Report by

WISE
WORLD INSTITUTE OF SUSTAINABLE ENERGY

An initiative supported by

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

Status of RE Development in India in 2017-18

RENEWABLES INDIA 2018

Accelerating Market Development

Status of RE Development in India in 2017-18

Renewables India 2018

Accelerating Market Development

Report by

WORLD INSTITUTE OF SUSTAINABLE ENERGY

An initiative supported by

SHAKTI SUSTAINABLE ENERGY FOUNDATION

About WISE

The World institute of Sustainable Energy (WISE) is a not-for-profit institute established in 2004, committed to the cause of promoting sustainable development, with specific emphasis on renewable energy, energy efficiency, and climate change. Mediating public policy through proactive action is the prime objective of the institute.

About Shakti Sustainable Energy Foundation

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.

Acknowledgements

The World Institute of Sustainable Energy (WISE) would like to thank its team members for their significant contribution in the research, writing and development of this report. Special thanks are due to G M Pillai, Founder Director General, WISE, for his keen observations, valuable suggestions and overall guidance.

WISE would also like to thank Shakti Sustainable Energy Foundation for its insightful views, inputs, and valuable support in the preparation of the report.

Citation: WISE (2018). Renewables India 2018: Accelerating Market Development, Status of RE Development in India, 2017-18.

Contributors from WISE

Praveena Sanjay, Director & Lead Coordinator; Surendra Pimparkhedkar, Fellow and Head, Regulation & Policy; Satadru Chakraborty, Associate Fellow, Regulation & Policy; Anand Wagh, Associate Fellow, Wind Power; Debarshi Gupta, Sr. Research Associate, Climate & Sustainability; Vishwesh Pavnaskar, Sr. Research Associate, Energy Efficiency, and Dibin Chandran, Sr. Research Associate, Solar Energy.

Copy Editing & Proofreading: Noela Mendonza

Technical & Production Assistance: Vinita Phinehas, Research Officer, Communications & Coordination; Jyoti Fulpagar, Dy. Librarian.

Printing: Shailesh Art Print, Pune.

CONTENTS

FOREWORD

Renewable energy tariffs continued to fall in 2017–18 as solar and wind tariffs hit historic lows of ₹2.44/kWh and ₹2.43/kWh respectively. Competitive bidding continued to be the major game changer responsible for this ongoing trend. Other key factors that drove the Indian RE market in 2017–18 included falling prices of solar panels, increased investments in RE vis-a-vis the conventional power sector, and the growth of grid-connected solar rooftop via the net metering route. While accelerated market development of RE was a key trend in 2017–18, another major trend that continued during the year was capacity addition from renewables exceeding that of conventional energy, for the second year in a row.

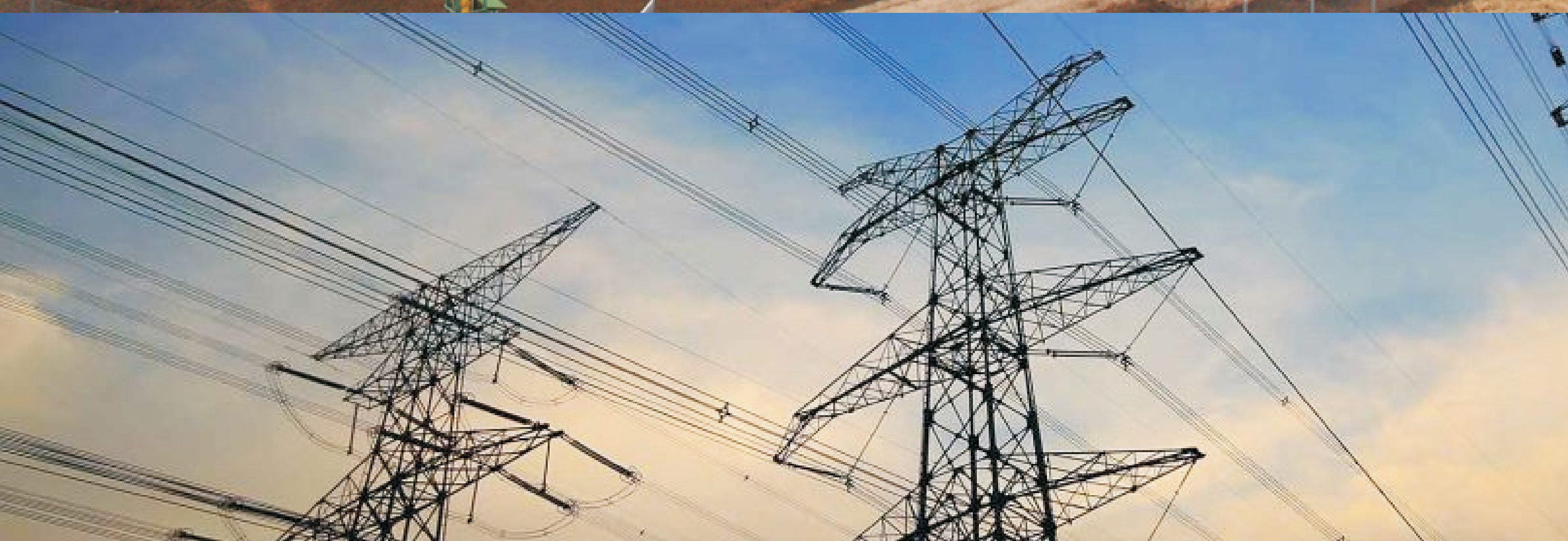
All these major trends and developments and much more, are presented in ***Renewables India 2018***, the second in the series of reports that assimilates data from the WISE-SHAKTI-IREF knowledge and information portal ***www.allaboutrenewables.com***—launched in November 2017—presenting an annual review of India's renewable energy sector. From power generation and policy and regulatory initiatives, to market trends, investment flows, and co-benefits of renewables, the report synthesizes it all.

Although a status report, ***Renewables India 2018*** provides analyses of issues that are critical to the long-term sustainability of the RE sector. We envision that the web portal and the subsequent reports in this series will be more comprehensive and updated with each passing year. In keeping with this objective, the current report introduces two new sections: 'Markets' and 'Co-benefits of RE'.

As mentioned in the first report, lack of robust data on renewable energy is an ongoing challenge that limits the ability of stakeholders to develop long-term, sustainable solutions. ***Renewables India 2018*** and ***allaboutrenewables.com*** endeavours to enhance and strengthen the current data regime and create an enabling environment for achievement of India's energy and climate goals. We hope that these information tools are useful to the stakeholders involved in advancing the deployment of renewable energy and enabling India's steady march towards a low-carbon economy.

(G M Pillai)
Founder-Director General
World Institute of Sustainable Energy



LIST OF TABLES AND FIGURES

Tables

Figures

ACRONYMS

ADB	Asian Development Bank
AHEC	Alternate Hydro Energy Centre
APPC	Average Power Purchase Cost
bn	Billion
BU	Billing Unit
CAGR	Compound Annual Growth Rate
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CO_2e	Carbon dioxide equivalent
Co-gen	Co-generation
CSS	Cross Subsidy Surcharge
DCR	Domestic Control Requirement
DDUGJY	Deendayal Upadhyaya Gram Jyoti Yojana
DISCOMs	Distribution Companies
DPR	Detailed Project Report
ECB	External Commercial Borrowing
EPC	Engineering, Procurement, Commissioning
ERC	Electricity Regulatory Commission
ESCO	Energy Service Company
ESMAP	Energy Sector Management Assistance Programme
FDI	Foreign Direct Investment
FIT	Feed-in Tariff
FOR	Forum of Regulators
FY	Financial Year
GBI	Generation Based Incentive
GDP	Gross Domestic Product
GERC	Gujarat Electricity Regulatory Commission
GHG	Greenhouse Gas
GoI	Government of India
GST	Goods and Services Tax
Gt	Gigatonnes
GW	GigaWatt
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
INR	Indian Rupee
InvITs	Infrastructure Investment Trusts
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
JNNSM	Jawaharlal Nehru National Solar Mission
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt – peak
LCR	Local Content Requirement
LULUCF	Land Use, Land-use Change and Forestry
MCLR	Marginal Cost of Funds based Lending Rate
MDB	Multilateral Development Bank
MGO	Mini Grid Operator
mn	Million

ACRONYMS

MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MOSPI	Ministry of Statistics and Programme Implementation
M-SIPS	Modified Special Incentive Package Scheme
MW	MegaWatt
NAPCC	National Action Plan on Climate Change
NBFC	Non-Banking Financial Company
NEP	National Energy Policy/ National Electricity Plan
NISE	National Institute of Solar Energy
NITI Aayog	National Institution for Transforming India Aayog
NIWE	National Institute of Wind Energy
NLDC	National Load Dispatch Centre
NRDC	National Resources Defence Council
NTP	National Tariff Policy
NTPC	National Thermal Power Corporation
NVVN	NTPC Vidyut Vyapar Nigam Ltd
O&M	Operation and Maintenance
OA	Open Access
OEM	Original Equipment Manufacturer
PFC	Power Finance Corporation
PPA	Power Purchase Agreement
PSU	Public Sector Undertaking
PV	Photovoltaic
RBI	Reserve Bank of India
RE	Renewable Energy
REC	Rural Electrification Corporation
REC	Renewable Energy Certificate
RLDC	Regional Load Dispatch Centre
RLMM	Revised List of Models and Manufacturers
RPO	Renewable Purchase Obligation
SBI	State Bank of India
SECI	Solar Energy Corporation of India
SERC	State Electricity Regulatory Commission
SHP	Small Hydro Power
SNA	State Nodal Agency
VGF	Viability Gap Funding
WB	West Bengal/World Bank
WDV	Written Down Value
WRI	World Resources Institute
WtE	Waste-to-Energy
WTG	Wind Turbine Generator
WTO	World Trade Organisation

EXECUTIVE SUMMARY

As on 30 September 2018, the installed power generation capacity from renewables in India was 72 GW. This comprised 34.6 GW of wind (48%), 24 GW of solar (33%), 4.5 GW of small hydro (6%), 8.7 GW of bio-power (12%) and 0.13 GW of waste-to-energy (0.2%). The capacity added during 2017–18 was 11.8 GW (9.3 GW solar, 1.7 GW wind, 0.5 GW bio-power, 0.1 GW small hydro and 0.02 GW waste-to-energy). An additional 3 GW of renewable energy was added from April 2018 to September 2018.

In 2017–18, electricity generation from renewables was 101.8 BU, a 24.3% increase from 2016–17. Further, around 73.39 BU was added between April 2018 and September 2018. For the second consecutive year, capacity addition from renewables (11.8 GW) surpassed the capacity added from conventional sources (5.2 GW) by a two-fold margin in 2017–18.

Renewables contributed 10.35% of the electricity generated in the country between April 2018 and September 2018. A major development that took place during the year was the expansion of grid-connected, solar rooftop projects through the net-metering route. As on December 2018, around 1354 MW rooftop solar was installed in the country.

POLICY AND REGULATION

2017–18 witnessed the announcement of the *Kisan Urja Suraksha Evam Utthaan Mahaabhiyan* (KUSUM) scheme which aims to promote solar power among farmers and enable them to sell surplus solar power generated through the solarization of existing grid-connected agriculture pumps, as also installation of standalone off-grid solar water pumps and installation of grid-connected solar plants of 2 MW capacity each. The second scheme proposed during the year was the *Sustainable Rooftop Implementation for Solar Transfiguration of India* (SRISTI), which aims to integrate the DISCOMS as the implementing agency in Phase II of JNNSM and incentivize solar rooftop installations in the residential sector. Other notable developments included proposed amendments to the Tariff Policy, 2016, and the Electricity Act, 2003, the announcement of the new solar and wind bidding guidelines, introduction of the Solar Photovoltaics, Systems, Devices and Components Goods (requirements for compulsory registration) order; and pilots for flexibilisation of coal-based power plants, such as Dadri in Uttar Pradesh and Simhadri in Andhra Pradesh. While there were no major policy developments in the mini/microgrid sector, some key happenings in off-grid renewables included introduction of the scheme for 70 lakh solar study lamps to support children's education in the states of Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh, and the discontinuance of empanelled suppliers for off-grid systems by MNRE, which will henceforth allow consumers the freedom of choice to select their own suppliers.

EXECUTIVE SUMMARY

MARKETS AND INDUSTRY

2017–18 was the year of accelerated market development in India. The major development that took place during the year was the total transition from the feed-in tariff mechanism to competitive bidding, especially for wind power procurement. Solar and wind power tariffs hit historic lows of ₹2.44/kWh and ₹2.43/kWh respectively. These low rates, especially for solar power, were also facilitated by declining prices of solar panels, better structuring of projects leading to lowered risks, and availability of financing at competitive rates. States such as Karnataka and Maharashtra too initiated the competitive bidding mechanism for purchase of wind, solar, and bagasse-based cogeneration power. In keeping with the accelerated pace of RE development, CERC proposed 'redesigning of the real time electricity market in India' that aims to conduct real time trading once every hour, on a daily basis.

The Indian RE market continued to blaze ahead as its market value increased from ₹293 billion in March 2014 to around ₹671 billion in March 2018. While the market value of solar increased from approx. 11.7% in 2013–14 to 29.8% in 2017–18, that of wind reduced from 50% in 2013–14 to 33% in 2017–18. Market predictions upto 2022 forecast that solar will rule with a market value of ₹540 billion, followed by wind with ₹366 billion, biomass with ₹274 billion, and small hydro with ₹81.7 billion.

Solar power is now the fastest growing RE technology in India. However, it has only two main types of manufacturing industries in the country viz. solar cell manufacturing (installed capacity 3.1 GW) and assembling of solar PV modules (installed capacity of 8.3 GW). Considering the installed capacity of 9.3 GW in 2017–18, the industrial capacity in the sector is quite inadequate. Manufacturing of upstream elements in the supply chain like polysilicon and wafers are absent in India. As already mentioned in the previous report (*Renewables India 2017*), creating such a vertically integrated supply chain would be critical for future sustainability of the sector. In contrast, wind has an installed manufacturing capacity of ~12 GW; however, the supply chain of components needs to be augmented. Special policy focus is therefore needed to support domestic RE manufacturing and export. While solar exports continued to decline from 2014 to 2017, with almost 92% of solar panels being imported during 2017–18, both wind exports and imports showed a steady increase from 2015 to 2017.

INVESTMENT FLOWS

Investments in RE grew at a CAGR of 20% from 2008 to 2017. Technology-wise, investments in wind and solar increased in 2017 compared to 2016, while biomass and waste-to-energy were status quo, and small hydro declined. A positive trend that was observed was the two-fold growth in investments in RE from 2015 to 2017 and a reduction in investments during the same period in conventional energy. Debt investments in the form of major non-convertible debenture investments were worth ₹27,200 million, while convertible debentures were ₹13,964.5 million. Equity investments included private equity of `7800 million and venture capital of ₹282.8 million. Green bonds issued in 2017–18 were to the tune of ₹244,740 million.

CO-BENEFITS OF RE

With India committing to 33%-35% emissions intensity reduction by 2030 from 2005 levels, emissions reduction is seen as an important co-benefit of renewable power generation. Based on the assumption that wind and solar (the largest contributors to capacity addition in renewables in 2017–18) replaced coal-based generation, it is estimated that avoided CO_2 emissions were approximately 86.1 metric tonnes in 2017–18, up from 62.7 million metric tonnes in 2016–17. Further, around 256.9 million metric tonnes of CO_2 emissions could be reduced if India achieves its target of generating 160 GW from wind and solar by 2022.

With regard to creation of jobs as a co-benefit of RE, it is observed that majority of employment in 2017–18 has taken place in the solar PV sector – EPC segment (39.47%). In comparison, employment in the wind sector is only 4.4% and that in the SHP sector is 0.67%.

INTRODUCTION AND SCOPE

Renewables India 2018: Accelerating Market Development, is the second in the series of annual publications that provides a holistic snapshot of the status of grid-connected renewable energy in India during 2017–18. The report aims to provide policy makers, government officials, renewable energy professionals, civil society and other key stakeholders with insights on developments taking place in the RE sector on an annual basis, enabling them to make informed decisions, and aiding the transition to a low-carbon and sustainable economy. Based on validated data sourced from government reports, industry and think-tank chronicles and publications, and other relevant journals and market updates, the report reviews each financial year. The current report is for the period April 2017 to March 2018.

Chapter 1 provides the status of renewable electricity (grid and off-grid) in 2017–18. Starting with a brief global overview of RE and moving on to presenting India's targets and achievements in installed capacity and capacity addition, the chapter provides a critical overview of grid-based electricity generation in India (conventional and renewables), concluding with a summary on off-grid electricity in the country.

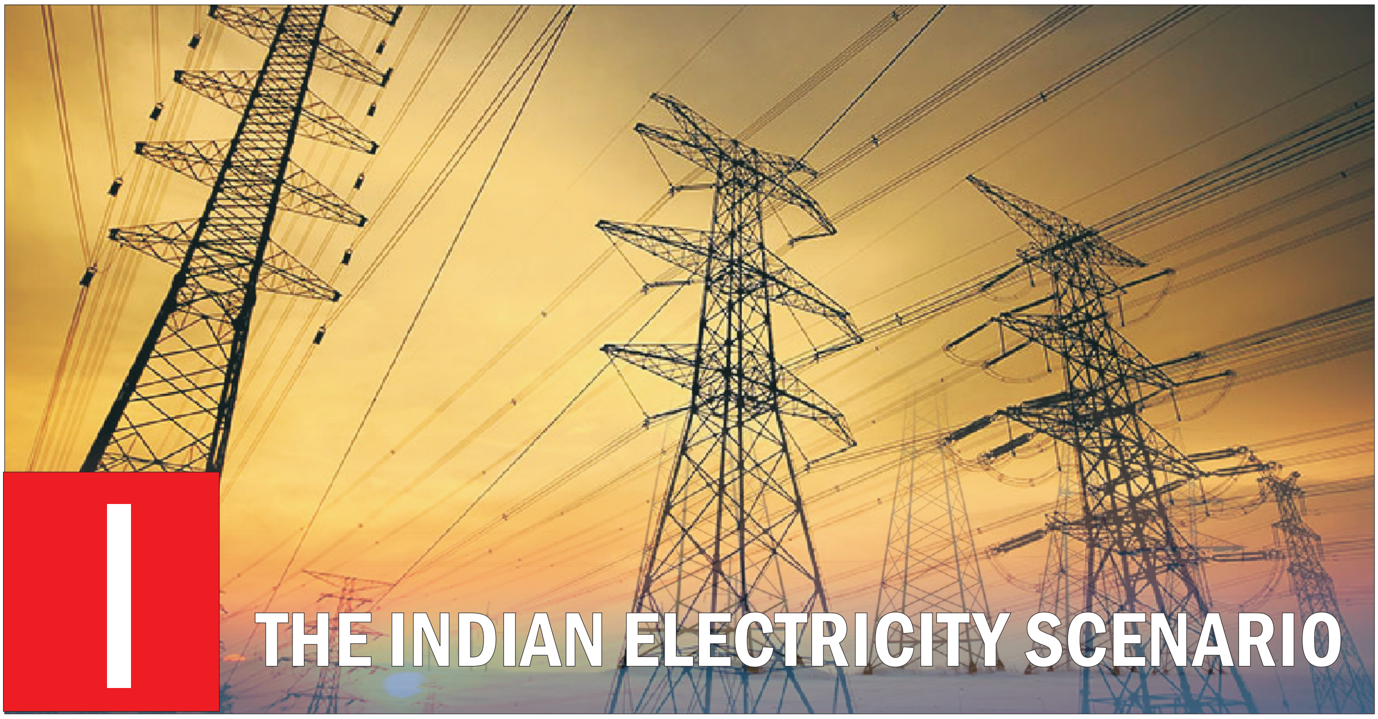
Chapter 2 summarizes the policy and regulatory landscape of grid-connected renewables (including off-grid) in 2017–18, reviewing the status of different policies and fiscal/financial incentives across states, along with their impact on RE development in India. It also delves into the different regulatory processes that guided grid-connected renewable energy development in 2017–18, namely tariff regulations, forecasting and scheduling regulations, and net metering regulations for rooftop solar projects. A brief analysis of state RPO compliance for the year is also made herein.

A new section on 'Markets' has been introduced in Chapter 3. Titled 'Markets and Industry', the 'markets' section assesses the RE market in 2017–18, showcasing the region-wise share of RE, and technology-wise share of RE in terms of installed capacity and value in currency. Forecast of the market potential in 2022 is also made. In addition, market mechanisms and their impacts are also discussed, along with a brief analysis of RPO compliance for the year.

The announcement of the 'Make in India' initiative by the Government of India to promote indigenous manufacturing has spurred huge opportunities of growth for renewable energy manufacturing. Whilst an area of critical development, the topic finds very little mention in printed literature. An attempt has thus been made in Chapter 3 to capture data on wind and solar manufacturing—the two sectors that were responsible for the largest capacity addition in 2017–18—focusing on the wind and solar industry supply chains and exports/imports in the wind and solar sectors.

Chapter 4 dwells on the investment flows in renewables in 2017–18, showcasing and reviewing the basket of investments that were provided for renewables during the year, both in terms of debt and equity.

Chapter 5 focuses on the critical co-benefits that are accrued from the development and deployment of renewable energy in India. These include the co-benefits of emissions reduction and jobs creation. The first part of the chapter focuses on India's emissions scenario (especially from the use and production of energy) and the role of renewable energy (wind and solar) in emissions reduction, while the second part throws light on renewable energy's potential in generating employment in this ever-growing sector.



HIGHLIGHTS OF 2017–18

- In 2017, India ranked fourth in global cumulative installed capacity of wind power, and third and fifth in terms of annual capacity addition of solar PV and wind power respectively.
- Total installed grid-connected renewable energy capacity in India reached 72 GW at the end of December 2018.
- Capacity addition of grid-connected power was 11.8 GW: wind 1.7 GW, solar 9 GW, small hydro 0.11 GW, bio-power 0.5 GW, and waste-to-energy 0.02 GW.
- Peak power deficit reduced from 15 GW (12.7%) in 2009–10 to 3.3 GW (2%) in 2017–18 [up from 2.6 GW (1.6%) in 2016–17], and total energy deficit fell from 83.9 BU (10%) in 2009–10 to 8.6 BU (0.7%) in 2017–18 [up from 7.5 BU (0.7%) in 2016–17].
- The percentage growth of renewable electricity in the total electricity generation mix was 24.38%, which was almost constant compared to the previous year. In contrast, the growth in generation from conventional sources declined from 4.72% in 2016–17 to 3.95% in 2017–18.
- For the first time in 2016–17, renewable capacity addition at 11.3 GW exceeded that of conventional energy, and the trend continued in 2017–18 with capacity addition at 11.8 GW.
- In the off-grid sector, around 14.7 lakh home lighting systems were installed, while renewable energy-based stand-alone power installed capacity was about 181 MWp.

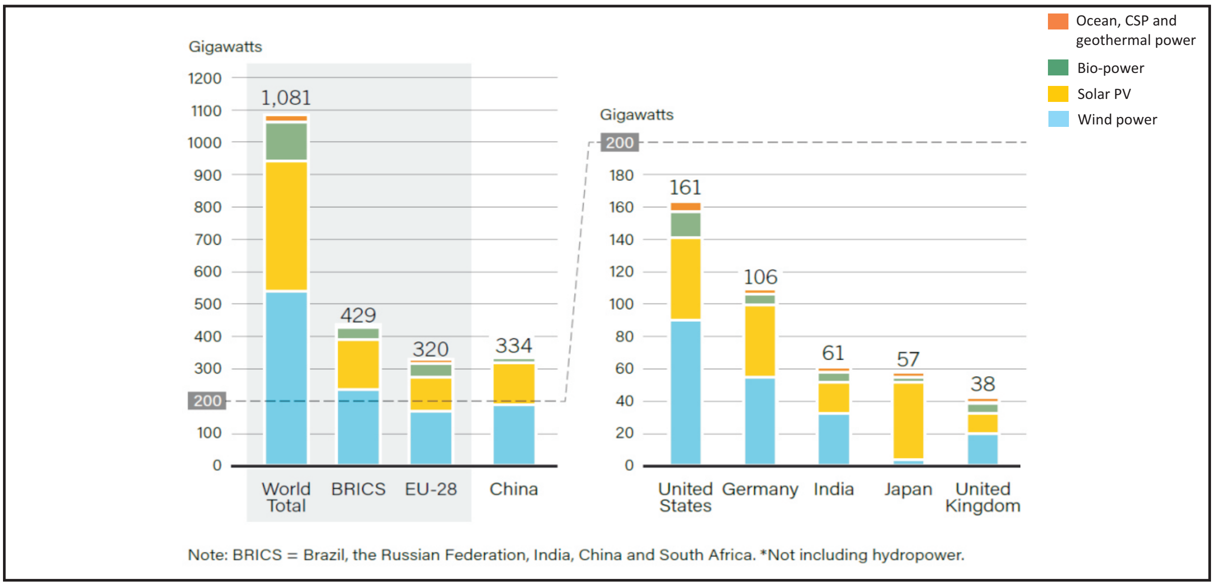
1.1 RENEWABLE ELECTRICITY: GLOBAL OVERVIEW

In 2017, an estimated 178 GW (including large hydro) of renewable energy capacity was added worldwide. This is the largest annual increase till date, up almost 9%, as compared to 2016, taking the cumulative installed renewable capacity to about 2,195 GW (including large hydro) at the end of 2017 enough to supply an estimated 26.5% of global electricity.[1] Solar PV dominated the landscape with 55% newly installed renewable power capacity (more than net additions of fossil fuels and nuclear power combined), while wind and hydropower accounted for about 29% and 11%, respectively. Thus, renewables accounted for an estimated 70% of net additions to global power generating capacity in 2017, up from 63% in 2016.

If large hydro is accounted for, then the top countries with total installed renewable electric capacity continue to be China, the United States, Brazil, Germany, India and Canada (India moved ahead of Canada in 2017). Excluding hydro, the top countries were China, the United States, Germany, India, Japan and the United Kingdom. Renewable installed capacity for the top six countries is summarised in Figure.1.1.

Tables 1.1 and 1.2 rank the countries as per capacity addition in 2017, and cumulative installed capacity till end 2017, respectively. China is undoubtedly seen as the leader in the RE sector, topping both in cumulative and annual

Figure 1.1: Top Six Countries and their RE Installed Capacity (2017)*



Source: Renewables 2018, Global Status Report.

Table 1.1: Country Ranking by Capacity Addition in 2017

	1		2		3		4		5		World
		GW		GW		GW		GW		GW	GW
Geothermal	Indonesia	0.275	Turkey	0.24	Chile	0.048	Iceland	0.045	Honduras	0.035	0.707
Hydropower	China	7.3	Brazil	3.4	India	1.9	Angola	1.4	Turkey	0.6	19
Solar PV	China	53.1	US	10.6	India	9.1	Japan	7.0	Turkey	2.6	98
Wind	China	15/19.7	US	7.0	Germany	6.1	UK	4.3	India	4.1	52
Bio-Diesel	US	-	Brazil	-	Germany	-	Argentina	-	Indonesia	-	-

Source: Renewables 2018, Global Status Report.

Table 1.2: Country Ranking by Cumulative Installed Capacity (2017)

	1		2		3		4		5		World
		GW		GW		GW		GW		GW	GW
Geothermal	US	2.5	Philippines	1.9	Indonesia	1.8	Turkey	1.1	New Zealand	1.0	12.8
Hydropower	China	313	Brazil	100	Canada	81	US	80	Russia	48	1114
Solar PV	China	131.1	US	51.0	Japan	49.0	Germany	42.4	Italy	19.7	402
Wind	China	168.7	US	82.1	Germany	49.5	India	28.7	Spain	23.1	487
Bio-Diesel	US	-	Brazil	-	Germany	-	Argentina	-	Indonesia	-	-

Source: Renewables 2018, Global Status Report.

capacity addition (solar, wind, and hydro). India ranks fourth in cumulative installed capacity of wind power, third in terms of annual capacity addition for solar PV, and fifth for wind power.[1]

1.2 RENEWABLE ELECTRICITY: INDIA

The Ministry of New and Renewable Energy (MNRE) has revised and raised the renewable energy potential for India to an estimated 900 GW. Solar is seen to have the largest potential, with a revised estimate of 750 GW (taking into consideration use of 3% wasteland for solar installations), followed by wind with 102 GW (at 80 m mast height); the National Institute of Wind Energy (NIWE) has revised the estimate for wind power to 302 GW at 100 m mast height. Potential for small hydro and bioenergy is 20 GW and 25 GW, respectively.[2]

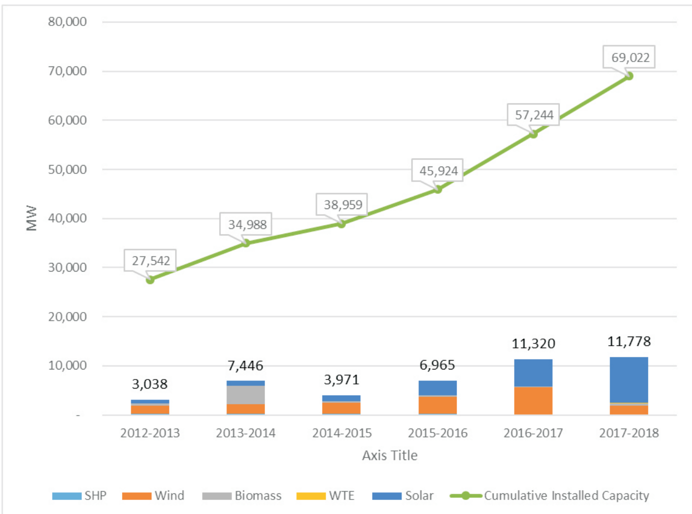
1.2.1 Targets and Achievements

In the 2015 Union Budget, the Government of India set the target of achieving 175 GW of RE by 2022. The target comprises 60 GW from wind, 100 GW from solar, 10 GW from biomass, and 5 GW from small hydro. Out of 100 GW solar, 40 GW is estimated to come from rooftop solar while the remaining 60 GW is anticipated from ground-mounted, grid-connected medium and large solar projects. If the target of 175 GW by 2022 is achieved, it would contribute to 19.44% of the total RE potential of 900 GW and about 20.3% of electricity in the total demand. This would mean generation of around 327 BU of electricity (162 BU from solar, 112 BU from wind, 38 BU from biomass, and 15 BU from SHP).[3]

The southern, western, and northern regions of India are expected to install more than 91% of the total target while the remainder is expected to be contributed by the north-eastern and eastern regions. Maharashtra has the highest target of 22 GW followed by Tamil Nadu with 21.5 GW.

From 57 GW in 2016–17, the total installed grid-connected renewable energy capacity reached 69 GW at the end of 2017–18. Figure 1.2 provides the growth trajectory of annual capacity addition and cumulative installed capacity of RE for the period 2012–13 to 2017–18. In 2017–18, RE contributed 20% of the total installed power generation capacity in the country. Of this, the share of wind was 34 GW (9.9%), followed by solar with 22 GW (6.2%), small hydro with 4.4 GW (1.3%), biomass and co-generation with 8.7 GW (2.5%) and waste-to-energy with 0.13 GW (0.04%) (Table 1.3 and Table 1.6).[4]

Figure 1.2: Annual Capacity Addition and Cumulative Installed Capacity of Grid-Connected RE (2012–2018)



Source: WISE, 2018 (compiled from MOSPI, CEA data).

Table 1.3: Share of Grid-Connected Renewable Energy in Total RE Capacity (as on 31 March 2018)

Source	Achievement (MW)	Share in Total RE Capacity (%)
Wind Power	34,046.00	49.33%
Solar Power	21,651.48	31.37%
Small Hydro Power	4,485.81	6.50%
Bio-power (Biomass & Gasification and Bagasse Co-generation)	8,700.80	12.61%
Waste-to-Energy	138.3	0.20%
Total	**69,022.39**	**100.00%**

Source: CEA, Installed Capacity, March 2018.

State-wise, Karnataka topped the list with 12 GW installed capacity, followed by Tamil Nadu with 11 GW and Maharashtra with 8.5 GW.[4] The list of state-wise/UT-wise installed capacity against targets for 2022 is provided in Table 1.4.

Table 1.4: State & UT-wise Targets and Installed Capacity (as on 31 March 2018)

Sr. No.	Sector	RE Target 2022	Installed Capacity (MW)			
			Central Sector	Private Sector	State Sector	Total
1	Delhi	2,762	0	121.57	0	121.57
2	Haryana	4,376	5	347.45	59.3	411.75
3	Himachal Pradesh	2,276	0	597.23	256.61	853.84
4	Jammu & Kashmir	1,305	0	51.36	129.03	180.39
5	Punjab	5,066	0	1,154.62	127.8	1,282.42
6	Rajasthan	14,362	294	6,455.79	23.85	6,773.64
7	Uttar Pradesh	14,221	30	2,621.91	25.1	2,677.01
8	Uttarakhand	1,797	0	479.53	67.87	547.4
9	Chandigarh	153	0	25.2	0	25.2
	Northern Region Total	**46,318**	**329**	**11,854.66**	**689.56**	**12,873.22**
10	Goa	358	0	0.91	0.05	0.96
11	Gujarat	17,133	238.3	7,049.02	8	7,295.32
12	Chhattisgarh	1,808	0	524.3	11.05	535.35
13	Madhya Pradesh	12,018	300	3,635.84	83.96	4019.8
14	Maharashtra	22,045	123	8,247.75	208.13	8,578.88
15	D&N Haveli	449	0	5.46	0	5.46
16	Daman & Diu	199	0	10.61	0	10.61
	Western Region Total	**54,010**	**661.3**	**19,473.89**	**311.19**	**20,446.38**
17	Andhra Pradesh	18,477	250	6,427.13	48.75	6,725.88
18	Telangana	2,000	10	3,609.30	40.22	3,659.52
19	Karnataka	14,817	0	12,283.52	155.33	12,438.85
20	Kerala	1,970	50	178.44	151.02	379.46
21	Tamil Nadu	21,508	181.9	10,860.81	122.7	11,165.41
22	Puducherry	246	0	0.16	0	0.16
	Southern Region Total	**59,018**	**491.9**	**33,359.36**	**518.02**	**34,369.28**
23	Bihar	2,762	0	255.45	70.7	326.15
24	Jharkhand	2,005	0	25.67	4.05	29.72
25	Odisha	2,377	10	178.3	6.3	194.6
26	West Bengal	5,386	0	343.87	91.95	435.82
27	Sikkim	86	0	0	52.11	52.11
	Eastern Region Total	**12,616**	**10**	**803.29**	**225.11**	**1,038.4**
28	Assam	688	0	16.55	30.01	46.56
29	Manipur	105	0	0.06	5.45	5.51
30	Meghalaya	211	0	0.02	31.03	31.05
31	Nagaland	76	0	1	30.67	31.67
32	Tripura	105	5	0.09	16.01	21.1
33	Arunachal Pradesh	539	0	5.39	104.61	110
34	Mizoram	97	0	0.2	36.47	36.67
	North Eastern Region Total	**1,821**	**5**	**23.31**	**254.25**	**282.56**
35	Andaman & Nicobar	27	5.1	1.46	5.25	11.81
36	Lakshadweep	4	0	0.75	0	0.75
	Islands Total	**31**	**5.1**	**2.21**	**5.25**	**12.56**
37	Others	720				
	All India Total	**1,74,534.00**	**1,502.3**	**65,516.72**	**2,003.38**	**69,022.4**

Source: CEA, Installed Capacity, March 2018.

For 2017–18, the capacity addition target of grid-connected power was 20.2 GW. Against this, the actual capacity installed in 2017–18 was 11.8 GW, the technology-wise break-up of which is given in Table 1.5.[2]

India added 1.7 GW wind capacity in 2017–18, taking the total installed wind capacity to 34 GW. Maximum capacity addition is seen in the states of Karnataka (750 MW) and Andhra Pradesh (344 MW).

With the installation of 9.3 GW solar power in 2017–18, the cumulative installed capacity of solar reached 22 GW. This was a quantum jump over the previous year. The six leading solar power states in India (in terms of installed capacity), are Karnataka, Tamil Nadu, Rajasthan, Gujarat, Maharashtra and Andhra Pradesh. During the next four years, 78.3 GW capacity will have to be installed to achieve the 100 GW target by 2022.

Table 1.5: Capacity Addition in 2017–18 (Grid Power Only)

Sr. No.	Technology	Capacity Installed (MW)
1	Solar	9,362.65
2	Wind	1,766.23
3	Biomass	519.10
4	Small Hydro	105.95
5	Waste-to-Energy	24.22
	Total	**11,778.15**

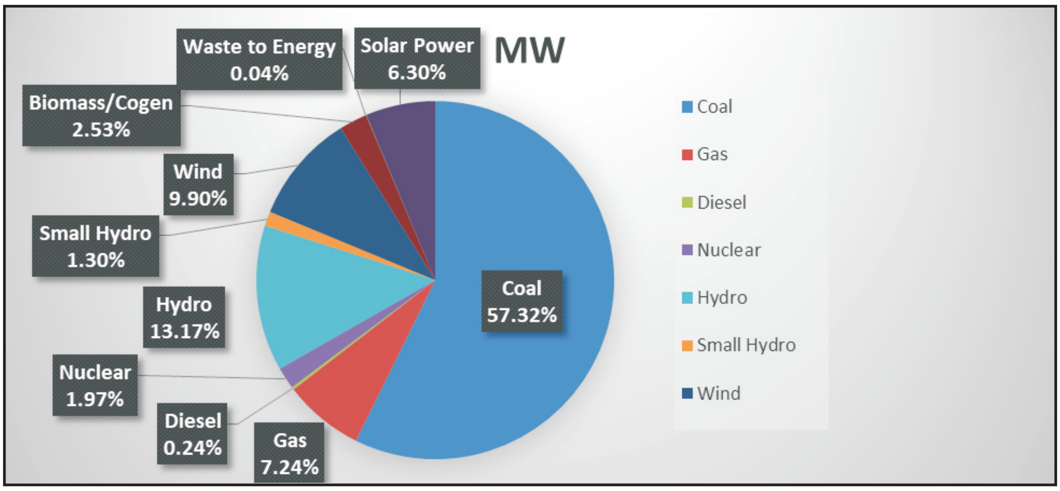
Source: WISE, 2018 (compiled from CEA data).

1.3 ELECTRICITY GENERATION

1.3.1 Installed Capacity Mix

India is the world's third largest producer of electricity having a total installed capacity of 3.4 GW (3,44,002 MW). Of this, around 65% is from thermal energy (57.3% from coal, 7.2% from gas and 0.2% from diesel), 2% from nuclear power, 13% from large hydro, and 20% from renewables (wind, solar, biomass, waste-to-energy) (Figure 1.3 and Table 1.6).

Figure 1.3: Source-wise Installed Capacity (March 2018)



Source: CEA, Installed Capacity, March 2018

Table 1.6: India Electricity Capacity Mix

Source	Installed Capacity (MW)	% of Total Installed Capacity
Coal	1,97,171.50	57.32%
Gas	24,897.46	7.24%
Diesel	837.63	0.24%
Total Thermal	**2,22,906.59**	**64.80%**
Nuclear	6,780.00	1.97%
Large Hydro	45,293.42	13.17%
Small Hydro	4,485.81	1.30%
Wind	34,046.00	9.90%
Biomass/Co-gen	8,700.80	2.53%
Waste-to-Energy	138.3	0.04%
Solar Power	21,651.48	6.29%
Total Renewables (excluding Hydro)	**69,022.39**	**20.06%**
Grand Total India	**3,44,002.40**	**100.00%**

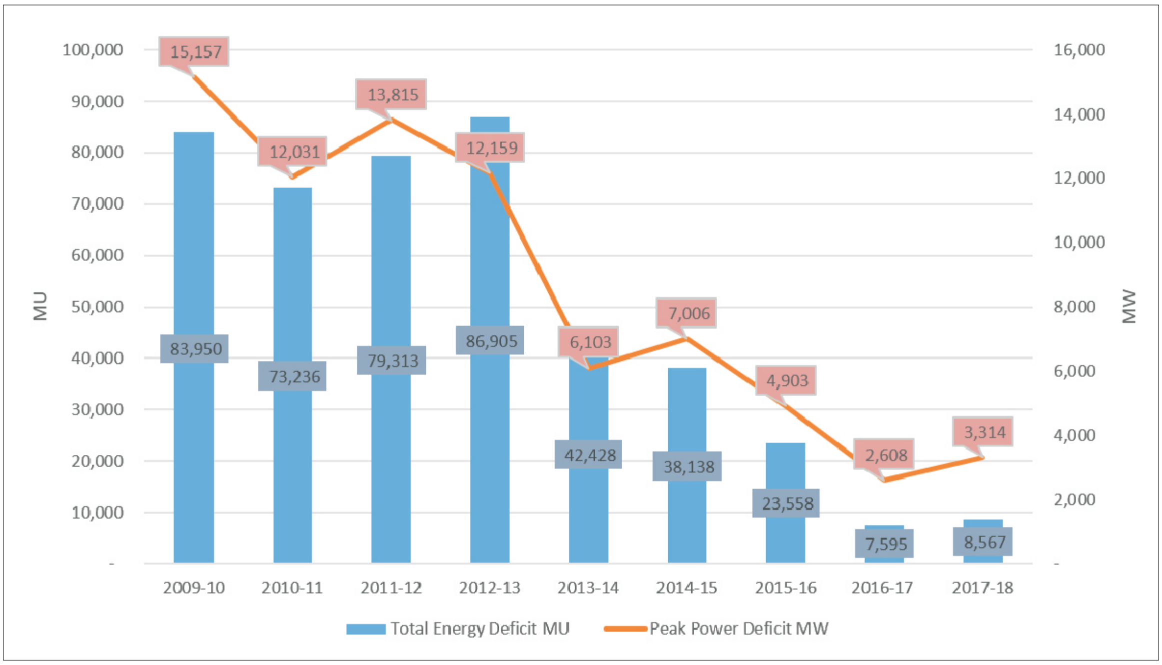
Source: CEA, Installed Capacity, March 2018.

Peak power deficit in India reduced from 15.1 GW (12.7%) in 2009–10 to 3.3 GW (2%) in 2017–18 and total energy deficit fell from 83.9 BU (10.1%) in 2009–10 to 8.5 BU (0.7%) in 2017–18. The power supply trend from 2009–10 to 2017–18 is represented in Figure 1.4.[5]

1.3.2 Generation from Conventional Energy

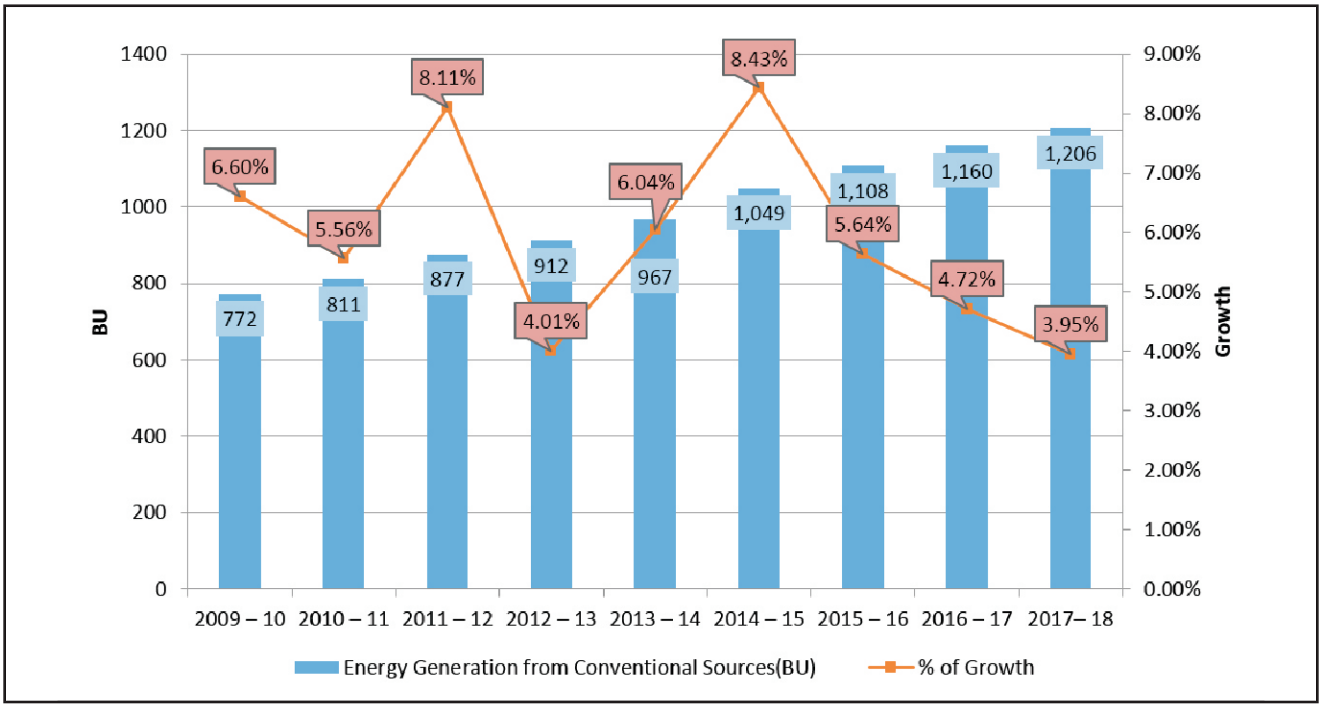
The total electricity generation from conventional sources in India in 2017–18 was 1,206 BU. This is a growth of 3.9% over 1,160 BU generated in 2016–17. The performance of conventional sources in electricity generation during the last decade is shown in Figure.1.5.[5]

Figure 1.4: Peak Power and Energy Deficit Trend (2009–10 to 2017–18)



Source: Ministry of Power website, 2018.

Figure 1.5: Electricity Generation from Conventional Sources (2009–10 to 2017–18)



Source: Ministry of Power website, 2018.

1.3.3 Generation from Renewable Energy

For the last three years electricity generation from renewable energy has been rising rapidly. In 2017–18 the total RE generation in India was around 102 BU, up from 81.8 BU in 2016–17. This marked a 24% growth from the previous year. Though electricity generation from solar almost doubled in 2017–18, wind continued to dominate renewable electricity generation in India. However, share of wind in total RE electricity generation decreased from 56% in 2016–17 to around 52% in 2017–18. In the same period, share of solar increased from around 16% to 25%, with biomass, small hydro and waste-to-energy accounting for around 15%, 7.5% and 0.3%, respectively. (Table 1.7).

1.3.4 Renewables and Conventional Electricity Generation: Comparative Analysis

During 2016–17 and 2017–18 the share of electricity generation from renewable energy increased from 6.5% to 7.7% of the total generation. The percentage growth of renewable electricity in the total electricity generation mix was around 24% in 2017–18, which remained almost constant compared to the previous year. In contrast, the growth in generation from conventional sources declined from 4.7% in 2016–17 to about 4% in 2017–18 (Table 1.8).

For the first time in 2016–17, renewable capacity addition at 11.3 GW exceeded that of conventional energy, and the trend continued in 2017–18 with capacity addition at 11.8 GW. The movement in annual capacity addition of both energies in the last four years is shown in Figure 1.6.

Table 1.7: Renewable Electricity Generation (BU) with % Share in Total RE Electricity (2014–15 to 2017–18)

	Wind		Solar		Biomass		Small Hydro		Waste-to-Energy		Total	%Growth
	BU	%	BU	%	BU	%	BU	%	BU	%	BU	
2014–15	33.77	54.65	4.6	7.44	14.95	24.19	8.06	13.04	0.41	0.67	61.79	-
2015–16	33.03	50.21	7.45	11.32	16.68	25.36	8.35	12.7	0.27	0.41	65.78	6.47
2016–17	46.00	56.19	13.5	16.49	14.15	17.28	7.92	9.68	0.3	0.37	81.88	24.47
2017–18	52.67	51.72	25.87	25.4	15.25	14.97	7.69	7.55	0.36	0.35	101.84	24.38

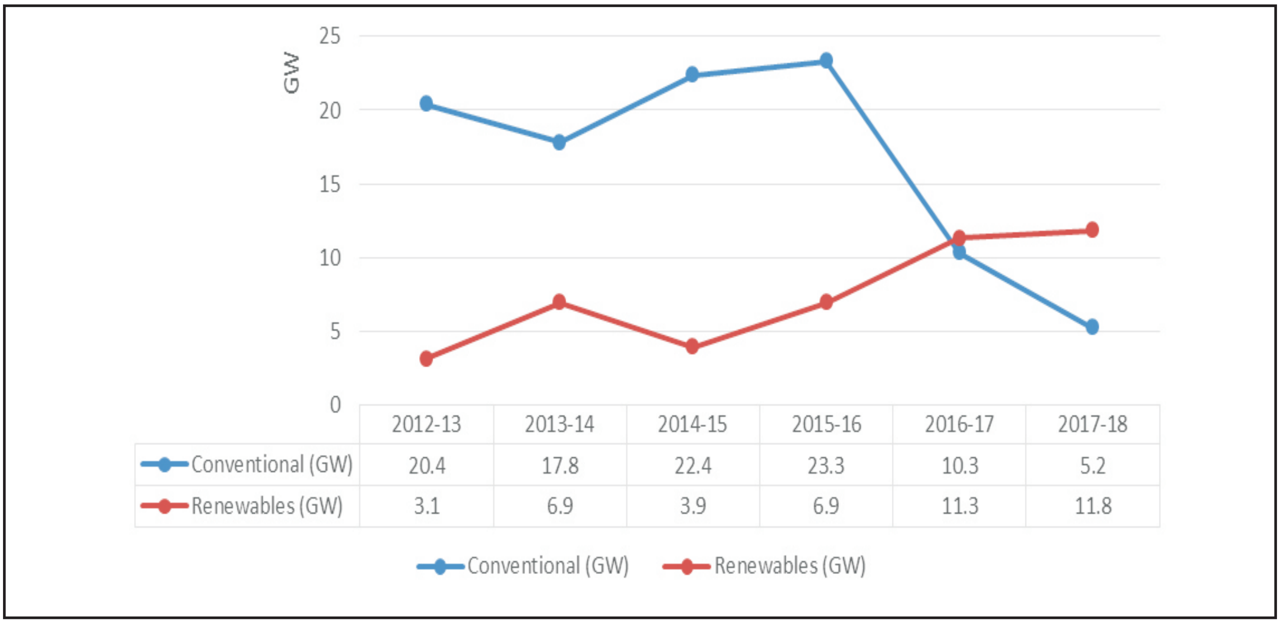
Source: WISE, 2018 (compiled from CEA reports).

Table 1.8: Generation from Conventional and Renewable Energy Sources (2014–15 to 2017–18)

	Total Generation (BU)	Conventional Sources (BU)	Growth in Conventional (%)	Renewable Sources (BU)	Growth in Renewables (%)	Conventional Share in Total %	Renewables Share in Total %
2014–15	1110.45	1048.67	-	61.78	-	94.44	-
2015–16	1173.65	1107.82	5.64	65.78	6.47	94.39	5.61
2016–17	1242.01	1160.14	4.72	81.88	24.47	93.41	6.59
2017–18	1307.76	1205.92	3.95	101.84	24.38	92.21	7.79

Source: WISE, 2018 (compiled from CEA reports and Ministry of Power website).

Figure 1.6: Capacity Addition of Conventional Energy and RE (2012–13 to 2017–18)



Source: WISE, 2018 (compiled from Ministry of Power and CEA data).

1.4 OFF-GRID RENEWABLE POWER

As per MNRE data, in 2017–18, around 14.7 lakh home lighting systems were installed, while renewable energy-based stand-alone power installed capacity was about 181 MWp. State/UT-wise status is given in Table 1.9.

While MNRE offers incentives and subsidies for promotion of off-grid electricity solutions, most of these systems have

Table 1.9: State/UT-wise Status of Off-grid Renewable Energy Systems (as on 31 December 2017)

Sr. No.	State / UT	Solar Home Lighting Systems (Nos)	Stand-Alone Renewable Energy-Based Power Plants (kWp)
1	Andhra Pradesh	22,972	3,785.595
2	Arunachal Pradesh	18,945	650.1
3	Assam	6,926	1,605
4	Bihar	12,303	4,168.6
5	Chhattisgarh	7,754	28,660.04
6	Delhi	0	1,269
7	Goa	393	32.72
8	Gujarat	9,253	13,576.6
9	Haryana	56,727	2,321.25
10	Himachal Pradesh	29,342	1,905.5
11	Jammu & Kashmir	65,319	7,719.85
12	Jharkhand	9,450	3,539.9
13	Karnataka	52,638	7,754.01
14	Kerala	41,912	15,825.39
15	Madhya Pradesh	4,016	3,654
16	Maharashtra	3,497	3,857.7
17	Manipur	3,900	1,241
18	Meghalaya	7,844	1,084.5
19	Mizoram	6,801	2,019
20	Nagaland	1,045	1,506
21	Odisha	5,274	567.515
22	Punjab	8,626	2,066
23	Rajasthan	1,66,978	10,850
24	Sikkim	15,059	850
25	Tamil Nadu	2,73,015	12,752.6
26	Telangana	0	6,643
27	Tripura	32,723	667
28	Uttar Pradesh	2,35,909	10,041.46
29	Uttarakhand	91,595	2,365.023
30	West Bengal	1,45,332	1,730
31	Andaman & Nicobar	468	167
32	Chandigarh	275	730
33	Lakshadweep	600	2,190
34	Puducherry	25	121
35	Others	24,047	23,885
36	NABARD	1,16,226	0
	Total	**14,77,189**	**1,81,901.36**

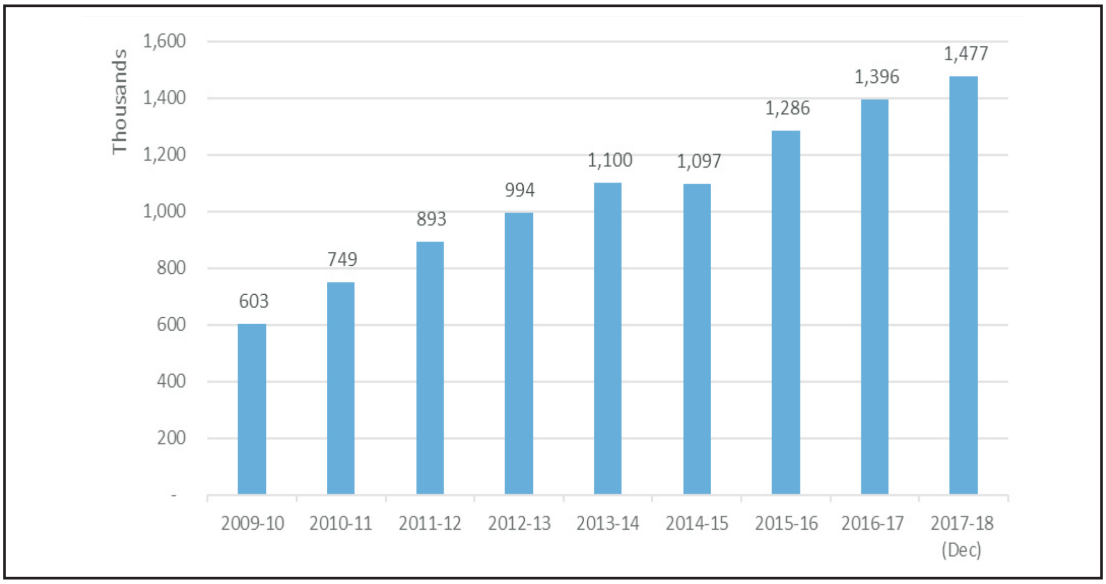
Source: MNRE Annual Report 2017–18.

been promoted by private players who also sell their products through dealers in the rural sector. Given the huge demand for electricity in unelectrified areas, private players will need to play a more significant role in the expansion of off-grid systems in the years to come.

1.4.1 Growth Trajectory of Off-grid RE Electricity

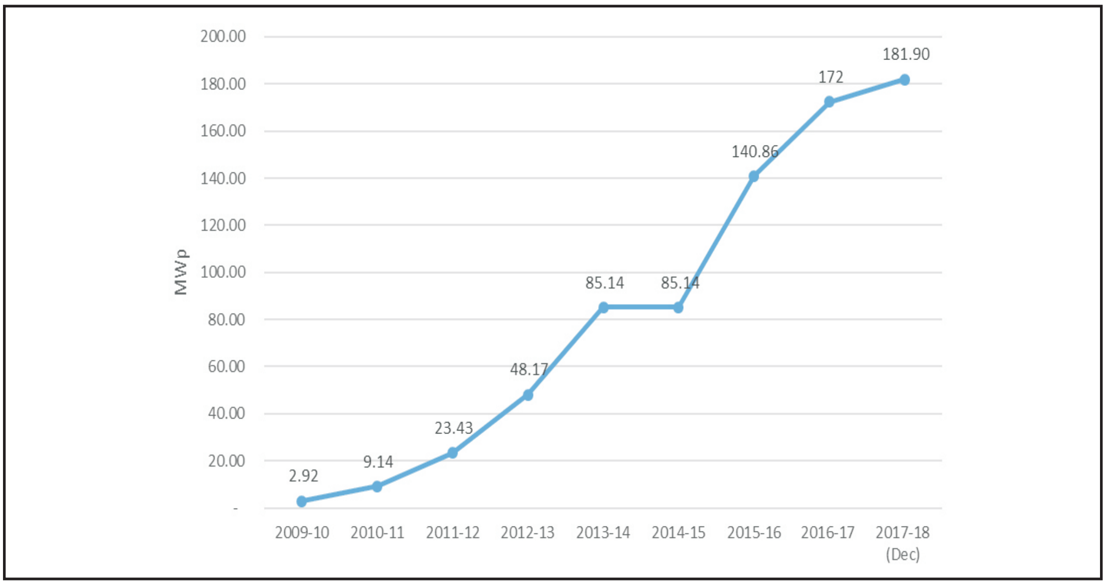
Like grid-connected RE, a major leap in installations was also be seen in the off-grid sector (Figures 1.7 and 1.8). With the rapid decline in costs of off-grid RE systems coupled with an increased level of awareness among the rural masses, private and self-sponsored off-grid RE system installations grew due to market economics. From 603 systems with about 3 MWp in 2009–10 to 1,477 systems with 182 MWp in 2017–18, the growth has been significant. Such a huge increase in capacity, with fewer numbers of systems, signifies the growth of large sized rooftop solar systems in the last few years.

Figure 1.7: Growth Trajectory of Off-grid Home Lighting Systems (Numbers)



Source: WISE, 2017 (compiled from India Energy Statistics, MOSPI).

Figure 1.8: Growth Trajectory of Off-grid Power Plants (Capacity)



Source: WISE, 2018 (compiled from India Energy Statistics, MOSPI).

***

2 POLICY & REGULATION

HIGHLIGHTS OF 2017–18

POLICY

- Major policy amendments were proposed in 2018 in the Tariff Policy, 2016 and Electricity Act, 2003 respectively (Box 2.1).
- The Draft National Energy Policy, 2017, Draft Technology Development and Innovation Policy, 2017, and Guidelines for Wind Bidding (Box 2.2), were significant new interventions introduced in 2017–18.
- Provision for no inter-state transmission losses and charges has been extended till 31 March 2022.
- New solar photovoltaic based project bidding guidelines were established that aimed to address the risks associated with project development due to early termination of PPA by the DISCOMs, non-off-take of power generated, high penalties, declining CUF of power plants, etc.
- To avoid the possibility of creating stranded assets in future, the government introduced the Solar Photovoltaic Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017 (Box 2.3), which mandates that manufacturers follow nationally acclaimed standards for solar PV. Another move in this direction is the declaration of penalties for violation of DCR norms, wherever applicable.
- Guidelines to utilise the National Clean Energy Fund for developing the Green Energy Corridor in select states was established.
- With the introduction of the goods and services tax (GST) in 2017–18, exemption from the earlier state-specific taxes has been abolished, which is expected to increase the levelised tariff of RE-based electricity.

REGULATION

- An important development that surfaced during the year was the growth of grid-connected rooftop, solar photovoltaic projects through dedicated policies. Net metering based ESCO model, which is the most popular model, was adopted by various states; some states like Bihar allowed development of such projects by government organizations. States that have initiated policy interventions for rooftop solar are Bihar, Assam, Jharkhand, Chhattisgarh, Mizoram, Uttar Pradesh and Goa.
- SERCs of Bihar and Assam published Draft Open Access Regulations, as also did the Joint Electricity Regulatory Commission of Goa and UTs.
- The Andhra Pradesh Electricity Regulatory Commission finalized its Forecasting and Scheduling Regulations, while Uttar Pradesh and Tamil Nadu published their Draft Regulations.
- Bihar finalized its revised Net Metering Regulations, and Uttar Pradesh, Odisha, Gujarat, Assam and Maharashtra issued amendments or related orders.

POLICY

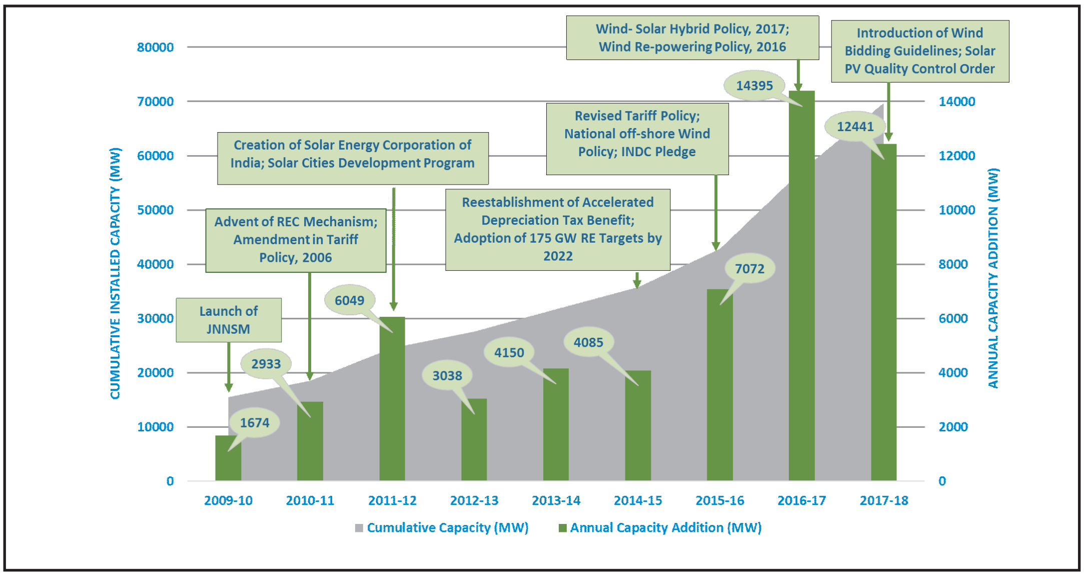
2.1. GRID-CONNECTED NATIONAL POLICIES

2.1.1 Policy Evolution of Grid-Connected RE

The most important development in India's RE policy canvas during the last decade was the advent of the Jawaharlal Nehru National Solar Mission (JNNSM, under the aegis of the National Action Plan on Climate Change) in 2009–10, and its subsequent revision in 2015–16. The creation of the Solar Energy Corporation of India (SECI) in 2011–12[1] and directives provided by the National Tariff Policy 2016 to devise RPO targets such that solar RPO reaches 8% by 2022,[2] paved an easier path for solar energy development in India. If JNNSM was a path-breaking intervention for solar development in India, then the announcement of the national target of 100 GW solar by 2022[3] in 2015–16, prompted an upward growth trajectory, encouraging development at a faster rate.

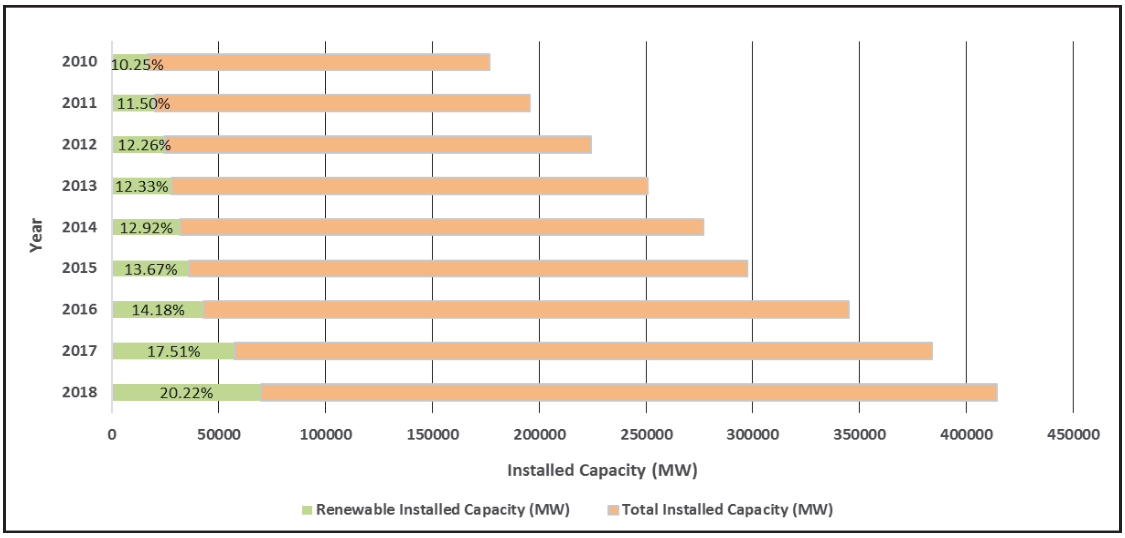
Fiscal incentives, such as accelerated depreciation and generation based incentives, were key to the growth of wind in India. In addition, growth was facilitated by technological innovation along with the introduction of MW class machines suitable for low wind, steadily falling wind turbine prices due to technological innovations, and less stringent trade requirements on wind electricity generating components. Small hydro and biomass and bagasse-based co-generation projects using combustion technology showed moderate growth over this period with help from Central Financial Assistance (CFA) providing for various activities. The decadal evolution of national level RE policies that led to an increase in RE installed capacity in India is depicted in Figure 2.1. With suitable policy interventions over the last decade, the share of RE technologies in the total installed capacity doubled from 10% in 2009–10 to 20% in 2017–18.[4] The decadal growth in the share of RE technologies in total installed capacity in India is depicted in Figure 2.2.

Figure 2.1: Decadal Policy Evolution and Growth of RE Installed Capacity in India (2009–10 to 2017–18)



Source: WISE Analysis, 2018 (Compiled from MNRE, MoEFCC, MoP, websites and reports).

Figure 2.2: Decadal Trend of Renewable Energy Share in Total Installed Capacity in India



Source: WISE Analysis, 2018 (based on MNRE data).

Box 2.1: Major Policy Amendments Proposed in 2018

Proposed Amendments in the Tariff Policy 2016 (as on 30 May 2018)[5]

The Government of India proposed amendments to the National Tariff Policy, 2016, to amend provisions related to generation, transmission and distribution of electricity in India. The objectives of the proposed amendments are as follows:

- Attract investment in the electricity sector from public as well as private sources.
- 24×7 uninterrupted power supply to all consumers.
- Improve efficiency in the operation of distribution business.
- Address certain constraints faced in implementing change-in-law provisions.
- Issues in open access, compliance and related aspects.
- Tariff design related issues.
- Simplification of tariff categories and rationalization of retail tariff.

Highlights of certain key proposed amendments are mentioned below:

- All state regulatory commissions will adopt the "Long Term Growth Trajectory of RPOs" issued by the Ministry of Power
- Simplification of tariff categories and rationalization of retail tariff
- No requirement of license for setting up of any charging stations for electric vehicles
- AT&C Losses in excess of 15% shall be borne by DISCOM and not by the consumers.
- 24×7 uninterrupted power supply to all categories of consumers by March 2019 or earlier.
- In case of power cuts, other than in *force majeure* conditions or technical faults, an appropriate penalty, as determined by the SERC, shall be levied on the Distribution Company and credited to the account of the consumers.
- Appropriate Commission would ensure that cross-subsidies are reduced and the tariff for all consumer categories is brought within ± 20% of the average cost of supply effective from 1 April 2019 or earlier.
- Subsidy to any category of consumers would be required to be given through Direct Benefit Transfer, i.e. directly into the bank account of such consumers.
- The license of the DISCOM will be liable to suspension if the DISCOM fails to show long term/ medium term PPAs to meet the annual average power requirement in their area of supply.

The Forum of Regulators has been acknowledged as the facilitator to maintain consistency in legal approach across the country under the provisions of the Act.

Proposed Amendments to the Electricity Act, 2003, for Accelerating RE Development (as on September 2018)[6]

The Ministry of Power, Government of India, has proposed draft amendments to the Electricity Act, 2003, which provides few avenues for accelerated development of renewable energy in the country. The renewable purchase obligation (RPO) trajectory is proposed to be set by the Central Government from time to time, instead of the current practice of it being issued by respective state electricity regulatory commissions. The amendments also propose to impose a renewable generation obligation on coal or lignite based thermal generating stations which are established or expanded after a date notified by the central government. The most important proposal came in the form of enforcing the power purchase agreement (PPA), violation of which is proposed to attract penalties of upto ₹1 crore per day. Further punitive actions in the form of penalties from ₹1 per unit to ₹5 per unit of shortfall from RPO have been proposed in case of non-compliance of RPOs by the licensee.

Source: Compiled from Ministry of Power website.[5,6]

2.1.2 Status of Major National Level Policies for Grid-Connected RE in 2017–18

The key features of the major national policies in 2017–18 are given in Figure 2.3 and technology-wise interventions active till the end of March 2018 are depicted in Figure 2.4.[7to17] One major fiscal intervention during 2017–18 was the introduction of the goods and services tax (GST). Although electricity as a commodity is kept outside the purview of GST, capital goods, inputs and input services required to produce RE-based electricity are taxable under GST regime. Thus GST has subsumed state-specific VAT or sales tax, octroi and entry tax and other surcharges or cess imposed by the states on inputs and input-related services. Consequently, exemption from earlier state-specific taxes are now abolished which is expected to put upward pressure on levelised tariff of RE-based electricity. The impact of GST on the levelised tariff of various RE technologies as predicated by MNRE is summarized in Table 2.1. [18]

2.1.2 (A) Wind Policies

In 2017–18, wind energy was mainly promoted through fiscal incentives such as accelerated depreciation (AD) benefit, and generation based incentives (for those projects not availing AD). In addition, the government reduced customs duty and exempted excise duties for materials used in wind electricity generation (WTG and controller unit). Table 2.2[19,20,21] depicts the fiscal incentives provided for wind in 2017–18 vis-à-vis 2016–17. Interestingly, excise duty was allowed to be levied on materials used for wind generation during 2017–18, which was not applicable in the previous year. From 1 July 2017, excise and customs duty was replaced by the Goods and Services Tax (GST) at the rate of 5%.[19]

Figure 2.3: Major National-level Policy Interventions in 2017–18: Key Features

New Policies/Guidelines	Key Features
Draft National Energy Policy, 2017	Suggesting measures that are required to ensure that envisaged renewable energy capacity integrates well with the electricity system.
NCEF Disbursal Guidelines for Green Energy Corridor	Three stage release of funds depending upon report from CEA and recommendations from the PAC in the first stage and performance appraisal in the next two stages
New Bidding Guidelines for Grid-Connected Solar PV Power Projects	Generation compensation, blocking of unilateral termination of PPA, termination compensation, incentivizing early and part commissioning, rationalization of penalties, repowering, permission of bidding in capacity (MW) and power (MU) terms.
SPV Requirement for Compulsory Registration order, 2017	Manufacturers manufacturing, storing, selling, or distributing goods should be registered with Bureau of Indian Standards; mandatory accreditation of all test labs by the National Accreditation Board for Testing and Collaboration Laboratories (NABL) and approved by Bureau of Indian Standards (BIS).
Draft Technology Development and Innovation Policy	Support project proposals in focused areas taking into account scalability and bankability; encourage the exploration of new ideas and concepts; establish a strong institutional mechanism for collaboration; provide cash rewards for innovative ideas; provide up to 100 percent of funding for policy studies and analysis purported to renewable energy.
Guidelines for Bidding of Wind Power Projects	Provide a framework for procurement of wind power through a transparent process of tariff based bidding; standardize the process and define roles and responsibilities of various stakeholders; enable DISCOMs to procure power generated from wind projects at a competitive tariff in a cost effective manner.
Amendment in the guidelines for the VGF program under the National Solar Mission (NSM) Phase-II Batch-IV	Tie up with SECI for selling arrangements with states/other buying entities before issue of RfS for the whole capacity to be invited; first priority to the host state for off-take of capacity to be invited by SECI and remaining capacity for other willing states or buying entities; abolition of Domestic Content Requirement (DCR) category under VGF scheme for grid-connected solar PV projects.
Penalty for Project Developers for violating DCR Provisions wherever applicable	Actions under criminal offences code; blacklisting of developer for a period of 10 years; forfeiting of relevant bank guarantee; disciplinary action against officers of concerned CPSU/state government.
No Interstate Transmission Charges and Losses on Solar and Wind Power Projects	No interstate transmission charges and losses for sale of power using inter-state transmission system by projects commissioned till 31st March, 2022; available for a period of 25 years from the date of commissioning of projects which enters into PPAs with entities requiring to comply with RPOs; applicable only for projects awarded through competitive bidding following central government guidelines.
Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI)	Performance based incentives to DISCOMs for implementing grid-connected rooftop solar projects in household sectors with a capacity cap up to 5 kWp.
Kisan Urja Suraksha evam Utthaan Mahaabhiyan (KUSUM)	Rs. 48,000 crore worth schemes to be implemented in four phases to allow farmers to generate safe and clean energy for irrigation purpose along with generating income by selling excess power to the government.

Objectives

To accelerate renewable energy growth by –

1. Removing infrastructural bottlenecks
2. Reducing risk for developers
3. Encouraging indigenous development of technology and manufacturing
4. Ensuring quality
5. Reducing risks of financing
6. Discovering competitive prices of power through competitive bidding
7. Ensuring time bound implementation of projects

and

8. Making renewables cost competitive

Source: WISE 2018, (Compiled from MNRE, MoP reports/websites).

Table 2.1: Expected Percentage Increase in RE Technology-wise Levelised Cost due to GST Regime

	Wind	Solar	Small Hydro	Biomass
Expected % increase in levelised cost of electricity generated from RE	11%–15%	12%–16%	1%–11%	11%–14%

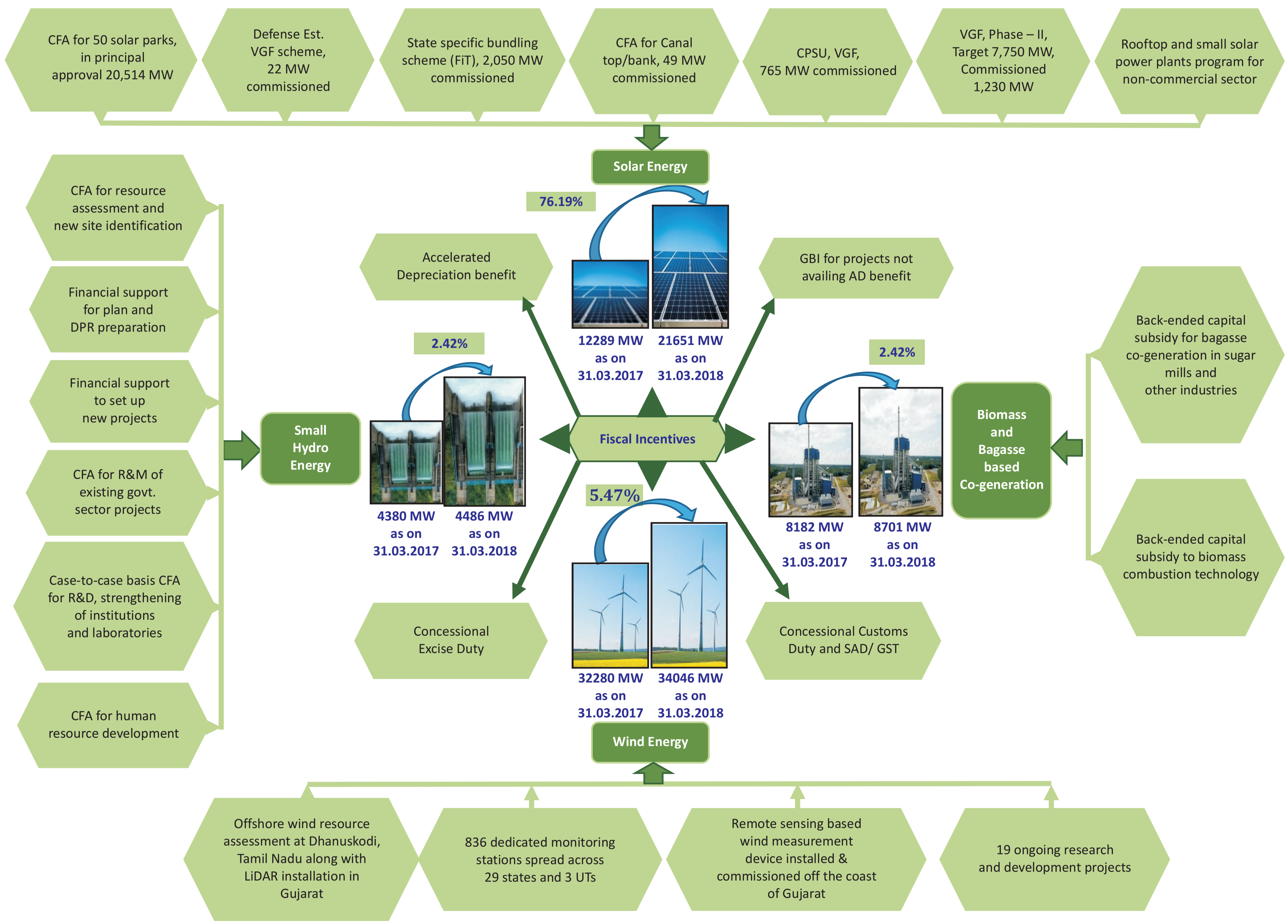
Source: Implications of GST on delivered cost of RE, MNRE.

Table 2.2: Fiscal Incentives for Wind Power in 2016–17 vis-a-vis 2017–18

Nature of Duty	Description of Goods	2016–17	2017–18
AD Benefit	On project cost of wind power projects	80%	40%
Customs Duty	Catalysts and resins for use in the manufacture of cast components of Wind Operated Electricity Generator	7.5%	5%
Special Additional Duty (SAD)*		4%	-
Excise Duty*		-	-
Goods and Services Tax (GST)	Components produced within the country used in generation of wind electricity	-	5%

Source: Budget, 2017-18; ICMI Budget Analysis, 2017–18.
*Exempted only till 30 June, 2017.

Figure 2.4: National Level Grid-Connected Technology-wise Policy Interventions in force till 31 March, 2018



Source: WISE, 2018 (based on MNRE, MoP data).

Box 2.2: Wind Project Bidding Guidelines, 2017

Objectives:

- Provide a framework for wind power procurement through competitive bidding.
- Standardisation of transparent bidding process.
- Define roles and responsibilities of various stakeholders.
- Enable DISCOMs to procure power from wind projects at a competitive rate.

Features:

- Applicable to:
  - o Intra-state projects–minimum individual capacity of 5 MW at one site – minimum bid capacity of 25 MW.
  - o Inter-state projects–minimum individual capacity of 50 MW at one site – minimum bid capacity of 50 MW.
- Minimum CUF – 22% deductible to the extent of non-availability of grid – penalty on the generator for supplying energy less than that corresponding to 22% CUF.
- Technical Criterion–procurer is free to set criterion to ensure proper implementation.
- Financial Criterion–net worth of at least 20% of the capital cost for the year of bid invitation.
- An intermediary procurer–acting as a trader between DISCOM and the generator–may be required to aggregate power from different generators or to enhance credit profile.
- Necessary documentation – land lease agreement within 7 months of the execution of PPA; environment/forest/any other clearance, if applicable, as per schedule in the bidding document; letter of confirmation from concerned transmission utility for connectivity.
- Penalty for delay in commissioning project beyond scheduled commissioning date .

Incentives:

- Risk mitigation through payment of security provided to the wind power generators – revolving letter of credit and payment security fund.
- Generation compensation – off-take constraints due to grid unavailability or back-down.
- Part commissioning or early commissioning subject to certain constraints.

Source: Guidelines for Bidding of Wind Power Projects, MNRE, 2017.

Box 2.3: Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017

Objectives:

- Improve quality and reliability of solar PV based projects in India.
- Develop and update the standards of various renewable energy systems and their related components.
- Set up performance testing and certification facilities to ensure quality.
- Reduce the risk of future low performance of solar PV projects in the country.

Features

- Mandatory registration with the Bureau of Indian Standards (BIS) by any manufacturer who manufactures, stores for sale, sells or distributes goods.
- Mandatory accreditation of all test labs by the National Accreditation Board for Testing and Collaboration Laboratories (NABL) and approved by BIS.
- Goods manufactured for export are exempted.
- Provisions of the Code of Criminal Procedure, 1973, shall be applicable for search and seizure by an appropriate authority.
- Specifications of Indian Standard number corresponding to solar PV product.

Source: Press Information Bureau, Government of India, 2017.

2.1.2 (B) Solar Policies

Major solar photovoltaic schemes in 2017–18 are summarised in Table 2.3, while the progress of solar rooftop is providedf in Box 2.4.

Table 2.3: Major Existing Schemes for Grid-Connected Solar Photovoltaics in 2017–18[22,23,24]

Parameters	Provisions
Development of Solar Parks and Ultra-Mega Solar Power Projects	₹25 lakh/MW grant for DPR preparation. Grant of up to ₹20 lakh/MW or 30% of the project cost, including grid-connectivity cost, whichever is lower, for project development.
Defense Establishment Scheme	Viability gap funding (VGF) based online auction for setting up projects in defense establishments (including paramilitary), subject to fulfillment of mandatory DCR.
3 GW capacity Solar PV 3 plants under Tranche-I of Batch-II of Phase-II of NSM	Bundling of solar power with unallocated thermal power in the ratio of 2:1 through reverse bidding.
Canal-top and Canal-bank Projects	CFA for pilot-cum-demonstration projects of 50 MW canal-top and 50 MW canal-bank projects.
CPSU and Government Organisation Schemes	VGF for setting up 1 GW solar power projects by central public sector utilities and government organisations.
VGF scheme for Phase – II	750 MW under Batch - I with ₹2.5 crore/MW VGF support or 30% of the project cost, whichever is lower.
	2000 MW under Batch - III with VGF upto ₹1.31 crore/MW for Domestic Content Requirement (DCR) category and VGF up to ₹1 crore/MW for open category.
	5000 MW under Batch - IV with VGF upto ₹1.25 crore/MW for DCR category and VGF up to ₹1 crore/MW for open category.
Grid-Connected Rooftop and Small Solar Power Plants Programme for Grid-Connected Rooftop Solar Power Plants in Non-commercial Sector	Subsidy upto 30% of benchmark cost for general category states, and upto 70% of the benchmark cost for special category states, for installation in residential, institutional and social sectors.
	Achievement linked incentives upto 25% of the benchmark cost in general category states/UTs and 60% of the benchmark cost for special category states/UTs in the government sector.

Source: WISE, 2018, (Compiled from various MNRE reports).

Table 2.4 provides the fiscal benefits available for grid-connected solar projects during 2017–18. Excise duty on solar tempered glass was restricted to 6% till 30 June 2017. From 1 July 2017, excise duty was replaced by GST at the rate of 5%.

Table 2.4: Fiscal Incentives Applicable to Solar Energy in 2017–18

Nature of Duty	Description of Goods	Rate in 2017–18
AD Benefit	On project cost of solar power projects.	40%
Customs Duty	Solar tempered glass or solar tempered anti-reflective coated glass for use in manufacture of solar cells/panels/modules.	0%
Excise Duty*	Solar tempered glass for use in the manufacture of: a) Solar photovoltaic cells or modules. b) Solar power generating equipment or systems. c) Flat plate solar collectors. d) Solar photovoltaic modules and panels for water pumping and other applications.	6%

Source: Union Budget, 2017–18; ICMI Budget Analysis, 2017–18.
*Exempted till 30th June, 2017.

Box 2.4: Progress of Solar Rooftop Projects in India

The Government of India has set an ambitious target of installing 40 GW grid-connected solar rooftop projects in India by 2022. However, till the financial year 2017–18, installed capacity of grid-connected solar rooftop projects was 1063.63 MW (1 GW).[24] Thus, about 39 GW needs to be installed in the next 4 years (2018–19 to 2021–22). Although the pace of tender announcement and auctions have gained momentum over the last few months, the sector needs a further push to achieve its target by 2022. Major grid-connected solar rooftop project related auctions and their results are given in table 2.5.[25]

Between April 2017 and August 2018 almost 625 MW capacity grid-connected, solar rooftop projects have been awarded. These projects are either installed completely or partially or will be installed in the near future. The median capacity of projects awarded is 3 MW; meaning 50% of the projects have capacity above 3 MW and 50% have capacity less than 3 MW. The bid prices of the projects are in the range of ₹1.58/kWh and ₹4.97/kWh. However, the median price is ₹3.84/kWh and it is skewed towards the highest price of ₹4.97/kWh. Thus the price of solar rooftop projects is still greater than the price discovered for many ground mounted projects. Apart from announced auctions, many tenders have also been announced and their auctions will be completed in the near future. This will give a further push to grid-connected solar rooftop projects. Although there is optimism in the accelerated development of the sector, there are certain factors that need to be addressed. The off-takers of grid-connected solar rooftop projects are not as enthusiastic as those for ground mounted projects. Besides, there are distribution transformer capacity constraints that create major hindrances to large-scale adoption.

Table 2.5: Summary of Major Solar Rooftop Project Auctions during April 2017 and August 2018

Auctioneer	Awardee	Capacity (MW)	Bid Price (₹/kWh)	Place
CIAL Infrastructures Ltd	Sterling and Wilson	2.4	--	CIAL premises
SECI	--	500	2.20 - 4.59	All states in India
NREDCAP	CleanMax Enviro Energy Solutions Pvt. Ltd	3	3.64	Andhra Pradesh
NREDCAP	Azure Power	5	3.69	Andhra Pradesh
NREDCAP	Rich Phytocare	3	3.98	Andhra Pradesh
NREDCAP	TEPSOL Solar	4	3.99	Andhra Pradesh
Madhya Pradesh Urja Vikas Nigam Limited	--	35	1.58	Various government, PSU and private buildings in Madhya Pradesh
National Thermal Power Corporation (NTPC) Vidyut Vyapar Nigam (NVVN)	Azure Power	1	3.19 -4.11	Ministry of Health and Family Welfare
Railways Energy Management Company	Multiple	67.3	2.39 -4.49	Premises and properties of Indian Railways
--	Azure Power	2	4.97	152 *Navodaya Vidyalayas* spread across 6 Indian states
Udaipur Smart City Limited	Azure Power	2	--	Udaipur

Source: MERCOM, 2017–18.

2.1.2 (C) Small Hydro Policies

Development of small hydro is mostly driven by Central Financial Assistance which provides for resource assessment and new site identification, preparation of detailed project report (DPR) for new projects, setting up of new projects, and repair and maintenance of existing government sector projects. Besides, the central government provides, on case-to-case basis, financial assistance for R&D, technical institutional strengthening, building of turbine laboratories, etc. Human resource development is encouraged through training programmes, courses, fellowships, business meets, etc. A sediment monitoring and impact analysis laboratory is being developed to carry out studies of various river basins. Table 2.6 summarises major CFA provisions to small hydro technologies in India.[22,23]

Apart from CFA, SHP is eligible for accelerated depreciation @40% of capital cost in written down value (WDV) method.

Table 2.6: Major Central Government Schemes for Small Hydro Projects in 2017–18

Parameters	Provisions
CFA for RA, Site identification, DPR preparation	₹6 lakh/project – up to 1 MW capacity
	₹10 lakh/ project – beyond 1 MW and up to 25 MW capacity
	Provided to state government departments, agencies and local bodies
Capital subsidy for setting up of new SHP plants in private, co-operative, joint sector, etc.	₹1.5 crore/MW limited to ₹5 crore per project for special category states
	₹1 crore/MW limited to ₹5 crore per project for other states
Capital subsidy for setting up of new SHP plants in government/state sector	₹7.5 crore/MW limited to ₹20 crore per project for special category states
	₹3.5 crore/MW limited to ₹20 crore per project for other states
Renovation and modernization of old government projects	₹1 crore/MW limited to ₹10 crore per project
R & D	Case-to-case basis CFA
Capacity Building	Up to 100% of the activity cost

Source: MNRE, Annual report 2017–18.

2.1.2 (D) Biomass and Bagasse-based Co-generation using Combustion Technologies

Back-ended capital subsidy is provided to grid-connected biomass projects and bagasse-based co-generation projects to be installed in sugar mills and other industrial units. Capital subsidy is released in one installment after successful commissioning and commencement of commercial generation and performance testing of the plant. Apart from this, biomass and bagasse-based co-generation projects are eligible to receive AD benefit @ 40% on project cost in WDV method.[22, 23]

2.1.3 Status of Major State-level Grid-Connected Policies/Incentives in 2017–18

The key features of the most notable prevailing policy interventions till March 2018 at the state level are presented in Table 2.7[26] while state-wise incentives/exemptions are provided in Table 2.8, and overall performance of RE in Indian states based on targets and achievements is depicted in Table 2.9.

Table 2.7: State Level Policy Interventions Applicable to the Grid-Connected RE Sector: Key Features

Incentives	Key Features
Land Lease Rent/Property Tax	Applicable to projects developed on state government owned land.
Water Usage Charges	Royalty payable by small hydro plants to govt for use of water.
Electricity Duty	State level tax levied on the consumption of electricity by power projects.
Stamp Duty	A tax levied to legalize documents related to RE activities.
Goods and Services Tax	Indirect tax payable to the government on inputs for RE generation.
Banking Charges	Facility given by DISCOM to OA consumers by levying of charge in kind.
Cross Subsidy Surcharge	Payable by open access consumer procuring power from entity other than DISCOM.
T&D and Wheeling Charges	Charges payable in cash by an entity requesting access to the transmission / distribution system of utility for wheeling power. Losses are charged in kind.
Merit Order Dispatch	RE is not subjected to cost based dispatch.
Industrial Policy Incentives	Extending industry status to RE projects to enable them access to industrial policy incentives.
Solar Park Development	Through joint venture with private developers or on its own initiative by investing in equity.
Single Window Clearance	Notify an organization for facilitating grid-connected RE related clearances and application.
Solar Park Development	Through joint venture with private developers or on its own initiative by investing in equity.
Resources and Land	Land identification, resource or potential assessment, facilitating land acquisition in case of state government owned land.

Source: WISE, 2018, (Compiled from various state government policy documents).

Table 2.8: State-wise Incentives/Exemptions for Renewable Energy in 2017–18*[26]

State/Union Territory	Electricity Duty Exemption	Stamp Duty Exemption	CSS Exemption	Wheeling Charges Waiver	Transmission Charges Exemption	Distribution Charges Waiver	Allowance of Contract Demand Cut	Banking Facility	Royalty on Water Usage	Moratorium on Free Power	Industry Policy Incentives
Andaman and Nicobar	⊗							⊗			
Andhra Pradesh	†●		●		†	†		†		◆	
Arunachal Pradesh										◆	
Assam	●			◆●	●						
Bihar	⊗		⊗			⊗	⊗	⊗			
Chandigarh											
Chhattisgarh	●										†●
Dadra and Nagar Haveli											
Daman and Diu											
Delhi	●			●	●			●			
Gujarat	†●◆★			●			†●◆★	●			
Goa											
Haryana	●	●	●	●	●			●			
Himachal Pradesh										◆	
Jammu and Kashmir							●	●	◆		
Jharkhand	●	●	●	●			●	●			
Karnataka		●					⊗				⊗
Kerala	●			●				●			
Lakshadweep											
Madhya Pradesh	◆●■	†●◆■		†■			■	†●◆■	◆	◆	†◆
Maharashtra	⊗		⊗								
Manipur	⊗		●	●◆				●		◆	
Meghalaya	⊗							⊗			
Mizoram	●⊗	●		●			●⊗	●⊗			◆⊗
Nagaland											
Odisha											⊗
Puducherry							●				●
Punjab	⊗	⊗									⊗
Rajasthan	■										†■
Sikkim											
Tamil Nadu	●										●
Telangana	●	†●									
Tripura	⊗							⊗			⊗
Uttar Pradesh					●						†
Uttarakhand		●									
West Bengal							⊗				

Source: WISE, 2018, based on various state government policy documents.
* Timeframe of the incentives is as per the policy period in existence in the respective states.

† Incentives for wind energy
● Incentives for solar energy
◆ Incentives for small hydro
■ Incentives for biomass power
★ Incentives for MSW
⊗ All renewables

Table 2.9: Performance of RE in Indian States based on Targets and Achievements

State / Union Territory	Wind					Solar					Biomass					Small Hydro				
	Target (MW)	Policy Prevalence	CAGR Achieved %	CAGR Reqd. %	Performance	Target (MW)	Policy Prevalence	CAGR Achieved %	CAGR Reqd. %	Performance	Target (MW)	Policy Prevalence	CAGR Achieved %	CAGR Reqd. %	Performance	Target (MW)	Policy Prevalence	CAGR Achieved %	CAGR Reqd. %	Performance
Andaman and Nicobar	—	✓	—	—	👎	27	✓	66	24	👍	—	✓	0	—	—	—	✓	5	—	👍
Andhra Pradesh	8100	✓	66	27	👍	9834	✓	105	60	👍	543	—	5	9	👎	—	—	12	—	👎
Arunachal Pradesh	—	—	—	—	—	39	✓	325	100	👍	—	—	—	—	—	500	✓	5	63	👎
Assam	—	—	—	—	—	663	—	11	270	👎	—	—	—	—	—	25	✓	5	-13	👍
Bihar	—	✓	—	—	👎	2493	✓	455	151	👍	244	✓	70	25	👍	25	✓	5	-32	👍
Chandigarh	—	—	—	—	—	153	—	76	94	👎	—	—	—	—	—	—	—	—	—	—
Chhattisgarh	—	✓	—	—	👎	1783	✓	46	108	👎	—	—	-5	—	👎	25	27	—	-33	👍
Dadra and Nagar Haveli	—	—	—	—	—	449	—	0	414	👎	—	—	—	—	—	—	—	—	—	—
Daman and Diu	—	—	—	—	—	199	—	70	158	👎	—	—	—	—	—	—	—	—	—	—
Delhi	—	—	—	—	—	2762	—	112	250	👎	—	—	—	—	—	—	—	—	—	—
Goa	—	—	—	—	—	358	—	11	668	👎	—	—	—	—	—	—	10	—	—	👍
Gujarat	8800	✓	19	16	👍	8020	✓	16	75	👎	288	—	14	58	👎	25	✓	5	11	👎
Haryana	—	✓	—	—	👎	4142	✓	284	163	👍	209	✓	73	16	👍	25	✓	5	-33	👍
Himachal Pradesh	—	—	—	—	—	776	✓	186	679	👎	—	—	—	—	—	1500	✓	9	—	👍
Jammu and Kashmir	—	—	—	—	—	1155	✓	62	661	👎	—	—	—	—	—	150	✓	7	-6	👍
Jharkhand	—	—	—	—	—	1995	✓	26	326	👎	—	—	—	—	—	—	—	5	—	👍
Karnataka	6200	✓	25	11	👍	5697	✓	271	42	👍	1420	✓	43	-7	👍	—	✓	6	—	👍
Kerala	—	✓	10	—	👍	1870	✓	174	167	👍	—	✓	—	—	👎	—	✓	11	—	👍
Lakshadweep	—		—	—	—	4	—	5	69	👎	—	—	—	—	—	—	—	—	—	—
Madhya Pradesh	6200	✓	8	35	👎	5675	✓	32	62	👎	118	✓	72	5	👍	25	✓	5	36	👍
Maharashtra	7600	✓	1	17	👎	11926	✓	48	141	👎	2469	✓	38	2	👍	50	✓	7	-49	👍
Manipur	—	✓	—	—	👎	105	✓	4833	314	👍	—	✓	—	—	👎	—	✓	5	—	👍
Meghalaya	—		—	—	—	161	—	600	1220	👎	—	—	—	—	—	50	—	5	13	👎
Mizoram	—	✓	—	—	👎	72	✓	48	589	👎	—	✓	—	—	👎	—	✓	5	—	👍
Nagaland	—		—	—	—	61	—	12	378	👎	—	—	—	—	—	15	—	5	-24	👍
Odisha	—	✓	—	—	👎	2377	✓	15	200	👎	—	✓	67	—	👍	—	✓	5	—	👍
Puducherry	—		—	—	—	—	✓	—	—	👎	—	—	—	—	—	—	—	—	—	—
Punjab	—	✓	—	—	👎	4772	✓	58	68	👎	244	✓	18	4	👍	50	✓	5	-36	👍
Rajasthan	8600	✓	4	26	👎	5762	✓	42	31	👍	—	✓	11	—	👍	—	—	5	—	👍
Sikkim	—	—	—	—	—	36	—	0	1433	👎	—	—	—	—	—	50	—	5	-5	👍
Tamil Nadu	11900	—	4	13	👎	8884	✓	38	64	👎	649	—	24	13	👍	75	—	5	-18	👍
Telangana	2000	✓	14	171	👎	—	✓	151	100	👍	—	—	—	—	—	—	—	—	—	—
Tripura	—	✓	—	—	👎	105	✓	6	165	👎	—	—	—	—	—	—	—	5	—	👍
Uttar Pradesh	—	✓	—	—	👎	10697	✓	106	160	👎	3494	✓	59	17	👍	25	✓	5	-4	👍
Uttarakhand	—	—	—	—	—	900	✓	158	49	👍	197	—	3	34	👎	700	—	7	43	👎
West Bengal	—	✓	—	—	👎	5336	✓	139	397	👎	—	✓	258	—	👍	50	✓	5	-23	👍

'–' Indicates unavailability of data for respective technology.

Source: WISE Analysis, 2018, based on MNRE website, various state government policy documents.[4, 24, 26]

2.2 POLICIES FOR OFF-GRID RE SYSTEMS

Off-grid RE systems occupy an important place in India's energy scenario as grid connectivity is not technically and economically feasible in all regions, especially in remote and inaccessible areas. While 100% village electrification is stated to be achieved during 2017–18, it has been observed that most of the households have electricity only for one-fourth or one-third of the day, that too with frequent low voltage supply. Thus, round-the-clock access to good quality electricity necessitates the need for off-grid/decentralized solutions. In India, just like most grid-connected RE technologies, off-grid RE technologies, too, are promoted through central financial assistance (CFA), in combination with state government subsidies.

2.2.1 National Level Policy Interventions for Off-grid RE

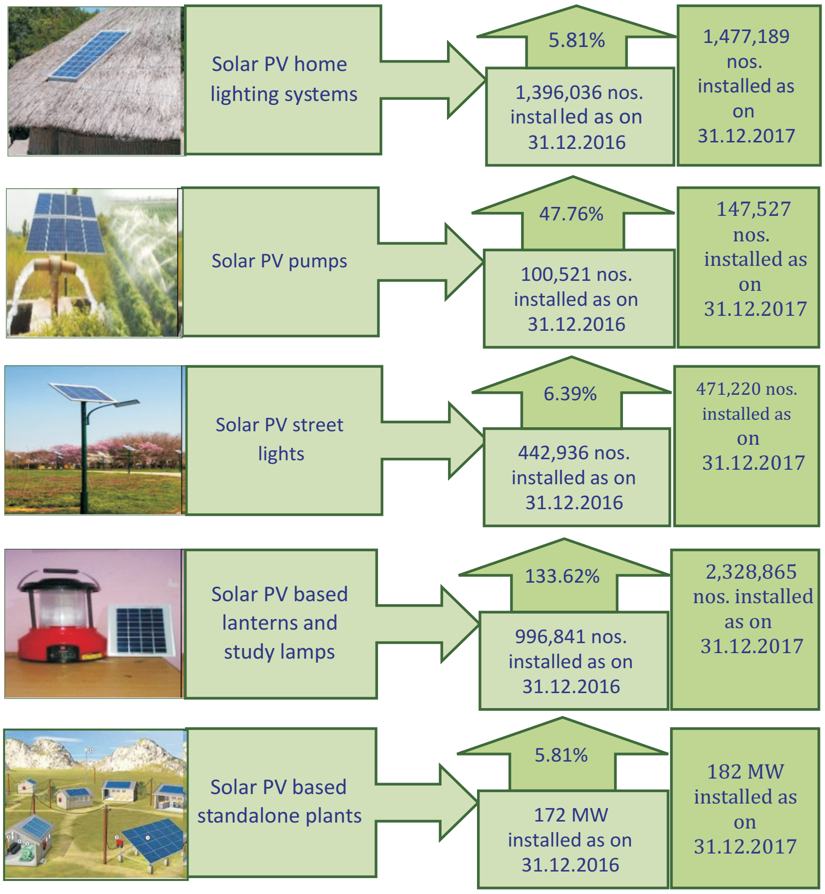
Looking at the technology-wise coverage of national schemes and CFA, the national policy interventions for off-grid RE systems are divided into two parts: solar and non-solar policies. Solar policies are further divided

into two sub-parts, viz., policies for solar photovoltaic and solar thermal.

Status of Solar Off-grid Policies

Central financial assistance is provided to the implementing agencies of off-grid solar PV schemes announced by the central government. State Nodal Agencies (SNAs) are the primary implementing agencies through which CFA of 30% is being provided.[22] NABARD is one of the implementing agencies for solar photovoltaic pumps and solar lighting systems through which CFA of 40% of the benchmark cost is being

Figure 2.5: Solar Off-grid PV Systems being Promoted by the Central Government (as on Dec 2016)



Source: WISE Analysis, 2018, based on MNRE Annual Report 2017–18.

Box 2.5: Scheme of 70 Lakh Solar Study Lamps (2017–18)

Objectives:
- Supporting education of school students in un-electrified rural households.
- Employment/livelihood generation through localization of solar energy.
- Awareness & confidence building of solar technology through a first-hand experience of solar products.

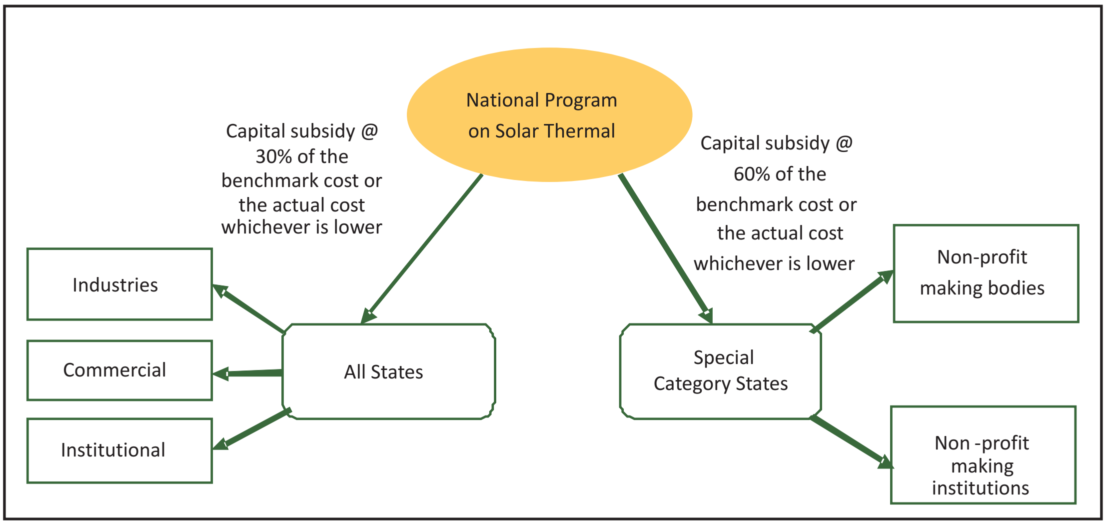
Features:
- Covers five states – Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh.
- Basis for selection of blocks–over 50% kerosene consumption at household level as the main lighting source, and percentage of marginalized population.
- The target beneficiaries in block–60% of school going students enrolled.
- Procuring agency–Energy Efficiency Services Limited (EESL).
- Chief implementing agency–IIT, Bombay.
- Grassroots implementation through Assembly and Distribution Centers (ADC) at block level – set up by Block Level Execution Agencies (BEA)–basically State Rural Livelihood Mission (SRLM) promoted cluster level federation/block level federation/village organisations of women self-help groups.
- Employment of local rural people for assembly, distribution and after sales services.
- Emphasis on local skills development through appropriate capacity building training.

Source: MNRE Annual Report, 2017–18.

provided. The schemes available for solar off-grid systems are shown in Figure 2.5, while a scheme for solar study lamps is provided in Box 2.5.

Central financial assistance is also provided for solar thermal technologies. A schematic representation on how the national level programme on solar thermal is being implemented is shown in Figure 2.6. During the financial year 2017–18, 11 CST systems with 3130.2 m^2 collector/ reflector area were installed and commissioned and 48 CST projects with 16,555 m^2 collector/reflector area are under installation for process heating, air conditioning and steam cooking requirements in industrial, institutional and commercial establishments.[22]

Figure 2.6: Central Financial Assistance for Off-grid Solar Thermal Systems in 2017–18



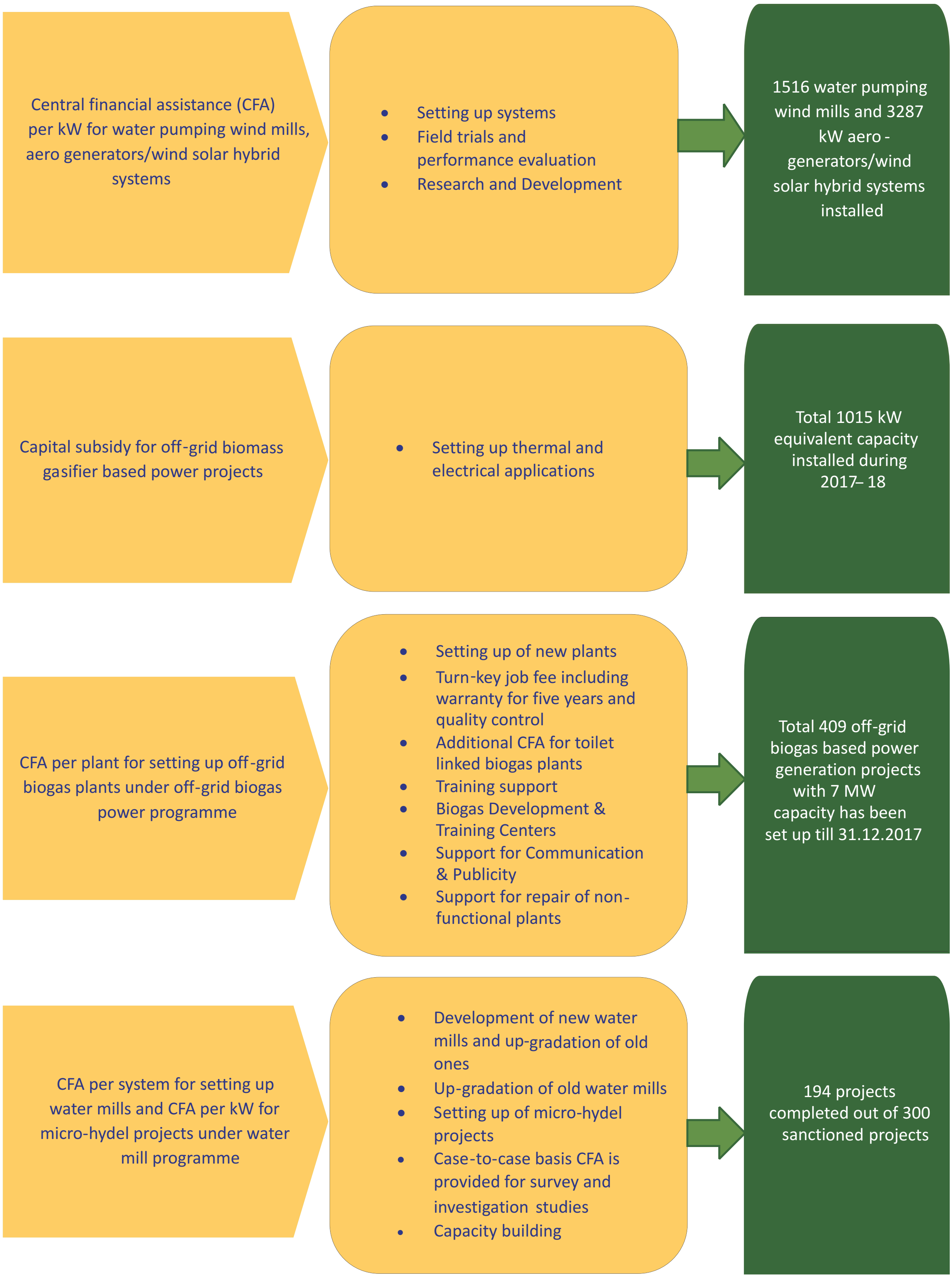
Source: WISE, 2018 (based on MNRE data).

Status of Non-Solar Off-grid Systems[22]

Four major technologies are being promoted in the category of non-solar off-grid RE systems.[22] They are:
- Small Wind Energy and Hybrid systems
- Biomass gasifier systems
- Off-grid biogas power programme
- Watermills programme

Figure 2.7 summarizes central financial assistance for various non-solar off-grid technologies, their utilization and performance.

Figure 2.7: Non-Solar Off-grid Systems being Promoted by the Central Government in 2017–18[22]



Source: WISE, 2018 (based on MNRE data).

An important development of off-grid implementation is that MNRE has stopped empanelment of suppliers or channel partners for the systems. The Ministry believes that the consumers should have freedom in choosing the suppliers instead of the government designating a particular supplier for a given region.

2.2.2 State Level Policy Interventions for Off-grid RE

Almost all state governments provide additional incentives over national incentives for development of off-grid RE systems in their respective states. More often than not, state governments provide up to 40% subsidy over and above central government subsidies for various off-grid RE technologies. Few technologies, such as solar home lighting systems, solar lanterns, solar PV pumps, mini and micro hydro projects, and biomass gasifiers, receive larger weightage in total subsidy allocated by state governments for off-grid RE technologies. Besides, there are subsidies for technologies such as solar high mast, and biogas digesters, etc.

A brief status of mini/microgrid projects in Indian states is given in Box 2.6.

Box 2.6: Status of Mini/Microgrid Projects in 2017–18

No major development was witnessed in mini/microgrid policies across states in 2017–18. States that have dedicated mini/micro grid policies are Madhya Pradesh and Uttar Pradesh.[27,28] In 2016–17, Bihar announced the establishment of 100 MWp equivalent microgrid based projects by 2022 as part of its Renewable Energy Policy.[29]

Models:

- Central government subsidy based projects under DDUGJY schemes with provision for 90% central subsidy.[30, 31]
- State government subsidy based projects.[27, 28, 29]
- Renewable Energy Service Company (RESCO) based projects developed under either BOOM or BOOT business models.[27, 28, 29]

Challenges and Opportunities:

With poor 24x7 supply and low voltage issues, microgrid projects are the need of the hour. Moreover, governments are considering different business models to safeguard microgrids from the risk of grid extension, eg. existing microgrid projects continue to operate in parallel to the grid as a franchisee to the DISCOMs against a fee received from the DISCOMs. Additionally, microgrid operators may choose to transfer their assets to the DISCOM against a one-time lumpsum payment and cease operating on their own.[27,28,29,30]

Source: Compiled from various central and state government policy documents.

REGULATION

The Electricity Act, 2003, provides the legislative framework for regulation and development of the power sector (including renewable energy), in India. As per the Act, the Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commissions (SERCs) are responsible for regulating the generation, distribution and transmission of electricity, based on the jurisdiction and powers vested in them. The Tariff Policy formulated by the central government as per provisions of the Act, further enunciates the tariff setting methodologies and principles, including ways to promote renewables, by enacting/enabling regulations by the SERCs and CERC. The process of regulation is therefore continuously evolving to facilitate increased electricity generation from RE sources.

2.3 FEED-IN TARIFF

CERC in its 2017–18 regulations provides project specific tariff for wind, solar and municipal waste to energy projects, whereas, generic tariff is specified for all other RE technologies like biomass, small hydro and bagasse-based co-generation. Most solar and wind projects are now established, primarily, through the competitive bidding route on pan India basis. The CERC declared feed-in tariff for 2017–18 for RE, other than wind and solar, is specified in Figure 2.8.

At the state level too (although SERCs have specified feed-in tariffs for wind and solar through respective tariff orders spanning the next one to two years), DISCOMs are adopting the competitive bidding route for procurement of electricity from solar and wind power. SERC declared feed-in tariff for solar and wind is specified in Table 2.10 and 2.11, respectively.[32,33]

2.4 FORECASTING AND SCHEDULING

In 2017, CERC has notified Framework for Forecasting, Scheduling and Imbalance Handling for Variable sources (wind and solar). The forecasting and scheduling framework provides methodology for day-ahead scheduling of wind and solar energy generation forecast, with an interval of 15 minutes for the next 24 hours, for the aggregate generation capacity of 50 MW and above.

Figure 2.8: CERC declared Feed-in Tariff for 2017–18 (SHP and Bio-power)

Small Hydro projects: ₹4.29 – 6.00/kWh
Biomass (water and air cooled condenser)
Other than Rice Straw and Juliflora
Travelling Grate Boiler: ₹6.85 – 8.09/kWh
AFBC boiler – ₹6.76 – 7.98/kWh
Rice Straw and Juliflora
Travelling Grate Boiler: ₹6.95 – 8.20/kWh,
AFBC boiler – ₹6.86 – 8.09/kWh
Bagasse co-generation: ₹5.32 – 6.65/kWh
Biomass Gasifier: ₹6.36 – 7.25/kWh

Source: CERC RE tariff order FY 2017–18.

Table 2.10: SERC declared Solar Tariff (₹/kWh) in 2017–18

Gujarat (2015)	Tamil Nadu (2017)	Rajasthan (2017)	Madhya Pradesh (2016)	Maharashtra (2017)	Karnataka (2013)
MW SCALE PLANTS: 5.34 KW SCALE PLANTS: 6.61	4.41	3.66	5.45	Solar rooftop and other small solar projects: 5.24 Others: 4.74	MW scale plants: 6.51 kW scale plants: 4.4 to 6.03

Source: SERCs feed-in tariff orders related to solar power projects.

Table 2.11: SERC declared Wind Tariff in 2017–18 (₹/kWh)

Gujarat (2016)	Tamil Nadu (2016)	Rajasthan (2017)	Maharashtra (2017)	Karnataka (2017)	Andhra Pradesh (2016)
4.19	3.70	4.87/5.15	Wind Zone-wise 3.38 to 4.92	3.74	4.25

Source: SERCs feed-in tariff orders related to wind power projects.

Box 2.7: Summary of Forecasting and Scheduling Mechanism for Andhra Pradesh

- The objective is to maintain grid stability and security as envisaged under the State Grid Code through forecasting, scheduling and deviation settlement of wind and solar generators.
- This is applicable to all wind and solar generators connected to the grid, including through pooling stations, and those supplying power to distribution utilities, third party consumers or captive consumers, within or outside the state.
- The existing projects shall establish the forecasting tools before 1 January 2018 and no firm shall be allowed to be commissioned after this date, without the establishment of forecasting tools. The mechanism shall commence from 1 January 2018, and the commercial settlement shall commence from 1 July 2018.
- Wind or solar generators, either by themselves or through Qualified Coordinating Agencies (QCA), shall provide technical specifications of the generating units to the State Load Dispatch Center (SLDC) in the format prescribed by it. Concerned generators shall provide real-time power generation parameters and weather data to the SLDC.
- Every generator or QCA shall submit a day-ahead and week-ahead schedule for each generating station or each pooling station, as the case may be. Day-ahead schedule shall be prepared for intervals of 15 minutes (time block) for the next day, starting from 00:00 hours. A maximum of 16 revisions in a day will be allowed, starting from 00:00 hours for wind generators; 9 revisions in a day, between 05:30 hours and 19:00 hours, for solar generators with one revision for each time slot of one and a half hours.
- Any commercial impact of deviation shall be borne by the generator or through the representing QCA.
- **Role of QCA:**
  - o Single point-of-contact with SLDC on behalf of its coordinated generators.
  - o Providing schedules with periodic revisions on behalf of wind and solar generators.
  - o Coordinating with DISCOM/STU/SLDC for metering, data collection, communication and issuance of instructions for dispatch and curtailment.
  - o Undertaking commercial settlement arising out of any deviations on behalf of generators.
  - o All other ancillary and incidental matters.
- Deviations for intra-state and inter-state transactions shall be accounted for separately.
- QCA shall separately settle deviation charges for inter-state and intra-state transactions. QCA shall de-pool energy deviation as well as deviation charges to each of the generators connected to the pool.
- QCA will have the option to adopt 'virtual pooling' in agreement with generators of different pooling stations to aggregate the forecasting and scheduling of various pooling stations. However, while computing the deviations, they shall be considered as combined pool and the QCA shall be responsible for de-pooling the deviations, upto the generator level.

Source: APERC, 2017.[34]

As per CERC Regulations, the schedule for energy injection given by wind and solar generators—who are regional entities supplying inter-state power under long-term, medium-term or short-term open access—may be revised by giving advance notice to the Regional Load Dispatch Centre (RLDC). The charges payable for deviation from schedule by the wind and solar generators shall be delinked from frequency, and shall be accounted for and settled in accordance with the provisions of the Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) Regulations, 2014, as amended from time to time.

Subsequently, for state level transactions, the mechanism for forecasting and scheduling has been evolving through regulations framed by SERCs. In 2017–18, APERC finalized the said regulations, while UP and Tamil Nadu published their draft regulations. The state level mechanism, as given for Andhra Pradesh is summarized in Box 2.7.[34] The deviation charges are given in Table 2.12.

The absolute error for deviation settlement is calculated as:

Absolute error (%) = 100 x [Actual generation – Scheduled Generation]/Available Capacity

In view of the infirm nature of wind and overall instability of the grid to take in huge quantum of renewable energy, a pilot for flexibilization of coal plants was conducted by NTPC. A summary is provided in Box 2.8.

Table 2.12: Deviation Charges under Forecasting and Scheduling for Andhra Pradesh

Outside the state		
Absolute error in 15-min Block	**Under injection (charges payable to state pool account)**	**Over injection (charges payable to generators)**
< 15%	Fixed rate for error up to 15%	Fixed rate for absolute error up to 15%
> 15% but < = 25%	Fixed rate for error up to 15% + 110% of the fixed rate for balance energy beyond 15% and up to 25%.	Fixed rate for absolute error up to 15% + 90% of the fixed rate for excess energy beyond 15% and up to 25%.
> 25% but < = 35%	Fixed rate for error up to 15% + 110% of the fixed rate for balance energy beyond 15% and up to 25% + 120% of the fixed rate for balance energy beyond 25% and up to 35%.	Fixed rate for absolute error up to 15% + 90% of the fixed rate for excess energy beyond 15% and up to 25% + 80% of the fixed rate for excess energy beyond 25% and up to 35%.
> 35%	Fixed rate for error up to 15% + 110% of the fixed rate for balance energy beyond 15% and up to 25% + 120% of the fixed rate for balance energy beyond 25% and up to 35% + 130% of the fixed rate for balance energy beyond 35%.	Fixed rate for absolute error up to 15% + 90% of the fixed rate for excess energy beyond 15% and up to 25% + 80% of the fixed rate for excess energy beyond 25% and up to 35% + 70% of the fixed rate for excess energy beyond 35%.
Within the state for over or under injection (payable to state pool account)		
Absolute error in 15-min Block		
< 15%	Nil	
> ±15% and < ± 25%	₹0.50/kWh for the shortfall or excess energy for absolute error beyond 15% and up to 25% .	
> ±25% and < ± 35%	₹0.50/kWh for the shortfall or excess energy for absolute error beyond 15% and up to 25% + ₹1.0/kWh for balance energy beyond 25% and up to 35%.	
> ± 35%	₹0.50/kWh for the shortfall or excess energy for absolute error beyond 15% and up to 25% + ₹1.0/kWh for balance energy beyond 25% and up to 35% + ₹1.5/kWh for balance energy beyond 35%.	

Source: APERC, 2017. [34]

Box 2.8: NTPC Pilot for Flexibilization of Coal Based Power Plants

Fluctuation in demand for power is a regular phenomenon in India. It is aggravated by the infirm nature of RE. There is an urgent need to ensure future stability of power grids when injecting large quantum of renewable energy into the grid. Flexibilization of coal based power plants is one such measure in that direction. For this purpose, demonstration of technical and economic feasibility was carried out at two plants of NTPC, viz., Dadri (210 MW) and Simhadri (500 MW). The final report (after a series of meetings of the task force formed for the purpose) recommended three measures:

- Minimum load down up to 50% - to be implemented in all stations requiring no or minimal investment.
- Minimum load down up to 40% - to be implemented in non-pit head NTPC plants, similar ISGS, IPPs and state utilities at an investment of ₹1 to 2 lakh/MW for NTPC non-pithead stations.
- Minimum load down up to 25% - impractical for India as the quality of coal is not up to the mark.

Flexibilization of coal based power plants requires frequent start/stop. Thus start-up optimization will need to be implemented along with other measures for achieving 40% minimum load. However, this may not be necessary for downsizing load up to 50% since NTPC power plants in the country are successfully operating at 55% technical minimum.

Source: Compiled from Forum of Regulators technical committees minutes and Task Force committee report. [35,36]

2.5 NET METERING REGULATIONS FOR SOLAR ROOFTOP

The Government of India aims to achieve 100 GW solar capacity by 2022. Of this, 40 GW is planned to be deployed through rooftop PV. Typically, solar rooftop has two distinct ownership arrangements:

- Self-owned arrangement, wherein the rooftop owner also owns the PV system.
- Third party ownership, in which a developer owns the PV system and enters into a lease/commercial arrangement with the rooftop owner.

Irrespective of the ownership arrangement, the major advantages of solar rooftop are savings in transmission and distribution losses, low gestation time, absence of land requirement and reduction in system congestion with higher self-consumption and savings in electricity cost for the rooftop owner.

The guiding regulations for net metering were prepared by the Forum of Regulators (FoR). Based on these, most SERCs issued their own net metering regulations. However, the concept of gross metering for rooftop projects, i.e. energy sale to other entities such as DISCOMs apart from the rooftop owners, was also introduced. In 2017–18, Bihar

Table 2.13: Rooftop Solar Net / Gross Metering Regulations of Bihar

Parameters	Provision
Eligibility Conditions	• All consumers in the supply area of the distribution licensee. • Minimum capacity of 1 kWp. • Maximum limit: Limited to sanctioned / contracted load.
Capacity Target for Distribution Licensee	• As determined by the Commission but not exceeding 100 MW cumulative capacity in a year. • Cumulative capacity shall not exceed 80% of distribution transformer's capacity.
Interconnection with the Grid	The interconnection of the rooftop solar system with the network of the distribution licensee shall conform to the technical specifications, standards and provisions as provided in the Central Electricity Authority (Technical Standards for Connectivity of the Distributed Generation Resources) Regulations, 2013 as well as Central Electricity Authority (Measures related to Safety and Electric Supply) Regulations, 2010 and Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006, amended from time to time.
Metering Arrangement	• The metering should be as per provisions of various CEA orders, as discussed above • The eligible consumer shall install the Net/Gross Meter at the interconnection point of the eligible consumer with the network of the distribution licensee. • The eligible consumer shall also install solar meter at the delivery point of the solar energy system. • Check meters shall be mandatory for projects with capacity above 20 kW, but optional otherwise.
Energy Accounting and Settlement	**Net metering** • Excess export of electricity over import shall be carried forward to the next billing period for adjustment against energy consumed in subsequent billing periods within the settlement period. At the end of the settlement period, unadjusted net energy credits shall lapse without any carry forward or payments. • For electricity import over export, distribution licensee shall raise an invoice for the net electricity consumed after adjusting for credited units. • In case of time of day tariff, electricity consumption in any time block shall be first compensated with the quantum of electricity injected in the same time block, and any excess injection over consumption during any other time block shall be accounted as if the excess injection has occurred during off-peak hours. • Gross metering • The licensee shall make payment to the eligible consumer or the third party, as the case may be, for the quantum of such injected electricity at the feed-in tariff approved by the Commission.
RPO	The quantum of electricity consumed by the eligible consumer (who is not defined as obligated entity) from the rooftop solar system under net-metering arrangement shall qualify towards compliance of Solar RPO for the distribution licensee.
OA Charges	The rooftop solar producer under net or gross metering arrangement, whether self owned or third party owned, shall be exempted from banking and wheeling charges and cross subsidy charges.

Source: BERC, 2018. [37]

finalized its revised regulations in this regard. Also, states like UP, Odisha, Gujarat, Assam and Maharashtra issued amendments or related orders regarding net metering regulations. Table 2.13 describes various provisions under the BERC (Rooftop Solar Grid Interactive Systems Based on Net and Gross Metering) Regulations, 2018.

The summary of orders/amendments regarding solar rooftop net metering regulations published during 2017–18 are given in Box 2.9.

Despite these supporting policies and regulations, the 40 GW target by 2022 appears challenging. Although the net metering regulations are notified by the SERCs (at state level), real challenges are being faced at the implementation level. The regulations specified that operating guidelines should be issued by the concerned distribution utilities after publication of regulations. However, since the preparation of operating guidelines is the responsibility of the utilities, they should publish the guidelines and implement the solar rooftop projects accordingly.

Box 2.9: Summary of Orders/Amendments of Net Metering Regulations (2017–18)

Uttar Pradesh (Order)

- Capping limit of distribution transformer is unchanged at 25%.
- No revision of maximum installed capacity of solar project as 1 MW; reconsider this limit on case-to-case basis.
- Although Commission noticed the declining trend of cost, settlement rate is kept as ₹2/kWh.
- Allow aggregator model under net-metering, where group or third party owner can install solar captive project up to total capacity of cumulative contracted load of the consumers connected with same distribution transformer.

Assam (First Amendment)

- For LT / HT consumers, solar panel capacity of individual consumer will be limited to 80% of connected load / contract demand.
- Provided that for all such LT consumers, the cumulative solar panel capacity will be limited to 20% of peak capacity of the concerned distribution transformer. For HT consumers, the cumulative solar panel capacity will be restricted to 20% of the peak capacity of the concerned 33/11 kV substation.

GERC (First Amendment)

The maximum solar project capacity to be installed at any eligible consumer's premises, except residential consumers, shall be upto a maximum of 50% of the consumer's sanctioned load/contract demand; in case of residential consumers, the solar project capacity shall be irrespective of their sanctioned load/contract demand.

Maharashtra (First Amendment)

The regulations are applicable to renewable energy projects as defined in the Maharashtra Electricity Regulatory Commission (Terms and Conditions for Determination of Renewable Energy Tariff) Regulations, 2015, and such other sources as are recognized or approved by the Ministry of New and Renewable Energy, Government of India.

Odisha (Order)

In case of multiple solar generation sources on a single premises, separate solar meters will have to be installed by the solar power generator/prosumer for each of the sources, with facility for installation of modem along with all solar meters for remote recording of monthly generation. Alternatively, the consumer can provide the soft copy of dump data of solar generation meter in .xml/cdf/dmd/emd/mrd format, through email, to the concerned licensee in the first week of the succeeding month. Also, manual reading can be taken by the licensee in case of emergency or if the situation so warrants.

Source: Net Metering orders of various states, 2017–18.[38]

***

3 MARKET AND INDUSTRY

HIGHLIGHTS OF 2017–18

Market

- The cumulative installed RE capacity, as on 31 March 2018, was highest in the southern region (34,369 MW) followed by the western region (20,446 MW), northern region (12,873 MW), eastern region (1038 MW) and north-eastern region (282.5 MW), respectively. In terms of CAGR, the southern region registered the highest of around 29.4%, followed by the northern region (23%), western and eastern regions (23%), and north-eastern region (2.8%).
- Share of wind has come down from 67% of cumulative installed capacity in 2013–14 to 49% in 2017–18 (CAGR of 12.6%). In contrast, solar's share has increased from 8% to 31% (CAGR of 69%) during the same period, while small hydro has declined from 12% to 6.5% (CAGR of 4%), and that of biomass has decreased from 13% to 12.8% (CAGR of 21%).
- The market value of grid-connected RE technologies has increased from ₹293 billion ($4.84 billion) on 31 March 2014 to around ₹671 billion ($10.42 billion) on 31 March 2018.
- Share of market value of wind has declined from around 50% in 2013–14 to 33% in 2017–18, as also has small hydro, from approximately 14% in 2013–14 to 8% in 2017–18. A sharp increase in the share of market value of solar technologies from approximately 11.7% in 2013–14 to 29.8% in 2017–18 is observed, and the share of market value of biomass has increased from approximately 24.6% in 2013–14 to 29% in 2017–18.
- Market predictions upto 2022 show that solar will rule in terms of market size at ₹540 billion, followed by wind (₹366 billion), biomass (₹274 billion) and small hydro (₹81.7 billion). Total market value size for grid-connected RE technologies till 2021–22 is expected to be ₹1262.5 billion.
- Competitive bidding tariff rates of solar and wind reached a historical low of ₹2.44/kWh and ₹2.43/kWh, respectively.
- Andhra Pradesh, Delhi, Himachal Pradesh, Kerala, Tamil Nadu, and Tripura met their solar RPO targets, while Arunachal Pradesh, Delhi, Himachal Pradesh, Karnataka, Kerala and Maharashtra met their non-solar RPO targets.
- 15.98 million non-solar RECs were traded in the exchanges. In non-solar REC trading, IEX share was 57.8% and PXIL share was 42.2%.

Industry

Solar

- Cumulative manufacturing capacity of solar cells increased from 1,468 MW (16 manufacturers) in 2016–17 to 3,164 MW (20 manufacturers) in 2017–18, a 115% year-on-year growth.
- Cumulative manufacturing capacity of solar modules increased from 4,307 MW (94 manufacturers) in 2016–17 to 8,398 MW (117 manufacturers) in 2017–18, a 94% year-on-year increase.
- Solar imports increased from $3,157 million in 2016 to $4,540 million in 2017 and exports increased from $126.7 million in 2016 to $138.4 million in 2017.

Wind

- Top five wind manufacturers in terms of annual manufacturing capacity in 2017-18 were Suzlon (626 MW), Gamesa (552 MW), Vestas (181.6 MW), Inox Wind (174 MW), and GE India (97 MW).
- Wind electric generator exports increased from $8 million in 2016 to $18 million in 2017, while import of critical components too increased from $7 million in 2016 to $8.8 million in 2017.

3.1 MARKET UPDATE

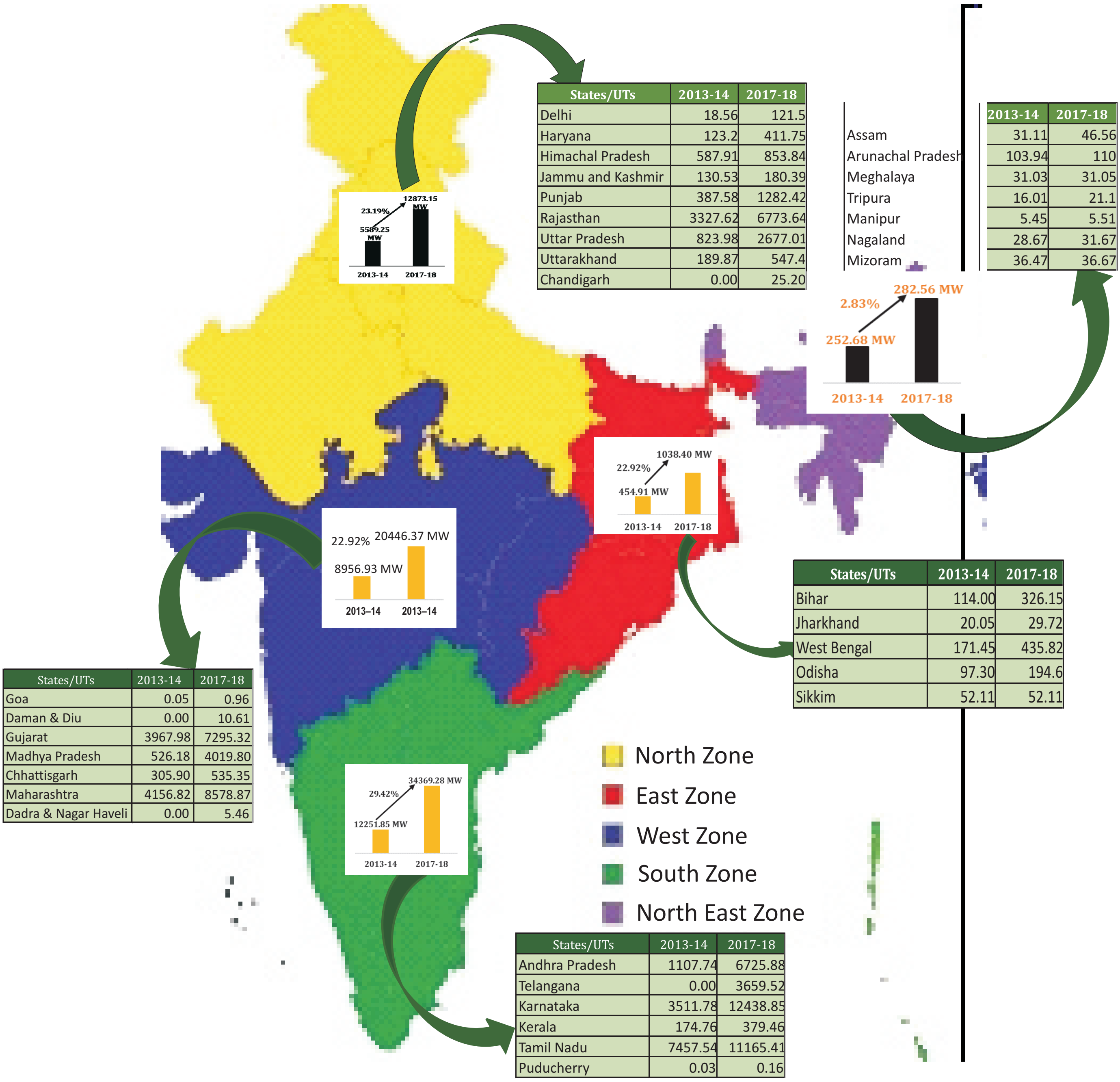
3.1.1 Region-wise share of RE

If we consider the distribution of cumulative RE installed capacity across the five regions of India over the last five years (2013–14 to 2017–18), the cumulative installed capacity as on 31 March 2018 is highest in the southern region (34,369 MW) followed by the western region (20,446 MW), northern region (12,873 MW), eastern region (1,038 MW) and north-eastern region (282.5 MW), respectively. The southern region registered the highest CAGR of 29.4%, followed by the northern region (23%), western and eastern regions (23%) and north-eastern region (only 2.8%).[1] Figure 3.1 depicts the region-wise distribution of the cumulative RE installed capacity as on 2013–14 and 2017–18.

In terms of cumulative RE installed capacity over the last five years, percentage share of the southern region has increased from 44.5% in 2013–14 to 49.7% in 2017–18, while that of all other regions has decreased.[1] Region-wise details are shown in Table 3.1.

When considering state-specific installation of grid-connected RE in the country, a huge disparity is observed. Almost 94% of capacity is installed in about

Figure 3.1: Region-wise Growth in Renewable Energy Installed Capacity in India at the end of 2013–14 and 2017–18



States/UTs	2013-14	2017-18
Delhi	18.56	121.5
Haryana	123.2	411.75
Himachal Pradesh	587.91	853.84
Jammu and Kashmir	130.53	180.39
Punjab	387.58	1282.42
Rajasthan	3327.62	6773.64
Uttar Pradesh	823.98	2677.01
Uttarakhand	189.87	547.4
Chandigarh	0.00	25.20

	2013-14	2017-18
Assam	31.11	46.56
Arunachal Pradesh	103.94	110
Meghalaya	31.03	31.05
Tripura	16.01	21.1
Manipur	5.45	5.51
Nagaland	28.67	31.67
Mizoram	36.47	36.67

States/UTs	2013-14	2017-18
Bihar	114.00	326.15
Jharkhand	20.05	29.72
West Bengal	171.45	435.82
Odisha	97.30	194.6
Sikkim	52.11	52.11

States/UTs	2013-14	2017-18
Goa	0.05	0.96
Daman & Diu	0.00	10.61
Gujarat	3967.98	7295.32
Madhya Pradesh	526.18	4019.80
Chhattisgarh	305.90	535.35
Maharashtra	4156.82	8578.87
Dadra & Nagar Haveli	0.00	5.46

States/UTs	2013-14	2017-18
Andhra Pradesh	1107.74	6725.88
Telangana	0.00	3659.52
Karnataka	3511.78	12438.85
Kerala	174.76	379.46
Tamil Nadu	7457.54	11165.41
Puducherry	0.03	0.16

Source: WISE Analysis, 2018, based on data collected from CEA reports.

Table 3.1: Percentage Share of Regions: Cumulative RE Installed Capacity at the end of 2013–14 and 2017–18

Sr. No.	Region / UT	2013–14	2017–18
	National Level Cumulative Installed Capacity (MW)	27511.72	69022.32
1	Northern Region	20.32%	18.65%
2	Western Region	32.56%	29.62%
3	Southern Region	44.53%	49.79%
4	Eastern Region	1.65%	1.50%
5	North-Eastern Region	0.92%	0.41%
6	Union Territories	0.02%	0.02%

Source: WISE Analysis, 2018, based on Executive Summary of Monthly Power Sector Status, CEA.

Table 3.2: Top 10 States in terms of Cumulative RE Installed Capacity (2013–14 to 2017–18)

Year	No.	States	Installed Capacity (MW)	Year	No.	States	Installed Capacity (MW)
2013-14	1	Tamil Nadu	7457.54	2017-18	1	Karnataka	12438.85
	2	Maharashtra	4156.82		2	Tamil Nadu	11165.41
	3	Gujarat	3967.98		3	Maharashtra	8578.87
	4	Karnataka	3511.78		4	Gujarat	7295.32
	5	Rajasthan	3327.62		5	Rajasthan	6773.64
	6	Andhra Pradesh	1107.74		6	Andhra Pradesh	6725.88
	7	Uttar Pradesh	823.98		7	Madhya Pradesh	4019.80
	8	Himachal Pradesh	587.91		8	Telangana	3659.52
	9	Madhya Pradesh	526.18		9	Uttar Pradesh	2677.01
	10	Punjab	387.58		10	Punjab	1282.42

Source: WISE Analysis, 2018, based on Executive Summary of Monthly Power Sector Status, CEA.

10 states (93.9% in 2013–14 and 93.6% in 2017–18). This RE concentration has remained almost constant over the years.[1] The list of the top 10 states in terms of cumulative RE installed capacity from 2013–14 to 2017–18 is summarized in Table 3.2.

3.1.2 Market Size in Terms of Installed Capacity (2013–14 to 2017–18)

India's grid-connected RE installed capacity has grown at a compound annual growth rate (CAGR) of 21.4% over a period of five years (2013–14 to 2017–18).[1] The four major technologies contributing to this growth are wind, solar, small hydro (up to 25 MW capacity) and biomass (including bagasse-based co-generation). While wind has historically contributed the highest share,[1] in recent times it has come down from 66.6% of cumulative installed capacity in 2013–14 to 49% in 2017–18 (CAGR of 12.6%).[1] In contrast, solar's share has increased from 8% to 31% (CAGR of 69%)[1] during the same period. Where small hydro is concerned, there has been a decline from 12% to 6.5% (CAGR of 4%),[1] and biomass has decreased from 13% to 12.8% (CAGR of 21%),[1] during 2013–14 to 2017–18. The technology-wise, cumulative grid-connected RE installed capacity is shown in Figure 3.2.

3.1.3 Market Value of RE (2013–14 to 2017–18)

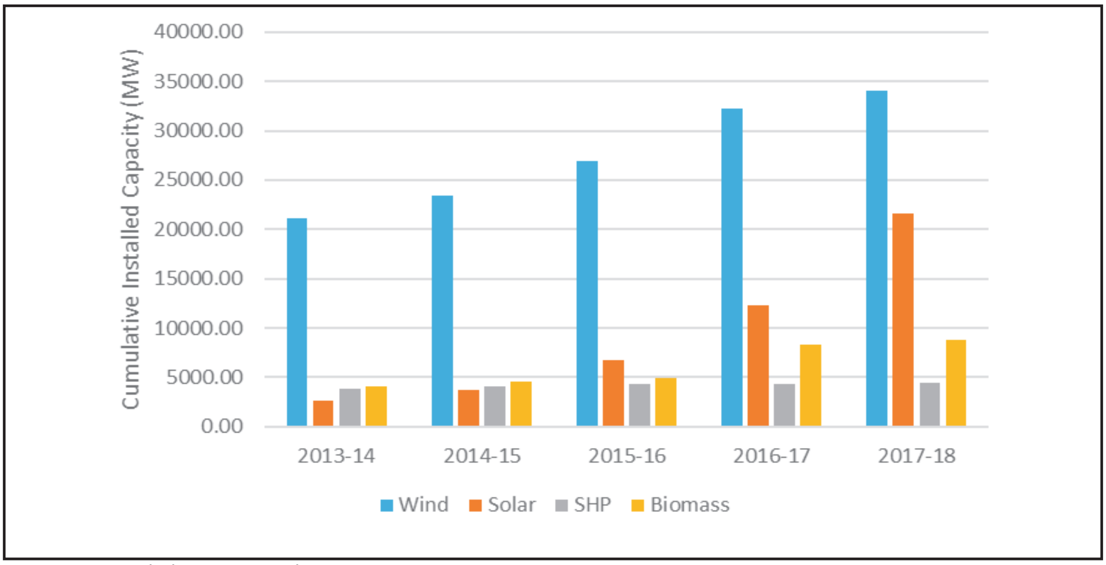
The huge potential for RE to become a viable substitute for conventional energy has been complemented by a stream of policy interventions from central and state governments to galvanize investments in the sector, resulting in many private investors entering the market in large numbers in 2017–18. In the current year under review, the government's share in grid-connected RE installed capacity came down from 12% in 2013–14 to a mere 5% in 2017–18[1], while private investors controlled the rest.

In order to assess the total market size of RE in terms of its value in currency, the gross value creation across the entire value chain (from project planning, manufacturing, installation, to electricity generation and O&M) for the period 2013–14 to 2017–18 has been considered.

The following assumptions have been made in deriving the market value of RE:

- This analysis leaves out the scope for additional value created by exports of RE equipment manufactured in India. Nevertheless, in near future most of the capacity manufactured in India is expected to be absorbed in India due to ambitious

Figure 3.2: Technology-wise Cumulative Grid-Connected RE Installed Capacity from 2013–14 to 2017–18



Source: Central Electricity Authority, 2013–14 to 2017–18.

RE installed capacity targets and the return of trade protectionism across the globe.

- The market size has been derived based on the cumulative installed capacity of grid-connected RE projects at the end of each financial year from 2013–14 to 2017–18.
- The market size reflects the market value as on 31 March of every financial year. In other words, the time interval between the expansion of markets has been assumed to be one year (taking into consideration market ups and downs over a passage of time).
- The average PLF achieved by respective technologies over the last three years have been assumed to hold true for the entire period. This is so because of relative stability in PLF over the short-term.[1&2]
- The market size has been derived using state specific technology-wise levelized cost of electricity (LCOE) set by the Central Electricity Regulatory Commission (CERC) from 2013–14 to 2016–17.[3] In order to arrive at the market value average of the state specific tariff has been considered.
- For 2017–18, CERC has not decided any generic LCOE for wind and solar technologies. In this case, an average of the tariff given by states has been taken as the representative LCOE.[4]
- For representative LCOE derived from various states' LCOE of wind and solar technologies in 2017–18, sample standard deviation for wind and solar technologies is 0.37 and 1.35 respectively. Thus there exists a chance for variability in the estimate of market value for RE.
- The market size is expressed in both billion ₹ terms and billion $ terms. For conversion of market size expressed in billion ₹ terms, annual average exchange rate between ₹ and $ has been adopted.[5]

Methodology for arriving at the future tariff for Computing Potential RE Market Value for Future

- Average of annual reduction in tariff over last five years for each technology has been derived. Then tariff for each successive year has been arrived at by deducting the average annual reduction in tariff from previous year's tariff.

Based on these assumptions, the market value of RE technologies as on 31 March of each year, for the period 2013–14 to 2017–18, is provided in Table 3.3.

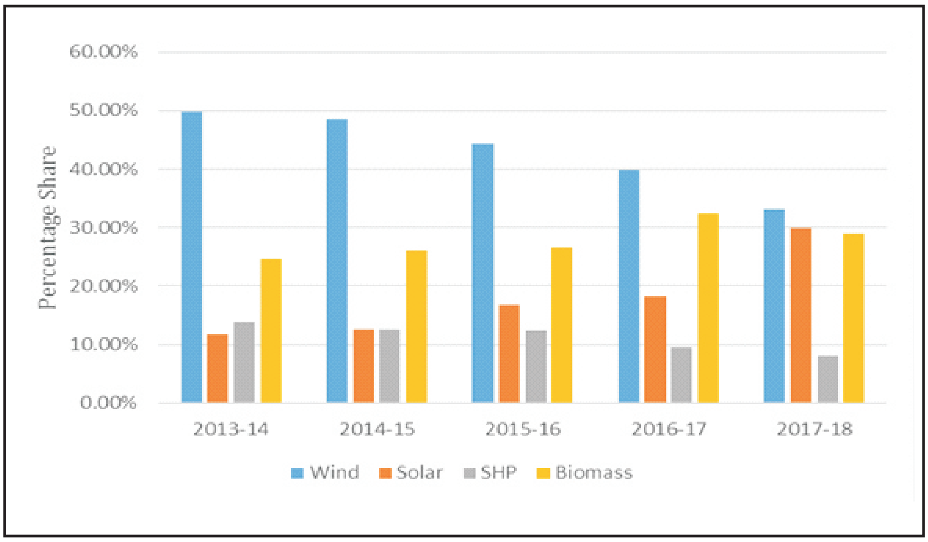
As can be seen from Table 3.3, the market value for grid-connected RE technologies has increased from ₹293 billion ($4.84 billion) on 31 March 2014 to ₹671 billion

Table 3.3: Technology-wise, Market Value as on 31st March (2013–14 to 2017–18)

Year	Technology-wise Market Size (₹Billion)				Total Value (₹Billion)	₹/USD Exchange Rate	Total Value ($ Billion)
	Wind	Solar	SHP	Biomass			
2013–14	145.99	34.48	40.51	72.09	293.06	60.50	4.84
2014–15	167.44	43.31	43.88	90.09	344.72	61.15	5.64
2015–16	188.04	71.48	52.62	112.62	424.75	65.46	6.49
2016–17	226.61	103.90	54.44	184.92	569.88	67.10	8.49
2017–18	221.81	200.31	54.49	194.69	671.30	64.45	10.42

Source: WISE Analysis, 2018, based on data compiled from CEA and CERC reports.

Figure 3.3: Percentage Share of Market Value of different Grid-Connected RE Technologies (2013–14 to 2017–18)



Source: WISE Analysis, 2018, based on the data compiled from CEA and CERC reports.

at liberty to make investments based on the market's internal return criterion. Thus, this projection will serve the purpose of providing a representative idea of the market size of grid-connected RE technologies.

- The market size has been expressed only in ₹ billion terms as the high volatility in the currency market and the worldwide obscure trade policy leaves room for a significantly high error band for predicted exchange rate in the long run.

($10.42 billion) on 31 March 2018. The dynamics of percentage share in total market size for grid-connected RE technologies is shown in Figure 3.3. Although the proportion of wind technologies in total market size is maximum over the last five years, it has declined from 49.8% in 2013–14 to 33.4% in 2017–18. Similarly, the market value share of small hydro has declined from approximately 13.8% in 2013–14 to 8% in 2017–18. A sharp increase in the market value share of solar technologies from approximately 11.7% in 2013–14 to 29.8% in 2017–18 is observed. Market value share of biomass has also increased from approximately 24.6% in 2013–14 to 29% in 2017–18.

3.1.4. Potential Value Size for Grid-Connected RE Technologies upto 2021–22

Given that India plans to achieve 175 GW RE by 2021–22, the potential RE market size upto 2022 is based on following assumptions:

- The 175 GW target has been distributed over 2018–19 to 2021–22 using the CAGR required to achieve the target from realized capacity as on 31 March 2018.[6]
- The market size has been predicted using technology-wise LCOE projections up to 2021–22. This may be contested on the ground that the tariff for wind and solar technologies will be decided through competitive bidding. However, the price discovered through competitive bidding is difficult to predict. On the other hand, the LCOE is computed considering 14% to 16% post-tax return-on-equity (RoE),[7] and temporal reduction in LCOE is mainly due to reduction in capital costs. So, if the price discovered through competitive bidding falls well below the projected LCOE, the investor will have to take a cut in RoE. Hence, the investor will be

Based on the above assumptions, the potential market value derived for grid-connected RE technologies up to 2022 is shown in Table 3.4. As can be seen, solar is predicted to have the highest potential in terms of market size at ₹540 billion, followed by wind (₹366 billion), biomass (₹274 billion) and small hydro (₹81.7 billion). Total market size for grid-connected RE technologies upto 2021–22 is expected to be ₹1262.5 billion.

Figure 3.4 depicts the market value in (percentage) of grid-connected RE in India by 2021–22. The market value of solar is expected to increase to 42.8% in 2021–22 from 29.8% in 2017–18, while the market value of small hydro is expected to drop to 6.4% in 2021–22 from a little over 8% in 2017–18. The value of wind is expected to come down to 29% in 2021–22 from 33% in 2017–18, and that of biomass is expected to reduce to 21.7% in 2021–22 from 29% in 2017–18. Clearly, solar is predicted to rule the market in the days ahead.

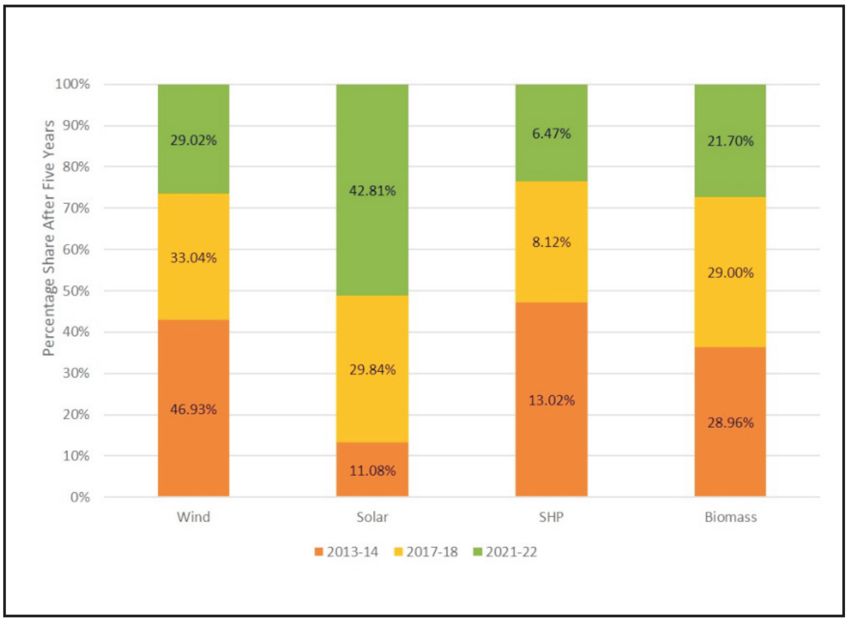
Table 3.4: Potential Market Value (cost) of Grid-Connected RE up to 2021–22

Technology	2018–2019 (in ₹)	2019–2020 (in ₹)	2020–2021 (in ₹)	2021–2022 (in ₹)
Wind	251.34	285.05	323.19	366.34
Solar	263.12	340.98	434.26	540.43
SHP	68.54	72.75	77.13	81.71
Biomass	234.46	247.08	260.25	274.01
Total	**817.46**	**945.85**	**1094.83**	**1262.50**

Source: WISE Analysis, 2018, based on data compiled from MNRE, CERC, and various state electricity regulatory commission reports

In order for the RE market to achieve its potential and meet its targets, it is essential to have a well-defined and strong energy storage deployment plan in place. Box 3.1 provides a brief of the current energy storage market and its deployment potential upto 2025.

Figure 3.4: Potential Market Value Share (Percentage) of Grid-Connected RE by 2021–22

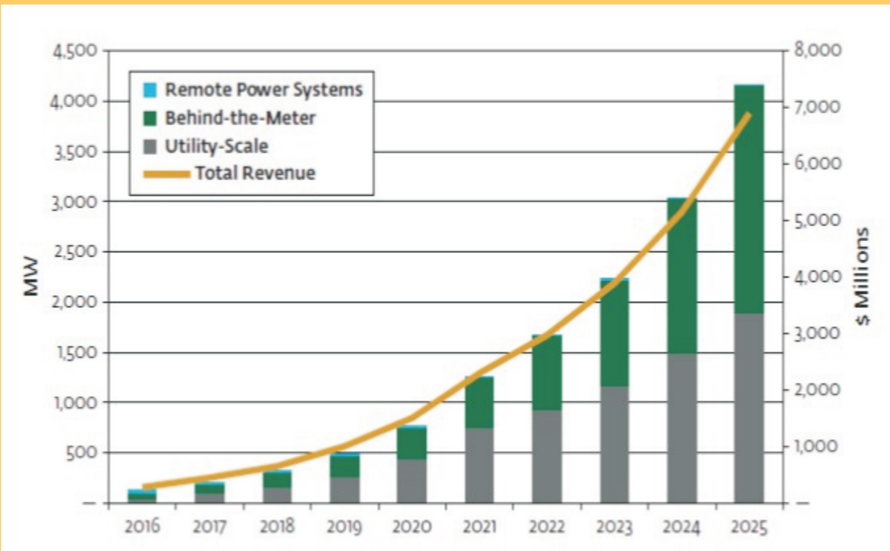


Source: WISE Analysis, 2018, based on data compiled from MNRE, CERC, and various state electricity regulatory commission reports.

Box 3.1: Energy Storage Market in India[8,9,10]

India's ambitious target of integrating electricity generated from 160 GW renewable energy installed capacity into the grid by 2022 in combination with rolling out 6 million electric vehicles by 2020 has made the advent of advanced energy storage technologies crucial. Quite obviously, the Indian energy storage market is gearing up with a number of large-scale pilot projects. Grid-scale energy storage project demonstrations in India started with the issuance of tenders by the Power Grid Corporation India Limited (PGCIL) for development of three different projects in Puducherry in 2016. These three projects based on lead acid batteries, Li-ion batteries, and flow batteries were tendered with the object of grid-balancing. By October 2017, 64 MWh of new RfPs were issued. By the end of 2017, 6 solar projects (300 MW) with energy storage capacity of 30 MW were supposed to be awarded by SECI for Karnataka and Andhra Pradesh. Central Electronics Limited (CEL) completed the tender process for 1 MW energy storage for solar power and BHEL completed expression of interest for development of few Li-ion based pilot projects in 2017. In addition, Rajasthan Electronics and Instruments Limited (REIL) and Indian Oil Corporation are also assigned to undertake pilot projects on solar integrated energy storage by MNRE, Govt. of India. Thus, the government and other stakeholders are actively participating in establishing energy storage integration projects in India. The Central Electricity Authority has already recommended large-scale energy storage demonstration projects and Central Electricity Regulatory Commission had issued a staff paper on introduction of electricity storage systems in India in 2017. With active stakeholder participation, the annual stationary energy storage deployment is expected to cross 4 GW by 2025. Figure 3.5 depicts the expected annual storage deployment in India by 2025.

Figure 3.5: Projected Annual Energy Storage Deployments, Power Capacity and Revenue by Market Segment, India: 2016–2025



Source: Energy Sector Management Assistance Programe, International Finance Corporation.

3.2 MARKET MECHANISMS AND THEIR IMPACTS

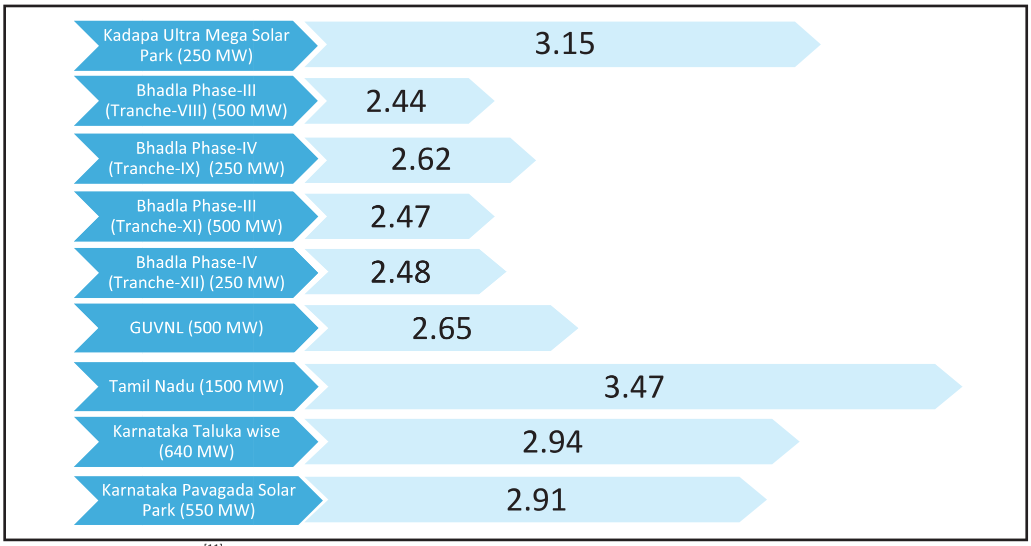
3.2.1 Tariff Discovery Through Competitive Bidding

In 2017, apart from solar energy, competitive bidding also became the norm for tariff discovery for wind power. Central government agencies [namely National Thermal Power Corporation (NTPC) and Solar Energy Corporation of India (SECI)], as well as some states, are key players in the competitive bidding process for purchase of electricity from solar and wind energy.

Where solar is concerned, a substantial reduction in tariff has been witnessed in successive biddings over the past five years. The initial tariff discovered under JNNSM Phase I, Batch I, in 2012, was around ₹11/kWh. The result of the solar bidding conducted in 2017 by NTPC, SECI, and some states, witnessed a drastic fall in tariff rates, with the 750 MW REWA, Madhya Pradesh, hitting a historic low of ₹3.30/kWh levelised tariff (as on February 2017). The tariff discovered for the REWA project is almost one-third of that discovered under JNNSM Phase I, Batch I. In February 2017, SECI conducted the first-ever bidding process for procurement of wind power from the inter-state transmission system. The tariff discovered through this exercise touched a record low of ₹3.46 per kWh. The aforementioned projects are expected to come up in Gujarat and Tamil Nadu.

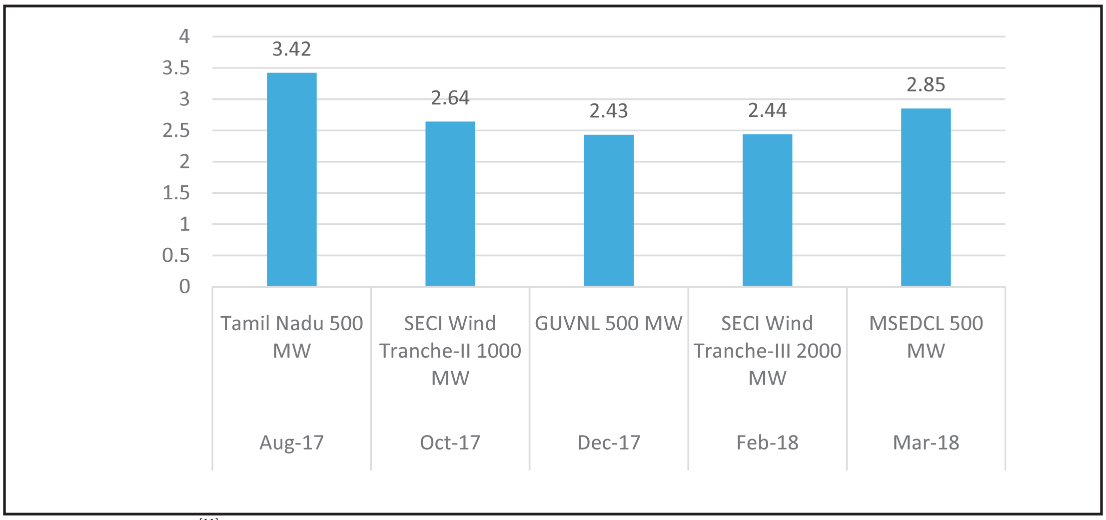
In 2017–18, solar and wind tariffs reached yet another historical low and the discovered tariffs were much below the average power procurement costs of distribution utilities in India. In case of solar, the lowest rate was ₹2.44/kWh for Bhadla Phase-III (Tranche-VIII of Batch IV), and for wind it was ₹2.43/kWh at the auction conducted by Gujarat Urja Vikas Nigam Ltd (GUVNL). ACME Solar Holding Limited claimed the lowest solar tariff and Sprng Energy Pvt Ltd., and K.P. Energy Limited quoted the lowest wind tariffs. Figures 3.6 and 3.7 show solar and wind bidding tariffs respectively, during 2017–18. [11]

Figure 3.6: Solar Bid Results (2017–18) (in ₹)



Source: CERC, 2017. [11]

Figure 3.7: Wind Bid Results (2017-18) (in ₹)



Source: CERC, 2017. [11]

At these rates, the cost of solar and wind are almost on par with thermal power generation. Besides, solar power tariff has also been declining on account of sharply falling prices of solar panels, better structuring of projects, and better deals, thereby reducing the risks for project developers and making financing available at competitive costs. Under SECI wind competitive bidding, the wind tariff reduced by almost 29% in the third tender (compared to the first tender) in a period of just one year.

In 2017–18, several states too initiated wind and solar energy purchase through the competitive bidding route. The Karnataka Electricity Regulatory Commission (KERC) published a discussion paper for procurement of wind power through competitive bidding. Earlier in the year, KERC revised and reduced the control period of the previous wind tariff order (dated 04.09.2017) and a new order was announced applicable from the date of the earlier order until 31 March 2018.[12]

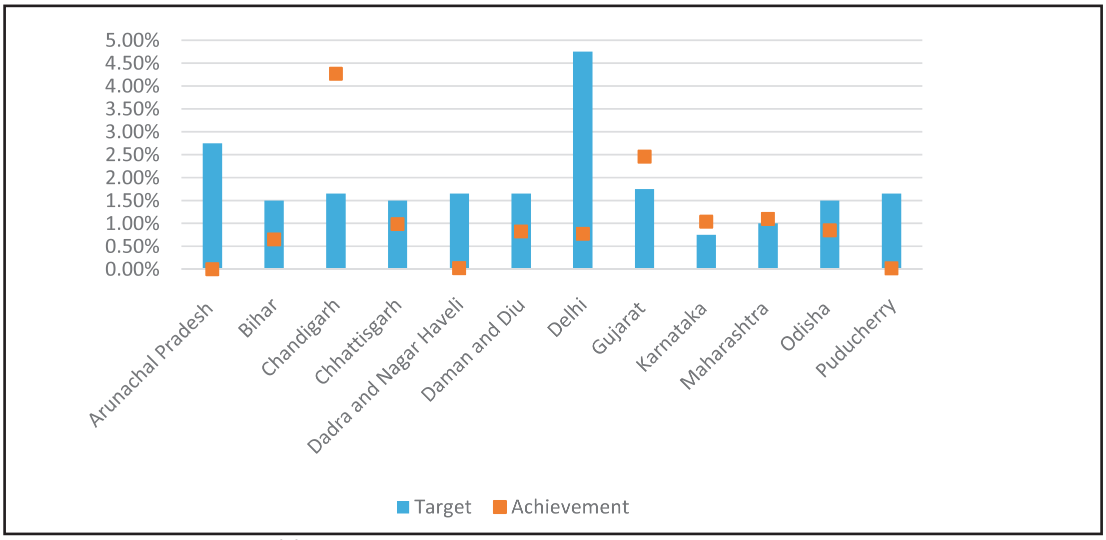
Similarly, MSEDCL approached MERC for procurement of wind, solar, and bagasse-based co-generation power at the rate discovered through tariff based competitive bidding. MERC, through its order dated 6 December 2017, approved the same. In case of procurement of power on short-term basis, distribution licensees shall refer to the Ministry of Power's (MoP) Notification dated 15 May 2012 and the amended guidelines notified by MoP on 30 March 2016, 'Guidelines for Short Term (i.e. for a period more than one day and upto one year) procurement of Power by Distribution Licensees through Tariff based Bidding Process'. In the case of procurement of power in the medium and long-term, MERC specified the following MoP's guidelines on 'Tariff Based Competitive Bidding Process for Procurement of Power from Grid-Connected Solar PV Power Projects' dated 3 August 2017. Subsequently, MERC approved the draft tender document (Rfs) and PPA with deviations for procurement of long-term bagasse based co-generation power for meeting non-solar renewable purchase obligation.[13]

3.2.2 Renewable Purchase Obligation (RPO) & Renewable Energy Certificate (REC) Mechanism

Section 86 (1)(e) of the Electricity Act, 2003, empowers SERCs to mandate purchase of a percentage of the total consumption of electricity in the area of a distribution licensee, from renewable energy sources. While the introduction of the RPO mechanism illustrated the national shift towards renewable energy, the response from states has not been encouraging due to reluctance of obligated entities to procure RE to meet their respective RPOs. Figures 3.8 and 3.9 illustrate the RPO target and achievement by different states in 2016–17 (latest available data) for solar and non-solar RPO, respectively.

The RPO compliance analysis is based on 'true-up' tariff orders published by the SERCs. Actual RE purchase data from the true-up orders has been considered, but due to non-availability of true-up orders for all the states, the overall country-wide status of RPO compliance in 2016–17 has not been determined. Further, for states where more than one utility is operating, the highest RPO compliance percentage among utilities has been presented. Thus, the state-specific compliance cannot be termed as RPO compliance by all the utilities; it is the achievement of that specific utility only. Based on this assumption, the analysis shows that Chandigarh, Gujarat, Karnataka, and Maharashtra achieved their respective solar and non-solar RPO targets in 2016–17.

Figure 3.8: State-wise Solar RPO Target and Achievement in 2016–17



Source: WISE Analysis, 2018.[14]

Figure 3.9: State-wise Non-Solar RPO Target and Achievement in 2016–17

Source: WISE Analysis, 2018.[14]

The RPO regulations have provisions for meeting targets through purchase of RE power and / or RECs available in the market. However, without purchasing RECs, the states projected various reasons for the non-compliance. Rather than imposing a penalty on defaulters, as per provisions given in the RPO regulations, the trend was to allow distribution licensees to carry the shortfall forward to subsequent years. In such a scenario, it is very rare that separate data of RPO compliance for a particular year is available in terms of meeting the 'carry forward' RPO and the yearly RPO. Therefore complete analysis of compliance becomes difficult. Along with DISCOMs, in most states, other obligated entities, namely OA consumers and captive users, have also emerged as defaulters in terms of RPO compliance. The regular compliance monitoring for obligated entities other than DISCOMs, are rare and so compliance level of the obligated entities is difficult to judge.

The solar and non-solar targets vis-à-vis national targets for 2017–18 are given in Figure 3.10. In line with the current amendments to the National Tariff Policy, 2016, MNRE had emphasized the need for SERCs to notify their revised RPO trajectory in accordance with national targets, which includes 17% of renewable electricity in the total electricity mix by 2022 with at least 8% derived from solar energy. However, state targets are not on par with the central target. If these targets can be increased, then obligated entities can meet the same through RECs wherever RE electricity is not available. Thus, the REC market can get some momentum which is not there at present. This is discussed in the subsequent part of this report. Pursuant to the revised tariff policy, the Ministry of Power, on 22 July 2016, notified the long-term growth trajectory of RPO for solar and non-solar energy for the next three years, i.e. 2016–17, 2017–18 and 2018–19. Figure 3.11 shows the national level RPO trajectory for 2016–17 to 2018–19.

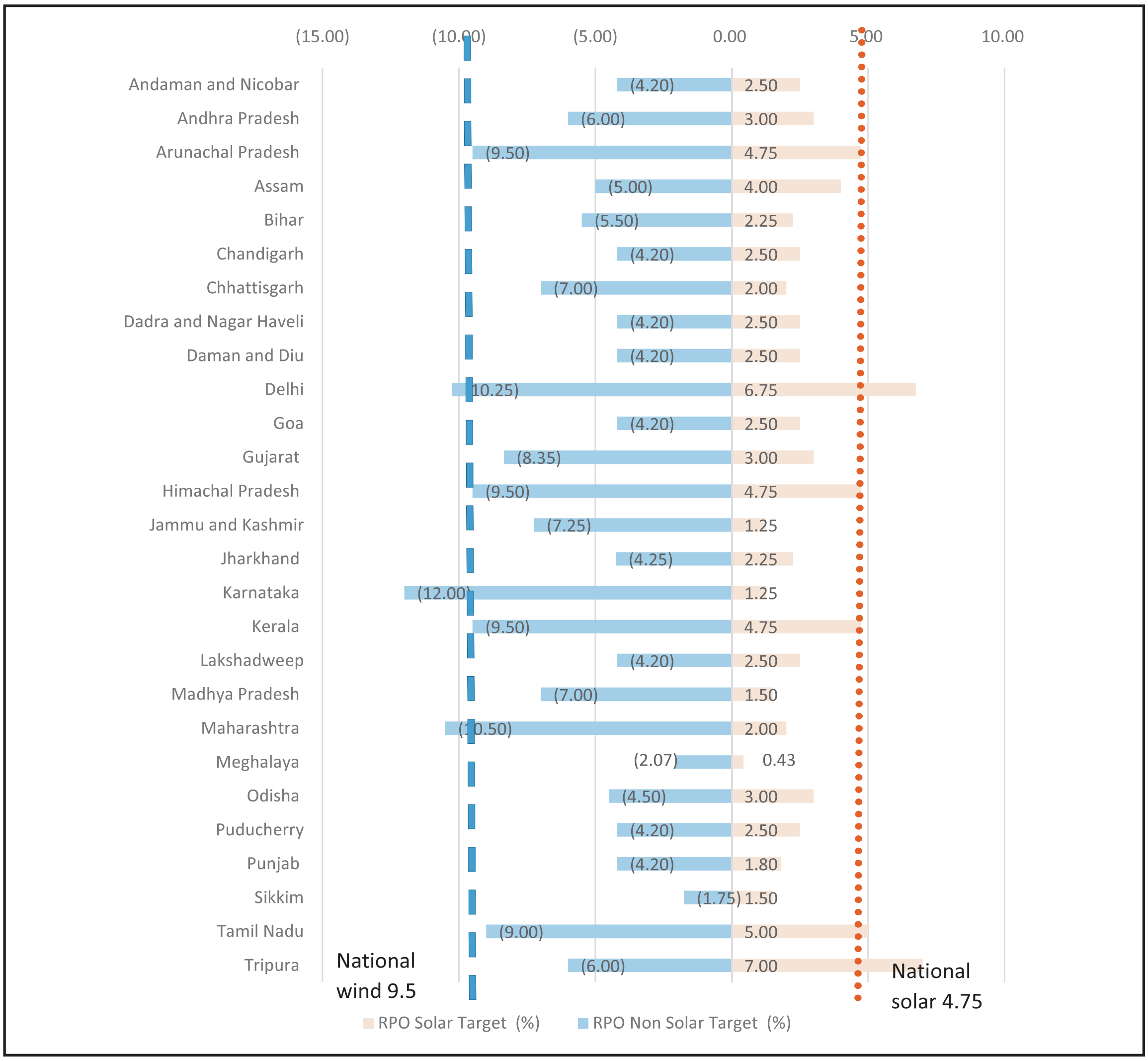
If we analyse the status for 2017–18, only six states viz. Maharashtra, Kerala, Karnataka, Himachal Pradesh, Delhi, and Arunachal Pradesh have met their national solar RPO target and six states—Tripura, Tamil Nadu, Kerala, Himachal Pradesh, Delhi and Arunachal Pradesh—have met the national non-solar target. Thus it can be seen that most states have not aligned their RPO compliance with the national RPO targets.

3.2.3 REC Mechanism

CERC introduced the Renewable Energy Certificate (REC) mechanism in 2010 basically to address the mismatch between availability of RE potential across the states and requirement for meeting the Renewable Purchase Obligation. As on 31 March 2018, the total accredited project capacity under RECs was 5,396 MW and registered project capacity was 4,274 MW, considering all RE technologies (Figure 3.12). The accredited figure is just 7.8% of total RE installed capacity in India.

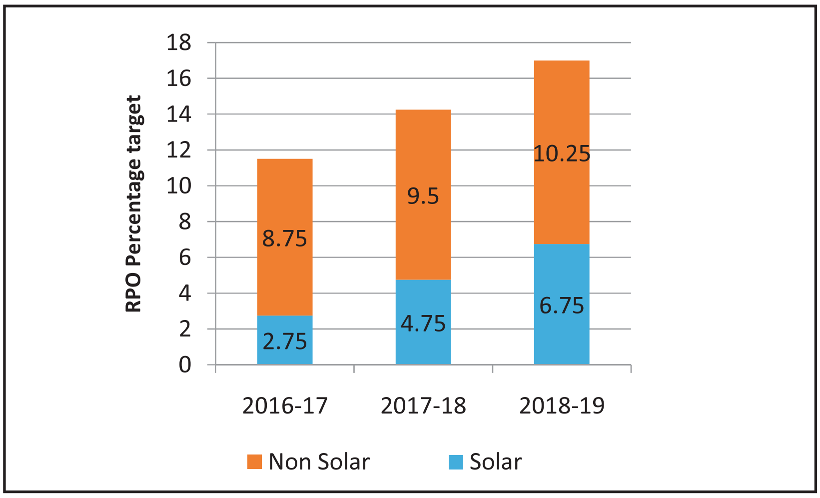
REC pricing: Under the provisions of the Electricity Act, 2003, CERC determines the floor price and forbearance price separately, for solar and non-solar RECs, from time to time. Initially, the REC prices were determined up to March 2012 through an order dated 1 June 2010. The Commission in its *suo moto* order of 2011 determined the floor price and forbearance price for the control period April 2012 to March 2017, but later in December 2014, revised the solar REC price for the remaining control period. The Commission further reviewed the market condition and considered the

Figure 3.10: State-wise RPO Targets vis-à-vis National Targets for 2017–18



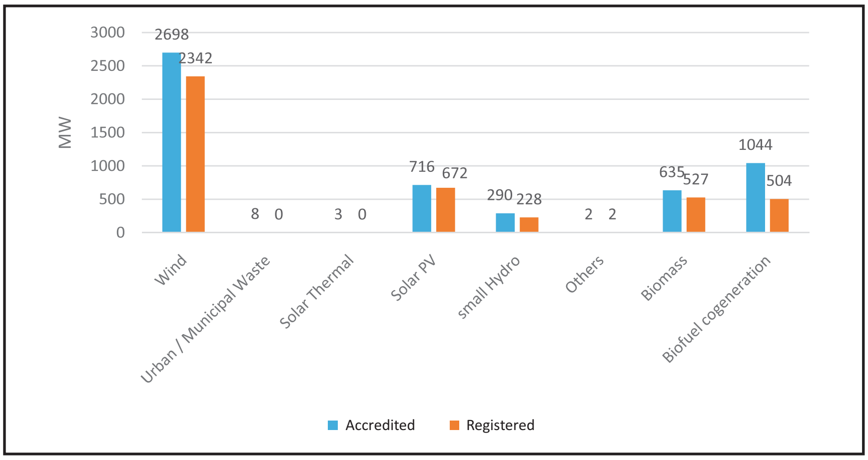
Source: WISE Analysis, 2018.[15,16]

Figure 3.11: National RPO Trajectory (2016–17 to 2018–19)



Source: WISE Analysis, 2018.[16]

Figure 3.12: Technology-wise Accredited and Registered Projects under RECs (as on 31 March 2018)



Source: WISE Analysis, 2018.[17]

price discovery through competitive bidding, and based on these determined the REC prices applicable from 1 April 2017. Table 3.5 shows the REC prices from 1 April 2017, as determined by CERC vide order dated 30 March 2017. The floor and forbearance prices reduced significantly as the market discovered prices reduced for RE technologies.

Cases were thus filed before the Supreme Court of India opposing the CERC Order. Vide its order dated 8 May 2017, the Supreme Court stayed the CERC Order and REC trading was suspended. Later, trading in non-solar RECs was resumed vide the Supreme Court's order dated 14 July 2017. However, as per the said order, the difference between the earlier floor price and the floor price determined by CERC through order dated 30 March 2017, has to be deposited to CERC.[18] The non-solar REC prices discovered during 2017–18 was ₹1500/MWh.

REC Liquidity: Since the REC mechanism is driven mainly by the needs of obligated entities to meet their RPO, its success depends crucially on whether SERCs enforce the compliance mechanism for RPO or not. Many SERCs have not initiated any action on obligated entities for non-compliance, and this has lowered the demand for RECs. Even CERC pointed out the non-compliance by states in its order on determination of REC price.[19] Over 7.5 million RECs are available in the market as on 31 March 2018 and RECs are being traded at the floor price, which is the minimum stipulated for trading.

Table 3.5: REC Price for 2017–18 onwards

	Non-Solar REC (₹/Mwh)	Solar REC (₹/Mwh)
Forbearance Price	3000	2400
Floor Price	1000	1000

Source: CERC, 2017.[18]

Due to the lack of interest shown by the obligated entities, particularly open access consumers and captive users, towards compliance of RPO, REC inventory is increasing. The total REC trading and inventory till 31 March 2018, is ₹7.49 million (₹1.49 million non-solar and ₹6 million solar RECs) (Figure 3.13). Figure 3.14 gives the technology-wise REC liquidity figures including cumulative figure of RECs issued and traded, as on 31 March 2018.

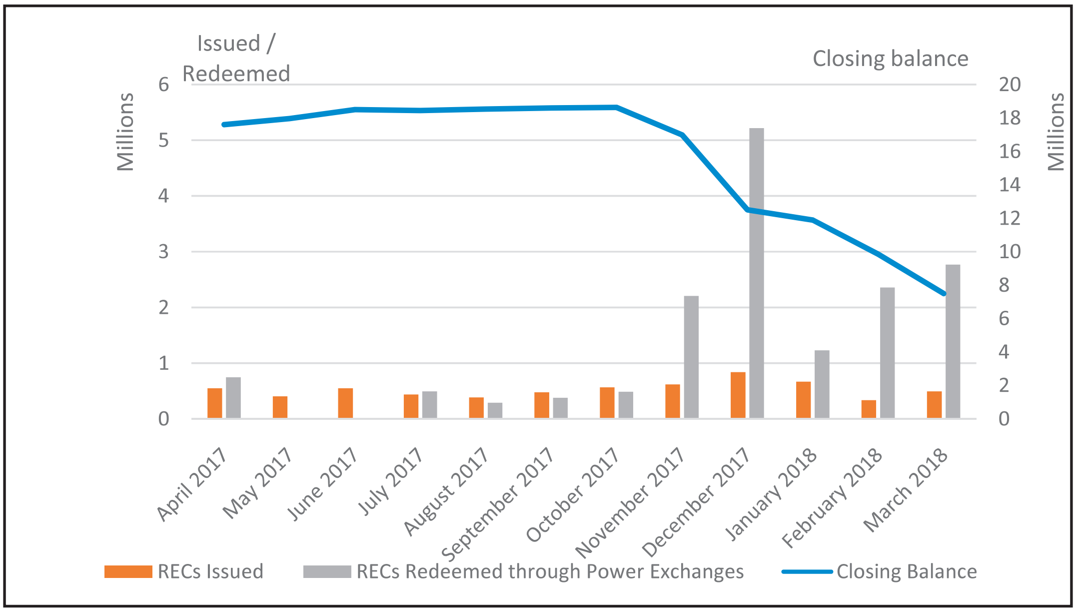
Solar REC trading was conducted only in April 2017, while non-solar REC trading was not conducted during May and June 2017. In 2017–18, 15.98 million non-solar RECs were traded on the exchanges. For non-solar REC trading, the IEX share was 57.8% and PXIL share was 42.2%. The details of monthly non-solar REC trading are given in Figure 3.15.

Other issues: According to the third amendment in the REC regulations, "vintage multiplier shall be provided to solar generating companies registered under REC framework prior to 1 January 2015 and shall be applicable for the period 1 January 2015 to 31 March 2017". As per CERC's order dated 30 March 2017, discontinuation of vintage multiplier with effect from 1 April 2017 was statutorily provided and hence no such multiplier would exist. Also, considering the concerns of RE developers, CERC extended the validity of RECs and directed that those expiring between 31 March 2017 and 30 September 2017 would remain valid up to 31 March 2018.[19]

3.2.4 Open Access Mechanism

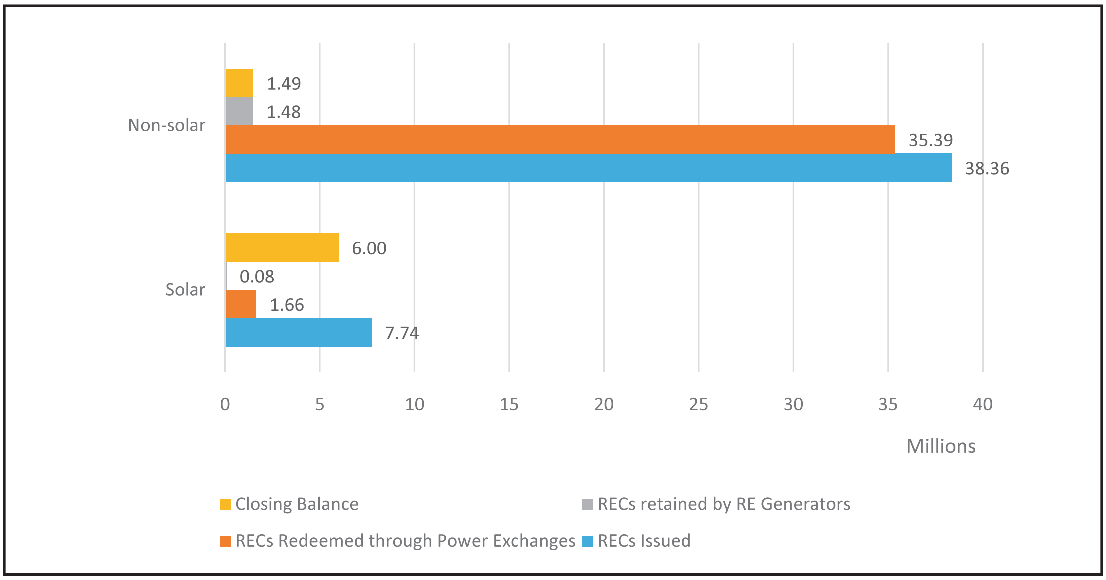
Open Access (OA) is primarily encouraged by industrial and commercial consumers due to the rate differential, viz. procurement from RE under OA and procurement from DISCOMs. Captive users are also guided by cost economics and requirement for meeting RPO.

Figure 3.13: REC Trading (solar and non-solar) and Inventory (2017–18)



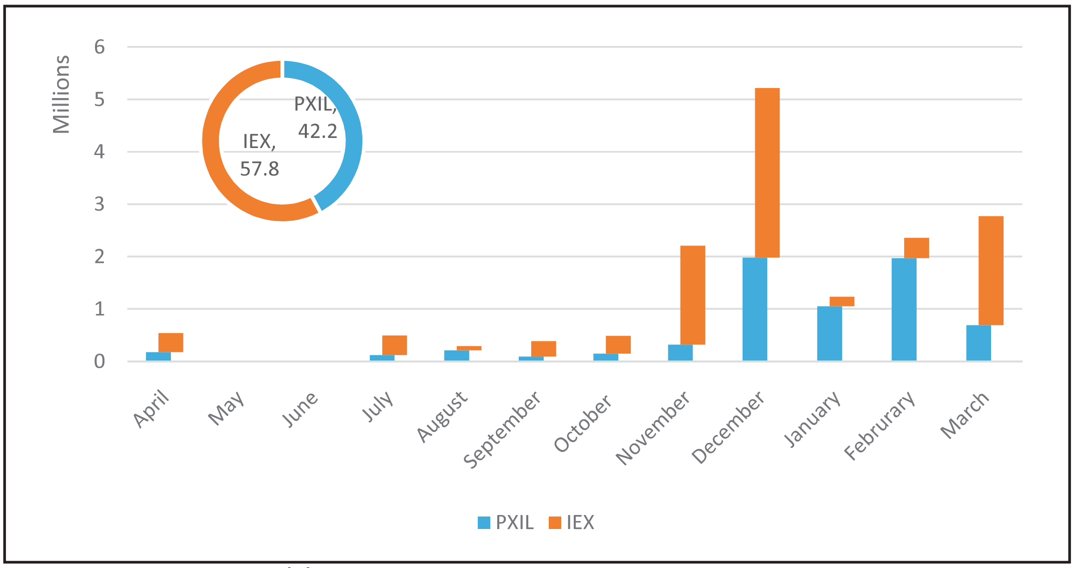
Source: WISE Analysis, 2018. [17]

Figure 3.14: Technology-wise REC Liquidity (upto March 2018)



Source: WISE Analysis, 2018 [17]

Figure 3.15: Non-Solar REC Trading during 2017–18



Source: WISE Analysis, 2018. [17]

Some states have notified their own open access regulations. The charges applicable decide the attractiveness for third party sale and captive consumption. In the initial phase, the applicable charges for renewable-energy-based open access were lower than conventional-based transactions. However, over the years, these charges increased. But in recent times, due to reduction in the cost of renewable-energy-based generation, RE-based open access is on par with conventional open access. The recent discussion paper of the Karnataka Electricity Regulatory Commission corroborates this fact[20]. The summary of open access charges is given in Box 3.2. Another unique regulation brought out in 2017–18 was on power evacuation by APERC. A summary is provided in Box 3.3. In 2017–18, SERCs of Bihar and Assam published the Draft Open Access Regulations, as did the Joint Electricity Commission (JERC) of Goa and UTs[21]. A summary of the JERC regulations is given below.

- The application fee for connectivity and open access transaction for RE projects is 50% of the applicable fee.
- There is no relaxation in charges and losses for RE open access transaction.
- The cross subsidy surcharge, in case of RE transaction, shall be applicable as per relevant orders of the Commission.

3.2.5 Re-designing Markets

In order to keep pace with the rapidly developing RE market in India, it is imperative to re-design market models and structures and introduce new models of growth. 2017–18 witnessed the proposal by CERC to introduce 'real-time' electricity markets and the shift to a competive bidding business model. A summary of 'Real-time Electricity Markets' is given in Box 3.4. The different RE business models in play are captured in Box 3.5.

Box 3.2: Open Access Charges as determined by KERC

- The earlier wheeling charges were 5% of injected energy for wind, mini-hydel, biomass and bagasse based co-generation. The banking charges were 2% of injected energy for wind and mini-hydel.
- The payment by distribution utilities was 85% of the generic tariff for the banked energy unutilized at the end of the wind year, water year or financial year, as the case may be.
- However, for solar projects, all the charges, including cross subsidy surcharge (CSS), were exempted.
- Normal wheeling, banking and other charges were applicable to REC based projects.
- The above wheeling and banking charges were specified in the orders passed during 2014 and were applicable to projects commissioned up to 31 March 2018.
- Against the above background, KERC decided to review the charges due to cost competitiveness of RE projects with conventional projects, surplus electricity scenario, favorable conditions for RE investment, and because most RE rich states were moving from concessional charges to normal wheeling and banking charges.
- The proposed charges are 25% of normal transmission charges and/or wheeling charges payable in cash, and banking charges at 2% of injected energy. These charges are applicable to all non-REC projects, existing and new.

Source: KERC, 2018.[20]

Box 3.3: APERC Regulation on Power Evacuation from Captive Generation, Co-generation and Renewable Energy Source Power Plants

This is a unique regulation which provides norms for evacuation of RE projects. Independent projects shall be connected to the nearest grid substation of APTRANSCO /DISCOM, as the case may be; and projects developed in cluster shall be connected to the nearest grid substation through polling bus / substation. Power evacuation at 11 kV level to the existing 33/11 kV substation shall be limited to 3 MW only, and power evacuation at 33 kV level to the existing 33/11 kV substation shall be limited to 10 MW only. Power evacuation up to 40 MW is possible through 33 kV level of EHT substation. For small hydro, biomass and MSW-to-energy projects, metering shall be provided at the outgoing feeder of the power project. For others, metering shall be provided at the outgoing feeder of pooling bus or at incoming feeder of the grid substation if pooling bus is absent. In any case, metering at project's switchyard shall be available. The cost up to grid substation has to be borne by the project developer. For small hydro projects, up to 2 km of evacuation line, the responsibility is that of the developer. After completion, the infrastructure from common metering point of polling station to grid substation shall be transferred to transmission or distribution utilities, who will undertake the necessary O&M.[22]

Source: APERC, 2017.[22]

Box 3.4: Redesigning Real Time Electricity Market in India

Large-scale penetration of RE into the grid is a challenge as it creates energy imbalance and adversely affects systems operations and planning processes. On the demand side too, power systems are undergoing important changes. The market models and structures are largely required to coordinate the supply and demand sides of the system and to keep pace with the same. In this scenario, effective management of real time energy imbalance is critical. At present, real time energy imbalance is managed in India by means of :

(i) Deviation Settlement Mechanism (DSM) and Ancillary Services (AS) Mechanism
(ii) Intra-day bilateral contingency transactions
(iii) Intra-day market segment of the power exchanges
(iv) Re-scheduling/ revision of schedule four blocks ahead (right to recall)

The DISCOMs and the generators tend to use DSM, whereas POSOCO uses the AS mechanism, for managing imbalances in grid frequency. On the other hand, exchanges operate according to intra-day trading market (based on continuous trade) to address the need for meeting energy requirements closer to real time. Re-scheduling / revision of schedule or the right to recall provides flexibility to the generators to adjust their output and the DISCOMs to meet their contingent demand closer to real time.

Nonetheless, the challenges caused due to the substantial growth in RE generation prompts changes in the electricity market design. Keeping this in mind, CERC proposed changes through a discussion paper on 'Re-designing Real Time Electricity Market in India'. The most important proposed change is the conduct of real time market trading, once every hour instead of continuous trading from 00:30 hrs to 20:00 hrs, on a daily basis. The new proposal suggests delivery of electricity in four, fifteen minute blocks, each hour, instead of three hours' time gap between trade commencement and delivery of power. However, for day-ahead schedules, the supplier will receive revenues as per the schedule, irrespective of real time trading of power. It also proposes that POSOCO declare (in advance) the transmission corridor margin available for real-time transaction.

Source: Energy storage trends and opportunities in emerging markets; ESMAP, IFC.

Box 3.5: Renewable Energy Business Models in India

Grid-connected Renewable Energy: Shift to Competitive Bidding based Models

Until two years ago, feed-in-tariff-based business models dominated renewable energy development.[23] Under feed-in tariff model, the DISCOMs are mandated by the respective electricity regulatory commissions to purchase electricity at preferential tariff from RE projects developers. In the recent past, a shift from feed-in tariffs to competitive bidding based tariff discovery has taken place.

There are two other business models which are adopted for grid-connected renewable energy projects, viz., APPC/REC and third party open access sale.[24] In APPC/REC mode, the developers sell power to the DISCOMs at average power procurement cost and trade the RECs equivalent to the electricity sold in the market. In third party sale mode, the developers enter into agreements to sell power to an entity other than the DISCOMs at Commission determined tariff or mutually determined tariff.

Decentralized Renewable Energy: Increasing Involvement of DISCOMs

- Mini/Microgrid Projects: These projects are developed under build, own, operate and transfer (BOOT) model or build, own, operate and maintain (BOOM) model. Once the central grid extends to the area of the mini/micro grid project, the project owner may decide either to continue its operation in parallel to the grid or may merge its operations with that of the grid.[25]
- Grid-connected Rooftop Solar Projects: These projects are developed in two modes – CAPEX mode and OPEX mode. It is observed that the current business models for solar rooftop involves high up-front cost which is compounded by unavailability of easy credit.[26] Active participation of the DISCOMs is envisaged to be pivotal in removing these obstacles. DISCOMs are expected to eliminate upfront capital investment required from the consumers, act as payment guarantor to the lenders, and demand and supply aggregator for rooftop solar.

Source: Complied from various market reports and state policy documents.

3.3 INDUSTRY

3.3.1 SOLAR MANUFACTURING

With the solar target set at 100 GW by 2022, the Government of India has decided to put its thrust on the local manufacture of solar panels. Currently, India has around twenty solar cell manufacturers having planned / installed manufacturing capacity of 3.1 GW, and around 117 solar module manufacturers with 8.3 GW capacity. Total installed capacity of cell and module manufacturing in India is provided in Annexures I and II, respectively (pgs. 62 to 65).

Indian solar cell cumulative manufacturing capacity has increased from 1,468 MW (16 manufacturers) in 2016–17 to 3,164 MW (20 manufacturers) in 2017–18, which is a 115% growth year-on-year. Similarly, the Indian solar module manufacturing cumulative capacity has increased from 4,307 MW (94 manufacturers) in 2016–17 to 8,398 MW (117 manufacturers) in 2017–18, a 94% year-on-year increase. Despite removal of domestic content requirement of solar modules in most of the large scale bids, the consistent growth in the manufacturing capacity of solar cells and modules in India was mainly achieved due to the conducive national policies and targets set by the Government of India.

However, in spite of the cumulative installed solar module manufacturing capacity of 8,398 MW, the actual production in 2017–18 was around 842 MW, which is close to 8.6%. Further, out of the total production of 842 MW, around 785 MW of solar modules were in domestic sales while the remaining 57 MW was exported. Drastic reduction in the price of Chinese solar modules created major challenges (in terms of cost competitiveness) to Indian solar module manufacturers, (Sec Box 3.6 regarding Safeguard Duty on Imported Solar Panels) and 25 year generation warranty along with the latest manufacturing technologies posed additional challenges to Indian manufacturers. Though the country's solar manufacturing capacity has improved significantly, around 92% of the installed capacity/domestic demand was catered through imported panels. The solar modules produced in India, their consumption in the domestic market and export vis-à-vis total domestic demand and capacity of imported panels is shown in Figure 3.16.

3.3.2 Wind Manufacturing

In 2017–18, the procurement of wind power through competitive bidding commenced. This resulted in a major industrial shift from small scale investors to large scale IPPs (with average project size ranging from 150 to 250 MW), thus increasing demand for higher capacity wind turbines, leaving no space for sub MW capacity wind turbines. Currently, there are around twenty-one wind turbine manufacturers in India (registered with MNRE/NIWE), offering more than fifty wind turbine models.[27] The list of wind turbine manufacturers and models (along with hub height and rotor diameter) as on January 2018 is provided in Annexure III (pgs. 65 and 66). The total manufacturing capacity and product portfolio of Indian wind manufacturers for 2017–18 is given in Table 3.6.

Change in policy mechanism from FIT+GBI to competitive bidding resulted in a dip in installation of wind turbines from 5,525 MW in 2016–17 to only 1,776 MW in 2017–18. This addition was made by five major

Box 3.6: Safeguard Duty on Imported Solar Panels

Over 90% of total solar panels have been imported into India from 2014–15 to 2017–18. This huge import of solar panels has made the market for domestic manufacturers highly competitive, thereby reducing sales of solar panels manufactured in the country. As a remedial measure, the Indian Solar Manufacturers' Association (ISMA) has sought the help of the Directorate General of Trade Remedies (DGTR) to impose a safeguard duty (SGD) on import of solar cells and modules. However, due to successive deferment of dates of hearing, the issue was not settled before the end of financial year 2017-18.

Although it would not be wise to immediately quantify the impacts of SGD on solar manufacturing in India, the solar industry may witness sluggish growth due to its imposition. Domestic manufacturing capacity in India is not sufficient to meet the domestic demand. In addition, the SGD is likely to inflate the price of solar energy as the entire demand for solar panels may not be fulfilled by domestic manufacturers. This may become detrimental to the rapid growth of solar energy in India.

Moreover, the domestic solar manufacturing industry may lose its intent to become competitive and at par with foreign manufacturers. This, in effect, may lead to loss of manufacturing efficiency which may further lead to the country becoming more dependent on imports of solar cells and modules.

Source: Compiled from various reports published by MERCOM 2017–18.

Table 3.6: Indian Wind Manufacturers Product Portfolio and Manufacturing Capacity for 2017–18

Sr. No.	Manufacturer	Wind Turbine product portfolio (rating in kW)	Manufacturing Capacity Per annum (in MW)
1	Acciona Wind Power India Pvt. Ltd	3000	NA
2	Gamesa Renewable Pvt. Ltd	850/2000	1500
3	Garuda VaayuShakthi Ltd	700	NA
4	GE India Industrial Pvt. Ltd	1600/1700/2330/2430	450
5	Global Wind Power Ltd	1500	600
6	Inox Wind Ltd	2000	800
7	Kenersys India Pvt. Ltd	2000/2400/2625	400
8	Lietwind Shriram Manufacturing Ltd	1500/1800/1500/3000	250
9	NuPower Technologies Pvt. Ltd	2050	NA
10	Para Enterprise Pvt. Ltd	750	NA
11	PASL Wind Solution Pvt. Ltd	1500/150	200
12	Power Wind Ltd	900	NA
13	ReGen Powertech Pvt. Ltd	1500/2800	750
14	RRB Energy Ltd	500/600/1800	300
15	Suzlon Energy Ltd	2100	3700
16	Vestas Wind Technology India Pvt. Ltd	1800/2000/2100/2200	1000
17	Wind World India Ltd.	800	960
18	Winwind Power Energy Pvt. Ltd	1000	1000
19	Shriram EPC Pvt. Ltd	250	NA
20	Shiva Windturbine India Pvt. Ltd	250	15
21	Southern Wind Farms Ltd	225	NA
		Total	**~12,000MW**

Source: Compiled from market reports/company websites.

Table 3.7: Top Five Wind Manufacturers of 2017–18 (annual capacity) and their Percentage Share

Sr. No.	OEM	Annual Capacity (in MW)	Percentage Share
1	Suzlon Energy Ltd	626.30	35.27
2	Gamesa Renewable Pvt. Ltd	552.20	31.10
3	Vestas Wind Technology India Pvt Ltd	181.60	10.23
4	Inox Wind Ltd	174	9.80
5	GE India Industrial Pvt. Ltd	96.90	5.46
	Others	**144.75**	**8.14**
	Total	**1775.75**	**100**

Source: Compiled from market reports/company websites.

wind turbine manufacturers. Details along with the total percentage share of wind are given in Table 3.7.

3.3.3 Export-Import in the Solar and Wind Sectors

Solar Sector

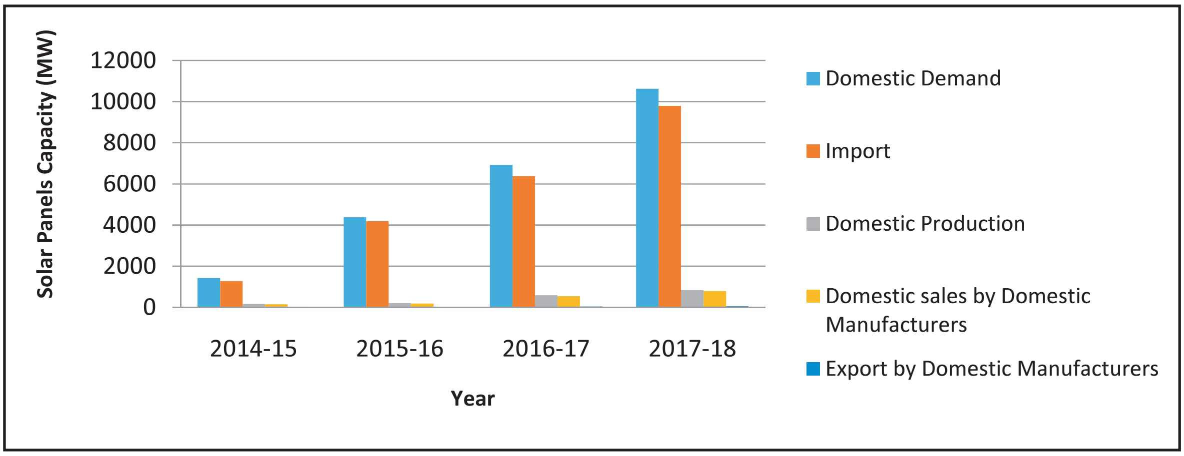
The values of PV imports and exports are shown in Figures 3.17 and 3.18, respectively. Solar PV imports to India have been increasing and peaked at $4,540 million in 2017 owing to strong domestic demand. This indicated a 43% increase in 2017 (mainly from China), vis-a-vis 2016.

Similarly, the export of solar modules from India also increased from $126.74 million in 2016 to $138.44 million in 2017.

Wind Sector

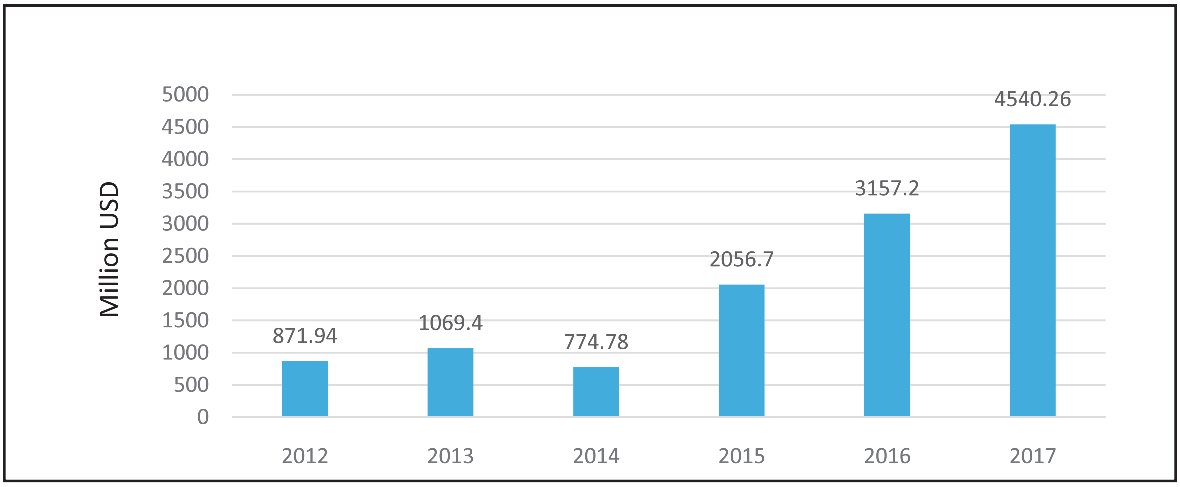
Indian wind manufacturing has matured and therefore, no major changes or addition of manufacturers was witnessed in 2017. After starting the procurement of

Figure 3.16: Sources vs. Capacity of Solar Module Deployment in the Domestic Market (in MW)



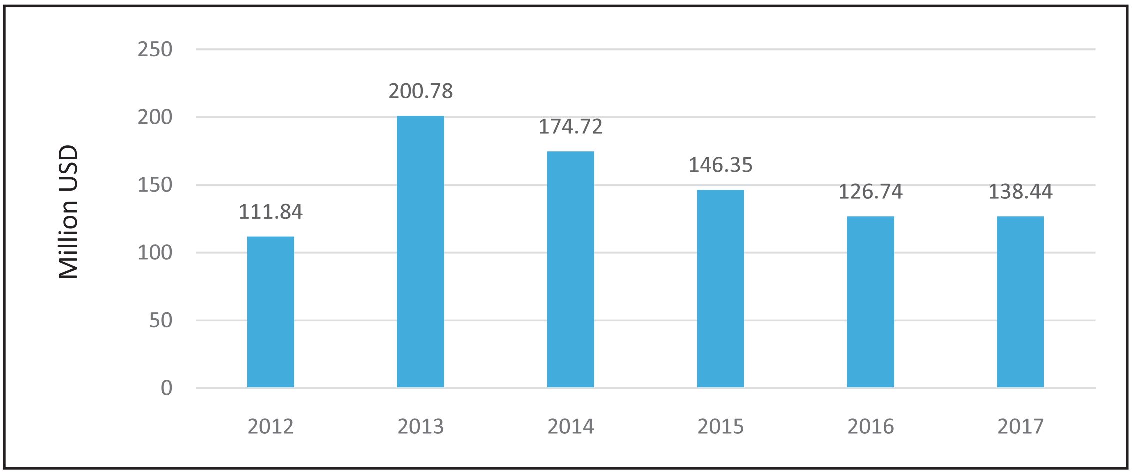
Source: Derived from UN comtrade database.

Figure 3.17: Solar PV Imports (in Million USD)



Source: Derived from UN comtrade database.

Figure 3.18: Solar PV Exports (in Million USD)

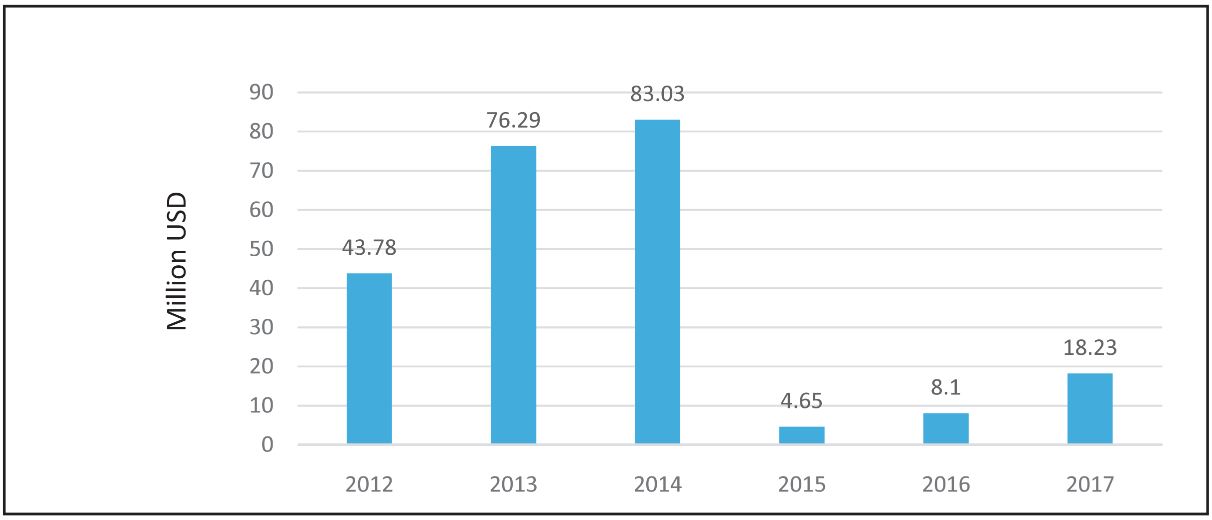


Source: Derived from UN comtrade database.

wind power through competitive bidding, the trend of wind turbine installations in the Indian market shifted to MW scale wind turbines, especially 2 MW and above. This year, the export of wind electric generators increased from $8.10 million in 2016 to $18.23 million, as shown in Figure 3.19.

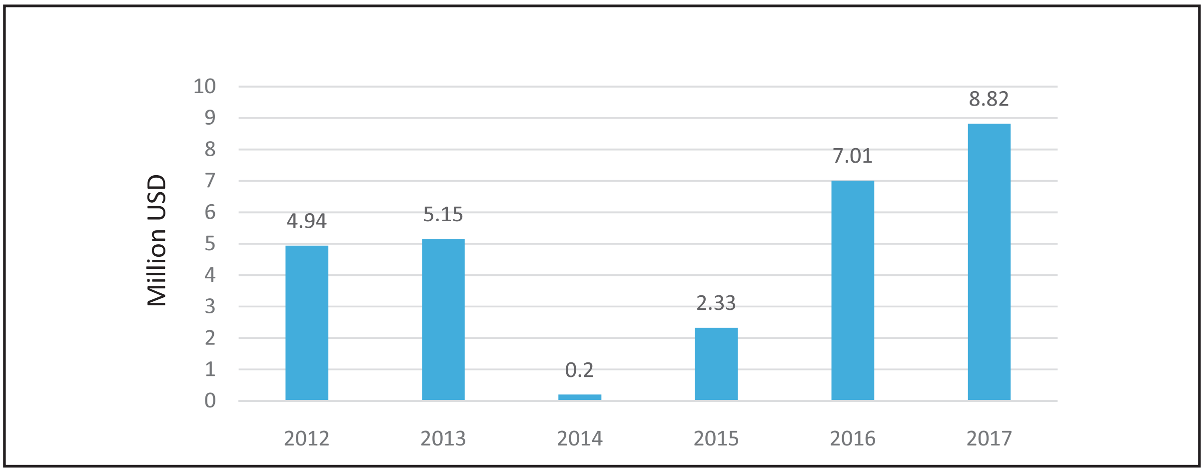
Some critical components of wind turbines are still imported by Indian manufacturers. The import of wind turbine generators also increased from $7 million in 2016 to $8.82 million in 2017, as shown in Figure 3.20.

Figure 3.19: Wind Electric Generator Exports (in Million USD)



Source: Derived from UN comtrade database.

Figure 3.20: Wind Electric Generator Imports (in Million USD)



Source: Derived from UN comtrade database.

***

HIGHLIGHTS OF 2017–18

- Investments in RE have grown at a CAGR of 20% from 2008 to 2017. The wind and solar sectors showed an increase in investments in 2017 vis-a-vis 2016, while biomass and waste-to-energy remained the same, and small hydro projects declined.

- Investments in thermal projects went down in the period 2015 to 2017, while RE project investments grew two-fold in the same period.

- ₹123.92 billion ($1.91 billion) came through the external commercial borrowing channel.

- Debt investments in the form of major non-convertible debentures were worth ₹27,200 million, and convertible debentures were ₹13,964.5 million. Equity investments included private equity of ₹7,800 million and venture capital of ₹282.8 million.

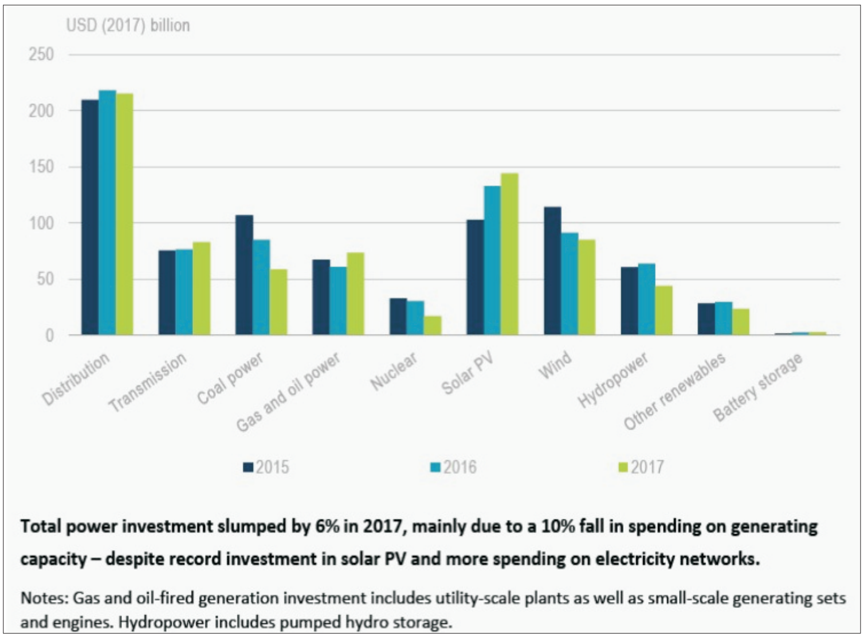
- Green bonds issued were to the tune of ₹244,740 million.

- As on 31 December 2017, ₹67,660 million worth of projects were awarded under the Green Corridor Project and approx. ₹14000 million was disbursed to the states by the Government of India.

4.1 CURRENT STATUS

Global investment in the power sector declined during 2017 mainly due to fall in expenditure of generating capacity. However, investments in solar PV technology along with the electricity network (transmission and distribution) continued to increase even in 2017.[1] Figure 4.1 throws light on technology-wise investments in the power sector, globally. Investments in RE, in India, grew at a CAGR of 20% from 2008 to 2017. The flow of investments during this period[2] is shown in Figure 4.2. Investments in 2017 vis-a-vis 2016 showed an increase in the wind and solar sectors, while biomass and waste-to-energy remained the same, and small hydro projects declined. Table 4.1 shows the technology-wise investments in RE in 2017 vis-à-vis 2016. [1&2]

Figure 4.1 Global Technology-wise Investments in the Power Sector



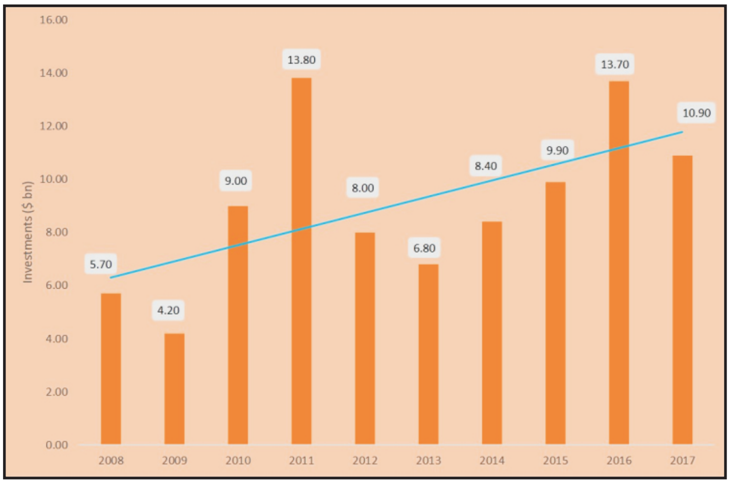
Source: World Energy Investment, IEA, 2018.

Table 4.1: Technology-wise Investment Pattern in 2017 vis-à-vis 2016

Technology	2016 In ₹ billion	2017 In ₹ billion
Solar	5.5	6.7
Wind	3.8	4.0
Small hydro	0.3	0.1
Biomass and Waste-to-Energy (WtE)	0.1	0.1

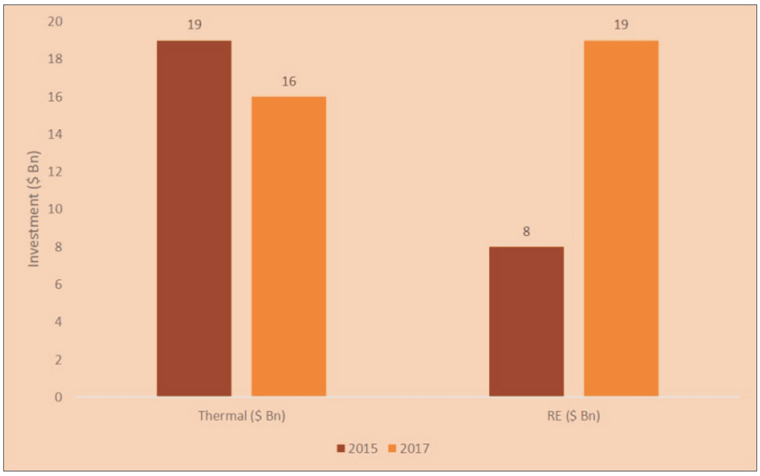
Source: FS, UNEP, 2017, 2018.

Figure 4.2: Investment Trend in Renewable Energy in India (2008 to 2017)



Source: Global Trends in RE Investment, FS-UNEP Collaborating Centre, 2018; WISE, 2018.

Figure 4.3: Investment Pattern for Conventional Fuel Based and Renewable Energy Based Generation (2015–2017)



Source: World Energy Investment; IEA; WISE, 2018.

Interestingly, investments in renewable energy exceeded that of conventional energy for the first time in 2017.[2] Figure 4.3 shows a comparison of investments in conventional fuel-based and renewable-energy-based electricity generation from 2015 to 2017. It is evident that investments in thermal projects have gone down over this two year period[1] whereas investments in RE projects have increased two-fold during the same tenure. The reason for reduction in thermal power investments can be attributed to fewer new coal-fired power projects being established. Besides, retirement of existing coal-fired power plants weighs heavily against new coal plant additions.[1]

4.2 MAJOR RE FINANCING INSTRUMENTS

RE financing in 2017–18 came through debt and equity funding. Many debt instruments were used for financing RE projects. Most prominent among these were bonds. Apart from these, senior notes*, non-convertible debentures and flexi line of credit were also used to extend debts to RE projects. On the equity front, venture capitalists invested in new projects while private equity holders invested in relatively older projects. Although there was some acquisition activity in 2017–18, the number of acquisition deals declined significantly compared to the previous year. [2]

4.2.1 Debt Instruments

Around 65% to 75% of RE project costs are financed through debt. Prominent sources of debt financing are commercial banks, non-banking finance corporations, companies and multilateral development banks. Table 4.2 presents major institutions contributing to debt financing of RE in India. All debt instruments have been received either from Indian origin firms or international firms. In 2017–2018, ₹123.92 billion ($1.91 billion)[3] came through the external commercial borrowing channel. Major loans to the RE sector in 2017–2018 are depicted in Table 4.3.

One of the major debt instruments used for financing RE projects during 2017–18 was debentures. The debentures were mainly of two types – convertible and

Table 4.2: Institutions Contributing to Debt Financing of Renewable Energy

Banks	NBFCs	Companies	Multilateral Development Agencies
• State Bank of India • Punjab National Bank • Central Bank of India • Yes Bank • Axis Bank Ltd. • Exim Bank	• Indian Renewable Energy Agency • Power Finance Corporation • Rural Electrification Corporation • L&T Infrastructure Finance • Tata Capital	• RE Project Developers through the issuance of bonds or equivalent • Other companies through the issuance of bonds on behalf of some project developer	• Asian Development Bank • World Bank Group • European Investment Bank • Kfw • United Nations Development Program

Source: Compilation from various financial reports, 2018.

* A debt instrument which entitles the right to be repaid before other categories of debt holders.

Table 4.3: Major Loans from Financial Institutions to the RE Sector in 2017–18[4]

Lender	Beneficiary	Loan Amount (₹million)	Loan Amount ($ million)	Purpose
Solarpack	An Indian FI	4430.00	69.00	Financing 6 solar projects with total capacity of 104 MW in Telangana
Orb Energy	Overseas Private Investment Corporation	636.00	10.00	To expand its in-house finance facility for rooftop solar projects; for small and medium sized enterprises in India and Kenya
Mahindra Renewables	Yes Bank	7500.00	115.50	To finance solar PV projects in India

Source: WISE Analysis, 2018, based on data from MERCOM reports.

non-convertible. Convertible debentures were issued as loan instruments, initially, but later converted to equity, while non-convertible debentures were treated as debt for the entire tenure. Debentures were mostly issued by non-financial companies. They include:[4,5&6] IDFC Alternatives, Fotowatio Renewable Venture, ReNew Power, Cleanmax Solar.

Figure 4.4 summarizes major investments through issue of debentures during 2017–18.

The most prominent debt instrument used in 2017–18 was green bonds. These bonds were mainly issued by Indian non-banking financial corporations and multilateral development banks on behalf of domestic investors and project developers. Details are given in Table 4.4.[7,8&9]

4.2.2 Equity Instruments

Equity investments occur mainly in two forms–private equity and venture capital. Two major private equity deals were accomplished in 2017–18. Investments were made in Cleanmax Solar and Husk Power Systems. Figure 4.5 provides the details of private equity deals completed during the year. [10&11]

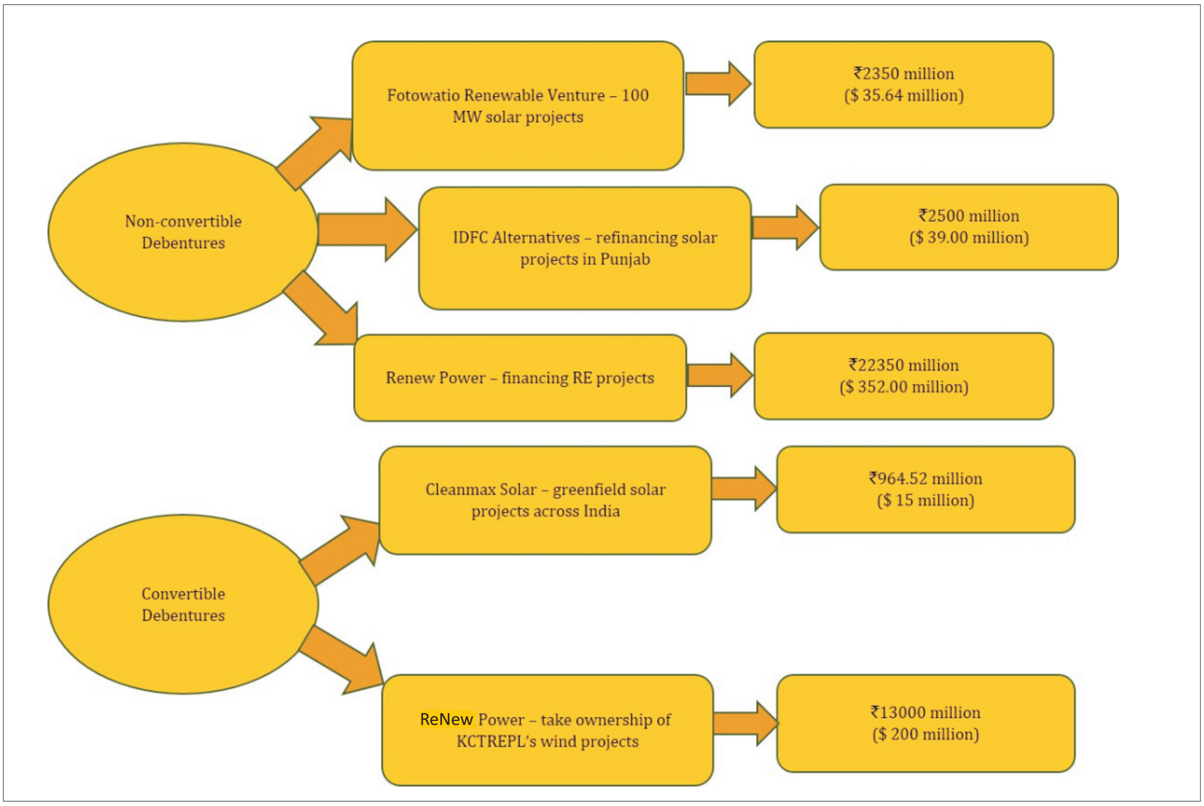
Oorjan Cleantech managed venture capital worth ₹28.80 million ($ 0.45 million) from various investors[4] during 2017–18. Proceeds from this deal were earmarked for scaling operations, augmenting sales efforts, and further building technology advantage in the rooftop solar segment. Apart from this, Netherlands Development Finance Corporation (FMO) infused equity worth ₹254 million ($4.00 million)[4] in Orb Energy. Figure 4.6 depicts major venture capital deals completed during 2017–18.[4,12,13]

Table 4.4: Major Green Bonds Issued by Various Agencies in India during 2017–18

Issuer	Bond Value (₹ million)	Bond Value* ($ million)	Purpose
Asian Development Bank	33000.00	500.00	Development of 709 MW of solar and wind projects across the states of Andhra Pradesh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, and Telangana.
L&T Infrastructure Finance Company Limited	6670.00	103.00	Lending to solar power projects
Azure Power	32600.00	500.00	Financing Azure Power's existing and future eligible solar power projects
Greenko Energy	98000.00	1500.00	Financing Greenko's clean energy projects
Indian Renewable Energy Development Agency	19500.00	300.00	Financing renewable energy projects
Rural Electrification Corporation	29250.00[1]	450.00	Financing renewable energy projects
Power Finance Corporation	25720.00	400.00	Investment in renewable energy projects

Source: MERCOM, 2018.
* Average exchange note of the month of July 2017 is considered.

Figure 4.4: Major Investments through Issue of Debentures in 2017–18

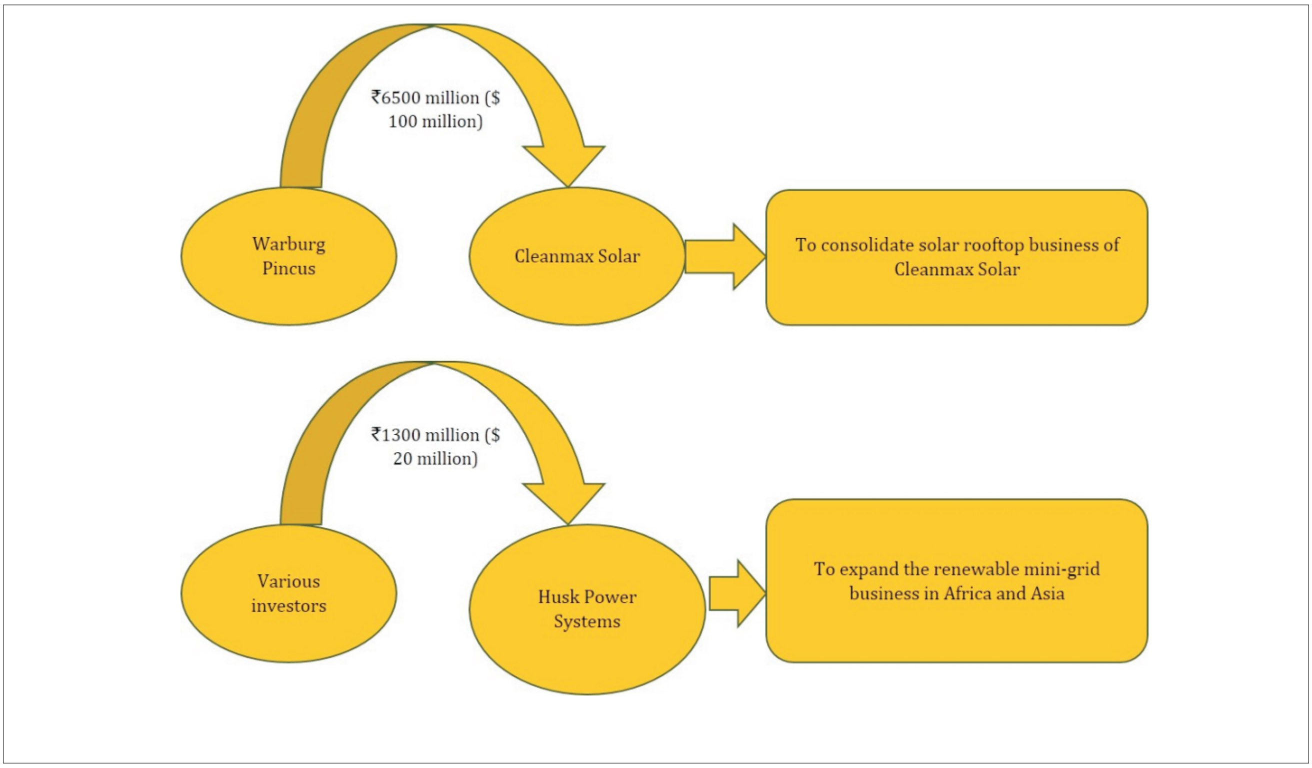


Source: WISE Analysis, 2018, compiled from data from MERCOM reports.

4.3 ACQUISITIONS

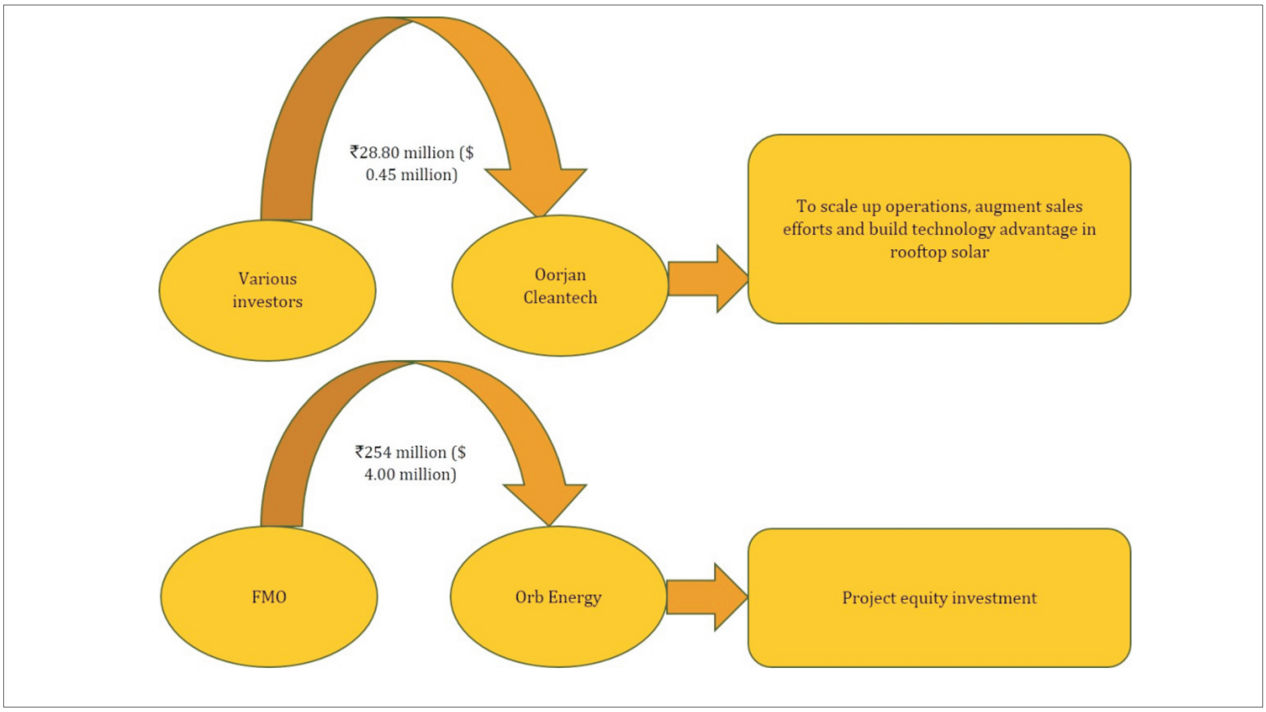
Acquisitions in 2017–18 came by way of project acquisitions and equity acquisitions. The major acquisition deals accomplished during 2017–18 are shown in Figure 4.7. [1,2&4]

Figure 4.5: Major Private Equity Deals in 2017–18



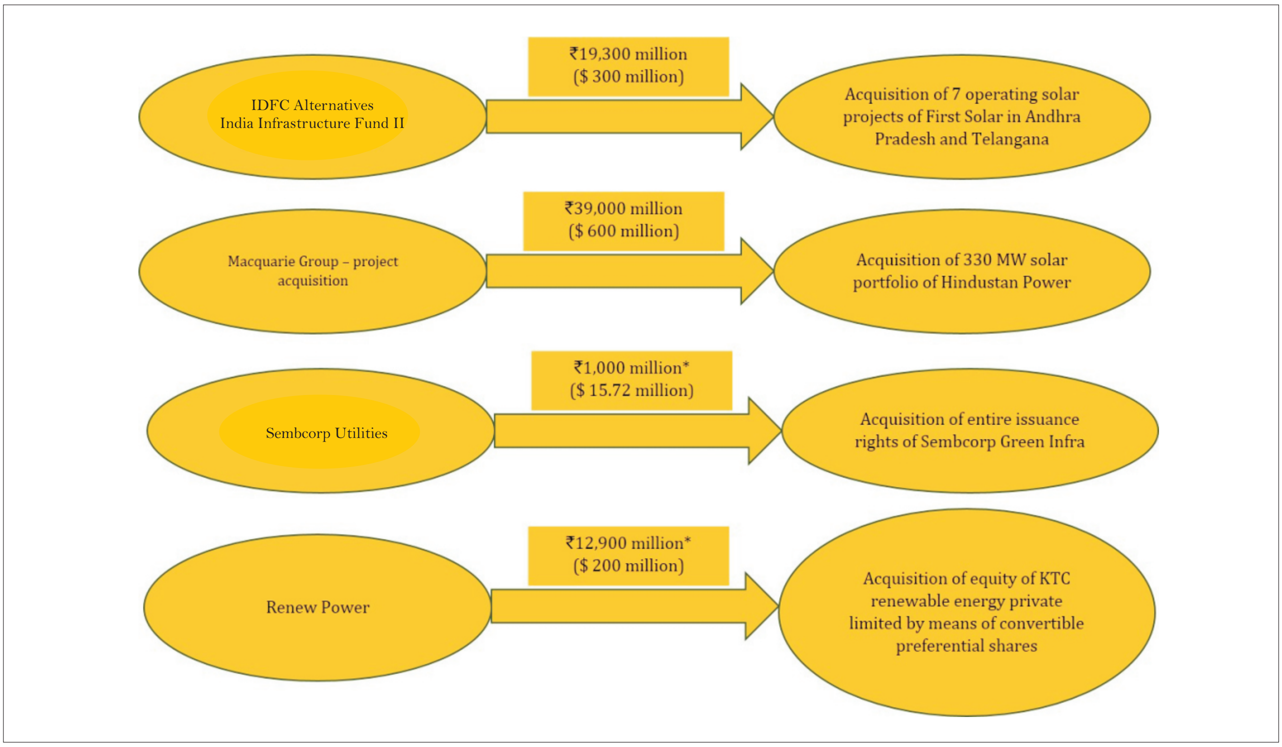
Source: WISE Analysis, 2018, based on data collected from MERCOM reports.

Figure 4.6: Major Venture Capital Deals in 2017–18



Source: WISE Analysis, 2018, compiled from reports by MERCOM.

Figure 4.7: Major Acquisition Deals in 2017–18



Source: WISE Analysis, 2018, compiled from reports by MERCOM.

Financing Rooftop Solar and Transmission Network Scheme[14, 15, 16, 17, 18]

Rooftop Solar

The Government of India has emphasized the expansion of grid-connected rooftop solar projects across the country. In consonance with this, various agencies and FIs have come forward to finance grid-connected rooftop solar in India. State Bank of India (SBI) and Punjab National Bank (PNB) have engaged in credit access arrangement with the World Bank and Asian Development Bank respectively. SBI has already announced a ₹4 billion ($62.2 million) loan to private developers for financing at least 100 MW grid-connected rooftop solar power projects. Asian Development Bank sanctioned a $100 million loan to PNB, backed by government guarantee, for financing large scale rooftop solar systems on commercial and industrial buildings. This is the first tranche loan of the $500 million, multi-tranche finance facility, for the Solar Rooftop Investment Program (SRIP) approved by ADB in 2016.

Green Energy Corridor

The green energy corridor scheme aims to strenghten the transmission network for enhanced evacuation and integration of RE into the grid. Currently this is being implemented by eight renewable rich states (Tamil Nadu, Rajasthan, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Himachal Pradesh and Madhya Pradesh) with a total project cost of ₹1,01,410 million. As on 31 December 2017, ₹67,660 million worth of projects have been awarded and approx. ₹14,000 million has been disbursed to the states by the Government of India.[15,16]

Source: WISE, 2018, Compiled from websites of ADB, WB, IFC, and CEA/competive bidding reports.

Terms of Financing Renewable Energy in India

Renewable energy projects are financed through debt and equity. More often than not, 70% of total project cost is financed through debt whereas 30% is financed through equity. Most of the loans provided to RE projects in India are recourse loans[17] holding the developer personally liable for repayment of loan. For solar rooftop projects, banks and NBFCs often ask for collaterals against loans. The rate of interest on debt for renewable energy in India is 10% to 19% higher[18] than the US. In contrast, the return on equity in India is 2% to 3% higher as compared to that in the US.[19] On average, the repayment period for RE loans is 10 years, while in the US and European markets it is generally 10 to 15 years. Some of the terms of financing as determined by IREDA, the central nodal financing agency is given below.[20]

Eligible Entities: Private sector companies/firms/LLPs; central public sector undertakings; state utilities/DISCOMS/TRANSCOS/GENCOS/corporations and joint sector companies. However, there are certain exclusions such as – trusts, societies, individuals, proprietary concerns and partnership firms (other than limited liability partnerships, LLPs) unable to provide bank guarantees or pledge of fixed deposit receipts; loss making applicants or organizations with accumulated losses who are unable to provide bank guarantees or pledge of fixed deposit receipts; green field projects involving second hand equipment and defaulting institutions.

Minimum Loan Amount: ₹50 lakh for IREDA projects unless otherwise specified by any scheme or program.

Debt to Equity Ratio: The maximum debt to equity ratio for RE projects for which IREDA provides loans is 70:30. However, under certain conditions, wind and solar projects may be eligible for debt to equity ratio up to 75:25.

Repayment Period: Normally the repayment period for loans will be a maximum of 10 to 15 years depending on the project cash flows, DSCR of the project, PPA period, etc., and it shall be after the construction and grace periods. The grace period shall be 6 months to 1 year from the date of COD of the project.

Rate of Interest:

Rate of Interest Schedule for Select Renewable Energy Projects Financed by IREDA

Sector	Grade I*	Grade II*	Grade III*	Grade IV*
Solar Rooftop	9.55%	9.90%	10.20%	10.50%
Wind Energy and Grid-Connected Solar PV	9.55%	10.00 %	10.35%	10.75%
Co-generation, Hydro and CSP, Solar Thermal/Solar PV Off -Grid, Biomass Power	10.10%	10.60%	11.00%	11.25%

* Grades given after credit rating of grid-connected projects based on risk assessment

Source: WISE, 2018, based on data from ADB, IREDA, and other market reports.

***

5 THE CO-BENEFITS OF RENEWABLE ENERGY

HIGHLIGHTS OF 2017–18

EMISSIONS REDUCTION

- According to the Emissions Gap Report 2018, global greenhouse gas emissions, including emissions from land use, land-use change and forestry (LULUCF), were estimated to be 53.5 $GtCO_2e$ in 2017, up from 51.9 $GtCO_2e$ in 2016, which marked and increase of 0.7 $GtCO_2e$ (1.3%).
- As per the International Energy Agency, global energy-related CO_2 emissions grew by 1.4% in 2017, reaching a historic high of 32.5 giga tonnes (Gt), an increase after three years of emissions remaining flat.
- India's per capita emissions in 2016 were 1.7 tCO_2, which was well below the global per capita average of 4.3 tCO_2.
- India's First Biennial Update Report to the UNFCCC estimated GHG emissions from the energy sector in 2010 at 1510,120.76 $GgCO_2eq$, which is about 71% of the total GHG emissions (excluding LULUCF) and 80% (including LULUCF). Of these emissions, the energy industries accounted for the maximum number, followed by manufacturing industries and the transport sector.
- In 2017–18, India is estimated to have avoided 83.14 million metric tonnes of emissions from wind and solar generation (based on certain assumptions). If the country achieves its target of producing 160 MW from wind and solar power by 2022, it will enable displacing around 256.9 million metric tonnes of CO_2 emissions.

RE JOBS

- In 2017–18, the highest employment in RE took place in the solar PV sector. Within the sector, the employment in the solar EPC segment in proportion to the total employment is 39%, while for wind it is around 4% only and for the SHP sector a mere 0.6%.
- As per the Draft Report-Economic Rate of Return of Various Renewable Energy Technologies (supported by MNRE), per MW full-time equivalent (FTE) employment for solar rooftop projects is 23.5 nos/MW, whereas for ground-mounted projects it is 6.24 nos/MW. Thus, significant potential for employment generation in the rooftop segment is envisaged.

5.1 EMISSIONS REDUCTION

5.1.1 Background

Climate became part of India's energy discourse with the advent of the National Action Plan on Climate Change (NAPCC) in 2008. This was followed by the submission of its Intended Nationally Determined Contributions (INDCs) on 1 October 2015, prior to the UN climate conference in December 2015 (COP 21) in Paris. Of the eight INDCs, the following three are specific targets and critical to moving towards a low-carbon and renewable energy economy:[1]

1. Reduce emissions intensity of its GDP by 33 to 35 percent by 2030 (above 2005 levels).
2. Achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including Green Climate Fund (GCF).
3. Create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

5.1.2 Emissions Scenario

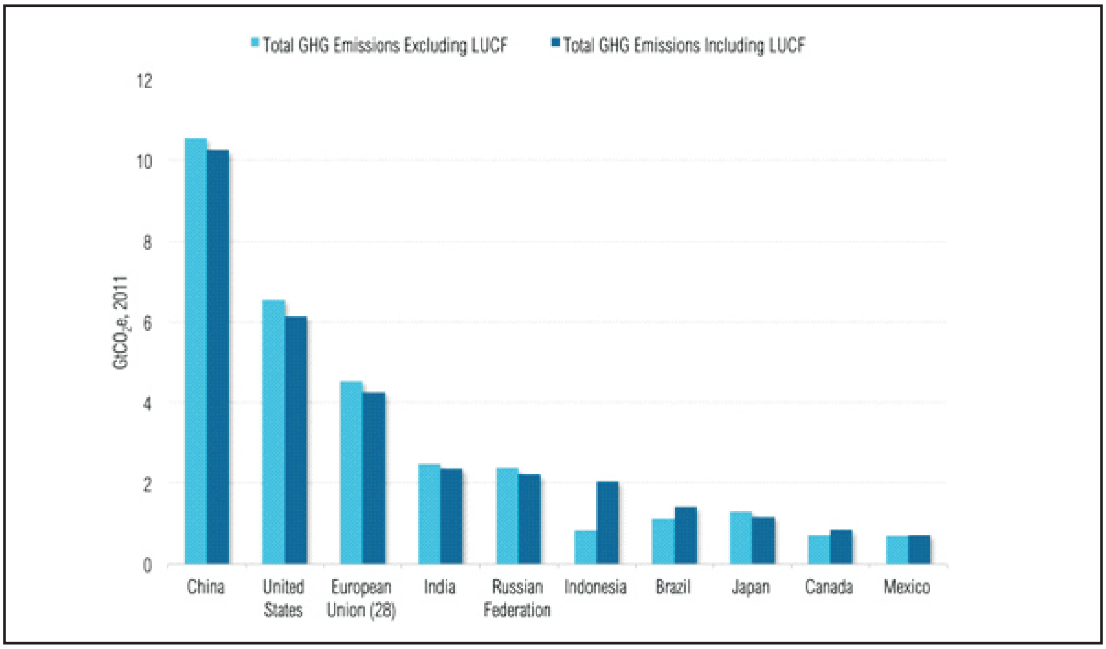
According to the Emissions Gap Report, 2018. Global greenhouse gas emissions, including emissions from land use, land-use change and forestry (LULUCF), were estimated at about 53.5 $GtCO_{2e}$ in 2017, 51.9 $GtCO_{2e}$ in 2016, 35.6 $GtCO_{2e}$ in 2015 and 51.7 $GtCO_{2e}$ in 2014. This depicts an increase of 0.7 $GtCO_{2e}$ growth from 2016 (1.3%).[2] This increase is the result of stronger GDP growth and decline in energy and carbon intensity in 2017.

Data from the World Resources Institute shows that the top three greenhouse gas emitters—China, the European Union and the United States—contribute more than half of total global emissions, while the bottom 100 countries account for only 3.5 percent.[3] 70% of global GHG emissions emanates from the top 10 emitters of GHGs in the world. Figure 5.1 shows the absolute emissions of GHGs in 2011 considering emissions excluding and including land use, land use change and forestry (LULUCF). While India ranks fourth in the list of absolute emissions, it ranks last in per capita emissions (Figure 5.2). In 2014, India emitted 6.6% of global emissions.

According to the 'India: Greenhouse Gas Emissions 2007' report, the total GHG emissions (without LULUCF) has grown from 1251.95 million tonnes in 1994 to 1904.73 million tonnes in 2007 at 3.3% compounded annual growth rate (CAGR) and with LULUCF at 2.9% CAGR.[4] Between 1994 and 2007, some of the sectors indicated significant growth in GHG emissions such as cement production (6%), electricity generation (5.6%) and transport (4.5%). A comparative analysis of GHG emissions by sector is shown in Table 5.1.

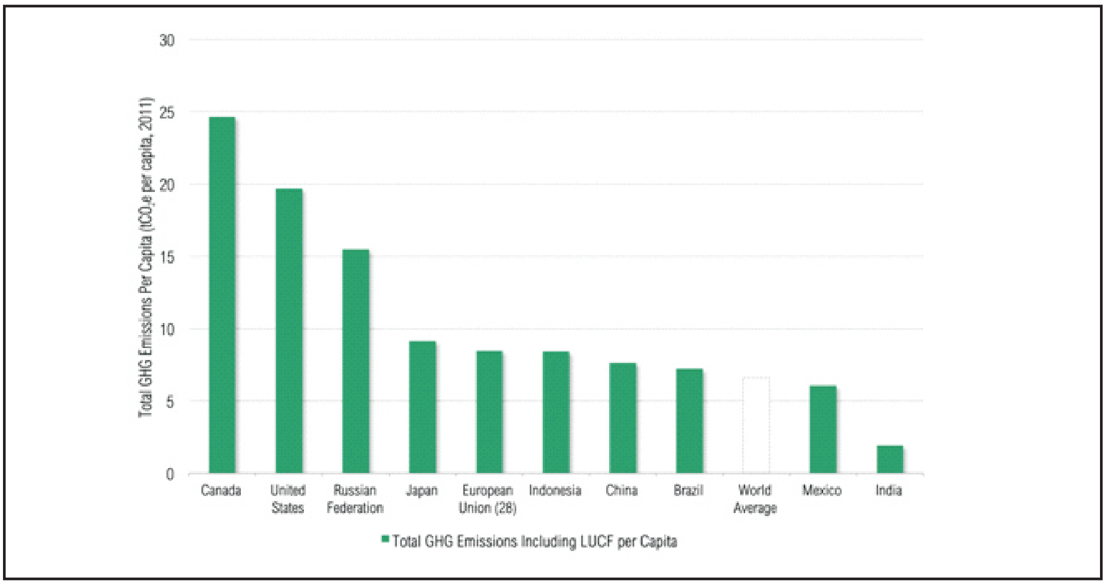
In 2017, India's CO_2 emissions grew by an estimated 4.6%. But in terms of per capita, it is still very low –1.8 tonnes of CO_2 per capita – which is much lower than the world average of 4.2 tonnes.[5] Nevertheless these emissions have been growing steadily, with an average growth rate of 6% over the past decade.

Figure 5.1 Top 10 Emitters of GHGs in the World (2011)



Source: World Resources Institute, 2014.

Figure 5.2: Per capita emission of GHG by top 10 emitters in the world



Source: World Resources Institute, 2014.

Table 5.1 GHG Emissions by Sector (1994 and 2007)

	1994		2007		CAGR %
Electricity	355.03	(28.4%)	719.30	(37.8%)	5.6
Transport	80.28	(6.4%)	142.04	(7.5%)	4.5
Residential	78.89	(6.3%)	137.84	(7.2%)	4.4
Other Energy	78.93	(4.9%)	100.87	(5.3%)	1.9
Cement	60.87	(7.2%)	129.92	(6.8%)	6.0
Iron & Steel	90.53	(10.0%)	117.32	(6.2%)	2.0
Other Industry	125.41	(27.6%)	165.31	(8.7%)	2.2
Agriculture	344.48	(1.9%)	334.41	(17.6%)	-0.2
Waste	23.23		57.73	(3.0%)	7.3
Total without LULUCF	1251.95		1904.73		3.3
LULUCF	14.29		-177.03		2.9
Total with LULUCF	1228.54		1727.71		

Source: INCCA, 2010.

Note : Figure in brackets indicate percentage emissions from each sector with respect to total GHG emissions without LULUCF in 1994 and 2007, respectively.

5.1.3 Emissions from the Energy Sector

Global Energy-related Emissions

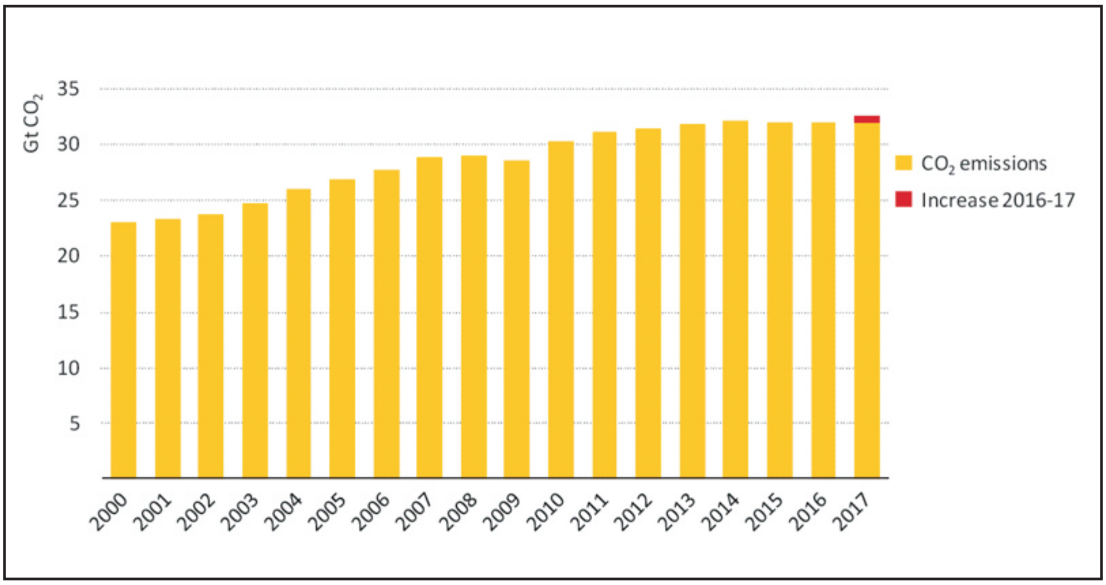
During the last decade, the energy sector remained the largest contributor of emissions globally representing 72 percent of global emissions in 2013. According to the International Energy Agency, global energy-related CO_2 emissions grew by 1.4% in 2017, an increase of 460 million tonnes, reaching a historic high of 32.5 giga tonnes (Gt), an increase after three years of emissions remaining flat (Figure 5.3).[6] The increase in emissions was not universal. While most countries saw a rise, others experienced a decline, including the United States, United Kingdom, Mexico and Japan.

The increase in energy-related emissions (equivalent to emissions of 170 million additional cars), was the result of robust global economic growth of 3.7%, lower fossil-fuel prices, and weaker energy efficiency efforts.[6] These three factors contributed to pushing up global energy demand by 2.1% in 2017. While coal-to-gas switching played a major role in reducing emissions in previous years, in 2017 the drop was due to higher renewables-based electricity generation and decline in electricity demand. The share of renewables in electricity generation reached a record level of 17% in 2017.[6]

India's Energy-related Emissions

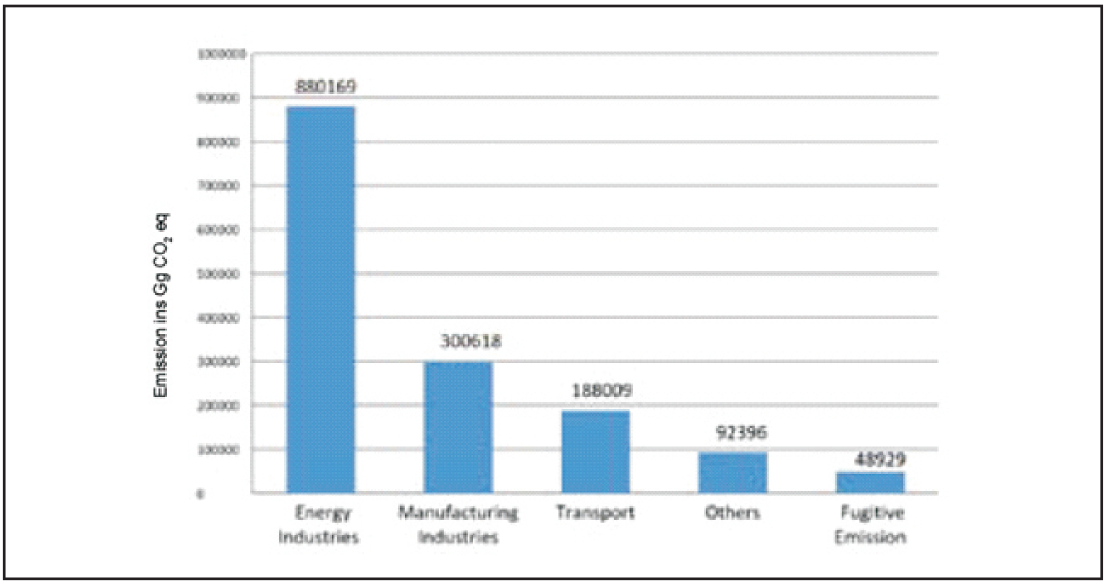
In India, economic growth bolstered rising energy demand and continued to drive up emissions but at half

Figure 5.3: Global energy-related CO_2 Emission, 2000–2017



Source: IEA, 2017.

Figure 5.4 Distribution of Emissions in India's Energy Sector in 2010



Source: India's first Biennial Report, 2015.

the rate seen during the past decade. India's per-capita emissions in 2016 were 1.7 tCO_2, well below the global per capita average of 4.3 tCO_2.[6]

As per India's First Biennial Update Report to the UNFCCC, GHG emissions from the energy sector in 2010 was estimated at 1510,120.76 Gg CO_2eq, which is about 71% of the total GHG emissions (excluding LULUCF) and 80% (including LULUCF).[7] Figure 5.4 shows the distribution of emissions across the energy sector. It can be seen that the energy industries (viz. power plants or electricity) account for the maximum number of emissions (880,169 Gg CO_2eq), followed by manufacturing industries (300,618 Gg CO_2eq) and transport (188,009 Gg Co_2eq).

5.1.4 Emissions Reduction through the RE Route

With India's decisive action (INDCs) to achieve 40% cumulative electric installed capacity from non-fossil-fuel-based sources, renewable energy development has received a major boost. Electricity generation through the renewable route provides tremendous potential in contributing to India's NDC target of reducing emissions intensity 33–35% by 2030 (from 2005 levels). As wind and solar contributed over 80% of electricity generation from renewables in 2017–18, these two sources have been specifically considered for deriving estimates for emissions reduction. During 2017–18, India's annual average wind and solar power capacity was 33162.89 MW and 16970.16 MW respectively. Assuming that wind and solar power plants were in operation throughout the year, total energy generation works out to 103.78 GWh. The International Energy Agency (IEA) has computed CO_2 emissions for wind power generation, solar power generation and coal-based power generation. The results of the IEA study are summarised in Table 5.2.

The average savings of CO_2 emissions from one MWh of electricity production is 0.80 t/MWh. The assumption here is that the entire electricity generated by wind and solar has replaced generation from coal-based power plants. Thus, the resulting avoided emissions of CO_2 from wind and solar generation is approximately 83.14 million metric tonnes in 2017–18.

5.1.5 RE and Future Emission Trends

IEA's Sustainable Development Scenario charts a path towards meeting long-term climate goals. In this scenario, global emissions need to peak soon and decline steeply by 2020; this decline will now need to be even greater, given the increase in emissions in 2017. The share of low-carbon energy sources must increase by 1.1 percent every year, more than five-times the growth registered in 2017. In the power sector specifically, generation from renewable sources must increase by an average 700 TWh annually, an 80% increase compared to the 380 TWh increase registered in 2017.[6]

Table 5.2: CO_2 Emissions in Metric Tonnes per MWh Generated

Technology†	CO_2 Emissions (t/MWh)
Wind	0.008
Solar	0.1
Coal	0.87

Source: Climate Report, Cecile Bordier, 2008.
†Emissions from wind and solar technologies are indirect emissions.

According to the Emissions Gap Report 2018, India is expected to be more than 10% below its unconditional NDC targets, given the existing policies in place.[2] This comes as a setback, as the 2017 report projected that it would over-achieve its NDC targets.

If India achieves its target of producing 160 GW of power from wind and solar technologies by 2022, it will enable displacing around 256.95 million metric tonnes of CO_2 emissions and replacing coal-based power generation with clean energy.

5.2 RE JOBS

Rapid growth in the renewable energy sector has opened various avenues for direct and indirect employment related to RE in India. Many previous studies have attempted to address the employment gap and consequent skills gap in the sector. But as policies and drivers for RE changed over time, so did the estimates for employment generation. Table 5.3 summarizes a few noteworthy India-specific studies that estimated RE related jobs creation in India.

Table 5.3: Summaries of Few Noteworthy India-Specific Studies that Estimated RE Related Job Creation in India

	Name of the Study	Year	Jobs Estimate
1.	Human Resource Development Strategies for Indian Renewable Energy Sector; Confederation of Indian Industries (CII), Ministry of New and Renewable Energy (MNRE)[8]	2010	3,50,000[1]
2.	Clean Energy Powers Local Job Growth in India; Council On Energy Environment and Water(CEEW) and National Resources Defense Council (NRDC)[9]	2014	70,000[2]
3.	Solar Power Jobs: Exploring the Employment Potential in India's Grid-Connected Solar Market; Council on Energy Environment and Water(CEEW) and National Resources Defense Council (NRDC)[10]	2015	23,884[3]
4.	Skill Gap Report for Solar, Wind and Small Hydro Sector; Skill Council for Green Jobs[11]	2016	1,83,954[4]
5.	Draft Report - Economic Rate of Return of Various Renewable Energy Technologies; Supported by Ministry of New and Renewable Energy[12]	2018	1,50,657[5]

Source: Compiled from different agency reports.

[1] It is the most comprehensive study covering four technologies, viz., wind, solar, small hydro and biomass.
[2] Only for wind and solar sectors.
[3] Only for grid-connected solar sector between 2011 and 2014.
[4] It considers only three sectors, viz., wind, solar (PV and thermal) and small hydro.
[5] It considers three sectors, viz., wind, solar (only PV) and small hydro.

All these studies have adopted the 'employment factor' approach to estimate employment related to RE in India. This report also follows the same methodology, based on the following assumptions and scope:

- In order to maintain brevity, aggregated employment – direct and indirect - in the RE sector as on 31 March 2018 has been estimated.
- Units of employment have been reported as full-time equivalent employment (FTE).
- Employment of only engineering, procurement and construction (EPC), and operation and maintenance (O&M) stages have been considered. This is because the project planning stage involves simultaneous activities by the same individual for more than one project and manpower may not necessarily be employed from India. Similarly, manufacturing may not exhaust the entire capacity installed in India.
- Employment for EPC has been computed only for the financial year 2017–18, while employment for operation and maintenance has been estimated based on cumulative installed capacity as on 31 March 2018.
- EPC work has been assumed to be completed during 2017–18.
- In order to get the best possible contemporary employment figures, the latest report[12] (No.5, Table 5.3) has been adopted as the reference for getting employment factors. Consequently, due to lack of sufficient data, only three sectors, viz., wind, solar PV, and small hydro sectors have been considered.
- Due to data constraints, employment in the solar PV sector is shown as a combined figure for both ground mounted and solar rooftop projects.

Based on the above assumptions, employment factors have been adopted for the three major technologies based on 2016 data, and are shown in Table 5.4 and FTE employment figures for 2017 are shown in Table 5.5.

As can be seen from Table 5.5, a majority of employment in 2017–18 has taken place in the solar PV sector. More importantly, employment for EPC in proportion to total employment is 39.4%, whereas that for wind and small hydro are 4% and 0.6% respectively, implying a much faster growth of solar PV in India and slow growth of the wind and SHP sectors. As per the Draft Report - Economic Rate of Return of Various Renewable Energy Technologies, supported by Ministry of New and Renewable Energy, 2018, per MW FTE for rooftop projects is 23.59 nos/MW, whereas for ground mounted solar projects it is 6.24 nos/MW. Thus, significant employment generation potential is envisaged for rooftop solar projects.

Table 5.4: Full Time Equivalent (FTE) Employment Factors for Three Major Technologies

Technology	EPC	O&M	Total
	(FTE/MW)	(FTE/MW)	(FTE/MW)
Solar PV (Ground Mounted and Rooftop)	4.75	3.15	7.90
Wind	0.51	0.60	1.11
Small Hydro	3.07	10.75	13.82

Source: Draft Report - Economic Rate of Return of Various Renewable Energy Technologies, Supported by Ministry of New and Renewable Energy, 2018.[6]

Table 5.5: Full Time Equivalent (FTE) Employment for Solar PV, Wind, and SHP in 2017–18

Technology	EPC (FTE)	O&M (FTE)	Total (FTE)
Solar PV (Ground Mounted and Rooftop)	44,472	68,202	112,675
Wind	901	20,428	21,328
Small Hydro	325	48,222	48,548

Source: WISE Analysis, 2018.[12]

From this analysis, it may be inferred that the solar sector has significant potential for employment, which may be used to devise policies for skills development related to the sector. However, one should use these figures cautiously, as these figures are based on inductive methodology, i.e. sample survey. Moreover, the policy formulation should also consider the probable technological interventions such as use of drones which may impact employability to a large extent.

***

[6] Calculations have been based on Skill Gap Report for Solar, Wind and Small Hydro Sector; Skill Council for Green Jobs.

ANNEXURES

Annexure I: Solar Cell Manufacturing Capacity in India

Sr. No.	Name of Company	Installed in MW (as on 31-05-2017)
1	BEL	10
2	Bharat Heavy Electricals Limited	115
3	Central Electronics Limited	10
4	Dev Solar	3
5	Euro Multivision Limited	40
6	Indosolar Ltd	240
7	IYSERT Energy Research Pvt. Ltd.	1
8	Jupiter International Ltd	260
9	Jupiter Solar Pvt. Ltd	133
10	Kl Solar Company Pvt Ltd.,	12
11	Maharishi Solar Technology	10
12	Moser Baer Solar Limited	250
13	Mundra Solar PV Limited (Adani Group)	1200
14	Premier Solar Systems Ltd	60
15	Renewsys India Private Limited (RIPL)	130
16	Surana Solar Limited	120
17	Tata Power Solar Systems Limited	300
18	Udhaya Energy Photovoltaics Pvt Ltd	10
19	Websol Energy System Limited	200
20	XL Energy Ltd.	60
	Total (MW)	**3164**

Source: MNRE, 2017.

Annexure II: Solar Module Manufacturing Capacity in India

Sr. No.	Name of Company	Installed in MW (as on 31-05-2017)
1	Access Solar Ltd.	80
2	Adito Solar Pvt. Ltd.	25
3	Agrawal Solar	40
4	Ajit Solar Pvt. Ltd.	35
5	Akshaya Solar Power Pvt. Ltd .	25
6	Alectrona/Zynergy	
7	Alpex Exports Pvt. Ltd.	300
8	AMV Energy Systems Pvt. Ltd.	4
9	Andromeda Energy Technologies (P)Ltd.	30
10	Andslite	20
11	Arion Solar Pvt. Ltd.	5
12	AVI	15
13	BEL	10
14	Bharat Heavy Electricals Ltd	226
15	Blue Bird Solar	20
16	Brawn Battery	25
17	Central Electronics Limited	42
18	Deity Fuel Energy Pvt. Ltd.	20
19	Deshmukh Solar Energy Systems Pvt. Ltd	25
20	Dev Solar	3
21	Electromac Solar System Pvt. Ltd.	20
22	Emmvee Photovoltaic Power Pvt. Ltd.	500
23	Empire Photovoltaic Systems	36
24	Enfield Solar Energy Limited	20
25	Enkay Solar Power & Infrastructure Pvt. Ltd.	15
26	Evergreen Solar Systems India Pvt. Ltd.	20
27	Gautam Solar	65
28	Genus Solar	20
29	Goldi Green Technologies Pvt. Ltd.	125
30	Green Brilliance Energy Pvt. Ltd.	50
31	Greentek India Pvt. Ltd.	25
32	H. R. Solar Solution Pvt. Ltd.	15
33	HBL Power Systems Limited	20
34	HHV Solar Technologies	100
35	Himalayan Solar Pvt. Ltd.	100
36	ICON Solar-en Power Technologies Pvt. Ltd.	75
37	Innovative Solar Solutions	20
38	Integrated Solar	25
39	Iti Ltd	8
40	Iysert Energy Research Pvt. Ltd.	10
41	Jain Irrigation Systems Ltd.	55
42	Jakson Solar	60
43	Ji PV Solar Pvt. Ltd.	24
44	JP Solar	20
45	Junna Solar Systems Pvt. Ltd.	20
46	Jupiter Solar Pvt. Ltd.	0
47	Jyotitech Solar LLP	35
48	Karishma Solar Pvt. Ltd.	15
49	KCP Solar Industry	12
50	Kohima Solar	55

Annexure II: Solar Module Manufacturing Capacity in India (contd)

Sr. No.	Name of Company	Installed in MW (as on 31-05-2017)
51	Kotak Urja Pvt. Ltd.	75
52	Lanco Solar	175
53	Maharishi Solar Technology	15
54	Mainframe Energy Solutions Pvt Ltd	25
55	Mas Solar	20
56	Mas Solar System Pvt Ltd	20
57	Microsol Power P Ltd.	60
58	MicroSunSolar Tech Pvt. Ltd.	60
59	Modern Solar Pvt. Ltd.	40
60	Moser Baer Solar Ltd.	230
61	Mundra Solar PV Ltd (Adani Group)	1200
62	MX Power Solar Ltd.	10
63	Navitas Green Solutions Pvt. Ltd.	75
64	Neety Euro Asia Solar Energy	15
65	Novergy Energy Solutions Pvt. Ltd.	45
66	Nucifera Renewable Energy Systems	15
67	Omsun Power Pvt. Ltd	25
68	Photon Energy Systems Ltd	50
69	Photonix Solar Pvt. Ltd.	40
70	Plaza Power & Infrastructure Co.	30
71	Powertrach Solar Ltd	20
72	Premier Solar Systems Ltd	100
73	Prosun Energy Pvt. Ltd.	5
74	PV Power Technologies	50
75	Raajratna Ventures Ltd.	35
76	Radiant Solar Pvt. Ltd.	80
77	Rajasthan Electronics & Instruments Ltd.	20
78	Reliance Industries Ltd - SOLAR	30
79	Renewsys India	180
80	Rhine Solar Ltd.	40
81	Ritika Systems	40
82	Rolta Power Pvt. Ltd.	60
83	Saatvik Green Energy Pvt. Ltd.	175
84	Sahaj Solar Pvt. Ltd	25
85	Satyam Enterprises	10
86	Savitri Solar	80
87	Seemac Pvt. Ltd.	40
88	Shan Solar Pvt. Ltd.	30
89	Shukra Solar Energy Pvt. Ltd.	5
90	SLG Solar System	8
91	SolarMaxx	15
92	Solex Energy Ltd.	30
93	Sonali Energees Pvt. Ltd.	100
94	Sova Power Limited	200
95	Stellar Solar Works	20
96	Sun Solar Techno Ltd.	30
97	Sunbless Green Enertech Pvt Ltd.	25
98	SunFuel	15
99	Sungrace Energy Solutions Pvt Ltd	10
100	Sunrise Solar Solutions	8

Annexure II: Solar Module Manufacturing Capacity in India (contd)

Sr. No.	Name of Company	Installed in MW (as on 31-05-2017)
101	Sunshine Power Products Pvt Ltd.	10
102	Surana Solar	120
103	Synergy Solar	50
104	Tamilnadu Energy Solutions Pvt. Ltd	10
105	Tata Power Solar Systems	400
106	TITAN Energy Systems	100
107	Topsun Energy Limited	100
108	Udhaya Energy Photovoltaics Pvt. Ltd.	7
109	USL Photovoltaics Pvt. Ltd.	7
110	Vikram Solar	500
111	Vimal Electronics	3
112	Vinova Energy Systems Pvt. Ltd.	10
113	Vipul Solar	25
114	VRV Energy India Pvt. Ltd.	25
115	Waaree Energies	500
116	Websol Energies Ltd.	90
117	XL Energy Ltd.	210
	Total (MW)	**8398**

Source: MNRE, 2017.

Annexure III: WTG Manufacturers and Models Registered with MNRE/NIWE (as on 24.01.2018)

Sr. No.	Make	Turbine Capacity (kW)	Hub Height (m)	Rotor Diameter (m)
1	Acciona Wind Power India Pvt. Ltd	3000	120	125
2	Gamesa Renewable Pvt. Ltd	850	49/55/65	58
		2000	78/90	97
		2000	78/90	97
		2000	78/90	97
		2000	104/108	97
		2000	106/110	114
		2000	80/93/125	114
		2000	110/114	114
3	Garuda Vaayu Shakthi Ltd	700	73	54
4	GE India Industrial Pvt. Ltd	1600	80	82.5
		1600	80	87
		1700	79.7/91	103
		2330	94	116.7
5	Global Wind Power Ltd	1500	75	77.36
		1500	80	89.3
6	Inox Wind Ltd	2000	80	93.3
		2000	80/92	100
		2000	92/120	113
7	Kenersys India Pvt. Ltd	2000	80/98	82
		2400	85/95	109
		2625	85	109
8	Lietwind Shriram Manufacturing Ltd	1500	80	83.3
		1800	80	83.3
		1500	80/90	86.4
		3000	93.5	100.9

Annexure III: WTG Manufacturers and Models Registered with MNRE/NIWE (as on 24.01.2018) (contd)

Sr. No.	Make	Turbine Capacity (kW)	Hub Height (m)	Rotor Diameter (m)
9	NuPower Technologies Pvt. Ltd	2050	85/98.2	93.2
		2050	98.2/117/141	100.13
10	Para Enterprise Pvt. Ltd	750	61.1/75.3	49
11	PASL Wind Solutions Pvt. Ltd	1500	80	83.64
		1050	74	68
12	Power Wind Ltd	900	71	56
13	ReGen PowertechPvt. Ltd	1500	70/75/85/100	82.34
		1500	85/100	86.6
		1500	85	88.34
		2800	90	108.82
14	RRB Energy Ltd	500	50	47
		600	50/65	47
		1800	80/100	82.5
15	Suzlon Energy Ltd	2100	80/90/100	95
		2100	80/90/100/120	97
		2100	90/120	111.8
16	Vestas Wind Technology India Pvt. Ltd	1800	95	100
		2000	80/95	100
		2000	80/95/120	100
		2000	110	110
		2000	80/95	100
17	Wind World India Ltd.	800	75	52.9
18	Winwind Power Energy Pvt. Ltd	1000	70	60
19	Para Enterprise Pvt. Ltd	250	50	29.6
20	Shriram EPC Pvt. Ltd	250	41.5	28.5
		250	51.5	28.5
21	Shiva Windturbine India Pvt. Ltd	250	50	30
22	Southern Wind Farms Ltd	225	45	29.8

Source: MNRE/NIWE-Revised List for Manufacturers and Models as on 24.01.2018.

REFERENCES

CHAPTER 1 : ELECTRICITY IN INDIA: AN OVERVIEW

1. REN21 (2018): Renewables 2018 Global Status Report, Renewable Energy Policy Network for 21st Century, Paris.
2. CEA (2016): Draft National Electricity Plan, Central Electricity Authority, New Delhi, Chap.5, pp 19.
3. CEA (2008): Installed Capacity March 2018, Central Electricity Authority, New Delhi.
4. MNRE (2017): Annual Report 2016-17, Ministry of New and Renewable Energy, Government of India.
5. MOP (2018): Ministry of Power website - https://powermin.nic.in/en/content/power-sector-glance-all-india.
6. MOP (2018): Ministry of Power website - https://powermin.nic.in/en/content/power-sector-glance-all-india.
7. MOP (2018): Ministry of Power website - https://powermin.nic.in/en/content/power-sector-glance-all-india.

CHAPTER 2 : POLICY & REGULATION

1. SECI (2017): Official Website - http://seci.gov.in/content/innerpage/introduction.php.
2. MoP (2016): National Tariff Policy, 2016, Ministry of Power, Government of India.
3. JNNSM (2015): Revised Document of Jawaharlal Nehru National Solar Mission, Government of India.
4. CEA: Archives of Annual Reports, Central Electricity Authority, New Delhi.
5. MoP (2018): Draft Amendments to the National Tariff Policy, 2016, Ministry of Power, Government of India.
6. MoP (2018): Proposed Amendments to the Electricity Act, 2003, Ministry of Power, Government of India.
7. MNRE (2017): Amendments in Guidelines for Disbursal of NCEF Grant for the Development of Intra-state Transmission System under Green Energy Corridor, Ministry of New and Renewable Energy, Government of India.
8. MNRE (2017): Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid-connected Solar PV Power Projects, Ministry of New and Renewable Energy, Government of India.
9. MNRE (2017): Solar Photovoltaics Systems, Devices and Components Goods Order, 2017, Ministry of New and Renewable Energy, Government of India.
10. MNRE (2017): Draft Technology Development and Innovation Policy, 2017, Ministry of New and Renewable Energy, Government of India.
11. MoP (2017): Guidelines for Tariff-based Competitive Bidding Process for Procurement of Power from Grid-Connected Wind Power Projects, Ministry of Power, Government of India.
12. MNRE (2017): Amendments in Guidelines for Tariff-based Competitive Bidding Process for Procurement of Power from Grid-connected Solar Power Projects under Phase II, Batch IV of VGF Scheme, Ministry of New and Renewable Energy, Government of India.
13. MNRE (2017): Office Memorandum on Penalties for Violation of Norms of DCR under Solar Power Projects under MNRE's Schemes/Programmes, Ministry of New and Renewable Energy, Government of India.
14. MoP (2018): Waiver of Inter-state Transmission Charges and Losses on Transmission of the Electricity Generated from Solar and Wind Sources of Energy Order 2018, Ministry of Power, Government of India.
15. MNRE (2017): SRISTI (Sustainable Rooftop Implementation for Solar Transfiguration of India), Ministry of New and Renewable Energy, Government of India, https://mnre.gov.in/file-manager/UserFiles/comments-on_RTS.pdf.
16. PIB (2018): Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) Scheme to Harness Solar Power in Rural India, Press Information Bureau, Ministry of New and Renewable Energy, Government of India, http://pib.nic.in/newsite/PrintRelease.aspx?relid=177489.
17. NITI (2017): Draft National Energy Policy, 2017, NITI Aayog, Government of India.
18. MNRE: Implications of GST on Delivered Cost of Renewable Energy, Ministry of New and Renewable Energy, Government of India, https://mnre.gov.in/file-manager/UserFiles/Implications-of-GST-on-delivered-cost-of-Renewable-Energy.pdf.
19. MLJ (2017): The Central Goods and Services Tax Act (2017), Ministry of Law and Justice, Government of India.
20. ICMI (2018): ICMI Budget Analysis, 2017-18.
21. GoI (2018): Central Sales Tax Act 1956, Government of India.
22. MNRE (2018): Annual Report, 2017-18, Ministry of New and Renewable Energy, Government of India.
23. MNRE (2018): Various Scheme Documents and Administrative Approvals, Ministry of New and Renewable Energy, Government of India.
24. MNRE (2018): Official website - www.mnre.gov.in.
25. MNRE (2018): Official website - www.mnre.gov.in.
26. RE Policy Documents of Various States (2018).
27. GoMP (2018): Draft Madhya Pradesh Decentralized Electricity Policy, 2016, Government of Madhya Pradesh.
28. GoUP (2018): Uttar Pradesh Mini-Grid Policy, 2016, Government of Uttar Pradesh.
29. GoB (2017): Policy for Promotion of New and Renewable Energy Sources, 2017, Government of Bihar.

30. MoP (2018): Guidelines for Micro-grid Project Development under DDUGJY, Ministry of Power, Government of India.
31. MoP (2017): Guidelines for Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) Scheme, Ministry of Power, Government of India.
32. SERC (2017-18): Feed-in tariff orders related to solar power projects of various State Electricity Regulatory Commissions.
33. SERC (2017-18): Feed-in tariff orders related to wind power projects of various State Electricity Regulatory Commissions.
34. APERC (2017): Forecasting, Scheduling and Deviation Settlement of Solar Wind Generation Regulations, Andhra Pradesh Electricity Regulatory Commission, date 21.08.2017, <http://www.aperc.gov.in/aperc1/assets/uploads/files/5cb4f-forecast-regulation.pdf>.
35. GoI (2018): Report on flexibilization of thermal power plants, progress under IGEF Sub-group – 1, Ministry of Power Taskforce Committee.
36. FoR (2018): Minutes of twelfth meeting of technical committee for implementation framework on renewables at the state level, Forum of Regulators.
37. BERC (2018): Rooftop Solar Grid-interactive System based on net and gross metering Regulations, Bihar Electricity Regulatory Commission, 2018.
38. SERC (2017-18): Net metering related orders / regulations, including amendments, published by the SERCs of Assam, Gujarat, Maharashtra, Odisha, and Uttar Pradesh in 2017-18.

CHAPTER 3: MARKET AND INDUSTRY

1. CEA (2018): Executive Summary of India's Power Sector, Central Electricity Authority, Government of India.
2. CEA (2018): Monthly RE Generation Report, Central Electricity Authority, Government of India.
3. CERC: Renewable Energy Tariff Orders (2013-14 to 2017-18), Central Electricity Regulatory Commission, Ministry of Power, Government of India.
4. SERC (2017-18): Renewable Energy Tariff Orders of Various State Electricity Regulatory Commissions.
5. RBI (2018): Exchange Rate Archives; Reserve Bank of India.
6. MNRE (2018): Grid-connected RE Technology-wise Targets by 2021-22, Ministry of New and Renewable Energy, Government of India.
7. CERC and Various State Electricity Regulatory Commissions (2018): Renewable Energy Tariff Determination Regulations.
8. India Energy Storage Alliance (2018): Official Website - http://indiaesa.info/.
9. EES (2017): Energy Storage in India: A Fast Evolving Landscape, Dr Rahul Walawalkar, The Electrical Energy Storage Magazine, https://www.ees-magazine.com/energy-storage-in-india-a-fast-evolving-landscape-rahul-walawalkar-cem-cdsm-csdp-indian-energy-storage-alliance-iesa/.
10. ESMAP, IFC (2018): Energy Storage Trends and Opportunities in Emerging Markets Energy Sector Management Assistance Program and International Finance Corporation.
11. SECI, Various Other Agencies (2018): Reports on discovery of wind and solar tariff through competitive bidding.
12. KERC (2017): Revision of Generic Tariff for Wind Power Projects and Mandatory Procurement of Wind Power through Competitive Bidding, Karnataka Electricity Regulatory Commission, order dated 4th September, 2017.
13. MERC (2017): Approval of Long/ Medium/ Short term Procurement of Renewable Energy through Competitive Bidding under Regulation 5 of MERC (Terms and Conditions for determination of Renewable Energy Tariff) Regulations, 2015, Maharashtra Electricity Regulatory Commission, order dated 6th December, 2017.
14. SERC (2018): SERCs' order on Truing up of ARR of respective distribution utilities for FY 2016-17, published in 2018.
15. SERC (2017-18): Various SERCs' Orders / Regulations on Renewable Purchase Obligation specified for FY 2017-18.
16. MoP (2016): Long-term RPO Trajectory Notification, Ministry of Power, dated 22 July 2016.
17. REC (2017): Renewable Energy Certificate Registry of India, https://www.recregistryindia.nic.in/.
18. CERC (2017): Letter dated 20th July 2017 on Supreme Court order dated 8.5.2017 in Civil Appeal Nos 6083/2017 and 6334 /2017, regarding CERC order dated 30.3.2017 on REC Floor & Forbearance Price, Central Electricity Regulatory Commission, Ministry of Power, Government of India.
19. CERC (2017): Determination of Forbearance and Floor Price for the REC framework to be applicable from 1st April 2017, order dated 30th March 2017, Central Electricity Regulatory Commission, Ministry of Power, Government of India.

20. KERC (2018): Discussion Paper on 'Wheeling and Banking Charges' for Renewable Power Projects, Karnataka Electricity Regulatory Commission, dated 10.1.2018, http://www.karnataka.gov.in/kerc/Discussion%20papers%20%20Draft%20Discussion%20papers/Discussion%20Papers/Discussion%20paper%20on%20W%20and%20B%20charges%20%20%20Final.pdf.
21. JERC (2018): Connectivity and Open Access in Intra-State Transmission and Distribution) Regulations, 2017, Joint Electricity Regulatory Commission (JERC) of Goa and UTs, dated 14th March 2018, http://jercuts.gov.in/writereaddata/UploadFile/openaccess_1908.pdf.
22. APERC (2017): Power Evacuation from Captive Generation, Co-generation and Renewable Energy Source Power Plants Regulations, 2017, Andhra Pradesh Electricity Regulatory Commission, dated 05.06.2017, http://www.aperc.gov.in/aperc1/assets/uploads/files/d8537-gazettes-1496742983181.pdf.
23. PWC (2015): Renewable Energy's Transformation of the Indian Electricity Landscape, Pricewaterhouse Coopers, https://www.pwc.in/assets/pdfs/publications/2015/renewable-energys-transformation.pdf.
24. PWC (2015): Renewable Energy's Transformation of the Indian Electricity Landscape, Pricewaterhouse Coopers, https://www.pwc.in/assets/pdfs/publications/2015/renewable-energys-transformation.pdf. (SAME AS 23).
25. Different State Governments of India (2018): Renewable Energy Policies of various States.
26. CEEW (2018): Scaling Rooftop Solar - Powering India's RE Transition with Households and DISCOMs, Council on Energy, Environment and Water, June 2018.
27. MNRE (2018): Ministry of New and Renewable Energy, Website - https://mnre.gov.in/.

CHAPTER 4: INVESTMENT FLOW

1. FS (2017): Global Trends in Renewable Energy Investment 2017, Frankfurt School-UNEP Centre/BNEF, Frankfurt School of Finance & Management gGmbH, http://www.fs-unep-centre.org.
2. FS (2018): Global Trends in Renewable Energy Investment 2018, Frankfurt School-UNEP Centre/BNEF, Frankfurt School of Finance & Management gGmbH, http://www.fs-unep-centre.org.
3. RBI (2018): External Commercial Borrowing Data, Reserve Bank of India official website - https://www.rbi.org.in/
4. MERCOM (2018): Various Reports, official website - https://mercomindia.com/.
5. IEA (2016): World Energy Investment, 2016, International Energy Agency, Paris.
6. IEA (2018): World Energy Investment, 2018, International Energy Agency, Paris.
7. ADB (2018): Project Document, official website - https://www.adb.org/projects/49419-001/main.
8. ADB (2018): Official website - https://www.adb.org.
9. PIB (2017): Year-end review of India's Renewable Energy Sector 2017, Ministry of New and Renewable Energy.
10. WP (2018): Warburg Pincus, official website – https://www.warburgpincus.com.
11. HPS (2018): Husk Power Systems, official website - www.huskpowersystems.com.
12. AP (2018): Azure Power, official website – https://www.azurepower.com.
13. SGI (2018): Sembcorp Green Infra, official website – www.sembcorp.com.
14. ADB (2018): Project document - https://www.adb.org/news/100-million-adb-loan-punjab-national-bank-finance-solar-rooftop-projects.
15. WB (2018): World Ban Group Official website – www.worldbank.org.
15. IFC (2018): Official website – https://www.ifc.org.
16. CEA: Monthly Installed Capacity Reports, Central Electricity Authority, Government of India.
17. Documents for various competitive bidding for RE projects.
18. ADBI (2018): Green Energy Finance in India, Challenges and Solutions.
19. EI (2014): Solving India's Renewable Energy Financing Challenge – Which Federal Policies can be Most Effective?, Gireesh Shrimali et al, Energetica India, AGO 14, pp.4-6.
20. EI (2014): Solving India's Renewable Energy Financing Challenge – Which Federal Policies can be Most Effective?, Gireesh Shrimali et al, Energetica India, AGO 14, pp.4-6. (SAME AS 20).
21. IREDA (2018): Financing Norms and Schemes, 2018, Indian Renewable Energy Development Agency.

CHAPTER 5: CO-BENEFITS OF RENEWABLE ENERGY

1. GOI (2015): India's Intended Nationally Determined Contribution: Working Towards Climate Justice, Government of India.
2. UN (2018): Emissions Gap Report 2018, United Nations Environment Programme.
3. WRI (2017) https://www.wri.org/blog/2017/04/interactive-chart-explains-worlds-top-10-emitters-and-how-theyve-changed.

REFERENCES

4. INCCA (2010): India Greenhouse Gas Emissions 2007, Indian Network for Climate Change Assessment, Ministry of Environment, Forest and Climate Change, Government of India.
5. CB (2017): https://www.carbonbrief.org/guest-post-why-indias-co$_2$-emissions-grew-strongly-in-2017.
6. IEA (2017): Global Energy and CO2 Status Report, International Energy Agency, March 2018.
7. MoEFCC (2015): India's First Biennial Update Report, Ministry of Environment, Forest and Climate Change, Government of India.
8. CII-MNRE (2010): Human Resource Development Strategies for Indian Renewable Energy Sector; Confederation of Indian Industries (CII) and Ministry of New and Renewable Energy (MNRE), Government of India.
9. CEEW-NRDC (2015): Clean Energy Powers Local Job Growth in India, Council on Energy, Environment and Water and National Resources Defense Council (NRDC), https://www.ceew.in/sites/default/files/CEEW_Clean_Energy_Powers_Local_Job_Growth.pdf.
10. CEEW-NRDC (2014): Solar Power Jobs - Exploring the Employment Potential in India's Grid-Connected Solar Market, Council on Energy Environment and Water and National Resources Defense Council (NRDC), https://www.nrdc.org/sites/default/files/renewable-energy-solar-jobs-report.pdf.
11. SCGJ (2016): Skill Gap Report for Solar, Wind and Small Hydro Sector, Skill Council for Green Jobs, September 2016, http://sscgj.in/wp-content/uploads/2016/06/SCGJ-skill-gap-report.pdf.
12. MNRE (2018): Draft Report - Economic Rate of Return of Various Renewable Energy Technologies, Supported by Ministry of New and Renewable Energy, Government of India, https://mnre.gov.in/file-manager/UserFiles/Draft-Report-Study-on-ERR-for-RETs.pdf.

WORLD INSTITUTE OF SUSTAINABLE ENERGY

44 Hindustan Estates

Road No. 2, Kalyani Nagar, Pune 411 006

Tel: +91-20-26613832/55 Fax: +91-20-26611438

Email: wiseinfo@wisein.org Website: www.wisein.org