2020

INDIA'S **POWER** OUTLOOK

VOLUME 2

THE ROAD TO CLEAN ELECTRICITY

VASUDHA FOUNDATION
Green ways for a good earth!

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

The Power Outlook Series developed by Vasudha Foundation with support from Shakti Sustainable Energy Foundation provides an overview of the current status of India's power sector with a focus on significant and emerging developments. The series aims to develop a more informed understanding of the power sector and act as a tracking tool for stakeholders. 'The Road to Clean Electricity' is second in the series of India Power Outlook Reports.

Volume 2 provides an overview of renewable energy (RE) progress in India and assesses its impact across the power sector value chain. It covers the present and future status on RE generation capacity, transmission planning, grid integration practices and demand requirements. The Volume further details the existing status and roadmap for energy storage in India.

The Volume 1 of the series looked at the status of the power sector by capturing its latest trends and transitions. The report can be found here.

The Volume 2 further builds on the first version by deep-diving on different aspects of India's trajectory towards meeting one of its most ambitious 175 GW target.

All the data pertains to 31st March 2020, unless otherwise mentioned.

CONTENTS

1 OVERVIEW

India with its population of over 1.36 billion (United Nations;2020)[1], is one of the fastest growing economies in the world. It is the third largest emitter of carbon dioxide emissions after China and the United States of America. With its rising population, rapid development and widespread urbanization, the emissions curve is only expected to get steeper under the business as usual scenario. Hence, the country is taking several measures to decarbonize its power sector contributing to almost 70% of the total emissions and having one of the highest grid emission intensities[i] (Goel, 2019)[2] in the world. The 175 GW RE target by 2022 and its rapid progress in the past few years showcases India's unwavering commitment towards a low-carbon future. India has further ramped up its appetite for clean energy by announcing ambitious targets such as 455 GW of renewable energy capacity addition by 2030, 30% electric vehicles (EVs) sales by 2030 and 50 GW of lithium-ion battery manufacturing in India[ii] by 2024 (Gupta, 2019)[3].

The year 2020 marks the beginning of a new decade for power sector reforms characterized by better demand management, cleaner energy mix and competitive market operations despite the temporary setback expected due to COVID-19. The recent Electricity Amendment Bill 2020 sets the stage upfront for the beginning of a more reformed sector threaded with the principles of sustainability, viability and transparency. India has commendably provided electricity access to all its households and now, gearing up efforts to ensure 24*7 power to all by promoting off-grid electrification solutions, real time monitoring of supply at the end-user level, network enhancement etc. With an impressive track record of adding 51.25 GW of renewable capacity since 2015, there is a greater priority for system integration and grid balancing for accommodating rising shares of wind and solar. Enhanced efforts are underway to enable greater supply flexibility by building a flexible coal fleet, expanding pumped hydro and gas capacities and exploring new ancillary services. A higher demand side flexibility via demand response and decentralization, penetration of smart appliances and EVs will further help in creating a more reliable and resilient grid.

Another key innovation that is expected to change the way power sector works is energy storage systems. Either grid scale or behind the meter, batteries have emerged as the most lucrative storage technology for short term flexibility due to its unique capability of quick absorbing, retaining and providing energy whenever needed. While battery storage continues to be a costly proposition in India, the Government has been issuing pilots and tenders across the country for testing its applicability and use.

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[i] Almost 50% higher than the global average of 485 gCO_2/ kWh.
[ii] The country currently imports almost all its lithium-ion batteries and cells.

Amidst all these positive developments and a favorable future scenario, the COVID-19 pandemic has adversely impacted the Indian economy. While the quantum of losses to the power sector is yet to be assessed, the ripple effect of a subsequent economic slowdown will be seen on the RE supply chains, demand growth and overall target realization. However, the COVID-19 induced setback is also an opportunity for India to move faster towards a more inclusive and more sustainable power sector that will be less carbon intensive and more equitable.

INDIA POWER SECTOR
A Snapshot

GENERATION

370 GW (Gigawatts)
Total installed capacity

1,385 BUs (Billion units)
Overall generation

87.03 GW
Installed RE capacity (excluding large hydro)

132.72 GW
Total Installed RE capacity

56%
Average thermal PLFs (provisional values)
(excluding gas-based plants)

TRANSMISSION

4,25,071 ckm (Circuit kilometers)
Number of transmission lines

9,67,893 MVA (Mega Volt-Ampere)
Substation transformation capacity

4635.2 ckm
Number of transmission lines completed under the Green Energy Corridor
(as of 5th July 2019)

17,757 MVA
Capacity of transmission substations completed under the Green Energy Corridor (as of 5th July 2019)

DISTRIBUTION

1,291,010 MUs
Total energy requirement

1,284,444 MUs
Total energy available

1,83,804 MW
Total peak demand

1,82,533 MW
Total peak met

18.93%*
Average AT&C loss

0.42 Rs/unit*
ACS - ARR gap

* As per UDAY Dashboard, as on 19th May, 2020

CONSUMPTION

~21.44 Crores
Number of households electrified

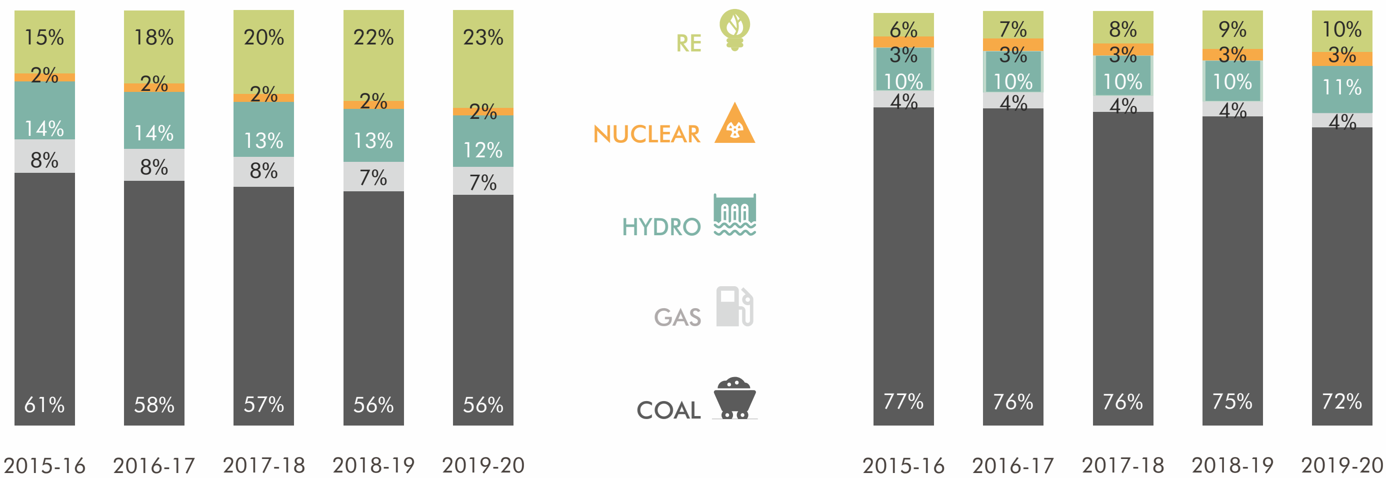
1,181 kWh
Per capita electricity consumption
(provisional as on 2018-19)

42% (Industry sector as on 2017-18)
Percentage electricity share by the highest demand sector

2 GENERATION

Installed Capacity Mix
In last 5 years

Electricity Generation Mix
In last 5 years



Source:
CEA, MoP, 2020. Executive Summary. https://bit.ly/2BUwdpb
CEA, 2019. Growth of Electricity Sector in India from 1947-2019. https://bit.ly/37lmkMF

Source:
CEA, 2019. Growth of Electricity Sector in India from 1947-2019. https://bit.ly/37lmkMF
CEA, MoP, 2020. Executive Summary-03. https://bit.ly/2BUwdpb
NPP, MoP, 2020. Energywise-Performance Status All India. https://bit.ly/2zmp8gf
NPP, MoP, 2020. Energy Generation, Programme and Plant Load Factor. https://bit.ly/2XQy2Ms
NPP, MoP, 2020. Energywise-Performance Status All India. https://bit.ly/30vjp2E

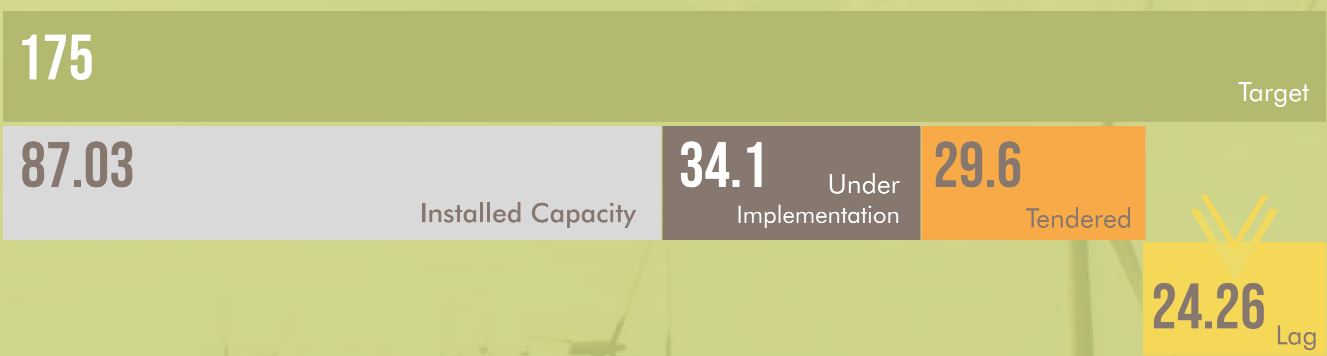
The country's power picture is set for a major change in the electricity mix with rising shares of wind and solar.

In the past five years, the installed capacity addition has increased from 305 GW in 2015-16 to 370 GW in 2019-20 at a CAGR of 4%. Renewable energy is the fastest growing source of energy, accounting for more than 50% (51.25 GW) of capacity addition since March 2015.

Likewise, the electricity generation has increased from 1,168 BUs in 2015-16 to 1,385 BUs in 2019-20 at a CAGR of 3.5%. The RE share in overall electricity generation mix has risen from 6% in 2015-16 to 10% in 2019-20.

Despite these developments, thermal-based power plants continue to meet the bulk of the power requirement of the country.

India's Progress Towards Achieving 175 GW RE by 2022 (in GW)



Source:
MNRE, GoI, 2020. Press Information Bureau. https://bit.ly/2XN9CTY
CEA, MOP, 2020. Installed Capacity. https://bit.ly/3dsgpqM

While the 175 GW target appears daunting, the increased pace of capacity addition and favorable policy scenario shows the Government's serious intent towards a low carbon future. As on 31st March, 2020, the country had achieved (installed, under implementation and tendered) a total of 150 GW of renewable energy, only 14% less than the existing target.

Considering source-wise RE targets, almost all of the hydro and biomass have already met their planned commitments. However, the actual installed solar and wind capacity by March 2020 is only at a 34.6 GW and 37.6 GW (Authority, 2020)[4] respectively, with solar more than 60% away from the targeted capacity (in the next graph) to be achieved by 2022.

According to the CEA reports, India has installed 9.4 GW (Authority, 2020)[5] RE capacity in 2019-20, against 8.6 GW (CEA, 2018)[6] in 2018-19. In 2016-17, 11.3 GW (CEA, 2018)[7] was added.

Hence, there is some level of success, but a lot needs to be done to maintain the momentum and ensure timely action.

Over the past few months, there has been a slowdown in capacity addition due to structural issues resulting in tepid participation and auction delays. The COVID-19 outbreak has further added to the challenges due to interruption in procurement of raw material, supply chain bottlenecks and dwindling project financing.

2.1 Renewables on the Rise

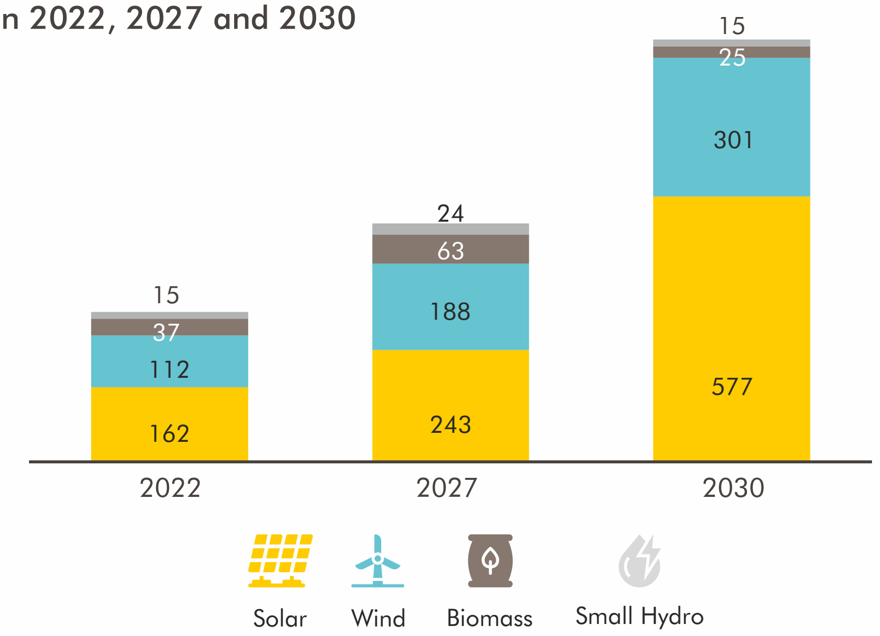
Future Renewable Energy Target Trajectory

RE (GW)	by Dec 2022	by 2026-27	by 2029-30
	175	275	455

The country has set massive targets to increase its solar capacity from 100 GW in 2022 to 150 GW by 2026-27 and similarly, wind capacity from 60 GW in 2022 to 100 GW by 2026-27.

Source:
MNRE, 2020. Public Information. https://bit.ly/37njiYn
POSOCO, 2019. Large Scale Grid Integration of Renewable Energy in India. https://bit.ly/2MIK3NA

Projected RE Generation Trajectory (in BU)
in 2022, 2027 and 2030



RE generation is expected to rise by almost seven times in 2030 from 2020 existing levels.

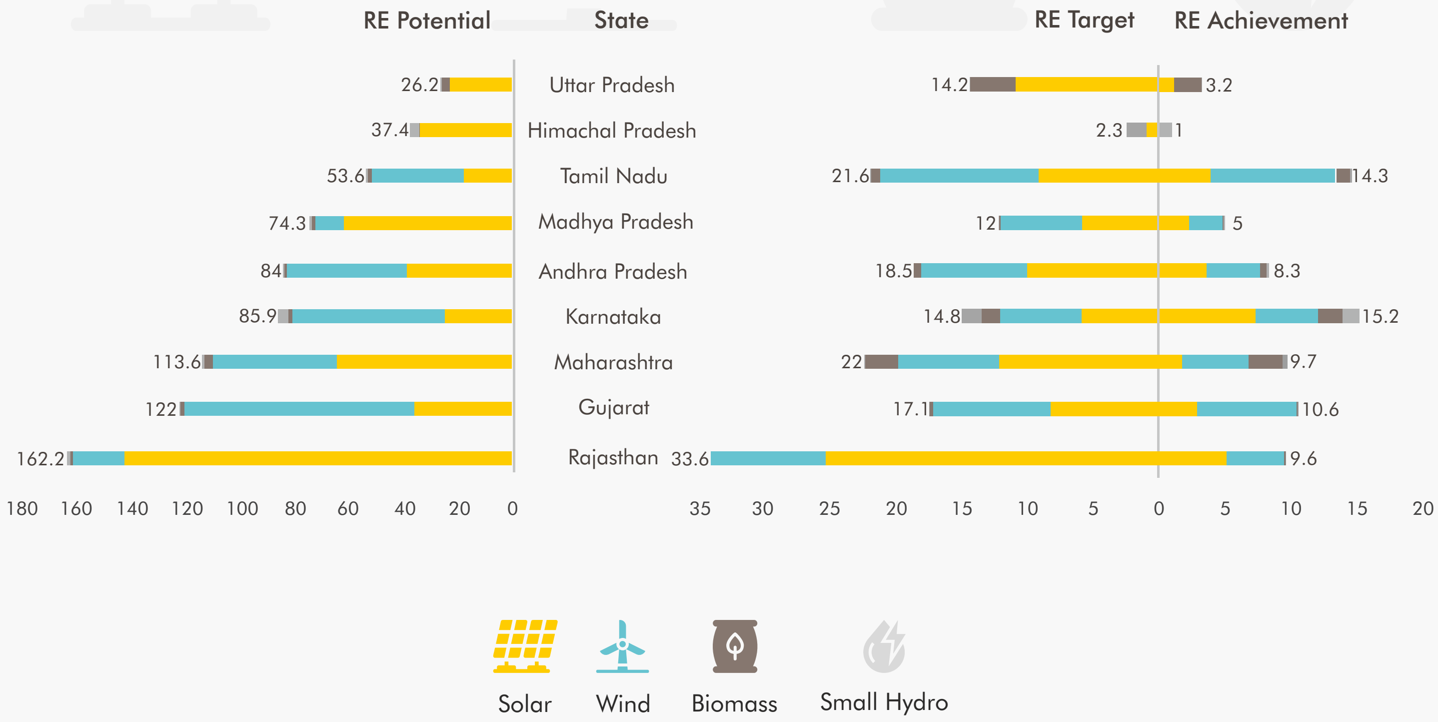
Source:
CEA, 2018. National Electricity Plan, Volume-I. https://bit.ly/2BUnEuw
CEA, 2019. Draft Report on Optimal Generation Capacity Mix for 2029-30. https://bit.ly/30pmUrw

The next decade is going to ensure a pivotal position for India in the global renewable-energy leadership. The testimony to this lies in the numbers below:

- As per the above targets, the share of electricity generated from intermittent renewables would show a remarkable increase from the 2020 level of 10% to ~20%[8], 24% and 37% in FY 2022, FY 2027, and FY 2030, respectively.
- Accordingly, the share of coal-based electricity generation would drastically reduce from present levels of ~71% to 50% in 2029–30.
- Considering the shares from large hydro and nuclear, India is all set to exceed its INDC target of 40% share of non-fossil fuel-based power capacity in 2030.

2.2 RE Deep-dive at the State Level

RE Potential, 2022 Target and Achievement (in GW)



Source
MNRE, 2020. State-wise Details of Estimated Potential of Renewable Energy in India. https://bit.ly/3dMbsdj
MNRE, 2020. State-wise Break-up of RE target (175 GW) to be Achieved by 2022. https://bit.ly/2B1tBVR
MNRE, 2020. State-wise Installed Capacity of Grid Interactive Renewable Power. https://bit.ly/3dRDIRj

While Karnataka has already surpassed its target achievement, states like Uttar Pradesh and Rajasthan are far behind meeting their targets.

Interestingly, Rajasthan represents the state with the highest RE potential in the country followed by a 33.6 GW target achievement by 2022.

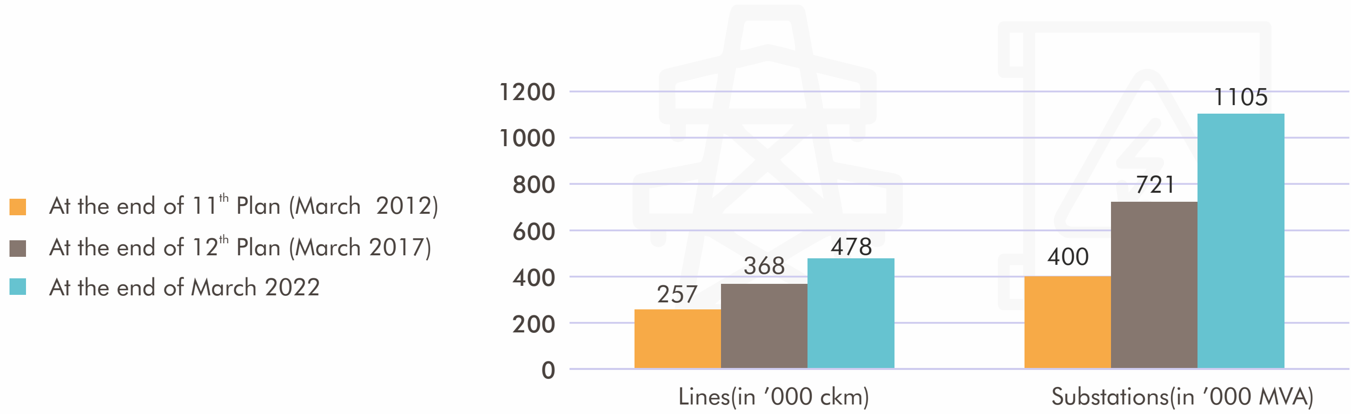
Himachal Pradesh, Madhya Pradesh, Andhra Pradesh and Maharashtra are yet to achieve 50% of their set targets.

3 TRANSMISSION

A renewable dominant system will need an expansive transmission system and grid modernization techniques to accommodate a large, variable and flexible grid. A robust transmission network will enable RE evacuation and ensure smooth transfer of surplus power across regions and states. Accordingly, the 175 GW RE target is leading to power networks in India towards a new phase of network augmentation and grid integration.

3.1 Network Augmentation

Transmission Network Adequacy



Source:
CEA, 2019. National Electricity Plan, Volume-II. https://bit.ly/2zmd7Yb

The National Electricity Plan (NEP), 2019 envisages a network enhancement for the 2012 to 2022 decade at a CAGR of 6% and 11% for the transmission lines and substation capacity respectively.

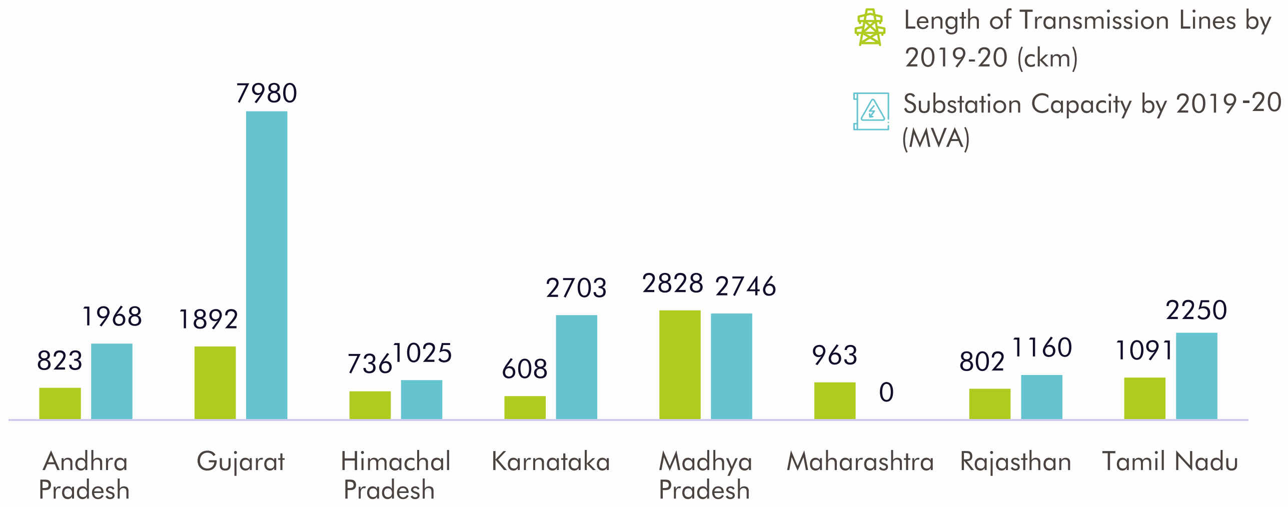
It has further estimated an additional 1.1 lakh ckm of powerlines and 3.8 lakh MVA of transformation capacity to adequately meet the projected demand in 2021-22.

The total inter-regional transmission capacity is expected to increase almost four times since 2012 to 118 GW in 2022, thus providing a wider balancing area. Over the years, the system has seen infrastructure enhancements at higher voltage levels. Such augmentation increases the capacity of the transmission network to carry bulk power over longer distances, thus minimizing losses and improving grid reliability.

While this is progressive, the year 2019-20 witnessed drastic reductions in the transmission lines addition compared to the previous years. This is reportedly attributed to the decrease in RE capacity addition and uptake by states.

GREEN ENERGY CORRIDOR

State-wise Break-up of the Approved Intra-State Transmission Planned under the GEC by 2019-20



Source:
MoP-GOI, 2019. Annual Report 2018-19. https://bit.ly/2MKoWdx
MNRE, 2019. Green Energy Corridor. https://bit.ly/3hdOdLi

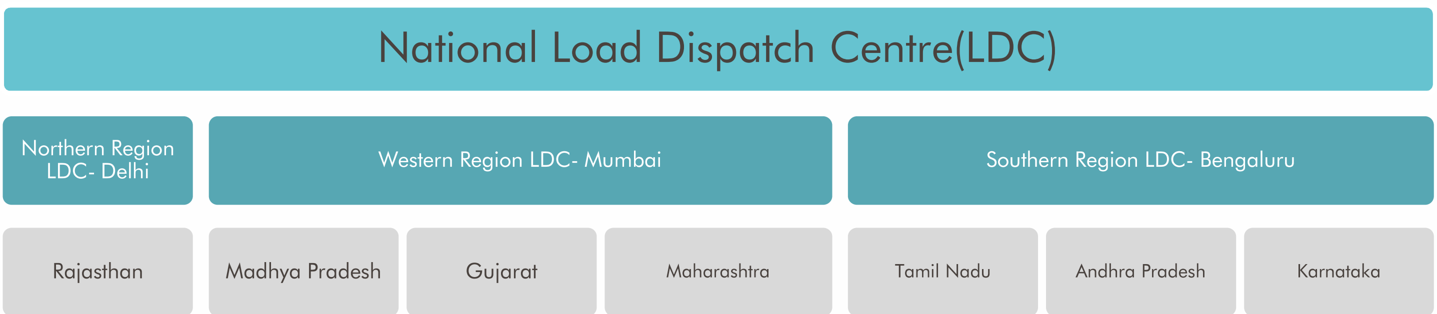
India has been augmenting its transmission infrastructure most notably through the two phases of the Green Energy Corridor -

In 2012, GEC Phase I was approved to establish transmission infrastructure at interstate and intrastate levels in eight renewable rich states for integrating a total of 33 GW RE capacity expected to come online during 2012-17. The second phase announced in 2015 looked at building the transmission infrastructure for the 40 GW of solar parks expected to be built in meeting the 175 GW RE target.

All the 11 Renewable Energy Management Centre's (REMCs) planned under the GEC were recently commissioned in February 2020 (Ramesh, 2020)[9] to facilitate grid integration of large-scale RE.

A total of 9,400 ckm of transmission lines and 19,000 MVA of substation capacity under the Intrastate transmission; and 3,200 ckm of transmission lines and 18,000 MVA of substations under Interstate transmission system were planned to be built by March 2020 (MNRE, 2019)[10].

List of 11 REMCs



Significant delays in the form of target achievement and fund allocation are observed under both phases of the Green Energy Corridor more specifically at the Intrastate level (MNRE, 2019)[11] and (CEA, 2018-19)[12]. This will further result in lack of power evacuation and forced RE curtailments thus slowing India's clean energy ambition.

3.2 Grid Integration

The need for RE integration is a function of various factors such as system size, share of variable renewable energy, grid flexibility and market design. In 2017, RE generation in India accounted for only 5% of the total electricity generation, occupying the eighth lowest share compared to other countries. This is expected to rise to ~20% by 2021-22. Global experiences especially from Ireland, Germany, United Kingdom indicate that grid integration is far easier at 15-20% RE penetration levels.

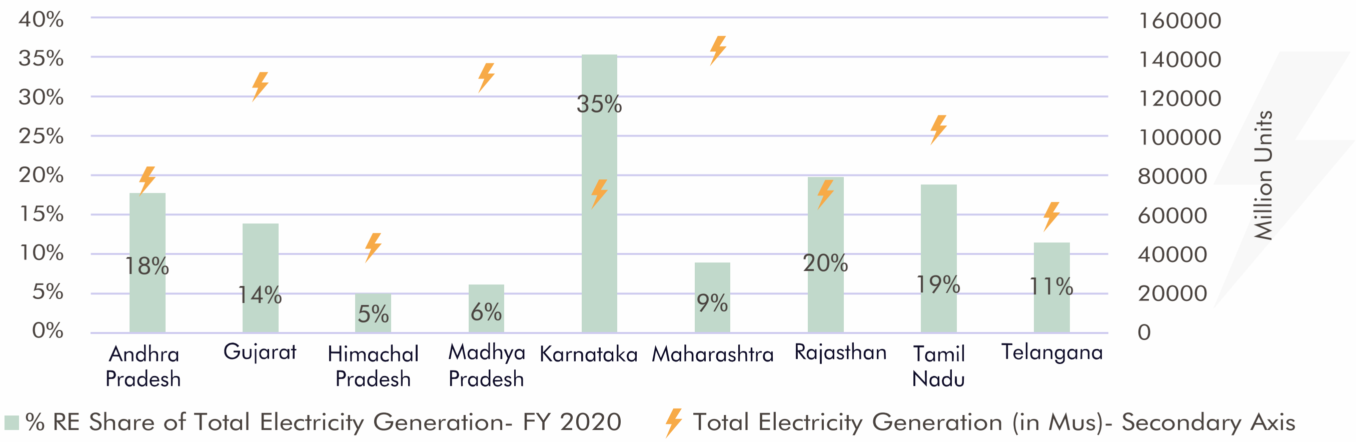
"The Greening the Grid report by POSOCO and NREL concludes that integrating 100 GW of solar and 60 GW of wind can be achieved at a curtailment of only 1.4 per cent without fast-ramping infrastructure such as batteries, pump-hydro or gas-based plants"

Percentage RE Share of Total Electricity Generation- FY 2022

SCENARIO	SOLAR AND WIND PENETRATION RATE OF ANNUAL GENERATION	RE CURTAILMENT
NO NEW RE	4.8%	0.0%
20 GW Solar + 50 GW Wind	12%	0.0%
100 GW Solar + 60 GW Wind	22%	1.4%
150 GW Solar + 100 GW Wind	33%	8.3%

Source:
Ministry of Power, 2017, Greening the Grid- Regional Study Report. https://bit.ly/3dT9szX

Percentage RE Share of Total Electricity Generation- FY 2020



Source:
CEA, 2020, Monthly Renewable Energy Generation Report. https://bit.ly/2AZEffL
CEA, 2020, Daily Renewable Energy Generation Report. https://bit.ly/2UybNIX
CEA, 2020, Daily Renewable Energy Generation Report. https://bit.ly/2UtS78Y

According to IEA, out of the six levels of grid maturity, India qualifies for the second phase under grid integration and hence poses only a minor to moderate impact on system operation. This is because currently India has a lower percentage ratio of variable RE to total generation. But at a state level, this picture is continuously changing with few states already facing grid integration challenges due to its higher RE generation.

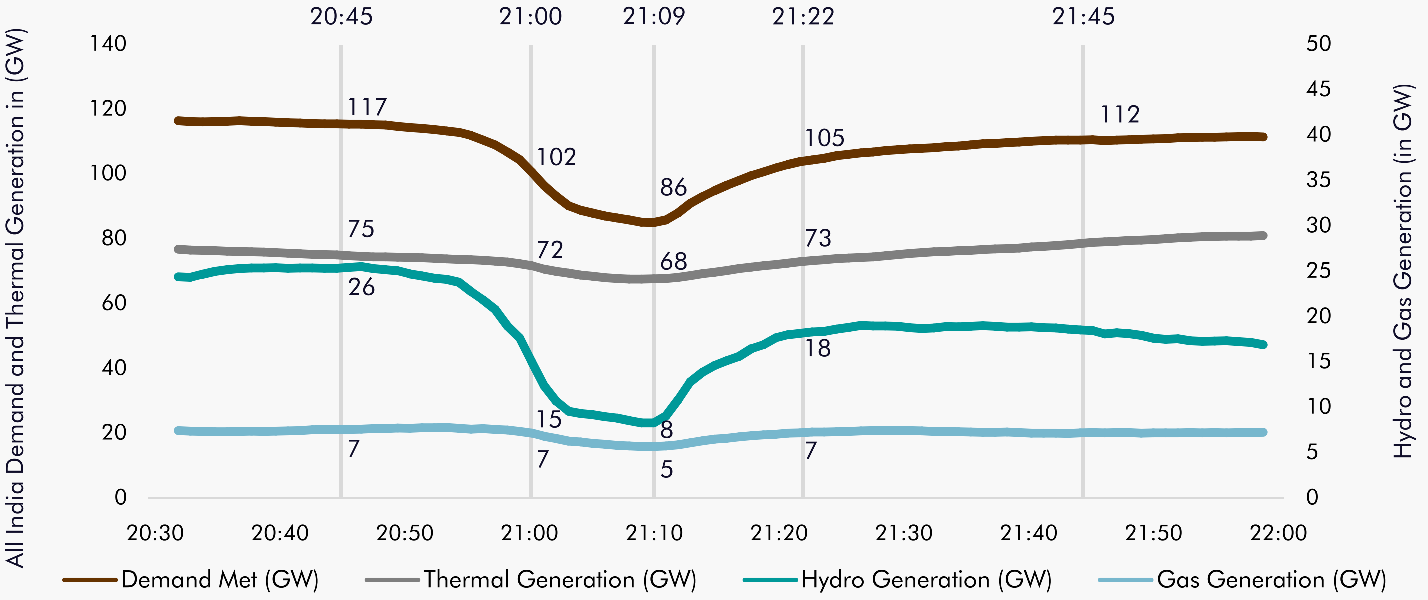
RE curtailment is already a big issue with high RE generating states like Karnataka, Andhra Pradesh and Tamil Nadu.

2022 RE integration Analysis for Six High-RE states

State (Estimated state-wise installed RE capacity in 2022)[1]	Characteristic	Integration Capacity in 2022	Annual wind and solar curtailments (%)	Average projected daily peak curtailment in July (Approx)	Import/ Export status	Key Reasons for RE curtailment
Andhra Pradesh (19 GW)	*Highest RE penetrations of any state*	*Wind and solar produce 51% of its total generation and meet 56% of load.*	*5.6%*	*4.7 GW*	*Net exporter*	*Availability of large amounts of low-cost RE*
Gujarat (21 GW)	*Highest RE generating state in the Western region*	*Wind and solar produce 35% of its total generation and meet 35% of load.*	*2.4%*	*0.8 GW*	*Net exporter*	*Transmission congestion*
Karnataka (17 GW)	*Highest RE curtailment as a percent of available capacityin the Southern region*	*Wind and solar produce 48% of its total generation and meet 49% of load.*	*6.6%*	*3.5 GW*	*Net exporter*	*Lowest ratio of thermal to RE capacity, Transmission constraints, trade barriers*
Maharashtra (14 GW)	*Lowest RE curtailment of any state vis a vis significant RE capacity*	*Wind and solar produce 20% of its total generation and meet 17% of load.*	*0.4%*	*0.08 GW*	*Net importer*	*Transmission congestion and trade barriers*
Tamil Nadu (24 GW)	*Limited interstate transmission capacity due to its geographic location*	*Wind and solar produce 40% of its total generation and meet 39% of load.*	*4.3%*	*3.7 GW*	*Net importer*	*Inflexible thermal fleet, Intrastate transmission issues*
Rajasthan (20 GW)	*Highest percentage of RE capacity outside the Southern region*	*Wind and solar produce 49% of its total generation and meet 47% of load.*	*5.6%*	*2.25 GW*	*Net importer*	*Intrastate transmission issues, Limited use of flexible resources such as coal or hydro*

Source :(NREL, 2017)[13](Power, 2017)[14]
[1]The state wise installed RE capacity considered under the 'Greening the grid' study is slightly different from the MNRE state-wise targets for wind and solar.

9 minutes at 9 pm: A Perfect Example for Testing Grid Flexibility and Readiness



The total reduction in all India demand during the 9-minute event was **~31 GW, almost 60%** higher than the estimated 12-13 GW.

The minimum demand of **85.7 GW** was recorded at 21.10 Hrs.

The sharp reduction in load was chiefly met by **hydro** and **gas** resources.

Source:
POSOCO,2020, Preliminary Report on Pan India Lights Switch Off Event on 5th April 2020. https://bit.ly/2UwELsE

STORAGE APPLICATIONS
Grid Scale

Energy storage remains an important technology option for reliably integrating a large proportion of variable RE into larger grids and many countries are evaluating different storage applications as part of their RE strategies. For a short-term period, flexible coal power can be handy, but with the ambitious 455 GW RE target, India will have to explore energy storage options to effectively integrate RE. With the Lithium-ion battery costs declining rapidly, it has become the most favorable storage options for many countries.

Grid scale storage (IRENA, 2019)[15] refers to storage systems connected to distribution or transmission networks or in connection with a generation asset. The storage capacities generally range from a few Megawatt hours (MWh) to hundreds of MWh. These applications find use in solar and wind integration, Transmission and Distribution deferral, ancillary services etc.

Pumped Hydro to form an Integral Part of India's Storage Journey

Globally, pumped storage makes up for almost 96% (World Energy Council, 2019)[16] of the existing world storage capacity. India too has identified 63 sites with a pumped storage potential of 96.5 GW. Out of this, only 4.78 GW is designed to work as pumped storage units.

Progress of Pumped Storage Development in India (in MW)- As on March 2020			
Installed		Under Construction	Proposal Development
Operational	Not operational	Commissioning by 2022-23	
3,305	1,480	1,580	8,380

Source: (CEA, 2020)[17]

India is expected to further increase its pumped storage capacity by ~10 GW in the next few years. However, due to the high social and environmental costs associated with its development, the projects have been stalled for many years.

Nonetheless, existing or planned pumped storage may exclusively be used for peaking or balancing of system on the direction of regional/ national level system operator only.

Some recent developments in the last year has given the much-needed boost to pumped storage. India amended its 'National Wind-Solar Hybrid Policy' to clarify that any form of storage – not just batteries – could be used in solar, wind or hybrid projects, including pumped hydro, compressed air and flywheels. The Ministry of Power (MOP) has also issued policy changes to incentivize electricity supply during peak demand.

World's Largest 1.2 GW Tender Discovers Cheapest Renewables + Storage Tariff in India

In February 2020, Greenko Group and Renew Power won the auction conducted by Solar Energy Corporation of India (SECI) for 1.2 GW of solar, wind and energy storage. The tender required guaranteed peak power supply and hence the bidders were required to submit a peak power tariff. The bid details are as follows:

Winners	Capacity won	Minimum Storage Capacity Required	Peak Power Tariff		Off-peak Power Tariff		Weighted Average Tariff		APPC-FY19
	MW	MWh	Rs/kWh	$/kWh	Rs/kWh	In $	Rs/kWh	$/kWh	Rs/kWh
Greenko	900	450	6.12	0.086	2.88	0.04	4.04	0.057	3.6
ReNew Power	300	150	6.85	0.096	2.88	0.04	4.3	0.06	

The bid results are quite exciting due to various reasons:

This is a unique bid asking for a peaking power tariff, thus delivering firm renewable energy. It further incentivised energy storage with Greenko deploying pumped hydro whereas Renew deploying batteries under energy storage.

It led to one of the lowest price discoveries for grid connected storage, thus reassuring the economic viability of storage in India.

The weighted average price for both the bidders is almost at par with the CERC's Average Power Purchase Cost (APPC) for conventional plants, thus encouraging Distribution Utilities to procure RE during peak hours.

Source: (Parikh, 2020), (CERC, 2019) and (JMK Research, 2019)[18]

Battery Storage is Critical to Ensure India's future RE success

Most of the developments in the storage sector has revolved around batteries, mainly due to the rapidly falling costs of Li-ion batteries around the world. The deployment of large-scale battery energy storage in India started only in 2017 with PGCIL commissioning its first pilot project to test different battery performances in Puducherry.

The journey of battery storage in India has been slow and limited mainly because of its high costs. But in 2019, India commissioned its first and biggest battery storage system of 10 MW in Delhi at the Tata Power Delhi Distribution Ltd. (TPDDL) substation developed by AES and Mitsubishi Corporation.

The year 2019 saw a large number of storage tenders owing to a steep decline in the price of Lithium-ion (Li-ion) batteries globally (to meet the growing demand for Electric Vehicles).

The (ISGF and IESA, 2019)[19] report estimated the energy storage requirement for grid support at 17 GWh by 2021. It further estimates a total potential of 190 GWh of stationary energy storage from 2019-2025. Remarkably, only ~16% of this storage is expected to be used for grid scale applications, while majority of them will be under behind the meter applications (discussed in section 4).

List of Energy Storage Tenders in India as on March 2020

	Agency	Capacity	Location	Issued
Grid Scale	NTPC	5 MW existing Solar + 2MWh BESS	Port Blair, Andaman & Nicobar Islands	Mar-18
	NTPC*	17MW Solar PV + 24MWh Storage	South Andaman, Andaman & Nicobar Islands	Mar-18
	NTPC*	8MW Solar PV + 3.2MWh/3.2MW storage	South Andaman, Andaman & Nicobar Islands	Mar-18
	NLC	20 MW Solar + 8MWh/16MW storage	Port Blair, Andaman & Nicobar Islands	Apr-18
	SECI	3 MW Solar + 5 MWh storage	Leh	Jul-18
	SECI	2 MW Solar PV + 1 MWh BESS	Kaza, Himachal Pradesh	Jul-18
	SECI	160 MW Solar-Wind-Hybrid + 10 MW/20 MWh BESS	Ramagiri, Andhra Pradesh	Aug-18
	SECI	20 MW Floating Solar + 60 MWh storage	Lakshadweep	Feb-19
	SECI	14 MW Solar + 42 MWh BESS	Leh and Kargil	Mar-19
	SECI	200 MW Solar PV + 300 MWh Energy storage	Andhra Pradesh	Mar-19
	SECI	3 MW Solar + 3.2 MWh storage	Leh	Mar-19
	REIL	1.7 MW Solar + 1 MWh storage	Andaman & Nicobar Islands	Apr-19
	SECI	160 MW Solar-Wind- Hybrid + 30-40 MWh storage	Andhra Pradesh	Apr-19
	MPPMCL	Grid Scale 500 MW Energy Storage	Madhya Pradesh	Jun-19
	SECI	1.95 MW Solar + 2.15 MWh BESS	Lakshadweep	Sep-19
	UHBVN/DHBVN	100 MW Solar & Wind/small hydro + Energy Storage System	Haryana	Sep-19
	SECI	400 MW Solar-Wind-Hydro-Hybrid RE + Storage	Delhi, NDMC	Oct-19
	MSEDCL	500 MW Solar Power + Storage through intra-state grid-connected projects (Phase – V)	Maharashtra	Dec-19
	SECI	1.2 GW Solar-Wind-Hybrid + 600 MWh storage	Pan India	Jan-20
	SECI	4 MW Grid-connected Floating Solar PV + 1 MWh BESS	Diglipurm North Andaman	Feb-20
	Agency	Capacity	Location	Issued
Distribution Scale	PGCIL and USAID	3 x 500 kW, 250 kWh BESS	Puducherry-Pilot project	2017
	TPDDL, AES & Mitsubishi	10 MW / 10 MWh BESS	Delhi	2019
	MPUVNL	25 MWp Solar Rooftop with and without energy storage	Madhya Pradesh	Jan-19
	TERI & BRPL	400 kW + Atleast 125 kW of BESS	Delhi	Dec-19
	AP Electric Utility	5 MW Solar PV + 4MWh BESS	Makkuva, Andhra Pradesh	2019
	Commissioned			
	*Tender cancelled due to high cost			

Energy Storage Potential for Grid-scale Applications (in GWh) ~ 30 GWh
From 2019-2025

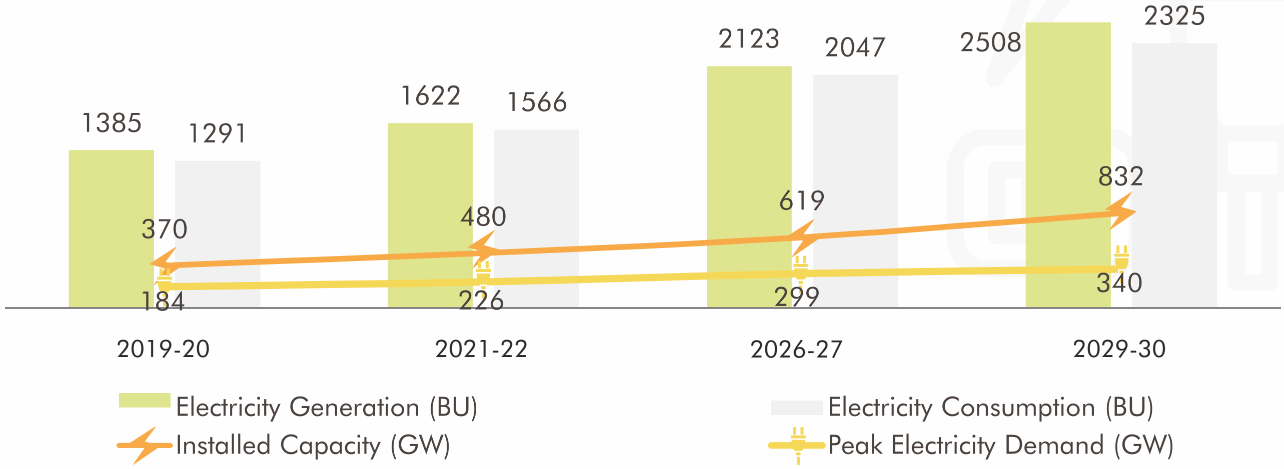
Fast Response Ancillary Services	Grid scale- Wind	Distribution Utility Storage	Grid scale- Solar
2	6	10	13

Source:
ISGF and IESA, 2019. Energy Storage Roadmap for India 2019-2032. https://bit.ly/2XOm3Pi

According to (CEA, 2019)[20], India would require about 34 GW / 136 GWh of grid-connected battery storage by 2030 to support the ambitious target of 455 GW of RE.

DISTRIBUTION

Comparison of Electricity Supply Vs Demand
for 2022, 2027 and 2030



Source:
CEA, 2019. Draft Optimal Mix Generation Capacity Mix For 2029-30. https://bit.ly/30pmUrw
CEA, 2019. National Electricity Plan, Volume-II. https://bit.ly/2zmd7Yb
CEA, 2016, 2017, 2018, 2019 and 2020. Power Supply Position Reports. https://bit.ly/2UvXwMK

The year 2019-20 observed an installed capacity of 370 GW with a peak demand at 184 GW. The capacity is expected to almost double in ten years to 832 GW with a peak demand of 340 GW.

This implies that installed capacity and peak demand are expected to grow at 8% and 6% (CAGR)respectively. While inferring this data, the country can be considered highly over capacitated. But the fact remains that over many years, India has been experiencing an evening peak demand, particularly when the sun is not shining and wind is highly variable. With increasing RE penetration in the grid, the system operators will require an even higher reserve margin to meet the rising peak load (mainly due to cooling). This is because without storage options, majority of the RE plants (mainly solar) will not be able to contribute to the evening peak. Hence, the grid operators will need to maintain an optimum reserve capacity to not only meet the rising demand but also cover up for the decrease in RE generation output.

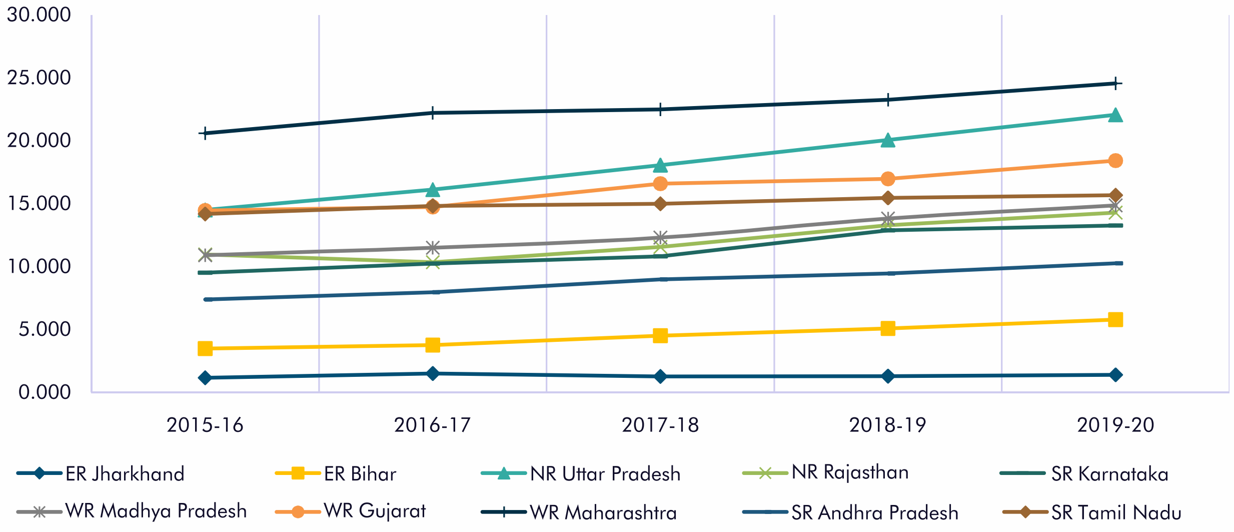
Moreover, with a considerable percentage of conventional generation plants under renovation, maintenance, technical faults etc., only a resultant small percentage of the capacity is available to meet the peak load.

Increasingly, there is a shift towards cross border trade which is also favoring a higher capacity addition.

A variety of measures are being planned to smoothen this clean energy transition. These include flexibilization of coal-based plants, utilization of incumbent underutilized gas plants, synchronized use of hydro and peaking hydro, creation of new storage capacity through advanced battery-based solutions.

4.1 Electricity Consumption – Deep Dive at the State Level

Year on Year Peak Power Met Position for Key States (in GW)



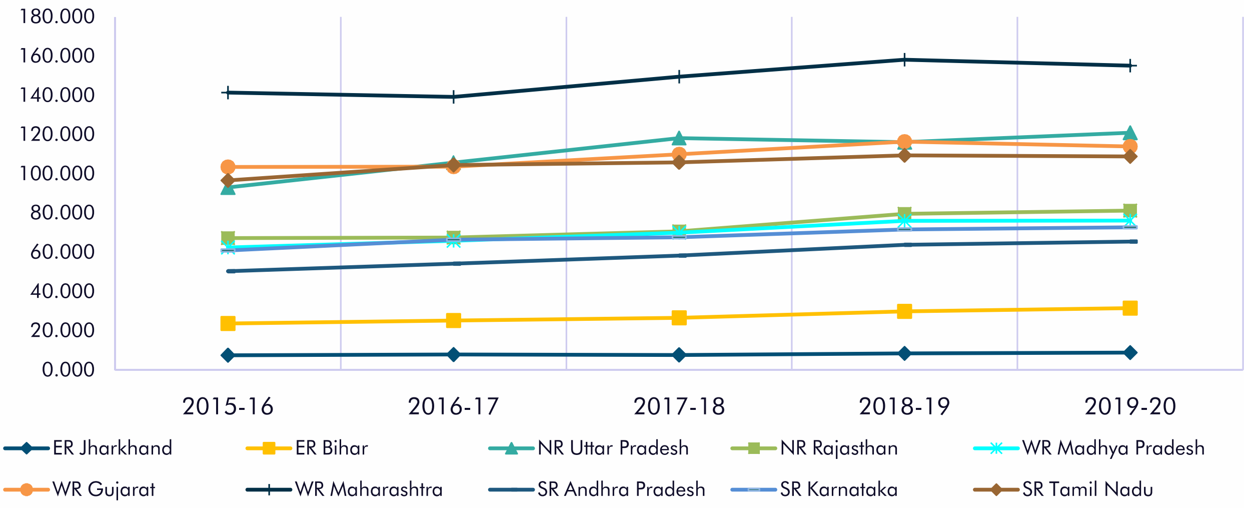
Source:
CEA, 2016, 2017, 2018, 2019 and 2020. Power Supply Position Reports. https://bit.ly/2UvXwMK

The average peak demand increase is highest for the state of Bihar at ~11% followed by UP with ~9% (CAGR) between 2015-16 and 2019-20.

UP, with one of highest power deficit state has tremendously brought down its peak power deficit levels from 15% in 2015-16 to 2.4% in 2019-20.

Tamil Nadu presents the lowest increase in the growth of peak electricity, saturating at ~15-16 GW since 2016-17. This is the result of the state's industrial slowdown and large migration from the grid to captive power generation (owing to high open access charges).

Year on Year Electricity Supply Progress for Key States (in BU)



Source:
CEA, 2016, 2017, 2018, 2019 and 2020. Power Supply Position Reports. https://bit.ly/2UvXwMK

Over the years, Bihar, Andhra Pradesh and Uttar Pradesh have seen the highest growth in its electricity demand vis-à-vis supply. Some of the combined factors for such impressive progress may be attributed to increased household electrification, higher generating capacities, and rapid progress on operational and financial reform measures to improve the working of its power sector.

The electricity consumption in three heavily industrialized states of Gujarat, Maharashtra and Tamil Nadu has grown the slowest at a ~2% CAGR. Moreover, Gujarat and Maharashtra slumped in its electricity consumption during 2019-20 while Tamil Nadu remained the same, thus indicating an industrial slowdown.

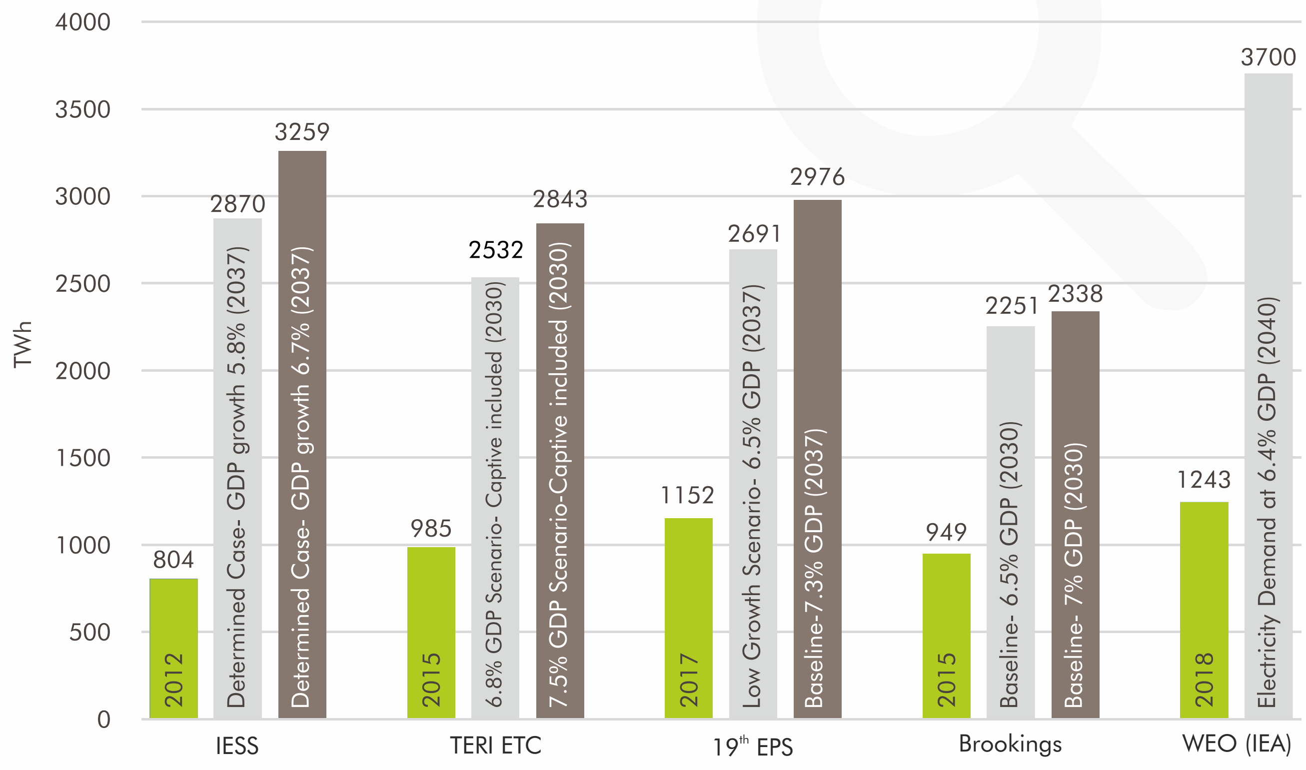
The electricity demand from Maharashtra, Gujarat, Tamil Nadu and Uttar Pradesh together occupied almost 40% of the total country's demand in 2019-20.

A large number of macroeconomic factors such as growth and development, climate, technological changes, consumer preferences, energy choices, policy environment etc are responsible for impacting electricity demand requirements in the short and long term. With the rising shares of intermittent RE in the power procured, it becomes imperative for Distribution Companies to accurately estimate the disaggregated electricity demand and understand its varying patterns.

Presented below is a graph comparing the electricity demand projections from the five studies as follows:

a. India's Energy Security Scenarios, 2047, NITI Aayog, 2015 (IESS)
b. Analysing and Projecting Indian Electricity Demand to 2030, TERI, 2015(TERI ETC)
c. 19th Electric Power Survey, CEA, 2019 (19th EPS)
d. The Future of Indian Electricity Demand, Brookings India, 2018 (Brookings)
e. India 2020, Energy Policy Review, IEA, 2020 (WEO)

Electricity Demand Projections Across Studies



Source:
NITI Aayog, 2015. India Energy Security Scenario 2047 Version 2. https://bit.ly/2Yh1oCA
TERI ETC, 2019. Analysing and Projecting Indian Electricity Demand to 2030. https://bit.ly/3cO8m79
CEA, 2019. Long Term Electricity Demand Forecasting. https://bit.ly/37gIcZO
IEA, 2019. World Energy Outlook; Brookings India, 2018. The Future Of Indian Electricity Demand. https://brook.gs/30vyDoA

As per the above studies, the energy and peak demand are likely to grow at an average rate above 6%.

But a lower electricity consumption is expected in the short-term due to the sluggish demand growth and weaker economic activity. As represented in the state wise graphs above, some states may account for higher electricity consumption owing to the recent fast track electrification measures, but at a country level the electricity demand is expected to decline from the projected levels.

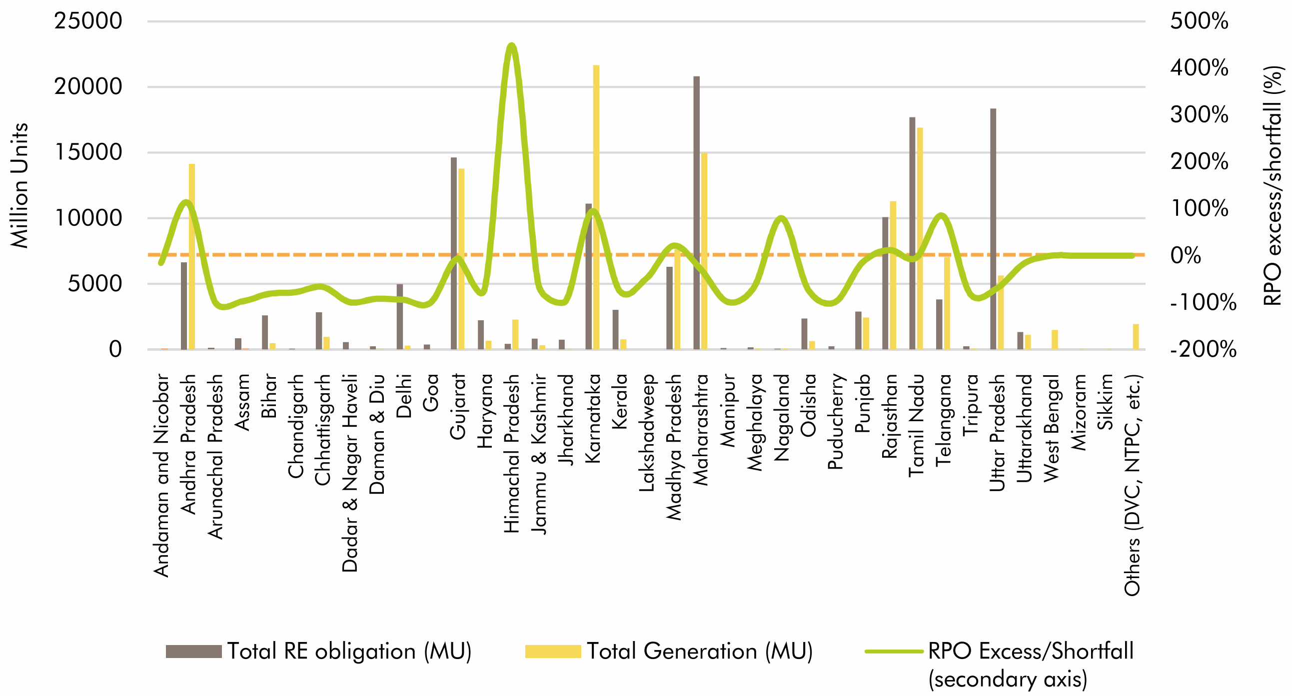
4.2 Renewable Energy Purchase Obligations (RPO)

Instituted in 2011, RPO for distribution utilities continue to be important for the growth of RE in the country.

RPO Regulations Issued by Ministry of Power (%)

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Solar	2.75	4.75	6.75	7.25	8.75	10.5
Non-Solar	8.75	9.5	10.25	10.25	10.25	10.5
Total	11.5	14.25	17.0	17.5	19.0	21.0

Statewise RPO Target and Compliance - 2018-19



Source:
MoP and MNRE, 2019. Conference of Power and Renewable Energy, Ministers of States and UTs. https://bit.ly/3f5DEYO
State-wise RPO Targets, 2019. All About Renewables. https://bit.ly/3fcEVxc

The RPO trajectory for most states does not align with the RPO guidelines issued by Ministry of Power in 2018.Varied consumer base, less availability of low-cost RE, poor financial situation of the utilities all leads to different RPO trajectories and its compliance.

Most of the states except for Gujarat, Karnataka and Andhra Pradesh are yet to announce their RPO trajectories in line with the union targets till 2022.

As per the graph above, for FY 2018-19, it is observed that states of Andhra Pradesh, Himachal Pradesh, Karnataka, Nagaland and Telangana surpass their RPO targets by more than 80%, whereas Madhya Pradesh and Rajasthan almost meet their exact targets.

While only seven states meet or exceed their RPO targets, all the other 26 States and Union Territories fell short of fulfilling their RPO compliance in 2018-19.

Himachal Pradesh has done exceptionally well by surpassing its target almost by four times. However, states like Chhattisgarh, Haryana and majority of northeastern states are far behind their targets.

5 CONSUMER TO PROSUMER TRANSITION

Traditionally, electricity supply followed a unidirectional flow from large centralized conventional coal-fired plants to the consumers via the transmission and distribution systems. But the power systems are now set for a dramatic change. With new technology advancements, anyone can be a producer or consumer of electricity. The advent of smart grids, electric vehicles and smart appliances will nudge consumers to manage their own demand efficiently. Further the integration of small-scale renewable systems and distributed generation is allowing consumers to produce their own electricity and supply it to the grid.

The Government of India is also keen to promote distributed renewable energy generation and hence launched two new schemes in 2019-

KUSUM

Kisan Urja Suraksha evam Utthaan Mahabhiyan

Notable Features

- More flexibility to states in deciding for distrbuted renewable energy generation for lesser capacities and sources other than solar.
- Standalone solar powered pumps to replace existing diesel pumps in off-grid areas.
- Solarisation of pumps to help reduce their dependence on distribution companies and hence lowering the agriculture subsidy bill.

SRISTI

Sustainable Rooftop Implementation for Solar Transfiguration in India

Notable Features

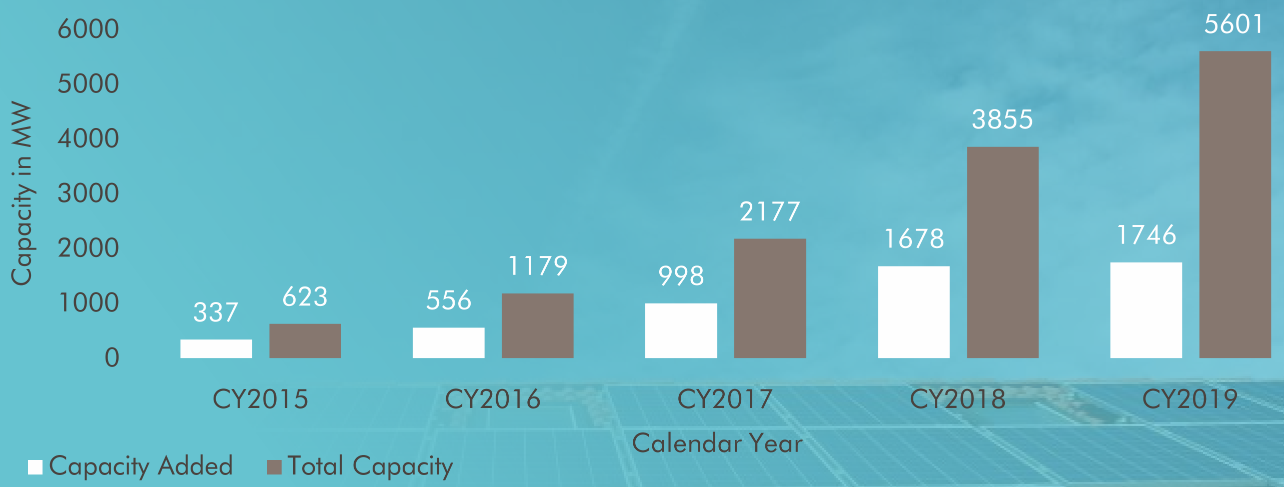
- Bringing Discoms to the forefront and incentivisng them for faster uptake.
- No Central Financial Assistance for the non-residential categories owing to economic viability of solar rooptop for these categories.
- Limits the residential rooftop solar target to just 4 GW.

(GOI, 2019)[21] & (MNRE, 2019)[22]

5.1.Decentralised and Distributed RE systems

Solar Rooftop PV (RTPV) Systems

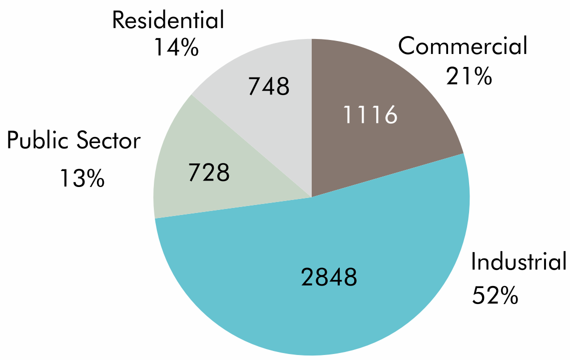
Year on Year Solar Rooftop Capacity Addition



Source:
Sai Siddhartha Nandamuri, T. T. V. R., 2019. India Solar Compass 2019 Q4. https://bit.ly/2XNKywa
Vibhuti Garg, T. B., 2019. Vast Pontential of Rooftop Solar in India.https://bit.ly/2XNsnqh.

Out of the three fragments under the planned solar capacity addition- Solar Parks (40 GW), Solar Rooftop (40 GW) and Distributed Generation (20 GW); the progress on the solar rooftop has been quite unsatisfactory.

Consumer-wise Solar Rooftop Capacity (MW)
As on 31st December 2019



Source:
Bridge to India, 2019. India Solar Rooftop Map. https://bit.ly/2B0YjhO

The ambitious 40 GW rooftop solar target saw an aggregated capacity of only 5.44 GW as on December 2019, of which only 748 MW was installed in the residential sector.

This is in huge contrast with some of the developed countries which have a sizeable residential RTPV. Countries like Australia, Germany, Spain and US (Chandra Bhushan, 2019)[23] have almost 50% and more of their total solar PV capacity under residential RTPV.

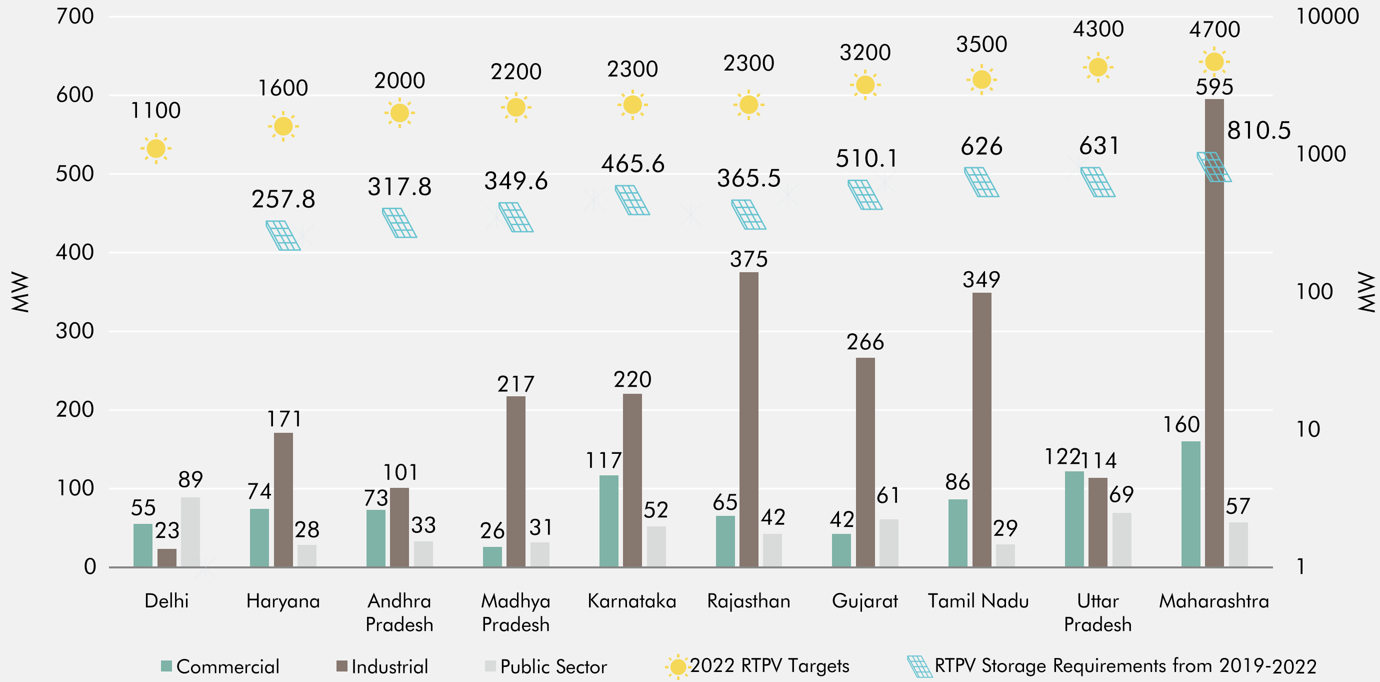
Sub-optimal financing schemes and lack of consumer awareness are the two key issues hindering the RTPV uptake. On a brighter note, 2019 witnessed the highest installation of the RTPVs compared to the previous years.

The industrial consumer leads the number of RTPV installations, followed by the commercial segment. This is due to the high tariffs owing to its cross subsidies and open access surcharges thus increasing the viability of solar rooftop for these consumers.

The lag within the residential category is largely linked to its subsidized tariffs and lack of consumer awareness.

The states are of crucial importance to help meet the 40 GW target by 2022. According to the recent State Rooftop Solar Attractiveness Index (SARAL)[24]— Karnataka, Telangana, Gujarat and Andhra Pradesh were ranked as the top A++ performers and 11 other states were rated as A+ and A performers. The Index is to evaluate Indian states based on their preparedness to support RTPV deployment.

Solar Rooftop Capacity 2019 Vs Target for Key States
As on 31st December 2019



Source*:
Bridge to India, 2019. India Solar Rooftop Map. https://bit.ly/2B0YjhO
ISGF and IESA, 2019. Energy Storage Roadmap for India 2019-2032. https://bit.ly/2XOm3Pi

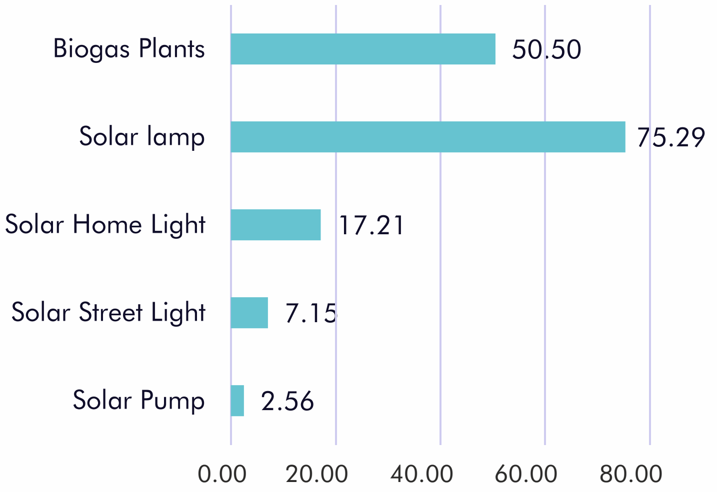
*The graph does not provide a breakup for the residential category.

To boost RTPV uptake, almost all the 38 states/Union Territories/State Electricity Regulatory Commissions (MNRE, 2020)[25] have notified regulatory frameworks on net/gross metering. The Government has also installed the SPIN- An online application for Solar PV installation to provide recent updates on RTPV.

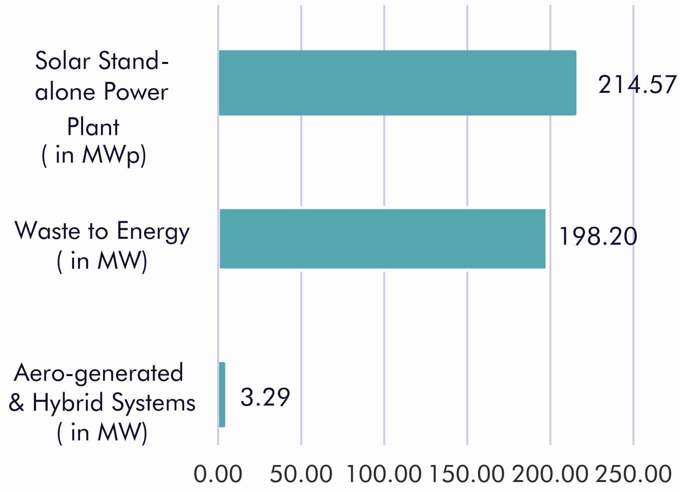
Other Decentralized/Offgrid Systems

A transition to renewables calls for a more decentralized mode of electricity; but the decentralized energy market suffers from its own barriers. At present, the sector is characterized by a number of subsides and schemes, which are often not monitored or implemented effectively. There is a need to boost investor confidence by developing stronger regulatory frameworks and supporting new business and financing models.

Number of Installed Offgrid RE Systems/Devices (In Lakhs)



Installed Capacity of Offgrid/ Decentralised RE Systems/Devices



Source:
MNRE, 2020. Programme/Scheme wise Physical Progress in 2019-20 & Cumulative upto March, 2020. https://bit.ly/3dRDlRj

As on 31st March 2020, maximum number of solar home lighting systems were distributed in Tamil Nadu followed by Uttar Pradesh, Rajasthan and West Bengal.

Under the stand-alone SPV based power plants, the year 2019-20 saw a system capacity addition of only 2.51 MW_p as compared to 30 MW_p in 2018-19.

Installation of Off-grid / Decentralised Renewable Energy Systems/ Devices Under Various Schemes

PARAMETERS	Target	Achieved (as on 2019-20)	Capacity/ Numbers Sanctioned
SOLAR PUMP PM-KUSUM SCHEME (COMPONENT B) (IN LACS)	17.5 (upto 2022)	0.19	1.711
SOLAR LED STREET LIGHT ATAL JYOTI YOJANA (AJAY) PHASE-II (IN LACS)	3.045 (upto Mar-21)	1.36*	1.936
SOLAR LAMP SOLAR STUDY LAMP (SOULS) SCHEME (IN LACS)	70	60.61	N.A.
SOLAR STAND-ALONE POWER PLANT OFF-GRID & DECENTRALISED SOLAR PV APPLICATIONS PROGRAMME: PHASE-III (IN MWP)	100	2.51	13.17

Source:
MNRE, 2020. Programme/Scheme-wise Physical Progress in 2019-20 & Cumulative upto March, 2020. https://bit.ly/3dRDlRj
MNRE, 2020. Annual Report 2019-20. https://bit.ly/3dVBqLu
EESL, 2020. Solar Study Lamp Target. https://bit.ly/2YlLpmJ
AJAY, 2020. Solar LED Street Light. https://bit.ly/30BjW30

*As on May14th, 2020

The Government of India has been running various initiatives to promote distributed RE in rural areas. This includes distribution of solar lamps, installation of solar pumps and solar street lights in these areas.

The 2019-20 target of installing 1.75 lakh standalone solar pumps under KUSUM was successfully achieved by accounting the number of sanctioned pumps and not installed. The maximum capacity was sanctioned in Maharashtra, followed by Madhya Pradesh, Rajasthan and Chhattisgarh.

The MNRE AJAY scheme to install solar LED based street lights launched the second phase due to its subdued progress in the first phase. The scheme which is now extended till March 2021 has met only 45% of its target as on May 14th, 2020.

5.2 Storage Applications – Behind the Meter (BTM)

Traditionally for a long period of time, India's energy storage market has been behind the meter mainly for providing back up power for consumers, telecom towers etc. The lack of reliable and poor supply quality has largely driven this demand.

Behind the meter energy storage (IRENA, 2019)[26] typically refers to storage systems connected behind the meter of consumers. The storage capacity generally ranges from kilowatt hours to very few MWh. These applications find use in telecom, rural electrification, solar rooftops, diesel replacements, inverter back-up, UPS back-up, thermal energy storage etc.

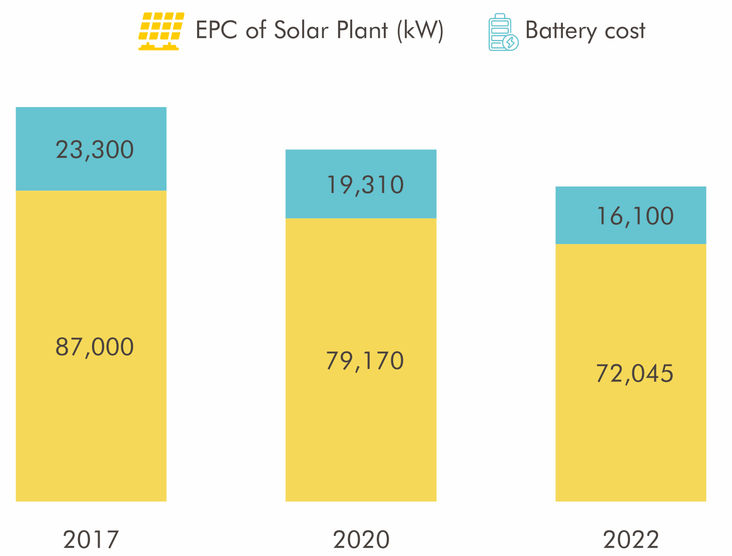
As discussed in the previous section, RTPV will play an integral role in the 175 GW renewable energy journey and, thereafter.The total energy storage (mainly batteries) estimated for integration of 40 GW of RTPV by 2022 lies at 9.4 GWh (ISGF and IESA, 2019)[27]. The break-up for potential energy storage for key states is provided in section 5.1.

Energy storage Potential for Behind-the Meter Applications (in GWh) ~ 160 GWh from 2019-2025

Diesel Replacement	HVAC	BTM Rooftop Solar	UPS	Telecom	Inverter
2	4	6	29	36	84

Source:
ISGF and IESA, 2019. Energy Storage Roadmap for India 2019-2032. https://bit.ly/2XOm3Pi

Cost Breakdown for 1kW Rooftop Solar PV with Battery (in INR)



In the graph here, the cost of battery storage is expected to decline at an average rate of 12% against the 6% decline for Solar PV, thus occupying ~23% of the project costs by 2022.

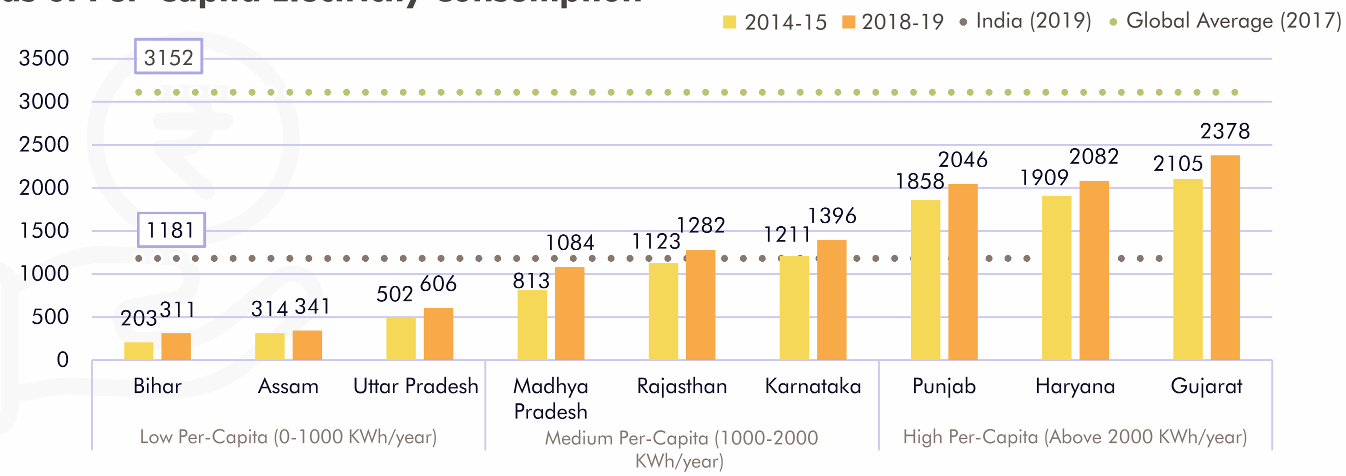
This can majorly be attributed to rapidly falling costs of battery components.

For most of the BTM applications, Li-ion technologies and advanced lead acid are increasingly becoming cost-competitive.

Source:
UK Government, 2018. Energy Storage Market Landscape Report, November 2018. https://bit.ly/2XRAMsR

6 ACCESS TO RELIABLE ELECTRICITY

Trends of Per-Capita Electricity Consumption



Source:
MoP, 2018-19. State-wise Per Capita Consumption of Power in India. https://bit.ly/2MJ1IVg;
CEA, 2019. Growth Of Electricity Sector In India from 1947-2019. https://bit.ly/37lmkMF
MoP, 2017. State wise details of per capita electricity consumption. https://bit.ly/2ATyBw5

It is observed that India ranks far below in its per capita electricity consumption in comparison with the global average. Going by state-wise per capita electricity consumption, the figures are even dismal for some states.

Many factors like GDP growth, infrastructure development and access to modern energy services plays an important role in raising the per capita electricity consumption. A lot will also depend on achievements related to electrification of demand in households, cooking, and mobility in near future.

Programs like 'Atmanirbhar Bharat Abhiyaan', Make in India will enhance the domestic production, thus yielding higher per capita electricity consumption in future.

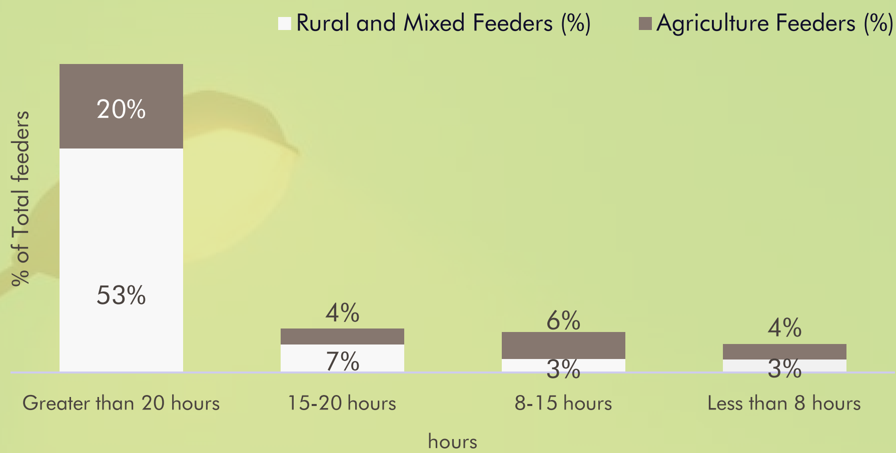
6.1 Quality of Supply

Over many years, different Government schemes like Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and Saubhagya led to large scale electrification efforts in the country. Despite this, many rural and urban households continue to experience frequent power outages and poor quality of electricity. Access to reliable electricity is a pre-requisite to social and economic development, especially in rural areas.

Avg. Power Supply Monitoring Statistics (In Hrs) (March 2020)

Total Feeders (11KV Only): 77882

*The data is for 1,02,522 feeders, out of which only 77,882 modems were communicating data.

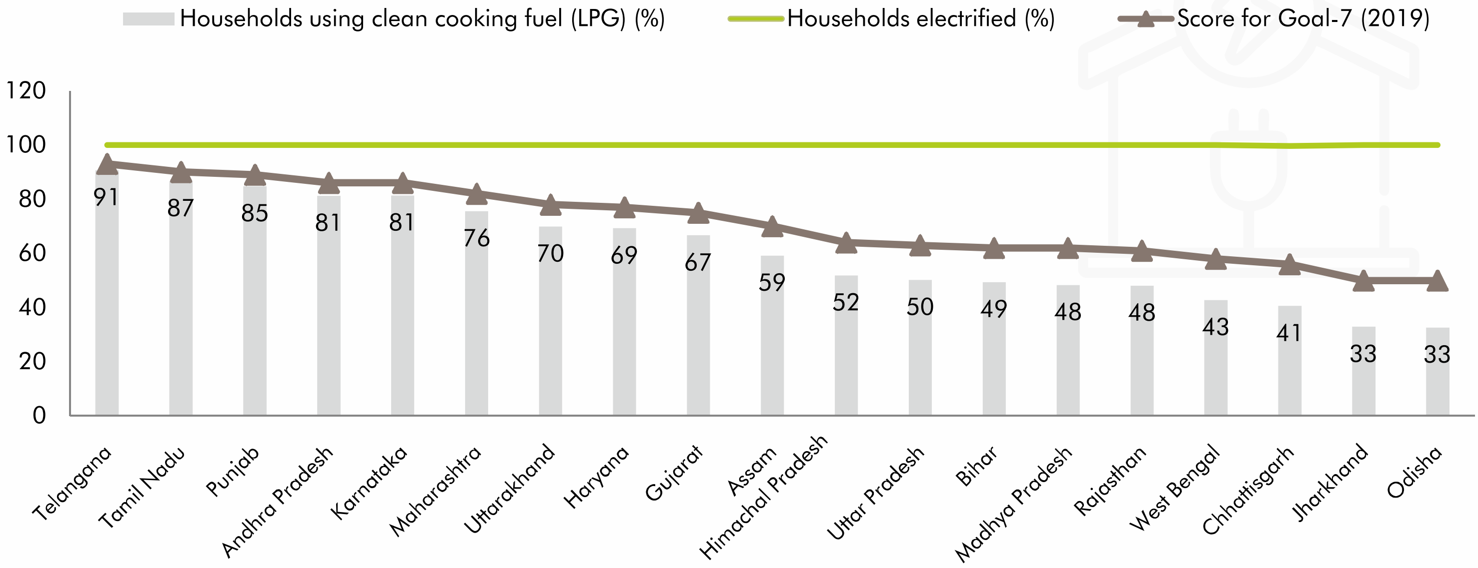


Source:
National Power Portal, 2020. Rural Distribution, Power Supply Outages. https://bit.ly/37hcrQa

Almost **84%** of the feeders across **37** distribution utilities in **19** major states receive electricity higher than **15** hours a day

6.2 SDG Index Ranking 2019

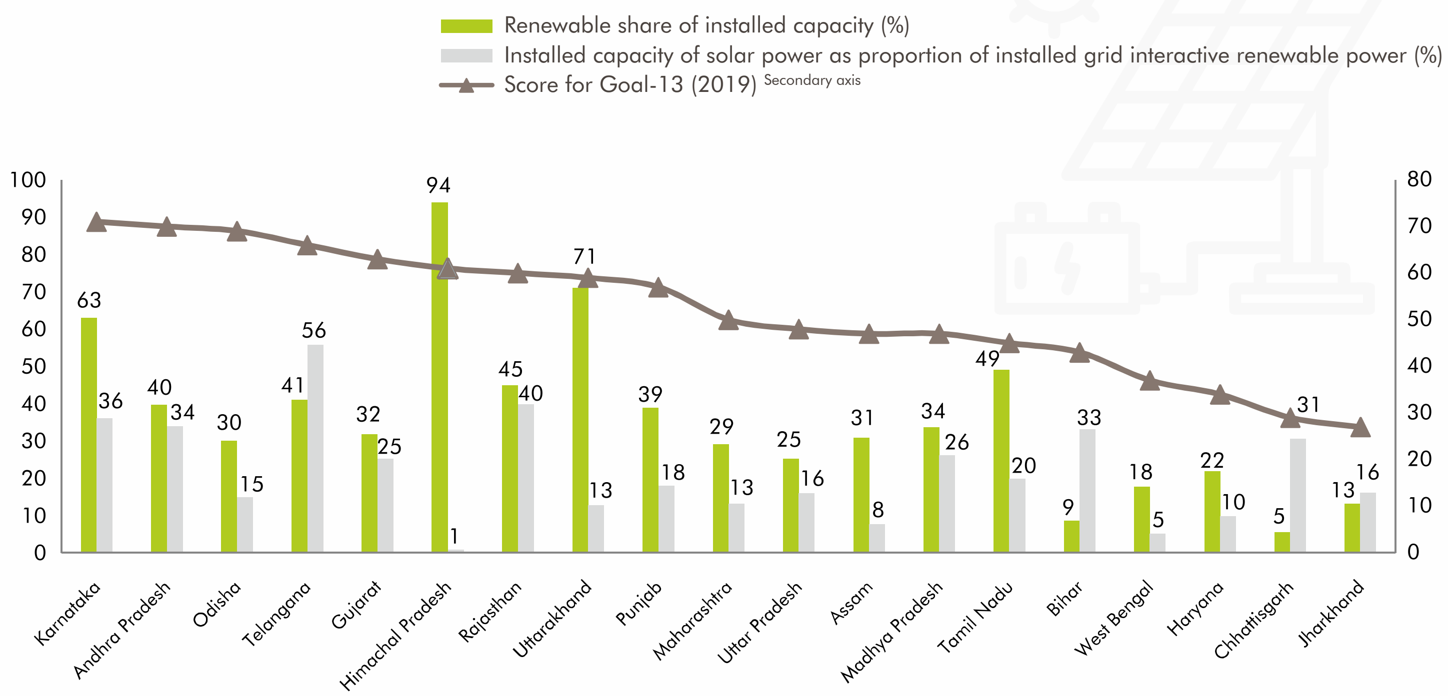
2019 State-wise Score for Goal 7 under SDG India Index
Goal 7 : Affordable and Clean Energy



Source:
Niti Aayog, 2019. SGD Index India. https://bit.ly/30vXVTo

Karnataka, Andhra Pradesh and Telangana remain the front runners by occupying the top five positions states within both the goals to provide clean and affordable power. Whereas, Jharkhand, Chhattisgarh and West Bengal remain amongst the five bottom most states under both the goals.

2019 State-wise Score for Goal 13 under SDG India Index
Goal 13 : Climate Action



Source:
Niti Aayog, 2019. SGD Index India. https://bit.ly/30vXVTo

7 ENVIRONMENTAL IMPACT

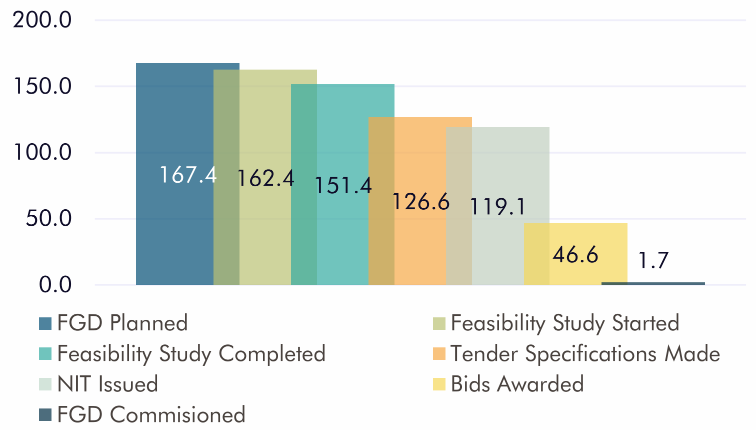
Thermal Power Plants (TPPs) produce a range of air pollutants in the form of particulate matter, oxides of nitrogen, SOx etc. These pollutants pose a variety of health hazards on humans. A study (IISD, 2019)[28] estimated an approximate 1.3 million deaths per year by 2050 in India, if the emission trends remained unaltered.

7.1 Flue-Gas Desulfurization (FGD)

India has committed to reduce the emissions intensity of its GDP by 30-35% from the 2005 levels by 2030 in accordance with the INDC.

Over the years, Ministry of Environment, Forest and Climate Change (MOEFCC) has issued notifications to reduce emissions of Suspended Particulate Matter (SPM), SOx, NOx and mercury at Thermal Power Plants (TPPs).

FGD Installation Status for the 167 GW Capacity Progress Stages
As on June 2020

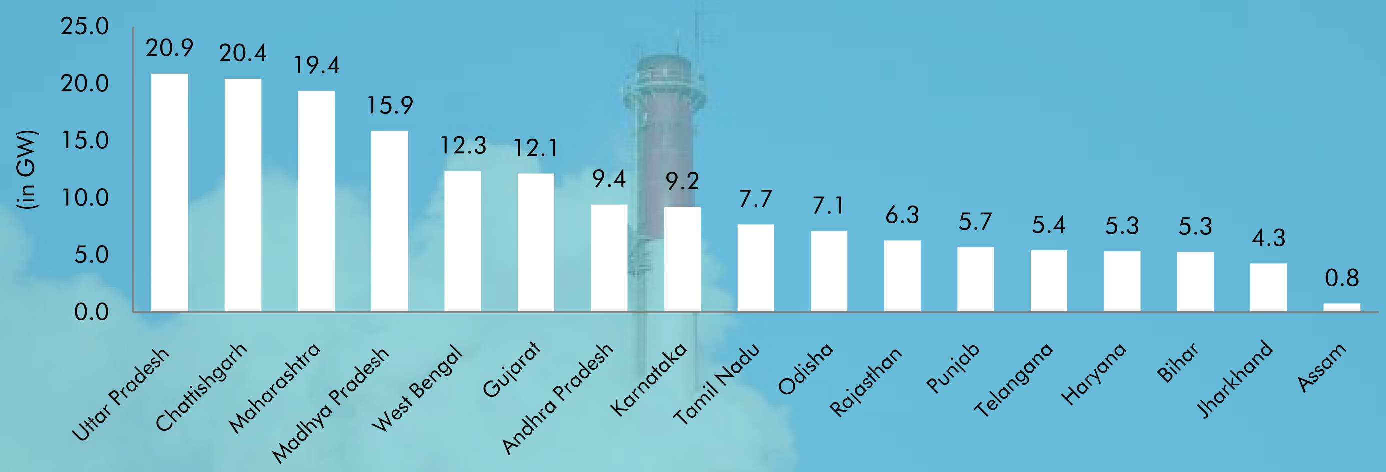


Source:
CEA 2020, FGD Installation Status. https://bit.ly/2UNCLwd

As on June 2020, only ~1% of the planned 167 GW coal power plants had installed FGD systems. However recently, the FGD has gained momentum with the new MoEFCC notification to limit SOx emissions (CEA, 2019)[29].

Indian coal is high in ash content but low in Sulphur but imported coal is high in Sulphur and low in ash content. Hence, FGD technology is mandated to be installed in all the existing and upcoming TPPs to curb SOx emissions. Although it is necessary to install FGD, there are many challenges such as time constraints, space constraint, generation cost, shut down and related MU losses.

State-wise Capacity of Power Plants with FGDs (To be installed and Already installed in GW)
As on June 2020

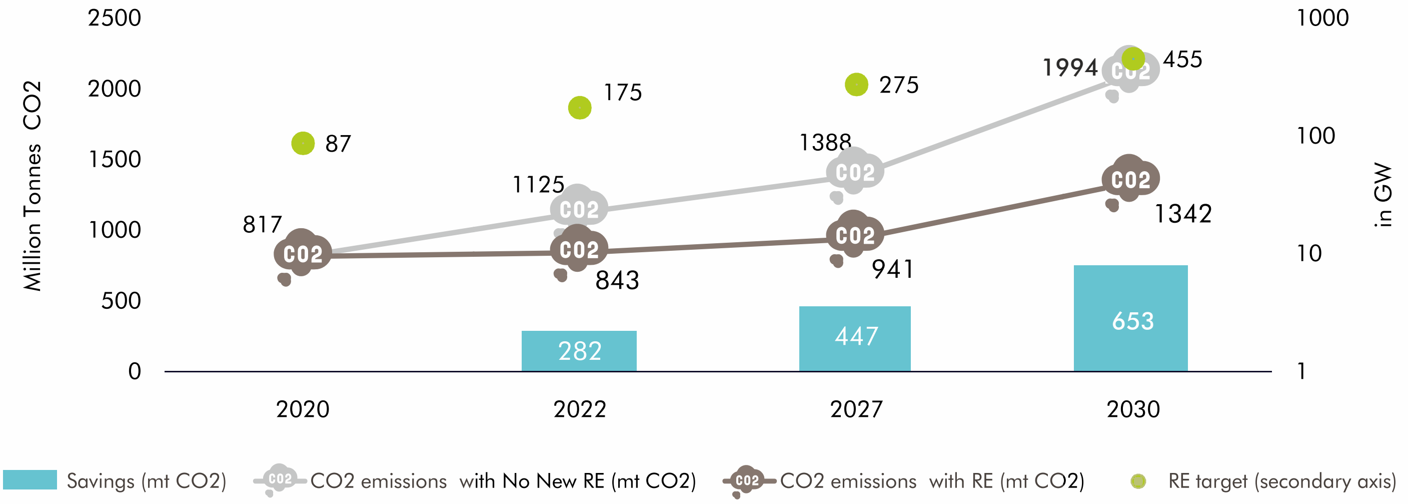


Source:
CEA 2020, FGD Installation Status. https://bit.ly/2Uw0d0O

7.2 Emissions Assessment

We have analyzed the impact of installing different RE targets of 175 GW, 275 GW and 455 GW by 2022,2027 and 2030 respectively. Here, we compare the Carbon Dioxide (CO_2) emissions from coal under the No new RE -scenario with targeted RE addition scenario

Potential Impact on Emissions with & without RE Scenarios



Source:
Vasudha's Analysis
Raghav Pachouri, T. S. a. G. R., 2019. Exploring Electricity Supply-Mix Scenarios to 2030. https://bit.ly/2MOswUc

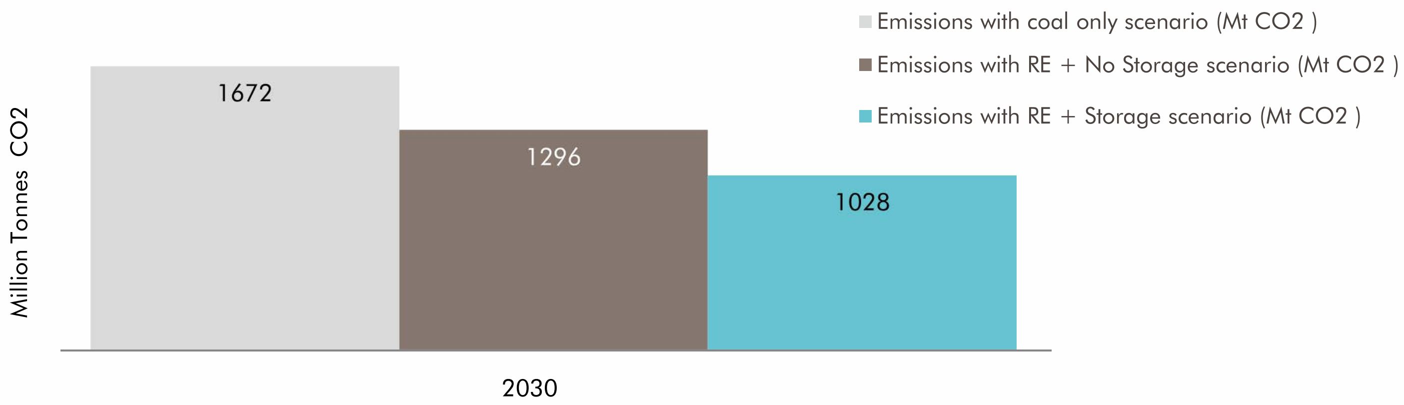
The NREL-POSOCO study concludes that the power system has the flexibility to manage 175 GW RE without deploying major storage options. Further, according to (CEA, 2019)[30], battery energy storage only appears from 2026-27 onwards due to reduction in cost of solar and BESS systems.

Therefore, the graph below looks at estimating the emissions in 2030 under the following three scenarios -

1) Coal only Scenario: When the entire generation in 2030 is met from coal-based power plants excluding existing RE generation.
2) RE + No Storage scenario: NREL 2030 scenario demonstrate that 22% annual penetration of wind and solar is manageable by Indian grid(David Palchak, 2019)[31]. The scenario looks at the resultant coal emissions in 2030 with only 22% wind and solar in the electricity mix.
3) RE+Storage scenario: The scenario looks at the resultant coal emissions in 2030 with 37% of RE penetration and 136 GWh of storage.

The emissions drop by 21% if storage is considered, from the RE + No storage scenario. This is because more RE is dispatched with 136 GWh of storage and hence lesser coal.

Potential Impact of Storage on Power Sector Emissions (in Mt CO_2)



Source:
Vasudha's Analysis
CEA, 2019. Draft Optimal Mix Generation Capacity Mix For 2029-30. https://bit.ly/30pmUrw

8 PIPELINE TECHNOLOGIES AND INVESTMENT TRENDS

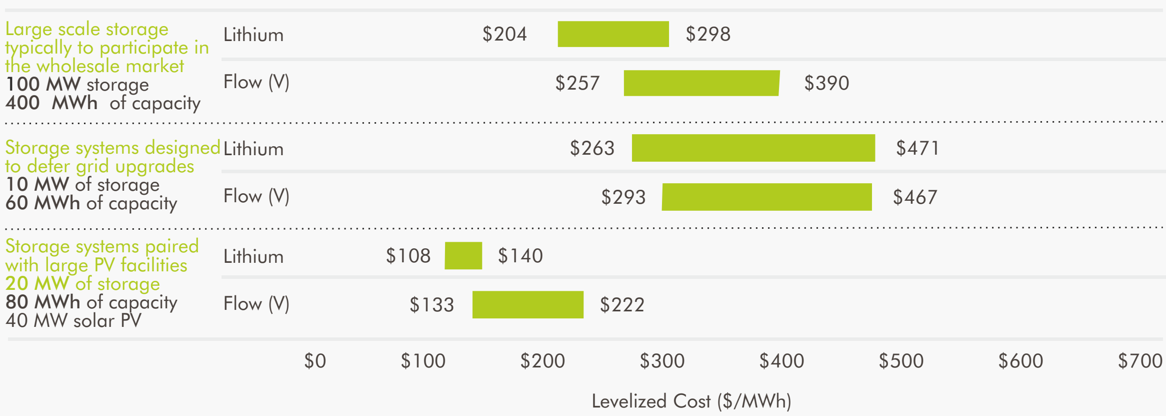
Energy Storage is going to be inevitable for integration and management of large shares of RE (350-500 GW). Presented below is an India Energy Storage Roadmap for the period 2019-2032.

India Energy Storage Requirements by Various Timeframes (in GWh)

Type	Type	Applications	Energy Storage (GWh)		
			2019-2022	2022-2027	2027-2032
Stationary Storage	Grid Scale	Medium/High Voltage	10	24	33
		Extra High Voltage	7	38	97
		Total Grid-Scale Storage	17	62	130
	Behind the meter	Telecom Towers	25	51	78
		Data Centre's	80	160	234
		Miscellaneous Applications (Railways, Rural Electrification, HVAC Applications	16	45	90
		DG sets replacement	0	4	11
		Total BTM storage	121	260	413
	Total Stationary Storage		138	322	543

Source:
ISGF and IESA, 2019. Energy Storage Roadmap for India 2019-2032. https://bit.ly/2XOm3Pi

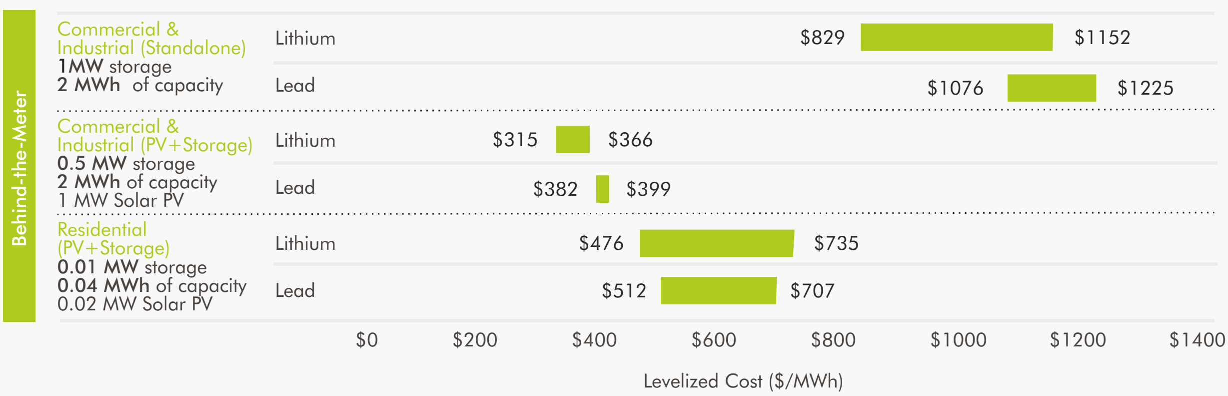
Levelized Cost of Grid-scale Storage Technologies



Source:
IRENA, 2019. Innovation Landscape Brief: Utiliy-scale Batteries. https://bit.ly/30vHXIL

Note: Flow (V) = flow battery-vanadium

Levelized Cost of BTM Storage Technologies



Source:
IIRENA, 2019. Innovation Landscape Brief: Behind-The-Meter Batteries. https://bit.ly/2YnxEE3

9 CONCLUSION

The 175 GW RE target by 2022 and its rapid progress in the past few years showcases India's unwavering commitment towards a low-carbon future. The transitioning process from fossil fuels to renewables will have its own risks and challenges. To achieve ambitious targets, the sector will have to go through major reforms in the generation, transmission and distribution sub-sectors. There will be a need for effective decision making, conducive policy environment and adequate financing schemes to sustain the efforts towards a low-carbon growth scenario. For example, while the Draft Electricity Amendments proposing for an RE Act set a positive outlook, the much awaited coal sector reforms coincides with the availability of cheaper RE.

The COVID-19 pandemic has caused unprecedented disruptions to the power sector in the form of suppressed demand (↓20%-25%), revenue losses, increased financial stress on the distribution companies, delayed capacity targets and generation hassles. To balance this demand depression, the power generation was adjusted by reducing coal outputs and increasing RE generation. Across countries, renewable energy has showcased its higher resilience vis a vis other fuels during the pandemic periods. The cost and operational competitiveness of renewable energy during such times is an opportunity that can help us ensure a sustainable and carbon free future.

The crisis presents an opportunity for the policymakers, private sector, civil society groups and other stakeholders to fast-track their efforts to support the clean energy transition. This can be achieved with streamlined and targeted plans to address the shortcomings and open up doors for new opportunities, thus relieving the sector from the Covid stress.

With this volume of power outlook series, we hope to inform the ecosystem to build an increasingly decarbonized, resilient and future-proof power sector that can be the keel of India's financial prowess.

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Shakti Sustainable Energy Foundation (Shakti) seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following sectors: clean power, energy efficiency, sustainable urban transport, climate policy and clean energy finance.

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