Status of RE Development in India in 2016-17

RENEWABLES INDIA 2017

Towards Grid Parity

Report by

WISE
WORLD INSTITUTE OF SUSTAINABLE ENERGY

An initiative supported by

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

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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 was established in 2009 and works to strengthen the energy security of India by aiding the design and implementation of policies that support energy efficiency and renewable energy.

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Contributors

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

Copy Editing & Proofreading: Noela Mendonza

Technical & Production Assistance: Vinita Phinehas, Research Officer, Communications & Coordination, WISE; Jyoti Fulpagar, Dy. Librarian, WISE; Aoudumbar Tanpure, Manager, IT, WISE.

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FOREWORD

The Government of India has ambitious plans to scale up renewable energy, and stakeholders are deliberating cost-effective ways to integrate ever increasing quantum of renewables with the power system. A challenge being faced today is the lack of robust data on renewable energy, which limits the ability of stakeholders to develop solutions. The current data regime is weak because of which it is difficult to obtain information on major trends and growth trajectories, market outlook, bottlenecks to deployment and procurement of renewable energy.

This initiative attempts to bridge this gap by compiling robust and accurate data on renewable energy from multiple sources and disseminating it through a comprehensive web-based portal, "All About Renewables". We are pleased to share that this report marks the launch of this portal. It is the first report in a series that will assimilate data from the portal for presenting an annual review of India's renewable energy sector.

This report synthesizes a host of developments in the renewables sector during the year 2016-17 covering power generation from various renewable energy technologies, advances in policy and regulatory frameworks, growth in manufacturing capacity and investment flows, and contribution of renewables to emissions reduction. The analysis shows that 2016-17 has been a landmark year for renewables in India – capacity addition surpassing capacity added from conventional sources for the first time, quantum jump of generation from renewables, record low tariffs of solar and wind power, India's largest power utility, National Thermal Power Corporation, expanding its renewables portfolio, as well as several policy developments.

While this is a status report, it also highlights the issues that can hinder the long-term sustainability of the sector. We envision that the web portal and the subsequent reports in this series will be more comprehensive and updated with each passing year.

This is a timely and much needed initiative contributing to improving the data regime in the sector, which is critical to achieving the national energy and climate targets. We hope that the web portal and the annual publications will be useful tools for all stakeholders engaged in advancing the deployment of renewable energy.

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

(Krishan Dhawan)
Chief Executive Officer
Shakti Sustainable Energy Foundation

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ACRONYMS

ADB	Asian Development Bank
AHEC	Alternate Hydro Energy Centre
APPC	Average Power Purchase Cost
bn	Billion
BNEF	Bloomberg New Energy Finance
BoS	Balance of System
BP	British Petroleum
BU	Billing Unit
CAGR	Compound Annual Growth Rate
CBDR	Common but Differentiated Responsibilities
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CO_2e	Carbon dioxide equivalent
Cogen	Cogeneration
COP	Conference of Parties
CPSUs	Central Public Sector Undertakings
CSP	Concentrated Solar Power
CSS	Cross Subsidy Surcharge
DCR	Domestic Control Requirement
DDUGJY	Deendayal Upadhyaya Gram Jyoti Yojana
DISCOM	Distribution Companies
DNES	Department of Non-conventional Energy Sources
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
FA	Franchise Agreement
FDI	Foreign Direct Investment
FIT	Feed-in tariff
FOR	Forum of Regulators
FY	Financial Year
GBI	Generation Based Incentives
GDP	Gross Domestic Product
GERC	Gujarat Electricity Regulatory Commission
GHG	Greenhouse Gas
GoI	Government of India
GST	Goods and Services Tax
Gt	Gigatonnes
GW	Giga Watt
HVRT	High Voltage Ride Through
IEA	International Energy Agency
IIT	Indian Institute of Technology
IMG	Inter-Ministerial Group
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
LVRT	Low Voltage Ride Through
MCLR	Marginal Cost of Funds based Lending Rate
MDB	Multilateral Development Bank
MGO	Mini Grid Operator
mn	Million
MNES	Ministry of Non-Conventional Energy Sources
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	Mega Watt
NAPCC	National Action Plan on Climate Change
NBFC	Non-Banking Financial Company
NCEEF	National Clean Energy and Environment Fund
NEP	National Energy Policy/ National Electricity Plan
NHPC	National Hydroelectric Power Corporation
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
PDN	Public Distribution Network
PFC	Power Finance Corporation
PGCIL	Power Grid Corporation of India Limited
PPA	Power Purchase Agreement
PSU	Public Sector Undertaking
PTC	Power Trading Corporation of India
PV	Photovoltaic
PwC	Price Waterhouse Cooper
RBI	Reserve Bank of India
RE	Renewable energy
REC	Rural Electrification Corporation
REC	Renewable Energy Certificate
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RLDC	Regional Load Dispatch Centre
RLMM	Revised List of Models and Manufacturers
RPO	Renewable Purchase Obligation
RPSSGP	Rooftop PV & Small Solar Power Generation Programme
SBI	State Bank of India
SECI	Solar Energy Corporation of India

SERC	State Electricity Regulatory Commission
SHP	Small Hydro Power
SNA	State Nodal Agency
SSS NIRE	Sardar Swaran Singh National Institute of Renewable Energy
TCD	Tonnes of Cane per Day
TPA	Tonnes per Annum
TWh	Terawatt Hours
UK	United Kingdom
UNEP	United Nations Environment Programme
UNEP SEFI	UNEP Sustainable Energy Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UPERC	Uttar Pradesh Electricity Regulatory Commission
US	United States
USD	United States Dollar
VAT	Value Added Tax
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

India's estimated potential for electricity generation from renewables is 900 GW. The target set by the Government of India for capacity addition from RE-based electricity generation is 175 GW by 2022. This comprises 100 GW from solar (60 GW from ground-mounted and 40 GW from rooftop), 60 GW from wind, 10 GW from biomass and 5 GW from small hydro. If this target is realized, the 327 billion units (BU) of electricity thus generated will cover 20% of total demand by 2022.

ELECTRICITY GENERATION

As of 31 March 2017, the installed power generation capacity from renewables in India was 57.24 GW (57,244 MW). This comprised 32.2 GW (32,279 MW) of wind (56.39%), 12.2 GW (12,288 MW) of solar (21.47%), 4.3 GW (4,379 MW) of small hydro (7.65%), 8.1 GW (8,181 MW) of bio-power (14.29%) and 0.11 GW (114 MW of waste-to-energy) (0.2%). **The capacity added during 2016-17 was a record 11,320 MW** (5525 MW solar, 5502 MW wind, 161 MW bio-power, 106 MW small hydro and 23 MW waste-to-energy). **In 2016-17, electricity generation from renewables was 81.88 BU, a 24.47% increase from 67.58 BU generated in 2015-16. For the first time in India, capacity addition from renewables (11.3 GW) surpassed the capacity added from conventional sources (10.3 GW) in 2016-17.**

Renewables now contribute 6.59% of the electricity generated in the country. A major development is the decision to allot setting up of 15,000 MW of grid-connected solar PV plants to the National Thermal Power Corporation (NTPC). Of this, total 3,000 MW capacity has been allotted across Andhra Pradesh, Karnataka, Rajasthan, Telangana and Uttar Pradesh, as on 31 December 2016. NTPC is also executing EPC projects for installing grid-connected solar projects under various schemes.

POLICY AND REGULATION

2016-17 was a year of major policy initiatives in India. Two important developments that took place were the policy for repowering of wind projects and the draft wind-solar hybrid policy. The repowering policy provides similar incentives to old wind power projects of capacity 1 MW or below as those provided to new projects, while the draft wind-solar hybrid policy aims to achieve wind-solar hybrid capacity of 10 GW by 2022. The year also marked the introduction of the first national-level draft mini/microgrid policy which aims to address the concerns of energy service companies regarding future extension of the grid in their area of operation. Another important development was the inclusion of renewable energy into the GST tax regime which annulled all previous individual taxes levied on renewable energy. While the 2015 decision to confer priority sector lending status to renewables continued to have a positive impact on the sector, the decisions to reduce accelerated depreciation benefit on renewables from 80% to 40%, do away with generation based incentives for wind power from 1 April 2018, and divert the proceeds collected from the National Clean Energy and Environment Fund to compensate the states for GST losses, could negatively impact development of renewables in the short-term.

The migration from the feed-in tariff mechanism to competitive bidding for solar power procurement under JNNSM Phase I and II was a major policy shift. Tariff discovery of solar power continued from 2012 through 2017 and was successful in moving solar power towards grid parity. In 2012, under JNNSM Batch-I of Phase-I, the quoted tariff was ₹10.95 per kWh. In the last bid in 2017 (REWA Project in Madhya Pradesh), the tariff discovered was ₹3.3 per kWh which was one-third of the Phase-I tariff. These low rates were also facilitated by a drastic reduction in capital costs from ₹17 lakhs/MW in 2012 to ₹5.3 lakhs/MW in 2016-17. The tariff policy announced by the Ministry of Power, Government of India, on 28 January 2016, went one step further in prescribing procurement of power by all states from all RE sources through competitive bidding, except for waste-to-energy projects. Consequently, in February 2017, competitive bidding for wind power procurement was also introduced by SECI at the national level, in which wind tariffs touched a record low of ₹3.46 per kWh. Thereafter, this trend picked up at state levels too. **Overall, it can be said that renewables are moving towards grid parity.** Pursuant to the revised Tariff Policy on 22 July 2016, the Ministry of Power notified the long-term growth trajectory of RPO for solar and non-solar sectors for the next three years viz. 2016-17 to 2018-19. This was another significant positive development during the year.

MANUFACTURING

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 1,468 MW) and assembling of solar PV modules (installed capacity of 4,307 MW). Considering the installed capacity of 5,525 MW in 2016-17, the industrial capacity in the sector is very inadequate. More significantly, manufacturing of upstream elements in the supply chain, like polysilicon and wafers are absent in India. Creating such a vertically integrated supply chain would be critical to future sustainability of the sector. In contrast, wind has an installed manufacturing capacity of 12,000 MW; however, the supply chain of components needs to be augmented. Special policy focus is therefore needed to support domestic RE manufacturing and export. In both solar and wind, exports declined drastically from 2008 to 2016, with almost 84% of solar panels being imported during 2016-17.

INVESTMENT FLOWS

An estimated ₹7,11,533 million was invested as debt and ₹3,04,943 million was invested as equity in the renewable energy sector. The largest estimated investment is seen in the solar sector with ₹3,34,602 million debt and ₹1,43,401 million equity. Interest rates on loans offered by NBFCs were marginally lower than that by banks. While ECB was US$429 million, multilateral development banks contributed significantly viz. ADB (57%), World Bank (32%) and European Investment Bank (11%). In a major development, NTPC and IREDA went ahead to issue green bonds during FY 2016-17.

EMISSIONS SECNARIO

With India committing to 33-35% emissions intensity reduction by 2030 (INDCs), renewable power generation is seen as an important contributor to emissions reduction. Based on the assumption that wind and solar (the largest contributors to capacity addition in renewables in 2016-17) replaced coal-based generation, it is estimated that avoided CO_2 emissions were approximately 62.72 million metric tonnes in the current year. Further, around 256.95 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.

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INTRODUCTION AND SCOPE

Renewables India 2017: Towards Grid Parity, provides a holistic snapshot of the status of grid-connected renewable energy in India for the year 2016-17. 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. It is 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 the financial year 2016-17 from April 2016 to March 2017.

Chapter 1 provides the status of renewable electricity (grid and off-grid) in 2016-17. Starting with a brief global overview of RE and moving on to presenting India's targets and achievements in capacity addition and installed capacity, the chapter provides a critical overview of grid-based electricity generation in India (conventional and renewable), concluding with a summary on off-grid electricity in the country.

Chapter 2 summarizes the policy landscape of grid-connected renewables in 2016-17, reviewing the status of different policies and fiscal/financial incentives across states, along with their impact on RE development in India. A section on the status of off-grid policy and regulation is also included.

The regulatory framework for grid-connected renewables has been evolving rapidly with the increasing share of renewables in the total energy mix. Chapter 3 delves into the different regulatory processes that guided grid-connected renewable energy development in India in 2016-17, namely tariff regulations, Renewable Energy Obligation (RPO) and Renewable Energy Certificate (REC) Mechanism, Open Access (OA) regulations, and forecasting and scheduling regulations, besides net metering regulations for decentralized rooftop solar projects. A brief analysis of state RPO compliance for the year is also made in the chapter.

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 4 to capture data on wind and solar manufacturing—the two sectors that were responsible for the largest capacity addition in 2016-17—focusing on the wind and solar industry supply chains and exports/imports in the wind and solar sectors.

Chapter 5 dwells on the investment flows in renewables in 2016-17. For the first time, an effort has been made to provide a holistic overview of investments made in the RE sector, both through debt as well as equity funding. The chapter showcases and reviews the basket of investments that were provided for renewables in 2016-17, and analyses its adequacy in financing RE development in India.

Chapter 6 is a slight deviation from the rest of the report. The growing concerns of rapidly increasing greenhouse gas emissions, especially from the use and production of energy, has positioned climate change as a focal point in India's energy discourse. It was, therefore, considered essential to provide a brief perspective of this critical interlinkage (between energy and climate), since energy is key to India's current and future developmental goals. The chapter focuses on India's emissions scenario (especially from the energy sector) and the role of renewable energy (wind and solar) in emissions reduction.

1.
ELECTRICITY GENERATION

The energy sector worldwide is on the cusp of a major transition. This is triggered by long-term concerns of fossil fuel depletion, energy security, climate change and sustainability of development. India is also a major participant in this global transition. In this chapter, in the background of an overview of global developments in the renewable sector, the chapter analyses renewables in India as it evolved during financial year 2016-17 by juxtaposing it with historical developments in the country.

1.1 RENEWABLE ENERGY: GLOBAL OVERVIEW

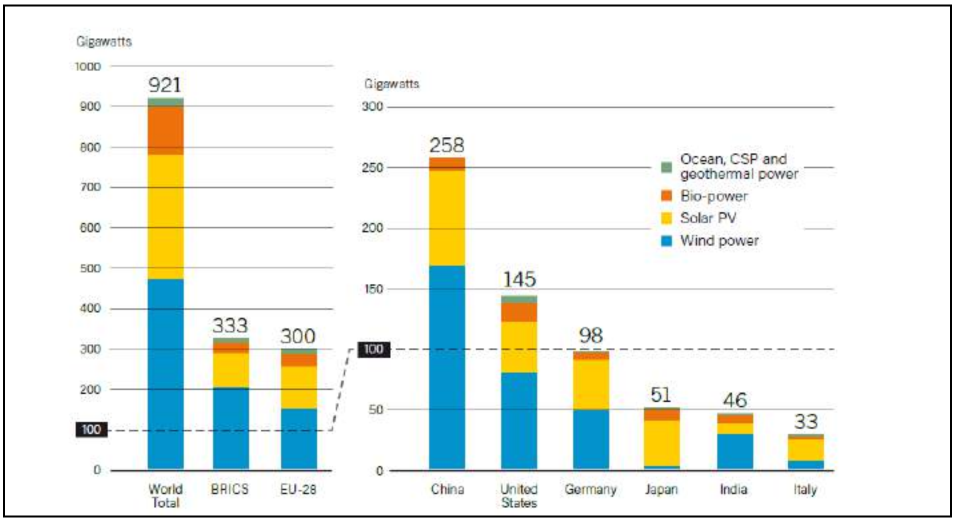
In 2016, an estimated 161 GW (including large hydro) of renewable energy capacity was added worldwide. This is the largest annual increase till date, up almost 9% compared to 2015, taking the cumulative installed renewable capacity to nearly 2,017 GW (including large hydro) at the end of 2016.[1] Solar PV dominated the landscape with 47% of newly installed renewable power capacity, while wind and hydropower accounted for about 34% and 15.5% respectively. Thus, renewables accounted for an estimated 62% of net additions to global power generating capacity in 2016. In India, wind power and solar PV capacity increased substantially, and bio-power generation was up 8% as compared to 2015. Top 6 RE countries is summarised in Fig.1.1.

If large hydro is accounted for, top countries for total installed renewable electric capacity continued to be China, the United States, Brazil, Germany and Canada. Excluding hydro, the top countries were China, the United States and Germany, followed by Japan, India and Italy, and Spain and the United Kingdom.

In 2016, global new investments in renewables (excluding large hydro) fell by 23% to $241.6 billion, the lowest since 2013, but roughly double that of fossil fuel generation for the fifth consecutive year. New investment in solar totalled $113.7 billion, down 34% from 2015. Wind followed closely at $112.5 billion globally, down 9% from 2015, biofuels $2.2 billion (down 37%), biomass and waste $6.8 billion (remained steady) and small hydro $3.5 billion. A combination of two factors, viz. lower costs of technologies (a positive trend), and considerable slowdown of renewable energy financing in some emerging markets like China and Japan (a negative trend), were the key reasons for fall in investments in 2016. The bright spot in investments was seen in assets financing, which totalled $110.3 billion, up 17% from 2015. Purchase of assets such as wind farms and solar parks reached a highest-ever figure of $72.7 billion, while corporate takeovers reached $27.6 billion, 58% up from 2015.[1]

Tables 1.1 and 1.2 ranks countries as per capacity addition in 2016 and cumulative installed capacity till end 2016 respectively. China is undoubtedly seen as the leader in the RE sector, topping both in cumulative and annual capacity addition (solar, wind, and hydro), while India ranks 4th in terms of cumulative installed capacity of wind, and annual capacity addition of solar PV and wind in 2016.

Figure 1.1: Top Six Countries and their RE Installed Capacity (2016)



Source: Renewables 2017, Global Status Report

Table 1.1: Country Ranking by Capacity Addition in 2016

	1		2		3		4		5		World
		GW		GW		GW		GW		GW	GW
Geothermal	Indonesia	0.2	Turkey	0.2	Kenya	0.03	Mexico	.015	Japan	.001	0.447
Hydropower	China	8.9	Brazil	5.3	Ecuador	2.0	Ethiopia	1.5	Vietnam	1.1	25
Solar PV	China	34.5	US	14.8	Japan	8.6	India	4.1	UK	2	75
Wind	China	23.4	US	8.2	Germany	5	India	3.6	Brazil	2	55
Bio-Diesel	US	-	Brazil	-	Argentina	-	Germany	-	Indonesia	-	-

Source: Renewables 2017, Global Status Report

Table 1.2: Country Ranking by Cumulative Installed Capacity (2016)

	1		2		3		4		5		World
		GW		GW		GW		GW		GW	GW
Geothermal	US	3.6	Philippines	1.9	Indonesia	1.6	New Zealand	1.0	Mexico	0.9	13.5
Hydropower	China	305	Brazil	97	US	80	Canada	79	Russia	48	1096
Solar PV	China	77.4	Japan	42.8	Germany	41.3	US	40.9	Italy	19.3	303
Wind	China	168.7	US	82.1	Germany	49.5	India	28.7	Spain	23.1	487
Bio-Power	US	-	China	-	Germany	-	Brazil	-	Japan	-	-

Source: Renewables 2017, Global Status Report

1.2 INDIA: RE POTENTIAL, TARGETS & ACHIEVEMENTS

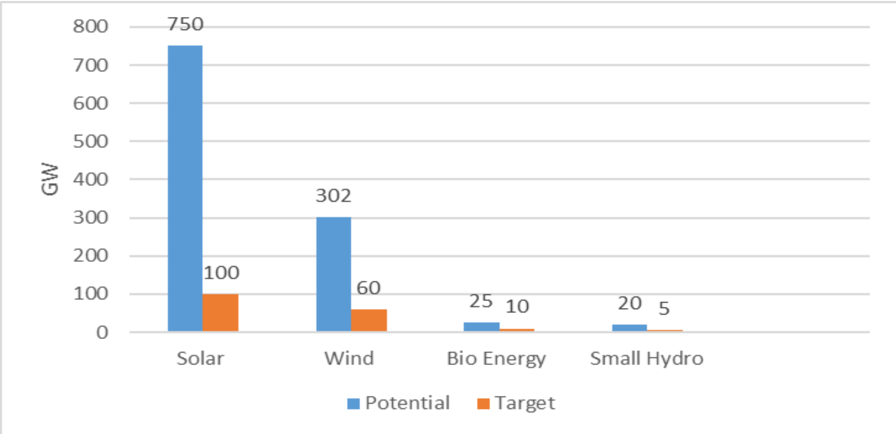
1.2.1 Renewable Energy Potential

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 (considering use of 3% wasteland for solar installations) followed by wind with 102 GW (at 80-meter mast height). The National Institute of Wind Energy (NIWE) has revised the estimate for wind power to 302 GW at 100m mast height. Potential for small hydro and bioenergy is 20 GW and 25 GW respectively. [2]

1.2.2 Renewable Targets and Achievements

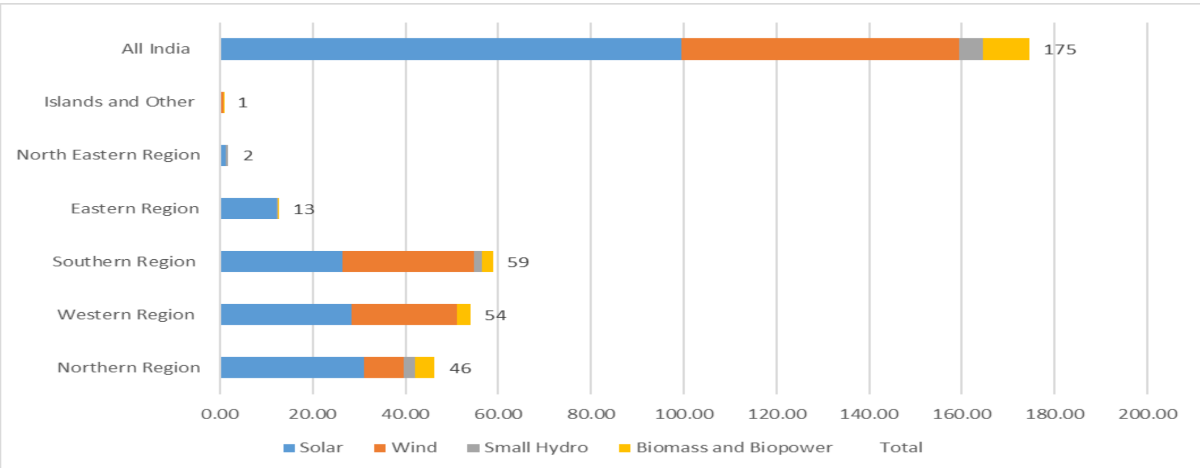
In the 2015 union budget, the Government of India set the target of achieving 175 GW by 2022. The target comprises 60 GW from wind, 100 GW from solar, 10 GW from biomass, and 5 GW from small hydro. Out of 100 GW solar, 40 GW is estimated from rooftop solar while remaining 60 GW is from ground-mounted, grid-connected medium and large solar projects. Fig 1.2 gives the potential for renewable energy vis-à-vis the RE target. Region-wise targets have also been detailed as shown in Fig. 1.3. Similarly, Table 1.3. shows the annual capacity addition targets from 2014-15 to 2021-22.[2]

Figure 1.2: Renewable Energy Potential vs 2022 Target (GW)



Source: WISE, 2017 (compiled from MNRE Annual Report 2017)

Figure 1.3: Region-wise Targets to Achieve 175 GW by 2022



Source: WISE, 2017 (compiled from MNRE data)

Table 1.3: Year-wise and Technology-wise Capacity Addition Targets to 2022 (Grid-connected RE only)

Year	Rooftop Solar	Ground-Mounted Solar	Solar	Wind	Small Hydro	Biomass	Total
	(GW)	(GW)	(GW)	(GW)	(GW)	(GW)	(GW)
Cumulative installed capacity by 2014-15			3	24	4.1	4.4	35.5
2015-16	0.2	1.8	2	3.2	0.14	0	5.3
2016-17	4.8	7.2	12	3.6	0.14	0.9	16.7
2017-18	5	10	15	4.1	0.14	0.9	20.2
2018-19	6	10	16	4.7	0.14	0.9	21.8
2019-20	7	10	17	5.4	0.14	0.9	23.5
2020-21	8	9.5	17.5	6.1	0.14	0.9	24.7
2021-22	9	8.5	17.5	8.9	0.14	0.9	27.5
Total	**40**	**60**	**100**	**60**	**5.08**	**9.98**	**175**

Source: Report on 175 GW RE by 2022, NITI Aayog, 2015

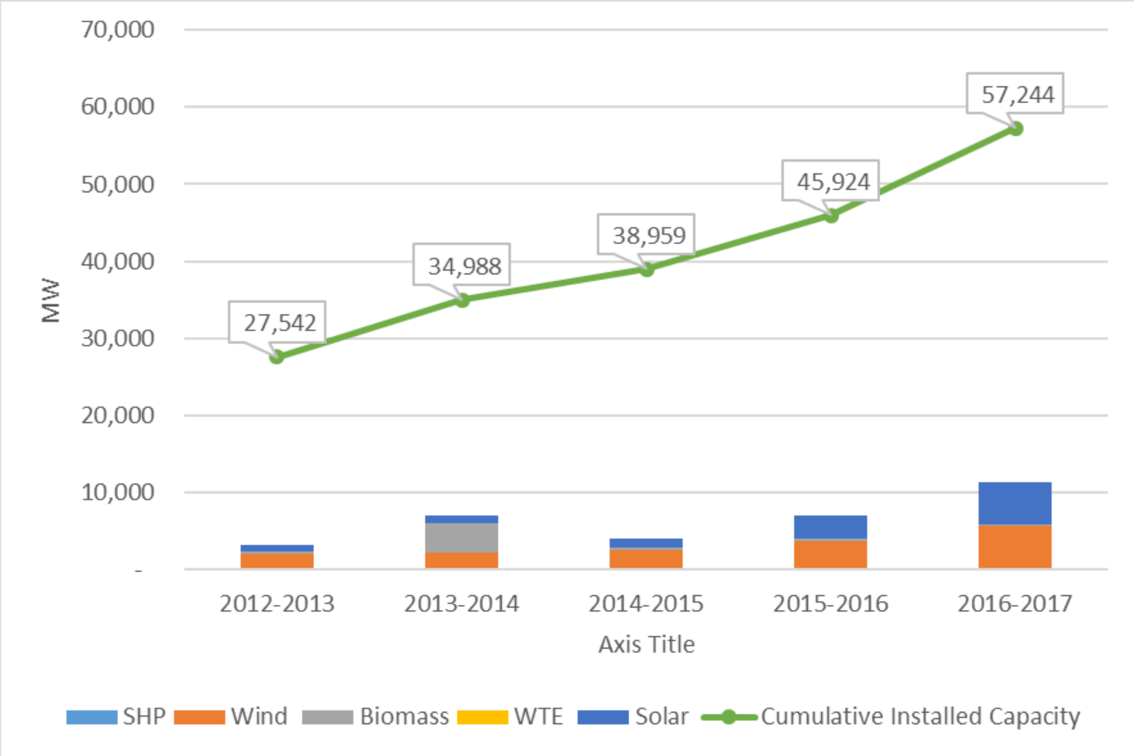
If the target of 175 GW by 2022 is achieved, it would contribute to achieving 19.44% of the total RE potential of 900 GW and about 20.3% of electricity in the total demand. This would mean generation of around 327 BU of electricity (162 BU from solar, 112 BU from wind, 38 BU from biomass, 15 BU from SHP).[3]

Southern, western, and northern regions of India are expected to install more than 91% of the total target while remaining is expected to be contributed by north-eastern and eastern regions. Maharashtra has the highest target of 22 GW followed by Tamil Nadu with 21.5 GW (Fig 1.3).

For the 12th Plan period (2012-17) a capacity addition target of 30,000 MW was set by the Government of India, which included 10 GW from solar, 15 GW from wind and 5 GW from other renewable energy sources. Against this target, India achieved 32.7 GW of grid-connected renewable energy capacity addition. This included 15 GW wind, 11.3 GW solar, 5.3 GW bio-power and WTE, and 1 GW SHP.

From 27.5 GW in 2012-13, total installed grid-connected renewable energy capacity reached 57.2 GW at the end of 2016-17, with over 20% annual average growth rate in the last five years. (Fig.1.4). With this, RE now contributes 17.51% of the total installed power generation capacity in the country. Wind accounted for 32.2 GW (32,279.77 MW) or 56.39% of renewable installed capacity, followed by solar with 12.28 GW (12,288.83 MW) or 21.47%, small hydro 4.37 GW (4,379.86 MW) (7.65%), while biomass with cogeneration and waste-to-energy (WTE) comprised 8.18 GW (8,181.70 MW) (14.29%) and 0.11 GW (114.08 MW) (0.2%) respectively (Table 1.4).[4]

Figure 1.4: Annual Capacity Addition and Cumulative Installed Capacity of Grid-Connected RE 12th Plan Period (2012-2017)



Source: WISE, 2017 (compiled from MOSPI, CEA data)

Table 1.4: Status of Grid-Connected Renewable Energy (as on 31 March 2017)

Sector	Achievements (MW)	Share in Total RE Capacity (%)
Wind Power	32,279.77	56.39%
Solar Power	12,288.83	21.47%
Small Hydro Power	4,379.86	7.65%
Bio Power (Biomass & Gasification and Bagasse Cogeneration)	8,181.70	14.29%
Waste to Energy	114.08	0.2%
Total	**57,244.24**	100%

Source: Installed Capacity March 2017, CEA

State-wise, Tamil Nadu topped the list with 10.6 GW (10,625 MW) RE installed capacity, followed by Maharashtra with 7.6 GW (7,647.60 MW) and Karnataka 7.4 GW (7,457.97 MW). List of state-wise/UT-wise installed capacity is provided in Table 1.5.

Table.1.5: State & U.T. Wise Targets and Installed Capacity (As of 31 March 2017)

		RE Target 2022	Installed Capacity by March 2017 (MW)		
			State Sector	Private Sector	Total
1	Delhi	2,762	-	56.27	56.3
2	Haryana	4,376	59.30	192.00	251.3
3	Himachal Pradesh	2,276	256.61	575.93	832.5
4	Jammu & Kashmir	1,305	108.03	51.36	159.4
5	Punjab	5,066	127.80	1,025.30	1,153.1
6	Rajasthan	14,362	23.85	6,213.95	6,237.8
7	Uttar Pradesh	14,221	25.10	2,274.73	2,299.8
8	Uttarakhand	1,797	62.87	452.94	515.8
9	Chandigarh	153	-	17.32	17.3
Northern Region Total		**46,318**	**663.56**	**10,859.80**	**11,523.4**
10	Goa	358	0.05	0.71	0.8
11	Gujarat	17,133	8.00	6,663.89	6,671.9
12	Chhattisgarh	1,808	11.05	421.81	432.9
13	Madhya Pradesh	12,018	83.96	3,453.93	3,537.9
14	Maharashtra	22,045	208.13	7,439.47	7,647.6
15	D&N Haveli	449	-	2.97	3.0
16	Daman & Diu	199	-	10.46	10.5
Western Region Total		**54,010**	**311.19**	**17,993.24**	**18,304.4**
17	Andhra Pradesh	18,477	89.50	6,074.92	6,164.4
18	Telangana	2,000	-	1,545.88	1,545.9
19	Karnataka	14,817	155.33	7,302.64	7,458.0
20	Kerala	1,970	145.02	193.70	338.7
21	Tamil Nadu	21,508	122.70	10,502.30	10,625.0
22	Puducherry	246	-	0.08	0.1
Southern Region Total		**59,018**	**512.55**	**25,619.52**	**26,132.1**
23	Bihar	2,762	70.70	221.52	292.2
24	Jharkhand	2,005	4.05	23.27	27.3
25	Odisha	2,377	6.30	188.15	194.5
26	West Bengal	5,386	91.95	332.69	424.6
27	Sikkim	86	52.11	-	52.1
Eastern Region Total		**12,616**	**225.11**	**765.63**	**991.7**
28	Assam	688	30.01	15.88	45.9
29	Manipur	105	5.45	0.03	5.5
30	Meghalaya	211	31.03	0.01	31.0
31	Nagaland	76	30.67	0.50	31.2
32	Tripura	105	16.01	5.09	21.1
33	Arunachal	539	104.61	0.27	104.9
34	Mizoram	97	41.47	0.10	41.6
North Eastern Region Total		**1,821**	**259.25**	**21.88**	**281.1**
35	Andaman & Nicobar	27	5.25	6.56	11.8
36	Lakshadweep	4	-	0.7	0.7
Islands Total		**31.0**	**5.25**	**6.73**	**12.5**
37	Others	720			
All India Total		**174,534.0**	**1,976.91**	**55,267.33**	**57,244.24**

Source: CEA, Installed Capacity, March 2017

1.2.3 Capacity addition in 2016-17

For 2016-17, the capacity addition target for grid-connected power was 16,660 MW: wind 4000 MW, solar 12,000 MW, small hydro 250 MW, bio-power 400 MW and waste-to-energy 10 MW. As against this, the actual capacity installed in 2016-17 was 11,320 MW, the technology-wise break-up of which is in Table 1.6. [2]

Table.1.6: Capacity Addition in 2016-17
(Grid Power only)

Sr. No.	Technology	Capacity Installed (MW)
1.	Solar	5525.98
2.	Wind	5502.37
3.	Biomass	161.95
4.	Small Hydro	106.39
5.	Waste to Energy	23.50
	Total	**11320**

Source: WISE, 2017 (compiled from CEA data)

Out of the total 5502.37 MW of wind power, maximum installations took place in the following top six states: Andhra Pradesh (2179.45 MW), Gujarat (1391.65 MW), Karnataka (905.55 MW), Madhya Pradesh (356.70 MW), Rajasthan (287.70 MW) and Tamil Nadu (256.13 MW). The balance was added in Maharashtra, Telangana and Kerala. While Andhra Pradesh (445%), Gujarat (255%) and Karnataka (292%) registered massive growth, Madhya Pradesh (-72%), Rajasthan (-58%), Maharashtra (-55%) and Telangana (-70%) registered huge decline compared to the previous year. With the addition of 5502.37 MW, wind power reached cumulative installations of 32,279.77 MW in 2016-17 with a total of 27,720 MW to be installed to achieve the 60 GW target upto 2022.[5]

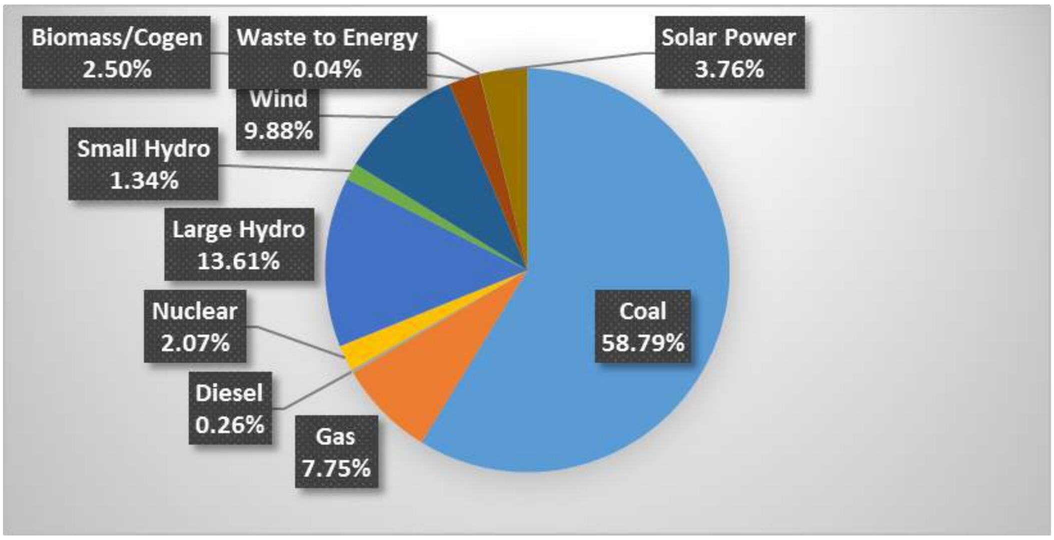
With the installation of 5525 MW in 2016-17, cumulative installed capacity of solar power in India reached 12,288.83 MW. This was a quantum jump over the previous year. The six leading solar power states in India, in terms of installed capacity are Tamil Nadu, Rajasthan, Gujarat, Telangana, Andhra Pradesh and Madhya Pradesh. During the next five years, 87,712 MW capacity will have to be installed to achieve the 100 GW target by 2022. According to the Bridge to India report, out of the 12,288 MW installed so far, the investor profile and share is as follows: Indian corporates (47%), private equity backed IPPs (25%), international developers (18%) and public sector developers (10%). Public sector companies like NTPC have started investing in the sector, which is a good development.[6]

1.3 ELECTRICITY GENERATION

1.3.1 Installed Capacity Mix

India is the world's third largest producer of electricity, having total installed capacity of 326,832.55 MW. Of this, 66.80% is from thermal energy (58.79% from coal, 7.75% from gas and 0.26% from oil), 2.07% from nuclear power, 13.61% from large hydro, and 17.51% from other renewables (Fig 1.5 and Table 1.7).

Figure 1.5: Source-wise Installed Capacity (March 2017)



Source: CEA, Installed Capacity, March 2017

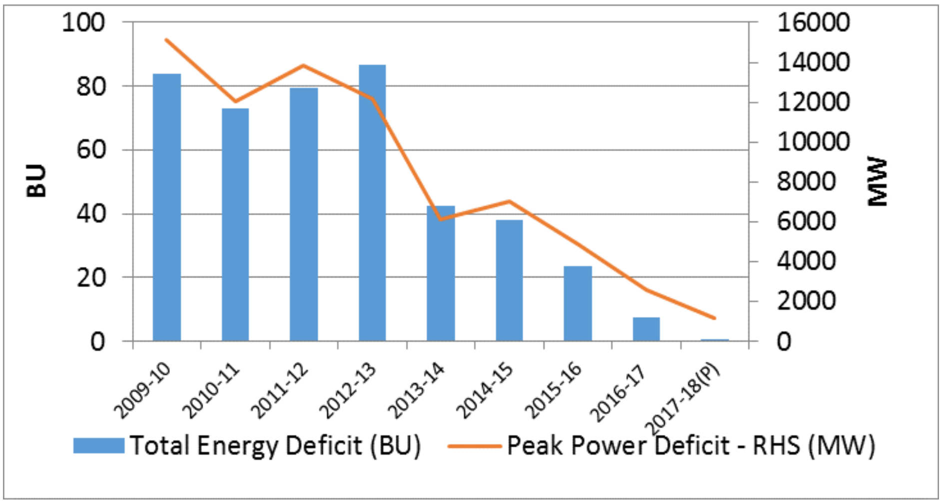
Table 1.7: India Electricity Capacity–Mix

Source	Installed Capacity (MW)	% of Total Installed Capacity
Coal	192,162.88	58.79%
Gas	25,329.38	7.75%
Diesel	837.63	0.26%
Total Thermal	218,329.89	66.80%
Nuclear	6,780.00	2.07%
Hydro	44,478.42	13.61%
Small Hydro	4,379.86	1.34%
Wind	32,279.77	9.88%
Biomass/Cogen	8,181.70	2.50%
Waste to Energy	114.08	0.03%
Solar Power	12,288.83	3.76%
Total Renewable (Excluding Hydro)	57,244.24	17.51%
Grand Total India	**326,832.55**	**100.00%**

Source: CEA, Installed Capacity, March 2017

Peak power deficit in India reduced from 15.1 GW (15,157 MW) (12.7%) in 2009-10 to 2.6 GW (2,608 MW) (1.6%) in 2016-17, and total energy deficit fell from 83.95 BU (10.1%) in 2009-10 to 7.59 BU (0.7%) in 2016-17. The power supply trend from 2009-10 to 2016-17 is represented in Figure 1.6. [7]

Figure 1.6: Peak Power and Energy Deficit Trend (2009-10 to 2016-17)

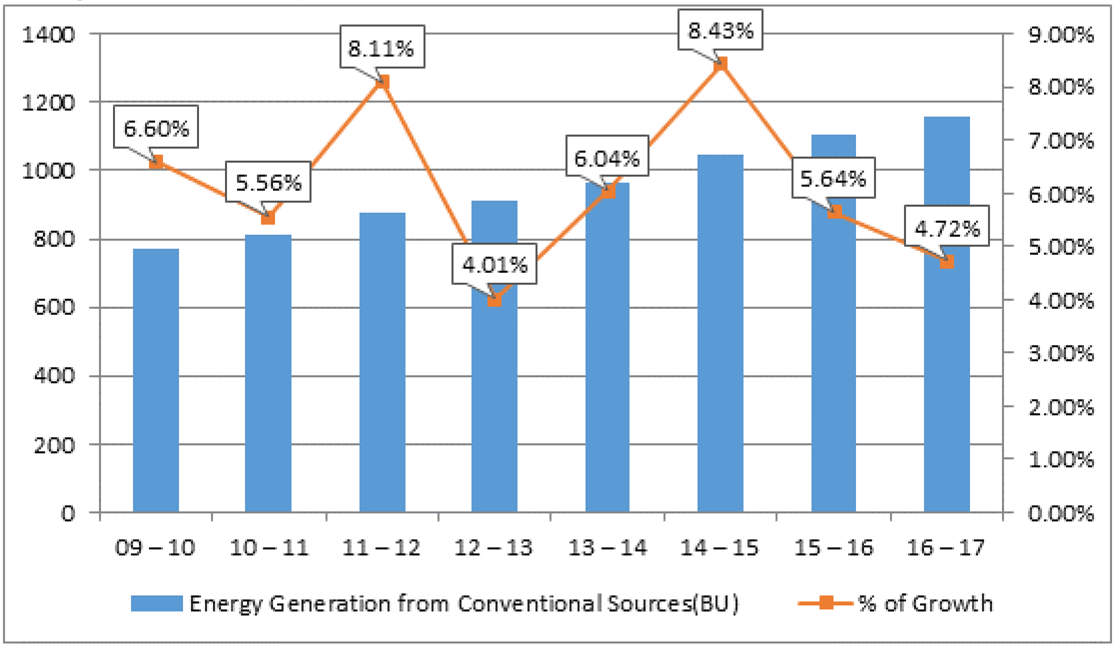


Source: Minstry of Power website, 2017

1.3.2 Generation from Conventional Sources

The total electricity generation from conventional sources in India in 2016-17 was 1,160.141 BU. This was a growth of 4.72% over the 1107.8 BU generated in 2015-16. The performance of conventional sources in electricity generation during the last decade is shown in Fg.1.7.[7]

Figure 1.7: Electricity Generation from Conventional Sources (2009-10 to 2016-17)



Source: Minstry of Power website, 2017

1.3.3 Generation from Renewable Energy

For the last three years, electricity generation from renewable energy sources has been rising rapidly. In 2016-17, total RE generation in India was 81.88 BU, up from 65.78 BU in 2015-16. This marked a 24.47% growth from 2015-16. Though electricity generation from solar almost doubled in

2016-17, wind continued to dominate renewable electricity generation in India. Share of wind in total RE electricity generation increased from 50.21% in 2015-16 to 56.19% in 2016-17. In the same period, share of solar increased from 11.32% to 16.49%, with biomass, small hydro and waste-to-energy accounting for 17.28%, 9.68% and 0.37% respectively. (Table 1.8).

Table 1.8: Renewable Electricity Generation (BU) with % Share in Total RE Electricity (2014-15 to 2016-17)

	Wind		Solar		Biomass		Small Hydro		Waste-to-Energy		Total	% Growth
	BU	%	BU	%	BU	%	BU	%	BU	%	BU	
2014-15	33.77	54.65	4.60	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	12.70	0.27	0.41	65.78	6.47
2016-17	46.00	56.19	13.50	16.49	14.15	17.28	7.92	9.68	0.30	0.37	81.88	24.47

Source: WISE, 2017 (compiled from CEA reports)

1.3.4 Renewables vis-à-vis Conventional Electricity Generation

During 2015-16 and 2016-17 the share of electricity generation from renewable energy improved from 5.61% to 6.59% of the total generation. The significant point is the growth in generation from renewables which achieved a quantum jump of 24.47% in 2016-17 compared to the previous year. In contrast, the growth in generation from conventional sources declined from 5.64% in 2015-16 to 4.72% in 2016-17 (Table 1.9).

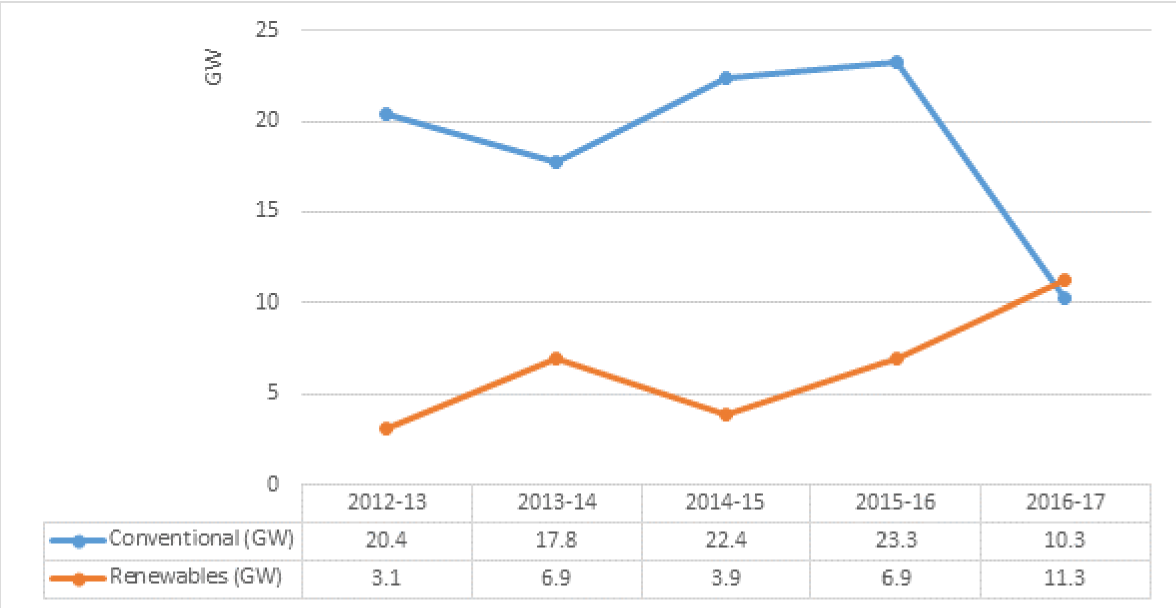
Table 1.9: Generation from Conventional & RE Sources

	Total Generation (BU)	Conventional Sources (BU)	Growth in Conventional (%)	Renewable Sources (BU)	Growth in Renewables (%)	Conventional share in total %	Renewable 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

Source: WISE, 2017 (compiled from CEA reports and Ministry of Power website)

According to the recent report published by the Ministry of Power, Govt. of India, for the first time in 2016-17, renewable capacity addition at 11.3 GW exceeded that of conventional energy, which was only 10.3 GW. (Figure 1.8). [8]

Figure 1.8: Capacity Addition in 12th Five-Year Plan Period (2012 – 2017)



Source: WISE, 2017 (compiled from Ministry of Power and CEA data)

1.4 OFF-GRID RENEWABLE POWER

With the advent of the *Rajiv Gandhi Grameen Vidyutikaran Yojana* (Now *Deen Dayal Upadhyay Gram Jyoti Yojana*) in 2005, India achieved rapid electrification of villages across the country. However, even after grid extension in the identified regions, a large number of households still remain without access to electricity. India currently has approximately 77 million households who lack adequate access to grid-connected electricity and about 20 million underserved households who receive less than four hours of electricity in a day (Census 2011, India). While grid connectivity is expected to improve over the next 10 years, at the current rate of grid expansion, urbanization and population growth, a large share of households will still not have access to reliable electricity in the near future. Thus, expansion of renewable-based, off-grid electricity in India assumes an important role in India's electrification process.

MNRE offers incentives and subsidies for promotion of off-grid electricity solutions. However, these systems have been promoted by private players also who sell their products through dealers in the rural sector. Given the huge demand for electricity in electrified areas, private players will need to play a more significant role in expansion of off-grid systems in these areas in the years to come.

As per MNRE data, presently, there are more than 13.9 lakh home lighting systems, while renewable energy-based stand-alone power plants have an installed capacity of about 172 MWp. State/UT-wise status is given in Table 1.10.[9]

Table 1.10: State/UT-wise Status of Off-Grid Renewable Energy Systems

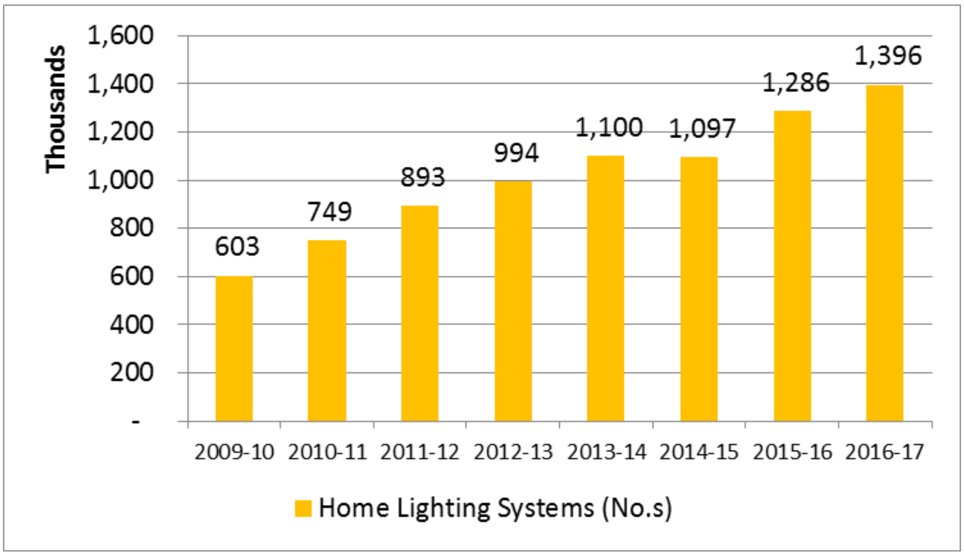
	State / UT	Solar Home Lighting Systems	Stand-Alone Renewable Energy-Based Power Plants
		Nos	**kWp**
1	Andhra Pradesh	22,972	3,785.595
2	Arunachal Pradesh	18,945	600.1
3	Assam	6,926	1,605
4	Bihar	12,303	3,968.6
5	Chhattisgarh	7,754	27,867.72
6	Delhi	0	1,269
7	Goa	393	32.72
8	Gujarat	9,253	13,576.6
9	Haryana	56,727	2,321.25
10	Himachal Pradesh	22,592	1,390.5
11	Jammu & Kashmir	65,319	7,719.85
12	Jharkhand	9,450	3,539.9
13	Karnataka	49,644	4,676.41
14	Kerala	40,412	13,894.39
15	Madhya Pradesh	4,016	3,654
16	Maharashtra	3,497	3,857.7
17	Manipur	3,900	1,241
18	Meghalaya	7,844	884.5
19	Mizoram	6,801	1,719
20	Nagaland	1,045	1,506
21	Odisha	5,274	567.515
22	Punjab	8,626	1,950
23	Rajasthan	1,51,964	10,850
24	Sikkim	15,059	850
25	Tamil Nadu	2,26,946	12,752.6
26	Telangana	0	5,368
27	Tripura	32,723	612
28	Uttar Pradesh	2,35,909	10,041.46
29	Uttarakhand	91,595	1,534.03
30	West Bengal	1,45,332	1,730
31	Andaman & Nicobar	468	167
32	Chandigarh	275	730
33	Lakshadweep	0	2,190
34	Puducherry	25	121
35	Others	24,047	23,885
36	NABARD	1,08,000	0
	Total	**13,96,036**	**1,72,458**

Source: MNRE Annual Report 2016-17

1.4.1 Growth Trajectory of Off-Grid RE Electricity

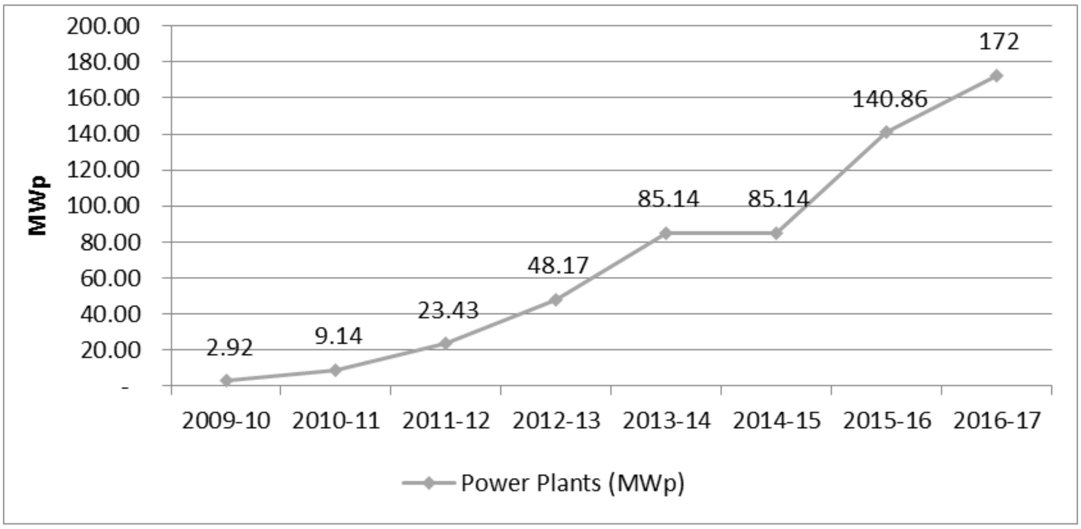
Like grid-connected RE, a major leap in installations can also be seen in the off-grid sector (Figures 1.9 and 1.10). With rapid decline in the cost of off-grid RE systems coupled with increased level of awareness among the rural masses, private and self-sponsored off-grid RE system installations are picking up due to market economics. From 603 systems with 2.92 MWp in 2009-10 to 1396 systems with 172 MWp, the growth has been significant. Such huge increase in capacity with fewer number of systems also signifies growth of larger sized rooftop solar systems in the country in the last few years.

Figure 1.9: Growth Trajectory of Off-Grid Home Lighting Systems (Numbers)



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

Figure 1.10: Growth Trajectory of Off-grid Power Plants (Capacity)



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

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2.
POLICY LANDSCAPE

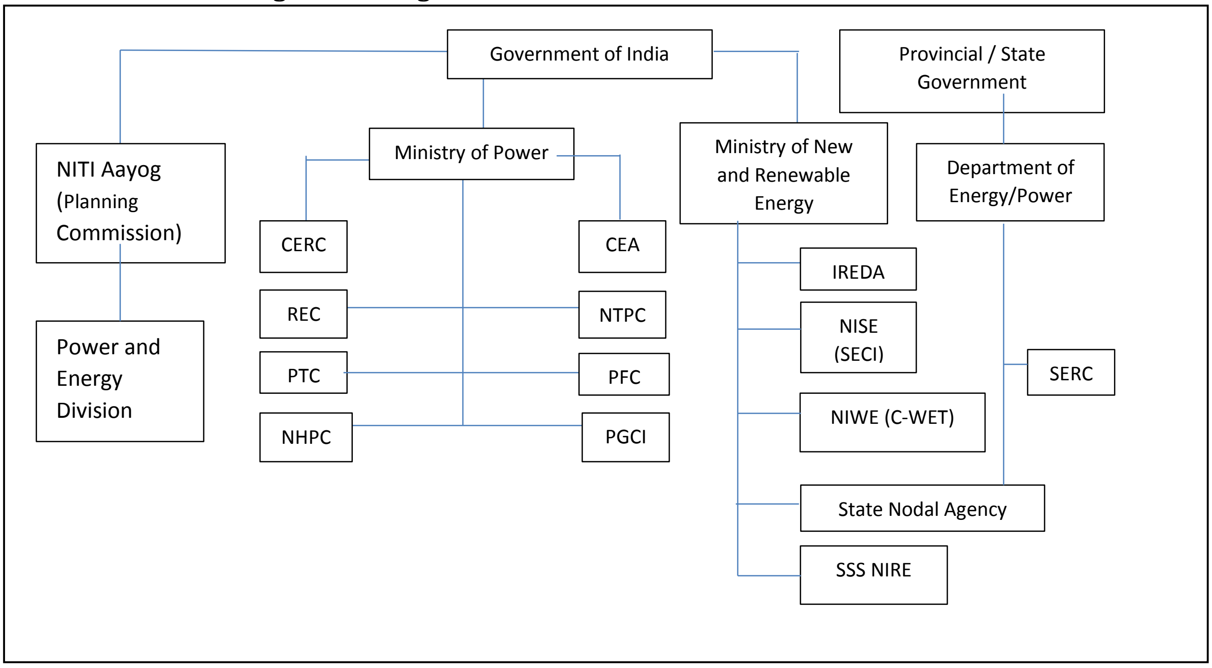
Policy initiatives by government are major catalysts in triggering technology transition. India has been an early mover in initiating policies for development of renewables, as also in establishing institutional structures for the same. Beginning with institutional structures in the power sector, this section surveys critical policy developments relating to renewables both at the national and state levels. While the national policy framework is the umbrella under which states operate, the real action takes place at the state level. Hence a detailed survey of state polices is included here. The year under review has been notable for many new policy initiatives spurring the growth of the sector. Here we try to capture the essence of it all.

2.1. NATIONAL POLICY FRAMEWORK

The planned development of renewable energy in India started in 1982, when the Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy to look after all aspects relating to new and renewable energy. The department was upgraded to a separate Ministry of Non-Conventional Energy Sources (MNES) in 1992 and was re-christened Ministry of New and Renewable Energy (MNRE) in October 2006. The current organizational structure of the power sector in India is represented in Figure 2.1.

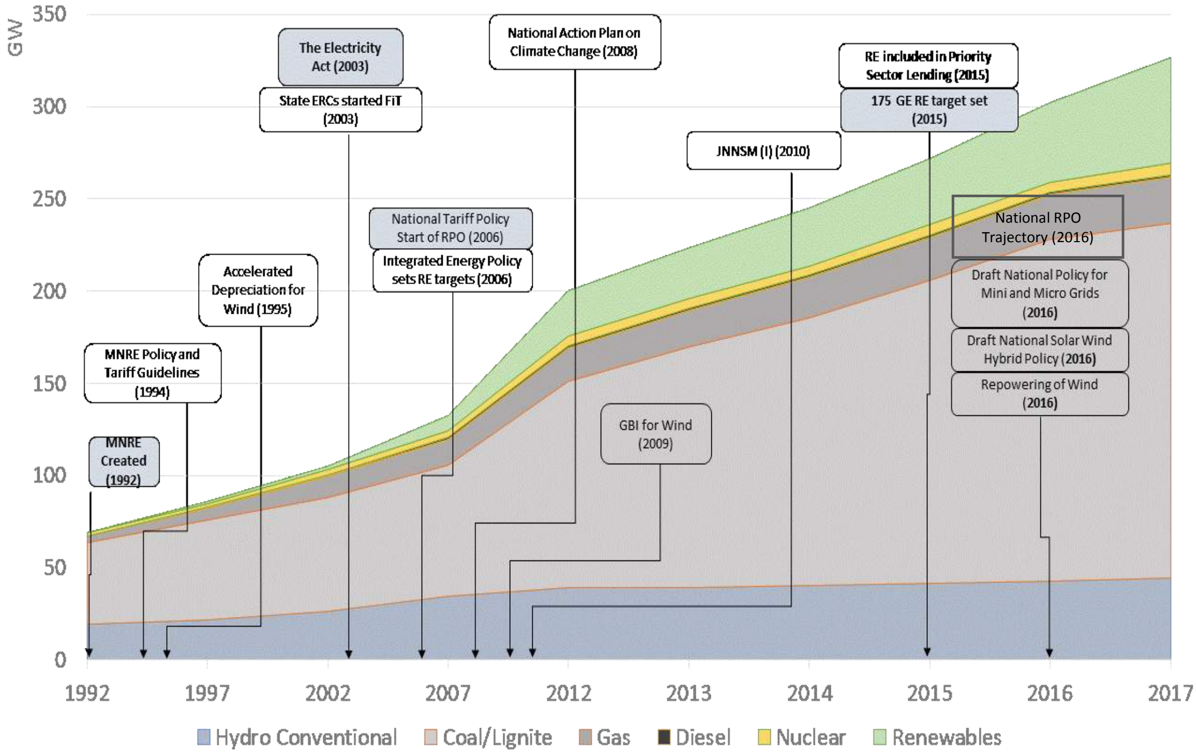
The introduction of feed-in tariff for wind power during the early 1990s was a milestone in India's journey towards mainstreaming renewable energy. With the enactment of the Electricity Act, 2003, (which is considered the 'umbrella' legislation for the power sector), renewable energy and the entire power sector got a major boost. The Act was the first legislation to give a clear direction on the development and integration of renewable energy into the grid.[1] In 2006, India got its National Tariff Policy through which the respective state commissions were entrusted with the responsibility of determining renewable purchase obligations for distribution companies at preferential tariff.[2] In 2008, the renewable energy sector got a further impetus with the advent of the National Action Plan on Climate Change (NAPCC).[3] The plan identified eight, core 'national missions' for sustainable development, of which one was the 'National Solar Mission', targeting a 20 GW solar capacity addition by 2022 (later revised to 100 GW). The national mission brought solar to the centre of the Indian renewable energy mix. While the annual capacity addition in wind power continued to dominate the RE scenario, the trend was reversed during 2016-17, when the capacity addition for solar power (5525 MW) exceeded wind power (5502 MW)[4], and the trend is likely to continue in future. A historical timeline of key policies instrumental in the development of RE is given in Figure 2.2. Figure 2.3 gives a representation of the historical growth of energy (RE and conventional) in India.

Figure 2.1: Organisational Framework of the Power Sector



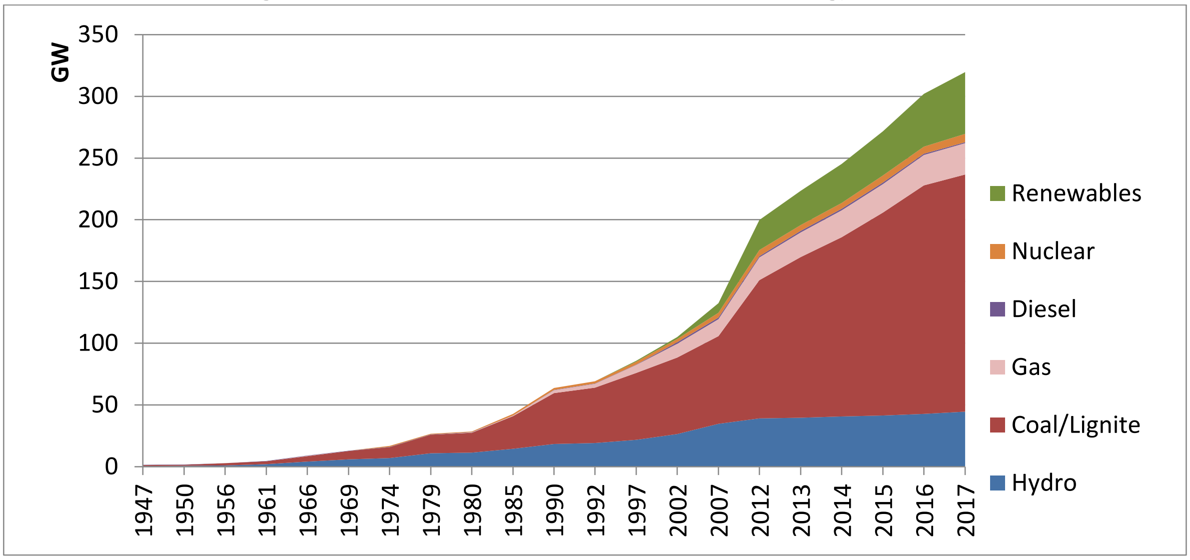
Source: WISE, 2016

Figure 2.2: Key Policies Instrumental in Development of RE in India - Timeline



Source: ESMAP, World Bank, 2010

Figure 2.3: Historical Growth of Renewable Energy in India



Source: CEA, 2017

2.2. POLICY SCENARIO ACROSS STATES

In India, besides the Electricity Act, 2003, the development of renewables is guided by two sets of policies: state government policies and central government policies. Of the 29 states and 6 union territories, 27 states and 2 union territories have declared state-level policies for renewable energy, some of which are integrated and some of which are technology-specific. Table 2.1 summarizes the policy landscape in India.[5]

Table 2.1: Policies Enacted in Various States and Union Territories

State	Wind	Solar thermal	Solar PV	Small hydro	Biomass	MSW	Integrated	Net metering	Micro/Mini Grid
Andaman and Nicobar							√		
Andhra Pradesh	√		√					√	
Arunachal Pradesh				√					
Assam				√					
Bihar								√	
Chandigarh									
Chhattisgarh	√	√	√						
Dadra and Nagar Haveli									
Daman and Diu									
Delhi			√						
Gujarat	√		√	√		√			
Haryana		√	√					√	
Himachal Pradesh			√	√					
Jammu and Kashmir			√	√				√	
Jharkhand		√	√						
Karnataka		√	√				√†	√	

State	Wind	Solar Thermal	Solar PV	Small Hydro	Biomass	MSW	Integrated	Net metering	Micro/MiniGrid
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, 2016

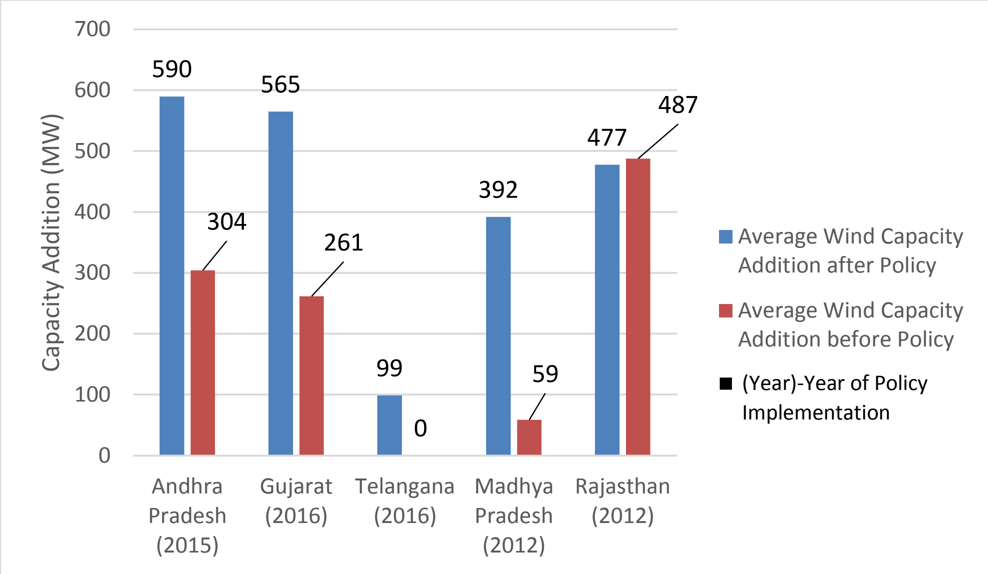
† Karnataka has published integrated RE policy and solar policy in 2014 but the integrated RE policy does not cover solar technologies. Kerala's integrated RE policy holds for all technologies other than wind and solar. Manipur integrated RE policy does not cover small hydro and rooftop. In Mizoram, small hydro and solar policies are not covered under integrated RE policy. Odisha RE integrated policy has superseded the Odisha solar policy.

2.2.1. Impact of State Policy on Wind and Solar

Impact on Wind

Most times, state policies work hand-in-hand with central policies to boost RE development. Also, other factors such as greater awareness about RE, financial assistance and fiscal incentives, etc., also contribute towards RE development. In this section, the contribution of state policies in enhancing RE installed capacity is analysed. Figure 2.4 provides the status of wind power development before implementation (-3 years) and after implementation (+3 years/till date) of state policies.

Figure 2.4: Average Wind Power Installed Capacity Addition Pre- and Post-implementation of State Policies



Source: WISE, 2016

As is evident from Figure 2.4, the average installed wind capacity addition after policy implementation almost doubled in Andhra Pradesh, more than doubled in Gujarat and increased almost eight times in Madhya Pradesh. Further, Figure 2.4 shows that although development of wind started much earlier in India (with the introduction of accelerated depreciation benefit and generation-based incentives), state policies played a major role in accelerating growth of wind power in the states.

According to latest data, compound annual growth rate (CAGR) of cumulative wind power installed capacity across the states varied from a mere 2% to 75% between 1 April 2014 and 31 December 2016. The significant growth in CAGR can be attributed to state policies. Highest growth of 75.42% was observed in Madhya Pradesh and lowest growth of 1.91% was registered in Tamil Nadu. The CAGR of cumulative installed wind capacity in wind-dominant states, between April 2014 and December 2016, is depicted in Table 2.2.

Table 2.2: CAGR of Cumulative Wind Installed Capacity in Wind-Dominant States (1 April 2014 to 31 December 2016)

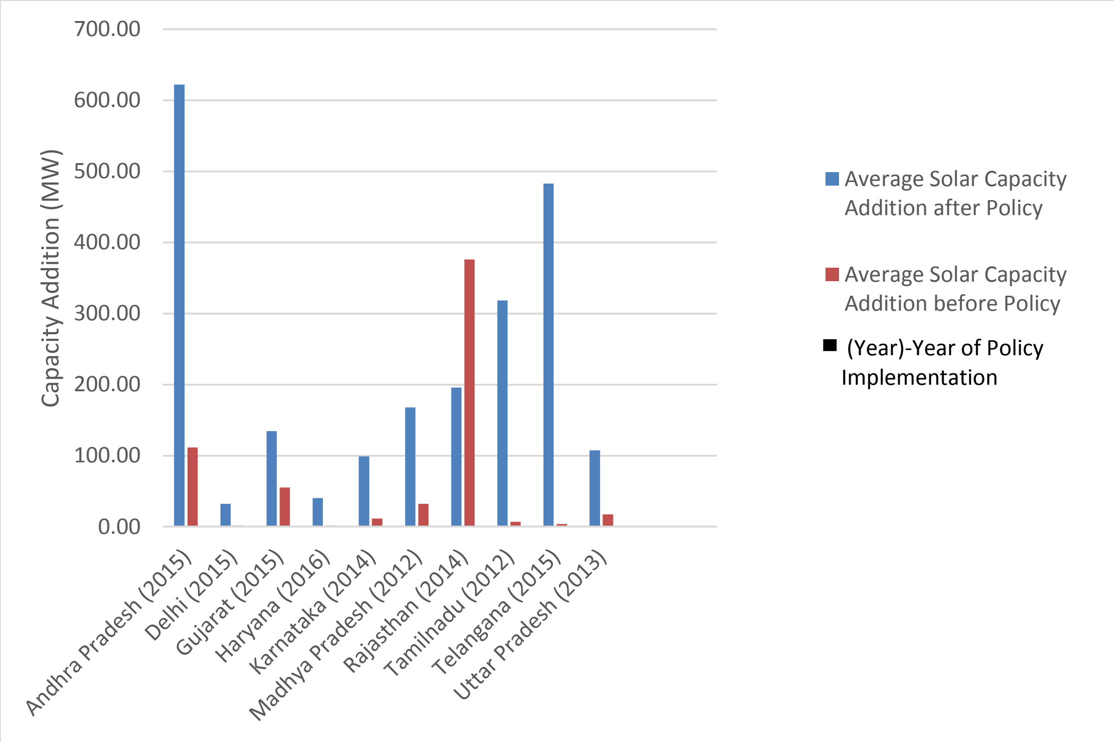
States	Cumulative Capacity as on 01.04.2014	Cumulative Capacity as on 31.12.2016	CAGR (%)
Andhra Pradesh	746	2,092.5	41.03
Gujarat	3,454	4,441.57	8.74
Karnataka	2,318	3,154.2	10.81
Kerala	35	43.5	7.52
Madhya Pradesh	424	2,288.6	75.42
Maharashtra	4,096	4,666.03	4.44
Rajasthan	2,785	4,216.72	14.83
Tamil Nadu	7,270	7,694.33	1.91

Source: MNRE, Annual Report 2013-14 to 2016-17

Impact on Solar

Figure 2.5 shows the average installed capacity addition before implementation (-3 years) and after implementation (+3 years/till date) of state policies.

Figure 2.5: Average Solar Power Installed Capacity Addition Pre- and Post-implementation of State Policies



Source: WISE, 2016

Andhra Pradesh, Tamil Nadu and Telangana show significant growth after implementation of state policies. This growth could further be attributed to the introduction of JNNSM as well. While state policies were the dominant force for annual installed capacity addition till 31 December 2015, thereafter, most of the installed capacity in solar technology may be attributed to the Jawaharlal Nehru National Solar Mission, as several projects were awarded under JNNSM then. Cumulative solar power installed capacity under central and state policies up to 31 December 2015 is shown in Table 2.3.

Table 2.3: Cumulative Installed Capacity of Solar Power under Central and State Policies (upto 31 December 2015)

States	JNNSM (MW)	State Policy (MW)
Andhra Pradesh	94.75	211.07
Chhattisgarh	4.00	64.08
Gujarat	40.00	877.15
Karnataka	15.00	66.00
Kerala	0.025	12.00
Madhya Pradesh	225.25	307.55
Maharashtra	72.00	126.00
Odisha	22.00	30.00
Punjab	10.50	182.05
Rajasthan	944.10	67.65
Tamil Nadu	26.00	182.075
Telangana	--	61.95
Uttar Pradesh	12.00	110.74
Total	**1465.63**	**2298.32**

Source: MNRE, 2016

According to the latest data, the CAGR in cumulative installed solar capacity has been nearer to or over 100% for many states between 1 April 2014 and 31 December 2016. A Significant jump in cumulative installed capacity can be seen in almost all the states. Growth in solar has been mainly observed in the last two years due to increased bidding activities by SECI, India. The CAGR of cumulative installed solar power capacity in solar-dominant states of India between April 2014 and December 2016 is depicted in Table 2.4.

Table 2.4: CAGR of Cumulative Solar Power Installed Capacity in Solar-Dominant States (1 April 2014 to 31 December 2016)

States	Cumulative Capacity as on 01.04.2014	Cumulative Capacity as on 31.12.2016	CAGR (%)
Andhra Pradesh	131.84	979.65	95.14%
Chhattisgarh	7.1	135.19	167.03%
Delhi	5.1538	38.78	95.96%
Gujarat	916.4	1,158.5	8.13%
Haryana	10.3	53.27	72.93%
Karnataka	31	327.53	119.43%
Madhya Pradesh	347.17	840.35	34.27%
Maharashtra	249.25	430.46	19.98%
Orissa	30.5	77.64	36.54%
Punjab	16.845	545.43	218.73%
Rajasthan	730.1	1317.64	21.75%
Tamil Nadu	98.36	1590.97	152.90%
Uttar Pradesh	21.08	239.26	124.73%
Uttarakhand	5.05	45.1	**107.47%**

Source: MNRE, 2014-2016

2.3. JAWAHARLAL NEHRU NATIONAL SOLAR MISSION

Launched as an initiative under India's National Action Plan on Climate Change (NAPCC) in 2008, the Jawaharlal Nehru National Solar Mission (JNNSM) aims at establishing India as a global leader in solar energy by creating a favorable policy environment for its deployment across the country.

Under the original plan of 2010, the Indian government sought to achieve total installed solar capacity of 20 GW by 2022.[6] Table 2.5 depicts the details of the targets to be achieved.

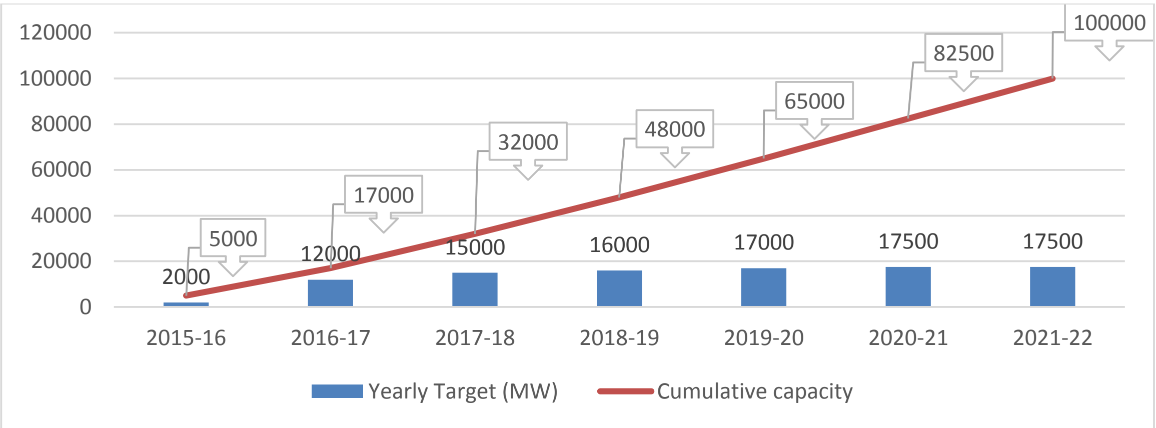
Table 2.5: Phase-wise Solar Targets as per JNNSM

Sr. No.	Segment	Target for Phase I (2010 - 2013)	Target for Phase II (2013 - 2017)	Target for Phase III (2017 – 2022)
1.	Utility Scale Solar including rooftop	1,100 MW	10,000 MW	20,000 MW
2.	Off-grid Solar applications	200 MW	1000 MW	2000 MW
3.	Solar collectors	7 million sq. metres	15 million sq. metres	20 million sq. metres

Source: MNRE, 2010

In 2015, the government revised the solar target for 2022 from 20 GW to 100 GW. To reach 100 GW, the yearly targets from 2015-16 onwards were also revised upwards. Details are shown in Figure 2.6.

Figure 2.6: Year-wise Revised Solar Targets to meet 100 GW by 2022



Source: MNRE, 2016

India's cumulative installed solar capacity including rooftop is 12,288.83 MW (as on 31 March 2017). This implies that 87,711.17 GW of solar capacity needs to be installed during the remaining five years to reach the 100 GW target. This amounts to 17,542 MW per year of installed capacity up to 2021-22. India added just above 5,000 MW solar capacity in 2016-17, which is still far below the average capacity addition required per year. Nevertheless, with intensified policies and programmes initiated by the government, the country is definitely expected to see a surge in solar installed capacity in the future. The policy initiatives have been fuelled by falling interest rates and tariff. However, it will be difficult to predict if the country will be able to achieve the 100 GW mark or not, especially, given the fact that module prices may go up as demand picks up in USA and China, and India's New Energy Policy (as on 27 June), 2017 anticipates withdrawal of incentives and support mechanisms for renewable energy over time.[7]

2.3.1. JNNSM Phase I (2010-13)

Under JNNSM Phase I, solar projects were allotted through a process of 'reverse bidding'+. Bids were invited in two batches: Batch-I of 150 MW Solar PV and 470 MW solar thermal, and Batch-II of 350 MW Solar PV.[8] A 'Migration Scheme' was also introduced to provide projects an option to migrate from their existing arrangements to JNNSM, subject to the consent of distribution licensee, state government and willingness of the developer. Rooftop PV and Small Solar Power Generation Programme (RPSSGP) was also introduced under the mission. Table 2.6 shows the achievements made in Phase I against the targets. It can be seen that the targets for Phase I were surpassed as on 31 March 2016.

+In reverse bidding, solar power generators quote the minimum tariff/minimum viability gap funding for the power that they sell to the buyers.

Table 2.6: Achievements of Phase I Targets: JNNSM

Application segment	Targets for Phase 1 (2010-2013)	*Achieved as on 31 March 2016
Grid-connected (large plants, rooftop & distribution grid-connected plants)	1100 MW	1686.44 MW
Off-grid solar applications	200 MW	252.5 MW
Solar Thermal Collectors (solar water heaters, solar cookers, solar cooling, industrial process heat applications, etc.)	7 million sq. metres	7.01 million sq.metres

Source: MNRE, 2016

*Realization of the projects takes 13 to 18 months after being sanctioned. This is the reason that achievement dates are different from target dates.

2.3.2. JNNSM Phase II (2013-17)

Following the success of Phase I, the solar industry witnessed a great momentum wherein grid-connected and off-grid projects were commissioned throughout the country. Phase II thus aimed at achieving higher targets. Several schemes like bundling, Viability Gap Funding (VGF) schemes for defense establishments, etc., were made available in this phase. These have been summarized in Table 2.7.

Table 2.7: Summary of Schemes in Phase II: JNNSM

	Viability Gap Funding	formerly through, National Thermal Power Corporation/ NTPC Vidyut Vyapar Nigam Ltd	Defence Schemes	Development of Solar Parks	Canal Top/Canal Bank	Decentralised solar rooftop, off-grid & decentralised solar applications
Salient Features	750 MW (Batch I); 3,000 MW (Batch II); 2,000 MW (Batch III); 5,000 MW (Batch IV); 1,000 MW (Batch V) by Central Public Sector Undertakings (CPSUs) and Government of India organizations under various central/state schemes/self-use/3rd party sale/merchant sale of grid-connected solar power projects. Solar Energy Corporation of India (SECI) has been designated the implementing agency for these schemes. Projects will be selected separately based on domestic	15,000 MW of grid-connected solar PV power plants through NTPC/NVVN in three tranches as follows: Tranche-I: 3,000 MW, 2014-15 to 2016-17. Tranche-II: 5,000 MW, 2015-16 to 2017-18. Tranche-III: 7,000 MW, 2016-17 to 2018-19. Currently, Tranche-I is under implementation. In Tranche-I, which is Batch-II of Phase-II of National Solar Mission, 3000 MW capacity of solar PV power plants will be based on bundling of solar power (3000 MW) with unallocated thermal power (1500 MW) in the ratio of 2:1 (in MW terms).	To be set up in various establishments of the Ministry of Defence, Govt. of India. Project capacity shall be, at least, 1 MW and up to a maximum capacity of 20 MW.	The capacity of the solar parks shall be 500 MW and above. The choice of implementing agency for developing and maintaining the park is left to the state government. The solar parks will provide suitable developed land with all clearances, transmission system, water access, road connectivity, communication network, etc.	100 MW grid-connected solar PV power plants on canal banks and canal tops (50 MW on canal tops and 50 MW on canal banks).	The scheme includes grid-connected solar rooftop with capacity from 1 kW to 500 kWp per project/system, off-grid solar applications, solar thermal systems and solar cookers. Grid-connected decentralised solar rooftop plants and small solar power plants can be implemented through business models which may be developed/adopted, depending upon market conditions, user's interest, and initiatives by the Energy Services Company (ESCOs).

Table 2.7: Summary of Schemes in Phase II: JNNSM						
	Viability Gap Funding	**formerly through, National Thermal Power Corporation/ NTPC Vidyut Vyapar Nigam Ltd**	**Defence Schemes**	**Development of Solar Parks**	**Canal Top/Canal Bank**	**Decentralised solar rooftop, off-grid & decentralised solar applications**
	content requirement and open category.					
Tariff	• For 750 MW scheme: Fixed tariff of ₹5.45/kWh for 25 years. • For 2,000 MW scheme: Fixed tariff of ₹5.43/kWh for 25 years. • For 5,000 MW scheme: ₹4.00/ kWh in states where tariff has fallen below ₹4.50/kWh in one or major tenders; and ₹4.50/kWh where tariff has remained over ₹4.50/kWh in all major tenders.	At tariff quoted during the bidding process with a tenure of 25 years.	• Developer mode: Fixed levelised tariff of ₹4.50/kWh for 25 years. • EPC mode: No tariff setting required.	The tariff could be either the CERC/SERC regulated price or that determined through the bidding process.	At tariffs mutually agreed or as fixed by the State Electricity Regulatory Commission.	The projects can be installed on Net Metering or Feed-in Tariff (FIT) basis. This will be decided by Regulators /DISCOMs/Distribution Licensee, in consultation with the implementing agencies.

Source: MNRE, 2016

Achievements of Phase II (against targets) are provided in Table 2.8.

Table: 2.8: Achievements of JNNSM Phase II Targets [9]

Category	Target for Phase II	Achievement (As on 31 December 2016)
Viability Gap Funding	Phase II, Batch I – 750 MW (2013-17)	680 MW projects commissioned
	Phase II, Batch III – 2,000 MW (2013-17)	2,395 MW PPA signed in 5 states
	Phase II, Batch IV – 5,000 MW (2013-17)	1,020 MW PPA signed in 3 states
Through NTPC/NVVN	Tranche I – 3,000 MW (2013-17)	2,700 MW PPA signed
Defense Scheme	300 MW (2014-19)	356 MW sanctioned in 7 establishments
Development of Solar Parks	25 Solar Parks (2014-19)	34 solar parks of aggregate capacity of 20,000 MW has been approved in 24 states
Canal Top/Canal Bank	Canal Top – 50 MW (2013-17)	1 MW canal top commissioned in Andhra Pradesh
		Another 49 MW allotted in 6 other states
	Canal Bank – 50 MW (2013-17)	5 MW and 10 MW commissioned in Andhra Pradesh and West Bengal respectively
		35 MW projects allotted in 3 states
Grid-Connected Decentralised Rooftop, Off-grid and Decentralised Solar Applications	40,000 MW (2022)	Under grid-connected rooftop solar and small power plants program 3,044 MW has been sanctioned and 506 MW has been installed

Source: MNRE, 2016

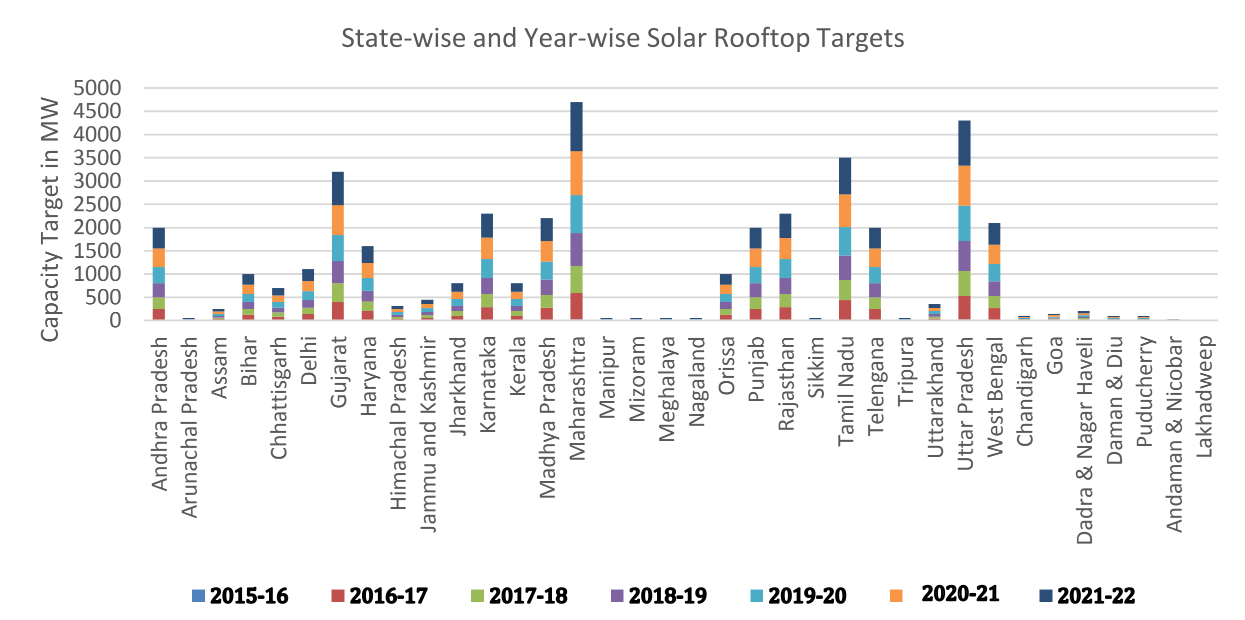
2.4. GRID-CONNECTED ROOFTOP SOLAR

India has unveiled the 'Grid-Connected Rooftop and Small Solar Power Plant Programme' with the aim of installing 40 GW of grid-interactive rooftop solar by 2022.[10] These rooftop plants would be set up in residential, commercial, industrial and institutional sectors, and government and state-owned sector enterprises. Till 31 March 2017, a total of 656 MW rooftop solar was installed in India.

The government offers 30% subsidy for rooftop projects in residential, social and institutional buildings and a 15% to 25% incentive for projects in government and state-owned enterprises (public sector undertaking or PSU). However, no subsidies or incentives are offered for rooftop solar projects in the industrial and commercial sectors.

Figure 2.7 shows the state-wise and year-wise capacity addition targets indicated by MNRE, to achieve the cumulative capacity of 40 GW by 2022. Maharashtra, Uttar Pradesh and Tamil Nadu are seen to have the highest targets with 4,700, 4,300, and 3,500 MW respectively.

Figure 2.7: State-wise and Year-wise Proposed Capacity Addition Targets for Achieving 40 GW Rooftop Solar by 2022



Source: MNRE, 2016

2.5. OTHER POLICIES

2.5.1. Policy on Repowering [11]

MNRE announced the policy for repowering wind power projects, in 2016, for projects with capacity of 1 MW or below, that are located at sites having high wind power potential. IREDA is providing loans at 0.25% which is lower than the applicable rates for new wind projects. Besides this, all fiscal and financial benefits extended to new wind power projects (such as accelerated depreciation, generation based incentives) are also provided.

2.5.2. Draft National Wind Solar Hybrid Policy [12]

MNRE published the Draft National Wind Solar Hybrid Policy in 2016 with the objective of promoting large grid-connected wind-solar PV systems. The goal of the policy was to reach wind-solar hybrid capacity of 10 GW by 2022. The draft policy proposed to extend all fiscal and financial incentives, available to wind and solar, to hybrid projects as well, along with low-cost financing by IREDA and other financial institutions, including multilateral banks.

2.6. FINANCIAL AND FISCAL INCENTIVES: A REVIEW

2.6.1. General Incentives and Exemptions

Incentives and exemptions enhance the strength of policies aimed at promoting RE. Different states offer different incentives/exemptions. Table 2.9 summarizes the general incentives/exemptions provided to different RE technologies across states and union territories in 2016-17.[13] While Dadra and Nagar Haveli, Daman and Diu, Lakshadweep, Nagaland, and Sikkim have not announced any specific incentives for promotion of RE, all other states and union territories have declared at least one incentive to encourage a particular RE technology.

As evident from Table 2.9, not all states have adopted the same instruments for development of RE. Even within a state, different policy instruments have been adopted for different technologies. For example, in Gujarat, electricity duty exemption has been allowed for wind, solar, small hydro and MSW. But wheeling charge waiver and banking facility have been allowed only for solar technologies.

Table 2.9: State-wise Incentives/Exemptions in Renewable Energy*

State	Electricity Duty Exemption	Stamp Duty Exemption	VAT Exemption	Entry Tax Waiver	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	†•				•		†	†		†		ф	
Arunachal Pradesh												ф	
Assam				ф		ф							
Bihar	⊗		⊗		⊗			⊗	⊗	⊗			
Chandigarh													
Chhattisgarh	•		•										†
Dadra and Nagar Haveli													
Daman and Diu													
Delhi	•		•			•	•			•			
Gujarat	†• ф♀					•			†• ф♀	•			
Haryana	•	•			•	•	•			•			
Himachal Pradesh												ф	
Jammu and Kashmir				ф					•	•	ф		
Jharkhand	•	•	•		•	•			•	•			
Karnataka		•							⊗				⊗
Kerala	•					•				•			
Lakshadweep													
Madhya Pradesh	• ф⧫	†• ф⧫				†⧫			⧫	†• ф ⧫	ф	ф	† ф
Maharashtra	⊗				⊗								
Manipur	⊗			ф	•	• ф				•		ф	
Meghalaya	⊗									⊗			
Mizoram	•⊗	•	•			•			•⊗	• ⊗			ф⊗
Nagaland													
Orissa													⊗
Puducherry			•						•				•

Punjab	⊗	⊗	⊗	⊗									⊗
Rajasthan	⧫												†⧫
Sikkim													
Tamil Nadu	•												•
Telangana	•	†•	†•	•									
Tripura	⊗		⊗							⊗			⊗
Uttar Pradesh							•						†
Uttarakhand		•											
West Bengal									⊗				

Source: WISE, 2016

* Timeframe of the incentives is as per the policy period in existence in the respective states.

† Incentives for wind energy
• Incentives for solar energy
ф Incentives for small hydro
⧫ Incentives for biomass power
♀ Incentives for MSW
⊗ All renewables

2.6.2. Accelerated Depreciation

In order to provide tax benefits during the early years of generation, accelerated depreciation benefit is provided, which is 80% of asset value in the first year. In the second year, the remaining asset value is derived using written down value method after deducting the depreciated asset value in the first year and 80% depreciation is charged on the remaining asset value. Thus depreciation continues to be charged on the remaining asset value in a tapered manner. This reduces the earning before taxes and hence total tax payable by the generator.

For 2017-18, the Government of India has capped accelerated depreciation at 40% in the first year on a written-down value (WDV) basis for equipment under Section 32(1)(i) of the Income Tax Act, 1961.

2.6.3. Generation Based Incentives (GBI)

Under GBI, wind power producers not availing Accelerated Depreciation are provided an incentive @ ₹0.50 per unit of electricity fed into grid with a cap of ₹100 lakh per MW, for a minimum period of 4 years and maximum period of 10 years.[14]

Under GBI I, II and demo schemes, a sum of ₹2,044.55 crore has been released upto 15 April 2017. Details are provided in Table 2.10.

Table 2.10: GBI (Wind) Registration Status and Disbursement as on 15 April 2017

Scheme	Period of scheme	Capacity Registered (MW)	Amount Released (₹Crore)
GBI- II	01.04.2012 – 15.04.2017	8,424.95	855.16
GBI- I	17.12.2009 - 31.03.2012	2,031.38	1,159.34
Demo	Limited to first 49 MW registered	48.9	30.05
Total		**10,505.23**	**2,044.55**

Source: IREDA, 2017

A similar GBI scheme was offered to Rooftop PV and Small Solar Power Generation (RPSSPG). Grid-connected solar projects in the capacity range of 100 kW to 2 MW each, connected to HT grid below

33 kV, were eligible. The first 100 MW capacity projects registered with IREDA were eligible for GBI. A capacity of 91.8 MW has been registered under GBI up to April 2017 and a total disbursement of ₹805.56 crore has been made.[15] From 2017-18, GBI has been discontinued.

2.6.4. Income Tax Holiday

Income tax holiday (elimination of tax for a given period on income) was offered for 10 years on income earned from sale of electricity of RE projects, under Section 80 IA of the Income Tax Act, 1961, within the first fifteen years of the life-cycle of all infrastructure projects, including renewable power generation. However, the scheme has been discontinued from 2017.

2.6.5. Goods and Services Tax

Table 2.11: Goods and Services Tax for Renewable Energy

GST Rate	
5%	Sr. No: 234, Tariff No. 84 or 85 Renewable energy devices & parts manufacture (a) Bio-gas plant (b) Solar power based devices (c) Solar power generating system (d) Wind mills, Wind Operated Electricity Generator (WOEG) (e) Waste to energy plants/devices (f) Solar lantern/solar lamp (g) Ocean waves/tidal waves energy devices/plants
5%	Sr. No: 232, Tariff No. 8419 19 Solar Water Heaters and Systems

Source: CBEC, 2017

In 2017-18, all existing fiscal and financial incentives (except accelerated depreciation) along with other tax related incentives such as concessional customs and excise duty exemption, etc., will be discontinued, and only one tax, the Goods and Services Tax (GST), will prevail. In GST, renewable energy equipment and manufacturing of parts are taxed at 5% (Table 2.11).

2.7. NATIONAL CLEAN ENERGY AND ENVIRONMENT FUND (NCEEF)[16]

In 2010-11, the Government of India, introduced a corpus called National Clean Energy Fund (NCEF), which was created out of a cess on coal produced/imported, ("polluter pays" principle) for the purpose of financing and promoting clean energy initiatives, funding research in the area of clean energy or for any other purpose relating thereto. Subsequently, the scope of the fund was expanded to include clean environment initiatives and renamed National Clean Energy and Environment Fund (NCEFF). An Inter-Ministerial Group (IMG) chaired by Finance Secretary approves the projects/schemes eligible for financing under the NCEEF. Till date, IMG has recommended 55 projects amounting to ₹34811.19 crore, spread over the past years.

In 2016-17, the proceeds of the NCEEF were used to finance projects under the Green Energy Corridor for boosting the transmission sector, *Namami Gange*, Green India Mission, Jawaharlal Nehru National Solar Mission, installation of SPV lights and small capacity lights, installation of SPV water pumping systems, SPV power plants, grid-connected rooftop plants, etc. The proceeds from the cess are distributed between a few ministries. Table 2.12 provides details of allocation of the NCEF in 2016-17.

However, the Goods and Services Tax (Compensation to States) 2017, which has been notified on 12 April 2017, provides that 2017-18 onwards, coal cess would be used towards the GST Compensation Fund for compensating states for potential losses on account of GST implementation, for five years. Any amount left over would be shared on 50% basis between centre and states.

Table 2.12: Allocation of Clean Energy Cess Among Various Ministries (2016-17)

Ministry	Amount (in ₹Crore)
Ministry of Environment, Forest and Climate Change	1,000.00
Ministry of New and Renewable Energy	4,947.00
Ministry of Water Resources, River Development and Ganga Rejuvenation	2,500.00
Total	**8,447.00**

Source: Department of Expenditure, Government of India, 2016

2.8. PRIORITY SECTOR LENDING

Renewable energy projects have been included in Priority Sector Lending norms of commercial banks by RBI in April 2015.[17] This means banks can lend up to a limit of ₹15 crore to borrowers for solar-based power generators, biomass-based power generators, wind turbines, micro-hydel plants, and for public utilities *viz*. street lighting systems, and remote village electrification. For individual households, the loan limit is set at ₹10 lakh per borrower. As a policy of the Central Government, banks have been instructed to encourage loan seeking households to install rooftop solar projects and consider the amount required for the purpose as part of home loan or home improvement loan.

2.9. DECENTRALISED OFF-GRID POLICY

Access to affordable and reliable electricity is crucial for spurring social and economic progress in rural India and for meeting the country's developmental aspirations. A major portion of the Indian population still does not have access to electricity. As per Census 2011 data, around 1.1 million households do not have any source of lighting-77% of which are from rural areas. Decentralised electricity generation through mini/microgrids is playing an important role in providing lighting to these remote rural areas.

Many Energy Services Companies (ESCOs) have already installed microgrids through various business models, but there are several challenges being faced by them. In order to overcome these challenges, MNRE has come up with the "Draft National Policy on RE based Mini/Micro grids" in June 2016, with the following objectives:

- Simplify the project development procedures for ESCOs.
- Provide operational framework to operate where the grid does not exist, or already exists (the Distribution Company grid).
- Access to central financial assistance and other incentives.
- Encourage innovative minigrid business models to cater to rural needs.

2.9.1. Draft National Mini/Microgrid Policy

In 2016, the Government of India introduced the draft National Mini/Microgrid policy for India. The main provisions of the policy are summarized in Table 2.13. [18]

Table 2.13: Main Provisions under Draft National Micro/Minigrid Policy

Eligibility	• Powered by RE sources such as solar, biomass, wind, small hydro or other notified sources and having diesel-based generator as backup. • Hybrid systems using a combination of resources such as solar-wind, solar-biomass, solar-hydro, etc.
Tariff	Tariff may be set as follows: (i) Where no subsidy or grid-connectivity is provided - As per market. (ii) Where subsidy is provided - With concurrence of defined state government authority. (iii) Where grid is connected - SERC. Tariff should adhere to the following principals: • Should be transparently set. • Should be fixed for at least one year to avoid frequent changes. • Should not give more than 16% return on equity if it is a business venture. • Should cover cost of battery replacement. • Money collected should be displayed prominently in the village for everyone's information.
Implementation	• To fast-track the process, ESCOs are empanelled as Rural Energy Service Providers (RESPs) - installer, owner, operator and service supplier - to implement mini grid projects, and envisages RESPs to be one of the predominant vehicles for implementation. RESPs can directly identify and implement projects by themselves. • The involvement of the State Government and/or DISCOMs in the SNA route for implementation makes the process straightforward thus making project identification more certain and the development and execution easier. • Private implementing agencies have to arrange for land, right-of-way permissions, seek local government and community consent, and deal with other aspects, themselves. A single window support channel, such as a special RE mini grid promotion cell, may be instituted for this purpose.
Coexistence of Mini Grids and Distribution Company	Policy framework to facilitate the coexistence of mini grids with the DISCOM grid is as follows: For both the entry situations – areas where the DISCOM grid pre-exists or areas where the DISCOM grid is yet to arrive - the ESCO will be allowed to "Open Market" i.e., continue supplying to its consumers and exist in parallel with DISCOM grid or continue to supply to its consumers and sell excess or unsold electricity to the DISCOM grid at the interconnection point and draw power from mini grid if required or supply all electricity generated to the DISCOM grid at the interconnection point. The ESCO: • Will be allowed to work in and migrate to an operating option of its choice. • Will abide by the tariff norms as prescribed under the existing policy or programme of the state. • Will be allowed to charge a tariff mutually determined with consumers if operating in "open market" option. • May be offered to undertake the role of a Distribution Franchisee, wherever feasible.
Exit Options	• Where the DISCOM grid arrives later, the DISCOM may choose to use the Public Distribution Network (PDN) of the ESCO, if it conforms to the standards laid down, by paying appropriate charges, or the ESCO is offered to sell the PDN to the DISCOM. • Where the mini grid opts to sell power to the DISCOM grid, the project should be compensated in accordance with the National Tariff Policy. Such instances of asset sale, exchange of power (through condition of Power Purchase Agreement (PPA) and Franchisee Agreement (FA)), and aspects such as wheeling, interconnectivity etc., fall under the technical purview of the SERC. The SERC will be required to develop a regulatory framework for enabling implementation.

	• Where mini grids connect with the DISCOM grid to sell surplus power, the ESCO will have to enter into a Power Purchase Agreement (PPA) with the Distribution Company. In the instance of a Franchisee Arrangement, the Distribution Company will have to enter into a Franchisee Agreement with the ESCO.

Source: WISE, 2016

The draft policy also provides specifications of quality and technical performance standards of the mini/microgrids. The policy is meant as a guideline for states, which can adapt or modify the policy based on their local needs. The Ministry will provide upfront capital subsidy for deploying minigrid projects under it various programmes. However, a state may consider providing additional incentives, over and above the existing central financial assistance, for projects under their policy.

2.9.2. UP Mini/Microgrid Policy

Based on the draft National Mini/Microgrid Policy, Uttar Pradesh is the first and only state to publish a state-specific policy for development of mini/microgrids in 2016 (as on 31 March 2017).

Salient Features of UP Minigrid Policy [19]

The policy has limited the size of the minigrid to 500 kW and laid down conditions for qualifying for state government subsidy, with developers requiring to procure land for their projects. The policy mandates a minimum eight hours of electricity supply–three hours in the morning and five hours in the evening–to all households willing to pay, in the chosen area. For production and commercial needs, developers need to supply for six hours.

The policy also specifies that the developer will charge ₹60 per month for load up to 50 Watt for eight hours, ₹120 per month for load up to 100 Watt for eight hours of electricity supply daily, and for load over 100 Watt the tariff will be determined by mutual consent between consumers and developer.

One of the most important concerns of minigrid developers has been the uncertainty of the plant when the grid arrives. Hence, the state has laid out two exit policies for developers:

- The energy generated from the plant will be received into the grid by the DISCOM at the tariff decided by Uttar Pradesh Electricity Regulatory Commission/tariff decided by mutual consent.
- Based on the cost benefit analysis, the project will be transferred to the DISCOM at a cost determined by mutual consent between DISCOM and developer, by estimating cost, profit/loss of the project installed by the developer.

Table 2.14: Summary of Minigrid Regulations of UP, J&K and MP

<table>
<tr><th></th><th>Parameters considered by SERCs</th><th>UP [20]
(06.04.2016)</th><th>J&K [21]
(19.12.2016)</th><th>MP [22]
(02.09.2016)</th></tr>
<tr><td>1.</td><td>Defined mini grid area</td><td colspan="2">Rural areas having inadequate supply of electricity during peak hours and/or compulsory supply hours.</td><td>Rural areas where grid is not in existence.</td></tr>
<tr><td>2.</td><td>Applicability</td><td colspan="2">New and existing mini grid projects.</td><td>New and existing minigrid projects.</td></tr>
<tr><td>3.</td><td>Permissible capacity</td><td colspan="2">Up to 500 kW</td><td>10 kW and above</td></tr>
<tr><td>4.</td><td>Business Model(s)</td><td colspan="2">No Grid
• Minigrid Operators (MGO) can supply entire electricity to consumer at mutually agreed tariff or as determined by the Government in case MGO avails govt. subsidy/grant.
• On arrival of grid, the MGO can continue with (i) sale of electricity to consumer at mutually agreed/govt. approved tariff OR (ii)MGO can sale part electricity to consumer and balance to DISCOM at Feed-In Tariff approved by SERC, OR (iii) MGO can opt for sale of entire electricity to DISCOM at FIT.
• The MGO has the option to transfer the PDN to DISCOM at depreciated cost provided the standards of PDN match the DISCOM’s system
• DISCOM may allow MGO to work as DF.
• The MGO may migrate to any of the options upon intimating the SERC, DISCOM and SNA.

Grid Pre-Exists
• MGO can supply entire electricity to consumer at mutually agreed tariff or as determined by the government in case MGO avails govt. subsidy/grant for a minimum period of 6 months, or may opt for any of the following three options: (i) continue supplying electricity at mutually agreed tariff (ii) sale part electricity to consumer and balance to DISCOM at FIT approved by SERC (iii) after supplying electricity in either of the above options for at least 3 years, MGO can opt for sale of entire electricity to DISCOM at FIT .
• The MGO has option to transfer the PDN to DISCOM at depreciated cost provided the standards of PDN match the DISCOM’s system.
• The MGO may migrate to any of the options above upon intimating SERC, DISCOM and State Nodal Agency.</td><td>• MGO is allowed to set mini grid in areas where DISCOM system doesn’t exist.
• Allowed to charge mutually agreed tariff.
• On arrival of grid, supply of the entire electricity to DISCOM at FIT determined by the Commission.
• Transfer ownership of Public Distribution Network (PDN) conforming to the standards of DISCOM, with mutual consent, at depreciated cost. The MGO shall rectify shortcomings in PDN as pointed out by DISCOM before transfer.</td></tr>
<tr><td>5.</td><td>Standard of Performance</td><td colspan="2">Compulsory Supply Hours - 1700 to 2300 Hrs.</td><td>NA</td></tr>
</table>

	Parameters considered by SERCs	UP [20] (06.04.2016)	J&K [21] (19.12.2016)	MP [22] (02.09.2016)
6.	FIT Guidelines	As per Uttar Pradesh Electricity Regulatory Commission RE Regulations 2014.	FIT determined by SERC, as per JKSERC RE Regulations 2013 Act as ceiling tariff.	As determined by SERC for procurement of electricity from mini grid projects by DISCOMs pursuant to Sec 61(h) of EA 2003.
7.	RPO	The quantum of electricity generated from a minigrid plant interconnected with DISCOM system shall qualify for compliance of RPO for DISCOM.		The quantum of electricity generated from minigrid plant shall qualify for compliance of RPO for DISCOM.
8.	Contractual Framework	Quantity declared by MGO shall qualify for PPA. PPA is allowed for sale of entire/partial electricity.		Quantity declared by MGO shall qualify for PPA. PPA is allowed for sale of entire/partial electricity.
9.	Exit/Migration Options	• MGO shall be allowed to exit the mini grid area after providing 90 days prior notice to the Commission, SNA and DISCOM. • Exit options will be governed by the agreement signed by MGO. • MGO intending to migrate shall inform the Commission, SNA and DISCOM. • SNA to facilitate the migration process.		• MGO shall be allowed to exit the mini grid area upon obtaining clearance from SNA. • MGO to mutually decide with DISCOM for transfer of PDN on advent of grid. • Migration within applicable supply model possible.

Source: WISE, 2016

The draft National Mini/Microgrid Policy also encourages states to develop state-specific regulations to enable the active participation of mini/microgrid developers. These regulations are expected to bring more clarity, stability and predictability to the developers/investors. In 2016-17, Uttar Pradesh, Madhya Pradesh and Jammu & Kashmir published their final regulations, and Bihar came up with a draft regulation for mini/micrograds. It should be noted that UP and J&K have adopted the same measures for their respective regulations. A summary of state regulations of UP, MP and J&K is made in Table 2.14.

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3.
REGULATORY FRAMEWORK

REGULATORY FRAMEWORK FOR PROMOTION OF RENEWABLES IN INDIA

The Electricity Act, 2003, provides the legislative framework for 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, under the Act.[1] The Tariff Policy formulated by the central government as per provisions of the Act, further elaborates 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]

The regulatory framework for grid-connected renewable energy in India is mainly guided by tariff regulations, Renewable Energy Obligation (RPO) and Renewable Energy Certificate (REC) mechanism, Open Access (OA) Regulations, and forecasting and scheduling regulations, while the development of decentralised rooftop solar PV projects is mainly guided by 'net metering' regulations enacted by the SERCs at the state level.

3.1 FEED-IN TARIFF

The provisions in the Electricity Act, 2003, empowers the Electricity Regulatory Commissions (ERCs) to determine the feed-in tariff (FIT) for RE, under Section 62 of the Act, by following the 'cost-plus' approach. Additionally, the tariff can also be discovered by following the transparent competitive bidding process as per provisions under Section 63 of the Act. The CERC in 2009 has, for the first time, notified RE Tariff Regulations (amended in 2012 and 2017), specifying the RE technology-wise normative technical and financial parameters for determination of RE tariff on cost-plus basis.[3,4,5] Subsequently, the State Electricity Regulatory Commissions has also developed similar regulations at the state level for determining feed-in tariff. The announcement of the Jawaharlal Nehru National Solar Mission, in 2008 (as part of the NAPCC) resulted in the discovery of solar tariff through the bidding process. The first ever price discovery of wind power through competitive bidding was done in February 2017.

Table 3.1: Comparison of CERC and SERC declared Solar Tariff (INR/kWh)

CERC (2016-17)	Gujarat (2015)	Tamil Nadu (2016)	Rajasthan (2014)	Madhya Pradesh (2016)	Karnataka (2013)
5.08	MW-scale plants: 5.74 kW-scale plants: 7.11	4.56	4.85	5.45	MW scale plants: 6.51 kW scale plants: 4.4 to 6.03

Source: CERC and SERC orders [4, 6, 7]

Table 3.2: Comparison of CERC and SERC declared Wind Tariff (INR/kWh)

CERC (2016-17)	Gujarat (2016)	Tamil Nadu (2016)	Rajasthan (2014)	Maharashtra (2016)	Karnataka (2013)	Andhra Pradesh (2015)
Wind zone-wise - 3.68 to 5.89	4.19	3.70	5.16/5.42	Wind zone-wise - 3.39 to 4.94	4.5	4.25

Source: CERC and SERC orders

Tables 3.1 and 3.2 show the net feed-in tariff applicable to solar and wind power respectively, across states with high wind and solar potential.[4, 6, 7]

3.1.1 Tariff Discovery through Competitive Bidding

Central Government agencies [mainly National Thermal Power Corporation (NTPC) and Solar Energy Corporation of India (SECI)] and various state governments are responsible for conducting the process of competitive bidding. A substantial reduction in solar tariff has been witnessed in successive biddings over the past five years.

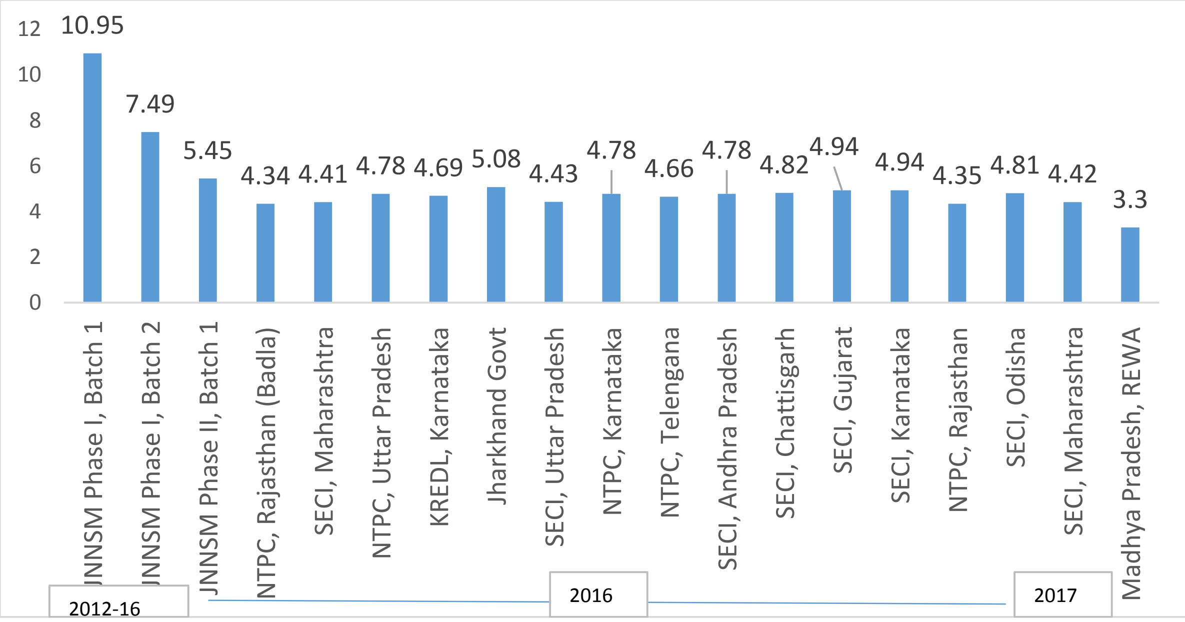
The initial tariff discovered under JNNSM Phase I, Batch 1, in 2012, was around ₹10.95/kWh. The result of the solar bidding conducted in 2017 by NTPC, SECI and some states witnessed a drastic fall in the tariff rates, with the 750 MW REWA, Madhya Pradesh bidding, hitting a historic low of ₹3.30/kWh levelised tariff (as on February 2017). The tariff discovered for the REWA project is almost one-third the tariff discovered under JNNSM Phase I, Batch 1. Figure 3.1 captures the trend of dropping tariffs in solar bidding from 2012 to 2017.[8]

In February 2017, SECI conducted the first-ever bidding for procurement of wind power at inter-state transmission system.[9] The tariff discovered through this bidding process touched a record low of ₹3.46 per kWh.[10] These projects are expected to be set up in Gujarat and Tamil Nadu.

At these tariff rates, the cost of solar and wind are almost on par with those of thermal power generation. Besides, solar power tariff has also been declining on account of sharply falling prices of solar panels; better structuring of projects, thus reducing risks for project developers; and better deals, making financing available at competitive costs.

Based on market dynamics, CERC also revised the benchmark capital cost of Solar PV on an annual basis. Figure 3.2 shows the decreasing trend of benchmark capital cost as determined by CERC during 2010-11 to 2016-17.

Figure 3.1: Solar Bid Tariff Trends (2012-2017)

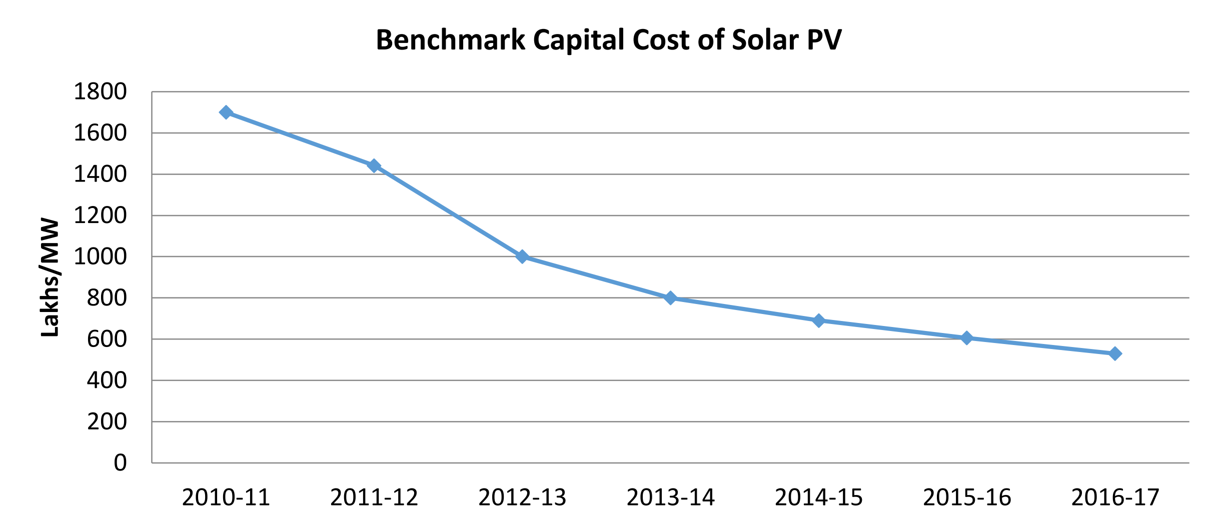


<u>Note</u>

Type of Tariff	Project Name	Type of Tariff	Project Name	Type of Tariff	Project Name	Type of Tariff	Project Name
Fixed Tariff/Bundling	NTPC, Rajasthan; Bhadla NTPC, Uttar Pradesh; NTPC, Karnataka; NTPC, Telangana; NTPC, Rajasthan.	**Levelized Tariff**	KREDL, Karnataka; Jharkhand Govt.; REWA, Madhya Pradesh	**Zero VGF**	SECI, Maharashtra	**With VGF**	SECI, Uttar Pradesh; SECI, Andhra Pradesh; SECI, Chattisgarh; SECI, Gujarat; SECI, Karnataka; SECI, Odisha.

Source: WISE Analysis

Figure 3.2: Decreasing Trend of Solar Benchmark Capital Cost (2010-11 to 2016-17)



Source: Based on CERC orders framed [3, 4, 5]

It can be seen from Figure 3.2 that solar capital costs have drastically dropped from ₹1700 lakhs/MW in 2010-11 to ₹530.02 lakhs/MW in 2016-17 (almost 68% reduction). Developers can source solar panels at even lower rates, resulting in reduced tariffs rates.

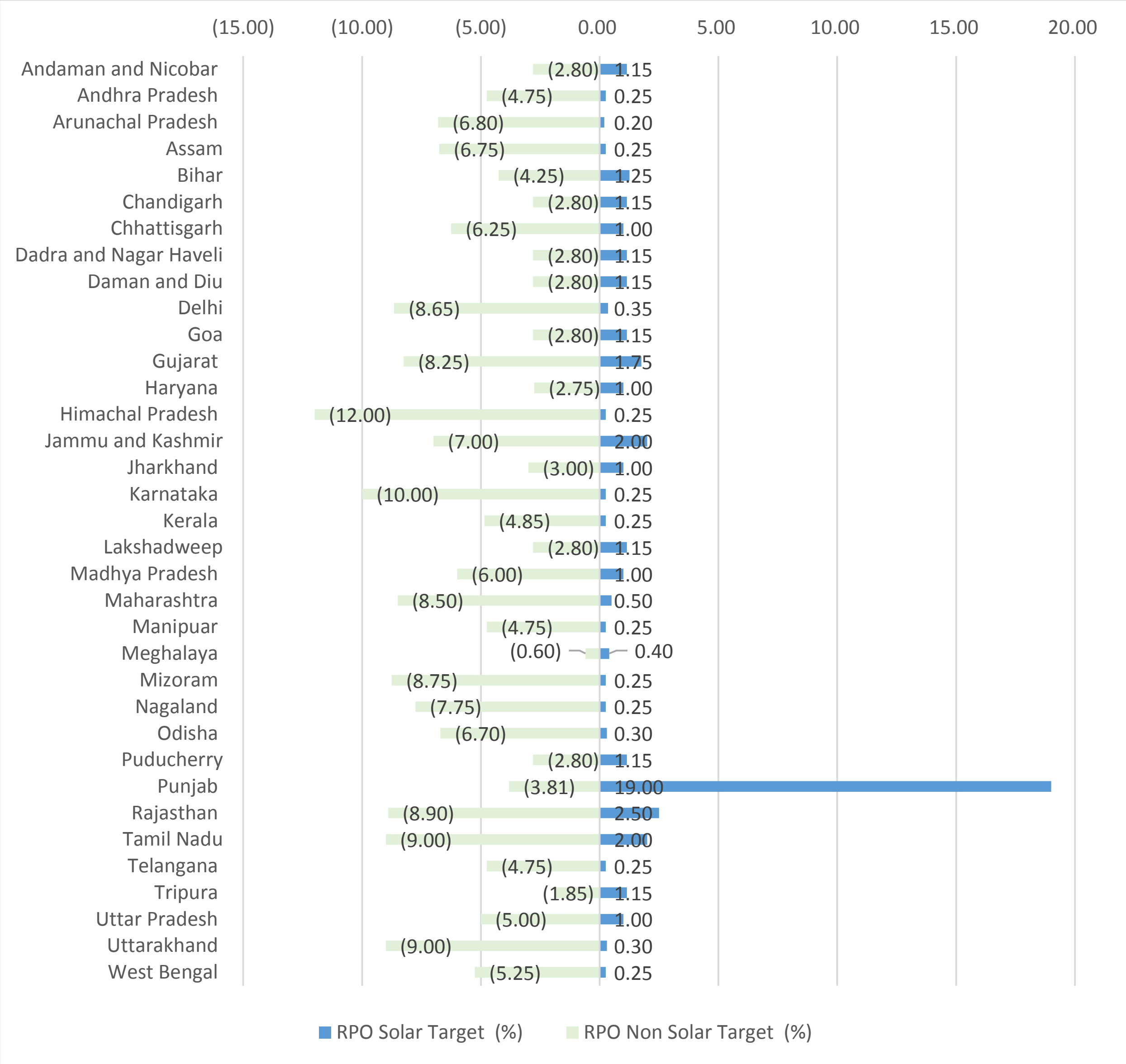
However, sustainability of these low bidding strategies may pose a challenge for the sector, especially for power purchase agreements (PPAs) signed earlier at higher rates. There are concerns whether distribution licensees will honour the PPA terms of higher tariffs or force generators to reconsider. State regulators have also begun the process of feed-in tariff revision based on experience gained from competitive bidding. Solar PV tariffs and capital costs may stabilize at sustainable levels achieved in competitive bidding, since the technology is not material-intensive and thereby not affected by low recurring annual O&M costs. However, the low tariffs seen for wind power are largely the result of inventory build-up in the sector and the manufacturers' willingness to hive off inventory (to avoid holding costs) even at a loss. Since wind is a material-intensive technology, its capacity for capital cost reduction and reduction in O&M cost may not match that of the solar sector. Hence, wind power tariffs need to be viewed differently vis-à-vis solar. Tariff rates need to be sustainable if the RE industry is to survive. While the industry has to be transparent in declaring real costs, the government and regulators need to address technology-specific issues. It is not reasonable to pit one technology against another since all renewable power generation technologies need to prosper.

3.2 RENEWABLE PURCHASE OBLIGATION (RPO) & RENEWABLE ENERGY CERTIFICATE (REC) MECHANISM

3.2.1 Analysis of State-Level RPO Compliance

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 at FIT determined by the SERCs. Figures 3.3 and 3.4 represent the RPO target and RPO compliance achieved by different states in 2015-16 (latest data available) respectively.[1]

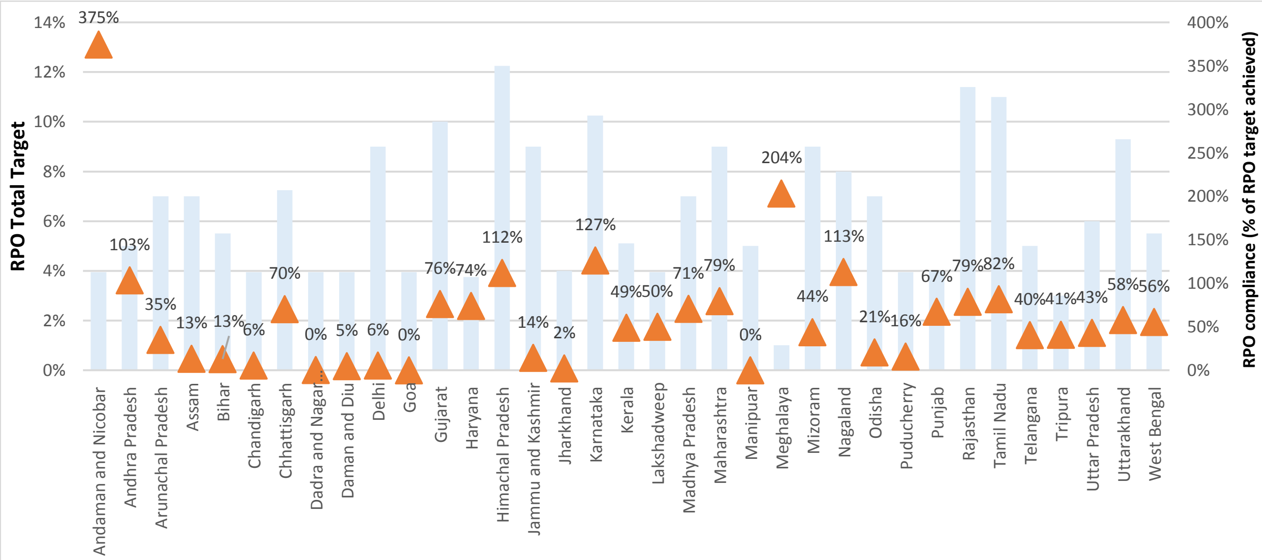
Figure 3.3: State-wise RPO Target (Solar and Non-solar) in 2015-16



Source: Based on MNRE, 2016 data and WISE analysis[12]

Figure 3.4 illustrates that only six states have met the set targets. These include Andhra Pradesh, Himachal Pradesh, Karnataka, and Nagaland, while Andaman and Nicobar Islands and Meghalaya achieved their obligations only due to very low RPO targets. The states cite concerns over grid integration, nature of infirm power, relative high costs of power procurement and adverse financial health of distribution licensees as reasons for the largely tepid response to RPO compliance. Rather than imposing a penalty on defaulters, the trend is for state electricity regulatory commissions to allow distribution licensees to carry the shortfall forward to the subsequent years. Along with DISCOMs, in most states, other obligated entities, namely OA consumers and captive users, have also emerged as defaulters in terms of compliance of RPO. The regular compliance monitoring for the obligated entities, other than DISCOMs, are rare and so, compliance level of the obligated entities is difficult to judge.

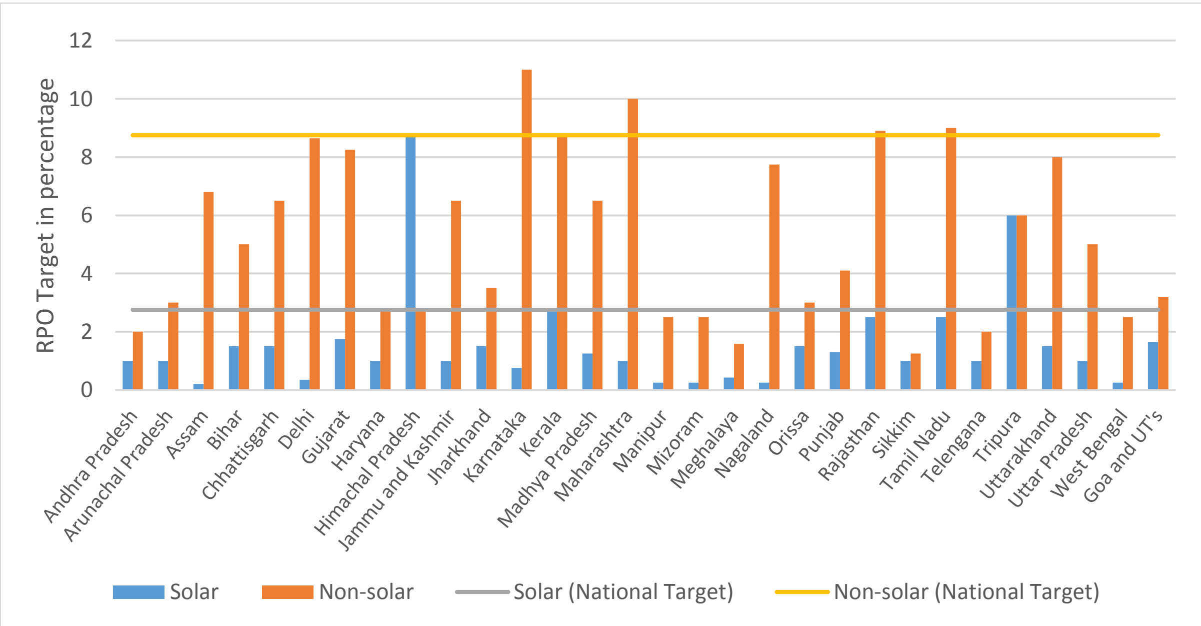
Figure 3.4: State-wise RPO Compliance in 2015-16



Source: MNRE, 2017 [12]

RPO targets set by SERCs have been typically lower than the nationally recommended standard set by the National Action Plan on Climate Change. Most recently, in line with the current amendments to the National Tariff Policy, 2016, MNRE has 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.

Figure 3.5: State-wise RPO Targets vis-à-vis National Targets for 2016-17



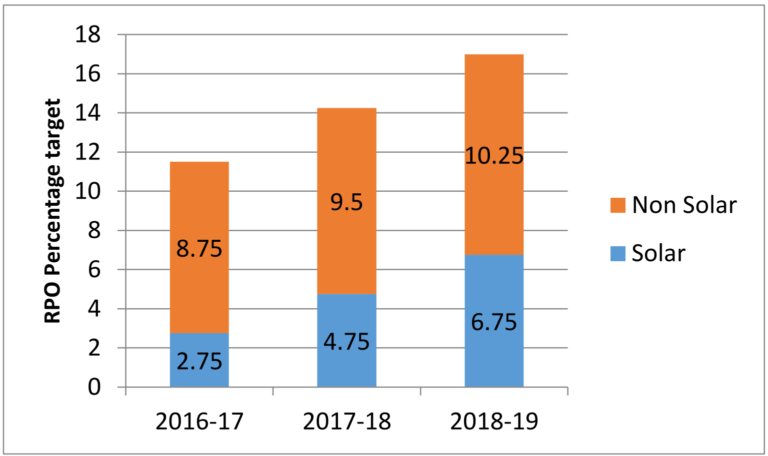
Note: For Karnataka, only BESCOM, MESCOM and CESC RPO data has been considered

Source: WISE analysis

Figure 3.5 shows the comparison between state-wise RPO targets and national targets for 2016-17.

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.[13] Figure 3.6 shows the RPO trajectory for 2016-17 to 2018-19.

Figure 3.6: RPO Trajectory (2016-17 to 2018-19)



So far, only three states, namely Andhra Pradesh, Madhya Pradesh and Rajasthan have issued regulations for aligning RPO trajectory as per the notifications from the Ministry of Power.

Source: Ministry of Power, 2016 [13]

3.2.2 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 Renewable Purchase Obligation.[14]

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. 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 2014, revised the solar REC price for the remaining control period[14, 15,16] Table 3.3 shows the REC prices upto 31 March 2017, as determined by CERC.

Table 3.3: REC Price for 2016-17

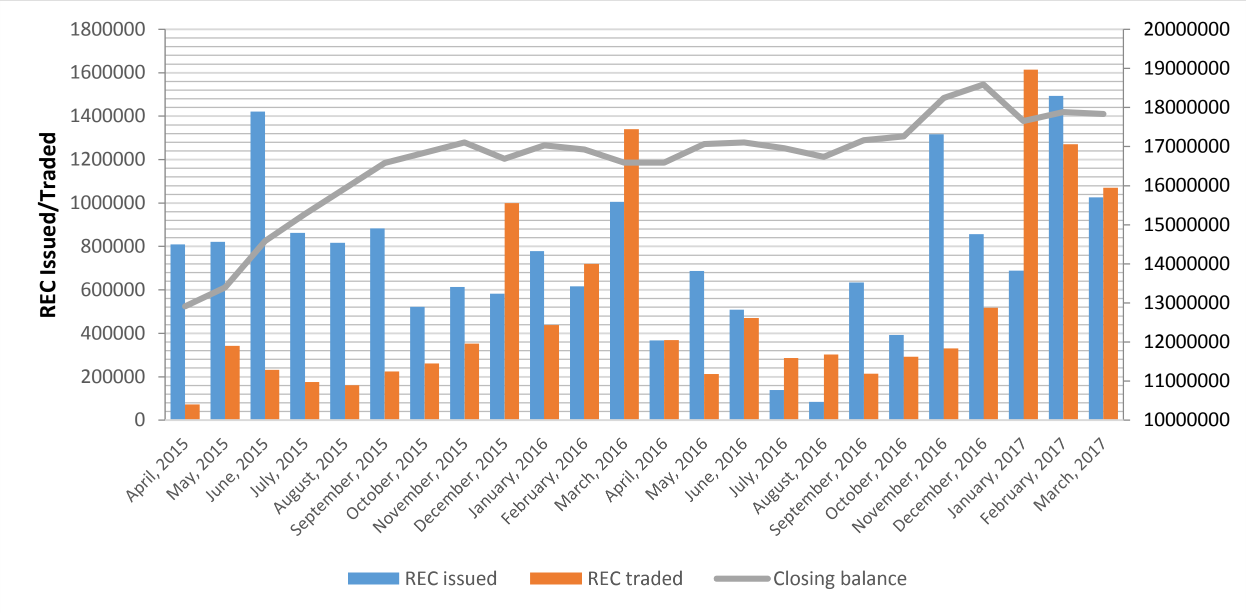
	Non Solar REC (₹/MWh)	Solar REC (₹/MWh)
Forbearance Price	3300	5800
Floor Price	1500	3500

Source: CERC, 2016

Since the REC mechanism is driven mainly by the needs of obligated entities to meet their RPO, the success of the REC mechanism 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. Over 20 million RECs are up for sale, whereas the demand is only a fraction of that.[17] Thus, RECs are being traded at the floor price, which is the minimum stipulated for trading.

Due to poor interest shown by the obligated entities, particularly open access consumers and captive users towards compliance of RPO, REC inventory is increasing. The total REC inventory, till 31 March 2017, was 17.83 million (12.92 million non-solar and 4.91 million solar RECs) (Figure 3.7).

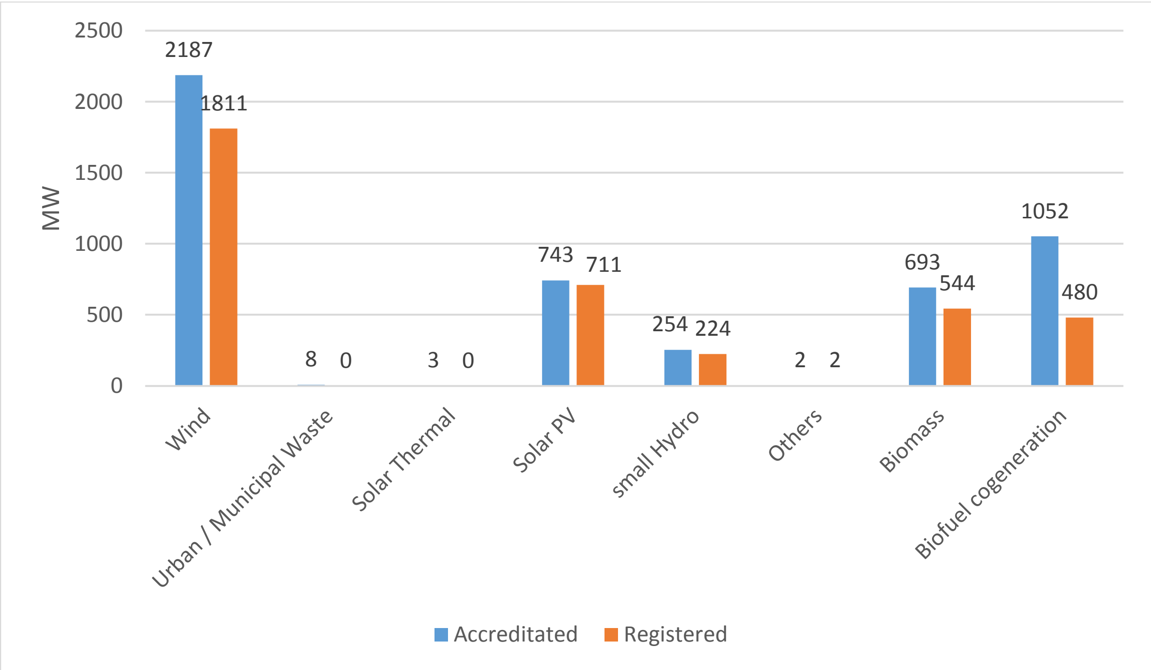
Figure 3.7: Increasing REC Inventory (upto March 2017)



Source: Renewable Energy Certificate registry, 2017

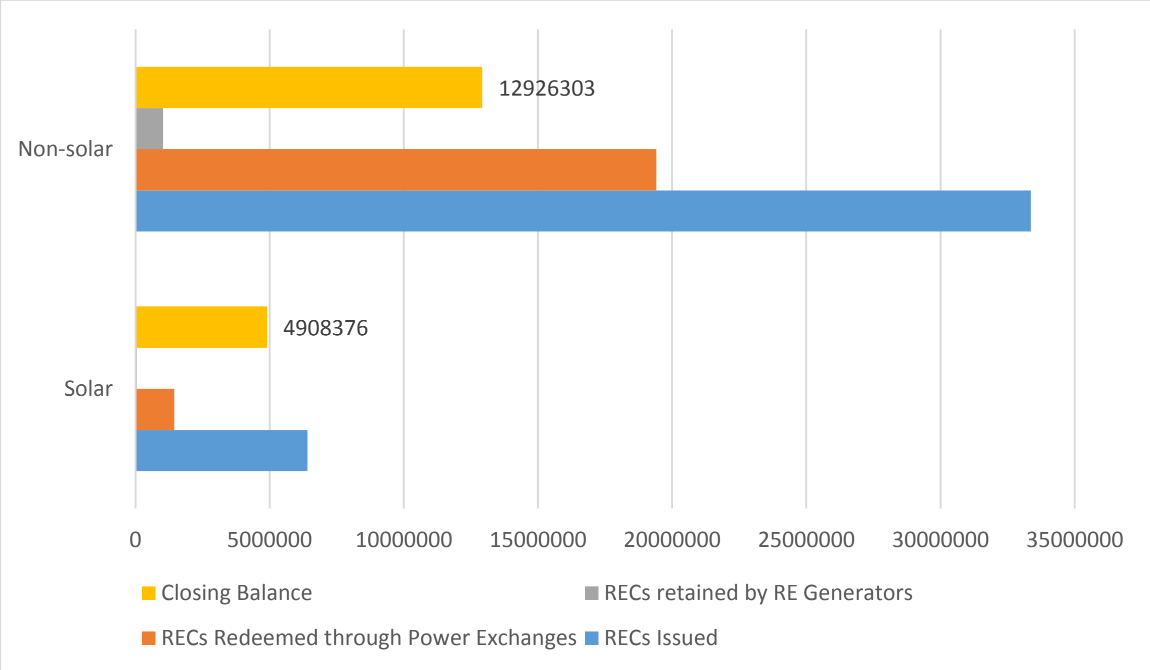
Figure 3.8 gives the technology-wise accredited and registered projects under REC mechanism and Figure 3.9 gives the technology-wise REC liquidity figures, for 2016-17 upto March 2017

Figure 3.8: Technology-wise Accredited and Registered Projects under RECs (upto March 2017)



Source: Renewable Energy Certificate registry, 2017

Figure 3.9: Technology-wise REC Liquidity (upto March 2017)



Source: Renewable Energy Certificate registry, 2017

3.3 OPEN ACCESS REGULATIONS

Open Access (OA) regulations are primarily encouraged by industrial and commercial consumers due to the rate differential, viz. procurement from RE under OA and procurement from DISCOMs. In case of captive users, it is also guided by cost economics as well as requirement for meeting the RPO. Some states have notified their own open access regulations. The charges applicable under each parameter are set by the respective SERCs who decide the attractiveness of third party sale and open access model.[18]

Table 3.4 gives a summary of the OA regulations applicable to select states with high RE potential.

Table 3.4: Regulations Prevailing in States with high RE Potential under Open Access

State	Transmission Charges	Wheeling Charges	Losses	Cross Subsidy Surcharge (CSS)
Andhra Pradesh	Exempted for solar and wind power projects for captive use/third party sale within the state.	Exempted for solar and wind power projects for captive use/third party sale within the state.	Applicable	Exempted for third party sale from solar projects set up within the state for a period of 5 years from the date of commissioning.
Gujarat	Applicable as determined by the Commission.	Applicable as determined by the Commission.	Applicable	No CSS for captive generation plants and MSW-to-energy plants. Applicable for other technologies.
Karnataka	No charges for developers who generate and supply RE within the state. Applicable to open access consumers.	Exempted for energy transmitted or wheeled from renewable energy consumers in the state.	Applicable	Not applicable to renewable energy generators who have been exempted by specific orders of the Commission.
Madhya Pradesh	Applicable	Not applicable for consumers availing open access from renewable energy sources.	Applicable	Not applicable for consumers availing open access from renewable energy sources.
Maharashtra	Applicable	Not applicable to consumers or generating stations connected to the Transmission System directly or using dedicated lines owned by the consumer or generating station. Applicable to all other cases.	Applicable	Applicable
Rajasthan	Applicable	Applicable	Applicable	Applicable
Tamil Nadu	Applicable	Applicable	Applicable; distribution losses borne by the customer.	Applicable

Source: SERC orders

3.4 FORECASTING AND SCHEDULING

With the scaling up of RE targets by the Government of India, large-scale deployment of RE creates a big challenge in terms of grid integration and grid management. These can be addressed through proper scheduling and forecasting of RE generation.

CERC has notified Framework for Forecasting, Scheduling and Imbalance Handling for Variable Renewable Energy 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.[19]

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.[20]

Table 3.5: Comparison of Deviation Charges, Centre vs Karnataka

CERC		
Absolute error in 15-min Block	**Underinjection**	**Overinjection**
< = 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%.
> 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%.
Karnataka (within state)		
Absolute error in 15-min Block		
>15%	Nil	
> ± 15% and < ± 25%	₹0.50/kWh for the quantum of shortfall or excess energy deviation from schedule.	
> ± 25% and < ± 35%	₹0.50/kWh up to ± 25% + ₹1.0/kWh for remaining quantum of shortfall or excess energy for deviation of > ± 25% and < ± 35% from schedule.	
> ± 35%	₹0.50/kWh up to ± 25% + ₹1.0/kWh for remaining quantum of shortfall or excess energy for deviation of > ± 25% and < ± 35% from schedule + ₹1.5/kWh for remaining quantum of shortfall or excess energy for deviation beyond ± 35% from schedule.	

Source: CERC, 2014

The absolute error for the deviation settlement is calculated as:
Absolute error (%) = 100 x [Actual generation – Scheduled Generation]/Available Capacity

States including Andhra Pradesh, Jharkhand, Madhya Pradesh, Rajasthan and Tamil Nadu, have already issued state-specific Draft Forecasting and Scheduling, Deviation and Settlement Regulations, and the State of Karnataka has issued its final regulations. Table 3.5 provides the comparison between deviation charges of the CERC Regulations and Karnataka Regulations.

3.5 NET METERING REGULATIONS FOR ROOFTOP SOLAR

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, rooftop solar 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 issues 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 regulations, most SERCs issued their own net metering regulations. However, states like Andhra Pradesh, Chhattisgarh, Karnataka, Nagaland, Tamil Nadu, Uttarakhand, and the union territories, have not notified any separate net metering regulations till date. Table 3.6 shows the comparison of state-wise net metering regulations of states having the highest planned capacity addition target until 2022.[21]

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. In some states, grant for connection is provided by the DISCOMs after several days of application. The net metering regulations of some states are too restrictive on system size, type of connections, eligibility of consumer categories and business models. Another big challenge lies in educating people, especially small domestic consumers, on the benefits of solar rooftop and facilitation of easy financing for installation. Therefore, lessons from industry experience and best practices adopted by other countries should be used to help improve the policy and regulatory framework of rooftop solar.

Table 3.6: Net Metering Regulations of States with Highest Rooftop Capacity Addition Targets (Until 2022)

PARAMETERS	MAHARASHTRA	UTTAR PRADESH	GUJARAT
ELIGIBILITY CONDITIONS	• Capacity less than 1 MW. • Maximum limit: Limited to sanctioned load.	Shall not exceed sanctioned connected load or contract load of the consumer.	• Maximum capacity installed–maximum of 50% of consumer's sanctioned load. • Installed capacity is between 1 kW and 1 MW.
CAPACITY TARGET FOR DISTRIBUTION LICENSEE	Cumulative capacity shall not exceed 40% of distribution transformer's rated capacity.	Shall not exceed 15%, or any other percentage as may be fixed by the Commission, of the rated capacity of such transformer.	Cumulative capacity should not exceed 65% of the peak capacity of the distribution transformer.
METERING ARRANGEMENT	Solar generation meter may be installed by consumer/licensee at an appropriate location if the consumer/licensee desires that such energy be counted towards meeting its RPO.	• Installing check meters shall be mandatory for capacity over 50 kWp and will be owned by the licensee. Charges for testing, installation and maintenance of meters shall be borne by the consumer. • For systems with capacity up to 50 kWp, licensee or consumer shall install check meter at their own cost.	Check meters should be mandatory for rooftop solar PV systems having capacity more than 20 kW. For installation size of less than or equal to 20 kW, the solar check meter would be optional.
ENERGY ACCOUNTING AND SETTLEMENT	• Excess export of electricity over import shall be carried forward to the next billing period as credited units of electricity. • 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	• Excess electricity injected by the consumer shall be carried forward to the next billing period as electricity credit. • In case the consumer is under the ambit of time of day tariff, electricity consumption in any time block shall be first compensated with the generation in the same time block, and excess generation shall be carried forward to the corresponding time block in the next month. • After each settlement period, any unadjusted excess electricity shall be paid @ ₹2/kWh by the distribution licensee.	• Electricity injected exceeding consumption during any billing period shall be paid by the licensee: •At APPC of the year in which the plant was commissioned to residential and government consumers and industrial, commercial and other consumers not registered under REC mechanism. •At APPC of the year in which plant was commissioned after adjustment of consumption in 15 minute time blocks to industrial, commercial and other consumers utilizing the renewable attribute for RPO compliance. •At 85% of APPC of the year in which plant was

PARAMETERS	MAHARASHTRA	UTTAR PRADESH	GUJARAT
	shall be accounted as if the excess injection has occurred during off-peak hours.		commissioned after adjustment of consumption in 15 minute time blocks to industrial, commercial and other consumers utilizing the renewable attribute for REC.
OTHER CHARGES	--	Eligible consumers or third party owners shall be exempted from wheeling charge and cross subsidy surcharge.	Exempted from transmission and wheeling charges and losses, cross subsidy surcharge and additional surcharge.
PENALTY	--	The provisions of penalty or compensation shall be as per the provisions of the UPERC (Electricity Supply Code) Regulations, 2005, and subsequent amendments	Penalty or compensation shall be payable as per the provisions of the GERC (Standard of Performance of Distribution Licensee) Regulations, 2005, as amended from time to time.

Source: SERC Regulations

TOWARDS GRID PARITY

Renewable energy based power projects have been developed under various business models in India. RE power generators can sell the electricity generated from their projects to the distribution licensees, third party customers or can set up for captive (own) use. For selling power to third party, the tariff rate can be mutually decided, without any regulatory intervention. However, in the Indian context, the tariff rate for selling electricity to distribution licensees is governed by the regulatory framework through the feed-in tariff mechanism. In 2012, competitive bidding was introduced for the first time in India for RE technologies, particularly for solar, under JNNSM. Under state policies also, solar power tariff was discovered through competitive bidding, with very few exceptions.

The revised Tariff Policy announced by the Ministry of Power on 28 February 2016 prescribed power procurement by states from all RE sources (except waste-to-energy projects) through competitive bidding. Consequently, in February 2017, competitive bidding for wind power procurement by SECI was introduced at the central level, kick-starting the process of competitive bidding at the state level.

In 2016-17, under competitive bidding, the lowest discovered solar tariff was ₹3.30/kWh (levellised) for Rewa Ultra Mega Solar Project. For other solar projects, the discovered tariff was in the range of ₹4–5/kWh. However, in case of competitive bidding for wind energy projects at the central level, the quoted tariff was ₹3.46/kWh. Five projects were selected under the said bidding to be developed in Gujarat and Tamil Nadu. The off-takers for competitive bidding in solar are SECI or NTPC who have a good credit rating. This factor has also influenced in lowering tariff rates.

Besides competitive bidding, certain other factors that have been influential in lowering tariff rates include reduced rate of solar module prices internationally, along with lower O&M costs due to economics of scale. Similarly, for solar parks, the required infrastructure is readily available, thus reducing overall costs. All these factors have resulted in reduced tariffs leading to renewables moving towards grid parity.

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4.

MANUFACTURING INDUSTRY

In 2011, the Government of India announced the National Manufacturing Policy and laid down the objective of increasing the share of manufacturing in GDP to 25% by 2020. In 2014, the newly elected government announced the 'Make in India' initiative to promote domestic manufacturing in all sectors; it also aimed at job creation and skill enhancement in renewable energy. With the government of India announcing ambitious targets of 175 GW by 2022, of which 100 GW is from solar power and 60 GW from wind power, these targets offer a major opportunity for growth of RE manufacturing in India. As of now, annual installed manufacturing capacity in wind turbine manufacturing in the country is about 12,000 MW (which is way above the annual capacity addition), whereas manufacturing capacity in solar PV is way below annual capacity additions. Many key upstream inputs in the value chain are completely absent which results in great dependence on imports. Both in wind and solar, there are issues relating to the supply chain viz. in terms of component manufacturing within the country. Strengthening domestic manufacturing by creation of vertically integrated value chains would be critical to the future sustainability of RE development in India. The emphasis in this chapter is on wind and solar manufacturing since they contribute maximum to annual additions.

4.1 SOLAR MANUFACTURING

Subsequent to the announcement of the National Action Plan on Climate Change in 2008, Government of India announced the Jawaharlal Nehru National Solar Mission (JNNSM). A key goal of the JNNSM was *"to take a global leadership role in solar manufacturing (across the value chain) of leading edge solar technologies and target 4-5 GW equivalent of installed capacity by 2020.*[1] By supporting a 6-fold increase in manufacturing capabilities, the mission was expected to catalyse innovation, expansion and dissemination of solar technologies, from silicon material to BoS components; all with a view to generating jobs, becoming a dominant player with export capabilities, achieving grid parity with fossil fuel-based technologies and creating greater flexibility for energy security.[1, 2] Table 4.1. gives solar cell manufacturing capacity in India (as on June 2016), and Table 4.2 provides data for solar module manufacturing. It can be seen that upto June 2016, the total installed manufacturing capacity of solar cells was 1.4 GW and that of modules was 4.3 GW.

Table 4.1: Solar Cell Manufacturing Capacity in India[3]

	Name of the Company	Installed in MW (As on 30-06-2016)
1.	BEL	10
2.	Bharat Heavy Electricals Limited	10
3	Central Electronics Limited	10
4	Dev Solar	3
5	Euro Multivision Limited	50
6	Indosolar Ltd	250
7	Jupiter Solar Pvt. Ltd	280
8	Maharishi Solar Technology	10
9	Moser Baer Solar Limited	250
10	Premier Solar Systems Ltd	75
11	Solar Semiconductor (Renewsys India)	30
12	Surana Solar Limited	120
13	Tata Power Solar Systems Limited	180
14	Udhaya Energy Photovoltaics Pvt Ltd	10
15	Websol Energy System Limited	120
16	XL Energy Ltd.	60
		Total 1,468

Source: MNRE, 2016

Table: 4.2: Solar Module Manufacturing Capacity in India[3]

Sr No.	Name of the Company	Present Status Module Capacity	
		Installed in MW (As on 30-06-2016)	Operational in MW (As on 30-06-2016)
1	Access Solar Ltd.	18	NA
2	Agrawal Solar	40	NA
3	Ajit Solar Pvt. Ltd.	35	20
4	Alpex Exports	200	150
5	AMV Energy Systems Pvt. Ltd.	10	NA
6	Andromeda Energy Technologies (P)Ltd.	30	15
7	Andslite	20	0.75
8	Arion Solar Pvt. Ltd.	5	5
9	AVI	15	15
10	BEL	10	10
11	Bharat Heavy Electricals Ltd	26	26
12	Blue brid Solar	20	20
13	Brawn Battery	25	NA
14	Central Electronics Limited	42	3.8
15	Deity Fuel Energy Pvt. Ltd.	20	20
16	Dev Solar	3	3
17	Electrona/Zynergy	36	35
18	Emmvee Photovoltaic Power Pvt. Ltd.	175	175
19	Empire Photovoltaic Systems	36	36
20	Enfield Solar Energy Limited	20	15

21	Enkay Solar Power & Infrastructure Pvt. Ltd.	20	20
22	Evergreen Solar Systems India Pvt. Ltd.	20	20
23	Gautam Solar	65	65
24	Genus Solar	20	10
25	Goldi Green Technologies Pvt. Ltd.	125	125
26	Green Brilliance Energy Pvt. Ltd.	50	50
27	Greentek India Pvt. Ltd.	25	10
28	H. R. Solar Solution Pvt. Ltd.	15	10
29	HBL Power Systems Limited	20	NA
30	HHV Solar Technologies	100	90
31	ICON Solar-en Power Technologies Pvt. Ltd.	50	24
32	Integrated solar	25	20
33	Jain Irrigation Systems Ltd.	55	55
34	Jakson Solar	60	50
35	JP Solar	20	NA
36	Jyoti Solar	25	NA
37	Jyotitech Solar LLP	35	28
38	Karishma Solar Pvt. Ltd.	20	NA
39	Kohima Solar	55	20
40	Kotak Urja Pvt. Ltd.	75	36
41	Lanco Solar	175	175
42	Maharishi Solar Technology	15	4
43	Mas Solar	20	5
44	Microsol Power P Ltd.	60	15
45	MicroSun Solar Tech Pvt. Ltd.	60	60
46	Modern Solar Pvt. Ltd.	40	32
47	Moser Baer Solar Ltd.	230	50
48	MX Power Solar Ltd.	10	10
49	Navitas Green Solutions Pvt. Ltd.	75	50
50	Neety Euro Asia Solar Energy	15	12
51	Novergy Energy Solutions Pvt. Ltd.	45	45
52	Nucifera	15	15
53	Photon Energy Systems Ltd	50	50
54	Photonix Solar Pvt. Ltd.	40	40
55	Plaza Solar	20	NA
56	Premier Solar Systems Ltd	100	100
57	Prosun Energy Pvt. Ltd.	5	3
58	PV Power Technologies	50	50
59	Raajratna Ventures Ltd.	30	30
60	Radiant Solar Pvt. Ltd.	80	30
61	Rhine Solar Ltd.	40	20
62	Rajasthan Electronics & Instruments Ltd.	20	19
63	Reliance Industries Ltd - SOLAR	30	NA
64	Renewsys India	180	80
65	Ritika Systems	40	40

66	Rolta Power Pvt. Ltd.	60	50
67	Saatvik Green Energy Pvt. Ltd.	175	175
68	Savitri Solar	80	NA
69	Seemac Pvt. Ltd.	40	40
70	Shan Solar Pvt. Ltd.	30	30
71	Shukra Solar Energy Pvt. Ltd.	5	NA
72	SLG Solar System	8	NA
73	SolarMaxx	15	12
74	Solex Energy Ltd.	30	25
75	Sonali Energees Pvt. Ltd.	100	100
76	Sova Power Limited	100	100
77	Stellar Solar Works	20	NA
78	Sun Solar Techno Ltd.	30	18
79	SunFuel	15	1
80	Sunshine Power	10	10
81	Surana Solar	120	120
82	Synergy Solar	50	50
83	Tata Power Solar Systems	300	300
84	TITAN Energy Systems	100	100
85	Topsun Energy Limited	75	60
86	Udhaya Energy Photovoltaics Pvt. Ltd.	7	7
87	USL Photovoltaics Pvt. Ltd.	7	NA
88	Vikram Solar	500	400
89	Vinova Energy Systems Pvt. Ltd.	10	2
90	Vipul Solar	25	NA
91	VRV Energy India Pvt. Ltd.	25	NA
92	Waaree Energies	500	500
93	Websol Energies Ltd.	90	90
94	XL Energy Ltd.	210	NA
	*NA- Information Not Available	**Total** **4,307.55**	–

Source: MNRE, 2016

4.2 WIND TURBINE MANUFACTURING

4.2.1. Background

Wind power development in India started around 1985. But it was only during the 8th Five Year Plan (1992-97), the then Ministry of Non-Conventional Energy Sources (MNES) started concentrated efforts towards creating a favourable policy environment for wind power in India. Thereafter, various policy measures were introduced to encourage investments in wind power development. Investors were initially offered capital subsidies to compensate for potential risks, thus ensuring project viability. Policy instruments like accelerated depreciation, interest subsidies, sales tax exemption, assured feed-in tariff, incentives for captive use, were introduced to encourage deployment of wind turbines in India. These measures spurred the already existing manufacturing and led to shift of wind turbine capacity from 225/600 kW to 600/1000 kW. As development progressed, the Indian wind turbine manufacturers began to introduce higher capacity (MW class) wind turbines to reduce project costs and increase electricity generation. With increasing penetration of wind turbines in the grid, manufacturers had to adapt technologies and practices compatible with electricity load dispatch centres.

4.2.2. Current Status

Today, wind is a mature technology and commercially driven, which had led to phase out of some of the incentives provided in the past. From financial year 2017-18, some of these incentives will cease to be available, while competitive bidding mechanism (operational from February 2017) will be in play. Even though it may restrict the original equipment manufacturers (OEMs) and developers' margins, it will ultimately promote efficient technologies, reduction in project costs, and development of best wind sites.

Currently, there are around twenty-one wind turbine manufacturers in India (registered with NIWE), offering more than fifty wind turbine models.[4] The list of wind turbine manufacturers and models (along with hub height and rotor diameter) is provided in Table 4.3.

Table 4.3: WTG Manufacturers and Models Registered with NIWE (as on October 2016)

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	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
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 Powertech Pvt. 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: NIWE-Revised List for Manufacturers and Models as on 26-10-2016

Table 4.4: Wind Turbine Manufacturer-wise Manufacturing Capacity and Product Portfolio

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 Vaayu Shakthi Ltd	700	NA
4	GE India Industrial Pvt. Ltd	1600/1700/2330	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	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 Wind turbine India Pvt. Ltd	250	15
21	Southern Wind Farms Ltd	225	NA
		Total	**~12,000MW**

Source: Compiled from market reports/company websites.

Apart from the above, some wind turbine manufacturers have been delisted and some are in the process of registering their companies and products with NIWE. The manufacturing capacities of these manufacturers are not publicly available. Based on the research conducted by WISE, the list of wind turbine manufacturers and their manufacturing capacities are shown in Table. 4.4. The total installed wind turbine manufacturing capacity in India is in the range of 12,000 MW. Current annual demand (even in peak years) is not even 50% of this capacity.

In 2016-17, the wind capacity addition of 5,525 MW was contributed by five major wind turbine manufacturers, given in Table 4.5.

Table 4.5: Top Five Wind Turbine Manufacturers with Annual Installed Capacity (2016-17)

Sr. No	OEM	Installed capacity (in MW)	Percentage share
1	Gamesa Renewable Pvt. Ltd	1900	34.39
2	Suzlon Energy Ltd	1750	31.67
3	Inox Wind Ltd	800	14.48
4	GE India Industrial Pvt. Ltd	300	5.43
5	Regen Powertech Pvt. Ltd	200	3.62
	Others	575	10.41
	Total	**5,525**	**100**

Source: Compiled from market reports/company websites

4.3 PROMOTION OF RE MANUFACTURING IN INDIA

While wind historically dominated annual capacity additions, currently it is solar PV that is in the forefront. In addition, while the wind industry has almost a three-decade history of project development and an established manufacturing base, solar manufacturing is a comparatively nascent sector in India (except for some early players like Tata Solar).

The wind and solar industry supply chains are mainly composed of developers or IPPs, OEMs, Tier I and Tier II suppliers. The overall supply chain of manufacturers is shown in Fig.4.1.

Figure 4.1: Wind and Solar Industry Supply Chain

Tier-II Suppliers
- Activity: Raw material/subcomponents, small component manufacturers
- Wind: Tata Steel, Winn Tek Power Systems Pvt.Ltd., Nu-Tech Industrial Spares & Services (P) Ltd., etc.
- Solar: Blistech International Pvt.Ltd., Dupont, Cape Electric Ltd., etc.

Tier -I Suppliers
- Activity: Make large components such as towers, blades, generators, etc. for wind turbines; manufacturers of cell, glass, encapsulant, backsheet, etc., for PV modules.
- Wind: Larsen & Toubro Ltd., Crompton Greaves, ZF Friedrichshafen, LM Wind Power, etc.
- Solar: Gujarat Borosil, Renewsys Pvt. Ltd., Polycom., Sukriti Vidyut Udyog Pvt. Ltd., etc.

OEM
- Activity: Purchase or make components, and assembly, sell completed wind turbine and solar panels to developers.
- Wind: Suzlon, Wind World, Gamesa, etc.
- Solar: EMVEE Solar, Tata Power Solar, Indosolar, Websol, etc.

Developers
- Activity: Secure land and buy wind turbines and solar modules, land levelling, installation etc. In India, most OEMs also work as developers, e.g. Lanco Solar, Tata Power Solar.
- Wind: Panama Wind Energy Pvt. Ltd., Mytrah Energy, etc.
- Solar: L&T Ltd., Juwi International, Mahindra Solar, First Solar, Vikram Solar, etc.

Source: Addressing the Challenges of RE Manufacturing in India, WISE, 2015

4.3.1 Solar Photovoltaics

A typical value chain for solar PV manufacturing is given in Fig.4.2.

Figure 4.2: The PV Value Chain (multi-crystalline)

In India, at present, solar PV manufacturing consists of crystalline silicon cell (c-Si) and PV module manufacturing. As shown in Table 4.1 and 4.2, the cell manufacturing capacity in India (1.4 GW) is way behind the module manufacturing capacity (4.3 GW). While the c-Si technology is likely to dominate the Indian PV sector, production of metallurgical grade, polysilicon ingot and wafers is absent in India, as of now. For solar PV development to become sustainable, it will be important to invest in this manufacturing sector.

After the government launched the National Solar Mission in 2008, a committee was established and given the task of *"identifying the critical elements/components which lend themselves to indigenous manufacturing and recommend the minimum indigenous content for solar power projects"*. The resultant policy option chosen to promote local manufacturing was local content requirements (LCRs) and feed-in tariff for solar PV and CSP plants.[2] In 2016, the Government of India decided to install 100 GW of solar capacity by 2022, augmenting the original 20 GW target of 2009 by almost five times. It was proposed that a small amount of this capacity be developed through Domestic Content Requirement (DCR) in order to protect and promote the budding solar cell manufacturing industry in the country.

The United States had earlier objected to this requirement and filed a complaint in 2013 with the World Trade Organisation (WTO). The WTO ruled in favour of the US and recently made its judgment public, observing that India's policy does not conform to international trade agreements. To arrive at a compromise, the Government of India proposed that it would buy DCR solar panels only for public sector consumption (e.g. railways and defence) and not for commercial purposes, but the US did not agree.[5] Bringing local manufacturers on par with foreign companies is therefore expected to take time. Currently, most of the solar developers in India have been sourcing solar modules and equipment from countries such as China as they are cheaper. India is working on a plan for making domestic manufacturing of solar power generation equipment competitive vis-à-vis countries such as China. As part of this strategy, the Central Government plans to come out with a policy to promote manufacturing of the entire range of solar power generation equipment in the country. Prescription of DCR may be interpreted as erecting a trade barrier; however it cannot stop India from strengthening its domestic industrial base and making it more viable than imports.

As part of meeting the goal of 'net zero imports' in the electronics sector by 2020, the government amended the Modified Special Incentive Package Scheme (MSIPS) in 2012 to promote large-scale manufacturing in the electronic system design and manufacturing sector by providing subsidies for capital expenditure. The MSIPS was expanded to include silicon wafer manufacturers. The government also plans to expand MSIPS' scope to make solar equipment manufacturing competitive in India.

Solar power tariffs have become more attractive due to the lower cost of financing and decreasing module prices. Solar tariffs declined from ₹10.95-12.76 per kWh during 2010-11 to ₹4.34 per kWh in 2016-17. The trend is such that the tariff is likely to continue to decline in the next financial year, enabling achievement of grid parity.

India recognizes the solar PV manufacturing sector as a strategic segment of development. However, in the recent past, many solar cell manufacturers have shut down, primarily due to global over supply from optimized manufacturing lines at cheaper prices. Historically, the nascent supply chain, lack of government initiatives and insufficient economics of scale are considered to be the three major factors for higher manufacturing costs in India. But this is expected to change soon when the new policy for RE manufacturing is announced.

Globally, countries providing strategic support to solar energy development also support solar manufacturing within the country. China has taken a giant leap in solar manufacturing by systematically providing incentive packages or investment support to manufacturing. Easy access to land and electricity were other initiatives taken by that country to become a major global supplier of RE equipment. Manufacturing in China has taken a more systematic form with efficient clusters strategically located near resources, (both physical and human), and logistics or infrastructure like ports.

Probable strategies India can adopt to support domestic solar manufacturing are:

- Establish a cost-effective manufacturing base for metallurgical grade silicon, ingots and wafers by providing government support (equity, etc).
- Promote cluster manufacturing, especially since the raw materials are still imported.
- Increase skilled manpower training at all levels of the downstream and upstream supply chain.
- Promote large domestic markets as they can increase the potential of cheaper sourcing and technology transfer.
- Enhance capabilities of manufacturing lines to cater to growing industry needs and widen the network for dissemination of finished products in a competitive market.
- Collaborate with research institutes, within and outside the country, for joint research development and production.

4.3.2 Wind Turbine Manufacturing

There are two basic types of wind turbines being deployed in India viz. gear and gearless. In 2016-17, more than 90.2% of wind turbines were geared with about 98.12% of WTGs in the range of 1500 kW to 3000 kW. The components and manufacturing processes vary for both these categories of turbines. Wind is a highly material intensive technology and has a long supply chain. The material intensity and large number of components also put constraints and limits on cost-cutting. So, even though the wind industry has a large established manufacturing base, there are many problems which need attention.

Some recent market events, policy changes, etc., which may directly or indirectly impact (positively or otherwise) wind turbine manufacturing in India are:

- **Discontinuation of Incentives:** The central government has discontinued the generation based incentive and 10-year tax holiday, from April 2017. The accelerated depreciation incentive has also been reduced from 80% to 40% from April 2017. This will certainly affect project profitability and impact short to medium-term market demand.[5]
- **Competitive Bidding:** The new Tariff Policy dated 28 January 2016[6] issued by the Central Government envisages procurement of renewable energy (except from waste-to-energy plants), in future, only through competitive bidding, as per its notified bidding framework. In an environment of low tariffs and zero incentives, the only way to give assured returns to investors is to increase efficiency by providing high plant load factor, reduce upfront capital

investment by cutting costs of turbines, and rationalize recurring O&M costs. This is going to be a big challenge for manufacturers.

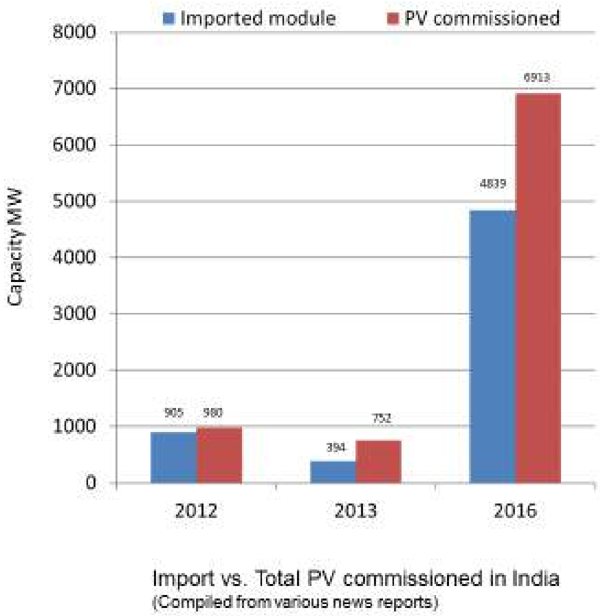
- **Modifications in CEA Grid Connection Guidelines:** With increasing wind power penetration into the grid, the load dispatch centers are facing fresh challenges. In order to regulate grid interconnectivity and quality of power, CEA had introduced applicability of low voltage ride-through (LVRT) for wind turbines. On similar lines, CEA has proposed modifications in grid connectivity regulations to introduce high voltage ride-through (HVRT) facility, specifically ramp-up and ramp-down rates, voltage regulation, short circuit ratio, limits on harmonics, reactive power control capability, etc. The new regulatory stipulations will require modifications in wind turbine technology and manufacturers will have to meet these requirements, which may have additional cost implications on wind turbine costing.[7]
- **Repowering Policy:** More than 3 GW of wind power capacity in India comes from wind turbines of capacity 500 kW and below, which are installed at the best windy sites and have completed more than twelve years of project life. New wind turbines with higher hub heights and power can yield more energy due to their high efficiency, and on repowering, resource utilisation can be optimized. On 5 August 2016, MNRE issued policy for repowering old wind power projects. This policy has enabling provisions on transmission augmentation, treatment of additional power generated, etc. If this policy is implemented effectively, it can positively impact manufacturing.[8]
- **O&M Costs and Independent O&M Service Providers:** The total installed wind power project capacity has reached 32.2 GW as of 31 March 2017. The number of wind turbines are greater than the total MW capacity. Mobilizing resources, maintaining manpower at widely spread out rural locations is a big challenge for the OEMs. Annual escalations in O&M costs have drastically increased the percentage of O&M cost vis-à-vis total revenue receipts from sale of electricity, thereby reducing returns to project owners. Some independent O&M service providers like Kintech Global Services Private Ltd., RENOM, Omkar Clean Energy Services Private Limited (OCE), POWERCON Ventures India Pvt. Ltd, etc., have now entered the wind turbine O&M market. It is hoped that rationalization of O&M costs and bringing competition and quality in wind turbine O&M services will reduce recurring O&M costs in the near future.[9, 10, 11, 12]

4.4. EXPORT-IMPORT IN THE RE SECTOR

Solar manufacturing in India is adversely affected by large scale import of PV panels. It can be seen from Figure 4.3 that the percentage of imported panels vis-à-vis total installed capacity for the three years viz. 2012, 2013 and 2016 is 92%, 52% and 70% respectively. The reasons for this high import content are manifold: insufficient manufacturing capacity in the country, sourcing from cheaper locations like China, developers opting for different PV technologies which are not domestically manufactured, etc.

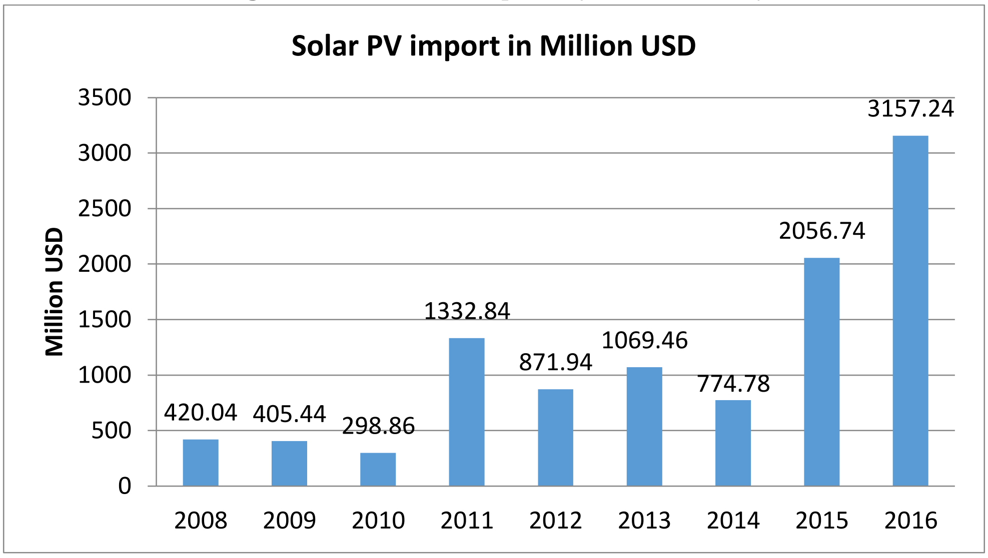
Imported polysilicon cells are cheaper than domestically manufactured ones. At present, domestically manufactured cells cost around ₹19/Wp; this is about 15% more than imported cells. The travails of the domestic cell manufacturing industry stems from this mismatch. As already mentioned, the absence of vertically integrated domestic supply chain (beginning with metallurgical silicon) also economically hampers manufacturing of cells in India.

Figure 4.3: Solar PV Installed Capacity vis-à-vis Import of Panels



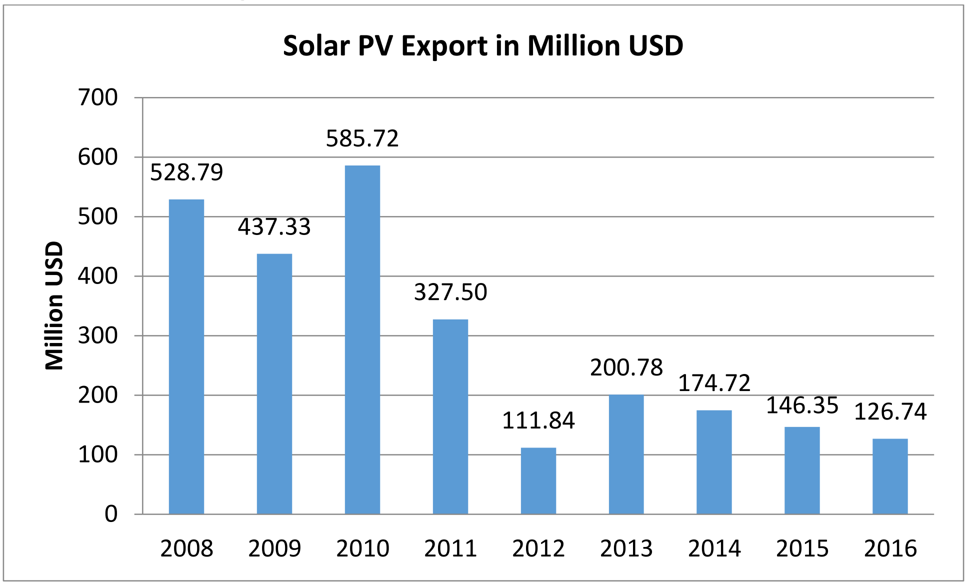
The values of PV imports and exports are shown in Figures 4.4 and 4.5 respectively. Solar PV imports to India have been increasing and peaked at 3157 million USD in 2016 due to strong domestic demand. In 2016, China supplied around 84% of solar PV imports to India. Apart from this, India also supplies PV panels to many countries and the exports are mainly to UK, Belgium, Nepal, USA, Italy, etc. While the volume of imports have increased by 650.9% the volume of exports have seen a steep decline of 76.03% percent during the period 2008 to 2016.

Figure 4.4: Solar PV Imports (in Million USD)



Source: Derived from UN comtrade database.[13]

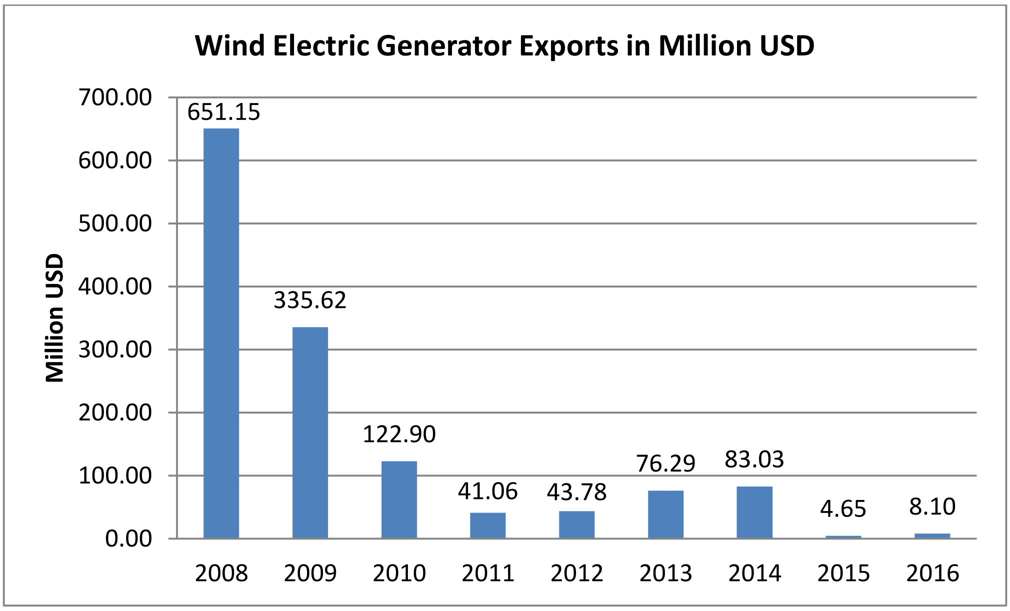
Figure 4.5: Solar PV Exports (in Million USD)



Source: Derived from UN comtrade database [13]

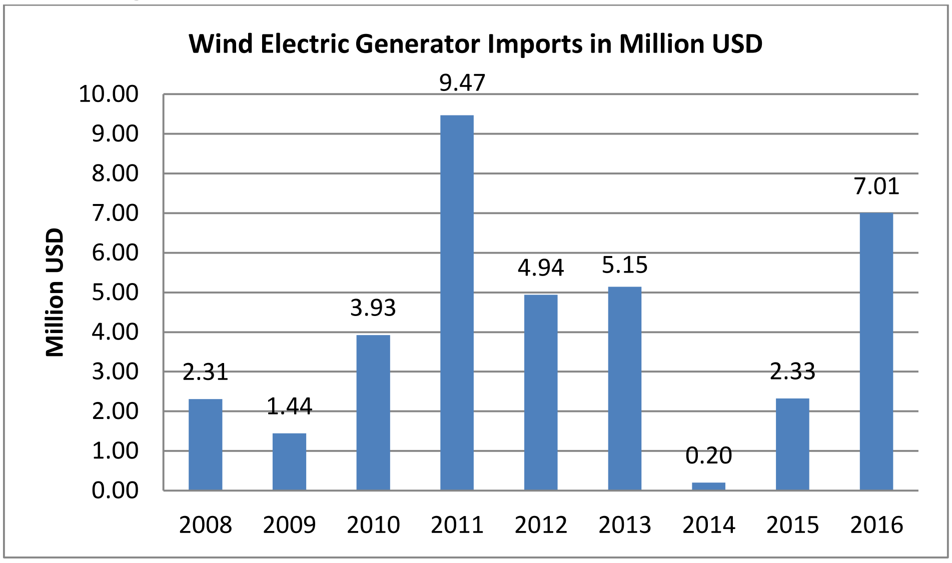
As can be seen in Fig .4.6, even in the wind manufacturing industry, that has a strong established base in India, exports have declined from a high of 651 million USD in 2008 to 8 million USD in 2016. This is a decline of 98.7%. In 2015 and 2016, export of wind electric generators reduced drastically and imports increased. (Fig.4.7). This may be partly due to increased domestic demand of wind electric generators in India. Also, the volume of imports in 2016 was comparatively small at 7 million USD. The wind electric generators are mainly imported from China and Austria.

Figure 4.6: Wind Electric Generator Exports (in Million USD)



Source: Derived from UN comtrade database [13]

Figure 4.7: Wind Electric Generator Imports (in Million USD)



Source: Derived from UN comtrade database [13]

With the introduction of competitive bidding, both solar and wind tariffs would decline and soon achieve grid parity. That would be a major step forward for India. However, for these rates to be sustainable, we will have to strengthen our manufacturing base. In solar, priority should be given to create facilitating mechanisms for establishing a vertically integrated c-Si PV module manufacturing capacity, beginning with domestic production of metallurgical grade silicon. Right now we are exporting large quantities of quartzite (the raw material for silicon production) from states like Rajasthan. Instead, if we create value addition by utilizing it for silicon production, it would help support our long-term objective of transitioning to a clean energy economy. It would also help conserve foreign exchange, both by cutting import of silicon or silicon wafers and fossil fuels. Both in solar and wind, we should focus on strengthening our manufacturing base, with a strong export orientation. The next policy package should focus on this aspect of strengthening RE manufacturing in India.

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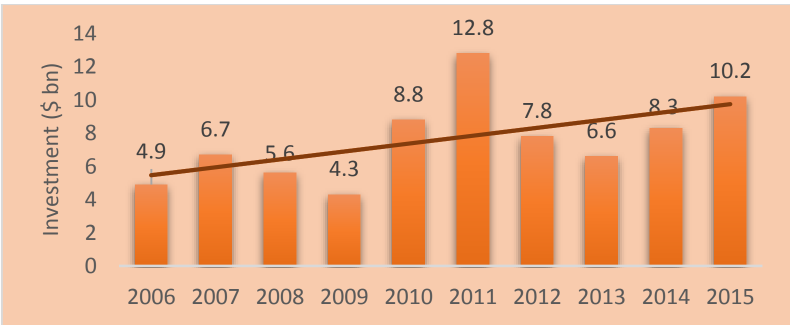
5.
INVESTMENT FLOWS

Policy, regulation and an industrial base are critical to the growth of any sector. However, growth is driven by investment flows which are also significantly impacted by the fiscal and financial framework for the sector, besides profitability. The year under review has been a boom year for investments in the sector. Besides Indian corporates and the public sector, international investors and multilateral funding institutions participated in this investment growth. This section surveys the investment flows to the RE sector.

5.1 INTRODUCTION

The central government has set an ambitious target of achieving 175 GW renewable energy by 2022. From this target, 57 GW has been achieved till 31st March, 2017.[1] The remaining 118 GW capacity needs to be installed within the next five years, which requires a capital amount of ₹9,414 billion, including ₹6,590 billion in the form of debt.[2]. In addition, huge investment is required for transmission and upgradation of infrastructure in order to utilize the power generated through RE sources. India's RE sector investment has grown steadily in the past 10 years (2006 to 2015). This period can be divided into two in terms of average annual investment – one from 2006 to 2010 and the other from 2011 to 2015. The average annual investment for the initial 5 years was ₹271 billion (US$6 billion) whereas for the next 5 years it was ₹512 billion (US$9 billion).[3] Figure 5.1 shows the growth trend in RE investments from 2006 to 2015.

Figure 5.1 Growth Trend in RE Investments (2006 to 2015)



Source: UNEP/WISE, 2017

5.2 STATUS OF RENEWABLE ENERGY FINANCING IN INDIA

RE financing in India is basically through debt and equity. Major sources of debt are banks and non-banking financial corporations (NBFCs). According to MNRE, a total of 40 banks and NBFCs have sanctioned ₹71,202 crore debt funding for financing various RE projects between February 2015 and March 2016.[4] Apart from domestic banks and NBFCs, debt is also raised from multilateral development banks (MDBs) and through external commercial borrowings (ECBs) and green bonds.

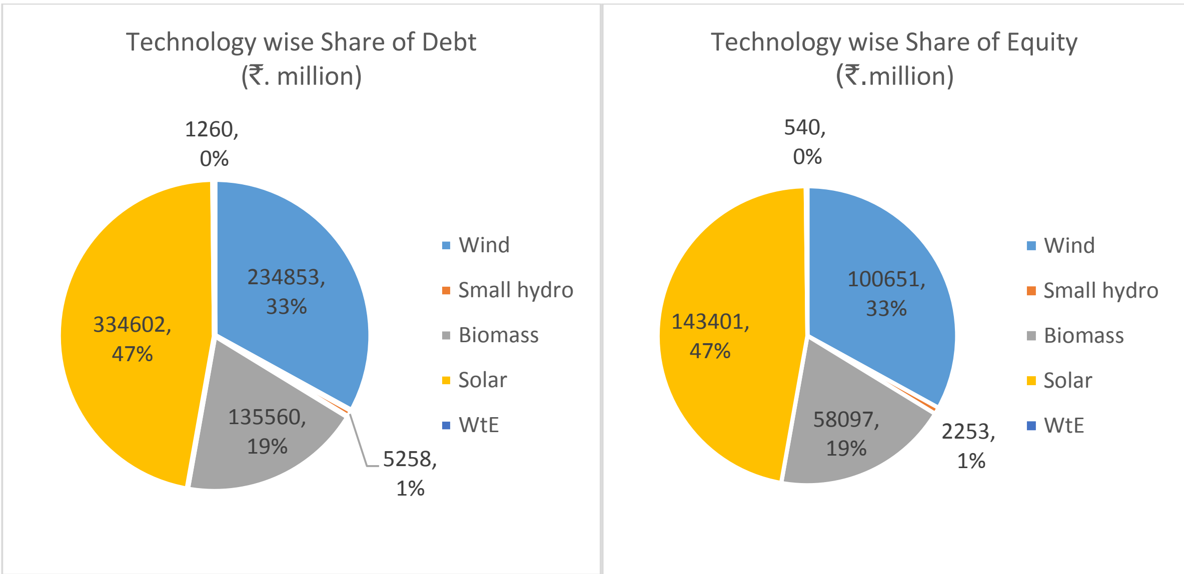
Equity investment comes from domestic investors, foreign direct investors, and multilateral development banks. An estimation reveals that India's total debt financing in 2016-17 was ₹7,11,533 million and equity financing was ₹3,04,943 million.+ For this estimation, capital cost as per CERC tariff order, 2016, has been considered. When capital costs for different types of same technology are given, the average over different types has been considered. Table 5.1 summarizes technology-wise capital costs as per CERC regulations.

Table 5.1: Capital Cost for Different Technologies for 2016-17

Technology	Capital Cost (₹lakh/MW)
Wind	620
Small hydro(average)	706
Biomass	578
Solar	865
Waste-to-Energy (WtE)	1,200

Source: CERC, 2016

Figure 5.2: Debt and Equity Investments in Renewable Energy in India (2016-17)* [5,6]



Source: WISE, 2016

*The share of WtE and small hydro is very small due to which they are hardly visible. However, for readers' convenience, their values have been shown in the figure.

Figure 5.2 provides the estimated sector-wise, debt and equity investments in RE in 2016-17. The largest investment is seen in the solar sector with ₹3,34,602 million debt and ₹1,43,401 million equity. Lowest investment is seen in the waste-to-energy sector with ₹1,260 million debt and ₹540 million equity.

+The estimation is based on the fact that India's annual installed capacity in 2016-17 was 14,410.85 MW. Taking the benchmark capital cost for different technologies (as pegged by CERC), the total capital cost for installing these capacities works out to ₹10,16,475.88 million (US $15,157.71 million), of which 70% is considered as debt and 30% as equity. Primary data is collected from sources such as Reserve Bank of India, Indian Bank Association, and MNRE.

5.2.1 Debt Funding in Renewable Energy

India's total debt investments in 2016-17 came mainly from commercial banks. Others included non-banking financial corporations, external commercial borrowings, and multilateral development banks. Commercial debt contributed roughly 70% of RE investments. Major banks and NBFCs financing RE through debt are listed in Figure 5.3.

Figure 5.3: Banks and NBFCs providing Debt in 2016-17

*Banks	NBFCs
• State Bank of India • Punjab National Bank • Central Bank of India • Yes Bank • Axis Bank Ltd. • Exim Bank	• Indian Renewable Energy Development Agency • Power Finance Corporation • Rural Electrification Corporation • L&T Infrastructure Finance • Tata Capital

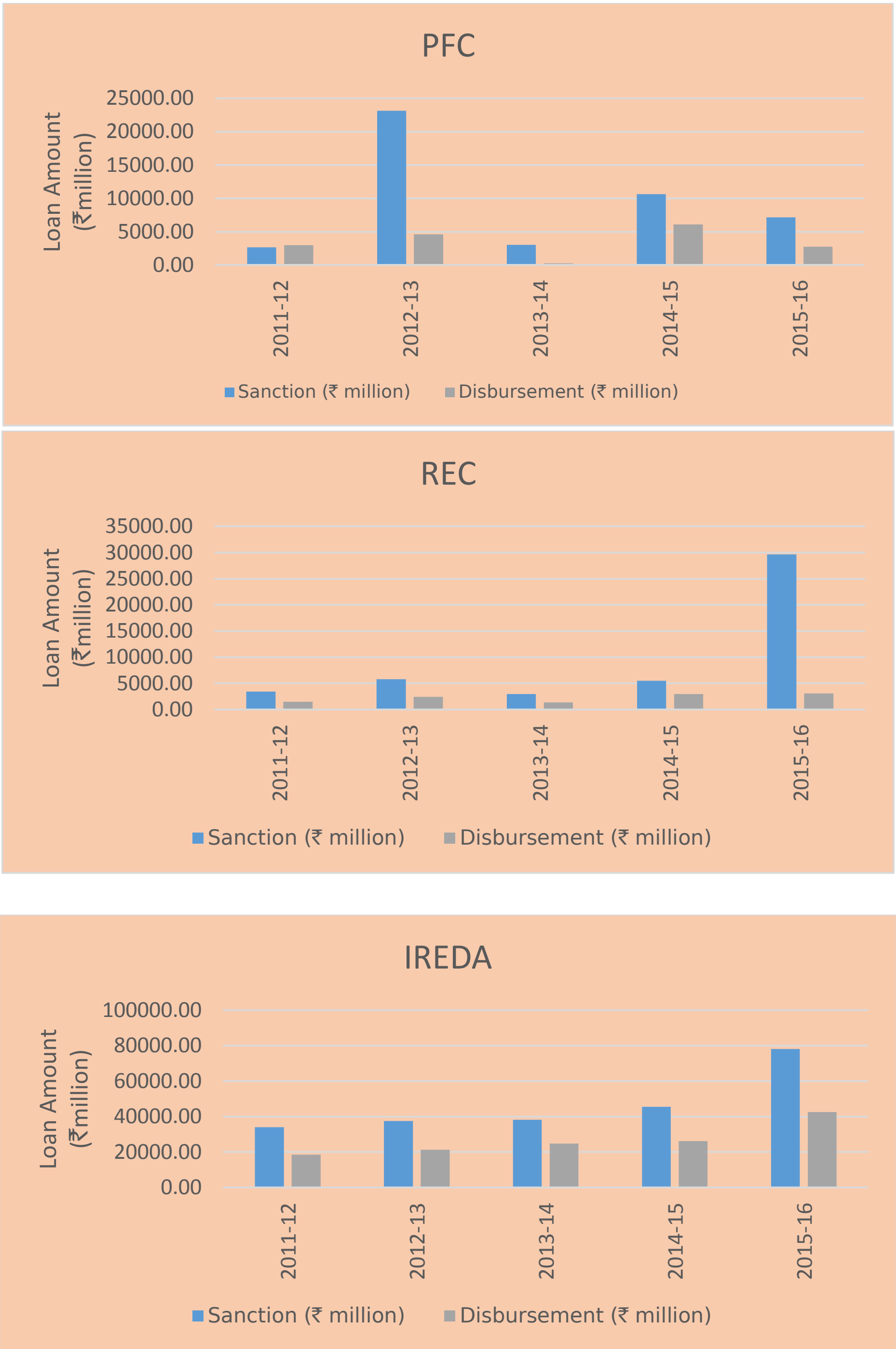
Source: WISE

*While major attempts were made to source data for loan disbursements made by Commercial Banks, these could not be procured. Hence data not provided.

The three major NBFCs in India are the Indian Renewable Energy Development Agency (IREDA), Power Finance Corporation (PFC) and Rural Electrification Corporation (REC). The amount sanctioned and disbursed for five years from FY 2011-12 to FY 2015-16 to the RE sector by these three public sector NBFCs is depicted in Figure 5.4. It can be seen that all NBFCs have carried out disbursal lower than the sanctioned amounts. PFC's sanctioned amount is highest in 2012-13 (₹23,130 million) and lowest in 2011-12 (₹2,680 million). There is no clear trend in disbursement of loans by PFC with highest disbursement (₹6,094 million) in 2014-15 and lowest disbursement (₹254 million) in 2013-14. REC has increased its sanctioned amount 440% in 2015-16 (₹29,657 million) from that in 2014-15 (₹5,479 million). Unlike these two NBFCs, sanction and disbursement by IREDA has increased steadily between 2011-12 and 2015-16. Its lowest sanctioned amount (₹34,059 million) was recorded in 2011-12 and increased almost 130% over five years to record sanction of loan to the amount of ₹78,064 million in 2015-16. Disbursal by IREDA also increased by almost 130% from ₹18,550 million in 2011-12 to ₹42,573 million in 2015-16. [7,8,9]

For 2016-17, the one-year Marginal Cost of Funds based Lending (MCLR) rate in Indian banks varied from 8.15% to 9.5%.[10] Generally, the interest rate on loan for renewable energy is considered to be 300 basis points above the MCLR. Consequently, the interest rate on term loans for renewable energy works out between 11.15% and 12.50%. Comparatively, the interest rate on term loans for renewable energy provided by NBFCs varies from 9.75% to 11.50%.[11,12,13] Thus loans given by NBFCs are marginally beneficial to investors than those given by banks.

Figure 5.4 Sanction and Disbursement of Loans by Major NBFCs (2011-12 to 2015-16)



Source: Annual Reports of respective institutions and WISE, 2011-12 to 2015-16

Apart from debt financing from banks and NBFCs, External Commercial Borrowing also played a crucial role in RE financing. Total ECB from April 2016 to March 2017 was US$429 million. However, a statistical analysis of ECB data shows that investment through ECB is still not popular in India, mainly due to regulated interests (all-in-cost ceiling), which fails to attract foreign lenders. A summary of statistics for ECBs is provided in Table 5.2. [14]

Table 5.2: Summary of Statistics of External Commercial Borrowings in 2016-17

	ECB (US$ Million)	ECB (₹Million)
Total	429	28,481
Average	20	1,356
Median	7	500
Standard Error	6	421

Source: RBI, 2016

As can be seen from Table 5.2, the average ECB for 2016-17 was US$20 million and median investment was US$7 million. Clearly, the large difference between mean and median reflects the concentration of ECBs towards smaller values, thereby indicating that large amounts from ECBs are still hard to come by in India.

While financing from banks and NBFCs are of paramount importance, often these loans are unaffordable. This happens due to the relatively high cost of investments and short loan tenures. The advent of Green Banks, worldwide, has addressed these two issues by providing loans to borrowers for a period equal to the payback period, at relatively lower interest rates. The features and benefits of establishing Green Banks are provided in Box 1.

Box 1 Green Banks [15] & [16]

Green banks tailor their offerings to match domestic needs and can help mainstream green investment locally. The characteristics of financing by green banks are threefold; first, they offer affordable lending for a period which matches the payback period of projects; second, they use financial products and techniques to mitigate specific risks; third, they engage in market development and demand generation.

Green banks use private sector experience and discipline in the service of the public good. They play a unique role since neither traditional government programs with their limited engagement with the market, nor competitive private sector can achieve this. These banks also provide low cost and longer tenure credit to the renewable energy sector that matches the payback period of the projects, thereby leading to more projects, being developed. Besides, green banks also help in mitigating perceived risks of renewable energy by local lenders. These risk mitigation products help private banks execute the initial transactions for clean energy projects.

Additionally, green banks play an important role in familiarizing other commercial banks with clean energy technologies through co-investment. Moreover, green banks identify and analyze technologies that are new to the local market, but which have a proven track record elsewhere. This can expand financing for commercially mature, but unfamiliar technologies in India. Green banks may also facilitate financing to the decentralized renewable energy sector in rural areas. These banks may establish standard norms as a requirement for receiving finances. This in turn reduces costs.

There have been discussions for converting IREDA into a green bank. This may be a timely intervention to fuel lending to renewable energy technologies in the country. The conversion of IREDA into a green bank will facilitate low-cost and higher tenure loans in the market. The option of providing low-cost financing to the renewable energy sector can be further leveraged by allowing IREDA to raise funds from foreign markets.

A healthy tranche of low-cost debt in 2016-17 came from multilateral development banks (MDBs). The main difference between lending by commercial banks and MDBs is in the interest rates and the tenure of loans. While the interest on loans by commercial banks mostly remains over 10%, the interest rate from MDBs ranges between 4% and 6%. However, these interest rates do not reflect hidden charges and do not accommodate losses due to exchange rate fluctuations. Albeit, the cost of financing loans from MDBs is lower than that from commercial banks and NBFCs. Also, the tenure of loans from MDBs is between 10 and 15 years with limited or no recourse, whereas tenure of most of the bank loans are 10 years or less. Besides, lending from MDBs brings 'financial additionality'. This can be achieved in many ways. For example, MDBs help in bringing financing partners into specific deals through syndication or co-financing arrangements. This also helps in increasing the confidence of other financial institutes. Thus, it is strategically important to attract more funding from MDBs to uplift the investment in the sector. Major debt investments from MDBs for RE, in 2016-17 are enumerated in Table 5.3.

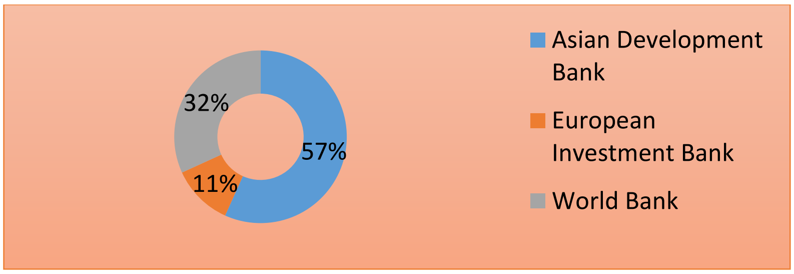
Table 5.3: Lending by Multilateral Development Banks in 2016-17*

Organization	Amount ($ million)	Description
World Bank	625	Loan to SBI for lending to grid connected solar PV projects
Asian Development Bank	500	Loan to renewable energy projects
Asian Development Bank	390	Project funding to Renew Power
European Investment Bank	213	Loan to SBI for mega solar projects
Asian Development Bank	175	Loan to Improve India's solar power transmission system
Asian Development Bank	50	Co finance from clean technology fund

Source: Press releases of respective organisations, 2016
*Annual average exchange rate for FY 2016-17 has been considered for rupee to dollar conversion

Table 5.3 shows that the major bulk of investments came from Asian Development Bank (57%), followed by the World Bank (32%) and European Investment Bank (11%) respectively. Figure 5.5 depicts relative share of financing by different MDBs during 2016-17.

Figure 5.5 Funding Share of Different MDBs in the RE Sector (2016-17)



Source: WISE, 2017

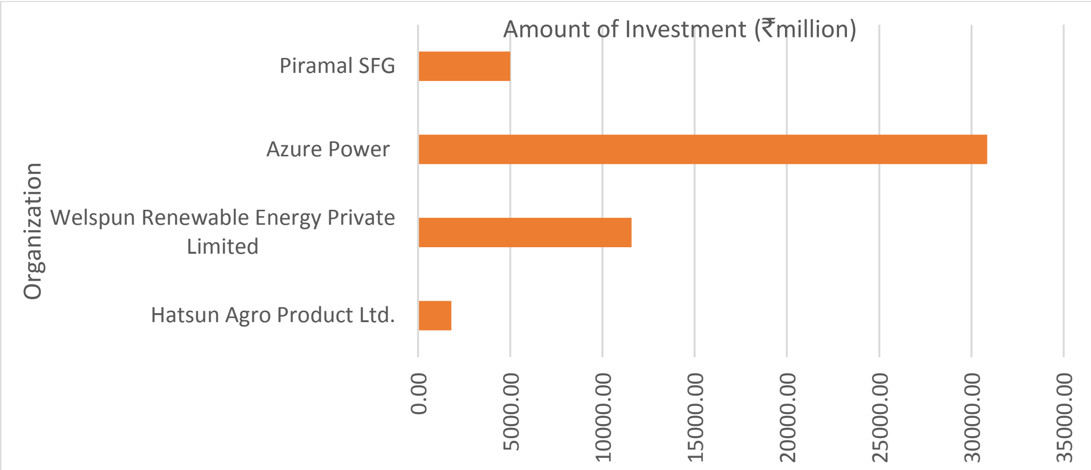
5.2.2 Equity Investments in Renewable Energy

Equity investments in 2016-17 came from domestic investors, foreign direct investors and multilateral development banks. The share of equity in total investments was roughly 30%.

Foreign direct investment (FDI) is through the automatic route and up to 100%, which has enhanced the ease of equity investment in the RE sector. Between April 2014 and September 2016, a total of US$904 million was invested in India in the form of FDI with highest and lowest values being US$200 million and US$32 million respectively.

Domestic equity investment from major investors in the RE sector in 2016-17 was ₹49,240.55 million with lowest investment at ₹1,800 million and highest at ₹30,865 million. However, the range has a downward bias with only one investment above ₹30,000 million and three investments below ₹12,000 million, thereby leaving huge variation in the level of investment by domestic investors. Company-wise domestic investments in 2016-17 are shown in Figure 5.6.

Figure 5.6: Investments by Major Domestic Investors in Renewable Energy in 2016-17



Source: Press releases of respective organisations; WISE analysis

Apart from FDI and investments by domestic organisations, International Finance Corporation has also pledged equity investment to the RE sector by committing US$140 million for 2016-17.

There are new investment vehicles that are gaining popularity in the Indian markets. These vehicles mobilize financial resources from domestic as well as foreign markets to finance renewable energy in the country. Looking at their future potential, the report features two such vehicles: Infrastructure Investment Trusts and Green Bonds (Box 2).

Box 2 POTENTIAL PUBLIC MARKET INVESTMENTS [17, 18]

According to Bloomberg New Energy Finance (BNEF), India's aggregate power sector spending will be more than $1 trillion by 2040, out of which the allocation to renewable energy will be 60%. A study by BNEF shows that most wind projects are financed by private lenders, whereas, most solar projects are financed by government banks and NBFCs. In order to meet the target of 175 GW RE by 2022, both public and private sector financial institutions need to enhance financing of renewables.

In addition, financing through public markets needs to be tapped, since currently it is not a much sought-after option in India. But huge capital requirement, in combination with high cost of debt and equity, means that fundraising from the capital market will be an important instrument of financing renewable energy projects in the country. Two key instruments for raising finance through the capital market are Infrastructure Investment Trusts and Green Bonds, and thus find critical mention here.

Infrastructure Investment Trusts

The concept of Infrastructure Investment Trusts (InvITs) has been under discussion in India for more than five years. InvITs are publicly traded vehicles that offer investors regular yields. Investors will be able to own, indirectly, part of the portfolio of the project that is part of an InvIT. Given that an InvIT consists largely of completed assets, the returns required by the investors are expected to be lower than the financing costs of the developer. These trusts release equity to finance/refinance infrastructure projects. They also assist in unlocking tied-up capital of developers, lowering domestic financial institutions' loan exposure and attracting foreign capital.

Green Bonds

Indian renewable energy companies have been issuing bonds for quite a long time. However, most of them were not labelled 'GREEN'. In February 2015, YES Bank floated the first green bond in India worth ₹10,000 million with a tenure of 10 years and 8.85% coupon. Since then, many Indian companies have floated green bonds. In 2016-17, green bonds were issued by 7 Indian companies as mentioned below.

Green Bonds Issued by Indian Companies in 2016-17		
Issuer	Amount (US$ Million)	Amount (₹Million)
Axis Bank	500	33,650
ReNew Power	75	5,000
NTPC	299	20,000
Greenko	500	33,465
Yes Bank	49	3,300
ReNew Power	475	31,872
IREDA	106	7,000

(Source: Climate Bonds Initiative)

Green bonds need not necessarily be raised in the domestic market. Offshore bond markets may be tapped as well. In May 2016, Axis Bank listed a $500 million green bond on the London Stock Exchange. Further, Masala bonds are a lucrative instrument for raising funds. These bonds are raised overseas, but the bonds are issued in Indian currency. Thus, it transfers the risk of exchange rate fluctuation to the investor. However, this type of bond requires higher ratings or offers higher returns to investors. The National Thermal Power Corporation (NTPC) issued green masala bonds of ₹20,000 million (US$299 million) in August, 2016 on the London Stock Exchange and Singapore Exchange.[19]

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6.
EMISSIONS SCENARIO

According to the International Energy Agency (IEA), energy production and use account for two-thirds of the world's greenhouse gas (GHG) emissions. The Intergovernmental Panel on Climate Change (IPCC) estimates that to preserve a 50% chance of limiting global warming to 2^0C, the world can support a maximum carbon dioxide emissions "budget" of 3000 gigatonnes (Gt), of which an estimated 1970 Gt has already been emitted before 2014.[1] Taking into consideration CO_2 emissions from industrial processes and land use, land-use change and forestry for the remaining period of the 21st century, the carbon budget for the energy sector works out to only 980 Gt (2014 onwards).

As on December 2015, the Government of India stated that the energy sector accounted for the maximum number of emissions (58%). Within the energy sector, electricity generation is the biggest contributor of GHG emissions, totalling 65.4%, followed by transport (12.9%) and buildings (12.6%).[2] IEA predicts that an additional 315 million people – almost the population of the United States today – are expected to live in India's cities by 2040. This transition is expected to have huge impact on energy consumption patterns. Currently, India is the world's third largest market in terms of gross electricity generation, of which coal-fired power provided 58.79% of India's electricity in 2016-17.[3]

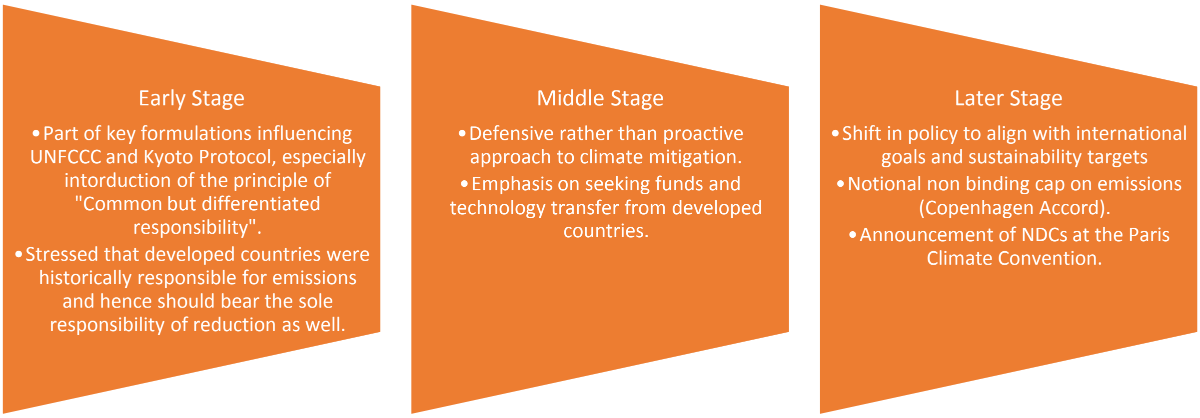
Given the above critical scenario (both global and India), the use and further development of fossil fuels in the energy sector needs to be urgently curbed by transitioning to a low-carbon pathway.

6.1. INDIA AND ITS 'CHANGING' CLIMATE ROLE

6.1.1. International Negotiations and India (Figure 6.1)

In the initial years of climate negotiations (early 1990s), India made key formulations that went on to defining the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. This included formulation of the principle of "Common but Differentiated Responsibility" (CBDR), that held the developed countries historically responsible for increased carbon emissions. In essence, it translated into the fact that developed countries bear the responsibility of reducing emissions, and transfer funds and technologies to developing countries to enable them to cope with the impacts of climate change. The official Indian stance after its initial activism gradually turned out to be defensive to the developed countries' position. India mainly focused on warding-off mounting pressure to take on mandatory emission cuts. It was only around 2008-09 that the country began to synergize itself with international goals and decided to voluntarily reduce its emissions intensity by 20-25 percent by 2020 (from 2005 levels). India formally placed this pledge on record at COP 15 in Copenhagen in 2009.[4]

Figure 6.1: India's Position in International Climate Negotiations



Source: WISE, 2017

6.1.2. Climate as part of India's Energy Discourse

National Action Plan on Climate Change

Box 1: NAPCC - The Eight Missions

1. National Solar Mission
2. National Mission on Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Eco-system
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change.

Climate became part of the nation's energy discourse with the advent of the National Action Plan on Climate Change (NAPCC) in 2008, which aimed to address India's developmental concerns along with mitigation and adaptation challenges posed by climate change through eight national missions (Box 1). As per the NAPCC, India's climate strategy would promote the country's developmental objectives and at the same time, yield co-benefits that address climate change.[5]

As part of the NAPCC, the government in 2009, directed all state governments and union territories to prepare State Action Plans on Climate Change (SAPCC), consistent with the strategy outlined in the NAPCC. Twenty-two states have since initiated the process of drafting SAPCCs.

Intended Nationally Determined Contribution (INDC)

The next big step taken by India to include climate as part of its energy discourse was with 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. India's pledge through its INDCs offers a comprehensive approach to curb the worst impacts of climate change while fostering economic growth, increasing energy access, creating jobs, protecting forests and providing cleaner air and water for its citizens.

Of the eight INDCs, the following three are specific targets and critical to India's climate and energy policy: [6]

1. Reduce emissions intensity of its GDP by 33 to 35 percent by 2030 from 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 from the 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.

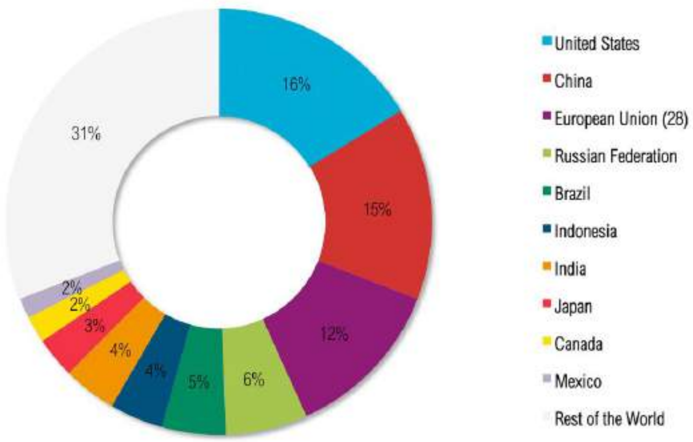
Apart from mitigation goals, there is also a strong focus on climate change adaptation in India's INDCs which highlights current initiatives in sensitive sectors, including agriculture, water, health and more.

6.2. EMISSIONS SCENARIO

6.2.1. Historical Emissions

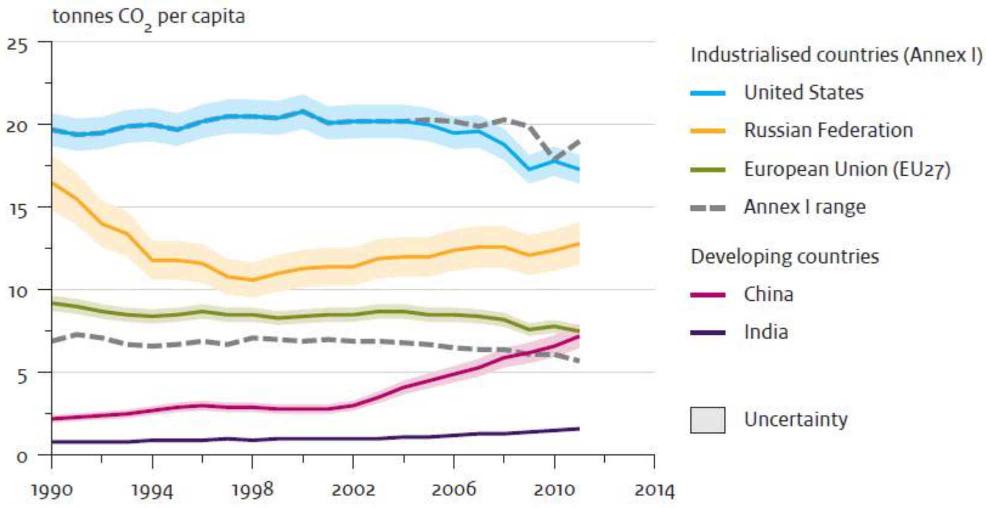
In order to determine responsibility of nations towards climate change, taking into account historical emissions by different countries in the past is crucial. Figure 6.2 illustrates the share of different countries (regions) in cumulative GHG emissions during the past decade, i.e. 1990 to 2011.[7] During this period, the United States occupied the first rank in cumulative GHG emissions (16%), followed by China (15%) and the European Union (12%). India ranked well below these countries (6th rank) with a share of 4%. In terms of per capita emissions, the country showed much lower emissions (1.6 tonnes) than those in industrialised countries (Figure 6.3).

Figure 6.2: Global Cumulative GHG Emissions between 1990 and 2011



Source: World Resources Institute, 2014

Figure 6.3: Global Per Capita GHG Emissions between 1990 and 2014[8]



Source: World Resources Institute, 2014

Table 6.1 GHG Emissions by Sector in India (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	(6.3%)	100.87	(5.3%)	1.9
Cement	60.87	(4.9%)	129.92	(6.8%)	6.0
Iron & Steel	90.53	(7.2%)	117.32	(6.2%)	2.0
Other Industry	125.41	(10.0%)	165.31	(8.7%)	2.2
Agriculture	344.48	(27.6%)	334.41	(17.6%)	-0.2
Waste	23.23	(1.9%)	57.73	(3.0%)	7.3
Total without LULUCF	1251.95		1904.73		3.3
LULUCF	14.29		-177.03		
Total with LULUCF	1228.54		1727.71		2.9

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

Source: INCCA, 2010

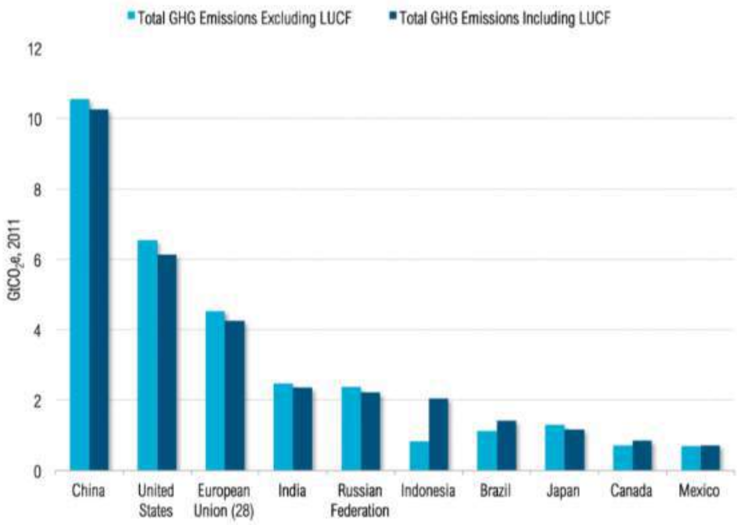
According to the 'India: Greenhouse Gas Emissions 2007' report, the total GHG emissions without land use, land-use change and forestry (LULUCF) has grown from 1251.95 million tonnes in 1994 to 1904.73 million tonnes in 2007 at 3.3% compound annual growth rate (CAGR) and with LULUCF at 2.9% CAGR.[9] Between 1994 and 2007, some of the sectors that show significant growth in GHG emissions include cement production (6%), electricity generation (5.6%), and transport (4.5%). A summary of GHG emissions by sector for 1994 and 2007 is shown in Table 6.1.

6.2.2. Current Emissions

According to the Emissions Gap Report, 2017, total global greenhouse gas emissions (including LULUCF), are estimated at about 51.9 $GtCO_2e$/year in 2016. The estimate for global total greenhouse gas emissions in 2014 was 51.7 $GtCO_2e$, and that of 2015 was 35.6 $GtCO_2$. Emissions show a slowdown in growth in the past two years, with calculated increases of 0.9 percent, 0.2 percent and 0.5 percent in 2014, 2015 and 2016 respectively.[10]

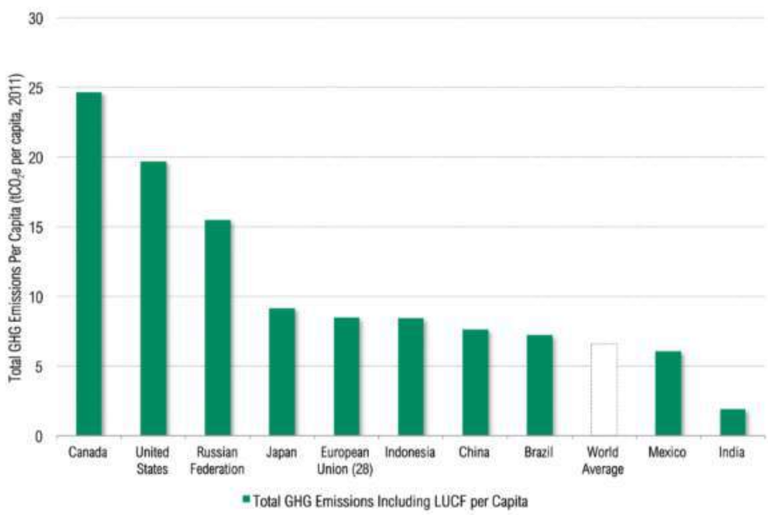
Data from World Resources Institute shows that around 70% of global GHG emissions emanates from top 10 emitters of GHGs in the world. Figure 6.4 shows the absolute emissions of GHGs in 2011 (excluding and including LULUCF). While India ranks fourth in the list of absolute emissions, it ranks last in per capita emissions (including LULUCF) (Figure 6.5).[7]

Figure 6.4: Global Top 10 Emitters of GHGs (2011)



Source: World Resources Institute, 2014

Figure 6.5: Global Per Capita Emissions of GHGs by top 10 Emitters (2011)



Source: World Resources Institute, 2014

6.3. EMISSIONS IN THE ENERGY SECTOR

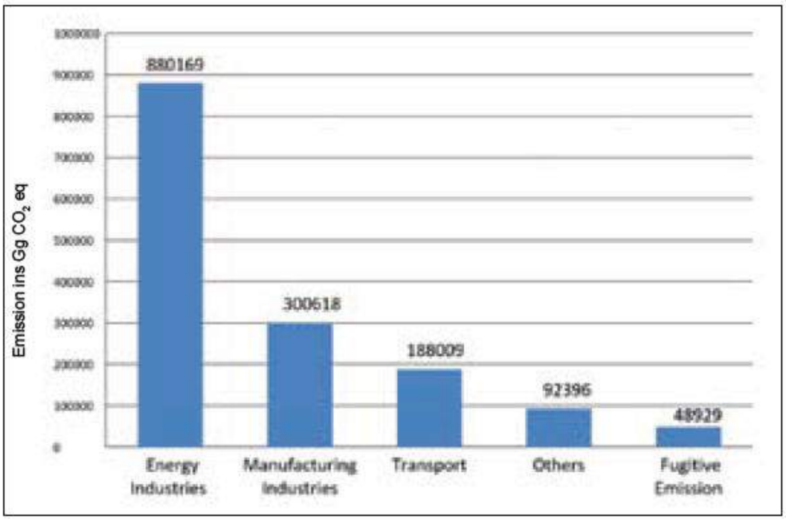
6.3.1. Global Emissions

Total volume of global energy sector CO_2 emissions over the past 27 years matched the total level of all previous years. Fossil fuels continued to meet more than 80% of total primary energy demand and over 90% of energy-related emissions were from CO_2 emanating from fossil fuel combustion.[1] At the beginning of the 20th century, energy related CO_2 emissions originated almost exclusively in Europe and the United States. But in 2014, this share dropped below 30% of total energy related CO_2 emissions in the world. However, a large share of emissions still came from a small number of countries. In 2012, China, United States and India contributed almost half of the global CO_2 emissions. An important development occurred in 2014, when the growth trend in global energy related CO_2 emissions stalled, with an estimated total of 32.2 Gt unchanged from the previous year.[1]

6.3.2 Emissions in India's Energy Sector

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). Figure 6.6 shows the distribution of emissions across the energy sector. It can be seen that the energy industries (viz. power plants) account for the maximum amount of emissions (880,169 Gg CO_2eq), followed by the manufacturing industries (300,618 Gg Co_2eq) and transport (188,009 Gg Co_2eq).[11]

Figure 6.6: Distribution of Emissions in India's Energy Sector in 2010



Source: India's First Biennial Report, 2015

6.3.3 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 INDC 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 2016-17, these two sources have been specifically considered for deriving estimates for emissions reduction. During 2016-17, India's annual average wind and solar power capacity was 29,528.59 MW and 9,525.84 MW respectively. Assuming that the wind and solar power plants were in operation throughout the year, total energy generation works out to 79.15 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 6.2.

Table 6.2: 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

The average savings of CO_2 emissions from one MWh of electricity production is 0.79 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 62.72 million metric tonnes in 2016-17.

6.4. FUTURE TRENDS

According to the Emissions Gap Report 2017, India is expected to overachieve its INDC targets of a) 33-35% reduction in emissions intensity levels by 2030 (from 2005 levels), b) increase the share of non-fossil energy in total power generation capacity to 40 percent, and c) create an additional cumulative carbon sink of 2.5–3 $GtCO_2e$ through additional forest and tree cover, if it continues with its achievement of current targets. In addition, India can also avoid emissions if it achieves its target of producing 160 GW of power from wind and solar technologies by 2022. This will enable displacing around 256.95 million metric tonnes of CO_2 emissions and replacing coal-based power generation with clean energy.

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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