Confederation of Indian Industry

Energizing South 2016

Smart–Reliable–Sustainable power

Theme paper

22–23 August 2016, Bengaluru

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Preamble

In the context of current power scenario in India, a lot of efforts are being taken by the Government and industries to meet the current and future demand. The Hon'ble Prime Minister of India Shri Narendra Modi during RE-Invest 2015[1] mentioned that India need to add solar, wind and biogas power apart from thermal, gas, hydro and nuclear power.

The government of India has initiated a radical transformation of the coal mining, renewable energy, power generation, transmission and distribution sectors. Hon'ble Minister of State with Independent Charge for Power, Coal, New and Renewable Energy and Mines in the Government of India Shri Piyush Goyal has set extremely ambitious targets in regard to increasing Indian energy supply, including adding 175 GW of renewable energy installation by 2022, a 50 bn USD modernisation of the electricity grid and a target that would increase India's domestic coal production to an estimated 1,500 mtpa.

The southern states have a commendable share in the national power agenda in terms of generation and consumption. While share of renewables need to be enhanced, conventional power will be the dominant source of power and we have to look at ways to make this source sustainable and clean. Therefore, an efficient mix of the conventional and renewable power has to be brought to meet the current and future power requirements and thereby supporting our industrial, economic and social growth.

In line with power and renewable agenda of the Government of India, CII is organizing "Energizing South 2016", a two day conference and exposition on "Smart–Reliable–Sustainable power" on 22–23 August 2016 at Bengaluru, Karnataka. This conference will serve as an ideal platform for participants to gain a strong understanding on how the power scenario will be in the near future, challenges to be addressed, opportunities for the industries and the role of various stakeholders.

1 India's 1st Renewable Energy Global Investors meet held during 15 – 17 Feb 2015 in New Delhi

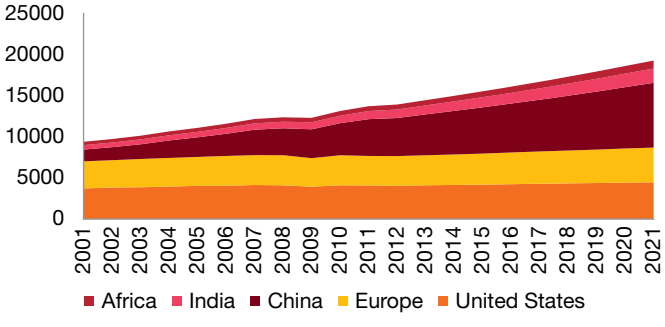
Energy market outlook – clean energy playing a vital role

The global power sector is responsible for 40% of all carbon dioxide emissions from burning fossil fuels and about 25% of total greenhouse gas emissions. Global carbon dioxide emissions have increased by 2.4 times during the last 40 years and emissions in Asia Pacific have grown sevenfold in the same duration. Options to cut down on emissions are energy efficiency, switching to cleaner fuels such as gas and capacity addition through RE sources. Regions across the globe have acted swiftly in response to the global concerns on energy security and global warming, and have achieved a renewable capacity of 785 GW[2] by the end of 2015 (excluding hydro).

India saw 12.9 billion USD invested in renewables over the last three years and the share of renewables, excluding hydropower, in India's energy mix reached 5.7% as of February in 2016 up from 4.97% in 2012–13.

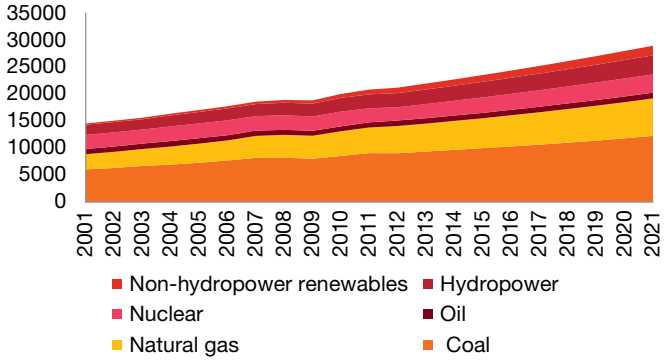
Electricity demand is stable in developed markets such as the US and Europe. Mobilised economies such as India and China are the primary drivers of global capacity additions, with a 6% annual growth rate in power consumption. Electricity consumption in Africa will continue to grow at around 5% till 2021. Coal was the most dominant fuel source with a 42% market share in 2015 and will continue as the primary fuel source in developing markets for power generation. Oil had a market share of 4% as fuel source in 2015. Power generation from renewable sources (non-hydro) has grown by around sixfold in the last fifteen years. Despite this sharp growth, renewables constitute only 5% of global electricity generation.

Electricity generation by region (billion kWh)



Source: EIA

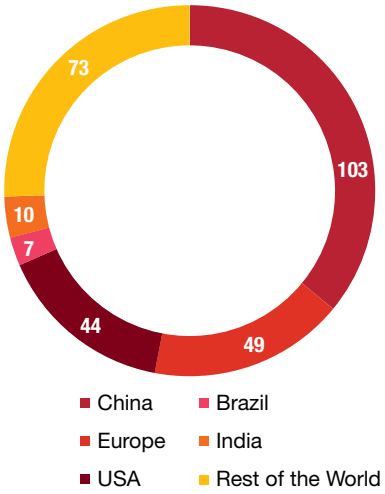
Electricity generation by fuel source (billion kWh)



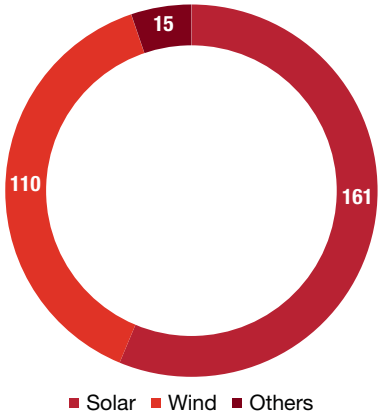
2 REN 21 – Renewables 2016 global status report http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

In 2015, for the first time, investment in RE in developing countries was higher than that in developed economies. The renewable industry attracted investments worth 285.9 billion USD in 2015.[3] The share of global investment in developing countries has increased from 131.5 billion USD (49%) in 2014 to 155.9 billion USD (55%) in 2015, while developed countries made investments to the tune of 130 billion USD in 2015. China invested 102.9 billion USD in RE, while US was a distant second with investments worth 44.1 billion USD.[4]

Region-wise investment in RE, 2015(in billion USD)



Source-wise investment in RE, 2015 (in billion USD)

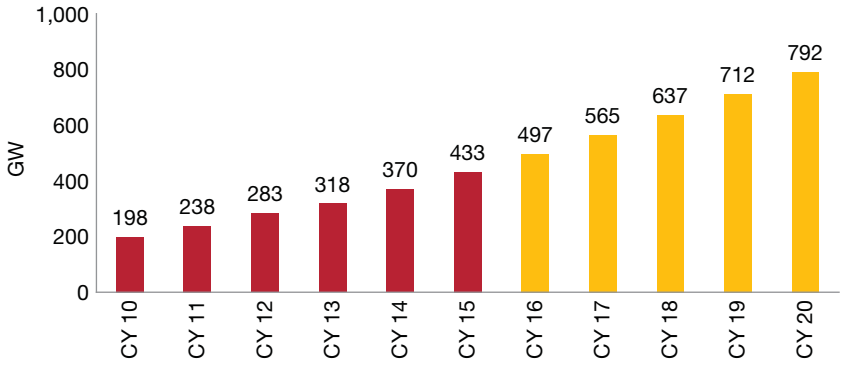


Source: EIA

Wind power

Wind has dominated the renewable growth story by increasing its capacity from 39 GW in 2005 to 433 GW by the end of 2015. The global wind sector has grown at a CAGR of 22% over the last year.[5] With a 5.8%[6] share in global wind installed capacity, India stands fourth after surpassing Spain and stands after China, the US, and Germany in terms of cumulative installations. In its annual market report 'Global Energy Outlook 2015', the GWEC indicated that the wind growth story is going to continue to be driven by global awareness of climate-friendly energy resources, decreasing cost of generation, and existing market stability in the US. China is the biggest wind market in the world with 34% of the installed capacity, followed by the US, which is the second biggest wind market (17% of the total installed capacity). But with the recent phasing out of production tax credit, the US wind industry now embarks on its longest-ever period of stability and the potential implications of this go far beyond the US market—in terms of company strategies, manufacturing location choices and development of the supply chain, as per the GWEC report. Based on these market drivers, the forecast for the next five years (calendar years) is as follows:

Global wind capacity: Present and future



Source: Global Energy Outlook 2015, GWEC, 2015

The GWEC forecast suggests a steady growth in wind capacity over the next five years at a CAGR above 13% as compared with a CAGR of 17% historically over the last five years. According to the study, cumulative wind capacity is assumed to grow from current 432.9 GW to 792 GW by the end of 2020.

3 REN 21 – Renewables 2016 global status report. Retrieved from http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

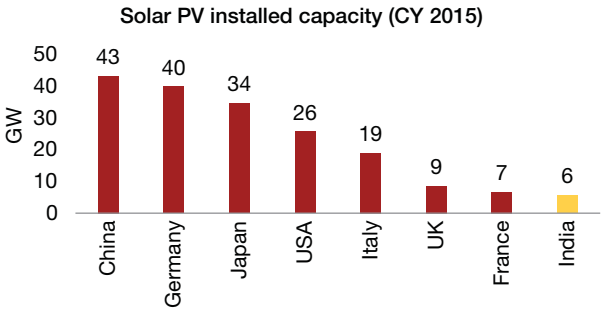
4 United Nations Environment Programme: Global Trend in Renewable Energy Investment 2016. Retrieved from http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2016lowres_0.pdf

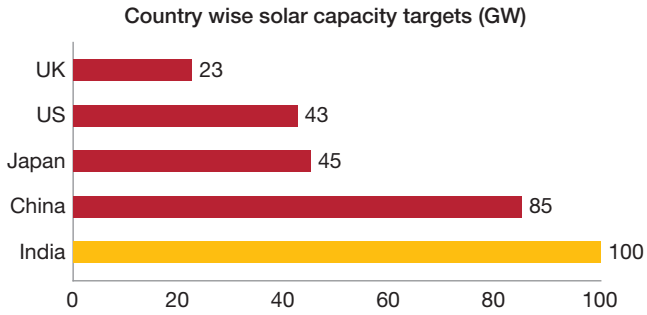
5 Global Wind Energy Outlook 2015, GWEC. Retrieved from http://www.gwec.net/publications/global-wind-report-2/

6 REN 21 – Renewables 2016 global status report. Retrieved from http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

Solar power

Globally, new solar capacity addition grew by 59 GW in 2015, with y-o-y growth of 25%. Led by China and Japan, Asian countries dominated the global solar landscape, representing about 59% of the global PV market in 2015.[7] India added more than 2 GW capacity in 2015 to reach a cumulative capacity of 5.6 GW by the end of the year. This allowed India to rise to the eighth position in terms of total installed capacity repetition as of 31 December 2015. The solar market in the Americas also continued to grow with the USA, with Canada and Chile leading the pace. However, Europe, which had previously led the way for the solar industry globally, has seen growth stall in recent times because of the pull back of the FiTs.





Source: Snapshot of global photovoltaic market, IEA; market news – Aug 2015[8]

In 2016, about 65 GW of solar capacity is expected to be added globally. Asian countries such as China, Japan and India are expected to be in the top five countries. China is expected to continue leading the global PV market while the US is set to overtake Japan as one of the largest solar market, exceeding the much-anticipated 10-GW mark. India is expected to be a major contributor in capacity addition along with European solar markets such as the UK, Germany and France, with expected new capacity addition of 12 GW in 2016.[9] Countries are revising their national targets upwards, with India setting a 100 GW solar capacity target by 2022.

7 Snapshot of Global Photovoltaic Market (December 2015), IEA. Retrieved from http://www.iea-pvps.org/fileadmin/dam/public/report/PICS/IEA-PVPS_-__A_Snapshot_of_Global_PV_-_1992-2015_-_Final_2_02.pdf

8 Snapshot of Global Photovoltaic Market (December 2015), IEA. Retrieved from http://www.iea-pvps.org/fileadmin/dam/public/report/PICS/IEA-PVPS_-__A_Snapshot_of_Global_PV_-_1992-2015_-_Final_2_02.pdf

9 Solar capacity addition plans by MNRE, Clean Technical, March 2016. Retrieved from http://www.mnre.gov.in/

Hydro power

Approximately 28 GW of new hydropower capacity (excluding pumped storage) was commissioned in 2015, increasing the total global capacity to about 1,064 GW. Persistent droughts continued to adversely affect hydropower output in many regions, including the Americas and Southeast Asia. China's domestic market continued to contract, but the country retained the global lead by a wide margin, with 16 GW added. Significant capacity was also added in Brazil, Turkey, India, Vietnam, Malaysia, Canada, Colombia and Lao PDR. Modernisation, retrofits and expansion of existing facilities continued in many markets, improving efficiency, flexibility and system resilience.

Biomass power

Bioenergy production continued to increase in 2015. However, the sector also faced a number of challenges, in particular from low oil prices and policy uncertainty in some markets. Bio-heat production for buildings and industrial uses grew slowly in 2015, with modern uses of bio-heat rising by approximately 3% from 2014 levels. There has been marked growth in the use of biomass for district heating in the Baltic and Eastern European regions. Further, the use of biopower has increased more quickly—averaging some 8% annually—with rapid growth in generation, notably in China, Japan, Germany and the United Kingdom. Ethanol production increased by 4% globally, with record production levels in the United States and Brazil.

Geothermal and ocean power

About 315 MW of new geothermal power capacity came online in 2015, bringing the global total to 13.2 GW. Low fossil fuel prices, coupled with a perpetually high project development risk, created unfavourable conditions for geothermal power. Turkey led the market, commanding about half of new global capacity additions, and 1.2 GWth was added in 2015 for a total capacity of 21.7 GWth. Ocean energy capacity, mostly tidal power, remained at about 530 MW in 2015. The year presented a mixture of tail- and headwinds for the ocean energy industry. A number of companies continued to successfully advance their technologies and deployed new or improved devices, mostly in European waters.

Nuclear power

Fifty-six countries operate about 240 civil research reactors, with over one-third of these in developing countries. The nuclear energy sector faced an investment setback after the March 2011 Fukushima Daiichi nuclear disaster. Nevertheless, nuclear power provided about 11% of the world's electricity and 21% of the electricity in OECD countries as on Dec 2015.[10] Today, there are some 440 nuclear power reactors operating in 31 countries with a combined capacity of over 386 GWe.[11] France leads this sector with 76% of its installed generation coming from nuclear plants totalling 63 GW capacity. It is expected that installed nuclear capacity growth will be 60%, reaching 543 GWe in 2030 and 624 GWe in 2040 out of a total of 10,700 GWe, with the increase concentrated heavily in China (46%), India, Korea and Russia (together accounting for 30%) and the US (16%), countered by a 10% drop in the EU.[12] Over 45 countries are actively considering embarking upon nuclear power programmes. About 65 more reactors are under construction. The front runners are the UAE, Turkey, Vietnam, Belarus, and Poland. In all, over 160 power reactors with a total net capacity of some 1, 82,000 MWe are planned and over 300 more are proposed. Significant capacity is being created by plant upgradation also despite a few shutdowns. India's target is to have 14.5 GWe total installed nuclear capacity by 2020.

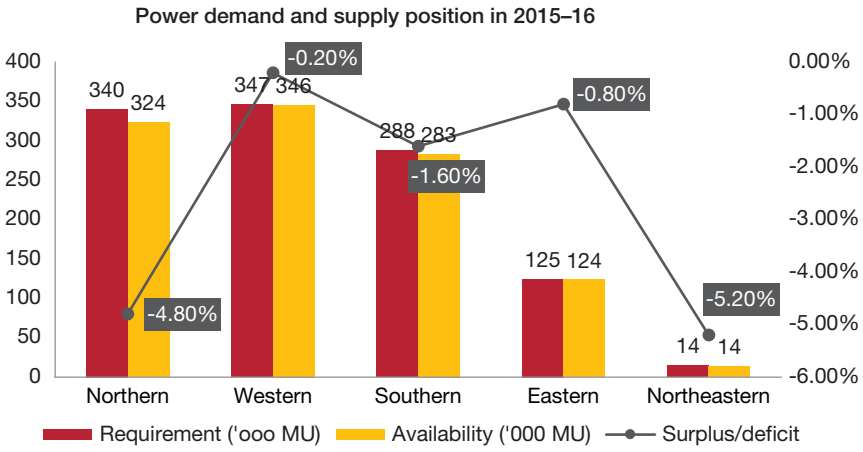
10 http://nis2016.org/wp-content/uploads/2016/02/world_energy_needs_and_nuclear_power.pdf
11 https://www.iaea.org/PRIS/WorldStatistics/NuclearShareofElectricityGeneration.aspx
12 http://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx#ECSArticleLink1

Dynamics of power supply and demand: getting prepared to meet price elasticity

The assessment of gross energy generation in the country during the year 2016–17 has been carried-out by the CEA taking into consideration the past performance of the thermal plants, their vintage and maintenance schedule of the generating units during the year, likely partial and forced outages and availability of fuel, etc.

Power supply position in FY 2016

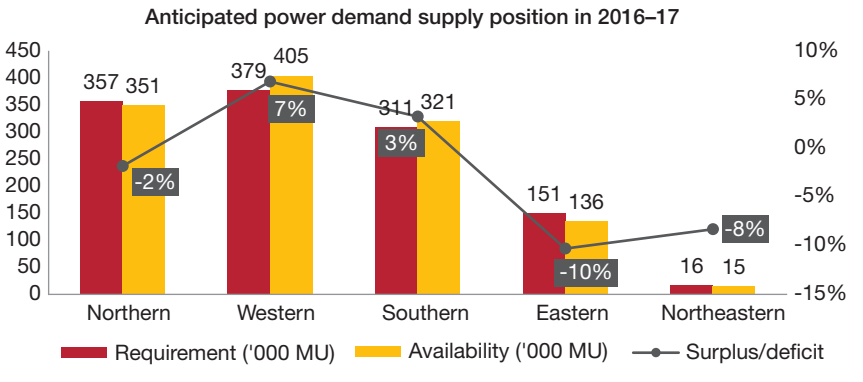
During FY 2016, the total ex-bus energy availability increased by 5.8% over the previous year and the peak met increased by 5.2%. The energy requirement registered a growth of 4.3% during the year against the projected growth of 8.7% and peak demand registered a growth of 3.5% against the projected growth of 5.9%. Overall, the energy shortage during the year was 2.1%.



Source: LGBR 2015-16

Anticipated demand supply scenario for FY 2017

During FY 2017, there could be an anticipated energy surplus of 1.1% and peak surplus of 2.6%. In the southern region, the energy surplus is expected to be 3.3%. The annual energy requirement and availability and peak demand and peak availability in the country vs the southern region is shown in the graph shown here.



Source: LGBR 2015–16

Key demand drivers

South India has seen a downward trend in both energy and peak deficits. Lower deficits are both on account of increased supply additions and conservative demand growth (owing to curtailed demand).

Some of the reasons for lower demand growth are:

- States preferring load curtailment over power purchases owing to financial health of the state utilities (under-recovery of costs, unrealised subsidy payments)
- Lack of sufficient transmission infrastructure (between the Northern, Eastern and Western grid and the Southern grid)
- Lower economic growth

However, macroeconomic factors indicate an increased industrial demand in the near future.

Supply planning covering capacity additions plans

Telangana: TSGENCO is planning significant investments to the tune of 6,840 MW to take the installed capacity for the state to 22,408 MW by end of FY 2019.

Andhra Pradesh: Andhra Pradesh state is planning to add 7,749 MW of conventional power in the period of FY 2015–19, while at the same time, it plans to add 9,180 MW of non-conventional energy. The likely installed capacity from all sources (existing and upcoming) by FY 2019 is 13,264 MW.

Karnataka: Karnataka plans to take its installed capacity to 25,193 MW from the current 17,324 MW by 2018–19, i.e. a planned addition of 9,277 MW during FY 2015 to FY 2019.

Tamil Nadu: In its vision 2023 document, Tamil Nadu profiles projects for the setting up of an additional 20,000 MW of power generating capacity.

Kerala: As per the generation plan of Kerala, capacity of around 2,332 MW is expected to be added by FY 2019. Out of this, 822 MW shall be added through non-conventional energy sources and the balance 1,510 MW through conventional sources. As such, the total available capacity by FY 2019 is expected to be about 6,745 MW.

Power evacuation and transmission plan

Telangana: To facilitate drawal of power by Telangana and to meet the projected peak load of 19,053 MW by 2019, a robust ISTS has been planned and is under construction. Further, for evacuation of power from state-generating stations as well as for transfer to various load centres within Telangana, an intra-state transmission network has been developed and planned.

- 17 nos. of 400 kV grid substations and 4,308 ckt km of associated lines are planned/ under construction
- 35 nos. of 220 kV substation and 1,990 ckt km of associated lines are planned/under construction
- 92 nos. of 132 kV substation and 2,508 ckt km of associated lines are planned/under construction.

Andhra Pradesh: To cater to the growing demand of Andhra Pradesh by FY 2019, a number of inter-state transmission schemes are under various stages of implementation. Further, new transmission schemes have been identified/planned under ISTS to cater to the future load growth in the state and the southern region as a whole. The planned augmentations include 765 kV high capacity interregional links as well as 765 kV high capacity corridors within the southern region passing through AP, which shall facilitate drawal of power through the ISTS network.

Karnataka: The total transmission capacity for Karnataka is planned to be enhanced from 10,725 MVA to 16,595 MVA, an increase of 54% in the same period, which is sufficient to meet the demand. There are two lines of 765 kV under construction by the PGCIL for wheeling power into the state from upcoming generation projects and for strengthening inter-state transmission capacity. In addition to the above, PGCIL has also planned to strengthen connectivity to the state at the 400 kV level, with additional lines of 342 ckt km planned till FY 2019.

Kerala: The present ISTS system capacity of PGCIL at the 400/220 kV level is 2,205 MVA and it would be increased to 3,150 MVA by FY 2019 after implementation of ongoing schemes. In addition to this, the existing transformation capacity at the 400/220 kV level of the KSEBL system is 945 MVA, and it will be increased to 3,205 MVA by FY 2019 after new addition and augmentation of substations.

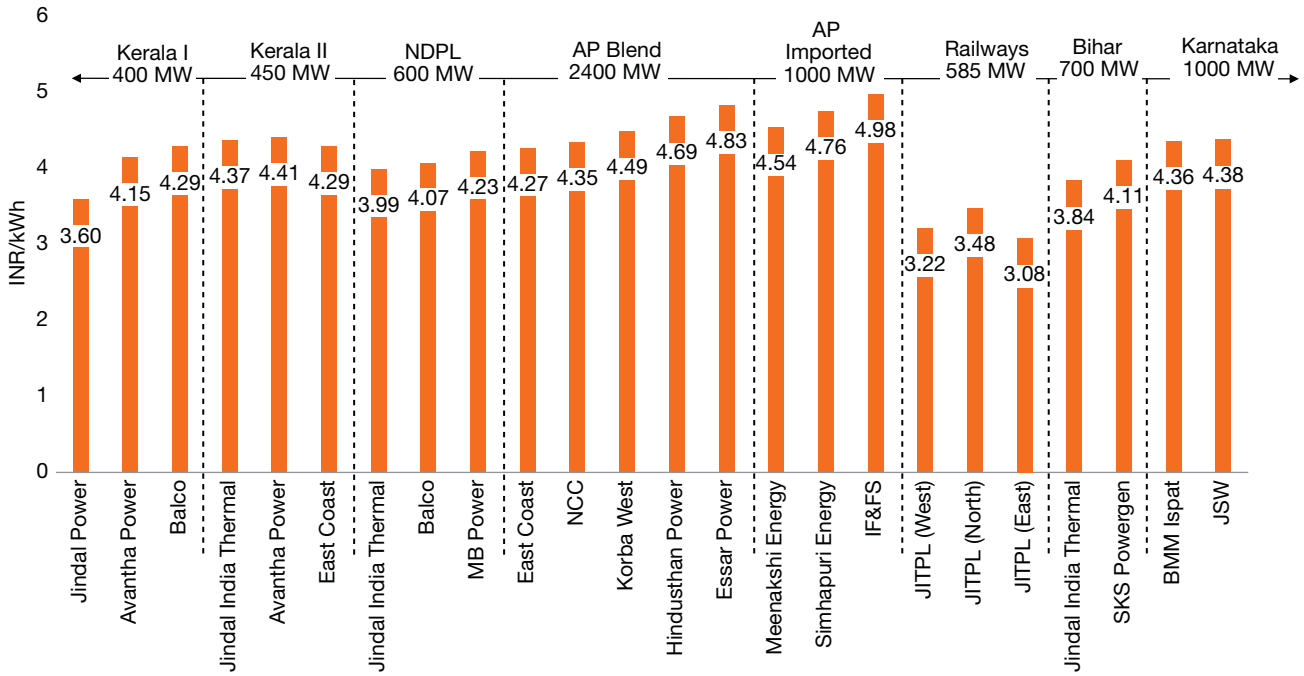
Tamil Nadu: TANTRANSCO has planned to develop the transmission infrastructure to effectively evacuate power from the existing and new power stations. Tamil Nadu has devised separate transmission schemes for wind power evacuation and for the effective utilisation of interstate power, establishment of a 400 kV substation at Thiruvalam, along with associated transmission lines from Thiruvalam to Mettur Thermal Power Station Stage-III and a 400 kV substation at Alamathy with a 696 circuit km associated transmission line at an estimated cost of 993.43 crore INR under progress.

Power tariff trends

The cost of power procured by distribution utilities from existing power generation contracts, largely fossil fuel based projects, has increased over the years as the costs of fuel, transportation, maintenance spares and labour cost have risen.

The costs of contracting new long-term capacity have also increased in recent years, with a few occasional exceptions. This is because investors have started factoring in construction and fuel supply risks. Further, under the new DBFOO model, fuel price increases are directly passed to the procurers, in contrast to the past, when generators exercised that option based on their fuel supply contracts.

Trend of DBFOO tariff (INR/kWh) over the last 2 years



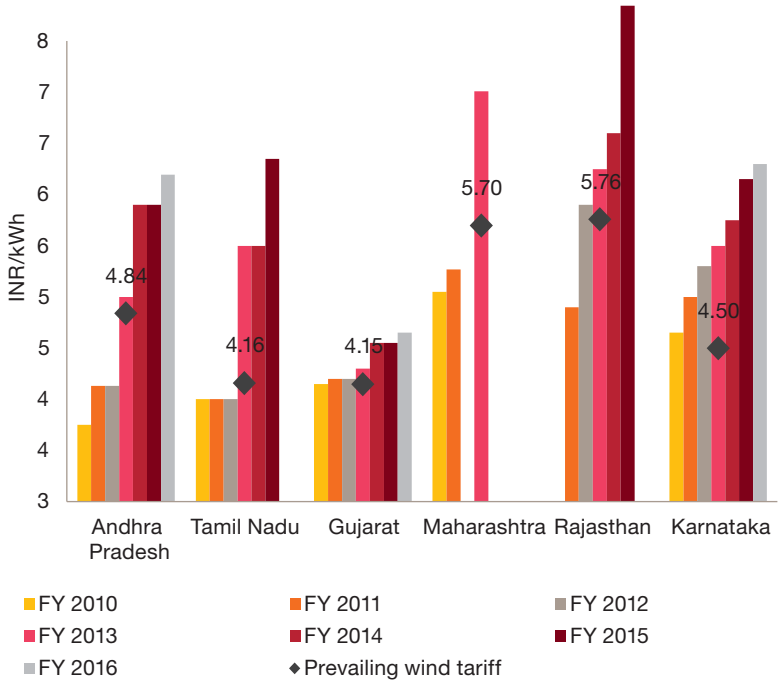
Thermal Powertech (only one qualified after RfQ stage of DBFOO) will be supplying 570 MW to Telangana state at INR 4.15/kWh for a period of 8 years

Source: PwC analysis

The higher power procurement costs are disproportionately borne by large commercial and industrial consumers on account of cross-subsidies. This means that large users see RE as a cheaper energy source, and in states with renewable energy potential, several have set up their own captive facilities or have entered into open access contracts. This is advantageous for RE generators too, as it offers higher realisation and better tariffs than FiT.

RE generators, it must be noted, incur additional costs on open access supply in the form of wheeling charges, imbalance levy and, in many cases, a cross-subsidy surcharge. However, if such arrangements are structured right, it is possible to contract at non-regulated prices that offer generators a better margin and the consumer-buyer, a lower cost.

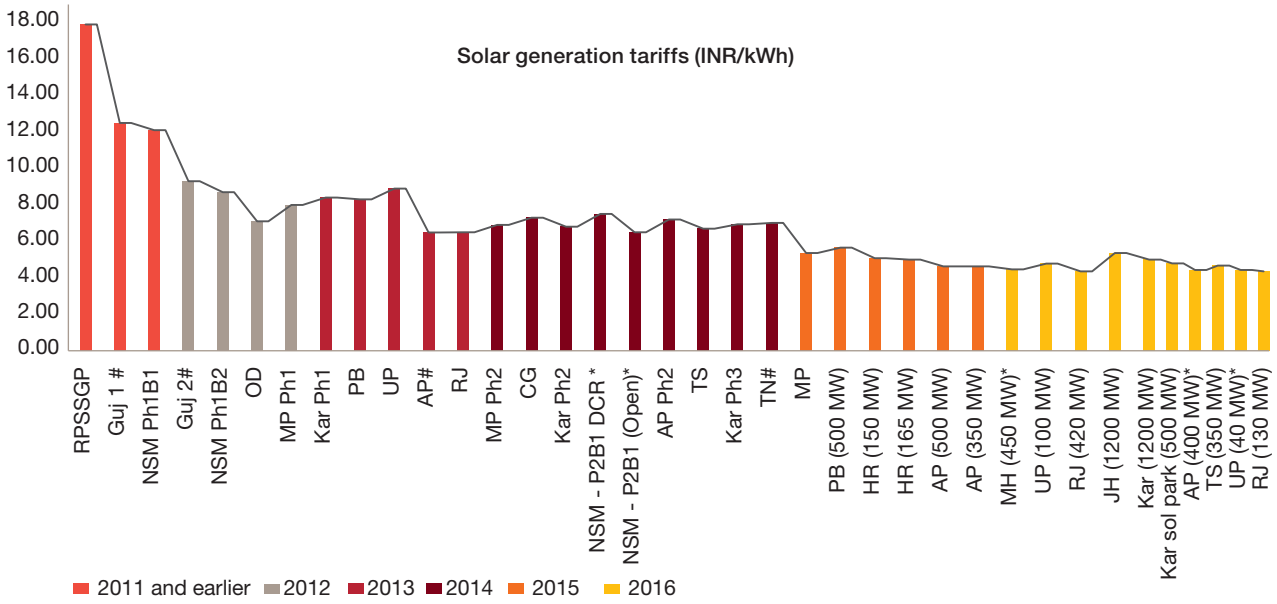
Increasing trend of industrial tariff and reducing tariffs for renewable power (INR/kWh)



Source: PwC analysis

The cost of buying electricity from DISCOMs has increased for both industrial and commercial consumers in key states. In contrast, RE tariffs have declined in recent times, with a fall in technology costs and improvement in the capacity utilisation factor. For example, NSM bids conducted in 2015–16 witnessed solar power tariffs ranging between 4.34–4.36 INR per kWh for the 420 MW programme capacity in Rajasthan.

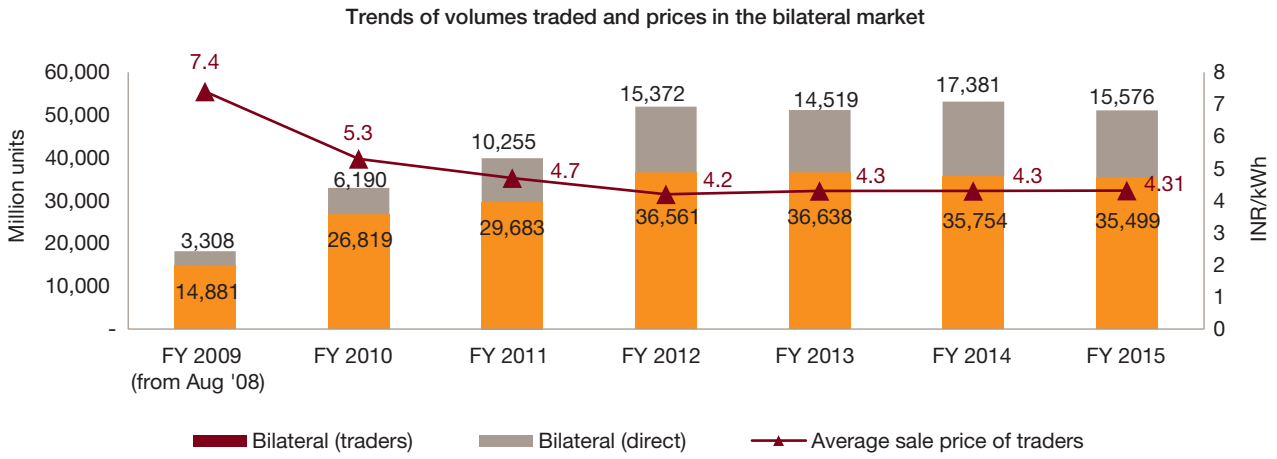
Similarly, the SERC's proposed tariffs for wind power reflect change in capital costs in line with the market developments. These tariffs are comparable to the initial tariffs of long term base load new generation capacity that distribution utilities potentially contract, and are below the scheduled tariffs that large energy users must pay to utilities, thus reflecting a changing economics for RE projects.



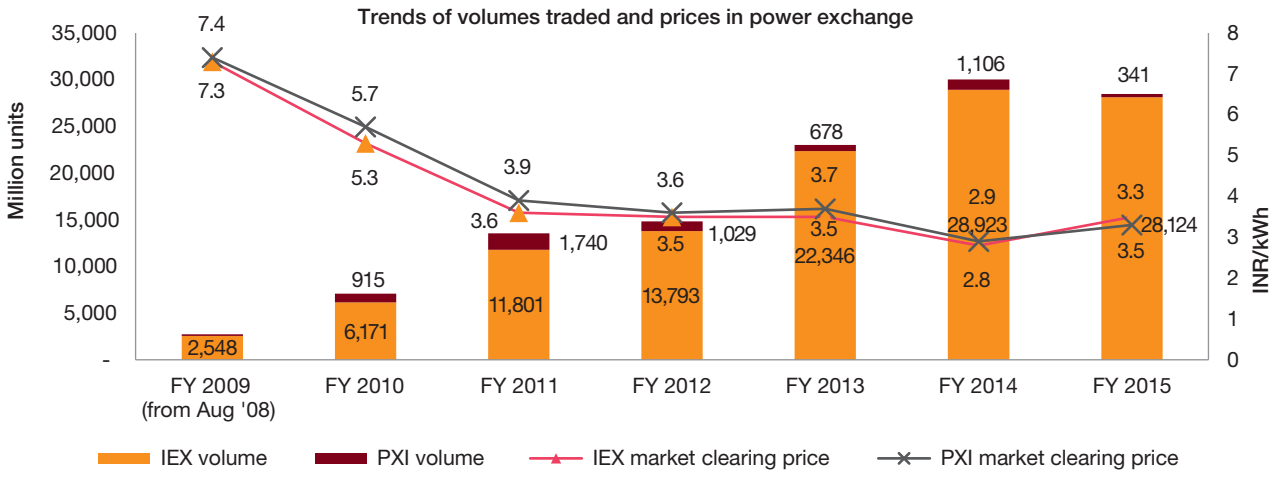
Source: PwC analysis

Trading through exchange, an option for both state utility and eligible consumers

The initial period of exchange was marked by infrequent trading activity with a high degree of price volatility. However, over a period of time, with a higher number of players and higher volumes being traded, the price volatility has reduced. This can be attributed to factors such as greater participation and relative increase in the supply compared to the past. The graphs below show the price movement over the past few years.



Source: CERC Market Monitoring Reports



Source: CERC Market Monitoring Reports

As observed from the above graphs, the decreasing trend in tariffs discovered on trading exchanges is indicative of the fact that distribution utilities can increase their reliance on short-term power where long-term assured sources are not available. In certain states such as Kerala, where the own generation portfolio is primarily dependent on hydro and diesel plants (fuel cost in the range of 9–12 INR/kWh), short-term power contributes towards a significant portion of the power purchase.

It can be seen that there have been a changing tariff determination mechanism in India for all the sources of generation. In thermal power, and solar power we have already moved to competitive bidding in line with the section 63 (determination of tariff by bidding process) of The Electricity Act, 2003 and such tariffs will be determined by the market forces. The Central Government has already issued detailed guidelines for tariff based bidding process for procurement of electricity by distribution licensees in line with the clause 5.1 of the National Tariff Policy dated 28 January 2016. Recently, MoP has issued a notification sanctioning the scheme for setting up of 1,000 MW CTU connected wind power projects vide notification no. F. No. 53/14/2016-WE dated 14 June 2016.

Southern state initiatives starting to enable power sectors grow including renewables in a large way

In focus: Andhra Pradesh

Vision of the power sector[13]

The government of Andhra Pradesh in its Sunrise Andhra Pradesh Vision 2029 has sets two primary targets in the energy sector for increasing the per capita power consumption to 3,600 kWh and installed capacity of renewable energy to the tune of 29 GW.

Power sector at a glance

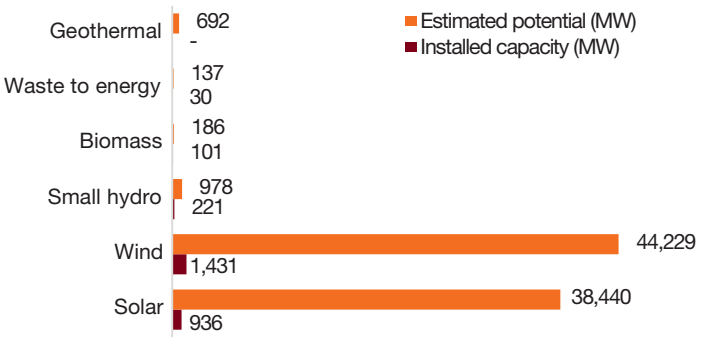
The state has an installed capacity of 15.3 GW,[14] with the private sector contributing to more than 55%[15] of the total capacity with an installed capacity to the tune of 8.54 GW.

The state has a 1,01,035[16] circuit km long transmission network along with a distribution network with a 2,14,844 circuit km of high tension distribution lines and 2,95,550 circuit km of low tension distribution lines respectively. Currently, the state is serving electricity to 16[17] million consumers.

Future growth of renewable energy

Andhra Pradesh being a new state is facilitating the expansion of its economy by providing a conducive policy framework, infrastructure, and power in order to attract larger investments. The state is blessed with all forms of energy, including solar, wind, biomass, biogas, bioenergy, waste to energy, mini hydel, and geothermal with a significant potential. Andhra Pradesh receives global solar radiation in the range of 4.00–6.50[18] kWh/m², with around 300 clear sunny days in a year.

The installed capacity vis-à-vis the estimated potential for all forms of energy is represented here.



Source: MNRE and PwC analysis

Transmission planning for the future

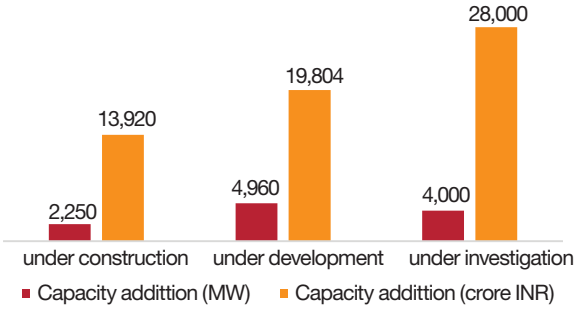
The state transmission utility has planned significant investments for FY 2017 of 2,430 crore INR, 1,246 crore INR for FY 2018 and 1,071 crore INR for FY 2019. The above capital investment includes strengthening of 400 kV and 230 kV substations, including renovation and modernisation improvement schemes, lift irrigation schemes, and telecom works.

13 www.apvision.ap.gov.in
14 As on 30 June 2016, CEA
15 As on 30 June 2016, CEA
16 APTRANSCO
17 APTRANSCO
18 NREDCAP

Ease of doing business in Andhra Pradesh

Shelf of projects in conventional power

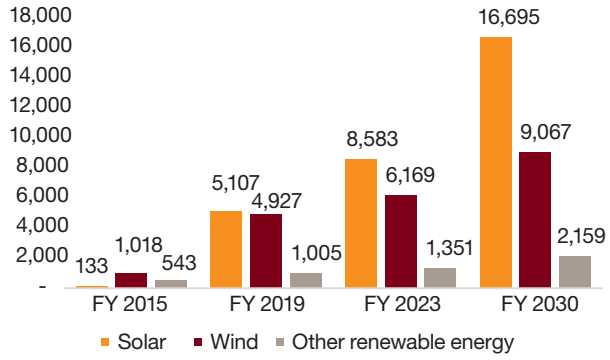
APGENCO has taken up a gigantic capacity addition to add 11,210 MW at an estimate cost of 66,538 crore INR. The status of implementation of various projects are mentioned below:



Source: APGENCO

Shelf of projects in non-conventional power

Taking up a target of over 30% renewable share among total energy consumption by 2029, the government of Andhra Pradesh plans to supply 56,700 million units annually by 2029 through an installed capacity shown below:



Source: Government of Andhra Pradesh

Policy, regulatory and statutory regime

The prevailing FiT determined by APERC for renewable projects are mentioned below:

Particulars	FiT (INR/kWh)
Solar rooftop	No payment for excess energy through net metering
Wind	4.84 (without AD benefit) 4.25 (with AD benefit)
Small hydro	Ranging from 2.69 to 1.92 for a period of 10 years
Biomass	2.85

The various initiatives taken by the authorities to encourage the developers are mentioned below:

- For solar projects, the wheeling and transmission charges are exempted for captive/group captive use within the state. They will be charged as applicable for a third-party sale. The transmission and distribution losses, however, are fully applicable for both third party within the state as well as captive use within the state.
- All solar power developers and wind power developers shall be awarded must-run status, and banking of 100% of energy shall be permitted for all captive and open access/scheduled consumers during the 12 months of the year. Banking charges shall be adjusted in kind at the rate of 2% of the energy delivered at the point of drawal.
- It is pertinent to mention that the wind power developers and solar power developers, being a part of green energy, will be given required clearances under pollution control laws within a week's time by the state pollution board control.

- The bagasse-based cogeneration power projects in Andhra Pradesh are eligible for MNRE capital subsidy ranging between 15–60 lakh INR/MW, with a maximum support of 8 crore INR per project as mentioned below:

Category	Capacity	
	Above 100 kW and up to 1,000 kW	Above 1 MW and up to 25 MW
Private sector	15 lakh INR/MW	For all projects
Cooperative/ public/joint sector	40 lakh INR/MW	40 bar and above
	50 lakh INR/ MW	60 bar and above
	60 lakh INR/MW	80 bar and above

- Central financial assistance for an amount of 40–50% of the total project cost subjected to a maximum of 1.5–3 crore INR/MW is being provided for the fast track implementation of waste to energy projects.
- The new small hydro power projects up to 25 MW capacity are eligible for MNRE financial support as mentioned below:[19]

Category	Capacity	
	Above 100 kW and up to 1,000 kW	Above 1 MW and up to 25 MW
Private sector, joint sector, Cooperative sector	12,000 INR/kW	1.20 crore INR for first MW + 20 lakh INR for each additional MW
The government department agencies, state electricity boards government department agencies, state electricity boards	25,000 INR/kW	2.50 crore INR for first MW + 40 lakh INR for each additional MW

Land acquisition

The developer shall initiate processes for allocation of land depending on type of land.

- Government land: The developer shall make an application to NREDCAP in the format as prescribed by the revenue department. Accordingly, NREDCAP shall forward its recommendation to deputy commissioner. Based on NREDCAP's recommendation, the land shall be allotted by the concerned district collector for advance possession to NREDCAP which shall in turn lease it to the developer for a period of 25 years.
- Forest land: The developer shall make an application to NREDCAP in the format as prescribed by the forest department. In case of forest land, 50% of the sanction fee has to be paid up front. Once the Stage I clearance has been accorded, it is the responsibility of the developer to fulfil all conditions, including compensatory measures as specified by the forest department. Further, the balance 50% of sanction fees shall be paid after the Stage I clearance and the agreement with NREDCAP shall now be signed. In case of rejection of the application during Stage I, 50% of the sanction fees collected by NREDCAP shall be returned within 10 working days.
- Private land: The developer shall acquire the land on their own and submit the non-agriculture status receipt to NREDCAP.

PPAs at the center of state's energy strategy

The creditworthiness of distribution utilities is good on account of the following factors:

- Low creditor days:
  - The distribution utilities have very low creditor days and have seen a decreasing trend.
  - Based on the discussions with private generators, we understand that distribution utilities pay within the due dates and in certain cases take early payment discount (payment before the due date, usually 30 days).
- Improving the financial situation:
  - Andhra Pradesh has seen a regular increase in retail tariffs, much better than most of the other states in the country.
  - On account of the bifurcation, distribution utilities have seen an increase in industrial consumers, which suggest a positive financial impact as they are a cross-subsidising category (i.e. tariff is higher than the cost of supply).
- Capital investments:
  - Regular investments have been made by the utilities to improve the operational performance of the distribution area.

Grid curtailments and connectivity to the network

- The power projects can be connected to suitable voltage levels subjected to the evacuation facilities available with the transmission and distribution utilities in line with the state regulations.

19 NREDCAP

- Metering shall be in compliance with the Central Electricity Authority (Installations and Operation of Meters) Regulations, 2006, grid code, metering code, and relevant regulations as issued by regulators.

RPO enforceability

- MoP[20] in consultation with MNRE has notified the revised RPO trajectory which will be applicable to all the states and union territories from FY 2017 till FY 2019, as mentioned below:

Sr. no.	FY 2017	FY 2018	FY 2019
Non solar	8.75%	9.50%	10.25%
Solar	2.75%	4.75%	6.75%
Total	**11.50%**	**14.25%**	**17.00%**

Single window clearance framework

- NREDCAP has introduced a single window clearance system which is aimed at creating an investor-friendly climate in Andhra Pradesh to facilitate speedy clearances for setting up solar or wind power plants. This aims to remove unnecessary hurdles that prevent investors from obtaining necessary sanctions for projects.
- This system provides a one-stop shop covering the complete cycle of setting up solar or wind power plants, starting from developer registration to registering a power project to obtaining a Feasibility and Estimation of Evacuation Report. It also has the provision to get necessary clearances for pre- and post-erection phase, i.e. commissioning of the project. All these clearance will be provided within a defined service level agreement period.
- To improve the effectiveness of the single window mechanism, an online system has been developed, which would enable real-time monitoring of various applications. The key functionalities of the system are as under:
  - The online system would function as the single point of contact, connecting the developer, NREDCAP, APTRANSCO and state distribution utilities.
  - The entire process is being followed by developers in engaging with APTRANSCO and state distribution utilities for integration into the online system with relevant workflows.
  - A checklist for submission of each request/ application of each activity would be available in the system.
  - Real-time monitoring and tracking of each project application by the developer and NREDCAP.
  - Timelines for completion of each key activity with exception reports.
  - Email alerts to developer and concerned activity owner on acceptance/rejection/delay in any activity.
- The nodal agency shall ensure timely processing of applications pertaining to APTRANSCO, state distribution utilities and CEIG. Statutory approvals other than those pertaining to the department of energy are not covered in the scope of the single window clearance facility, and the developer shall arrange all such clearances in his/her own interest. However, NREDCAP will extend necessary support for clearance of other statutory approvals also on a case- to-case basis.

20 Notification no. 23/3/2016-R&R dated 22 July 2016, MoP

In focus: Karnataka

Vision of the power sector

The government of Karnataka is committed to providing 24/7 power supply to all by the year 2020 in line with the following objectives:

- Committed to make Karnataka self-reliant
- Improving the efficiency of electricity companies
- Encouraging development of renewable energy
- Implementing energy conservation measures

Power sector at a glance

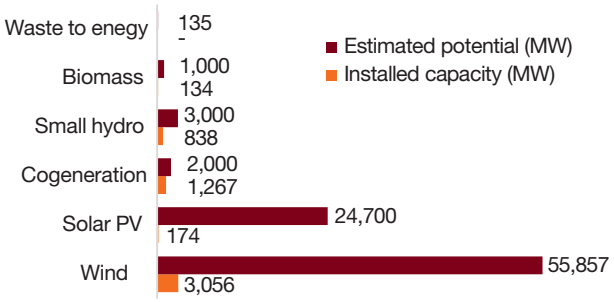
The state has an installed capacity of 17.32 GW,[21] having the largest installed capacity of hydropower to the tune of 3.6 GW[22] in the country. It is pertinent to mention that the private sector contributes to 41%[23] of the installed capacity, and has grown at a CAGR of 12%[24] in the last five financial years.

The state has a 43,022[25]-circuit-km-long transmission network along with a distribution network having 2,84,933 circuit km of high tension distribution lines and 5,16,032 circuit km of low tension distribution lines respectively. Currently, the state is serving electricity to 21 million consumers[26].

Future growth of renewable energy

Renewable energy contributes to 32%[27] of Karnataka's total generation, having an installed capacity of 5.50 GW[28] with the total potential exceeding 87 GW.[29] The energy potential for wind and solar is to the tune of 56 GW[30] and 24.7 GW[31] respectively. Also, it is pertinent to mention that Karnataka is having the highest potential of 7.9 GW[32] of pumped storage-based hydropower plants in southern India.

The installed capacity[33] vis-à-vis the estimated potential for all forms of energy, namely wind, solar PV, cogeneration, small hydro, biomass, and waste to energy represented below:



Source: MNRE and KREDL

Karnataka receives global solar radiation in the range of 3.8–6.4[34] kWh/m², making solar energy generation available across all seasons.

Karnataka is the first southern state to come up with its solar policy in July 2011 and the first state to set up

21 As on 30 June 2016, CEA
22 As on 30 June 2016, CEA
23 As on 30 June 2016, CEA
24 PwC analysis
25 KPTCL
26 KPTCL
27 CEA
28 KREDL
29 KREDL
30 At 100 m hub height;, (KREDL)
31 KREDL
32 CEA
33 As on Jul 2016, (KREDL)
34 KREDL

the largest utility scale solar power plant of capacity to the tune of 3 MW, operating since December 2009. Karnataka is implementing the world's largest solar park in Pavagada taluk of Tumakuru district for a total capacity to the tune of 2 GW,[35] which is expected to be commissioned in two phases; 1 GW by April 2017 and the remaining 1 GW by September 2017. Recently, Karnataka has conducted taluk-based bidding for implementation of solar power projects with a capacity of 1.2 GW across 60 taluks of Karnataka. In this bidding process, 1.10 GW solar projects were allotted to 26 bidders for an average winning tariff of 5.11 INR/kWh. Also, 500 MW solar power in the open category has been allotted to six developers selected through NTPC Ltd. as a part of JNNSM bundled power scheme for an average winning tariff of 4.79 INR/kWh.

Transmission planning for the future

KPTCL was awarded as the best transmission utility in the country by CBIP in the year 2016. It has invested in capital expenditure works for an amount to the tune of 27,350 million[36] INR in the last three financial years. The planned transmission capacity[37] are 20,230 MW, 21,505 MW and 22,270 MW at the end of financial year 2016–17, 2017–18, and 2018–19 respectively. It is pertinent to mention that the transmission and distribution network is covered under VSAT communication network and SCADA system. Also, it has set the ambitious target for reducing the transmission losses in the state to 3.27% in financial year 2018–19 from 3.66% in financial year 2014–15. Currently, the company is conducting extensive technical studies for determining the maximum penetration of renewable energy which can be integrated to the various voltage level of the transmission network.

35 KSPDCL
36 KPTCL
37 KPTCL
38 Without capital subsidy
39 With capital subsidy

Ease of doing business in Karnataka

Shelf of projects in conventional power

KPCL is planning to embark on development of 9,356 MW thermal projects through a mix of coal-based and gas-based power plants with a total capital investment layout to the tune of 59,730 crore INR within the next 10 years, in line with the vision 2025 of KPCL. Further, implementation of 4,326 MW conventional power projects are under various stages of development. It is pertinent to mention that such projects will be developed by KPCL, NTPC Ltd. (Kudgi), DVC, and central allocation for capacities up to 2,300 MW, 1,200 MW, 450 MW, and 376 MW respectively. The government of Karnataka is contemplating to encourage interested investors to establish a gas-based merchant power plant alongside the existing Dabhol-Bengaluru Gail gas pipelines.

Shelf of projects in non-conventional power

At present, Karnataka has allotted renewable energy capacities up to 22.20 GW and commissioned capacities up to 5.50 GW. MNRE has revised the target for Karnataka to develop 6,000 MW solar projects to be implemented in a phased manner by 2021, of which 2,400 MW is expected to be implemented through rooftop projects and the remaining 3,600 MW through ground mount projects. Further, Karnataka is planning to implement the remaining capacities of 1.50 GW in the Pavagada solar park through NTPC Ltd., SECI, and any other public sector unit or government agency. Also, tenders will be invited for capacities up to 1 GW under the VGF scheme to be implemented through distributed generation with minimum capacity of 10 MW in each location. It is pertinent to mention that the energy sector witnessed the signing of 23 MoUs pertaining to non-conventional energy with a yield of 71,728 crore INR, a potential to create 8,940 employment opportunities.

Policy, regulatory and statutory regime

The prevailing feed-in tariff determined by KERC for renewable projects are mentioned below:

Particulars	Feed-in tariff (INR/kWh)
Solar (1–3) MW	8.40
Solar	6.51
Rooftop solar	(5.20–7.08) (4.43–6.03)
Wind	4.50
Small hydro	4.16
Biomass	5.19
Cogeneration	4.83

The various initiatives taken by the authorities to encourage the developers are mentioned below:

- For solar projects:
  - The government of Karnataka has formulated an industry-friendly policy for the projects commissioned before 31 March 2018 to avail the exemption in paying any open access charges for a period of 10 years from the commercial operation date.
  - The developers are exempted from obtaining clearances by the state pollution control board for project capacities up to 5 MW.
  - Developers can avail tax concessions in respect of entry tax, stamp duty, and registration as per Industrial policy of the state.
  - VAT applicable to panels and inverters has been exempted.
  - Concessional excise duty and customs duty exemptions are allowed to developers in line with the guidelines issued by MNRE.
- For wind and small hydro projects,
  - Simplification of land acquisition and conversion process.
  - Expedition of forest clearances and industrial status to such power projects.
- For biomass and cogeneration projects,
  - Exemption under central excise duty
  - Provision of tax holiday period
  - Exemption under customs duty
  - VAT reimbursement up to 50%.

The government of Karnataka is actively involved in encouraging investors through development of solar parks, grid tied canal corridor projects, and solar powered irrigation pumpset through the Surya Raitha scheme. A new policy and regulation was notified for promoting gross metering projects to be implemented for consumers falling under domestic, hospital and educational institutions to harness the rooftop potential. Also, a new policy and regulation is underway to determine the tariff for hybrid energy with a combination of solar and wind. In order to encourage innovation, the government of Karnataka has established the Energy Centre of Excellence and Incubation Centre and Technology Innovation Centre.

Land acquisition

- The government of Karnataka simplified the land acquisition process by amending section 95 of the Karnataka Land Revenue Act, 1964, to facilitate deemed conversion of land, and section 109 of the Karnataka Land Reforms Act, 1961, for development of solar projects.
- In view of the above, solar developers can start project execution without waiting for formal approval on filing an application for conversion from agriculture land to non-agriculture land for setting up solar power projects on payment of conversion charges to the respective authority.

PPAs at the center of state's energy strategy

- PCKL facilitated the long-term PPAs with distribution utilities of Karnataka for capacities up to 17,358 MW since its inception. Such shares are allocated from the central sector, state sector, joint venture projects and IPPs, which includes 14,044 MW capacity additions in the state.
- The distribution utilities of Karnataka were allotted with capacities up to 22.20 GW renewable energy till July 2016.
- The government of Karnataka ensures signing of 100% PPAs for waste to energy projects in line with the new National Tariff Policy, 2016.

Grid curtailments and connectivity to the network

- The power projects can be connected to suitable voltage levels subjected to the evacuation facilities available with the transmission and distribution utilities in line with the state regulations.
- The government of Karnataka ensures time bound clearance for evacuation approval from transmission and distribution utilities along with securing the wheeling and banking agreement.
- The solar policy has made provisions for reduction of supervision charges from 10–5%.
- Metering shall be in compliance with the Central Electricity Authority (Installations and Operation of Meters) Regulations, 2006, grid code, metering code, and relevant regulations as issued by regulators.

RPO enforceability

- MoP[40] in consultation with MNRE has notified the revised RPO trajectory, which will be applicable to all the states and union territories from FY 2017 till FY 2019, as mentioned below:

Sr. no.	FY 2017	FY 2018	FY 2019
Non solar	8.75%	9.50%	10.25%
Solar	2.75%	4.75%	6.75%
Total	**11.50%**	**14.25%**	**17.00%**

40 Notification no. 23/3/2016-R&R dated 22 July 2016, MoP

Single window clearance framework

- The state has simplified the process of approval through constitution of single point clearance committees for facilitating new investments, as mentioned below:

Investment (crore INR)	Committee
> 500	State High Level Clearance Committee
> 15 and <= 500	State Level Single Window Clearance Committee
<15	District Level Single Window Clearance Committee

For solar projects, the state has appointed separate committees for the purpose of approval and overseeing progress of the projects.

Capacity (MW)	Committee
> 50	High Level Project Approval Committee
>1 and <= 50[41]	Government of Karnataka

41 Projects under Renewable Energy Certificate Mechanism (RECM), IPPs, and captive generation

In focus: Tamil Nadu

Vision of the power sector[42]

The government of Tamil Nadu's 2023 strategic plan for infrastructure development in the state targets the following:

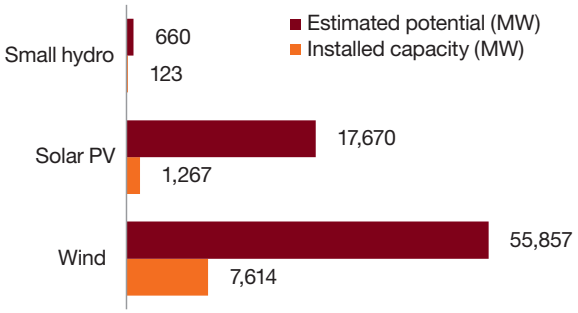
- Setting up of an additional 20,000 MW of power generating capacity, including two UMPPs of 4,000 MW each
- Thrust for green power by maximising investments in wind power and solar energy to create incremental renewable generation capacity of 10,000 MW
- Significant investment in the transmission sector to create the required evacuation capacity, with buffers for the higher power generation capacity. Select high capacity transmission corridors will be bid out on public private procurement basis to establish the necessary evacuation infrastructure
- Two greenfield LPG terminals with five MT per annum capacity each, and city gas pipeline infrastructure for 10 towns to be established
- Establishment of a smart grid system that enables lower cost of energy to consumers, sparks innovation in energy management at all levels in the energy chain across the economy and improves the reliability and security of the electricity grid
- Implementation of reforms in the power sector in a progressive manner so that the benefits of competition and innovation are delivered to consumers by way of reliable power supply at the most competitive price while ensuring that the vulnerable sections are protected

Power sector at a glance

The state has an installed capacity of 26 GW,[43] having the highest installed capacity of renewable energy projects (9.5 GW[44]) in the country. It is pertinent to mention that the private sector contributes to more than 50%[45] of the installed capacity. The transmission network is having extra high tension lines for a total length of 24,497[46] circuit km with total of 842[47] substations. It is pertinent to mention that 95[48] substations in and around Chennai have been provided with supervisory control and data acquisition systems and have been integrated into the Chennai distribution and control centre. Currently, the state is providing electricity to 26.47 million consumers.

Future growth of renewable energy

The installed capacity[49] vis-à-vis the potential for wind, solar, and small hydro energy is represented below:



Source: MNRE

Transmission planning for the future

The state transmission utility has planned significant investments for the financial year 2016–17 of 2,823.40 crore INR, 2,926 crore INR for financial year 2017–18 and 3,945 crore INR for financial year 2018–19.

The additional transmission includes strengthening of 765 kV, 400 kV and 230 kV substations and estimated 1,950 circuit km of 400 kV transmission line.

Ease of doing business in Tamil Nadu

Shelf of projects in conventional power

- SIPCOT is facilitating the creation of ICE along the national highways and has prepared the study of the corridor development plans for each region separately.
- The state generation utility and TANGEDCO have installed capacity of 13,231.44 MW which includes state projects, central share and private power projects. Other than this, the state has installations in renewable energy sources like windmills, solar, biomass and cogeneration up to 8,470.16 MW.
- To balance the excess power available during off-peak hours and to tide over the peak hour shortage, a pumped storage scheme in Kundah for 500 MW has been proposed. The thermal Projects of TANGEDCO for capacity to the tune of 4,380 MW has been proposed to be commissioned by FY 2018 and FY 2019.

42 Vision Tamil Nadu 2023 (Strategic plan for infrastructure development in Tamil Nadu), Government of Tamil Nadu
43 As on 30 Jun 2016, CEA
44 As on 30 Jun 2016, CEA
45 As on 30 Jun 2016, CEA
46 TANTRANSCO
47 TANTRANSCO
48 TANTRANSCO
49 MNRE

Shelf of projects in non-conventional power

In continuation to the bid process conducted in 2012, Tamil Nadu had signed off for capacity totalling 2,000 MW through TANGEDCO, which is under various stages of development. Tamil Nadu receives global solar radiation in the range of 5.6–6.0[50] kWh/m², with around 300 clear sunny days in a year.

Policy, regulatory and statutory regime

- Wind preferential tariff for FY 2017 has been increased to a levelised tariff at 4.16 INR per unit without AD benefit from 3.51 INR per unit issued in 2012. However, the solar tariff has been reduced from 7.01 INR per unit to 5.0 INR per unit.
- Special incentive package of incentives to encourage the new entrepreneurs willing to set up their industries in the existing as well as in the new industrial parks of SIPCOT are to be developed in the southern districts.
  - Allotment of land at 50% subsidised rate, the subsidy component will be directly remitted to SIPCOT by the government
  - 100% exemption from stamp duty on lease deed registration
  - Capital subsidy increase from 1.5 to 2 times
  - Reduction in the minimum investment required for obtaining VAT-based incentives from the present level of 50 crore INR to 10 crore INR.
- Tamil Nadu has come up with various e-initiatives to ensure the ease of doing business and has taken measures to climb up the first ever ease of doing business charts being compiled by the Centre. The single window clearance and the industry friendly laws make Tamil Nadu a favourable destination.
- An online consent management system has been implemented to provide an all-inclusive solution to environment clearances from the State Pollution Board Control.

Land acquisition

Land acquisition can be completed based on the applicable provisions mentioned in the Land Acquisition (Tamil Nadu Amendment) Act, 1948.

PPAs at the center of state's energy strategy

- The distribution utilities in Tamil Nadu has a proven track record of securing long term PPAs with the developers for solar, wind and other renewable energy sources .
- The government of Tamil Nadu ensures signing of 100% PPA for waste to energy projects in line with the new National Tariff Policy, 2016.

Grid curtailments and connectivity to the network

- The power projects can be connected to suitable voltage levels subjected to the evacuation facilities available with the transmission and distribution utilities in line with the state regulations.
- Metering shall be in compliance with the Central Electricity Authority (Installations and Operation of Meters) Regulations, 2006, grid code, metering code, and relevant regulations as issued by regulators.

RPO enforceability

- MoP[51] in consultation with the MNRE has notified the revised RPO trajectory which will be applicable to all the states and union territories from FY 2017 till FY 2019, as mentioned below:

Sr. no.	FY 2017	FY 2018	FY 2019
Non solar	8.75%	9.50%	10.25%
Solar	2.75%	4.75%	6.75%
Total	**11.50%**	**14.25%**	**17.00%**

Single window clearance framework

- Tamil Nadu has constituted the Guidance Bureau as a single window system for investment promotion and investor facilitation, thereby providing time bound approvals.
- Additionally, SIPCOT is the designated nodal agency for activities pertaining to promotion of industrial parks and distribution of incentives.

50 Solar Energy Policy 2012, Government of Tamil Nadu
51 Notification no. 23/3/2016-R&R dated 22 July 2016, MoP

In focus: Telangana

Vision of the power sector

The government of Telangana in a joint initiative with the Government of India has chalked out an action plan in its vision document 'Power for All' to make the state self-sufficient in power generation over the next few years. The Power for All programme is an excellent platform, considering that Telangana being a new state will require adequate energy to build a new economy, attract investments, and accelerate growth.

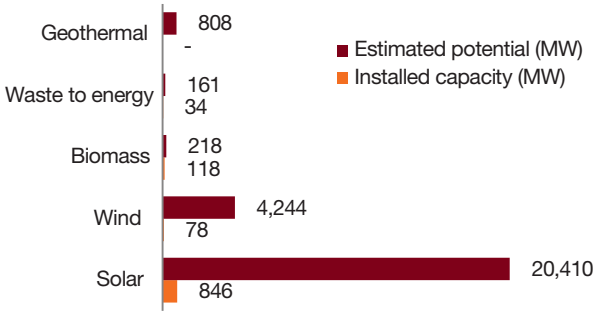
Power sector at a glance

The state has an installed capacity of 11.41 GW[52], with the state sector contributing to 61% of the total capacity, with an installed capacity to the tune of 6.94[53] GW.

The state[54] has a 16,698 circuit km long transmission network along with distribution network having 1,55,028 circuit km of high tension distribution lines and 3,03,080 circuit km of low tension distribution lines respectively. Currently, the state is serving electricity to 12.6 million consumers.

Future growth of renewable energy

Telangana being a new state is facilitating the expansion of its economy by providing conducive policy framework, infrastructure, and power in order to attract larger investments. The state is blessed with all forms of energy, including solar, wind, biomass, biogas, bioenergy, waste to energy, mini hydel, and geothermal with a significant potential. The installed capacity[55] vis-à-vis the estimated potential for all forms of energy is represented below:



Source: MNRE and PwC analysis

Transmission planning for the future

The state transmission utility has planned for significant investments to the tune of 17,803 crore INR (excluding the planned investments for solar parks) by the end of financial year 2018–19 for ensuring adequacy of the transmission system to provide reliable and quality power to the consumers in the state. The above proposed transmission system will be adequate in meeting the projected peak load exceeding 21,000 MW up to financial year 2018-19 and renewable energy power of about 6,016 MW which will be majorly implemented through solar generation. The additional transmission system for evacuation of anticipated renewable energy other than planned capacity shall also be identified, approved and implemented as per system requirement matching with the renewable energy generation plan.

Ease of doing business in Telangana

Shelf of projects in conventional power

TSGENCO is planning significant investments to the tune of 6,840 MW, amounting to a total project cost of 42,491 crore INR from its upcoming thermal power stations. Moreover, the distribution utilities of Telangana are planning to procure capacities from various sources, including 4,733 MW of power from central generating station sources, 4,819 MW of power from other long-term sources, and 6,016 MW from renewable energy sources. These capacity additions together sum up to 22,408 MW installed capacity by end of financial year 2018–19.

Shelf of projects in non-conventional power

The distribution utilities have successfully tied up solar capacity of 515 MW through the competitive bid process which was concluded in February 2015. The state is active in promoting solar pumpset schemes, solar rooftops and off-grid solar projects. Telangana receives global solar radiation with an average of 5.50 kWh/m² for more than 300 sunshine days in a year.

Policy, regulatory and statutory regime

The prevailing feed-in tariff determined by TSERC for renewable projects are mentioned below:

Particulars	Feed in tariff (INR/kWh)
Solar rooftop	Applicable retail tariff for net metering projects
Wind	3.5 for the first 10 years, prevailing tariff for the next 10 years
Small hydro	Ranging from 2.69 to 1.92 for a period of 10 years
Biomass	2.85

52 As on 30 June 2016, CEA
53 As on 30 June 2016, CEA
54 TSTRANSCO
55 TNREDCL

The various initiatives taken by the authorities to encourage the developers are mentioned below:

- For solar projects, the wheeling and transmission charges are exempted for captive/group captive use within the state. They will be charged as applicable for a third-party sale. The transmission and distribution losses, however, are fully applicable for both— third party within the state as well as captive use within the state.
- All solar power developers and wind power developers shall be awarded a must-run status, and banking of 100% of energy shall be permitted for all captive and open access/scheduled consumers during the 12 months of the year. Banking charges shall be adjusted in kind at the rate of 2% of the energy delivered at the point of drawal.
- It is pertinent to mention that the wind power developers and solar power developers, being a part of green energy will be given required clearances under pollution control laws within a week's time by the state pollution board control.
- The bagasse-based cogeneration power projects in Telangana are eligible for MNRE capital subsidy ranging between 15–60 lakh INR/MW, with a maximum support of 8 crore INR per project for as mentioned below:

Category	Capacity	
	Above 100 kW and up to 1,000 kW	Above 1 MW and up to 25 MW
Private sector	15 lakh INR/MW	For all projects
Cooperative/ public/joint sector	40 lakh INR/MW	40 bar and above
	50 lakh INR/ MW	60 bar and above
	60 lakh INR/MW	80 bar and above

- Central financial assistance for an amount of 40– 50% of the total project cost, subjected to a maximum of 1.5–3 crore INR per MW is being provided for the fast track implementation of waste to energy projects.
- The new small hydropower projects up to 25 MW capacity are eligible for MNRE financial support as mentioned below:[56]

Category	Capacity	
	Above 100 kW and up to 1,000 kW	Above 1 MW and up to 25 MW
Private sector, Joint sector, cooperative sector	12,000 INR/kW	1.20 crore INR for first MW + 20 lakh INR for each additional MW
Government departments, agencies, state electricity boards	25,000 INR/kW	2.50 crore INR for first MW + 40 lakh INR for each additional MW

- Project capacities totalling 160 MW has been sanctioned for implementation of geothermal energy.
- The distribution companies have created a page named as EoDB[57] on their website, highlighting the various services provided under this facility.

Land acquisition

- In order to facilitate the developers in acquiring the land, the government of Telangana has notified that the ceiling limit as per the Andhra Pradesh Land Reforms (Ceiling on Agricultural Holdings) Act, 1973, will not be applicable for any land acquisition for wind power projects, solar power projects, and solar parks.

56 TNREDCL

57 https://www.tssouthernpower.com/CPDCL_Home.portal;jsessionid=dYbrXvvGvGprS7nR1v8WW4IMTDNLVdymJQ1kGgXyvtxvhTQyLwvQ!-660701280?_nfpb=true&_pageLabel=CPDCL_Home_portal_page_EoDB

- Land acquired for grid-connected wind and solar power projects through sale to distribution utilities mode, captive use/group captive mode, third-party sales mode shall be automatically deemed to be converted to a non-agricultural land status on payment of applicable conversion charges, and no further conversion procedures need to be followed by the developers in respect of such land.
- The government of Telangana has notified that 25,000 INR per acre shall be levied on the developers towards development charges and layout fee, payable to the respective gram panchayat. On payment of such amount, the gram panchayat will accord the necessary approvals for setting up of the wind power projects, solar power project, and solar parks, including permission for bore wells. Further, no permission is required from the gram panchayat.

PPAs at the center of state's energy strategy

- Telangana has signed long-term PPA to the tune of 9,376 MW till date with the distribution utilities through state generation companies, central generating agencies, and private players.
- The government of Telangana ensures signing of 100% PPAs for waste to energy projects in line with the new National Tariff Policy, 2016.

Grid curtailments and connectivity to the network

- All renewable energy projects shall be evacuated at the appropriate voltage level at the interconnection point of transmission companies and evacuation up to the interconnection point shall be the sole responsibility of the developer.
- The developer shall bear the entire cost of the transmission infrastructure till the interconnection point; however, the following support shall be available to the developer:
  - Supervision charges levied by the transmission and distribution utilities shall be exempted
  - Transmission and distribution utilities shall process and close the proposals for technical feasibility within 30 days of receipt of application from the developer.
- Metering shall be in compliance with the Central Electricity Authority (Installations and Operation of Meters) Regulations, 2006, grid code, metering code, and relevant regulations as issued by regulators.

RPO enforceability

- MoP[58] in consultation with MNRE has notified the revised RPO trajectory, which will be applicable to all the states and union territories from FY 2017 till FY 2019, as mentioned below:

Sr. no.	FY 2017	FY 2018	FY 2019
Non solar	8.75%	9.50%	10.25%
Solar	2.75%	4.75%	6.75%
Total	**11.50%**	**14.25%**	**17.00%**

Single window clearance framework

- Among several initiatives, the Government of India has recommended the establishment of an online single window system through which all the incentives provided in the industrial policy are to be made available to the industries. In view of the above, the Telangana government created a single window clearance system called TS-iPass with a promise to grant all industrial approvals within 15 days.
- In order to encourage renewable energy-based generation, the Telangana government has prepared the following measures for improving the ease of doing business:
  - Facilitation of expeditious approvals through a single window clearance system.
  - The renewable energy policy cell will undertake single window clearance for all renewable energy projects. A transaction charge of 25,000 INR/MW is applicable for processing applications for single window clearance for wind power developers and 25,000 INR/MW is applicable for solar power developers.

58 Notification no. 23/3/2016-R&R dated 22 July 2016, MoP

Market expect the costs of harnessing wind and solar to drop sharply while steps for clean thermal power are taken

PV technologies designed to capitalize on new opportunities

The PV industry witnessed many improvements across the supply chain in 2015, from high quality of silicon (Si) wafers to better ingredients and formulas for conductive pastes. The conversion efficiency rates of cell products also dramatically increased in the last year, resulting in modules of 'higher wattage'. Currently, the power outputs of mainstream multi-Si 72-cell modules in utility scale projects and mono-Si 60-cell modules have exceeded 300 Wp and 270 Wp, respectively.

While there are a wide range of PV cell technologies in the market today using different types of materials, PV cell technologies are usually classified under three categories depending on the basic material used and the level of commercial maturity.

1st generation solar technology

Dominated by crystalline technology

2nd generation solar technology

Dominated by thin film technology like CdTe and CIGS

3rd generation solar technology

Includes technologies, such as CPV, organic solar cells and perovskites

In last few decades, there has been a lot of R&D activity in the field of solar technology, especially in the area of cell efficiency improvement. Improving solar cell efficiency is the basic step towards improving energy yield. In the last 15 years, average PV module efficiency has gone from about 11% to 16% for typical crystalline silicon modules to more than 20% for high-efficiency 'back-contact' modules, which have no light-blocking metallic traces on the front of the PV cells—this increases the available light-collection surface for higher conversion efficiency. Also more efficient (about 17% to 19%) are conventional modules using 'n-type cells', which have less light-induced-degradation and are less sensitive to cell impurities that the conventional 'p-type cells'.

Other technologies in the thin-film category—CdTe and CIGS, together broadly classified as thin film—offer module efficiency in the range of 13.5–16.5%. Market researchers claim that some of the new approaches could reach up to 50% efficiency and will make solar power increasingly affordable.[59]

The HJT cell design that combines two materials, often c-Si wafer and a-Si TF, into one single junction, resulting in higher efficiencies and performance ratio, give better resistance to high temperatures.

While some of the new technologies like HJT, PERC tested in the recent times look promising, the prominent trend seen in the industry is an increase in power output, with many modules moving from a 3-busbar to 4-busbar design and a rise in the quality of dual-glass modules (module design that replaces the traditional aluminium frames and backsheet substrate with an additional glass panel) that encapsulate cells fully in glass. The glass to glass modules thus manufactured are seen to have higher reliability with issues such as PID, wear out of EVA, resistance to moisture permeability, chemical corrosion and superior glass strength completely reduced, leaving module manufacturers to offer higher linear power warranty (30 years in this case compared to 25 years of conventional modules). With scale, this could achieve cost parity in the coming years and shift the market share for mainstream modules.

59 Will new technologies give critical boost to solar power? by Cheryl Katz (http://e360.yale.edu/)

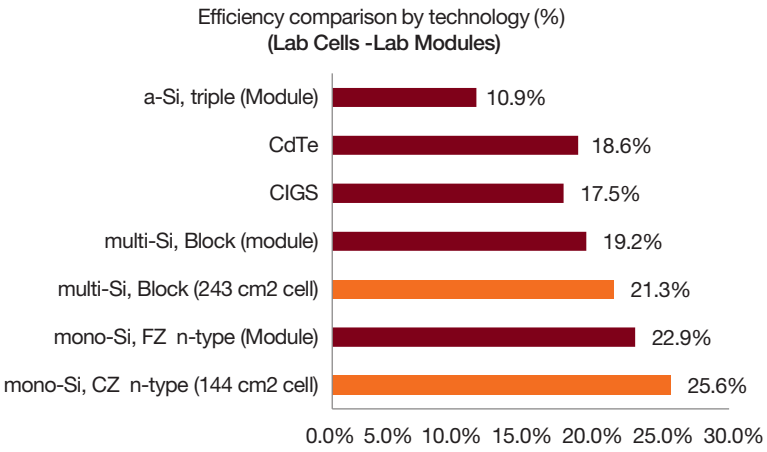
In the high-efficiency market, mono-Si wafer manufacturers managed to significantly cut down their wafer-slicing costs by switching from the 'standard slurry sawing process' to the 'diamond-wire sawing method'. Despite previous manufacturing-related problems, multi-Si wafer manufacturers are also considering adopting diamond-wire sawing to stay competitive in the industry. The industry's interest in 'black silicon' related manufacturing processes will grow to counter the advances of mono-Si technology as the overall quality of diamond-wire sawn multi-Si wafers stabilises.

To maintain high capacity utilisation and reap greater profits, PV manufacturers in general are focussing more on 'sources of market demand' in the high-efficiency market, such as India's 40 GW rooftop solar market. For this reason, they are expected to continue and optimise wafer production, conductive paste production and screen printing. At the same time, they could work on technologies like PERC and black silicon to improve the conversion efficiency rates of modules.

The improvement in technology has led to the fall in module prices. According to market research, the global average price for a tier-1 produced multi-crystalline PV module will reach 42 cents by end 2016 from 47 cents in early 2016.[60]

Third-generation novel PV devices, such as dye-sensitised cells, organic cells and thermoelectric devices, hold high promise for the future, before they can reach the mainstream market. Recent attempts have seen efficiency of 11% for organic cells and 12% for dye-sensitised cells achieved by Mitsubishi Chemical and Sharp, respectively. Such efficiency improvements may help these new technology options to enter the market successfully.

In summary, considering the evolution of the PV industry in the last decade, it is evident that more innovations, both in the manufacturing and cell technology, are expected to evolve with time. Materials that offer higher value and performance are likely to become popular. Module manufacturers will be expected to mitigate challenges by increasing their focus on research and development.



The market leader in CdTe technology recently revised its efficiency, targeting 25% for research cells and over 19% for commercial modules in three years and reduced degradation of performance to 0.5%/year.

In line with this target, commercially available modules are already at 16.3% efficiency and with a record 18.2% for an advanced, full-size module already achieved, such efficiencies seem achievable much ahead.

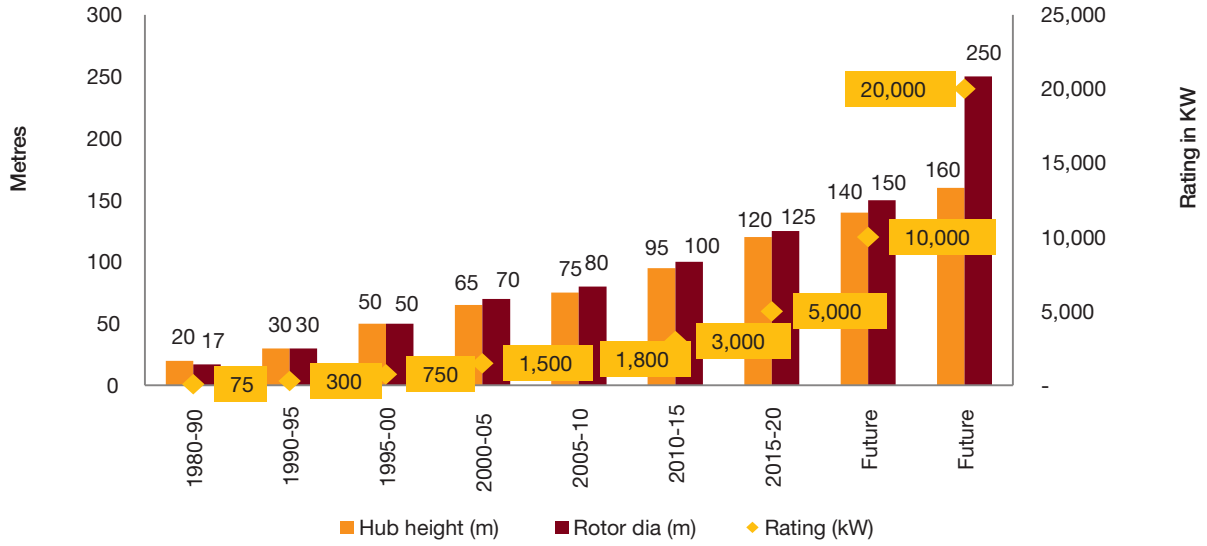
60 Market Research, 2016

Transition in wind technology encourage energy transition

The wind sector has grown enormously all over the world in the last two decades and has in turn given rise to the use of newer and more advanced technologies for the optimum utilisation of resources. Large-capacity wind farms are planned in the country, with the help of the latest technology such as larger MW class wind turbines, inclusive operation and O&M practices for the life of the plant, logistics required for construction and maintenance and seamless grid integration. All these are of paramount importance to sustain the growth outlook. Technology for wind turbine components such as rotor, drive train, tower, yaw system and nacelle have improved over time, in turn enhancing turbine performance and overall efficiency. The growth of the wind turbine industry is chiefly driven by increasing capacity, improving turbine dimensions and designs, drive-train technology, tower structure and advance power electronics.

The current research in wind turbine technology is towards higher power, efficiency, reliability and lower capital costs. Over the last two decades, the hub height and rotor diameter have increased fourfold in India,[61] while the average WTG rating increased almost tenfold. The increasing wind turbine dimensions are expected to assist in capturing more energetic winds that occur at higher elevations, thus increasing the energy generated per turbine.

One of the key drivers for increasing WTG capacities is the economics involved in manufacturing. The cost of a wind turbine is proportional to hub height. At higher hub heights, the small wind turbines of 100–200kW are expensive in terms of cost/MW compared to WTGs of larger capacity, thus making them uneconomical. In the past, India has lagged in adopting rapidly developing global technology. For example, the largest turbine installed in India is in the range of 2.25 MW, while Germany has 7.5 MW. In addition, the largest rotor and hub heights installed for WTGs in India are 20 to 30% lesser than the global standards. The development of technology trends for other key components of WTG is also contributing to improved ratings and utilisation factors.



Source: Technology Roadmap – Wind Energy – 2013 Edition - IEA

61 Windpro magazine

Development trends of key components of WTG

Parameter	Technology trends
Blade design	• Size of blades has increased from about 8 m in 1980 to more than 40 m for the large commercial wind turbines installed today. • A major effort in blade design is to develop aerodynamic profiles which are better at harnessing wind energy. • Industry and research establishments have been pushing the limits of aerodynamic performance of a horizontal axis wind turbine rotor by achieving a measured rotor performance in excess of 0.5. • Increase in the number of blades improves the aerodynamic profile. Most of the WTGs currently being installed have three blades. • The material used for making blades progressed from sheet metal to advance fibreglass optics through wood.
Variable speed WTGs	• Most of the wind turbines currently installed are of variable speed regime. Variable-speed turbines improve the utilisation factors by adjusting turbine speed with respect to wind speed to maximise power output.
Gear mechanism	• The share of gearless WTGs is gradually increasing, although most of the WTGs installed are geared. Permanent generators with high rotational torque used in gearless WTGs and reduced rotational inertia due to a lower number of rotational components are assisting in increasing the rated capacity of WTGs. Currently, the largest onshore wind turbine, Enercon's E-126 of 7.5 MW, is based on gearless technology.
Tower	• Current wind turbine towers use tubular steel, reinforced concrete, hybrid or lattice solutions depending upon the size and location site constraints. Efforts are being made to develop advanced tower configurations that are cheaper and can be easily transported and installed at the site.
Generator	• Grid-synchronised induction generators which have succeeded initial DC generators are now being replaced by variable speed designs employing concepts of advanced power electronics. Also, gearless machines are using permanent magnet generators.

Evolving wind turbine technology has played a critical role in determining costs. The decreasing trend in the turbine costs during the period 1997–2001 was succeeded by the increasing trend over the last decade. However, according to a report on wind turbine prices by Berkeley Lab, prices of wind turbines have started to again decline from 2010, with price quotes ranging from 900 USD to 1,400 USD per kW.[62] The reasons for the increase in turbine prices in the past are scaling up of turbine dimensions, increasing material input prices, shortage in certain turbine components and wind technology still being in the evolution phase. However, increased scale, improved efficiency, increased production capacity of WTGs and mature technologies have reduced the cost of turbines in recent years.

In addition to the increasing rated capacity of wind turbines, the use of lightweight materials (such as carbon-fibre reinforced plastic) and improvements in aerodynamic profile will be critical. Also, transportation will be an issue for high-rating turbines. Hence, concepts such as on-site manufacturing, segmented blades and hybrid towers (combining both lattice and tubular structure) are also being explored. Another innovation that is being evaluated at a smaller scale by EUI (Boise, Idaho) is a variable-diameter rotor that could significantly increase the capacity factor. Another company called Vortex Bladeless is working on a new technology where turbines will be bladeless and will produce electricity with very few moving parts. It relies on the oscillation of its tall mast in reaction to air whirlpools to move a series of magnets near its base to generate electricity.[63]

With continuous improvements in research, offshore wind turbines are available in the range of >5 MW with a rotor size of ~150 m. Apart from improvement in the efficiency and weight of offshores turbines, developers are planning to use floating structures in place of deep foundations, hence saving on cost and gestation period.

62 Understanding Trends in Wind Turbine Prices over the Past Decade, Berkeley Lab
63 http://www.vortexbladeless.com/

Wind turbine technology for low wind regimes

Wind turbines generate electricity from wind speed ranging from 3 m/s to 25 m/s. It is not economical to generate energy in regions with low wind regimes and where wind speed is less than 5 m/s. However, with recent developments in turbine technology such as increasing WTG dimensions, better aerodynamic designs and gearless technologies, energy generation in the low wind regimes is becoming economically viable. WTGs with taller hub-heights are used to improve utilisation factors in the low wind regime, as wind speed increases with the increasing height of towers. According to a study conducted by the US Department of Energy, the use of improved technology can increase energy production by 21 to 61%, with a change in capital costs from -36 to 21%.

Impact of WTG technological advancements[64]

Technical initiatives	Potential advances	Performance and cost increments (best/expected/least)	
		Annual energy production (%)	Turbine capital cost (%)
Advanced tower components	• Taller towers • New materials, advanced structures	+11/+11/+11	+8/+12/+20
Advanced (enlarged) rotors	• Advanced materials • Improved structural – aero design • Higher tip speed/lower acoustics	+35/+25/+10	-6/-3/+3
Reduced energy losses and improved availability	• Reduced blade soiling losses • Robust control systems • Prognostic maintenance • Damage tolerant sensors	+7/+5/0	0/0/0/
Drive train (gearbox, generators and power electronics)	• Fewer gear stages or direct drive • Medium/low speed generators • Permanent magnet generators • Advanced gear tooth profiles • New circuit topologies, semi-conductor devices, etc.	+8/+4/0	-11/-6/+1
Manufacturing and learning curve	• Sustained, incremental design and process improvements • Reduced design loads • •Large-scale manufacturing	0/0/0	-27/-13/-3
Total		+61/+45/+21	-36/-10/+21

Source: US Department of Energy report on 20% wind energy by 2030

Thus, the ever-changing and improvising technology is enabling developers to procure efficient equipment at competitive prices to produce more energy efficiently and at lower capital costs.

64 US Department of Energy report on 20% wind energy by 2030

New-age hybrid technologies and energy storage technol0gies on the rise

RE technologies that include power generation from RE sources, such as wind, PV, MH, biomass, ocean wave, geothermal and tides, are intermittent in nature. Therefore, hybrid combinations of two or more power generation technologies along with storage can improve system performance.

A HRES combines two or more renewable energy resources with some conventional source (diesel or petrol generator) along with storage in order to fulfil the demand of an area. Storage technology is important to ensure continuous supply of power to the load. There are many types of energy storage that can be used in a HRES, for example, CAES, PHS, hydrogen fuel cells, flywheels, supercapacitors, SMES and batteries.

In the recent times, stationary energy storage is becoming popular, especially in mature markets like Europe. Including energy storage in the grid significantly improves its stability, offers a combination of black start capacity, peak shaving and demand charge reduction, among others, while leveraging renewable energy sources. Such storage options are likely to become a key feature of solar tenders in the near future, and India has already taken attempts through to set up grid-connected solar PV projects (2 x 50 MW) with battery energy storage system (5 MW/2.5 MWh) under NSM Phase 2, Batch IV.

This clearly indicates that the future growth for stationary energy storage systems in India is looking positive—a growth attributed to significant cost decrease and the resulting competitiveness of energy storage systems compared to traditional, non-storage solutions.

Though batteries are an ideal solution for home renewable energy generation systems with their mature form of storage, high energy and high power density yield at low cost, other technology innovations in energy storage that allow better use of capital through innovative infrastructure investments are to create opportunities for investors.

Solar panel with built-in battery: In a project funded by the United States Department of Energy, Ohio State University researchers recently announced a battery that is 20% more efficient and 25% cheaper than anything on the market today. The design uses a rechargeable battery built into the solar panel.

Molten salt storage technology: Use of inorganic salts to transfer energy generated by solar PV systems into solar thermal using heat transfer fluid rather than oils (operate at a temperature over 500°C), which would result in a much higher power output and lower costs to store solar power.

Key characteristics of energy storage forms

Storage technology	Efficiency	Maturity of technology	Cost	Energy density	Power density
CAES	70%	Mature	High	High	High
PHS	75–85%	Mature	High	Depends on the size of reservoir	Depends on the height distance between reservoirs
Hydrogen fuel cells	50–60%	Early stages of maturity and commercially proven	High	Depends on hydrogen reservoir	Depends on speed of reaction
Flywheel	80–90%	Mature	Low	Low	High
Supercapacitor	80–95%	Immature	High	Low	High
SMES	90–95%	Immature	High	Low	High
Battery	75–85%	Mature and commercially proven	Low	High	High

Source: International Journal of Electronic and Electrical Engineering

Standardisation of storage options and methods and determination of storage costs are definitely needed to help set up the right level of expectation for energy storage solutions in India.

Clean thermal power generation helping to fight climate change

At the COP21 in 2015, India offered a 35% reduction in the greenhouse gas emission intensity of its economy from 2005 levels by 2030 as part of its INDCs. As per CSE's green rating project,, the average efficiency of Indian plants in the study was 32.8%, which is one of the lowest among major coal-based power producing countries.[65] Further, average CO_2 emission was 1.08 kg/kWh, which is 14% higher than China's. India's thermal power plants are estimated to withdraw around 22 billion cubic meter of water, which is over half of India's domestic water need. Even plants with cooling towers use an average of 4 m^3/MWh; in contrast, the average water consumption in Chinese plants is 2.5 m^3/MWh. Of the 47 plants in India, 36 were unable to meet the MoEF&CC's mandated target of utilising 90% of the solid waste (ash) generated (average use was only 54%). As around 69% (approximately 211GW) of installed capacity is in thermal power generation; hence, the committed reduction of greenhouse gas emission target cannot be achieved unless all steps are taken for clean generation in thermal power.

Quality and environmental norms and standards

Environment (Protection) Amendment Rules, 2015

MoEF&CC's notified the revised standards for coal-based thermal power plants on 7 December 2015[66] with the primary aim of minimising pollution. These standards are proposed to be implemented in a phased manner. Thermal power plants are categorised into three categories: (i) installed before 31 December 2003, (ii) installed after 2003 and up to 31 December 2016 and (iii) installed after 31 December 2016.

Water consumption standards

Parameter	Standards
Water consumption (Existing plants required to comply two years from date of notification)	• All plants with once-through cooling shall install a cooling tower and achieve specific water consumption up to a maximum of 3.5 m^3/MWh. • All existing cooling tower-based plants shall reduce specific water consumption up to a maximum of 3.5 m^3/MWh. • A new plant to be installed after 1 January 2017 has to meet specific water consumption up to a maximum of 2.5 m^3/MWh and achieve zero waste water discharge.

Air pollution standards

Parameter	Standards
Water consumption (Existing plants required to comply two years from date of notification)	• All plants with once-through cooling shall install a cooling tower and achieve specific water consumption up to a maximum of 3.5 m^3/MWh. • All existing cooling tower-based plants shall reduce specific water consumption up to a maximum of 3.5 m^3/MWh. • A new plant to be installed after 1 January 2017 has to meet specific water consumption up to a maximum of 2.5 m^3/MWh and achieve zero waste water discharge.

Latest technology

Apart from stringent rules, new technologies will help India to reduce coal use and create a pollution-free environment. Across the process chain of thermal plants, clean technology can play vital role in reducing the carbon footprint and meeting pollution norms. India is also working towards setting up a thermal power plant based on the advanced ultra-supercritical technology. This is a key technology as it burns less coal to derive more energy. Through the technology, which applies high heat and high pressure, the same amount of coal can give about 30–40% more energy. NTPC Ltd. is engaged in the development of advanced ultra-super critical technology with a cycle efficiency of 45–47%, resulting in an around 16% reduction in carbon emission compared to conventional subcritical technology based plants. Some of the measures which may be applied from pre-combustion to post-combustion are given below.

65 http://www.cseindia.org/userfiles/booklet.pdf
66 http://www.indiaenvironmentportal.org.in/files/file/Moef%20notification%20-%20gazette.pdf

Clean technology and control measures

Pollution control	Clean technology/control measures
Reduction of PM	• Coal washing , electrostatic precipitators, fabric filters
Reduction of SO_2	• Use of low sulphur content coal, use of GFD or scrubber with sorbent, use of FBC technology: CBFC, AFBC, PFBC
Reduction of NOx	• Retrofitting low NOx burner, use of SCR
Reduction of Hg	• Co-benefit mercury removal in coal washing, co-benefit mercury removal in ESP, wet FGD and SCR
Reduction of water usage	• Use of cooling towers, use of efficient pumps, reduction of water wastage, plugging of water leakages

Non-compliance

In recent days, non-compliance has led to the shutdown of a plant by NGT or denial of permission to construct or operate existing plants. For example, NGT directed the shutdown NTPC Ltd.'s 705-MW Badarpur Thermal Power Station and Indraprastha Power Generation Co. Ltd. 135-MW Rajghat Thermal Power Station for failure to comply with PM. The Maharashtra Pollution Control Board had refused approval to new 500-MW units (i.e. unit nos. 8 and 9) at Mahagenco's Chandrapur Super Thermal Power Station for failure to complete pollution control measures like effluent and sewage treatments plants and also refused to renew the consent to operate the existing 30-year old 210-MW units (i.e. unit nos. 1 2) at Mahagenco's Chandrapur Super Thermal Power Station for failure to comply with environmental norms and regulations.

Efficient and clean practices at various plants

Tata Power – Trombay Thermal Power Station: Tata Power is one of the pioneers in the clean generation of energy through various technologies that enabled it to reduce pollution and efficiently manage power stations. Some of the steps taken, from procuring coal to efficient energy-saving and management systems to emission, are:

- Captive jetty with screw unloader to unload coal without any spillage
- Pipe conveyors to ensure transfer of coal without any spillage
- ACW pump impeller coating, compressed air pressure controller, HPBFP, impeller trimming, VFD for condensate recirculation pump and low-pressure boiler feed pump, combustion optimisation heat rate analysis on daily basis using PI dashboards
- Installation of vacuum pumps for fly ash removal in place of hydro-ejector based ash water pumps
- Modification in air and flue gas path along with CFD analysis and silt curtain in CW Jetty

Udupi Power Corporation Limited: In the Udupi plant, the boiler is a single drum which adopts subcritical natural circulation, opposed burning of front and back wall, single reheating, single-furnace balanced draft, dry deslagging, outdoor arrangement, an all-steel framework and all-suspension structure, wherein the reheating temperature is regulated by gas bypass dampers and the air preheater is set in the main post of the boiler.

- Unit start-up logic modification and stoppage of MDBFP during start-up
- Service water pump bypass line for HVAC, FGD, AHP and CHP
- HP/IP turbine inlet strainer additional fine mesh removal
- Debris filter replacement for improving condenser vacuum

JSW Energy Limited, Toranagallu: JSW has taken several measures and implemented technology for clean and efficient power generation:

- eLAN system for EMS
- Installation of VFD to ID FAN and CEP
- Installation of spacer coupling for ID fans
- Retrofitting boilers to accommodate waste gas
- Installation of energy-efficient fans and bypass chute to transfer coal from conveyor
- Installation of LED lighting in control rooms, VFD and training hall
- Optimised ESP rapping motors operation and PA header pressure optimisation

Adani Power Limited, Mundra: APL has had a stellar performance—from commissioning 1320 MW in a single calendar year through effective monitoring to reducing auxiliary consumption and attaining 91.5% PLF through efficient operation and energy efficiency programmes. Some of the steps taken by Adani are:

- Reducing the pressure set points in instrument air compressor
- Interconnecting instrument and service air compressor
- Regulated cooling tower fans operation
- Stopping of one circulating water pump during winter
- Oil consumption reduced through optimising the process, monitoring and technology

Best practices followed at CIL

CIL is the largest coal producer company in the world and contributes around 82% of the coal production in India. Typical Indian coal is low- to medium grade, high ash and low moisture and sulphur, which has a significant impact on the environment. CIL's open cast mining accounts for approximately 90% of mining by CIL, leading to major air, noise, water pollution and land degradation. Hence, practicing and maintaining the highest standard and efficient day–to-day operations has become one of the most important attention area. According to CIL, the major reasons for slippage in the company's production is due to mismatch between production and transportation capacities on account of non-availability of adequate wagons and owing to the bottlenecks in the railway infrastructure. Restructuring and/or reallocation of the railway network, doubling of railway routes, enhancing road connectivity and port capacities and infrastructure development driven by PPPs are the other steps to address this bottleneck.[67]

Drilling is done with dust extractors and wet drilling mechanism. Blasting is done with proper design of blast geometry and charge weight with delay detonators. Regular water sprinkling, transportation through covered and not overloaded trucks on black-topped roads, installation of mist spray systems, and strips plantations are some of the other steps that have been taken to mitigate air pollution. Garland drains, oil and grease traps, effluent treatment and sewage treatment plants have been installed to curb water pollution. Improved froth, oleo floatation process and oil agglomeration process are used to increase process efficiency.[68]

67 https://www.pwc.in/assets/pdfs/industries/power-mining/icc-coal-report.pdf
68 http://www.indiaenvironmentportal.org.in/files/file/coal%20india%20limited.pdf

Grid integration of renewable energy sources

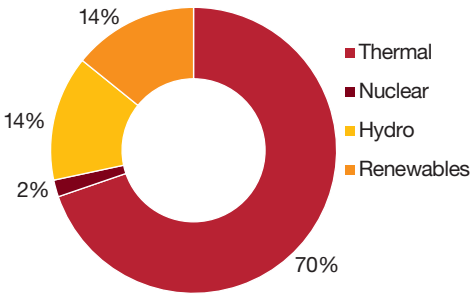
RE generation: Present and future

The RE sector in India has made remarkable progress, growing from 3% (2002) of the total generation capacity to 14% (2016). RE is a growing component of electricity grids 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.

The launch of MNRE's flagship programme, JNNSM, and its revised targets to achieve an RE capacity of 175 GW by 2022 (comprising 100 GW solar, 60 GW wind, 10 GW biomass and 5 GW small hydro) have triggered the growth of renewables in the country.

Fuel mix -March 2016

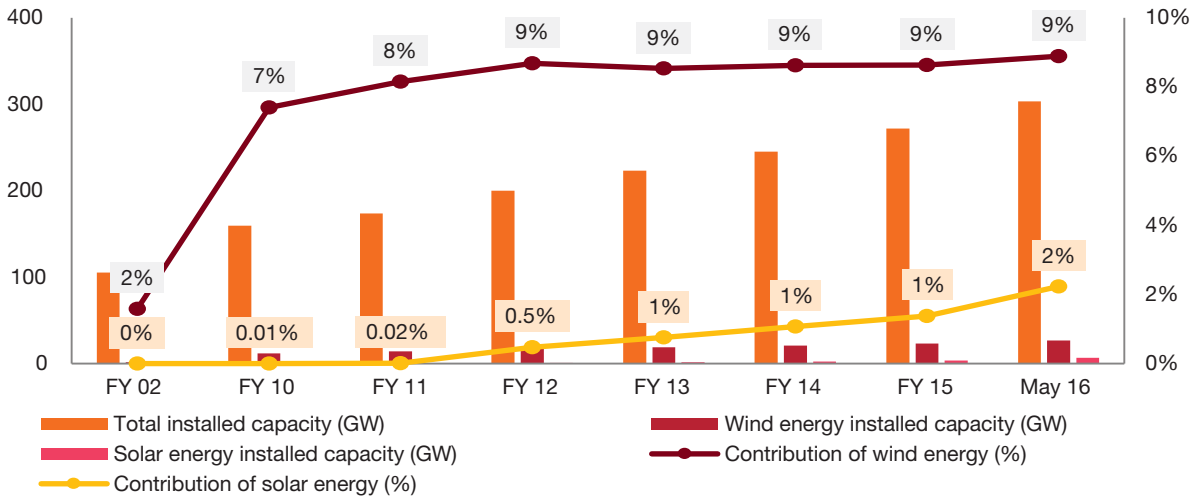


Source: CEA

There is a growing investment interest from both Indian and international developers in the sector. The southern states have also shown huge interest in solar power to overcome their growing power deficit. But with evacuation and grid stability issues becoming more challenging over time, areas of high renewable penetration can create major challenges for the growth of solar energy in India. Going forward, ensuring grid robustness and investment/lending appetite at aggressive tariff levels will be the two main challenges. Policy interventions to address these challenges, together with demand growth measures, will be key to the sustainable growth of the sector. In an attempt to develop concentrated zones of solar power generation, MNRE, in collaboration with states, has proposed the development of 33 solar parks in 21 states, amounting to a total solar generation capacity of 20 GW. Among the proposed solar parks, eight are ready to facilitate the development of solar projects. Bids have been invited for the same, and the development of projects will soon start.

India's wind energy sector has grown rapidly, reaching 26.93 GW of installed capacity in May 2016 from 1.7 GW in 2002,[69] registering a CAGR of 22% (FY 2002–2016). FY 2016, with a capacity addition of more than 3 GW, experienced the highest capacity addition ever in the wind sector in the country. The annual average wind capacity addition over the last three years is >2 GW. This swift capacity addition in recent past is also reflected in the increasing contribution level. The contribution of wind energy in the Indian capacity mix has increased from 1.6% in March 2002 to 8.9% by May 2016.

Increasing wind and solar installed capacity and share in mix



Source: MNRE as on May 2016

69 C-WET website; CEA Monthly Installed Capacity Report, May 2016

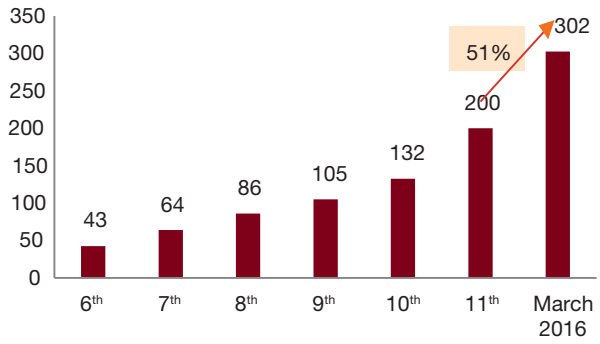
Historically, India has overachieved the targets set during the 10th and 11th Plan periods.[70] The target for the 10th Plan was 1,500 MW and actual installations were 5,247 MW. Similarly for the 11th Plan, 10,260 MW wind energy installations were done against the revised target of 9,000 MW. The historical trend and emerging challenges in the power sector indicate that the MNRE target for wind capacity addition of 11 GW (smart goal)[71] in the 12th Pan will be easily achieved. Recently, MNRE has set a revised target of 60 GW for the wind sector to be achieved by 2022 to further push renewable generation and tap the wind potential of the country.

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

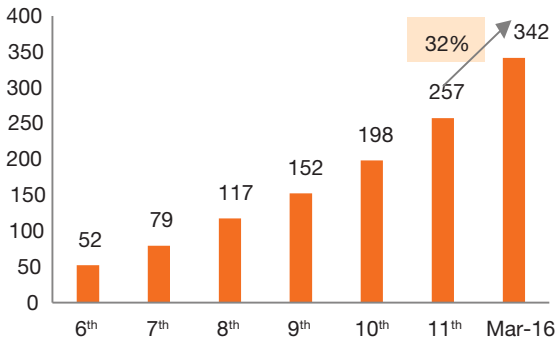
Existing infrastructure: Indian electricity grid

In January, 2014, south India joined the national electricity grid, completing the integration of the entire country into one seamless network for delivering power to consumers. The integration was achieved through the commissioning of the Raichur-Solapur 765 kV single-circuit transmission line by state-owned PGCIL. Charging of this line, a relief to the power-short southern region, will improve transmission and facilitate better management of demand, ensuring the stability of the electricity grid.

Installed power generation capcity
(in GW, as per 5-year plans)



Transmission line network strength
(in '000 ckm, as per 5-year plans)



The transmission network and capacity in India have seen a consistent increase over the years. The length of the transmission line (220kV and above) has increased from 52,034 ckm at the end of 6th Plan (1985) to 341,551 ckm by March 2016, while the transformation capacity (220 kV and above) has increased from 46,621 MVA to 658,949 MVA in the same period. However, the growth has not been comparable with the growth in generation capacity. The generation capacity in India has grown at 51% from the end of 11th Five Year Plan to the end of FY 2016, whereas the growth in the transmission network was only 32%.

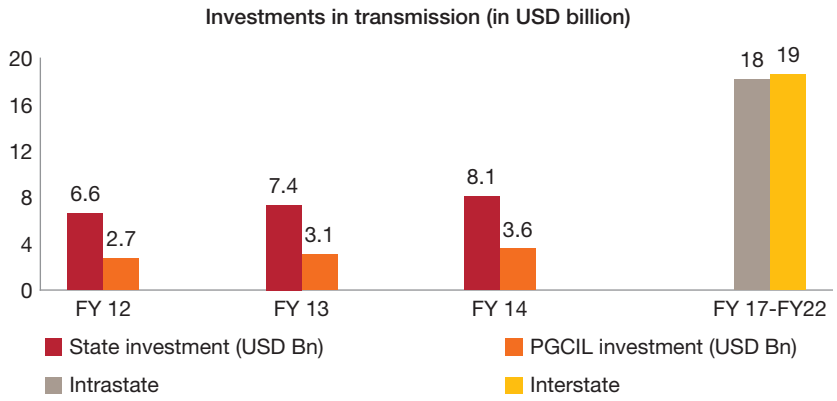
The present transmission system has to meet the firm transmission needs as well as open access requirements. Open access is one of the most important feature of the Electricity Act, 2003 (EA 2003), wherein distribution companies and eligible consumers have the freedom to buy electricity directly from generating companies or trading licensees of their choice. Correspondingly, the generating companies have the freedom to sell to any licensee or to any eligible consumer. EA 2003, mandates the usage of transmission and distribution systems under the open access route, subject to payment of transmission charges, wheeling charges and surcharges, if any to the licensee by the consumer. However, no surcharge shall be levied if such systems are used by the captive generating plant for carrying electricity to the destination of its own use. Curtailment of wind power is another major challenge in a few of the renewable-rich states.

The above stated issues, along with the emphasis on harnessing RE on a large scale, will need robust grid infrastructure. Without a significant increase in transmission capacity, all the renewable energy generated cannot be accommodated in the power system.

70 Indian Wind Energy Outlook 2012, GWEC
71 Strategic Plan for New and Renewable Energy Sector for the Period 2011-17, MNRE, Government of India

Development of evacuation infrastructure

Growth prospects for transmission are driven by a greater emphasis on grid reliability, decentralisation of generation due to a growing share of RE, and spread of new urban and rural load centres arising from urbanisation and rural electrification. 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 the contribution of PGCIL, the private sector will be roped in by MoP by awarding projects through the tariff-based competitive bidding route. The required funds for such huge capacity addition would be from the proceeds of the NCEF.



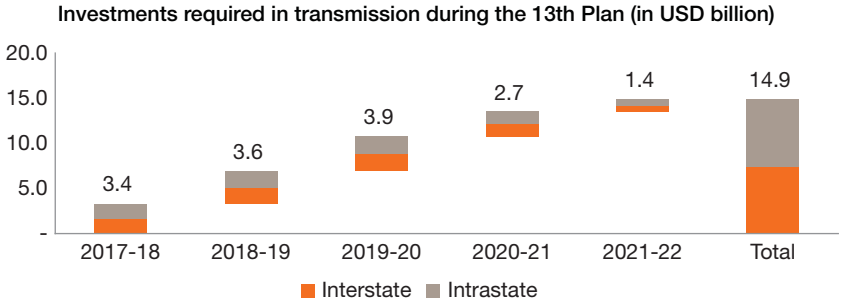
Note: Actual investment include investments made for RE projects

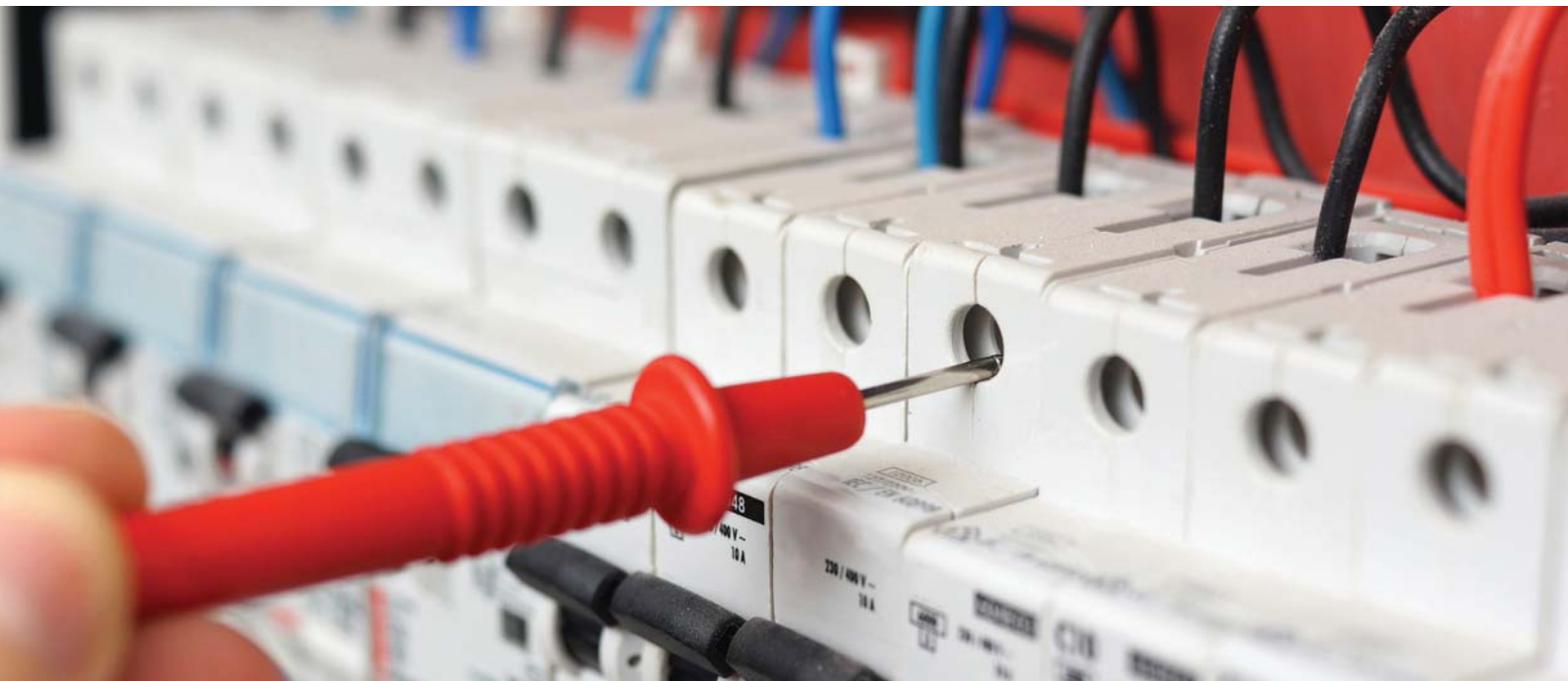
Investments to the tune of 37 billion USD have been planned under the 13th Plan. This investment requirement is exclusive of the amount which is required for the development of a green energy corridor which will evacuate large-scale RE from remote locations.

Green energy corridor

A comprehensive plan for the integration of renewable capacity addition for the 12th Plan has been prepared by the Power Grid with the development of National Green Energy Corridors. The plan envisages strong grid interconnections through intrastate and interstate strengthening. For this purpose, transmission infrastructure for evacuating renewable capacity generation within eight states (Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Rajasthan) has been identified.

Intrastate grid upgradation will be undertaken by PGCIL, while interstate 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 has been estimated during the 13th Plan for evacuating RE generation.





Electricity energy storage

Energy storage, due to its tremendous range of uses and configurations, may assist RE integration in any number of ways, including ensuring continuous supply of power to the load. These uses include, inter alia, matching generation to loads through time shifting; balancing the grid through ancillary services, load following, and load levelling; managing uncertainty in RE generation through reserves; and smoothing output from individual RE plants.

It may be noted that the SECI is planning to launch tenders for solar-plus-storage utility-scale projects in the southern states of Andhra Pradesh and Karnataka. Such projects that are based on storage should improve the system performance.

DR

DR, 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, but is still in its infancy. The rate at which it 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-capacity RE and the application of DR and other smart grid technologies will bring 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.

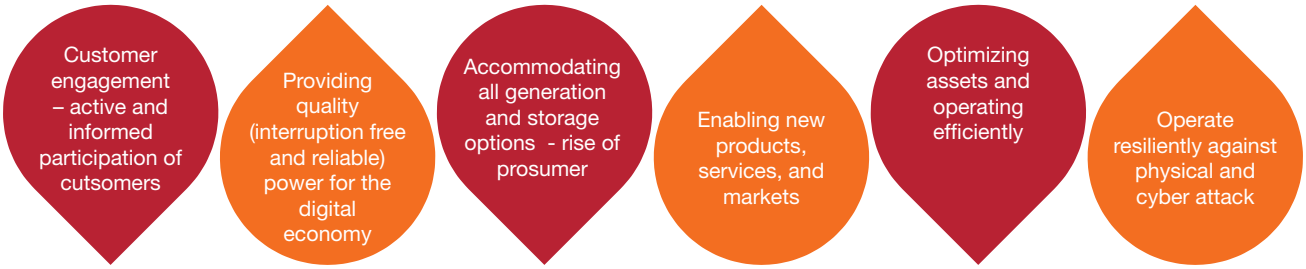
In summary, this means mitigating the impacts of RE generation on the power system, enabling it to contribute to system reliability and stability by improving its design and control technologies flexibility can also be achieved from the load side through demand response, and from energy storage that 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.

Securing and diversifying the energy mix by distributed generation

Indian electricity distribution utilities are facing increasing pressure to accommodate DER that can help them effectively disperse energy generation close to the points of consumption, bridge demand supply gaps, optimize distribution losses, achieve energy independence, reduce CO2 emissions and contribute to climate change mitigation. Distribution grid management is another area of concern for Indian utilities to monitor health and performance of distribution network components, reduce outages, repair time, maintain voltage level and improve asset management.

Smart grid technologies that adopt advanced information and communication technologies, big data analytics, and other intelligent systems will enhance the capacity of Indian utilities to manage both DER and the distribution network without compromising on the above mentioned goals. Accommodating all generation and storage options (the rise of prosumers), proactive customer engagement, utility DSM, asset optimization, quality power, self-healing and resilient grid are important characteristics enabled through smart grid technologies for Indian utilities.

Smart grid characteristics



Source: DOE, US

Smart grid technologies span the entire grid, from generation through transmission and distribution to various types of electricity consumers. However, in this document, we will discuss only those technologies that are actively being deployed for integration of DER and distribution grid management.

Integration of DER

Efforts to achieve energy independence and reduce CO2 emissions related to electricity generation have led to a significant increase in the deployment of renewable-based DER that are intermittent in nature (variable generation technologies). Among all the renewable-based DER, grid-connected rooftop PV power takes a prominent position due to its availability in abundance. From the technological point of view, solar PV has reached maturity. The challenges faced by utilities and grid operators now have less to do with core technology and more to do with integrating solar PV systems to the grid.

It is expected that all the southern states will be incorporating greater amounts of intermittent generation sources such as rooftop solar PV into their electricity networks in the foreseeable future. As the penetration rates of rooftop solar PV increase over levels of 5% to 20% (from the current levels of much less than 1%), it will become difficult to ensure the reliable and stable management of electricity systems relying solely on conventional grid architecture and limited flexibility. Smart grid technologies will support greater deployment of variable generation technologies by providing grid operators with real-time system information that enables them to manage generation, demand and power quality, thus increasing system flexibility and maintaining stability and balance.

Distribution grid management

Smart distribution grid management systems enable real-time monitoring and display of distribution system components (e.g. distribution transformers, substations) and performance across interconnections and over large geographic areas, helping utilities to understand and optimise distribution system components, behaviour and performance. An ADMS will enable utilities to optimise grid operations and plan works with a real-time network model based on an accurate geodatabase and incorporating data from operational systems such as a SCADA system and outage management system.

Along with real-time visualisation and monitoring of network status, ADMS provides a host of analytical tools that recommend the most optimal device operations, or optionally automate device operations, to maximise network efficiency and reliability. For example, the utility can apply volt/VAR control to reduce feeder voltage automatically with no effect on the consumer. Detailed load profiling and load forecasting based on integrated weather feeds yield network load forecasting for effective renewables integration. Network simulation helps forecast medium-term and long-term load and supports effective development and planning.

ADMS functionality and tools are demonstrating that utilities can effectively manage demand without building large-scale generation.

AMI

AMI is the principal smart grid system that constitutes smart meters, communication systems, computer-based hardware (data storage centres/servers) and software applications to gather and act on real-time information about end use energy in order to improve efficiency and the economics of end-use electricity consumption. Peak load management is the principal function of AMI among several other functionalities. AMI enables demand response by offering a variety of time-based tariffs (e.g. TOD tariff, peak time rebate), demand bidding and direct load control programmes during periods of peak demand in exchange for financial incentives and lower electric bills. Smart meters expand the range of time-based rate programmes that can be offered to consumers along with robust communication of real-time energy usage and pricing information that can make it easier for consumers to change their energy use behaviour and reduce peak period consumption. AMI can help electric utilities and governments defer the construction of new power system capacity (generation, transmission and distribution systems), specifically those reserved for use during peak times.

AMI comprises state-of-the-art electronic/digital hardware and software, which combines interval data measurement with continuously available remote communications. These systems enable the measurement of real-time (in fixed intervals) information and two-way communication of such information between consumers and electric utilities. AMI typically refers to the full measurement and collection system that includes meters at the customer site, communication networks between the customer and electric utility, data reception and management systems that make useful information available to these parties.

The customer is equipped with smart meters that are capable of time-based interval data measurement of electrical energy parameters. These meters also have the ability to transmit the collected data through communication networks. The meter data is received by the AMI host (data acquisition system) and further sent to the MDMS that manages data storage and analysis to provide the information in useful form to the utility. AMI enables two-way communication, so communication from the utility to the meter could also take place.

DR

DR is one of the key DSM applications enabled by smart grid technologies.

In the current scenario, most of the Indian utilities have adopted rate (tariff) induced DR (e.g. TOD tariffs) for HT consumers. Utilities mitigate their exposure to costly power purchase and system imbalance by financially exposing end-use customers to retail tariffs that change over time. Customer exposure to high retail tariffs financially incentivises load curtailment or shifting during peak hours and thereby helps utilities mitigate commercial risk stemming from wholesale power markets. Rate-induced designs are mostly voluntary in nature and customers can choose whether or not to curtail demand. Most of the Indian utilities have adopted TOD tariff structures for HT category consumers—mostly large industrial and commercial consumers. There is tremendous potential for peak load curtailment by introducing TOD tariff structures in the low-tension category by way of smart meters and AMI. Indian utilities can also adopt more dynamic tariff structures such as 'real-time pricing'—a rate in which the price for electricity typically fluctuates hourly, reflecting changes in the wholesale price of electricity, and customers are notified of real-time prices in a day ahead or hour ahead basis.

ADR is the ability to change electricity usage by end-use customers from their normal consumption patterns in response to incentive payments designed to induce lower electricity use at times of high wholesale prices or when system reliability is jeopardised. It is an innovative combination of technology and business relationships with large commercial and industrial consumers that enables utilities to get committed load curtailment when needed by offering attractive incentives.

There is tremendous potential to scale up incentive-based DR programmes, especially among utilities in urban areas and those that predominantly serve large industrial/commercial loads. Indian utilities can also adopt the innovative demand bidding/buy-back mechanism in which customers offer bids to curtail load based on wholesale electricity market prices or an equivalent.

Challenges for AMI roll-out in India

In the present scenario, the following are the challenges for AMI rollout in India.

Functionalities and standards

- What functionalities and design should be adopted?
- Are the current standards comprehensive and relevant to the Indian context?

Economics

- Who will pay for the smart meter and rest of AMI? Utilities or third party?
- Poor financial health of DISCOMs
- Justification of business case? Quantification of benefits?
- Perceived impact on consumer bills

Regulations

- Lack of smart grid regulations—targets for AMI roll-out (despite the existence of model smart grid regulations, the State Electricity Regulatory Commissions are yet to adopt them and notify comprehensive smart grid regulations)
- Data privacy—who all will have access to the meter data? What are norms for access?
- What are the cost recovery options? Should the DISCOM treat AMI traditionally as CAPEX or recover through on-bill charges from the beneficiaries only?
- Are there any options for 'opt out'? Will it be mandatory for consumers?

Capacity and resources

- Manpower limitations for deployment, usage and management in the DISCOMs
- DISCOMs averse to complete outsourcing of AMI solutions

Communication

- Limitations in last mile connectivity (smart meter to DCU/ HES
- Is the license-free RF spectrum adequate considering massive roll-out targets?
- Selection of last mile communication technology?
- Interoperability standards to integrate AMI systems

In summary

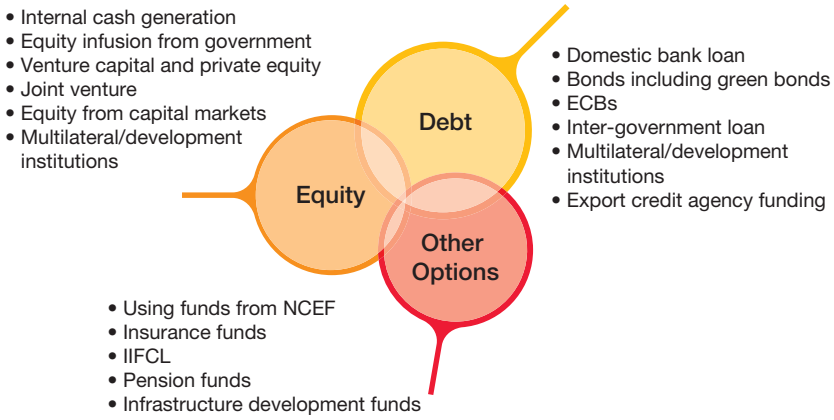
The physical and institutional complexity of electricity systems makes it difficult for the market to implement smart grids on the scale that is needed. Governments, utilities, the private sector and consumers must work together to define electricity system needs and determine smart grid solutions. Large-scale, system-wide demonstrations are needed to determine solutions that can be deployed at full scale, integrating the full set of smart grid technologies with existing electricity infrastructure.

Additionally, greater collaboration (both at the regional, national and international levels) is needed to share experiences with pilot programmes, to leverage national investments in technology development and to develop common smart grid technology standards that optimise and accelerate technology development and deployment while reducing costs for all stakeholders..

Emerging financing trends in the power sector

Financing of power projects around the world has faced various challenges due to large capital requirement, long payback periods, long gestation period, regulatory and policy hurdles, and viability of innovative technology. However, long-term finance for the power sector is critical to achieving the development goals in order to have a high socio-economic rate of return. A good amount of capital has been attracted by India in this space over the last 15–20 years as gauged from the capacity addition. Traditionally, there are three major sources of finance across public and private projects.

Sources of funding



Given the vast requirement of capital, multiple avenues need to be tapped. Funding has been non-recourse or limited recourse largely while depending on the project-specific parameters and at times also on project sponsors/promoters (individual/company as the case may be).

Means of financing

Debt financing

As far as domestic sources are concerned, the current exposure of banks to the power sector is high. Further advances to the power sector will majorly come through an increase in the asset base of banks. Therefore, other sources of debt funding will need to be utilized. However, EXIM banks can fund the projects if the capital goods/services are procured from the partner country. If foreign currency loans are considered, the project needs to have a comprehensive forex risk mitigation policy. Some of the major debt funding options are elaborated upon below.

Commercial bank loans

RBI has placed restrictions on the amount banks can lend to a borrower/group of borrowers. For the case of infrastructure projects (which include power generation), credit exposure to a single borrower may be increased to 20% capital funds for infrastructure. Similarly, in the case of a borrower group, the limit may be increased to 50% and 55% in exceptional circumstances. Under power, only RE has been considered as a priority sector. Further, internal norms on sectoral limits reduce the amount of capital available for the sector. The exposure of banks to the power sector, which is nearing its sector limits, stands at 5,82,269 crore INR.[72] The average lending rate of banks has been around 12% in the recent past. It has also been observed that renewables have taken a major share of the lending portfolio in recent years.

Bonds

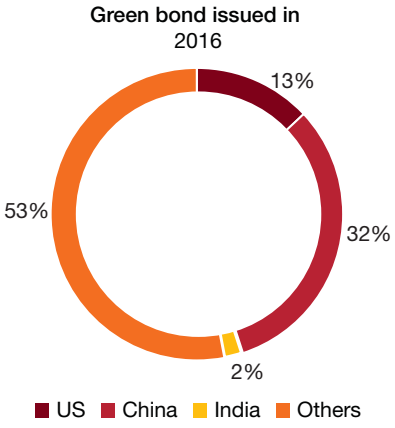
Asset-backed securities are bonds or similar instruments which are backed by the cash flows generated by a project or projects. Asset-backed securities are generally used for refinancing projects that are generating positive cash flows, although they can also be issued in the form of project bonds ahead of construction.

72 Source: Reply to question in Lok Sabha by Power Minister Piyush Goyal in March 2015; information from bank websites, moneycontrol.com

Green Bonds

Green bonds were launched by few development banks such as the European Investment Bank and the World Bank in 2007. However, lately, they have picked up in a big way, where the year 2013 saw participation from corporate sector, which substantially increased in 2014 (global issuance of green bonds in 2013 and 2014 was 11 billion USD and 36.6 billion USD respectively.[73]

- Global issuance of green bonds in the first quarter of 2016 reached 16.9 billion USD and India accounts for 2% of green bonds raised so far in 2016.
- Exim Bank of India issued a five-year 500-million USD green bond, which is India's first dollar-denominated green bond which was oversubscribed 3.2 times.
- In February 2015, a reputed bank raised 1,000 crore USD via a 10-year bond, which was oversubscribed twice.
- An IPP in India, issued a 550-million USD, five-year bond with an 8% coupon in 2014.
- A wind developer based out of Hyderabad raised 70 million in debt from private equity player.
- IFC issued green masala bonds for 3.15 billion INR (49.4 million USD) (5-yr, 6.15%, AAA) with proceeds used to invest in a reputed bank's domestic green bond.



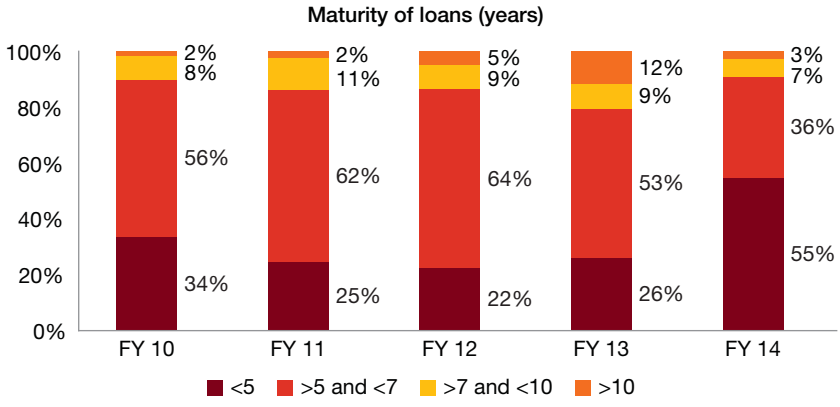
Source: Bloomberg

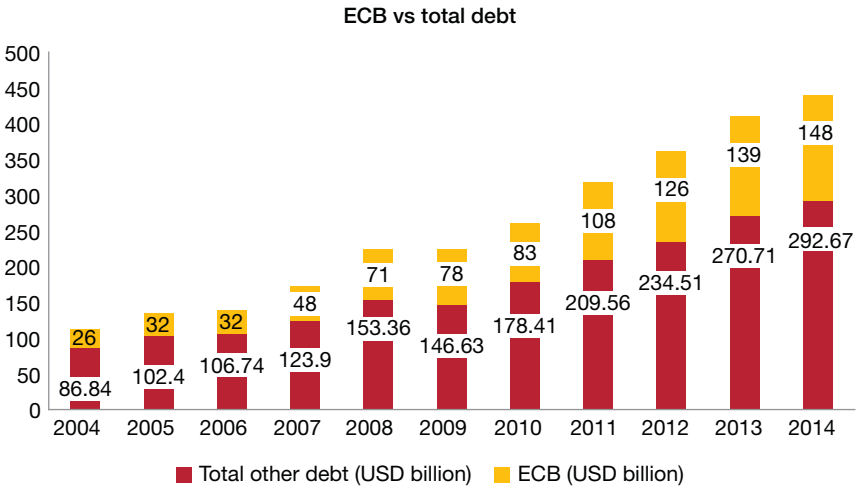
Masala bonds

A masala bond is a rupee-denominated bond sold overseas. Such bonds allow an issuer to raise funds in the overseas market without taking on the currency risk typically associated with foreign currency-denominated bonds or loans. A large renewable energy company raised 500 crore INR by privately placing rupee-denominated and is planning to raise about 400 million USD through a dollar bond issue. A large public sector unit company has also raised 2,000 crore INR at approximately 7.5% through issuance of green masala bonds.

ECBs

In India, 33 billion USD and 26 billion USD were raised through ECBs in FY 2014 and FY 2015 respectively. The major source of ECBs has been non-resident foreign banks that has accounted for around 60% of the lending. Non-resident Indian banks extended about a fifth of the total lending. A majority of the ECBs raised by PSUs are denominated in US dollars. Loans from commercial institutions and banks have a spread of 120–350 bps over the six-month LIBOR (~0.5%). A guarantee by GoI would help reduce borrowing costs. FY 2014 witnessed a sharp increase in the proportion of short-term loans due to highly fluctuating rupee. The tenor preference has been changing over time and is based on a company's view of the exchange rate and costs of hedging.





Source: India's external debt: A status report, 2013-14, Ministry of Finance, August 2014

73 Source: http://www.sebi.gov.in/cms/sebi_data/boardmeeting/1453349548574-a.pdf

Multilateral and export credit agencies

The majority of the debt from multilaterals has been from the World Bank (and related entities) and ADB. These multilaterals have assisted in shaping the sector by financing the projects during the sector's infancy. Other focused agencies include the DFID and OECD, which have participated in driving key policy-level initiatives and pilot programmes in the country. Some of the active EXIMs focussed in India are US, Japan, France, Russia and Korea. Export credit rates are likely to be linked to the OECD CIRRs, which are specified on a monthly basis. The maximum duration of a loan is 18 years.

Equity financing

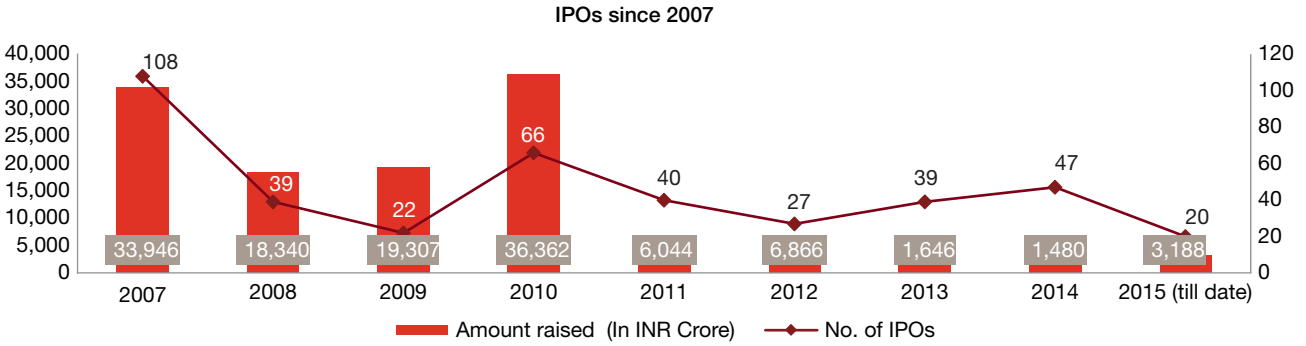
While the developmental/ multilaterals have focussed on the initial stage of projects, e.g. IPPs conceived and developed in late 1990s/early 2000s, whereas PE firms were active in funding the next set of projects implemented under the new act. There are couple of development agencies including domestic firms like NTPC Ltd., Tata and Reliance have relied on internal cash accruals in setting up the next set of projects. In transmission and distribution, it was largely public money which was spent on capacity augmentation before UMTPs and DFs started attracting private capital. Some of the major equity funding options utilised by the Indian utilities are described here.

PE

PE has largely driven conventional power generation till about 2012. Currently, there has been PE interest in renewable projects and a few transmission projects due to lower risks and assured returns due to FiT. A coal based thermal power company was able to raise funds from PE Fund. A leading global investment banker invested around 100 crore INR in a renewable energy company. A reputed bank's PE arm also invested 500 crore INR for a minority stake for a private player's transmission assets. Recently, even a multilateral agency has made 50 million USD in equity investment on a 13.3% equity stake in a renewable energy company. The multilateral agency had also invested 30 million USD in a renewable energy company.

Capital markets – IPO

Listing of a company through IPOs provides greater access to international capital, expertise and industry partners. The power sector in India has seen many such successful listings on the Indian exchange markets as well as foreign exchanges like the AIM on the London Stock Exchange, NASDAQ, etc. Market conditions would play a crucial role in this regard. While close to 1 lakh crore INR was raised during 2007–2010 from Indian capital markets, in the last four years, less than 20,000 INR has been raised through the IPO route.



Source: NSE, BSE and Moneycontrol

Other emerging financing options

Yieldco

Yieldco is the term used to refer to publicly traded companies formed to own operating power plants and dividend out the cash flows generated. The first yieldco was floated in 2013. This financing strategy seems to have strengthened its appeal in the eyes of both investors and renewable energy companies, especially in the US/Canada where about 15 yieldcos are listed. In India, SEBI came up with InvIT Regulations, 2014, to promote various infrastructure projects, especially power projects along the same lines as yieldcos. Also, insurance and pension funds can invest through these InvIT vehicles.

The yieldco IPO of Abengoa Yield raised $721 million. The parent company sold its first power plants – 131MW of solar and 50 MW of wind – to the yieldco and announced a secondary offering for 9.2 million shares in Abengoa Yield.

Insurance companies

The life insurance premium market in India has expanded at a CAGR of 15.3%, from 14.5 billion USD in FY 2004 to 60.3 billion USD in FY 2014. The non-life insurance premium market rose at a CAGR of 16.3%, from 3.4 billion USD in FY 2004 to 11.7 billion USD in FY 2014. In September 2013, the IRDA of India allowed life and general insurance companies to invest up to 20% (increased from 10%) of fund value in infrastructure investments. It should be noted that investment in the IDF will be considered as investment in the infrastructure sector for insurance companies. Insurance funds are generally risk averse and would be interested only with reasonable certainty in cash flows.

Subordinate debt from IIFCL

Under the extant rules, up to 10% of the project costs can be supported by IIFCL in the form of subordinated debt that normally functions as quasi-equity. A high level committee on financing infrastructure suggested that IIFCL should provide subordinated debt for up to 10% of the approved project costs with a moratorium of at least 12 years on repayment of principal.

Pension funds

Pension funds along with insurance funds (both in Indian and foreign) could provide an additional source of funding going forward. As per the PFRDA Act, the investment guidelines shown below w.e.f. 10 June 2015 are as follows:

Investment mandate	Government securities and related investments	Debt instruments and related investments	Short-term debt instruments and related investments	Equities and related investments	Asset-backed, trust structured and miscellaneous investment
Percent	45-50%	35-45%	5%	5-15%	5 %

Source: PFRDA and IREDA

IDFs

	NBFC	Mutual funds
Structure	Like banks: funded with equity and debt, but instead of bank deposits, NBFCs rely on bonds	Conceptually like PE funds: Issue periodic capital calls and return capital at a scheme's maturity
Maturity	Going concerns	Finite tenor of 5–15 years
Eligible assets	PPPs with tripartite agreements and at least 1 year of operations	Infrastructure at any life cycle stage 90% infrastructure debt instruments; 10% money market instruments and infrastructure equity and subordinated debt
Likely sectors	Roads and to a lesser extent airports and ports	Roads, airports, ports, water, power generation, power transmission, telecommunications, social infrastructure, etc.
Minimum credit rating of investments	Domestic BBB	30% limit on unrated or rated below domestic BBB (50% with approval of the asset management company's trustees and board)
Regulator sponsors	RBI and infrastructure finance companies	Securities and Exchange Board of India Mutual funds or companies in the infrastructure finance sector
Maximum loan takeout	85% of the project cost under the concession agreement	No limit

A number of new types of instruments have been introduced, mostly in the area of infrastructure under debt instruments and asset-backed funds. Over the last year, the government has also invited foreign pension funds to participate in India's infrastructure sector. IDFs would essentially act as vehicles for refinancing the existing debt of infrastructure companies, thereby creating fresh headroom for banks to lend to fresh infrastructure projects. IDF-NBFCs would take over loans extended to infrastructure projects which are created through the PPP route and have successfully completed one year of commercial production. IDFs (both NBFCs and mutual funds) are likely to become a key source of financing infrastructure projects going forward.

Funding through green energy cess

The NCEF was formed for funding research and innovative projects in clean energy technologies. Further, the clean energy cess was doubled from 100 INR per tonne to 200 INR per tonne in Union Budget 2015–16. Therefore, the yearly collection is also expected to increase. Further, equity from NCEF can also be used as 'bridge equity'. As per a PIB release, the corpus transferred to the Clean Energy Fund during the last four years is mentioned here.

Year	Funds (crore INR)
2011–12	1,066.46
2012–13	1,500.00
2013–14	1,650.00
2014–15	4,700.00

Source: PIB release

Acronyms

Acronym	Description
ACW	Auxiliary cooling water
AD	Accelerated depreciation
ADB	Asian Development Bank
ADMS	Advanced Distribution Management System
ADR	Automated DR
AFBC	Atmospheric Fluidised Bed Combustion
AHP	Ash handling plant
AIM	Alternative Investment Market
AMI	Advanced Metering Infrastructure
AP	Andhra Pradesh
APERC	Andhra Pradesh Electricity Regulatory Commission
APGENCO	Andhra Pradesh Power Generation Corporation Limited
APTRANSCO	Transmission Corporation of Andhra Pradesh
BSE	Bombay Stock Exchange
CAES	Compressed Air Energy Storage
CAGR	Compound Annual Growth Rate
CAPEX	Capital expenditure
CBFC	Circulating Fluidised Bed Combustion
CBIP	Central Board of Irrigation and Power
CdTe	Cadmium-telluride
CEA	Central Electricity Authority
CEIG	Chief Electrical Inspector to Government
CEP	Condensed extraction pumps
CERC	Central Electricity Regulatory Commission
CFD	Computation flow dynamics
CHP	Coal handling plant
CIGS	Copper-indium-gallium-selenide
CII	Confederation of Indian Industry
CIL	Coal India Limited
CIIR	Commercial interest reference rates
CPV	Concentrator Photovoltaics
CSE	Centre for Science and Environment
DBFOO	Design, Build, Finance, Own and Operate
DCU	Data Concentrator Units
DER	Distributed Energy Resources
DF	Distribution Franchisee
DFID	Department for International Development
DISCOM	Distribution companies
DOE, US	Department of Energy, United States
DR	Demand Response
DSM	Demand side management
DVC	Damodar Valley Corporation
ECB	External commercial borrowing
EIA	Energy Information Administration
EMS	Energy consumption monitoring
EoDB	Ease of doing business
ERP	Enterprise Resource Planning
ESP	Electrostatic precipitator
EUI	Energy Unlimited Inc.

Acronym	Description
EVA	Ethylene vinyl acetate
EXIM	Export–Import
FBC	Fluidised bed combustion
FGD	Flue-gas desulfurisation
FiT	Feed-in tariff
GFD	Geophysical fluid dynamics
GoI	Government of India
GPS	Global positioning system
GWEC	Global Wind Energy Council
HES	Head end system
HJT	Heterojunction technology
HP	High pressure
HPBFP	High pressure boiler feed pump
HRES	Hybrid renewable energy system
HT	High tension
HVAC	Heating, ventilating and air conditioning
ICE	Industrial Corridors of Excellence
ICT	Information and communication technology
ID	Induced draft fan
IDF	Infrastructure Debt Fund
IEA	International Energy Agency
IFC	International Finance Corporation
IIFCL	India Infrastructure Finance Company Limited
INDCs	Intended Nationally Determined Contributions
InvIT	Infrastructure investment trusts
INR	Indian Rupees
IP	Intermediate pressure
IPO	Initial public offerings
IPP	Independent power producer
IRDA	Insurance Regulatory and Development Authority
IREDA	Indian Renewable Energy Development Agency
ISTS	Inter-state transmission system
JNNSM	Jawaharlal Nehru National Solar Mission
KERC	Karnataka Electricity Regulatory Commission
KPCL	Karnataka Power Corporation Limited
KPTCL	Karnataka Power Transmission Company Limited
KSEBL	Kerala State Electricity Board Limited
KSPDCL	Karnataka Solar Park Development Company Ltd
kV	kilovolt
LED	Light emitting diode
LGBR	Load Generation Balance Report
LIBOR	London Interbank Offered Rate
LPG	Liquefied petroleum gas
MDMS	Meter data management system
MNRE	Ministry of New and Renewable Energy
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MoU	Memorandum of understandings
MVA	Mega volt ampere
NASDAQ	National Association of Securities Dealers Automated Quotations
NBFC	Non-Banking Financial Company
NCEF	National Clean Energy Fund
NGT	National Green Tribunal

Acronym	Description
NITI	National Institution for Transforming India
NLDC	National Load Despatch Centre
NREDCAP	New and Renewable Energy Development Corporation of Andhra Pradesh Ltd.
NSE	National Stock Exchange of India Limited
NSM	National Solar Mission
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
PA	Primary air
PCKL	Power Company of Karnataka Limited
PDR	People's Democratic Republic
PE	Private equity
PERC	Passivated Emitter Rear Cell
PFBC	Pressurised fluidised bed combustion
PFRDA	Pension Fund Regulatory and Development Authority
PGCIL	Power Grid Corporation of India Limited
PHS	Pumped hydro storage
PI	Performance improvement
PIB	Press Information Bureau
PID	Potential induced degradation
PM	Particulate matter
PPA	Power purchase agreement
PPP	Public Private Partnership
PSU	Public sector unit
PV	Photovoltaics
RBI	Reserve Bank of India
RE	Renewable Energy
RF	Radio frequency
RLDC	Regional Load Despatch Centre
RPO	Renewable purchase obligation
SCADA	Supervisory control and data acquisition
SCR	Selective catalytic reduction
SEBI	Securities and Exchange Board of India
SECI	Solar Energy Corporation of India
SIPCOT	State Industries Promotion Corporation of Tamil Nadu Ltd
SLDC	State Load Despatch Centre
SMES	Superconducting magnetic energy storage
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TANTRANSCO	Tamil Nadu Transmission Corporation Limited
TNREDCL	Telangana New and Renewable Energy Development Corporation Limited
TOD	Time of day
TSGENCO	Telangana State Power Generation Corporation Limited
UAE	United Arab Emirates
UDAY	Ujwal DISCOM Assurance Yojana
UMPP	Ultra mega power projects
USA	United States of America
USD	Unites States Dollar
VAR	Volt-amp reactance
VAT	Value added tax
VFD	Variable frequency drive
VGF	Viability gap funding
VSAT	Very small aperture terminal
WTG	Wind turbine generator

About CII

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has over 8000 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 200,000 enterprises from around 240 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

The CII theme for 2016-17, **Building National Competitiveness**, emphasizes Industry's role in partnering Government to accelerate competitiveness across sectors, with sustained global competitiveness as the goal. The focus is on six key enablers: Human Development; Corporate Integrity and Good Citizenship; Ease of Doing Business; Innovation and Technical Capability; Sustainability; and Integration with the World.

With 66 offices, including 9 Centres of Excellence, in India, and 9 overseas offices in Australia, Bahrain, China, Egypt, France, Germany, Singapore, UK, and USA, as well as institutional partnerships with 320 counterpart organizations in 106 countries, CII serves as a reference point for Indian industry and the international business community.

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