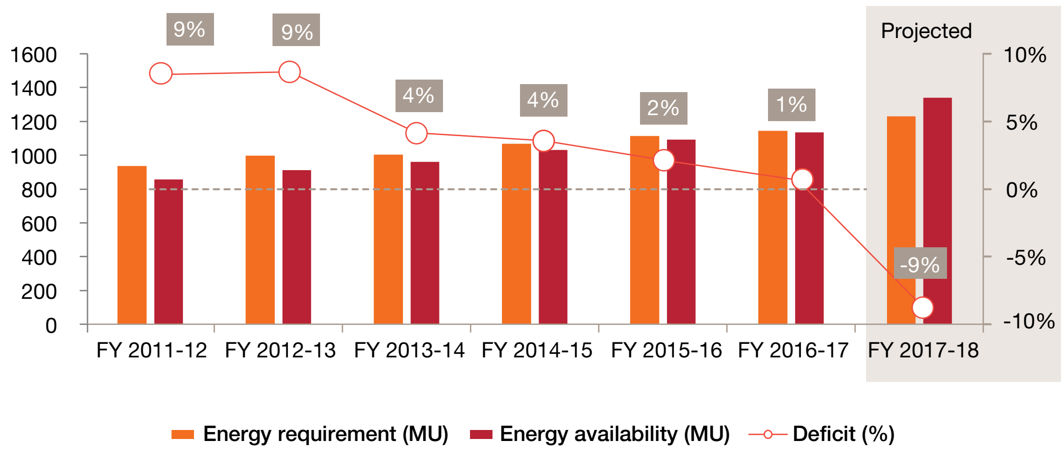
Is the power deficit scenario in the country a thing of the past?

Power supply position: India

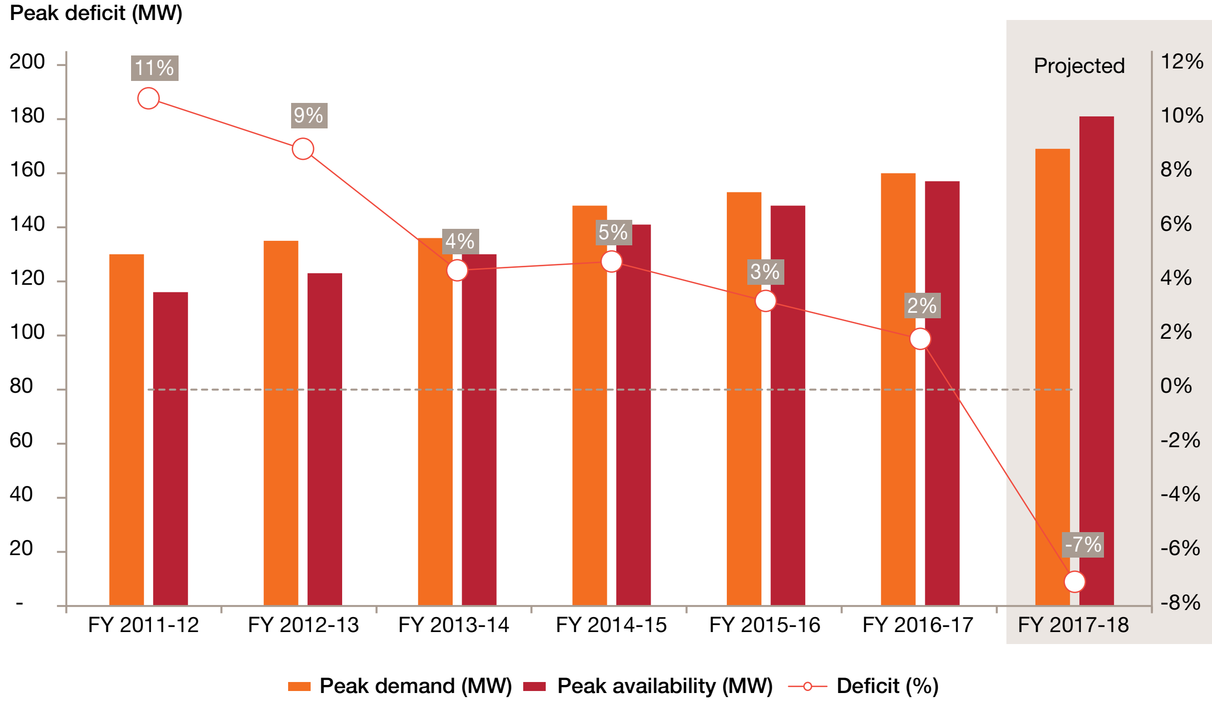
During FY 2016–17, the total ex-bus energy availability and peak power met increased by 4% and 6% respectively over the previous financial year[1].The energy requirement registered a growth of 3% during FY 2016–17 against the projected growth of 9%. Peak demand registered a growth of 4% during the same period against the projected growth of 8%. Overall, the energy shortage during FY 2016–17 was 1%, which is the lowest ever demand-supply gap achieved both in terms of energy and peak power requirement.

FY 2017–18 is anticipated to experience an energy and peak surplus of 9% and 7% respectively. If the Indian power sector meets its projected growth, then it will record an overall power surplus scenario for the first time ever in the history of the country.

Energy deficit (MU)



Peak deficit (MW)



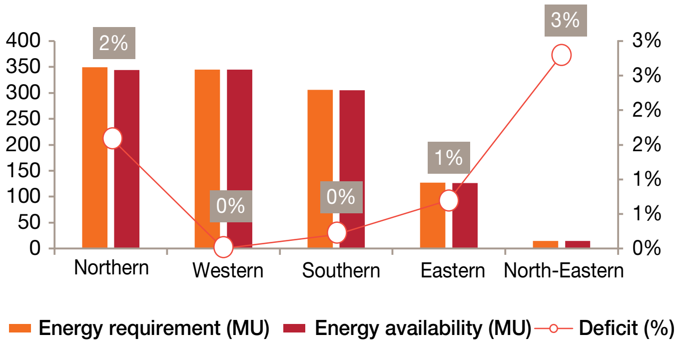
Source: LGBR
Note: Negative deficit in the chart means a power surplus position.

[1] CEA. (2017). Load Generation Balance Report 2017–18. Retrieved from http://www.cea.nic.in/reports/annual/lgbr/lgbr-2017.pdf (last accessed on 23 Aug 2017)

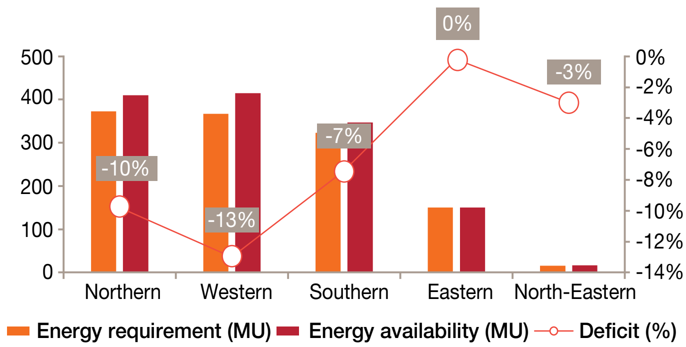
Power-supply position: Southern region

Southern states were very close to meeting their demand during FY 2016–17. An energy surplus to the tune of 3.3% was earlier projected for the region. The actual energy shortage in the region was negligible at 0.2%.

Actual energy deficit (MU) – FY 2016–17



Projected energy deficit (MU) – FY 2017–18



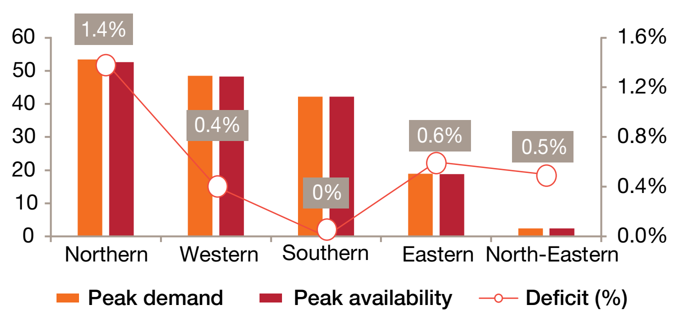
Source: LGBR
Note: Negative deficit in the chart means a power surplus position.

During FY 2016–17, AP and Telangana experienced no energy shortages against the forecasted energy shortages of 7.6% and 3.3% respectively. While the former managed its shortage by arranging for additional power, the latter managed it through demand side management. There was no energy shortage in Tamil Nadu as anticipated in view of the forecasted surplus of 11.2%.

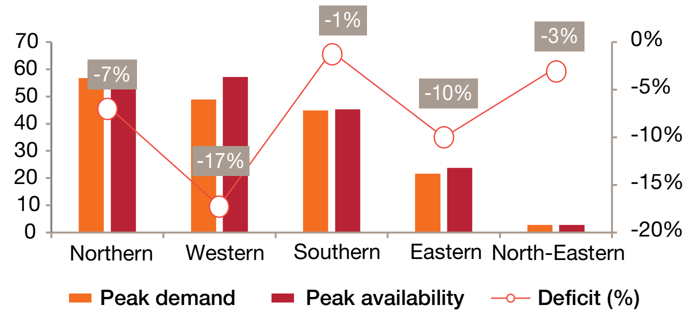
The actual energy shortage in Karnataka during FY 2016–17 was low at 0.5% (against the forecasted surplus of 4.6%). The actual energy shortage in Kerala during the same period was also miniscule at 0.2%, as anticipated in view of the forecasted surplus of 4.5%. The energy shortage in these states was on account of transmission and distribution constraints.

For FY 2017–18[2], the southern region is estimated to have an overall energy surplus position of 7.4%.

Actual peak deficit (MW) – FY 2016–17



Projected peak deficit (MW) – FY 2017–18



Source: LGBR
Note: Negative deficit in the chart means a power surplus position.

The actual peak demand in the southern region for FY 2016–17 was 5.6% higher than the projection. However, there was no peak deficit at the regional level. AP and Karnataka experienced a minimal peak deficit of 0.1% and 0.2% respectively. Tamil Nadu had a shortage of 135 MW, accounting to a peak deficit of 3.3%.

During FY 2017–18, southern region is anticipated to have a surplus capacity of 1% after meeting its peak demand. However, the states of Telangana, Kerala and Karnataka are likely to experience a deficit of 10.1%, 10.4% and 5.4% respectively. AP and Tamil Nadu are expected to have a surplus of 3% and 14.7% respectively.

Key demand drivers

Southern India has witnessed the narrowing down of the demand-supply gap in both energy and peak terms. Lower deficits are on account of both increased supply additions and conservative demand growth.

A few of the reasons for lower demand growth and the narrowing down of deficits are:

- States preferring load curtailment over power purchases owing to the financial health of their state utilities (under-recovery of costs, unrealised subsidy payments)
- Lack of sufficient transmission infrastructure (between the northern, eastern and western region and the southern region)
- Lower economic growth in recent years, when compared to the projection

However, factors such as expected increase in economic activities, improving financial status of power DISCOMs and increase in rural electrification levels are likely to push up the power demand in the near future.

Of the surveyed respondents, about **45%** believe that there are limited opportunities for power generators to set up new capacities in India on account of factors such as:

- Power surplus situation and huge pipeline of existing/announced projects, leaving little scope for new projects
- Utilities payment challenges acting as a deterrent for new capacity addition

The remaining **55%** respondents believe that there are opportunities to set up new capacities on account of factors such as:

- RPOs are creating opportunities for RE capacity addition
- Stricter environmental norms may lead to the shutdown of old plants, making way for new capacity addition
- Improvement in per capita consumption will lead to new capacity addition

[2] CEA. (2017). Load Generation Balance Report 2017-18. Retrieved from http://www.cea.nic.in/reports/annual/lgbr/lgbr-2017.pdf (last accessed on 23 Aug 2017)

Comments by survey respondents

Power demand-supply scenario

While significant generation capacity has been added to the grid and power flows seamlessly from other grids into the southern grid, we expect the power surplus situation to continue in the near term unless one sees a rise in demand.

– A prominent IPP with a presence across Asia

We expect the current situation to continue unless there is a significant uptick in capital investment by the private sector and addition of manufacturing capacity. The share of manufacturing in GDP needs to increase for power demand to be buoyant. Service sector focused GDP growth is not going to help power demand growth.

– One of the leading RE IPPs in India

The issue here is not about states having a power surplus—most of them do not if the cumulative demand and supply is considered—but of inadequate infrastructure to integrate renewable power. A majority of the curtailment is witnessed when the renewable energy sources are generating at peak load.

– A leading infrastructure finance company

As the government push for greater manufacturing in India picks up, there would be a demand for more power as more industries come online.

– A reputed multinational solar EPC company

Role of RE in meeting electricity demand

In the short to medium term, thermal energy is unlikely to be replaced as base load. In the long term, the answer to this question depends on how storage costs evolve over time. If storage costs plummet, one could see thermal energy being largely replaced by utility scale as well as smaller renewable energy based virtual power plants.

– A prominent IPP

Renewable energy, if adequately supported by economical storage systems and smarter grid operations, will be able to support our base load but cannot replace thermal energy altogether. It may be interesting to refer to the recent works of Mark Jacobson and their critique by Prof Clayton on modelling to power entire power systems with 100% renewable without fossil fuels. This shows that a 100% renewable power economy is not impossible.

– One of the largest RE IPPs in India

Given the ecological impact of coal, it is pertinent that more electricity is generated from renewable energy sources. However, the transition from conventional to renewable sources for base load power may take much longer to crystallise. For it to be workable, certain key requirements need to be met, including viable energy storage options, increased generation from peaking sources such as hydro and gas, efficient grid management and forecasting capabilities. All these requirements are, even with most optimistic sentiments, at least 5 years away.

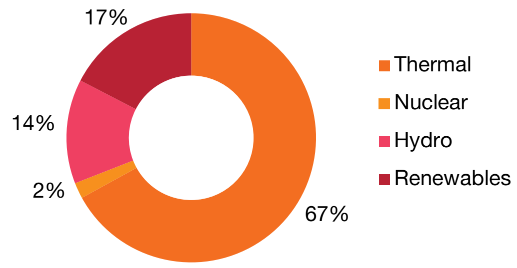
– A leading infrastructure finance company

Power evacuation infrastructure: Instrumental to ensure seamless growth of the power generation sector?

The RE sector in India has made remarkable progress, growing from 3% (March 2002) of the total generation capacity to 17% (July 2017)[3]. RE is a growing component of the electricity grid due to its contribution in addressing three of the country's pressing issues, namely bridging supply shortages, reducing carbon emissions and enhancing energy security.

With India's huge unexplored renewable potential and imminent challenges in securing conventional energy sources in a sustainable manner, there seems to be no limit to growth in renewable capacity addition.

Fuel mix – July 2017



Source: CEA

MNRE's flagship programme, JNNSM, has witnessed large capacity additions in the solar sector. The installed capacity of solar projects has reached approximately 13 GW as of June 2017 [4]. In an attempt to develop concentrated zones of solar power generation, MNRE, in collaboration with states, has proposed the development of 34 solar parks in 21 states, accounting for total solar generation capacity of 20 GW, which has recently been revised to 40 GW.[5]

India ranks fifth in the world in terms of wind capacity, with installations of about 32 GW growing at a 15% CAGR in the last five years. This is only about 10% of the estimated potential of 302 GW at 100 m hub height.[6] With the objective of wheeling power to lower wind potential states and promoting competition in the sector, in 2016, MNRE launched a scheme to award 1 GW wind power projects connected to the transmission network of the CTU.

The huge unexplored potential, coupled with the government's ambitious target to achieve 175 GW of RE capacity by 2022, presents a huge opportunity for renewables in the Indian power sector landscape. However, both wind and solar generation are location dependent, experience intermittency, and face a combination of non-controllable variability and partial unpredictability. These aspects create distinct challenges for generators and system operators in integrating renewables.

Indian electricity grid: Existing infrastructure[7]

The transmission network and capacity in India have seen a consistent increase over the years. The length of the transmission line (220 kV and above) has increased from 52,034 circuit km at the end of the 6th Five Year Plan (March 1985) to 3,76,217 circuit km by July 2017, while the transformation capacity (220 kV and above) has increased from 46,621 MVA to 7,70,815 MVA during the same period. However, the growth has not been comparable with that in generation capacity, which has grown at 64% from the end of 11th Five Year Plan to the end of FY 2016–17, whereas the growth in transmission network was 45%. However, harnessing RE on a large scale will need robust grid infrastructure. Without significant increase in transmission capacity, all the RE generated cannot be accommodated in the power system.

[3] CEA. (2017). Power sector – July 2017. Retrieved from http://www.cea.nic.in/reports/monthly/executivesummary/2017/exe_summary-07.pdf (last accessed on 23 Aug 2017)

[4] MNRE. (2017). Physical progress (Achievements). Retrieved from http://mnre.gov.in/mission-and-vision-2/achievements/ (last accessed on 23 Aug 2017)

[5] MNRE. (2017). Details of solar parks sanctioned. Retrieved from http://mnre.gov.in/file-manager/UserFiles/List-of-approved-Solar-Parks.pdf (last accessed on 23 Aug 2017)

[6] National Institute of Wind Energy. (2017). Wind power potential at 100 m agl. Retrieved from http://niwe.res.in/department_wra_100m%20agl.php (last accessed on 23 Aug 2017)

[7] CEA. (2017). Power sector – July 2017. Retrieved from http://www.cea.nic.in/reports/monthly/executivesummary/2017/exe_summary-07.pdf (last accessed on 23 Aug 2017)

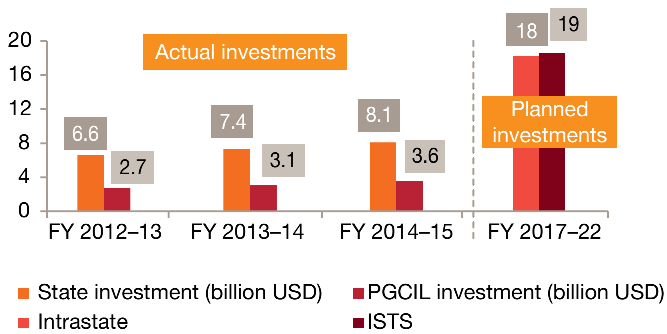
Development of power evacuation infrastructure

Growth prospects for transmission are driven by greater emphasis on grid reliability, decentralisation of generation due to the growing share of RE, and the spread of new urban and rural load centres.

Transmission lines have been added at the pace of 69 km a day in the past two years as against 46 km a day during 2012–2014. Given the scale of investment needs, apart from contribution from the PGCIL, the private sector is being roped in by the MoP by awarding projects through the tariff-based competitive bidding route.

Investments to the tune of 37 billion USD[8] have been planned during 2017–2022. This investment requirement is exclusive of the amount needed for the development of the GEC which will evacuate large scale RE from remote locations.

Investments in transmission (in billion USD)



Note: Actual investment includes investments made for RE projects

Source: PwC analysis and PFC Performance Summary Report of Utilities, Perspective Transmission Plan for Twenty Years (2014-2034), PGCIL Annual Reports

[8] Power Finance Corporation. (2016). The performance of state power utilities. Retrieved from http://www.pfc.gov.in/Default/ViewFile/?id=1490186954263_Report%20on%20Performance%20of%20State%20Power%20Utilities%202012-13%20to%202014-15.pdf&path=Page (last accessed on 23 Aug 2017), CEA. (2017). Perspective transmission plan for twenty years (2014-2034). Retrieved from http://www.cea.nic.in/reports/committee/scm/allindia/notices/3rd_report.pdf (last accessed on 23 Aug 2017), PGCIL annual reports, PwC analysis

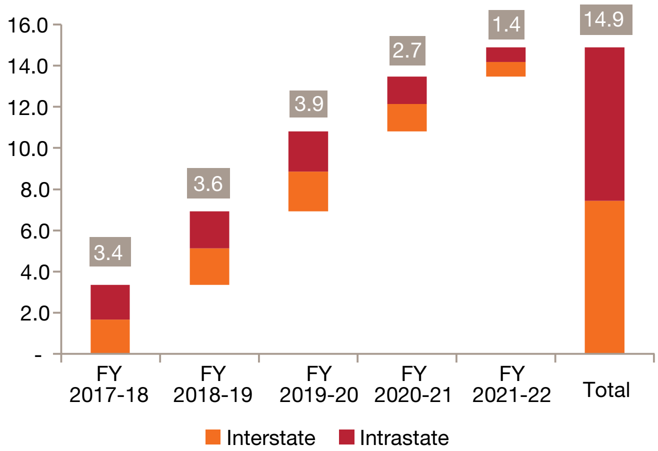
Green Energy Corridor

A comprehensive plan for the integration of renewable capacity addition for the 12th Five Year Plan was prepared by the PGCIL for the development of the GEC. The plan envisaged strong grid interconnections through intra- as well as interstate strengthening. For this purpose, transmission infrastructure for evacuating renewable capacity generation within eight states (Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Himachal Pradesh and Rajasthan) have been identified.

Interstate grid upgrade will be undertaken by the PGCIL while intrastate grid upgradation will be handled by the various state utilities. NITI Aayog has assumed the investment requirement for transmission strengthening as 0.15 million USD per MW, with a 50-50 share for intrastate transmission and interstate transmission strengthening. Total investments to the tune of 15 billion USD have been estimated during the 13th Five Year Plan for evacuating RE generation. In this regard, the GoI has also executed a loan agreement with KfW for 500 million EUR (around 5,000 crore INR) for financing the GEC project.

Recently, the PGCIL has undertaken work for a major GEC project where an 800 kV UHVDC link will be commissioned over 1,800 km between Raigarh and Pugalur. This line aims to connect Raigarh in central India to Pugalur in the southern state of Tamil Nadu. This link is a key element of integrating RE with the main grid. It will integrate thermal and wind energy for the transmission of power to high consumption centres located thousands of km away, supporting electricity demands in the south and transmitting clean energy to the north, when there is excess wind power.

Investments required in transmission during FY 2017–22 (billion USD)



Source: NITI Aayog's 'Report of the Expert Group on 175 GW RE by 2022'; PwC analysis

Importance of electricity grid discipline with the increasing share of RE

The share of renewables in total installed capacity is expected to touch 30% by 2022 with the revised capacity addition targets. With increasing RE penetration in the fuel mix, there are very high prospects for the SLDC to forecast skewed generation data. The CERC's 3rd amendment to the DSM Regulations have specified the permissible deviation bandwidth for RE generators. In order to adhere to the regulations and to ensure grid discipline and maintain system stability, it is imperative that the RE-rich states and generators have essential forecasting tools. Utilities are not well equipped with the institutional aspects of the RE sector. While this may not seem to be a huge problem at this juncture, looking at the rapid growth in RE capacity additions, it can be expected to create transient stability concerns from the perspective of system operations.

Currently, the government is working on implementing REMCs based on global best practices in order to facilitate large-scale RE integration into the grid. REMCs will be equipped with advanced forecasting tools, smart dispatching solutions and real-time monitoring of RE generation. These are being established in seven RE-rich states (Rajasthan, Gujarat, Maharashtra, Tamil Nadu, Madhya Pradesh, Karnataka, Andhra Pradesh). Three REMCs are being set up in regional LDCs (NR, SR and WR) and one in the NLDC. Each REMC project is segregated into three packages, namely Southern Region (Tamil Nadu, Andhra Pradesh, Karnataka SLDCs and SRLDC), Western Region (Gujarat, Maharashtra, Madhya Pradesh SLDCs and WRLDC), Northern Region (Rajasthan SLDC and NRLDC) and NLDC.

The installation and commissioning of the REMC project will take 15 months from the date of award. It is envisaged that REMCs in RLDCs will be commissioned progressively during FY 2018–19. The first REMC project has been recently awarded (June 2017). The project is expected to be functional from September 2018. Another REMC is being set up in the Rajasthan SLDC by the PGCIL. The DPR and specifications of the REMC are being finalised and an agreement was executed between the PGCIL and SLDC on 29 May 2017. The PGCIL is acting as a nodal agency for the development of REMCs, which are being implemented as part of the GEC.

Action plan: GoI

In addition to the implementation of the GEC, the MoP constituted a technical committee, which has made the following recommendations to address the issues of large-scale integration of renewable generation and enhance grid stability.

- Requirement of generation reserves for reliable operation of electricity grid: Generation reserve is estimated to have a primary reserve of 4 GW, secondary reserve of 3.6 GW and 7 GW of other reserves. In October 2015, CERC has provided a roadmap to operationalise the reserves in the country.
- To complement the reliable operation of electricity grids, certain ancillary services are to be procured and pressed into service by the system. With the approval from the CERC, ancillary services are expected to be rolled out for developing a framework at the interstate and intrastate level to operationalise the reserves.
- Improvements in operational technologies and practices should be made at each stage in power system operation, namely scheduling, dispatch and control.
- A robust imbalance settlement mechanism for independent states has to be in place. Every state should be responsible for balancing within its own control area. Karnataka has issued regulations on forecasting and scheduling, while Rajasthan, Tamil Nadu, Odisha and Jharkhand have issued draft regulations applicable for wind and solar generators.
- Flexibility in conventional power plants ('generation flexibility') is a major source of power system flexibility, and the need for increased generation flexibility is central to the challenges posed by intermittent renewables. Generally, hydropower plants with a reservoir are most flexible, followed by gas-fired power plants, then coal-fired power plants and finally nuclear power plants.
- Accommodation of large-capacity RE generation needs large-scale transmission grid expansion and reinforcement.
- REMCs need to be established at the SLDC, RLDC and NLDC level with full real-time data availability.
- In addition to the above, adherence to grid standard and regulations by RE generators also becomes important and needs to be notified at the earliest.

The way ahead

At the beginning of its development, RE generation technology focused more on tapping the maximum power from RE resources. In order to address the increased variability and uncertainty brought about by integrating higher levels of large-capacity RE, the power system must become more flexible so as to maintain a constant balance between generation and load.

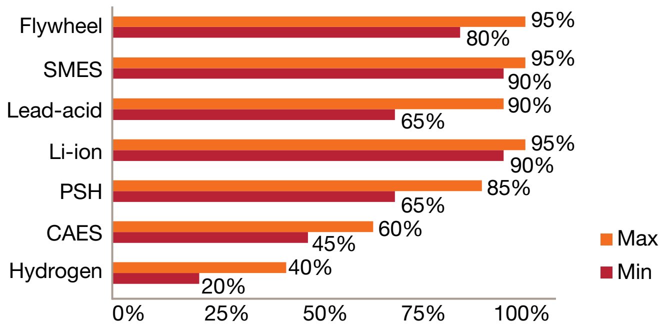
The required power system flexibility can be achieved on the generation side, from both RE generation and conventional generation. It should first be pursued by using grid-friendly RE generation. This means mitigating the impacts of RE generation on the power system, enabling it to contribute to system reliability and stability by improving its design and control technologies. Flexibility can also be achieved from the load side through demand response, and from energy storage that can act as either generation or load. It can be better exploited if system operating technologies and practices are improved, and based on control shared over wider geographic areas with the support of transmission expansion.

- **Grid-friendly RE generation**
  Forecasting and scheduling techniques are being continuously improved at the generating unit, plant and plant cluster level to make RE generation more predictable, controllable and dispatchable—in other, words more grid friendly.

- **Demand response**
  Demand response, the development and extension of traditional demand-side management or load management practices, supported by new smart grid, smart building and smart home technologies, is a promising source of power system flexibility in the future, although it is still in its infancy. The rate at which demand response will mature and be widely applied depends heavily on an understanding of customer behaviour underlying the load demand, as well as on institutional and commercial innovations.
  The integration of large RE capacity and the application of demand response and other smart grid technologies will lead to more challenges in cyber security. Harmonisation of cyber security solutions is required both vertically within the power sector and horizontally across sectors such as power, communications and weather forecast systems.

- **Energy storage technologies**
  Large-scale energy storage is a collection of methods used to store electrical energy within an electrical power grid. Storing large amounts of energy will remain a great challenge in the next couple of years. Currently, pumped hydro plants are the only economical solution for this task but capacities for new plants are limited or even completely utilised. An alternative to grid storage is the use of peaking power plants to fill in demand gaps.

Efficiency comparison of different technologies



Source: Report on 'Energy Storage Technologies & Their Role in Renewable Integration' by the GENI Niti Aayog's 'Report of the Expert Group on 175 GW RE by 2022' and PwC analysis

Storage technology	Pros	Cons
Flywheel	Low maintenance and long lifespan: up to 20 years; almost no carbon emissions; fast response times; no toxic components	High acquisition costs; low storage capacity; high self-discharge (3–20% per hour)
SMES	Fast response times; capable of partial and deep discharges; no environmental hazard	High energy losses (~12% per day); very expensive in terms of production and maintenance; reduced efficiency due to the required cooling process
Lead-acid batteries	Easy and therefore cheap to produce; mature technology; very high surge-to-weight-ratio	Very heavy and bulky; rather short-lived; environmental concerns – lead is very toxic and exposure can cause severe damage; corrosion caused by chemical reactions
Lithium-ion batteries	Highest energy density; provides higher voltage per cell (3.7 V compared to 2.0 V for lead acid); low energy loss; lithium and graphite as resources are available in abundance	Very expensive; complete discharge destroys the cells; deteriorates if unused (life cycle of about 5 years); lithium is flammable when it comes in contact with atmospheric moisture
Pumped storage hydroelectricity (PSH)	Mature technology, capable of storing huge amounts of energy; high overall efficiency (around 70–80%); fast response times; inexpensive way to store energy	Few potential sites; huge environmental impact; requires a suitable water source
CAES	Capable of storing huge amounts of energy; similar to PSH AA-CAES, capable of efficiencies nearly as good as PSH (around 70%); fast response times; inexpensive way to store energy	Requires sealed storage caverns; economical only up to a day of storage (for AA-CAES); competing against other storage needs (natural gas, hydrogen); not yet fully developed
Hydrogen-based storage	Clean sustainable way of storing energy; capable of storing huge amounts of energy; capable of storing energy for several days, even months	Very low efficiency (30–40%); potential for efficiency unlikely to pass 50%; requires a good constructed natural gas grid

A majority of the survey respondents believe that the following action items are the most important for improving the power evacuation infrastructure for generation projects:

- Proactive network expansion planning by state utilities
- Joint project monitoring, leading to timely completion of projects
- Addressing right of way issues
- Provision for future expansion in power substations

Other action items which are not rated very important are:

- Low-cost finance options for state utilities–multilateral funding, VGF, etc.
- Reallocation of open access approvals based on project status

Comments by survey respondents

Electricity grid infrastructure

At this point, we have seen significant congestion in grid and, therefore, there is an impact on dispatch from RE projects, especially in Tamil Nadu (and Rajasthan).

– A leading IPP

Power generation, whether renewable or thermal, is largely concentrated in regional pockets, given the different natural endowments. While power generation capacity has grown, power transmission capacity augmentation has failed to keep pace. Having said that, efforts are being made to improve the transmission infrastructure but are hampered by the relatively longer gestation time of transmission projects vis-à-vis renewable capacity implementation.

– A leading infrastructure finance company

Grid curtailments are already a major concern for developers that is hurting their revenue. Work on the Green Energy Corridor project is already underway, which if completed on time might substantially mitigate this issue. The grid of the future will have distributed generation and we need to prepare for such a scenario.

– A prominent RE IPP in India

Adequate infrastructure planning has to be done, especially along the Green Corridor to augment the capacity to transmit RE power to deficit regions..

– A reputed rotor blade manufacturer in India

Preparedness of grid infrastructure to integrate large-scale RE capacity addition

This is an ongoing process. With proper planning and proactive strengthening of the evacuation infrastructure (e.g. the Green Energy Corridor), coupled with the implementation of forecasting and scheduling regulations, the grid should be able to support and manage the increasing penetration of RE. Going forward, as energy penetration from RE becomes a significant part of the installed capacity we would assume that the government would consider implementing storage projects for frequency modulation (and this could be through the concession route) and also support the availability of gas-fired power stations that are capable of quick ramp-up to balance out the impact of variability from RE projects.

– A prominent IPP

> Increasing penetration has already started creating issues, though at a minor scale at present, and the authorities have started working on this issue in earnest. However, till the time the grid and system operations are ready to assimilate and integrate, given the fast pace at which RE projects are likely to be developed, the challenges may continue in the near term.
>
> **– A leading infrastructure finance company**

System operation challenges in light of large-scale solar rooftop implementation

> Given the size of these projects, we do not expect rooftop projects to impact grid operations.
>
> **– A leading IPP**

> It may disrupt in the long run. It is too early to predict this.
>
> **– A prominent solar EPC company**

> Implementation of rooftop solar in the current form will certainly impact the demand side for utilities as while they are required to put up the distribution network to last mile, they will not be sure of the demand for electricity. Therefore, once the penetration of solar rooftop increases, it would create a challenge and may disrupt grid operations.
>
> There is an urgent need to identify and develop a system which can collate real-time generation data from all rooftop plants and provide feedback to the system operation authorities.
>
> **– A leading infrastructure finance company**

Are lower prices in recent power purchase tenders containing the increasing power purchase cost of utilities?

Power generators have multiple options to sell power under the prevailing regulatory regime. These options are broadly divided into two categories—regulated market sales and open market sales. Under regulated market sales, the tariff and sales framework are governed by the electricity regulatory commissions. In case of open market sales, the framework is developed and promoted by electricity regulatory commissions. However, revenue realisation from the project is dependent on market dynamics (sales to power exchange) or on negotiation strategy of generator with consumers (third-party/captive sale).

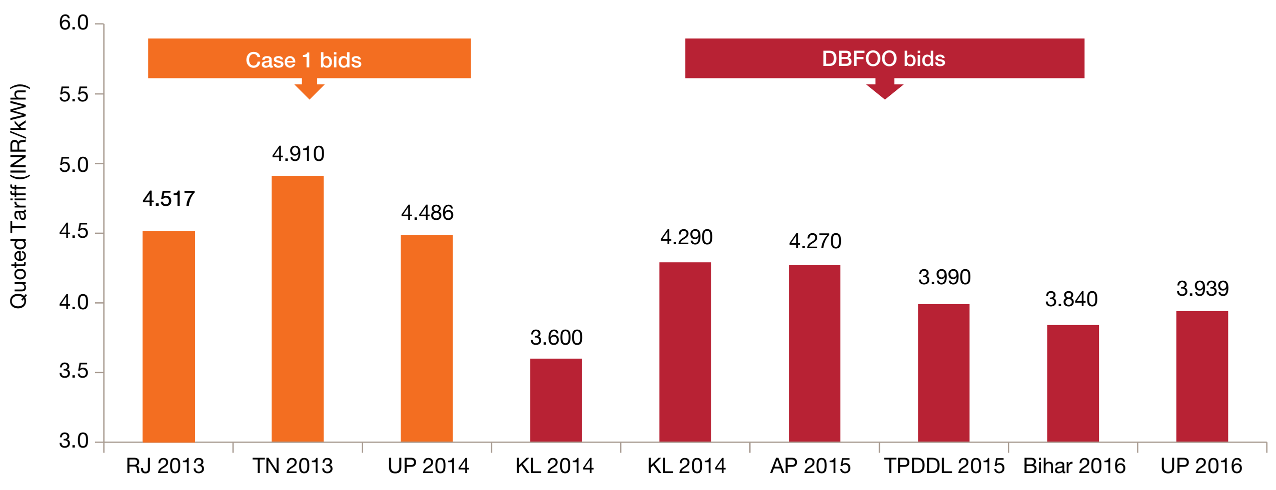
In case of regulated sales, generators are expected to feed power to the utility/DISCOM network and recover revenue from relevant DISCOMs based on tariff determined by the state commission and terms and conditions of the PPA. The arrangement under bid discovered price is also similar to regulated sales, apart from the fact that tariffs are based on the discovered price through bid/reverse auction.

In case of open market sales, wheeling of power is governed by the OA framework established by the CERC and SERCs. In the OA framework, the respective DISCOMs and transmissions companies are obliged to allow unrestricted access to their network in lieu of OA charges which are to be paid by the applicant of OA. Therefore, in this sales option, generators recover revenue from direct consumers/ at the exchange and pay OA charges to DISCOMs and/or transmission companies as fees for using the distribution/ transmission network.

Long-term thermal bids

Long-term bids for power purchase from coal-based power plants under the DBFOO model has received a good amount of participation from thermal power developers. From the tariff discovered in these bids, it can be observed that the market has been competitive, with each consecutive bid mainly attributable to the learning curve for developers.

Recent long-term competitive Case 1 and DBFOO L1 bids



Source: PwC analysis

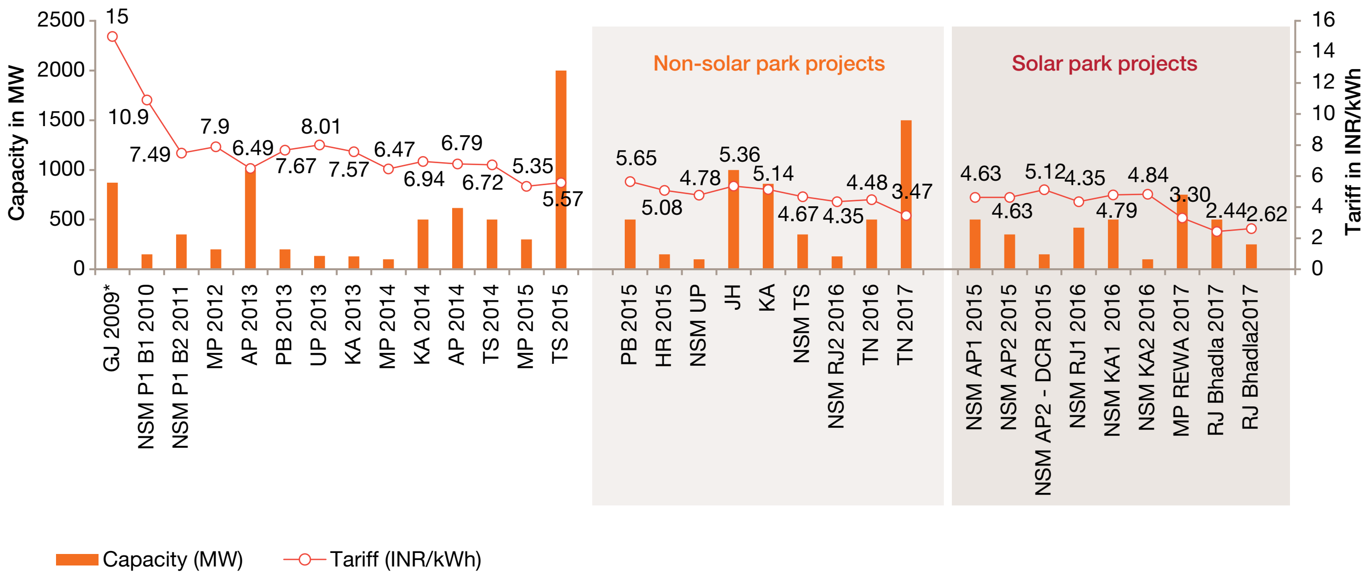
However, a few of these competitive bids did not translate into PPAs, including cases where utilities preferred tying up reduced capacity rather than the overall capacity of the tender. Considering these DBFOO prices are first-year tariff and have a provision for change as per actual coal price, these prices are predominantly higher than the APPC for utilities. Thus, these DBFOO bids are largely considered by utilities to meet the deficit scenarios if a demand growth is perceived by the utilities.

Renewable energy bids

The ambitious target under JNNSM by the GoI, coupled with the steep fall in prices of solar PV modules, has fuelled the unprecedented growth of the solar sector in India. Installed capacity has reached to the level of 13 GW from 2.6 GW in FY 2014, a CAGR of 119% over the last three years.

Further, with the introduction of reverse bidding process in the sector, tenders have been offered at prices even lower than conventional power plants, bringing the solar tariff closer to grid parity.

Solar tariffs discovered in various bids



Source: PwC analysis

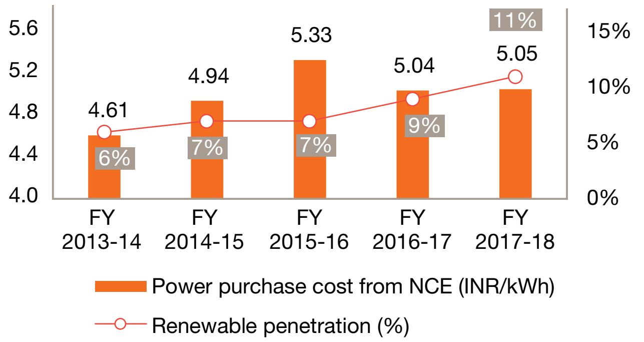
The trend of solar tariff discovered through various tenders in India presents a success story for the solar sector in India. The price variation pattern in auctions is largely attributed to the auctions being decentralised, where a few auctions were conducted by SECI/NTPC under the solar park model, while others were conducted by states under the non-solar park model. Also, each state adopted its own auction design which had an impact on the final bid result.

Through its first 1,000 MW wind competitive bidding for non-windy states, SECI discovered a much-discussed tariff of 3.46 INR per kWh[9] and has called for another 1,000 MW, which is yet to be concluded. However, drawing a parallel with other markets like Chile, Mexico, and South Africa, which have shown an impressive reduction in auction prices for wind projects, the same may likely be achieved in Indian wind biddings.

[9] SECI, PwC analysis. RE-rich states in the chart include Tamil Nadu, Karnataka, Andhra Pradesh, Telangana, Maharashtra, Gujarat, Madhya Pradesh and Rajasthan. Wherever approved power purchase cost in the respective years is not available, the same has not been considered for analysis.

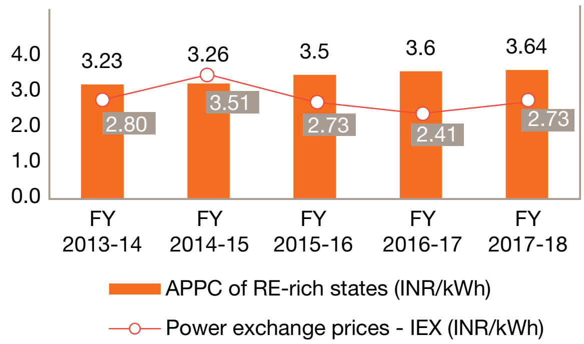
Power purchase cost of state utilities

Renewable purchases by RE-rich states



Source: SERC orders, PwC analysis

Renewable purchases by RE-rich states in INR/kWh



The steep downward trend in RE tariffs, resulting from recent auctions, suggests that a transition towards renewable and sustainable power systems is economically justifiable and feasible. With increased penetration of RE at such low prices (sub 3 INR per kWh), the average power purchase cost from RE is set to reduce. However, considering the cost of ancillary services and modernisation of system operations required for balancing the intermittency and fluctuating short-term power purchase prices, the impact on overall power purchase cost may be marginally higher. The impact will be even higher with the increasing penetration of RE in the power purchase portfolios of the utilities.

A majority of the survey respondents believe that the following factors, among several others, are assisting the growth of RE projects in India:

- Policy drivers such as NAPCC, JNNSM, RPO
- Fall in solar module prices
- RE tariffs achieving grid parity
- Lower costs of funding
- Solar park-based projects
- Reduction in PPA counterparty risk and better payment mechanisms
- Improving the financial health of state utilities
- Lower cost of funding

The other factors which are not rated very important by the respondents are:

- Improvements in technology
- Environment-friendly technology

Based on the survey question related to the ease of setting up RE projects in India's southern states, Andhra Pradesh and Telangana, followed by Karnataka, have been rated high in terms of responsiveness towards RE projects development approvals within stipulated timelines. Administrative expenses for getting these approvals is highest in Tamil Nadu, among all southern states. It is followed by Karnataka. Andhra Pradesh is rated as the least expensive. Regarding transparency of the RE project development approvals process (in terms of tracking one's application), again Andhra Pradesh and Telangana have been rated as the best states.

Most of the respondents feel that the following factors, among several others, are the most important thrust areas to further boost the RE sector in India:

- Availability of adequate power evacuation infrastructure
- Solar parks for large-scale capacity addition
- Open power market: To facilitate the sale of renewable power
- Guaranteed power off-take
- Timely energy bill payment by state utilities
- Availability of low-cost funding

Other factors which have not been voted as very important thrust areas are:

- Government support for funding
- Forecasting and scheduling infrastructure: Government interventions such as REMCs

Comments by survey respondents

Factors leading to significant reduction in wind/solar tariff in India

Solar

- Assured off-take with reliable payment-securing mechanisms (lower risk)
- Sovereign credit (in case of central bids and stronger payment security mechanisms in case of state bids) (lower risk)
- Largely de-risked projects in case of bids involving solar parks (land, evacuation taken care of by the government) (lower risk)
- ‘Expectation on continuing drop in forward-looking solar module prices
- Lower financing costs on the back of lower risk perception, macroeconomic scenario, etc.
- Lower capital costs on an overall basis on account of scale (larger projects) and visibility on future capacity additions (and therefore the ability of developers to tie-up capacities through long-term frameworks)
- India emerging as a preferred investment destination for global utilities and infrastructure/PE/sovereign funds (with limited options to invest in their home markets or elsewhere), coupled with the option to turn their portfolios ‘green’
- Overall lower risk perception leading to lower return expectations

Wind (in addition to some of the issues above that are common to wind and solar)

- Central government PPAs as against state government PPAs (better credit) (lower risk)
- Upfront execution of a PPA, unlike in the past where PPAs in several states were executed post commissioning, enhancing the tariff and PPA risk for equity as well as debt (lower risk).
- Lower back down/dispatch risk, given that projects are connected to the central grid as against the state grid (lower risk).
- Indigenous manufacturing (no imports and, therefore, no forex, supply price risk, etc.) (lower risk)
- Higher output from larger turbines with higher hub heights and larger rotors (turbines specially designed for Indian conditions)
- Lower WTG costs on account of competition among turbine suppliers to cater to minimum demand in the market (unlike the past FIT regime, today turbines can be manufactured and supplied only to projects that have won a bid)

– A leading IPP

Fall in rates is also due to the fact that land acquisition and evacuation infrastructure are taken care of by the nodal agencies of solar parks.

– A prominent RE IPP in India

The overall sector is overtaken by financial engineering models. Aggressive assumptions on equipment pricing and lower cost of funds are driving down bid tariffs. Any deviations in these assumptions will cause distress to bid winners.

– A reputed rotor blade manufacturer in India

The current fall in tariffs is largely driven by the reduction in equipment price and low cost of funds, which may not be sustainable. The tariffs have also reduced due to increased competition as the project award pipeline has been opened in fits and starts. Recent regulatory interventions have also taken the sheen off the renewables sector and has led to it being perceived as high risk, as far as regulatory actions are concerned. We expect bidders in upcoming tenders to take into account a certain amount of risk premium linked to regulatory uncertainties.

– A leading infrastructure finance company

Good quality PPA will ensure a better rate of interest and that's the way forward. Also, we need to get over the uncertainties of currency in project costs by increasing local content – PV modules.

– A reputed multinational solar EPC company

Sustainability of low tariffs discovered in wind/solar reverse auctions

Based on certain factors, these tariffs are sustainable. However, if these factors remain dynamic, the underlying risk perception or the market scenario will change, which will have an impact on the sustainability of the tariffs.

– A leading IPP

Projects financed by overseas lenders, one of the reasons for such low tariffs, face currency risk without hedging. Any price variations in the solar modules, for which we are heavily dependent on imports, will play spoilsport for the developers.

– A leading IPP

The answer to this question should be the prerogative of the firms which participated in the bids and actually won the projects after intense competition. However, based on our dialogue with people from the industry and our view on the key project parameters (such as capital cost, CUF, etc.), in our opinion, the tariffs discovered through such transparent reverse auction processes appear sustainable.
A word of caution though, since the business requirements/priorities are different for each bidder, such discovered tariffs are not replicable for any business entity and any opportunities. Instead, these tariffs are specific to the particular bidding entity, that particular project and for that particular time frame, which may lead to different considerations for other players.

– A leading infrastructure finance company

These are artificial in nature and will, in the longer term, reduce the confidence in the sector due to poor quality projects.

– A reputed solar EPC company

Directionally, LCOE from wind and solar will continue to reduce. However, this cannot be generalised as done for discovered wind bids. The current wind tariffs are discovered for wind sites with high PLF. This cannot be true across India.

– A reputed rotor blade manufacturer in India

Project returns in the current scenario of falling tariffs

> The developer's appetite for IRR is always the same. They just count on falling input prices to meet them. The fall in input cost is achieved via compromises, which are not healthy for the sector.
>
> **– A leading solar EPC company**

Based on the query related to major challenges for developing a conducive environment for retail competition and the sale of power, respondents consider the following factors as major challenges:

- Long timelines for grant of wheeling and banking approvals; augmentation of grid infrastructure
- Introduction of new OA charges
- Uncertainty of the quantum of change in OA charges

Other factors which are not rated as major challenges are:

- Cost and regulatory approvals associated with the change of meters and other related infrastructure

Comments by survey respondents

Power exchange and OA mechanisms for RE

> Given the nature of the resource, in the absence of viable storage solutions, the dispatch of power generated as and when the resource is available at viable tariffs net of all OA-related charges is critical for the commercial viability of an RE project. Achieving this objective, as things stand today, is challenging from the perspective of trading RE in the electricity exchange. In addition, forecasting and scheduling has not yet achieved a high degree of accuracy, thereby limiting the ability of generators to accurately deliver the guaranteed kWh.
>
> We understand that Karnataka has had a favourable OA regulation (with visibility for projects commissioned till March 2018, providing long-term clarity on OA charge exemptions, with it already implemented in spirit. However, in a few other states, we understand that the utilities have not been supportive of OA, notwithstanding favourable policies and regulations.
>
> **– A prominent IPP**

> The day ahead and week ahead trading of power on the spot markets has been exclusively a fossil fuel affair so far. There is very little renewable power being traded in the market. The recent extension of the exemption from ISTS for wind and solar power should give the necessary shot in the arm for increased trading of renewables over the exchange.
>
> The OA regime is patchy. Varying levies, wheeling charges, cross subsidies, electricity duties have made the OA market a quagmire. States have generally not been keen to allow free OA to RE generators. The record here has been a mixed one.
>
> **– One of the largest RE IPPs in India**

> Power trading regulations and energy exchanges are currently structured to cater to static power sources like thermal and gas. For RE sources that are intermittent sources of power, the current environment puts an unnecessary burden on RE-based projects so that they fall in line with the current requirements. There is a need to revamp the same by considering the inherent uncertainty built into the RE-based projects.
>
> The OA mechanism itself is not really welcome by DISCOMs, which believe that OA targets high-tariff customers, thus resulting in lower realisations per unit, while the average cost of supply remains as it is. Therefore, OA supply is mostly burdened with various charges in the form of OA charges, CSS, etc.
>
> Additionally, stringent forecasting and scheduling requirements make the OA framework unfavourable for RE projects due to their inherent intermittent nature.
>
> **– A leading infrastructure finance company**

Solar rooftop and distributed generation: The future is here

The audacious task of achieving 175 GW of RE capacity put forward by the nation has started reaping benefits. With the prudent choice to use more clean energy to fuel its growth, India is contributing to the bigger global cause of reducing its carbon footprints and ensuring a conducive environment for generations to come. Currently, clean sources of energy form about 17% of India's installed capacity.

India is expected to go a long way in tapping its abundant solar energy through solar rooftops and ground-mounted solar projects. While India's concrete cover is constantly increasing, it is also leading to the creation of massive roofs for the installation of rooftop panels. With nearly 300 sunny days every year and an average insolation of 4–7 kWh/m2, the opportunity to tap solar energy is immense.

Most Indian states (around 20) have promulgated their solar policies, thus showcasing their desire to promote solar power. Also, the central government has declared incentives such as subsidy on capex (for domestic/residential consumers), accelerated depreciation, tax holidays, etc. for RTS projects. Most states also have a net metering/gross metering regulation in place, which empowers a consumer to be a prosumer, thereby giving power to the grid.

40 GW – RTS by 2022
Robust policy guidelines and institutional frameworks to be the driving forces

There are also channel partners like SECI and financing partners like NABARD and REC to facilitate the transaction. SECI is implementing large-scale grid-connected rooftop projects in various phases. Apart from pilot projects, SECI has also conducted biddings for two 500 MW tenders[10] in 2016 and 2017. Presently, 13 GW of grid-interactive solar capacity is installed in India, of which around 1.4 GW comes from the RTS space. States such as Tamil Nadu and Rajasthan contribute to a higher share of these capacities.

India's southern states have not shied away from promoting the country's green energy initiative. A few key policy interventions by the southern states for promoting solar power are captured in the table below: [11]

	Net metering projects			Solar PV projects		
States	**Feed-in tariff (INR/kWh)**	**Capital cost subsidy**	**Electricity duty**	**OA charges for solar project**	**Banking for solar projects**	**Other exemptions**
Andhra Pradesh	For RTS, no payment for excess energy through net metering	Subsidy/incentive from MNRE under JNNSM	Exempted	Wheeling and transmission charges exempted for captive/group-captive use	• 100% of energy for all captive and OA consumers • Banking charges at 2% of energy injected	• Single window clearance framework • Supervision charges by utilities exempted
Karnataka	(5.20–7.08) (4.43–6.03)	Subsidy/incentive from MNRE under JNNSM	Applicable	Exemption in OA charges for 10 years if a project is commissioned before 31 March 2018	• 100% of energy for all captive and OA consumers • Banking charges at 2% of energy injected	• VAT exemptions, excise duty • Customs duty exemption • Reduction of 5% in supervision charges by utilities
Tamil Nadu	Carried forward to next month and lapses at end of the settlement year	• Subsidy/incentive from MNRE under JNNSM • CM's Solar Rooftop Capital Incentive Scheme	Exempted for 5 years	30% of applicable wheeling and transmission charges	• Availability of banking on a monthly basis • Zero banking charges	• Allotment of land at a 50% subsidised rate • VAT-based incentive • Stamp duty exemption
Telangana	Applicable retail tariff for net metering projects	Subsidy/incentive from MNRE under JNNSM	Exempted	Wheeling and transmission charges exempted for captive/group-captive use	• 100% of energy for all captive and OA consumers • Banking charges at 2% of energy injected	• Single window clearance framework • Supervision charges by utilities exempted

[10] SECI. (2017). Setting up of 500 MW rooftop solar PV projects: Updated list of successful bidders in parts A, B and C. Retrieved from http://seci.co.in/show_whats_new.php?id=461 (last accessed on 23 Aug 2017), PwC analysis

[11] Multiple sources: SERCs, state RE development agencies, state government gazettes

Even though with a deluge of policy pushes, the target of 40 GW of solar rooftop capacity by March 2022 seems to be a herculean task, with 96% of the target yet to be achieved. It is estimated that an amount of 1.8 trillion INR is required to achieve this target, after accounting for the current level of subsidies.[12] High upfront cost of installation is considered as a push back for this technology. Since regulatory interventions, such as limiting the rooftop capacity to the contract demand exists in various states, power-intensive consumers will not consider solar rooftops as a lucrative option. Owing to the perceived high risks and suspicions about performance, banks are also unwilling to lend to solar rooftop projects. Moreover, borrowing costs can be as high as 14%. The risk-aversive attitude of residential/small commercial consumers has also contributed to the slow offtake of solar rooftop projects in the country. Such issues could have been well addressed had the RESCO model of developing the project gained popularity in India, where RESCO takes the onus of developing and operating the RTS project. High capital costs of storage technology adoption is another factor that will impact returns and increase the payback period.

Distributed generation

As per the World Bank, around 240 million people[13] in India still have no legal electricity connection. Though significant thrust has been given to the power generation vertical, there is a lag in making electricity accessible to rural India. The reasons for this could be many such as the availability of distributed and small load centres only, the lack of grids, geographical barriers, etc. This underlines the importance of distributed/off-grid generation facilities, among which solar energy can become the torchbearer.

With only approximately 1.5 GW[14] of capacity installed in the off-grid space, India has a long way to go in lighting up the homes of rural India. Many non-conventional technologies such as waste to energy, biomass-bagasse, aero-generators/ hybrid systems and stand-alone SPV systems which are experimental in nature, eco-friendly and serve more than one purpose can be the game changers in this space.

Karnataka has promoted distributed generation vide its 'Surya Raitha' scheme where a farmer having 10 kWp solar power can earn nearly 50,000 INR per annum, apart from his self-consumption for irrigation. Tamil Nadu has the CM's Solar Powered Green House Scheme under which 3 lakh houses will be constructed with solar powered lighting systems.
In Andhra Pradesh, a total of 11 MW of off-grid stand-alone solar plants have been sanctioned by the NREDCAP.

SPV systems and distributed generation technologies to be the catalysts in lighting rural India

The next big disruption is already making its way through storage technologies and EVs. Hybrid vehicles may just be a curtain raiser. However, states like Maharashtra and Madhya Pradesh have sensed the market vibes and recognised such consumers under the tariff regime. The call for a cleaner and greener tomorrow was always on and the nation is responding to it through non-conventional sources of power, hybrid technologies, etc. This also questions the status quo in current infrastructure and thrust areas and may call for a thorough revamp.

[12] Sood, N. (21 June 2017). What is hindering solar roof top sector In India? Retrieved from http://businessworld.in/article/What-is-Hindering-Solar-Roof-Top-Sector-In-India-/21-06-2017-120587/ (last accessed on 23 Aug 2017)

[13] World Bank. (2017). Solar powers India's clean energy revolution. Retrieved from http://www.worldbank.org/en/news/immersive-story/2017/06/29/solar-powers-india-s-clean-energy-revolution (last accessed on 23 Aug 2017)

[14] MNRE. (2017). Physical progress (Achievements). Retrieved from http://mnre.gov.in/mission-and-vision-2/achievements/ (last accessed on 23 Aug 2017)

Comments by survey respondents

State policies for the development of solar rooftops

> Most states have favourable rooftop policies. However, it is important to ensure that the regulations and policies are aligned in terms of their intent. It will help if the state nodal agency is identified as a single point of contact to provide clarity to investors on any ambiguity with respect to policies and regulations.
>
> **– A prominent IPP**

> We have made a good beginning in net metering policies. Currently, more than 25 states have net metering policies in place. However, the framework is a patchy one. Capacity continues to be limited by contracted demand, limited by the capacity of the distribution transformer in the vicinity and a host of other non-technical conditions like a CEIG clearance for even behind-the-meter installations, etc.
>
> **– One of the largest RE IPPs in India**

> Most states have now adopted net metering policies for solar rooftops and are driving their implantation. However, the challenges are in smooth operations and approval clearances, which will get sorted out by building further experience.
>
> **– A leading infrastructure finance company**

Distributed generation

> Hybrid systems (both ground mounted and rooftop) on the RESCO model can be a viable option to further grow the distributed generation space. In remote areas, one may not find many usable roofs; hence, ground-mounted projects would also be needed.
>
> **– A leading infrastructure finance company**

Energy storage and solar rooftop projects

Storage is not likely to be viable in the short term. However, in the long term, if virtual power plants become a reality, with subsidy support from the government, this could gain momentum.

– A leading IPP

Storage system technologies for rooftop projects will be commercially viable only for C&I consumers once prices start reducing.

– A prominent RE IPP in India

Storage technology is still not commercially acceptable in India even for rooftop projects as the life of battery systems, operating/replacement costs, size of the systems remain a challenge. Going forward, as further breakthroughs in technologies are achieved, we may see increased momentum. While the current growth in the solar rooftop space has been impressive, it may slow down in the future. Currently, rooftops cater only to partial demand due to their availability for a limited number of hours and their inherent intermittency. Unless the RTS products are bundled with efficient storage solutions, their full potential will not be realised and it may not be possible for them to be marketed as grid-independent products.

– A leading infrastructure finance company

As grid becomes more stable and the lower cost of power is passed on to consumers, the impetus for solar rooftops will drop.

– A reputed solar EPC company

Will improvements in battery technologies and an all-electric transport by 2030 radically change the way we generate and use electricity?

The Indian automobile industry is one of the largest growing markets in the world and is expected to take the country's manufacturing GDP to 25% by 2022. With an EV target count of over 6 million on roads by 2020, and all electric transport by 2030, the infrastructure that will be rolled out could well be a dampener for the oil and gas sector. It could change the way peak power plants are currently used to meet peak load. In the process, it may also contribute in resolving 'intermittency'-related issues of renewables in some way, giving them a greater share of the overall electricity mix.

Such developments in the industry would mean that the electric utilities and automotive sector could become disruptive with energy storage solutions evolving to meet multiple functions such as meeting peak demand, absorbing power generation peaks, balancing intermittent renewable generation sources like solar and wind, supporting distributed power generation, replacing fossil fuel combustion engines for vehicles, meeting emission targets and others.

> 'We are going to make EVs self-sufficient…the idea is that by 2030, not a single petrol or diesel car should be sold in the country.'
>
> **– Shri Piyush Goyal**
> **Power, Coal, New and Renewable Energy and Mines Minister**

Battery storage

Batteries, being modular, scalable, and not restricted to particular locations, offer advantages over storage technologies used by utilities (e.g. pumped storage, peaking gas turbine plants, compressed air, synchronous machines in condenser mode etc.). Lithium ion and flow batteries are the two technologies that seem promising in the near future. However, with increased penetration of distributed generation, public policy changes and technological advances in software and hardware at customer and utility levels, there could be fundamental shifts in the electric utility business model, with growing options in battery storage.

Technology	Functional fitment area	Issues
Sodium metal halide	EVs, replacement for lead acid batteries	Limited cost gains ahead, requires high temperatures to operate
Sodium-sulphur	Utility scale balancing, standalone power systems	Limited cost gains ahead, high operating costs
Nickel-cadmium	EVs, stand by power	Toxic, requires optimum charging cycles
Nickel-metal hydride	EVs, stand by applications for industry	High levels of self-discharge, rapid degradation
Lead-acid	Back-up supply, EVs, RE generation, balancing	Limited cost gains ahead, poor performance in non-optimum temperatures

Renewables to benefit from battery technologies

Despite intermittency issues with wind and solar power generation, these energy sources have had wide acceptance among generators. Wind and solar power generation, when mapped, largely serve the off-peak baseload (mid-day and late night)—that is, the lowest time-of-day pricing. This current scenario can be altered substantially by the application of battery technology, wherein renewable generation could be stored and discharged during peak hours, thereby further improving the economics of a wind and solar generator in markets offering the highest peak to off-peak differential (e.g. Karnataka, Maharashtra and others). In the process, it also helps to tackle intermittency-related problems.

India has started experimenting with battery technology. A recent tender in Andaman and Nicobar for a 2 x 10 MW (AC) grid interactive solar PV project integrated with a 28 MW hour project is a starting point in this space. SECI is also working on few utility scale storage-based solar tenders.

Opportunities for battery storage	Threats
Reduced intermittence allows larger role for renewables in the energy mix.	Regulatory uncertainty or change could harm project economics.
Storage allows energy to be sold when prices are favourable, improving economics.	The renewables plus battery combination represents a higher up-front cost than a renewables plus fossil fuel combination.

Hydropower with pumped storage, gas and oil-fired power generation stations have been the traditional peaking plants maintained in reserve as spare production capacity to keep pace with daily and seasonal peak demands. The operational costs of these generators, in spite of being high, are currently used to fulfil the gap between the availability and the demand of the increased peak load. Battery storage and its subsequent utilisation to meet peak requirements can substantially reduce the peak to off-peak price differential, thereby, eventually, reducing the dependability on high-cost peaking plants.

Shift to EVs

India's EV industry is at nascent stage compared to other international markets such as the US, China and Europe. China, the market leader, held nearly 50% share of the global EV market in 2016, with India accounting for a share of 0.1% only. To boost the manufacturing of hybrid vehicles and EVs in India, the FAME scheme has been launched by the central government. This scheme targets to achieve a production of approximately 7 million EVs by 2020. Like China, India is also planning to spend largely on subsidising local companies with consumer incentives, thus gaining from technological advances already made globally.

While the plan to have only electric cars by 2030 is all very well towards reducing India's dependence on fossil fuels, the challenges seem to outweigh the opportunities in India. CII, through this event, is taking a step to understand the market needs and address key queries such as opportunity assessments for battery manufacturers, market sizing for plug-in EVs and battery EVs, identifying growth barriers, domestic manufacturing potential of India w.r.t. EVs and many more.

EVs – A market full of opportunities

Consumer acceptance	Product launches	Policy, market developments	Infrastructure
Broad acceptance of EVs by consumers: Competitive cost, recharge options, range of options and other factors	Focus by mainstream manufacturers on pure EVs rather than hybrids	Aggressive moves by regulators to promote EVs; subsidies for EVs	Acceleration of charge points infrastructure and convergence of technology/common standards

Among various emerging technologies, survey respondents believe that the following technologies are going to play a major role in India: Lithium ion batteries, EVs, RTS projects, and offshore wind and hybrid RE projects.
Other technologies such as mechanical storage (pumped hydro), fuel cell, hydrogen energy cell, micro grid and waste-to-energy projects did not get major ratings from the respondents.

Comments by survey respondents

Energy storage solutions for the RE sector

"While theoretically possible, storage technology is yet to prove itself as a commercially viable option, even with significant improvements over the last few years. Therefore, in the medium term—that is, the next two to three years, it appears difficult for storage technology to replace thermal energy as base load. Only upon seeing the on-field implementation of the initial few projects, further assessment should be made.

– A leading infrastructure finance company"

"This would call for a major upgrade to the existing infrastructure to handle storage and also a mechanism to factor the cost of storage. Storage technologies are costly today and the incremental cost of putting the same is way above the cost of renewables, thus making them look financially unviable.

– A reputed solar EPC company"

Status of energy storage technologies in India

"Technologies are available and developers are aware of the same. Associations such as the Indian Energy Storage Alliance are working with the government and developers to strengthen storage solutions. However, we believe that unless the market sees a significant drop in storage costs, the government and the off-takers may not encourage projects with storage as it is likely to have a negative impact on the tariffs being quoted for RE projects.

– A leading IPP"

"Prices have declined rapidly in the last few years but still prove to be costly at this point of time. However, they are expected to further reduce in the next five years. Here we are referring to imported and not indigenous products.

– A prominent RE IPP in India"

"There is a high amount of uncertainty when it comes to operational performance and costs; hence for developers to adopt it, they would certainly need an enabling environment where they are not penalised to invest in a futuristic technology. A separate set of guidelines and an enabling framework are needed to establish storage technology in India.

– A leading infrastructure finance company"

Preparedness of the Indian market for EVs

This will depend on the final terms of the GoI's EV policy that is expected to be notified later this year. If the proposed policy mandates the replacement of vehicles only through EVs post 2030, the direction would be clear and the market would evolve accordingly.

– A prominent IPP

EVs represent the future of the transportation sector and they need to grow in India, given current over-dependence on oil. However, the growth of EVs will be dependent upon the growth in battery storage technology and the commercial viability of the same. The infrastructure will get developed in the near term and can be developed at a fast pace if EVs prove to be a commercially viable option for mass transportation.

– A leading infrastructure finance company

The EV market is being driven by a large participation from market completion among private players and retail investors. These manufacturers have a global roll out of their products and the Indian products are in line with their global peers. So, this market will grow.

– A reputed solar EPC company

Preparedness is nil but the intent to go all electric is good. The EV market is still budding and is lacking in awareness, financing and good charging points. Whilst the government is bold to announce the usage of all EVs by 2030, there are a few suggestions:

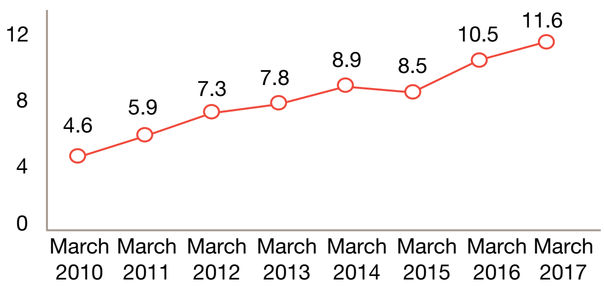
- GST for the sale of EVs is at 12% but GST for battery replacements is at 28%. This must be kept the same or lower rate.
- RTO rules for EVs must be standardised across all states.
- E-cycles must be included under the DHI scheme for subsidy until the industries get volume drivers.
- The government must aid lithium translation and must collectively bargain for lithium battery cells to help the mandate.
- All government projects must include EVs for people or material movement.

– A leading EV company in India

Long-term lending in the power sector and the availability of new funding options

The availability of the requisite funds is one of the most important milestones for setting up a power project, given the capital-intensive nature of the same. While financial closure acts as the final hurdle before the start of a project, the financing costs also form a significant portion of fixed costs a power project has to incur. With auctions driving the new capacity addition, the capability to raise funds at lower costs of capital is even more critical for a power sector player. Given the plans for the power sector, there is a concern on the availability of enough low-cost and long-term funding avenues. For example, implementing the 175 GW MNRE target of RE will require funding of 160 billion USD. However, the maturity of the power sector, with multiple years in existence, has led to the availability of numerous avenues to tap funding requirements. While a majority of projects still get funded through the traditional bank credit route, new avenues like masala bonds, USD-denominated bonds, IDF, green bonds and InvITs have opened up for players in the power sector. The cumulative FDI in the power industry has increased by 2.5 times since March 2010 (to 11.6 billion USD).

Cumulative FDI inflow in the power sector (USD billion)



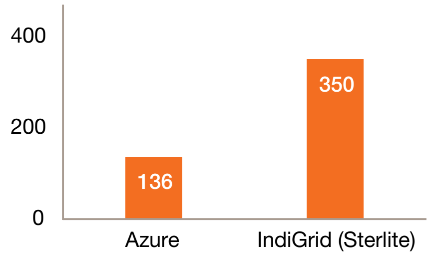
Source: Monthly IBEF report, PwC analysis

Equity funding

The power sector has been witnessing increasing investor interest in RE projects. Additionally, utility scale generation is seen as a mature industry with multiple investments. Even distributed generation developers, with RTS being the main business area, received PE funding from large funds. The equipment and solutions side has seen a fair amount of traction as well. The Indian power sector has witnessed investments coming from infrastructure funds with longer horizon, sovereign funds concentrating on hold-to-maturity portfolios and pension funds looking for long-term stable cash flows.

Apart from raising funds from funding agencies, other avenues such as capital markets have also been accessed by power sector players. An RE player has raised funds through IPO overseas. InvITs, as investment vehicles, were also formalised by regulators to attract investments in the power sector. Such investment vehicles provide increased entry and exit opportunities for developers, asset owners and financial investors, enabling them to monetise their assets. The power sector's first InvIT, India Grid Trust's IPO, was executed in May 2017.

Funds raised in capital markets (USD million)



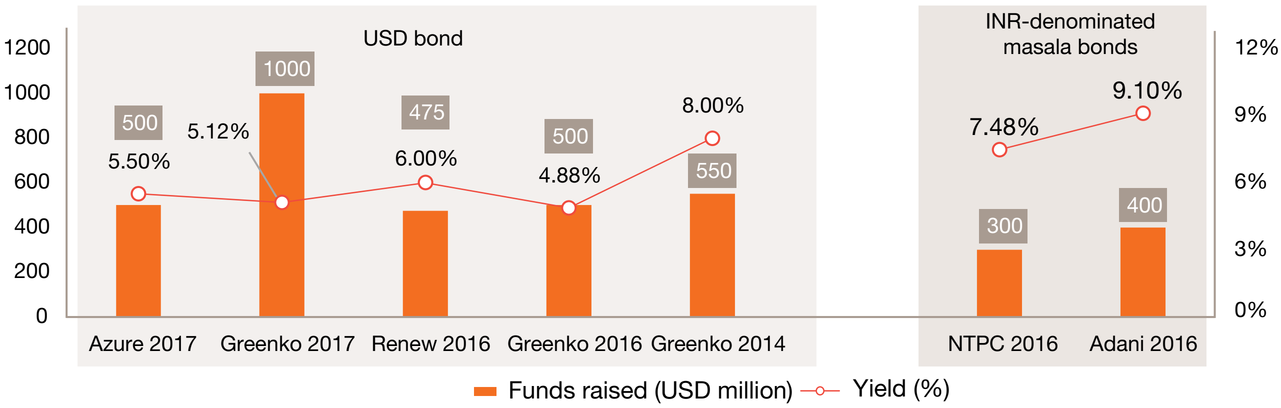
Source: PwC analysis

Debt funding

The majority of funding for setting up a power project comes from debt financing. Bank loans, the traditional source of debt funding, have been under pressure with domestic banks grappling with issues like sector exposure norms, group exposure limits and non-performing assets. Power sector players have accessed multiple avenues to avail of low-cost debt funding for their projects. This relieves the burden on domestic banking institutions to provide for all the development in power and other infrastructure sectors.

One of the most prominent sources of funding utilised is USD-denominated bonds from the overseas bond market. Despite their shorter duration, these bonds are attractive because of their lower interest cost and no repayment requirement till maturity. Multiple players have accessed the bond market with one of the players raising a total of 1 billion USD in a single tranche. Foreign bonds worth 2.5 billion USD were listed by Indian RE companies over the last 18 months. Green bonds and masala bonds are also being used by power sector players, including public sector companies. A large public sector unit company has raised 2,000 crore INR at approximately 7.5% through the issuance of green masala bonds.

Major fundraising in the power sector during FY 2016–18



Source: Investor presentations, offering memorandums, DRHP, PwC analysis

Investment vehicles like InvITs and YieldCos also help through the development of primary and secondary capital markets by the establishment of a perpetual structure for raising capital at a reduced cost from long-term investors. The replacement of bank debt with long-term capital can lead to a decrease in the financing burden of companies.

Most of the survey respondents believe that they are going to rely on conventional ways of financing, which include bank loans and PE. Among new innovative ways, respondents believe that they will rely on green bonds. Other avenues such as IPO, InvITs, IDF, masala bonds and USD-denominated bonds were not rated high by the respondents.

Comments by survey respondents

Innovative modes of financing

"Innovative modes of financing help reduce the cost of power generation. This is being leveraged by large players for short-term financing (three to five years)."

– A prominent RE IPP

"While the financing market is offering innovative options for RE-based projects, it is still riding on the back of strong sponsor support. Moreover, any regulatory uncertainty creates higher perceived risk, resulting in sub-optimal debt pricing for developers where, again, sponsor support is a key consideration for lenders."

– A leading infrastructure finance company

Other miscellaneous comments by survey respondents

Stressed assets in the power sector

> We believe that the major reasons for the creation of stressed assets are: 1) overhang in capacity owing to rapid capacity additions and sluggish demand in the recent past; 2) the inability of DISCOMs to make power available to all 24x7, owing to its financial health. Of course, all the reasons cited above have added to the gravity of the situation.
>
> **– A leading IPP**

> Local issues and difficulties in land acquisition also increase the stress on the projects, specifically solar power. Due to prolonged acquisition processes, little time is available for the actual construction of projects, thus impacting the cost/quality of the projects. It can also lead to frequent and last-minute changes in design.
>
> **– A leading infrastructure finance company**

> Aggressive prices result in compromised projects, thus increasing the operational costs.
>
> **– A prominent solar EPC company**

Level of preparedness for DSM

> We understand that in most states, power generators have started forecasting and scheduling power from RE projects. A couple of key issues to note are:
> 1. Older projects that have not considered the financial impact of forecasting and scheduling (both as a part of regulator's tariff order as well as investors base case) could be negatively impacted;
> 2. Some state regulators have been proposing draft F&S regulations which are not consistent with the CERC regulations (i.e. imposing more stringent conditions).
>
> **– A prominent IPP**

> While generators and system operators have carried out their initial preparations, the jury is still out on the implementation. Given the intermittent nature of the RE sources, till date, it is difficult to ascertain the financial impact on generations under the proposed DSM.
> The first few years will see many generators struggling with losses on account of the deviation settlement, but unless some sort of settlement mechanism is implemented, it will be difficult to bring in efficiencies.
> Given the importance of proper supply-side management for the stability of the grid, it is still preferable to go through the pain and achieve some efficiencies. However, it is also certain that the very nature of RE sources is intermittency and the same cannot be taken out of the equation. More focus in the coming years need to be accorded to the demand-side management and the implementation of smart grid and smart base load technologies.
>
> **– A leading infrastructure finance company**

175 GW RE target by 2022

Based on the capacity addition achieved in the last two years, achieving the target appears to be challenging. If some of the challenges plaguing the sector currently are resolved, given the strong investor interest in the market, the sector could well be on the path to achieving the stated target.

– A leading IPP

As per the current environment, the annual market is for approximately 10 GW in solar and approximately 4–5 GW in wind, except the current FY which is turning out to be a lean year for wind. Given these numbers, we expect the total capacity addition to reach approximately 100–125 GW.
The major challenge in achieving the target that remains is policy and regulatory uncertainty, which has started increasing even before half the target has been achieved.

– A leading infrastructure finance company

Future of thermal power generation in India

Thermal generation in the next 10 years depends a lot on how the demand picks up, especially on the industrial side and improvements in DISCOM health, thereby making cheaper and reliable power available to all segments of society. Presently, we believe that there is a capacity overhang in the system and, therefore, an immediate requirement of additional MW is not required till the time we are able to meet the above objective. However, coal-based generation through the usage of advanced technology will be required to meet India's growth objective in the long-term, if capacity addition in nuclear is insignificant.

– A leading IPP

Given that no visible alternative is available to replace thermal projects as the base load requirement as of now, the existing thermal generation capacity will be required. However, no further capacity addition is expected since solar and other RE are expected to lead the future of energy generation, both in terms of cost per unit and growth.

– A prominent infrastructure finance company

UDAY scheme

The UDAY scheme has brought some much-needed respite and is showing good progress for now. States, especially those under financial stress, which had witnessed delay in payments before, have started paying the generators, more or less, on time. Moreover, industry reports suggest that the UDAY scheme has already managed to yield a savings of nearly 12,000 crore INR, with a sharp reduction noted in revenue losses of up to 60% in some cases. As per the Rural Electrification Corporation, bonds worth 2.3 trillion INR have been issued to refinance 85% of the total distribution utility debt to be restructured, leading to a low rate of interest for DISCOMs. In the long run, its success will depend on the ability of each state to bring down T&D losses and setting up the right tariff levels so that DISCOMs don't incur losses for every unit of power being sold.

– A leading IPP

The debt burdens of the DISCOMs have reduced, thereby improving their cash flows for operations. However, efforts are necessary in bringing down the AT&C losses through 100% DT metering.

– A prominent RE IPP in India

The UDAY scheme has been able to rejig the thought process, with its effectiveness completely dependent on the states' willingness to usher in reforms. Unless DISCOMs focus on operational improvements and state governments don't discourage end user tariff rationalisation, the scheme may not be able to achieve its true potential.

– A prominent infrastructure finance company

Future of indigenous equipment manufacturing

In the case of wind, the manufacturing has largely been localised. In the case of solar, at least in the near term pending enhancement of efficiencies on the supply chain side, we expect the market to be dependent on imports. In case of thermal plants, in the near term, there is a lull in domestic requirement and hence facilities built in India to meet captive demand on the BTG side will have a challenging time ahead; however, opportunities do exist in the replacement space since significant capacities have completed 25 years of useful life.

– A leading IPP

We seem to be late in identifying opportunities for setting up manufacturing industries, be it in the case of solar modules or storage systems. China, the US and other European countries have already built or are in the process of building manufacturing facilities of largescale, with the integrated supply chain taking advantage of the economies of scale, which is not the case with India. However, setting up manufacturing facilities in India, in association with already existing global vendors, is expected going forward.

– One of the largest RE IPPs in India

Responding from a solar PV perspective, developing a strong and thriving manufacturing set-up demands meaningful investment in R&D support and a focus on quality. The Indian private sector would need visibility of scale and policies before making a huge commitment in R&D, quality and manufacturing. Considering the present scenario, we expect the Indian power equipment segment to remain import-dependent in the foreseeable future. At the same time, conventional power and wind equipment manufacturing is largely domestic. As a result, while a part of the market is supplied from domestic sources, the other part relies predominantly on imports.

– A prominent infrastructure finance company

List of abbreviations

Abbreviation	Definition
AA-CAES	Advanced adiabatic compressed air energy storage
AD	Accelerated depreciation
AMI	Advanced metering infrastructure
APPC	Average power purchase cost
CAES	Compressed air energy storage
CAGR	Compound annual growth rate
C&I	Commercial and industrial
CAPEX	Capital expenditure
CEA	Central Electricity Authority
CEIG	Chief Electricity Inspectorate to Government
CERC	Central Electricity Regulatory Commission
CII	Confederation of Indian Industry
CIL	Coal India Limited
CSS	Cross subsidy surcharge
CTU	Central Transmission Utility
CUF	Capacity utilisation factor
DBFOO	Design, build, finance, own and operate
DCR	Domestic content requirement
DHI	Department of Heavy Industry
DISCOM	Distribution company
DPR	Detailed project report
DRHP	Draft red herring prospectus
DSM	Deviation and settlement mechanism
DT	Distribution transformer
EPC	Engineering procurement construction
EV	Electric vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
FDI	Foreign direct investment
FiT	Feed-in tariff
FY	Financial year
GEC	Green energy corridor
GENI	Global Energy Network Institute
GoI	Government of India
GW	Gigawatt
ICRIER	Indian Council for Research on International Economic Relations
IDF	Infrastructure debt fund
IEX	Indian Energy Exchange
InvIT	Infrastructure investment trusts
INR	Indian rupees
IPO	Initial public offerings
IPP	Independent power producer

Abbreviation	Definition
IREDA	Indian Renewable Energy Development Agency
ISTS	Interstate transmission system
JNNSM	Jawaharlal Nehru National Solar Mission
km	Kilometre
kV	Kilovolt
kWh	Kilowatt hour
LCoE	Levelised cost of electricity
LDC	Load dispatch centre
LGBR	Load generation balance report
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MU	Million units
MVA	Mega volt ampere
MW	Megawatts
NABARD	National Bank for Agriculture and Rural Development
NAPCC	National Action Plan on Climate Change
NCEF	National Clean Energy Fund
NCE	Non-conventional energy
NLDC	National Load Dispatch Centre
NR	Northern region
NREDCAP	New and Renewable Energy Development Corporation of Andhra Pradesh Limited
NSM	National Solar Mission
OA	Open access
PE	Private equity
PGCIL	Power Grid Corporation of India Limited
PLF	Plant load factor
PPA	Power purchase agreement
PSH	Pumped storage hydro
PV	Photovoltaics
RE	Renewable energy
REC	Renewable energy certificate
REMC	Renewable energy management centre
RESCO	Renewable energy service company
RLDC	Regional load dispatch centre
RPO	Renewable purchase obligation
RTO	Regional transport office
RTS	Rooftop solar
SECI	Solar Energy Corporation of India
SERC	State Electricity Regulatory Commission
SLDC	State Load Dispatch Centre
SMES	Superconducting magnetic energy storage

Abbreviation	Definition
SPV	Solar photovoltaic
SR	Southern region
SRLDC	Southern Regional Load Dispatch Centre
T&D	Transmission and distribution
TPDDL	Tata Power Delhi Distribution Limited
UHVDC	Ultra high voltage direct current
UDAY	Ujwal DISCOM Assurance Yojana
USD	United States dollar
VAT	Value Added Tax
VGF	Viability gap funding
WTG	Wind turbine generator
WR	Western region
WRLDC	Western Regional Load Dispatch Centre

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With 66 offices, including nine Centres of Excellence in India and nine overseas offices in Australia, Bahrain, China, Egypt, France, Germany, Singapore, UK and USA, as well as institutional partnerships with 320 counterpart organisations in 106 countries, CII serves as a reference point for Indian industry and the international business community.

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VB/August2017-10532