VASUDHA FOUNDATION
Green ways for a good earth!

2020

INDIA'S POWER OUTLOOK

VOLUME 1 -

CURRENT STATE OF PLAY

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

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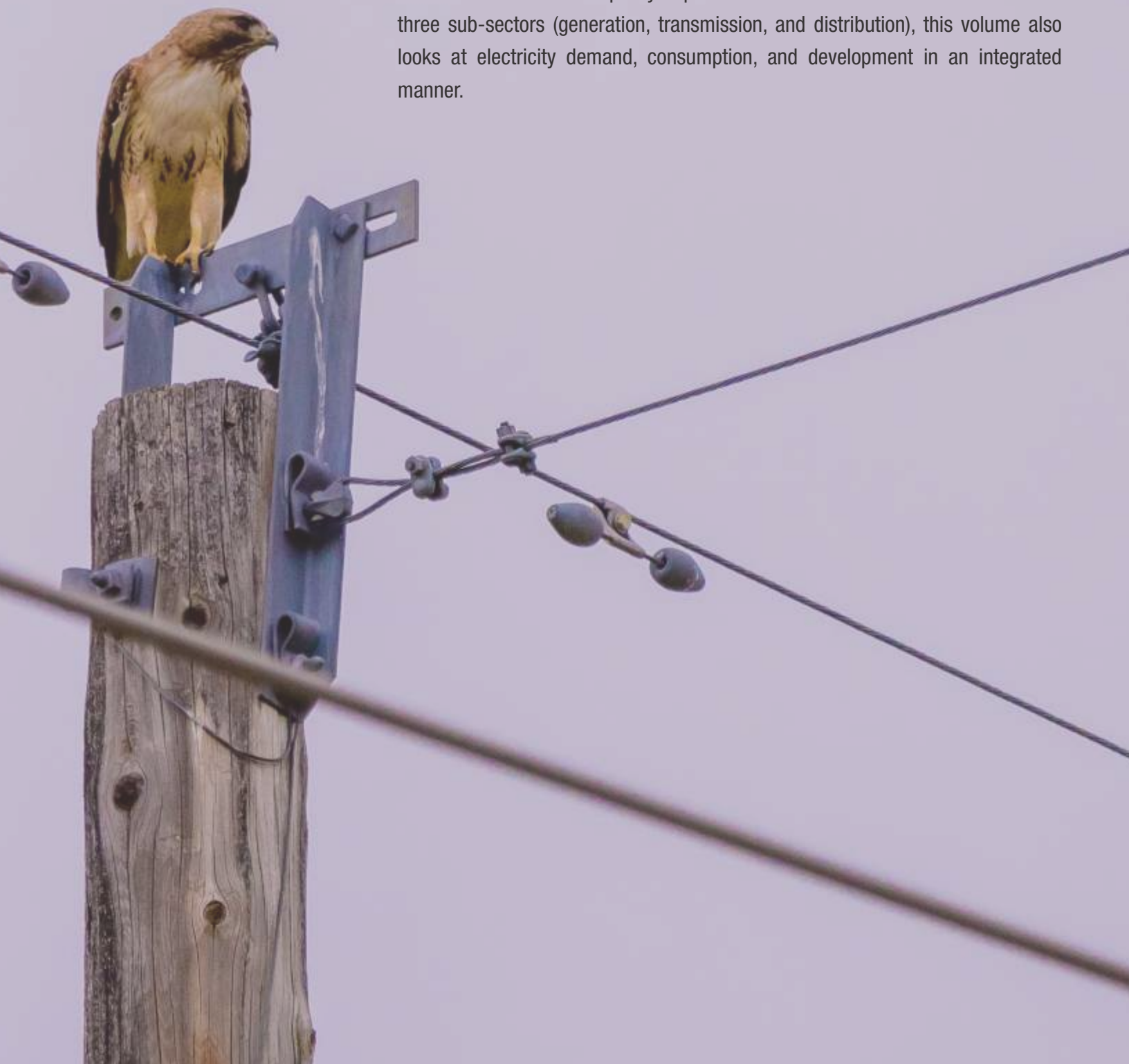
The data pertains to the 30th November 2019, unless otherwise mentioned.

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. This series aims to develop a more informed understanding of the power sector and may act as a tracking tool for stakeholders.

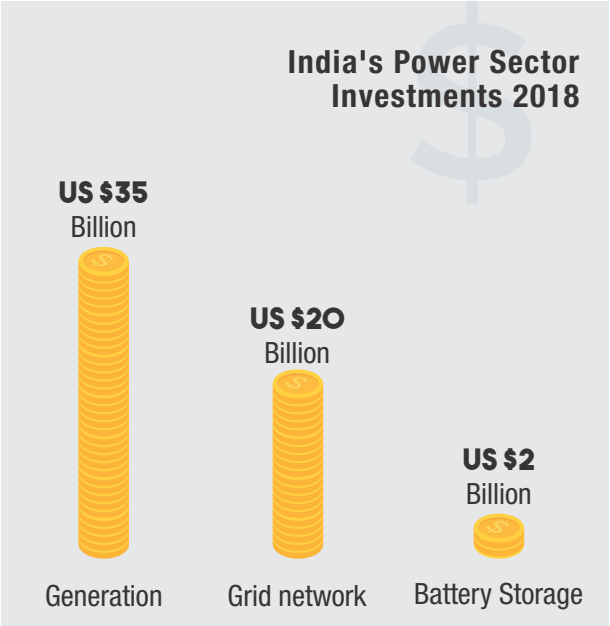
Volume 1 titled ***'Current State of Play'*** focuses on the entire power sector value chain and captures the key trends and transitions shaping the sector. It details the focus areas and lists the policy implications under each sub-sector. Besides the three sub-sectors (generation, transmission, and distribution), this volume also looks at electricity demand, consumption, and development in an integrated manner.



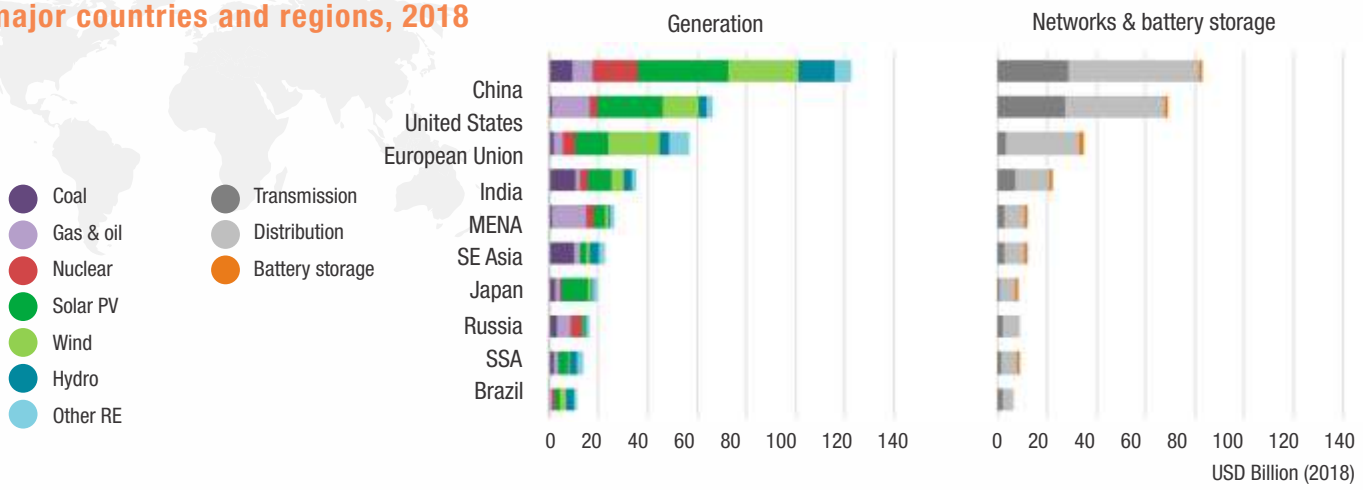
INTRODUCTION

1

India's growing population with an increasing per-capita energy consumption and a conducive policy environment have consistently attracted investments into its power sector. In 2018, India's power sector saw investments of US $35 billion in the generation sub-sector led by renewable power generation, another US $20 billion in the grid network led by transmission and approximately US $ 2 billion in battery storage[1]. Although China accounted for more than a quarter of the world's power sector investment, its growth declined by 7% between 2015 and 2018. India formed the second largest growing power market when compared with 2015 levels after the United States. Moreover, the power sector featured amongst the top ten sectors attracting foreign investment in India with approximately US $1.1 billion in 2018-19[2]. The 2018-19 India Economic Survey[3] further highlighted renewable energy (RE) investment plans (without transmission lines) of US $80 billion till 2022 and a cumulative investment opportunity of around US $250 billion to achieve 175 GW and 450 GW[4] of RE capacity by 2022 and 2030 respectively.



Power sector investments by major countries and regions, 2018



Source: World Energy Investment 2019, IEA[5]

The Indian Power sector has been evolving rapidly. It has come a long way from conventional generation, large energy deficits and a low-performing grid by making efforts towards large-scale RE-based capacity addition, ~100% household electrification and digitalisation of the power sector. The smarter grid is giving its consumers the ability to generate their own power and also manage its consumption by adopting innovative demand side management programs.

Still, the sector continues to grapple with a large number of traditional issues such as high Aggregate Technical and Commercial (AT&C) losses, non-cost reflective tariffs, old infrastructure and inefficient system level planning. Moreover, new developments such as large RE growth and its intermittencies, significant baseload capacity addition, rapidly declining prices for solar and wind, sales migration (via open access and captive), decentralization of power and massive household electrification efforts are bound to pose newer challenges for the grid. Despite this, India is expected to emerge as the largest market for power sector investments in the next decade.

THE POWER SECTOR INDIA
A Snapshot

GENERATION

365.98 GW (Gigawatts)
Total installed capacity

9,45,205 MUs (Million units)
Overall generation (provisional values)

84.4 GW
Installed RE capacity (excluding large hydro)

129.8 GW[1]
Total Installed RE capacity

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

TRANSMISSION

4,20,490 cKM (Circuit kilometers)
Number of transmission lines

9,49,923 MVA (Mega Volt-Ampere)
Substation transformation capacity

426 cKM*
Number of transmission lines completed under the Green Energy Corridor

770 MVA*
Number of transmission substations completed under the Green Energy Corridor

** Values taken from Tarang Dashboard, as on 27th December, 2019*

DISTRIBUTION

8,80,208 MUs
Total energy requirement

8,75,512 MUs
Total energy available

1,83,804 MW
Total peak demand

1,82,533 MW
Total peak met

21.35% **
Average AT&C loss

0.38 RS/UNIT **
ACS - ARR gap

*** Values taken from UDAY Dashboard, as on 24th December, 2019*

CONSUMPTION

~2.6 CRORES
Number of households electrified

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

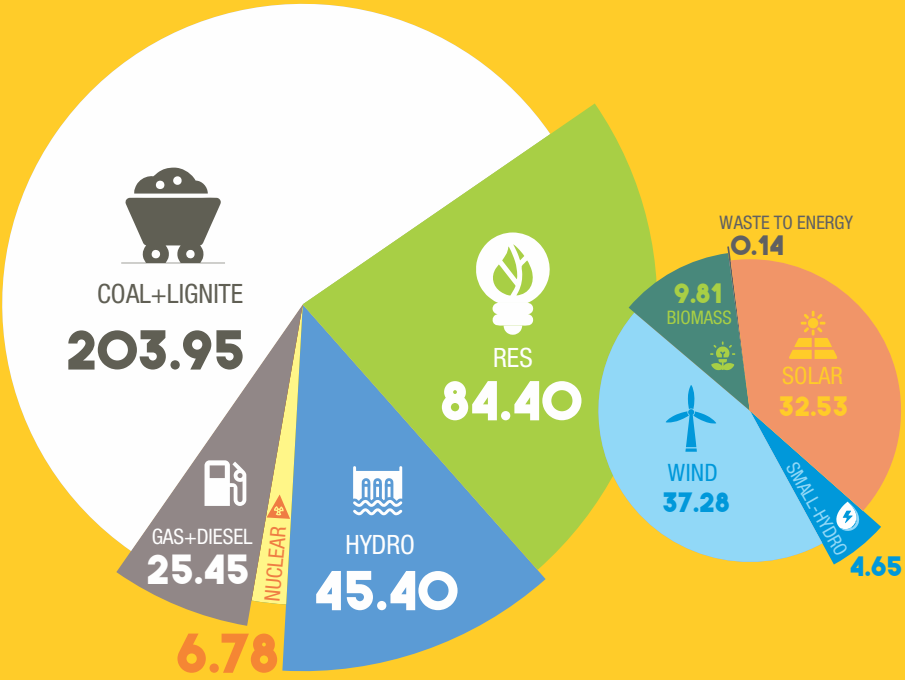
42% (Industry sector as on 2017-18)
Percentage electricity share by the highest demand sector

[1] https://pib.gov.in/Pressreleaseshare.aspx?PRID=1567817

2

GENERATION

INDIA'S INSTALLED POWER CAPACITY MIX (in GW)

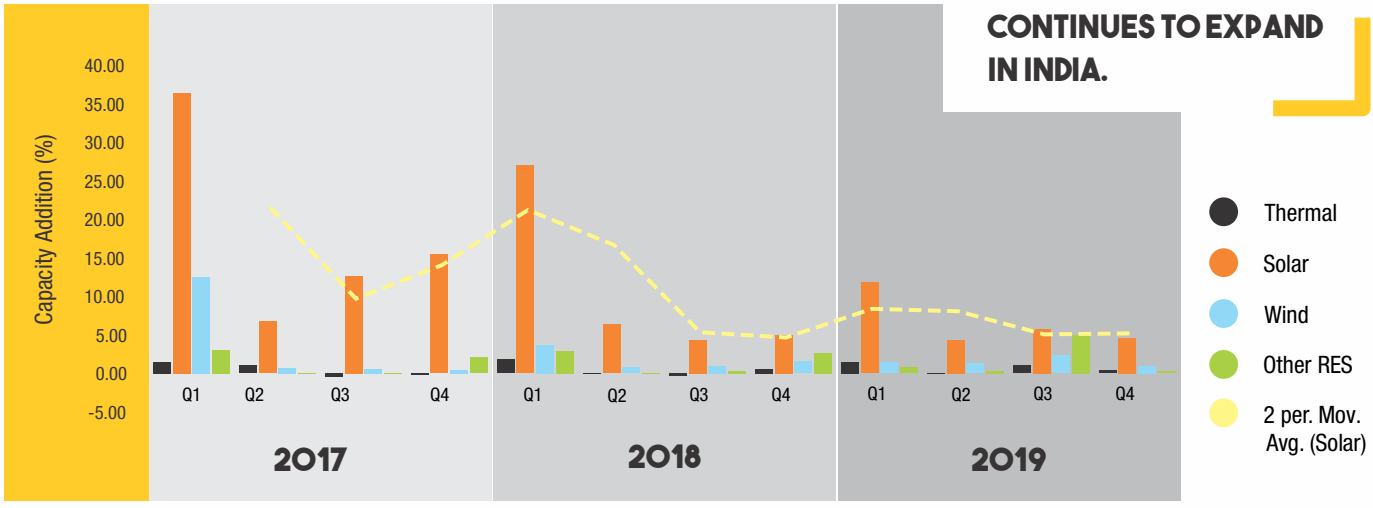


Source: CEA monthly reports on installed capacity[6]

As on 30th November 2019, India had an installed power capacity of 365.9 GW, of which coal dominated with 56%, followed by RE at 23%, hydro at 12%, gas and diesel together at 7% and the remaining 2% consisting of nuclear energy. Amongst RE sources, the key contributor was wind energy with a 10% share in total installed capacity, followed by solar energy (9%), biomass energy (3%), and other RE sources (1%). More private sector participation (almost 50% of the installed capacity) and the 175 GW target of RE capacity addition by 2022 gave a huge investment boost to the sub-sector. Globally, India ranks fourth in wind power, fifth in solar power and fifth in renewable power installed capacity[7].

Source-wise quarterly percentage capacity addition in India From 2017 to 2019

RENEWABLE ENERGY, LED BY SOLAR POWER, CONTINUES TO EXPAND IN INDIA.

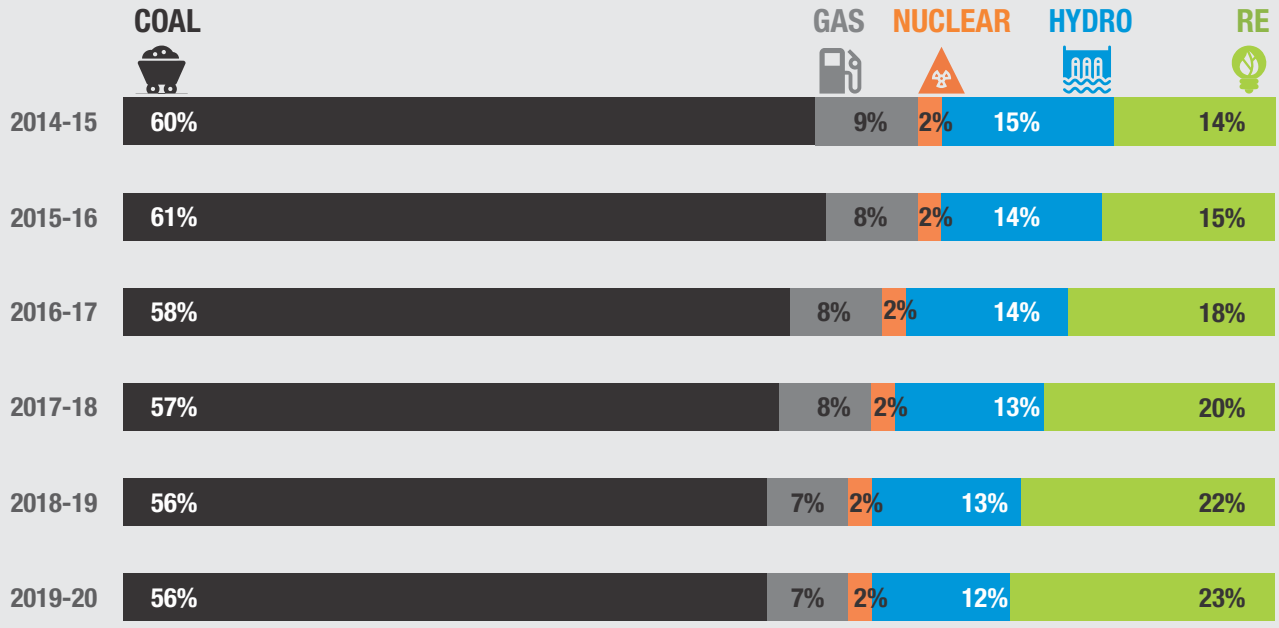


Source: CEA reports on installed capacity from 2017-2019[8]

- Following the 175 GW RE announcement in 2015, large solar capacity additions were made from Q1 2017 to Q2 2018 with a record of 14 GW of capacity within 18 months. The slowdown triggered from mid-2018, due to larger economic headwinds, states expectations of lowest possible tariffs and disregard of the signed power purchase agreements. While the country has commendably achieved almost 50% of the 175 GW target, setting up another 91 GW by 2022 could be an uphill task given the current policy and market environment.
- During almost the same period from Jan'17 to May'19, almost 5.6 GW of old and conventional thermal power plants were retired on account of increasing competition from RE sources, non buoyant demand, and uneconomic operation.

POWER CAPACITY MIX TRENDS FROM 2014-15 TO 2019-20 IN INDIA

DECLINING COAL AND RISING RE SHARE IN THE OVERALL CAPACITY MIX

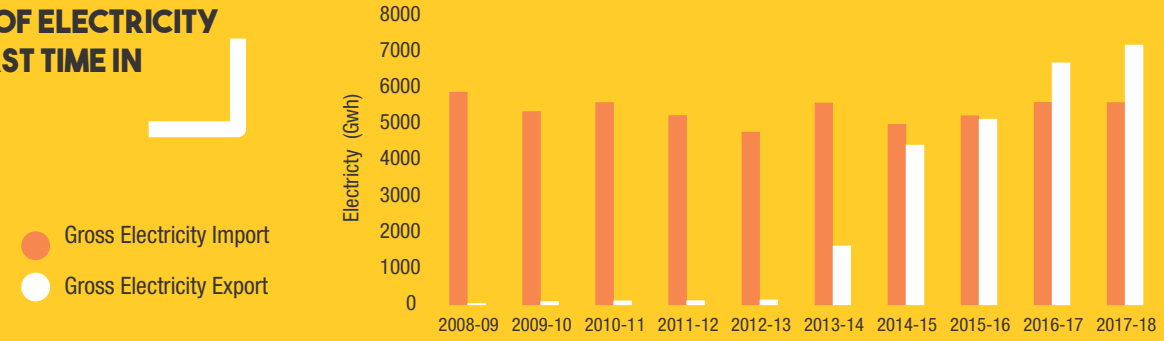


Source: CEA reports on installed capacity from 2015-2019[9]

The actual generation has also grown at par with the installed capacity at a CAGR of 6% from 1,110 BUs in 2014-15 to 1,376 BUs in 2018-19. While coal continues to dominate the capacity mix but it sees a declining year-on -year share in actual generation and overall capacity mix.

INDIA BECAME A NET EXPORTER OF ELECTRICITY FOR THE FIRST TIME IN 2016-17

Trends of import and export in electricity in India



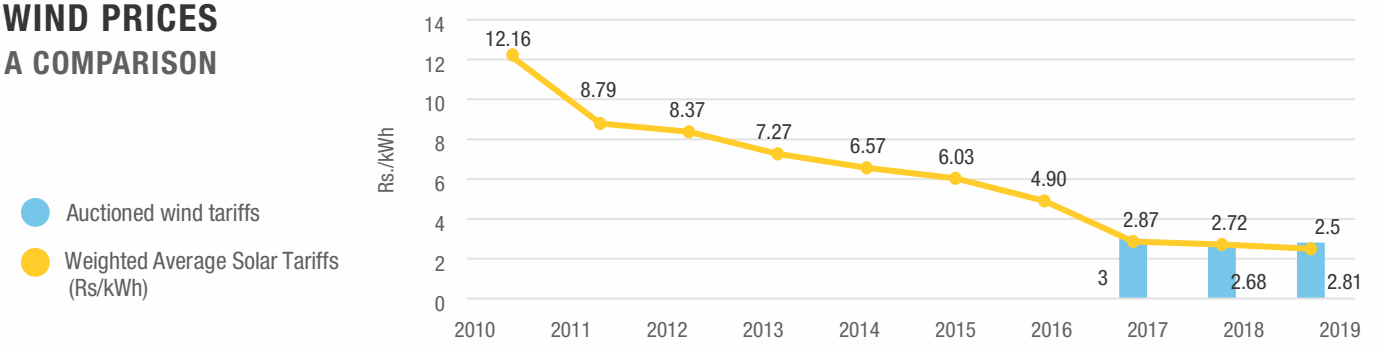
Source: Energy Statistics 2019, MOSPI [10]

- Over the past 10 years from 2008-09 to 2017-18, India's gross import of electricity decreased at CAGR of (-) 0.5%, (from 5,897 GWh in 2008-09 to 5,611GWh in 2017-18).
- The export of electricity increased from a negligible 58 GWh in 2008-09 to 7,203 GWh in 2017-18.
- During 2018-19, India imported 5,081 GWh of electricity annually from Bhutan and exported 2,813 GWh and 6,786[11] GWh to Nepal and Bangladesh respectively.

GENERATION TARIFF TRENDS IN INDIA

SOLAR AND WIND PRICES
A COMPARISON

India's solar and wind tariffs trajectory



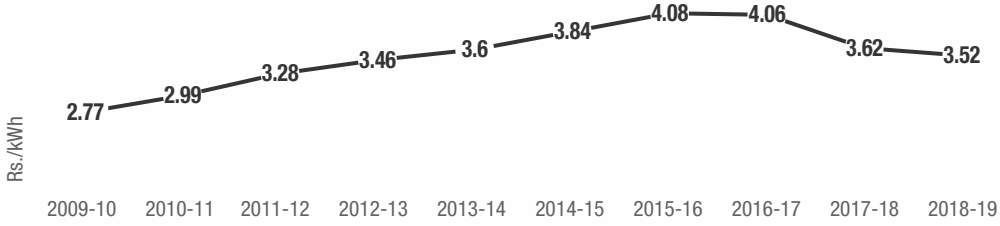
Source: Data taken from Standing Committee on Energy (2016-17 to 2017-18), MNRE[12] and India Wind Energy Association[13]
Vasudha Foundation Analysis

Solar prices have dropped by about 80% in India between 2010 and 2019. This has been possible because of a conducive policy environment for the sector and incentives that provided investor confidence. Also, setting up of aggressive targets and implementation of policies through streamlined efforts have favored faster implementation at lower costs.

COAL PRICES
ANALYSIS

GRADUAL RISE IN PER-UNIT COAL BASED POWER PURCHASE COST SINCE 2009-10

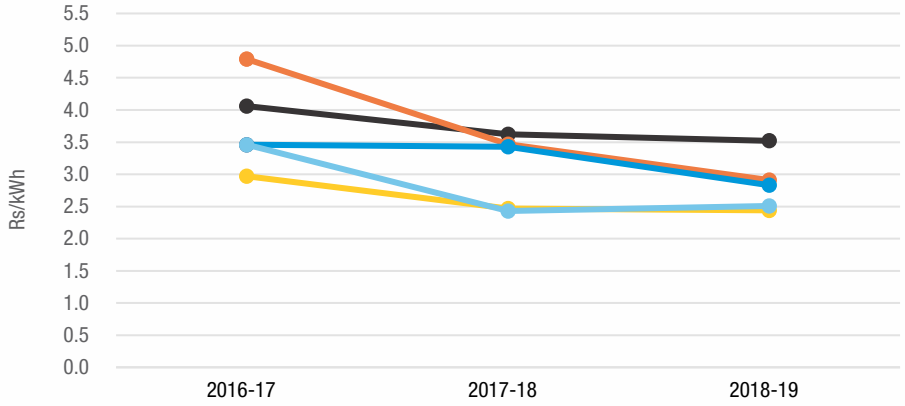
Power purchase cost of coal based thermal power plants (2009-10 to 2018-19)



Source: Data taken from various Discoms and Vasudha Foundation Analysis

COAL, WIND AND SOLAR
A COST COMPARISON

Tariff Trend for Coal, Solar and Wind (In Rs./ kWh)



	2016-17	2017-18	2018-19
Average Coal Tariff	4.06	3.62	3.52
Solar Highest Bid Weighted Average Tariff	4.79	3.47	2.91
Solar Lowest Bid Weighted Average Tariff	2.97	2.47	2.44
Wind Highest Bid Tariff	3.46	3.43	2.83
Wind Lowest Bid Tariff	3.46	2.43	2.51

Source: Vasudha Foundation Analysis

In the past two years, record low-tariffs were discovered for both wind (Rs 2.43/unit) and solar (Rs 2.44/unit), whereas the coal prices continued to hover around Rs 3.5/unit. Clearly, power generation prices are not going to be a hurdle for the accelerated deployment of renewable energy in the country.

The Central Government continues to promote policy and regulatory efforts to achieve the 2022 target of 175 GW of installed RE capacity. Some of these efforts include stronger compliance to revised renewable purchase obligation (RPO) targets, waiver of inter-state transmission system (ISTS) charges and losses, solar -wind hybrids and solar energy in agriculture, for example through the KUSUM (Kisan Urja Suraksha evam Uhaan Mahaabhiyan) scheme. While RE will continue to play a significant role in future, it is important to recognize that a smooth transition will depend on how specific regulatory and technical challenges associated with renewables are addressed. Further, the energy mix needs to be balanced for efficient capacity utilisation. The huge tariff declines in solar and wind are already posing competition to coal-based plants. Moreover, significant amounts of recent surplus baseload capacity have already been added in previous years. If not managed efficiently, this can lead to some of these thermal power plants becoming into non-performing assets (NPAs). This will further increase the financial burden of the already debt laden distribution utilities.

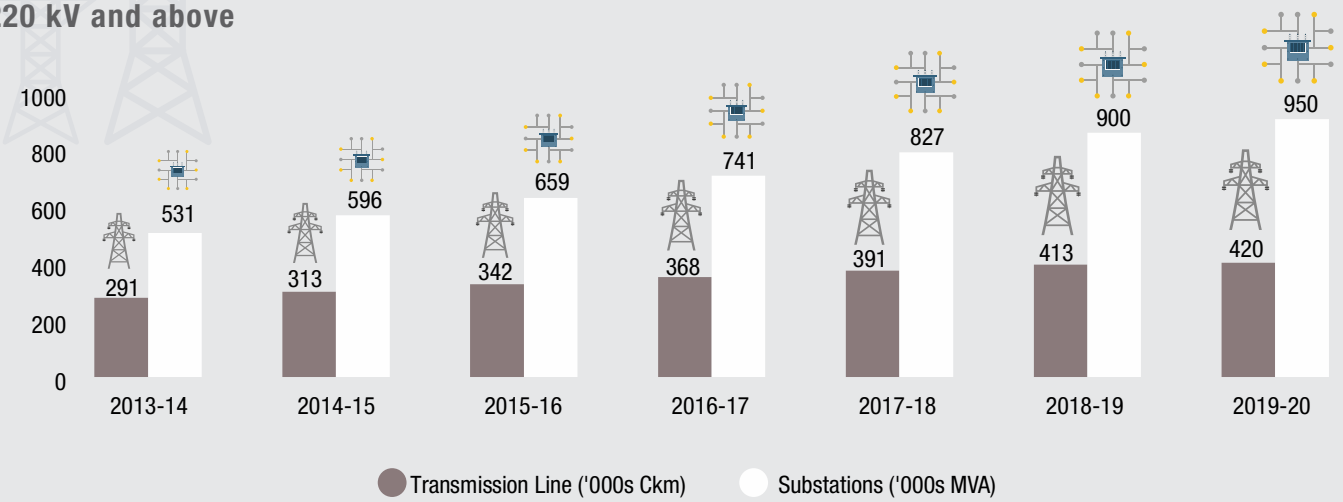
TRANSMISSION

3

The transmission sub-sector has consistently grown to become one of the largest operational and integrated grids with huge investments in high voltage lines and substations. This sub-sector is largely dominated by state utilities while the private sector currently accounts for only 3-4% of the total transmission capacity.

CUMULATIVE YEAR-WISE GROWTH OF TRANSMISSION LINES AND SUBSTATIONS

220 kV and above



Source: National Power Portal [14]

As on 30th November 2019, the Indian transmission system includes:

- 4,20,490 ckm of transmission network
- 9,49,923 MVA of transformation capacity
- 100,550 MW of national grid inter-regional capacity

Growth of India's transmission sector between FY 2014 to FY 2019

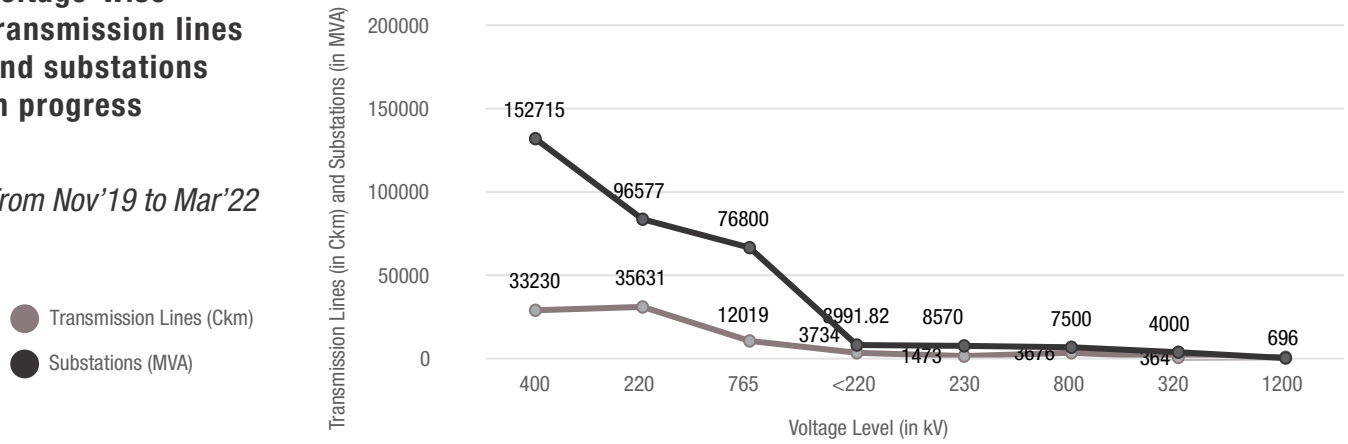
	As on March 2014	As on March 2019	Addition	CAGR
Inter-regional power transmission capacity of national grid (MW)	33,950	99,050	65,100	24%
All India power transmission network (ckm)	291,336	413,407	122,071	7%
Substation Transformation capacity (MVA)	530,546	899,663	369,117	11%

Source: CEA Executive Summary Reports, March (2014 and 2019)[15]

India's transmission network capacity grew at a CAGR of 11% between FY 2013-14 and FY2018-19. With regard to transmission lines, it expanded at a CAGR of 7% by adding 122,071 ckm since March 2014. Only under the 12th plan period (2017-22) ,6,124 ckm (till November 2019) of 800kV HVDC (high-voltage, direct current) transmission lines were constructed for the first time.

Voltage-wise transmission lines and substations in progress

From Nov'19 to Mar'22



Source: CEA monthly transmission report, November 2019[16]

The graph above shows the voltage-wise transmission lines and substations which are planned from November 2019 to March 2022.. The maximum number of transmission lines and substations are planned at 400 kV and 220 kV since these voltages are primarily used for bulk long-distance transmission.

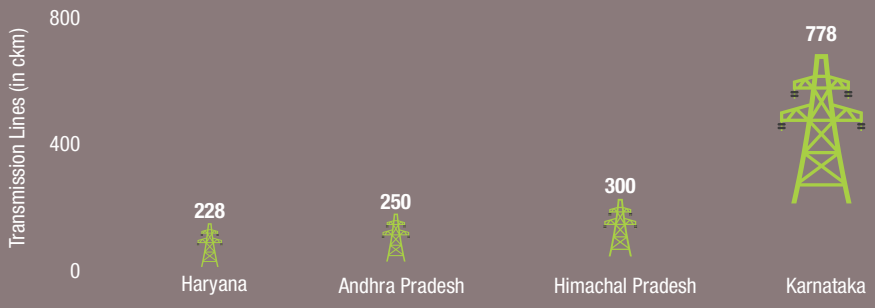
GREEN ENERGY CORRIDOR

Accelerated investments in RE generation capacity needs to be matched with an equivalent investment in grid capacity expansion. Hence, the focus of the transmission sub-sector is to ensure grid integration of large amounts of variable RE while minimising integration cost.

Accordingly, the Green Energy Corridor was devised as a comprehensive scheme for large scale evacuation and integration of 175 RE capacity by 2022. Further POWERGRID, has set a capex target of US$ 7.7 billion over 2018-2021[17] to implement the scheme. It is being implemented by the eight states of Tamil Nadu, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Madhya Pradesh which have a sizeable RE potential.

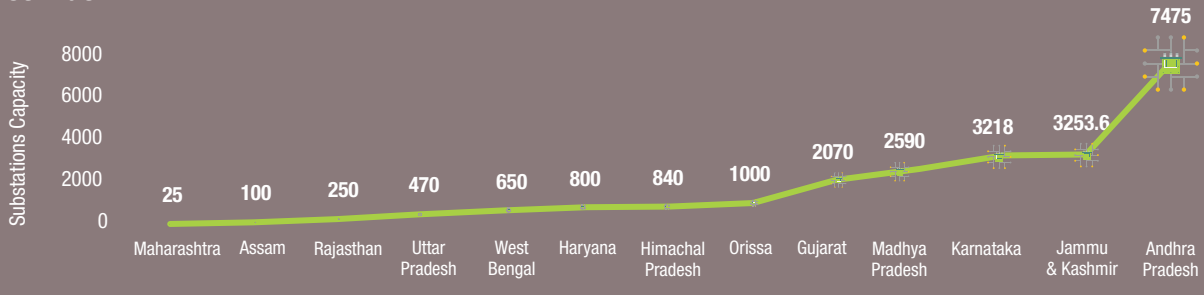
As per the Tarang Dashboard (on 27th December 2019), the total length of transmission lines and substation capacities to be constructed under the Green Energy Corridor are 1,556 ckm and 22,742 MVA[18].

Green energy corridor transmission lines in progress (in cKM)



Source: Tarang Dashboard (updated on 27th December 2019)[19]

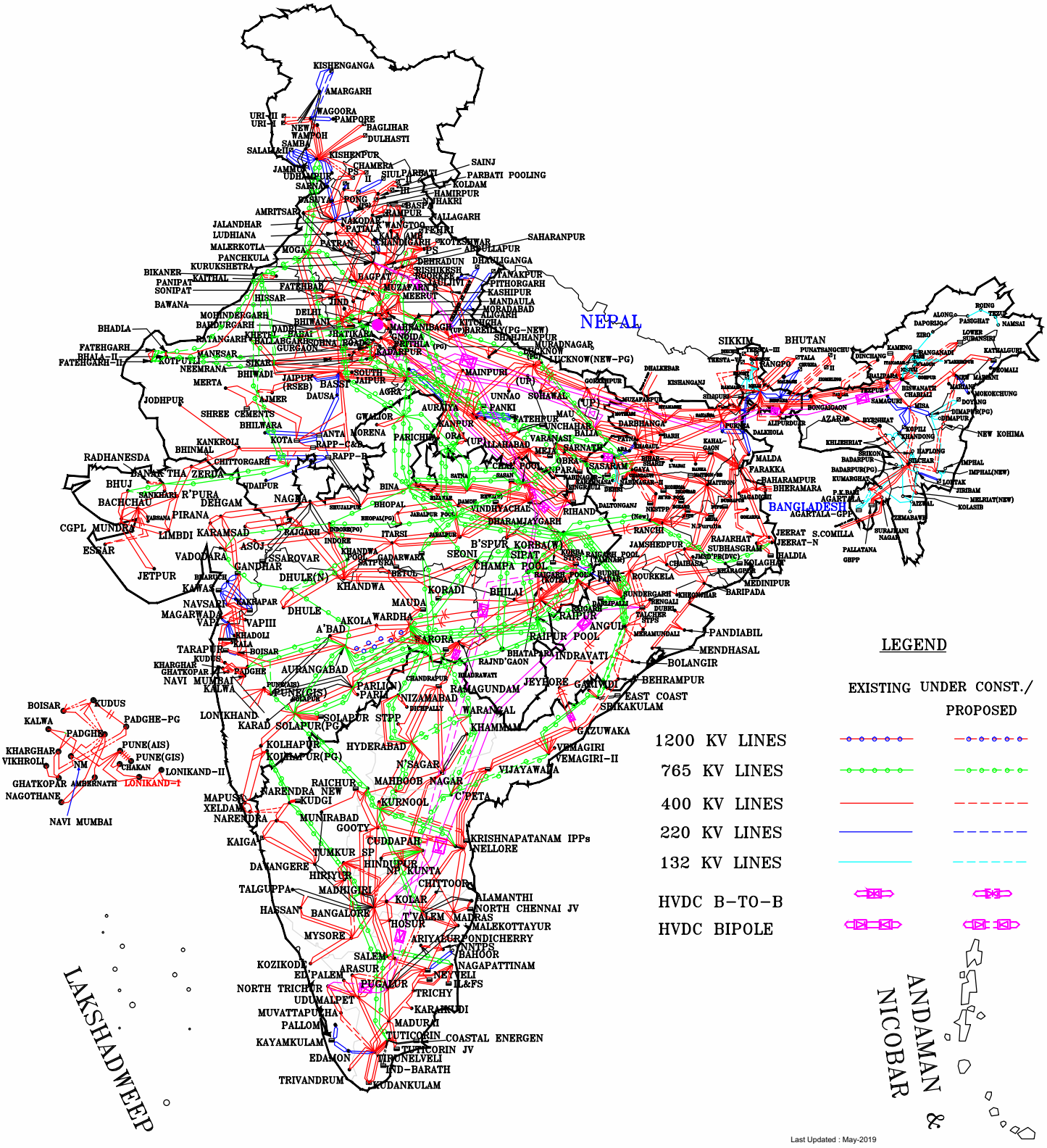
Green energy corridor substations in progress (in MVA)



Source: Tarang Dashboard (updated on 27th December 2019)[20]

TRANSMISSION NETWORK OF INDIA

Inter State Lines



Source: Power Grid Corporation of India Ltd

While the transmission system has matured extensively over many years, there are noteworthy challenges that are impacting the grid integration of renewables. For instance, some of the wind developers in Gujarat and Tamil Nadu continue to face uncertainties in getting access to the transmission network. It takes around 36-40 months to build the required transmission capacity, but wind projects are expected to be completed within 18 months of the project start date[21]. This has also resulted in low participation in some of the recent wind and solar auctions conducted by Solar Energy Corporation of India Limited (SECI)[22]. This can delay India's achievement of it's wind capacity target.

Robust planning and state of the art modelling will be necessary to address the additional congestion and complexity that the grid will experience with large quantities of intermittent RE share. Therefore, it is critical to enhance coordination between states to lower the price of RE integration in an effective manner. Accordingly, the Ministry of Power plans to set up 11 Renewable Energy Management Centres under the Green Energy Corridor, that will aid better forecasting of RE generation and demand. Out of these, eight REMC have already been commissioned in 2019[23].

It is further critical to ensure that strengthening of the transmission infrastructure happens at the same pace of announcement of the new tenders[24] . However, the progress under the Green Energy Corridor has already been slower than envisaged[25] and its timely completion is critical towards meeting the 175 GW target.

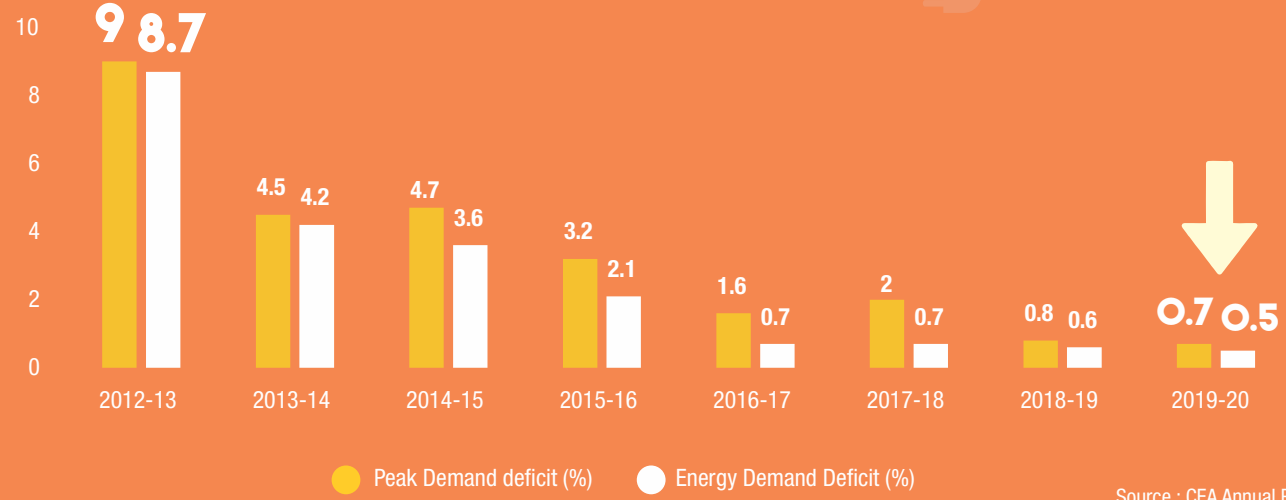
4 DISTRIBUTION

The electricity distribution sub-sector is often considered to be the weakest link in the overall power sector value chain. It is currently dominated by state power utilities with private sector participation only in the big cities. While it continues to battle serious challenges, it has also seen some improvements in the last few years.

There has been a significant reduction in overall peak and energy demand deficits. The deficits reduced from as high as 9% in 2012-13 to 0.7% and 0.5% peak and energy deficit as of November 2019. However, the deficit situation is higher in many states in the northern, eastern and north-eastern regions in particular. There has also been a gradual decrease in aggregate AT&C losses from ~25% in 2012-13 to 21.35% in December 2019[26]. Over the last few years, almost 25 states and union territories have adopted tariff revision exercises leading to more than 50% reduction in the gap between the average cost of supply and average revenue realized from 0.85/unit (on subsidy received basis) in 2012-13 to 0.38/unit in December 2019[27]. Further, with the implementation of the SAUBHAGYA (Pradhan Mantri Sahaj Bijli Har Ghar Yojana) scheme,all states reported electrification of all willing households except few in households in LWE[ii] affected Bastar region of Chattisgarh[28].

SIGNIFICANT REDUCTION IN PEAK AND ENERGY DEFICITS

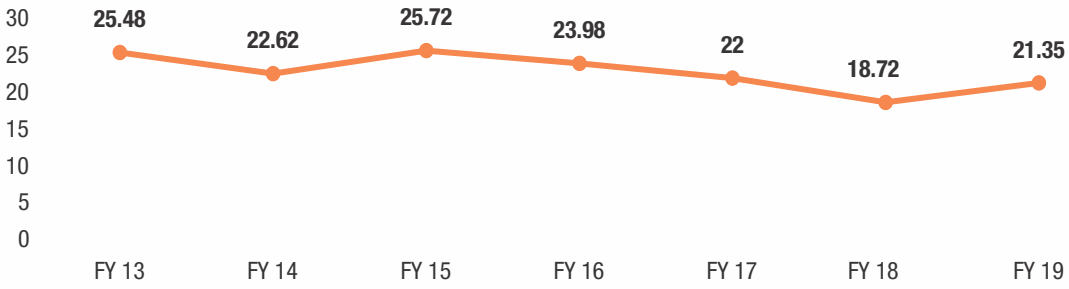
YEAR-WISE COMPARISON OF INDIA'S PEAK AND ENERGY DEMAND DEFICITS (IN %)



Source : CEA Annual Reports[29]

AT&C losses trajectory from 2012-13 to 2019-20 (in %)

As on 24th December 2019



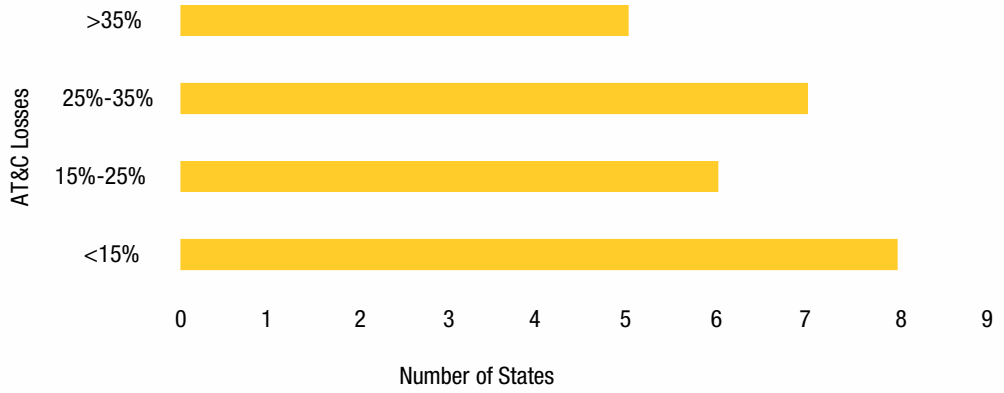
Source: PFC report on performance of state power utilities, CEA annual reports and UDAY Flyer 2019[30]

[ii] Left-wing extremism

STATES AND THEIR AT&C LOSSES

A comparison

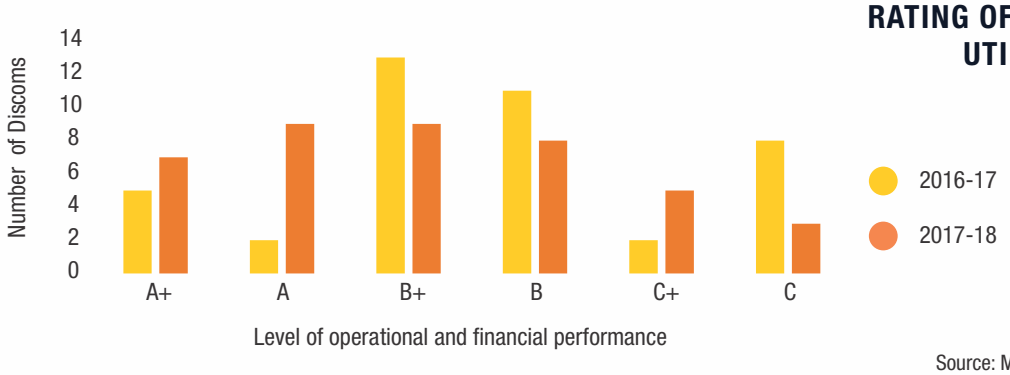
ALMOST 12 STATES HAVE AT&C LOSSES HIGHER THAN 25% GLOBAL STANDARDS ~8%[31]



Source : UDAY dashboard[32]

The technical losses are largely due to aged infrastructure and inefficient systems. But a considerable portion of such losses are also due to issues that are commercial in nature, including poor metering, billing and collection practices, electricity theft and ineffective human resource planning practices.

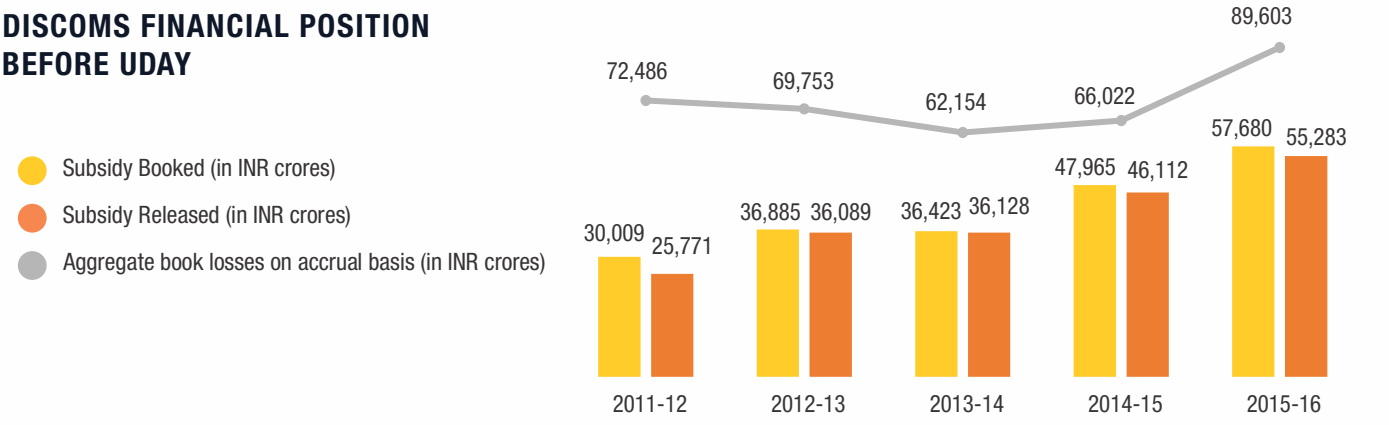
RATING OF 41 PUBLIC DISTRIBUTION UTILITIES ACROSS 22 STATES



Source: MOP Annual Integrated Ratings, October 2019[33]

Significant improvement can be observed in the operational and financial performance of the distribution utilities between 2016-17 and 2017-18. The number of distribution utilities with high to very high performance (A+, A) more than doubles in 2017-18. A slight decrease is also observed in the number of distribution utilities with low to very low performance (C+, C). Gujarat distribution utilities, BESCOM[iii] ,APEPDCL[iv] (Vishakhapatnam) and Uttarakhand distribution utility continues to be the better performers.

DISCOMS FINANCIAL POSITION BEFORE UDAY



Source: PFC performance reports of state power utilities (2011-12 to 2015-16)[34]

[iii] Bangalore Electricity Supply Company Limited

[iv] Eastern Power Distribution Company of Andhra Pradesh Limited (India)

The distribution sub-sector is battling two main challenges - ensuring financial viability and providing universal access to all households. The state subsidizes electricity for farmers and households which have resulted in mounting financial losses over the years. The revenue gap is partly cross subsidized by the commercial and industrial consumers and in part by budgetary support by the respective state Governments. Further, the Central Government has time and again initiated various bailout packages for the state distribution utilities, the most recent one being UDAY (Ujwal Discom Assurance Yojana). The UDAY scheme was launched in November 2015 for the operational and financial turnaround of the state distribution utilities. As per the recent RBI report[35], the total outstanding liabilities of State Governments under the UDAY scheme are expected to reach to 1.97 lakh crore by March 2020 from 0.98 lakh crore in 2016.

The amount of debt taken under UDAY was the highest as compared to the other previous programs. While the large impact of UDAY on the state finances was always known before; the impact of the future losses' to be taken over is highly dependent on the operational and financial improvement of the distribution utilities. Hence, it is crucial for the regulators and state governments to ensure that the improvement in performance of the electricity distribution sector is aligned as per the set targets.

UDAY REPORT AT A GLANCE

As Per Uday Dashboard on 24th December 2019

FINANCIAL AND OPERATIONAL PARAMETERS

FINANCIAL

RS 2,32, 163 CRORES
Bonds Issued

RS 2,69,056 CRORES
Bonds to be issued

21.35%
AT&C losses

RS 0.38/UNIT
ACS-ARR gap

25 OUT OF THE 27 STATES
Tariff Revision Done

OPERATIONAL

100%
Electricity access to unconnected households

100%
Feeder metering (Urban)

100%
Feeder metering (Rural)

87%
DT metering (Urban)

62%
DT metering (Rural)

5%
Smart metering (>500kWh)

4%
Smart metering (>200-500 kWh)

82%
Feeder segregation

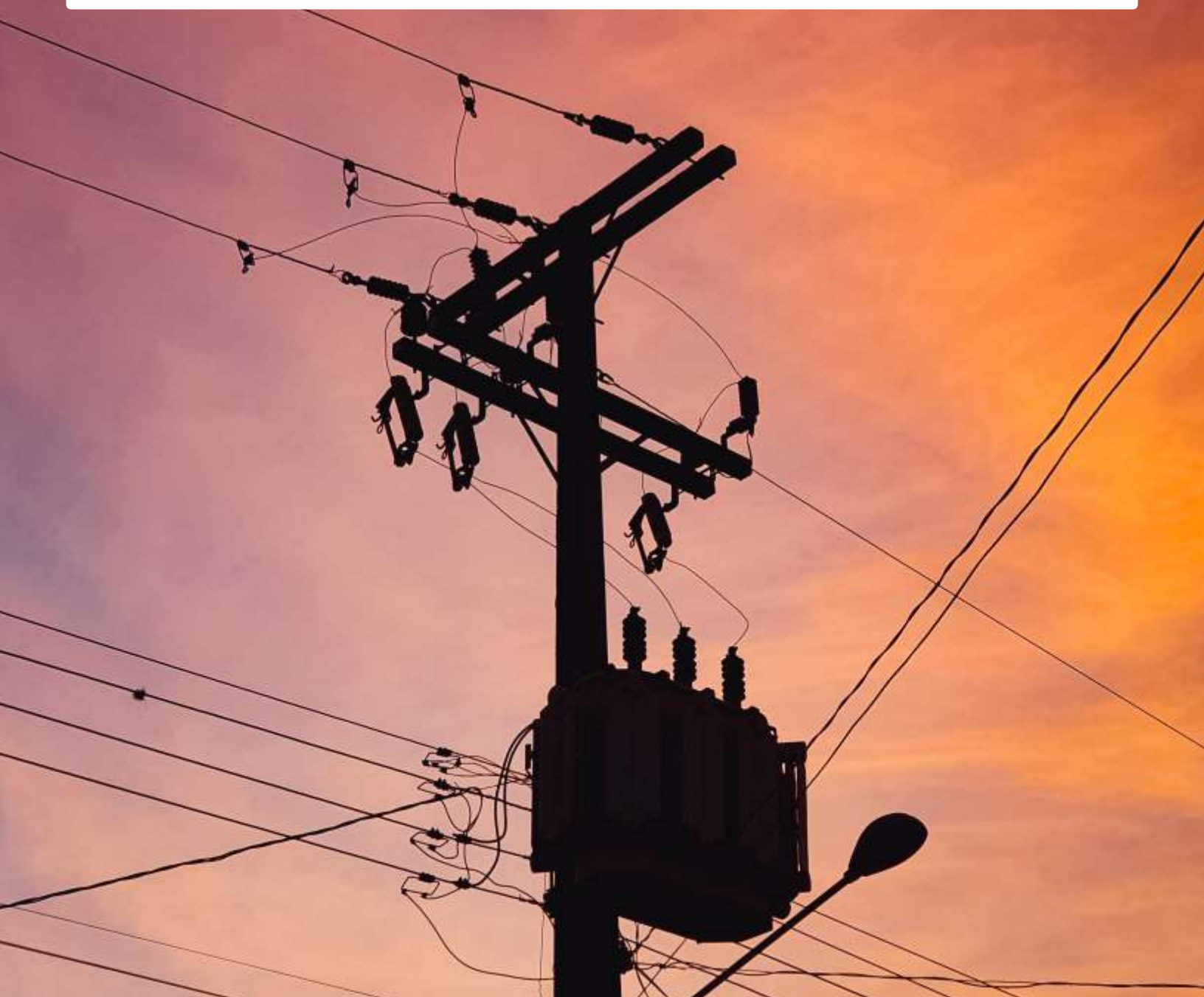
100%
Rural feeder audit

100%
Distribution of LEDs under UJALA

In the wake of new developments on the generation and consumption side, there is an urgent need for the distribution utilities to bring fundamental changes in their operations and functioning. With an uncertain demand and higher small-scale distributed generation; the power planning will become even more complex and tricky. Due to higher economic sense and better power quality, large consumers will move out of the grid. This will result in a gradual reduction of the cross-subsidy pie available with the distribution utilities. Lastly, an increasing impetus on quality of supply will further impact their finance and investments ability.

To address some of the above-mentioned issues; the Ministry of Power has already made the following headways:

- Additional reform measures to support the existing efforts under the UDAY scheme.
- A draft notification on separation of the carriage and content operations of existing distribution utilities.
- Focus on Direct Benefit Transfer (DBT) Scheme for better targeting of subsidies.
- Great efforts in smart metering and digitalization of processes.



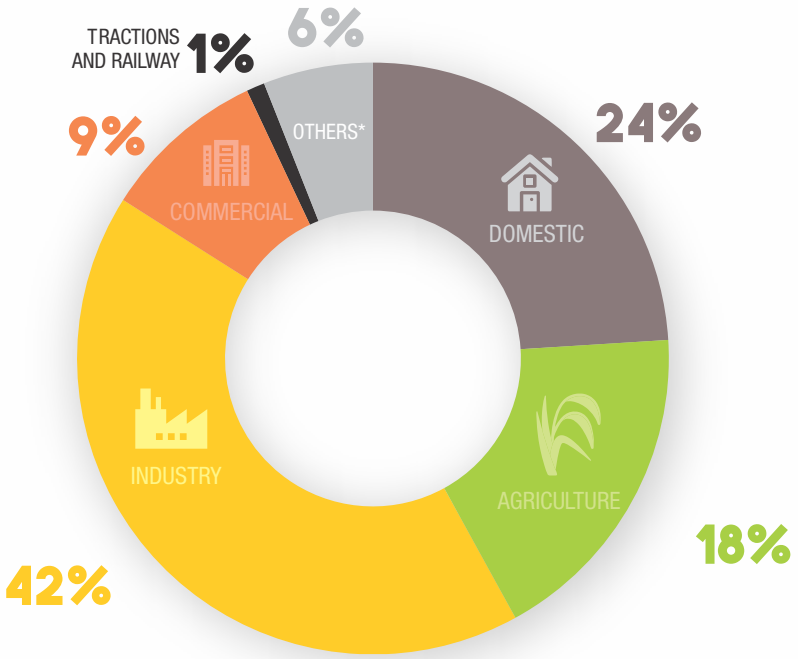
5

ELECTRICITY DEMAND AND CONSUMPTION

Traditionally, the Indian power sector has been focused on the supply side by consistently adding new power plants, laying transmission lines and upgrading distribution infrastructure. Nevertheless, power deficits and outages have never been non-existent and the demand-supply gap still persists. This is due to unequal attention to demand-side analysis and consumption patterns.

Electricity demand and consumption, due to its dynamic nature, is complex to understand and comprehend. Many studies such as the Electric Power Survey, India Energy Security Scenarios(IESS) tool and other independent studies have made an attempt to assess electricity demand. But these have to be updated at defined intervals to incorporate the variability in demand and usage. Also, such studies are critical for efficient planning and operations of the power sector.

SOURCE WISE ELECTRICITY CONSUMPTION IN 2017-18



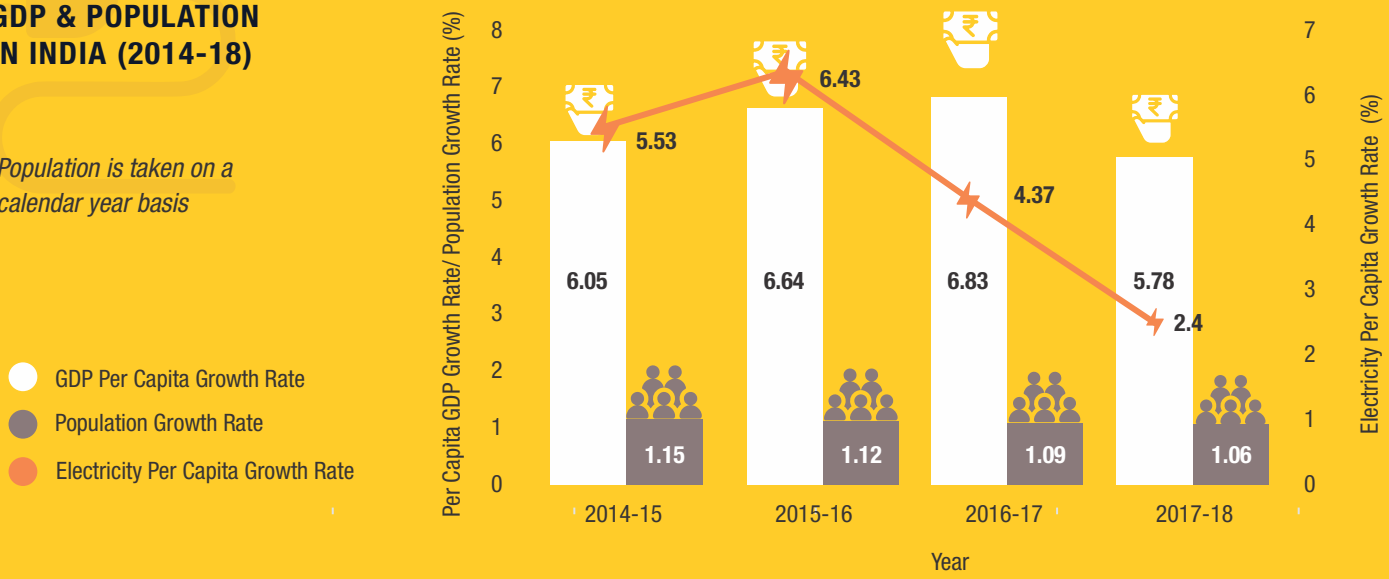
**Others include municipal street lighting, water pumping and others*

Source: Energy Statistics 2019[36]

According to the Energy Statistics 2019, the industry sector has always been a predominant consumer of electricity within the consumption matrix of India. Of the total consumption of electricity in 2017-18, the industry sector accounted for the largest share (42%), followed by domestic (24%), agriculture (18%) and commercial sectors (9%) and the rest 7% by others. Despite significant electrification and capacity enhancement, the overall electricity consumption increased at a nominal CAGR of 5% between 2013-14 to 2017-18. Moreover, the consumption mix remained unchanged for the same period indicating sluggish demand growth in the residential and industrial sectors.

ELECTRICITY CONSUMPTION, GDP & POPULATION IN INDIA (2014-18)

Population is taken on a calendar year basis



Source: RBI, World Bank(2019), CEA(2019)[37]

The per capita consumption has increased at a simlar CAGR of 5% from 1,010 kWh in 2014-15 to 1,181 kWh in 2017-18; which is only one-third of the world's average consumption[v]. A comparative assessment of per capita electricity consumption with per capita GDP and population growth rates shows the declining per capita electricity consumption with the decreasing per capita GDP and population.

A nation-wide electrification was achieved through SAUBHAGYA scheme. But the provision of an electricity connection does not guarantee quality and reliability of power supply. Also, these new connections are in the rural areas or for domestic consumers; who's tariff is either subsidized or free. Increasing the number of supply hours to these connections might increase the overall electricity demand business for distribution utilities but could be a loss making proposition. Hence, in order to avoid a catch 22 like situation, it is important to ensure metering of all the connections whether its free or subsidized. This will help the distribution utilities to better manage and plan their demand. Further, regulatory provisions should ensure cost -reflective tariffs or a direct transfer of state subsidy to these consumers in case of subsidized tariffs to avoid any future losses on account of these new consumers.

[v] https://www.ibef.org/download/power-Jan-2019.pdf

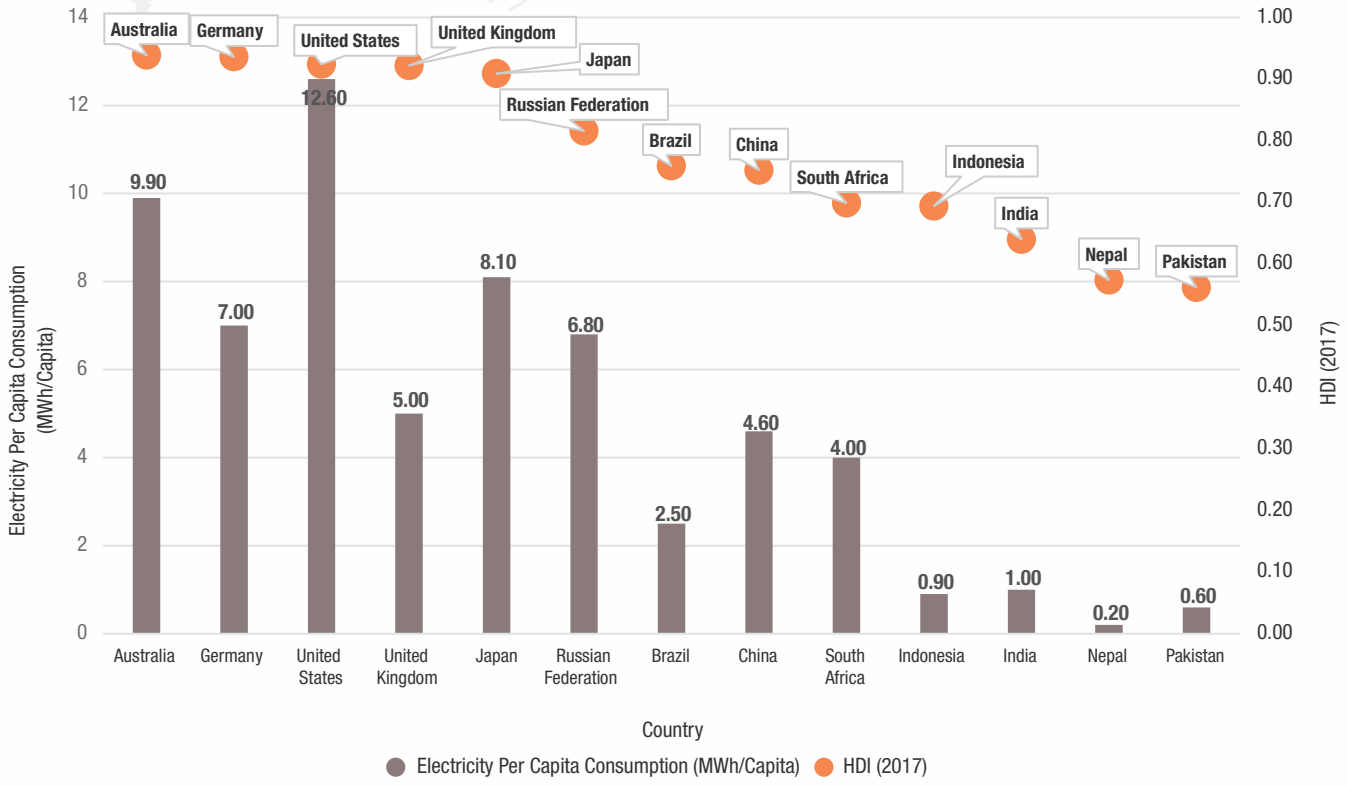
6

ENERGY ACCESS AND DEVELOPMENT

Access to adequate, reliable, sustainable, and affordable modern energy services is essential for the socio-economic development of a country. The Sustainable Energy for All (SE4All) initiative aims to achieve universal access to modern energy services for households, productive uses, and community applications, by 2030. Lack of affordable and clean energy (SDG7[vi]) poses barriers to the attainment of community good health and well-being (SDG3) and quality education (SDG4).

Accordingly, access to reliable electrification can positively impact healthcare services, improve the availability of quality education and generate livelihood opportunities. Although household access to modern energy has received increasing attention in the country, access to energy for the community (productive and consumptive) needs to be emphasized and tracked closely.

Electricity Per Capita Consumption and HDI Across Various Countries (2017)



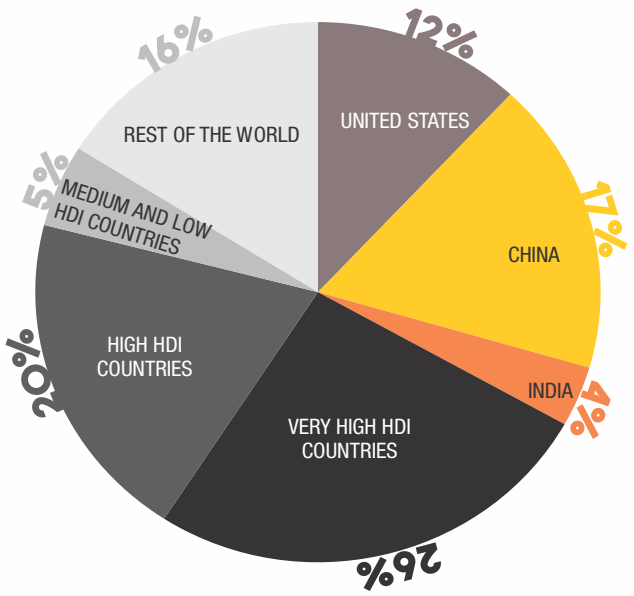
Source: Human development data (1990-2017), UNDP[38]

The above scatter graph shows a high degree of correlation between the per capita electricity consumption and Human Development Index (HDI) levels for the 13 shortlisted countries. This is even more significant for countries with low development indices since a small improvement in the per capita energy consumption correlates to significant improvement in their HDI levels.

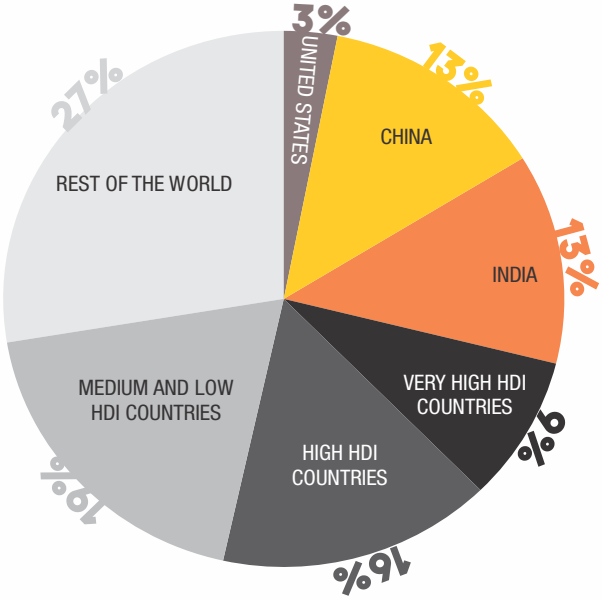
[vi] Sustainable Development Goal

As per the graph below, India constitutes 13% of the global population with an electricity consumption share of only 4% of the total consumption. The analysis is much like a mirror image for countries like the United States, high to very high HDI countries, where sparsely populated countries occupy a major share of electricity consumption.

WORLD SHARE OF ELECTRICITY CONSUMPTION (TwH)

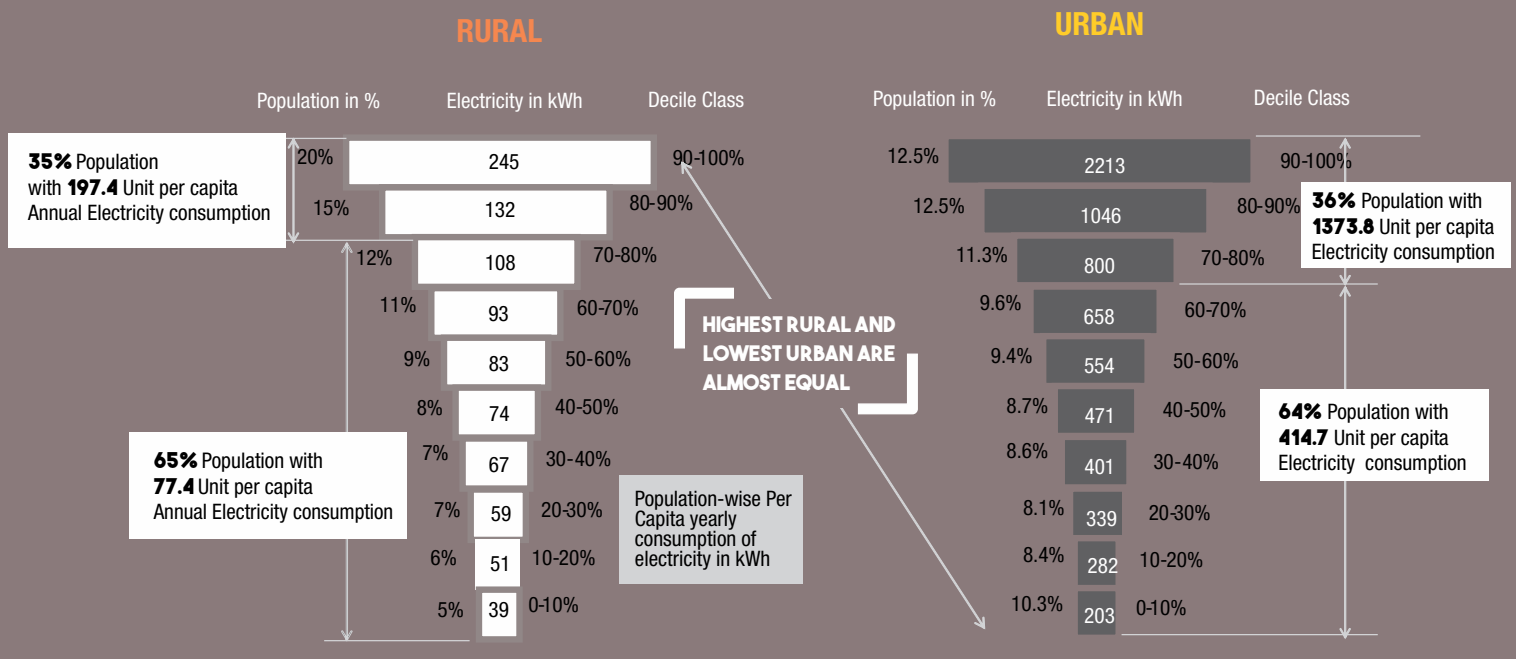


POPULATION DISTRIBUTION ACROSS COUNTRIES



Source: IEA Energy Atlas and World Bank[39]

RURAL-URBAN ENERGY CONSUMPTION ANALYSIS



Exclude 75 million households without electricity

Exclude 5 million households without electricity

Source: Presentation by Dr. Satish Balram Agnihotri, 2014[40]

India is making significant strides in providing grid-based household level electrification. But the Distributed Renewable Energy (DRE) options cannot be overlooked. DRE solutions are critical in providing reliable and quality energy access to unserved population. Not just electricity, but DRE applications can be used as a means to maximise growth and development by creating opportunities for better livelihoods in rural areas. Also, DRE technologies and the SDG are intrinsically linked. Hence, the DRE sector should be looked as a complementing opportunity and not competing.

ENVIRONMENT IMPACT

7

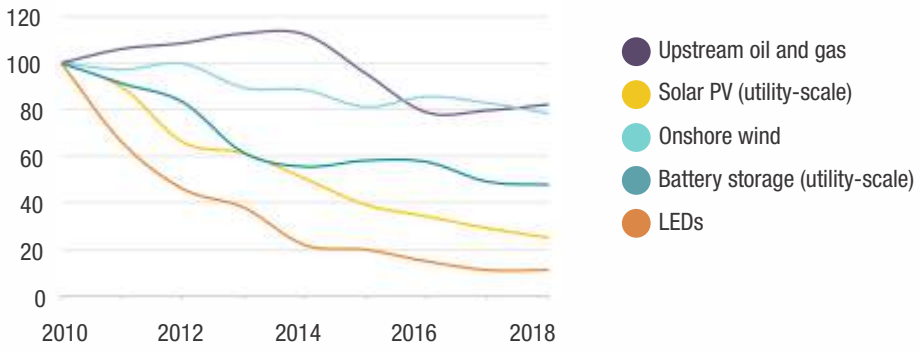
The emissions from public electricity generation rose by almost 80% over the ten-year period since 2005 levels (as mentioned in the graph below). While the emissions from electricity generation increased significantly by 2015, there has been only a marginal increase in its overall share of emissions from the energy sector (from 66.3% in 2005 to 68.3% in 2015). This is largely due to increasing efforts to decarbonize India's generation sector.

ALL INDIA TREND OF EMISSIONS FROM PUBLIC ELECTRICITY GENERATION

Source: GHG Platofrm India[41]

8 OTHER NEW TECHNOLOGY AND INVESTMENT TRENDS

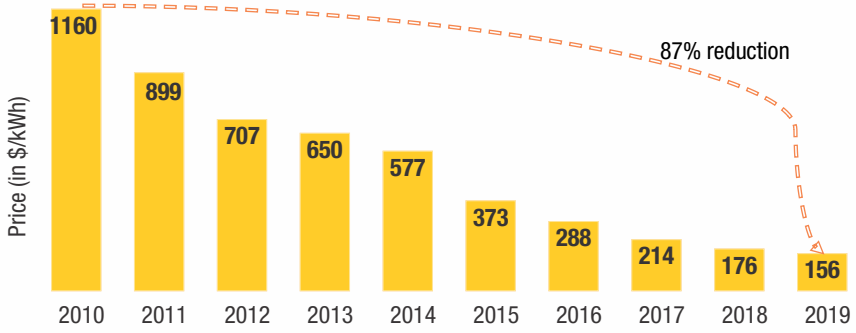
Capital costs trends in selected energy-related sectors



Source: World Energy Investment 2019, IEA[42]

In power, capital cost declines – reflecting technology progress and economies of scale – have been most evident in solar PV (-75% since 2010), onshore wind (-20%) and battery storage (-50%).

Trends in battery price pack (in $/kWh)



Source: Bloomberg NEF 2019 Battery Price Survey[43]

Lithum-ion is being considered as a predominant technology choice for electric storage-majorly due to rapid price reductions. Since 2010, lithium-ion battery prices have dropped by a whopping 87% in real terms, with the combined cost for a cell and pack at $156 in 2019.

This report outlines the current state of play of the India power sector. The sector is going through rapid transitions that will bring irreversible changes to the way we produce our electricity, make electricity access more equitable, fuel our cars, cool our buildings, identify our service provider etc. All these trends will have widespread impact on businesses, governments and people in the coming years. With these power outlook series, we hope to help all stakeholders navigate various developments shaping this inevitable transition. Further, we hope to focus on what is required for relieving the sector of its ineffciencies and shortcomings.

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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.

Vasudha Foundation is a not for profit organization set up in April 2010 with the belief in the conservation of Vasudha, which in Sanskrit means the Earth, the giver of wealth and with the objective of promoting sustainable consumption of its bounties.

The core mission is to promote environment -friendly, socially just and sustainable models of energy by focusing on renewable energy and energy efficient technologies and lifestyle solutions. The organization focuses to bring about reduction in greenhouse gas emissions in the environment and ensure energy efficiency, energy security, energy independence, and sustainable development and simultaneously, promoting the concept of “Low Carbon Solutions” and “Green Economies”. To know more about the Foundation visit, www.vasudha-foundation.org

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