Achieving 12% Green Electricity by 2017

Final Report, June 2011

Prepared by

WISE
WORLD INSTITUTE OF SUSTAINABLE ENERGY

Supported by

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

Achieving 12% Green Electricity by 2017

Final Report, June 2011

Prepared by

World Institute of Sustainable Energy, Pune

Supported by

Shakti Sustainable Energy Foundation

For Internal Circulation

The Report of the study 'Achieving 12% Green Electricity by 2017' is strictly for internal circulation. To reproduce any part of the text of the report for bona fide use, please obtain prior permission by writing to cra@wisein.org.

Research Team

Principal Investigator	**G M Pillai**, Founder Director General, WISE
Team leader	**Surendra Pimparkhedkar**, Fellow & Head, Centre for Renewable Regulation and Policy (CRRP)
Research Team Members	**Anand Wagh**, Associate Fellow **Satadru Chakraborty**, Sr Research Associate, CRRP
Supported by	Centre for Climate and Sustainability Policy, Centre for Wind Power, Centre for Solar Energy

Contact

Centre for Renewable Regulation and Policy
World Institute of Sustainable Energy
Plot No 44, Road No 2, Kalyani Nagar
Pune – 411006/India [Country code +91]

Tel. (020) 2661 3832 / 55
Fax (020) 2661 1438
E-mail cra@wisein.org
Web www.wisein.org

Contents

	Abbreviations	*iv*
	Figures and Tables	*vi*
	Executive Summary	*vii*
1	**Evolution of Policy Environment for Renewables in India**	**1**
1.1	Recent legal and policy environment for RE	1
1.2	Developments in RE Electricity Regulation	7
2	**Rational for and Benefits of Increasing RE in the Energy Mix**	**11**
2.1	Rational	11
2.2	The Benefits	15
3	**Potential and Status of Development of Renewables in India**	**19**
3.1	Renewable Energy Potential in India	19
3.2	Current Status of Development	23
4	**Capacity Addition Required for Achieving 12% RE by 2017 and 15% RE by 2020**	**27**
4.1	The Approach and Methodology	28
4.2	The Different Targets & Plans	29
4.3	The Existing Plans /and Shortfall vis-a-vis NAPCC	30
4.4	Capacity Addition Scenarios	32
4.5	Pan India Impact on Average Power Procurement Cost (APPC)	41
4.6	Possible State–wise /RE Technology–wise Capacity Addition Plan to Meet the NAPCC Target (Solar Dominant Scenario)	42
4.7	Key Outcomes	55
5	**Towards 15% RE by 2020: Removing the Barriers**	**57**
5.1	Financial Barriers and Remedies	57
5.2	Policy Barriers and Remedies	59
5.3	Regulatory Barriers and Remedies	63
5.4	Institutional Barriers and Remedies	69
5.5	Human Resources and Remedies	71
5.6	Other Barriers	73
6	**Road Map of Actions Needed**	**75**
6.1	Planning	75
6.2	Financing	75
6.3	Policy	76
6.4	Regulation	77
6.5	Capacity Building	78
6.6	Human Resources	78
6.7	Other Areas	79
	References	**80**

Abbreviations

APPC	Average Power Procurement Cost
ADB	Asian Development Bank
CAGR	Compounded Annual Growth Rate
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CPV	Concentrated Photovoltaic
CSP	Concentrating solar power
CUF	Capacity Utilisation Factor
C–WET	Centre for Wind Energy Technology
DTC	Direct Tax Code
EA	Electricity Act 2003
ERC	Electricity Regulatory Commission
ESMPA	Energy Sector Management Assistance Programme
EU	European Union
FDI	Foreign Direct Investment
Fis	Financial Institutions
FY	Financial Year, FY10 is FY 2010-11
GBI	Generation Based Incentives
GHG	Green House Gas
GoI	Government of India
GSI	Geological Survey of India
GW	Giga Watt
GWEC	Global Wind Energy Council
IEGC	Indian Electricity Grid Code
IEP	Integrated Energy Policy
IEX	Indian Energy Exchange
IREDA	Indian Renewable Energy Development Agency
JNNSM	Jawaharlal Nehru National Solar Mission
Kg	Kilo gram
kg/m^3	kilogram per cubic meter
km	Kilo meter
kW	Kilo Watt

kWh	Kilo Watt hours
LBNL	Lawrence Berkeley National laboratory
LCOE	Levelized Cost of Energy
m	meter
MNES	Ministry of Non Conventional Energy Sources
MNRE	Ministry of New & Renewable Energy
MW	Mega Watt
MWh	Mega Watt hour
NAPCC	National Action Plan for Climate Change
NCEF	National Clean Energy Fund
NEP	National Electricity Policy
NLDC	National Load Dispatch Centre
NTP	National Tariff Policy
NTPC	National Thermal Power Corporation
NVVNL	NTPC Vidyut Vyapar Nigam Ltd
OA	Open Access
PFC	Power Finance Corporation
PLF	Plant Load Factor
PPA	Power Purchase Agreement
RE	Renewable Energy
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligation
RPS	Renewable Purchase Standards
RRF	Renewable Regulatory Fund
Rs	Rupees
SERC	State Electricity Regulatory Commission
SEZ	Special Economic Zone
SHP	Small Hydro Power
UI	Unscheduled Interchange
WISE	World Institute of Sustainable Energy, Pune

Figures

	Title	Page
2.1	Increasing Competitiveness of RE-based Generation on LCOE basis	13
2.2	Expected Grid Parity for Solar-based Electricity	13
2.3	Comparative Costs of Nuclear Power and Solar PV Power in cents/kWh	15
3.1	Share of RE in Overall Power Generation Capacity (MW)	23
3.2	Share of RE Generation in Overall Power Generation (MU)	24
4.1	Requirement of renewable energy to meet NAPCC target (BU)	30
4.2	Planned RE injection and shortfall	31
4.3	Cumulative RE capacity addition projection over 2011-12 to 2019-20	40
5.1	Scenario-wise RE capacity addition vis-à-vis state-wise RPO targets (MW)	66

Tables

	Title	Page
2.1	India: Energy Sector GHG Emissions (million tonnes of CO2 e.q.) in 2007	16
2.2	Annual Avoided Emissions after 2016/17 (in million tonnes of CO2)	16
3.1	MNRE Estimate: Renewable Energy Potential in India	19
3.2	Grid-connected RE Potential in India (WISE Estimates)	21
4.1	Planned capacity addition for 11th, 12th, & 13th Five Year Plan periods	29
4.2	Targets specified under JNNSM	29
4.3	All India electricity demand and required RE injection to meet the NAPCC target	30
4.4	Planned RE injection and shortfall	31
4.5	RE capacity addition required as per Scenario 1 (2011-12 to 2019-20)	34
4.6	RE capacity required as per Scenario 2 (2011-12 to 2019-20)	36
4.7	RE capacity addition required as per Scenario 3 (2011-12 to 2019-20)	38
4.8	Cumulative RE capacity addition projection over 2011-12 to 2019-20	40
4.9	Impact on Pan India APPC due to purchase of RE	41
4.10	State wise projected RE capacity addition on cumulative basis (Wind dominant scenario)	43
4.11	State wise projected RE capacity addition on cumulative basis (Solar dominant scenario)	49
5.1	Likely Debt Requirement for RE Sector during 12th Plan Period	57
5.2	Likely Debt Requirement for RE by 2020	58
5.3	RPO Targets set by SERCs	63
5.4	Required capacity addition vis-à-vis capacity addition through state RPO (MW)	65
5.5	Job creation during 12th five year plan in RE sector (WISE Estimates)	71
5.6	Job creation in RE sector by 2020 (WISE Estimates)	71
5.7	Proposed revision required in the curricula of educational and training institutions	72

Executive Summary

The study titled **'Achieving 12% Green Electricity by 2017'** was undertaken by the World Institute of Sustainable Energy (WISE) and supported by Shakti Sustainable Energy Foundation with financial assistance from ClimateWorks Foundation , USA.

The focus of the study was to see ***how*** the national RE target specified in the National Action Plan on Climate Change (NAPCC) can be achieved – not ***whether*** it can be achieved – and to calculate the RE capacity additions required for meeting the target. The main objectives behind commissioning this study were to:

- ascertain whether the targets for RE capacity addition set by the government over the 12th and 13th Plan periods are adequate to meet 15% renewable energy injection into the national grid as specified in the NAPCC
- project the likely RE capacity addition scenarios at the national level and at the state level to match the RE targets specified in NAPCC
- identify sectoral (financial, policy, regulatory , institutional , HR and other) barriers to the development of RE and to suggest remedies to overcome them
- prepare a road map of actions needed for achieving 12% and 15% renewable energy in Indian grid by 2017 and 2020 respectively.

The report begins by analyzing the rationale for and benefits of increasing the share of RE in the all- India energy mix. The rationale for increasing the share of RE is the rising energy demand that the county is likely to face in the near future, issues with conventional sources of energy and the future cost advantages of RE . The benefits of increasing the share of RE are well known and can be visualized in terms of climate mitigation, energy security, saving of foreign exchange, generation of green jobs and the development of rural infrastructure .

While studying the RE potential in India it has been noticed that there is no supply- side constraint as far as the potential is concerned. However, the estimates of RE potential in India differ widely from one institution to another. The official figures of RE potential as estimated by the Ministry of New & Renewable Energy (MNRE) is 90,195 MW excluding solar. The Planning Commission, Government of India, has pegged the solar potential in India at 500,000 MW. A recent study of re-assessment of wind power potential undertaken by Lawrence Berkeley National Laboratory (LBNL) claimed the onshore and offshore wind potential as 676,218 MW and 214,304 MW respectively. A study by WISE put the RE potential in India at 546,881 MW. Such wide variations underscore the need for a realistic field level re-assessment of the potential of all RE sources, which will prove helpful in policy formulation and planning for transitioning to a post- fossil- fuel world.

Adequacy of government- planned RE capacity addition targets: Before projecting the likely RE capacity addition scenarios at Pan india/state levels the report critically verifies the adequacy of government-planned RE capacity addition targets over the 12th and 13th Plan periods to meet the 15% renewable energy injection into the national grid as specified in the National Action Plan on Climate Change (Chapter 4).

The NAPCC has recommended that the minimum share of renewable energy in the national grid be set at 5% in 2009/10, subsequently to be increased by 1% every year to reach 15% by 2019/20. The anticipated renewable energy injection envisaged under the NAPCC has been calculated by applying the National RPO targets to the all-India electricity demand projections given under the '17th Electric Power Survey of India Report' published by the Central Electricity Authority (CEA). The government-planned capacity addition targets (MNRE and JNNSM), are then converted into energy terms (in billion units) by applying the CERC-specified normative RE technology-wise capacity utilization factor (CUF) and compared with the anticipated RE injection envisaged under the NAPCC. The present installed RE capacity and corresponding generation are also factored in while making the comparison.

The comparison reveals that the MNRE-planned non-solar capacity additions for 11th and 12th Plan periods together with the JNNSM-targeted solar capacity addition (16,000 MW) over 2010–2020 are inadequate to meet the NAPCC target . The shortfall in energy terms will increase to 84 BU in FY 2019/20 from 0.57 BU in FY 2009/2010. The planned capacity addition, when realized, will represent approximately 9.88% of the energy mix in the national grid in 2020. Hence there is a shortfall of approximately 5% (84 BU) in meeting the NAPCC requirement of 15% by 2019/20. Considering an average CUF of 36% representing all RE technologies, about 26,000 MW of RE capacity over and above the planned RE capacity (MNRE and JNNSM) is required to overcome the shortfall by 2019/2020. This indicates that cumulative RE capacity installation of about 82,000 MW is required to be in place by 2019/20 to meet the NAPCC target with the specified assumptions.

The adequacy of SERC specified state-wise RPO targets to meet the national RPO in NAPCC is verified by comparing the possible renewable energy generation due to present state-wise RPO targets with the anticipated renewable energy generation envisaged in the NAPCC. The possible renewable energy injection into the national grid due to mandatory RPO targets specified by 25 SERCs in India has been worked out considering the state-wise solar and non-solar RPO targets and state-wise future energy consumption projected by CEA. Our analysis indicates that the current non-solar/solar RPO targets specified by the 25 SERCs taken together may not be sufficient to achieve the requisite RE capacity additions to raise the pan-India solar and non-solar RE-based generation to the 10% share stipulated by the NAPCC by 2014/15.

These calculations establish the need to revise the RE capacity additions originally planned by the working group. The revision in planned RE capacity in the 12th and 13th Plans is still possible as the 12th Plan Working Group Report on RE is yet to be finalized.

Three projected scenarios: With the broad objective of meeting the NAPCC target of 15% RE by 2020, different RE capacity addition scenarios were considered**,** keeping in mind the availability and commercial potential of each RE resource in India. Finally, three scenarios were arrived at (1) Wind dominant (2) SHP-biomass-dominant (on CAGR basis) and (3) Solar- dominant. A progressive growth rate was considered for each major RE source while the share of other RE sources was defined based on their historical growth rates. Later, the most beneficial scenarios were extended to the state level for working out the possible state-wise, RE technology-wise contribution towards meeting the national RPO of 15%.

Scenario 1 (Wind dominant) : Given the past growth rate, present stage of development and future potential availability reported under various studies, an accelerated growth rate slightly higher than the advanced scenario projected by the Global Wind Energy Council (GWEC) and WISE in the 'Indian Wind Energy Outlook 2011', is considered under scenario 1. A moderate growth rate lower than the historical growth rate was considered while projecting capacity additions for SHP and biomass technologies, whereas solar capacity addition targets were restricted to the lower limit specified under the JNNSM (4000 MW) by 2017 in order to reduce the impact on pan-India APPC. If the projected RE capacity additions under this scenario have to be realized, the cumulative wind power installation will have to grow to **74 GW by 2020.** During the 12th Plan period, on an annual average basis, addition of 5,662 MW of wind power and 740 MW of solar power capacity needs to be set up if the 12% RE target has to be met by 2017. During the first three years of the 13th Plan, the wind and solar capacity additions need to be further accelerated to 9,436 MW and 2,000 MW annually. The combined capacity of biomass and cogeneration technologies needs to be increased to 800 MW annually. The projected annual average capacity addition for wind is around 5.25 times the past capacity addition. However, if the capacity addition in 2010/11 is considered as a benchmark, a CAGR of 20% for the following years (which is realistic) can help to achieve this growth. Under this scenario, during the 12th five year Plan, India will have to install 37,680 MW of grid-connected capacities from renewables. The cumulative installed capacity of renewables would be 62,103 MW at the end of the 12th Plan and 100,267 MW, by 2020.

Scenario 2 (Biomass-SHP dominant) (On CAGR basis): While projecting RE capacity addition under this scenario, biomass and SHP were considered as dominant sources irrespective of their limitations. While projecting the likely capacity addition, the growth rate over past ten years was studied and a slightly higher growth rate was considered over the period 2010–2020.Wind power growth was placed at a moderate level based on historical CAGR of 16% and solar capacity addition was limited to the JNNSM targets, which were considered as realized.

If the RE capacity addition targets proposed under this scenario have to be realized, the cumulative biomass and SHP power project installations need to be raised to 13.4 GW and 8 GW respectively by 2019/20. In the 12th Plan period, on an annual average basis, 1,134 MW and 535 MW biomass and SHP capacity have to be set up if the 12% RE target has to be met. During the first three years of the 13th Plan period, biomass and SHP capacity addition needs to be further accelerated to 1,413 MW and 750 MW annually. The projected annual average capacity addition in case of biomass and SHP is approximately **3.5 times and 2.5 times** than the past capacity addition (on annual basis), which is difficult to achieve. During the 12th five-year-Plan, India will have to install 35,000 MW of grid-connected capacity from renewables. The cumulative installed capacity of renewables would be 59,061 MW at the end of 12th Plan and 89,355 MW by 2020.

Scenario : 3 (Solar dominant scenario) : The abundant solar potential in the country, experience of past three years in cost reduction , international projections of cost reduction and the fact that the cost reduction can be achieved by facilitating mass production and R&D efforts, have been taken into account in scenario 3. Promoting solar energy is essential in view of energy security and minimizing the dependence on imports of conventional fuels. All the above favourable conditions support the solar dominant scenario, under which total solar capacity additions of 35,490 MW are envisaged to be realized during year 2011–2020. During the 12th Plan period, on an

average annual basis, solar power capacity of 3,395 MW has to be set up if the 12% RE target has to be met along with moderate growth of wind at an average annual capacity addition of 3,400 MW. During the first three years of 13th Plan period, solar power capacity addition needs to be further accelerated to 6,000 MW annually. This differential approach is adopted because the third phase of JNNSM will begin in 2017. By then, solar energy would have seen significant cost reductions, if not grid parity. The conservative biomass projection made under this scenario is based on past growth rates, which is more realistic and achievable. The projected solar power capacity addition of 6,000 MW a year in the 13th plan needs special efforts from all stakeholders if it is to be realized. During the 12th five-year Plan, India will have to install 39,870 MW of grid-connected capacity from renewables. The cumulative installed capacity would be 63,471 MW at the end of the 12th Plan and 1, 02,755 MW, by 2020.

Comparative analysis of the three scenarios: Wind power capacity addition on an annual average basis projected under Scenario 1 (6,662 MW) is high, but achievable, if conducive policy environment of clear and unambiguous commitment to this leading RE source is made explicit through further policy and regulatory initiatives. In scenario 2 , the resource limitation of biomass and SHP sources may prevent the anticipated annual capacity addition of 1,197 MW and 598 MW respectively , whereas wind power capacity addition of 4,110 MW (annual average) is achievable considering the quantum jump achieved in FY 2010/11.

In Scenario 3 (solar dominant), biomass and SHP annual average capacity addition of 804 MW and 312 MW are achievable considering the historical trend of capacity addition. The position of wind is the same as in scenario 2 and therefore achievable. The projected solar annual average capacity addition of 3395 MW is 1.5 times that of the JNNSM target and is achievable, considering the state level developments in non-JNNSM project activities. However, the targeted capacity addition during the 13th Plan period (6000 MW) needs special efforts. Considering all aspects and the importance of promoting solar power projects from the point of view of energy security, all efforts should be directed to realize the capacity additions proposed under this scenario.

Impact on Pan India APPC under three scenarios: For the three likely supply scenarios above, the impact on average power procurement cost (APPC) of a utility is analysed over the period 2010–2020 at Pan India level. The time value of the impact has been calculated taking the discount factor as 9.35%. The discounted impact on APPC due to purchase of renewable-based energy under the three scenarios varies from 12–16 paisa / kWh under scenario 1, 13–18 paisa/kWh under scenario2 and 16–20 paisa/ kWh under scenario 3 .

The impact on the APPC under all the three scenarios is significant and it would be impossible for the utilities to absorb the same. Much of this is the result of high solar tariff, which means the government will have to exercise major policy options to make the projects viable. These options may include Interest subsidies to provide softer loans, measures to accelerate grid parity and generation-based incentives to keep tariffs low.

Capacity addition Plan by State and by RE technology to meet the NAPCC target (under the wind and solar- dominant scenarios) : Encouraging the solar-dominant scenario is important in view of achieving energy security. However the wind-dominant scenario with solar capacities restricted to the lower limit projected in phase 2 of JNNSM may also be

important from the point of view of minimal impact on Pan-India APPC. Therefore these two scenarios were considered for a detailed state by state analysis. The possible shares of states for each technology in total were matched with the corresponding pan-India share. While devising the state-wise/RE technology-wise shares as above, a detailed study of state-wise RE potential/installed capacity and unexplored RE potential and of the past growth rate of RE capacity addition was carried out. As the official potential assessment in terms of state-wise solar capacity is not available, the targeted solar potential is distributed in selected potential states based on solar radiation assessment. Table 4.10 and 4.11 provide the state-wise projected RE capacity additions (cumulative) based on the wind and solar dominant scenarios.

Key outcomes of the scenario analysis

- The government's plans for development of RE are not consistent with the policies. The RE capacity additions targeted by MNRE and those planned under the JNNSM are inadequate to meet the targets set by the NAPCC. The targets originally planned by the working group will have to be revised to achieve the 12% and 15% RE penetration by 2016/17 and 2019/20 respectively. The revision in planned RE capacity in the 12th and 13th Plans are still possible as the 12th plan Working Group Report on RE is yet to be finalized
- The potential of RE at the national level needs to be re-assessed urgently. In the absence of realistic potential assessment figures, policy decisions on power generation could be skewed in favour of conventional sources.
- Although all the three scenarios are capable of meeting the national RPO of 12% and 15% by year 2017 and 2020, considering the importance of scenarios 1 and 3, either of them may be adopted at the national level.
- Adoption of scenario 1 (wind dominant) against that of scenario 3 (solar dominant) at national level will reduce the impact on pan-India APPC by 4–5 paise / kWh.
- The huge untapped solar potential of the country is important from the point of view of energy security. International experience shows that cost reduction can be achieved by way of mass production and R&D efforts and therefore scenario 3 is also equally important.
- The targeted capacity addition envisaged under three scenarios can avoid approximately 141.82 million tonnes, 143.16 million tonnes and 142.64 million tonnes of CO_2 respectively beyond 2017.
- The targeted capacity addition envisaged under three scenarios if realized ,can create 15 lakh, 14.7 lakh and 16.6 lakh new jobs respectively by 2020.
- The likely debt requirement for realizing the RE capacity addition projected up to 2020 under the three scenarios ranges from Rs 361602 crore to 541659 crore .
- The capacity additions by State and by technology envisaged under the wind and solar-dominant scenarios show that individual states can share the national RPO within the available RE potential.
- The state-wise RE technology mix emerging from the state-level analysis indicates ample scope for wind power development in the states of Tamil Nadu, Karnataka, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Orissa. Significant contribution to SHP can come from the north and north-eastern states like Himachal Pradesh, J&K, Uttarakhand and Arunachal Pradesh,

whereas states like Tamil Nadu, Andhra Pradesh and Uttar Pradesh can still develop biomass power potential to a great extent.

- Based on the analysis of solar radiation data, geographical spread and availability of wasteland, states like Rajasthan, Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Orissa, Karnataka, and Tamil Nadu can play a decisive role in realizing the solar capacity addition under the solar- dominant scenario.

Proposed ROAD MAP and actions needed

Area	Critical action needed	Responsibility
Planning	Capacity addition plans for grid-connected RE for the 12th Plan needs to be revised to ensure achievement of 15% RE electricity injection into the grid by 2020.	Planning Commission & MNRE
	State-wise capacity addition plans should be communicated to the state planning boards, energy departments, and state nodal agencies, for incorporation in the 12th Plan of the states.	Planning Commission & MNRE
	Re-assessment of all RE sources to ascertain the real potential of RE in India, both grid-connected and off-grid.	MNRE
	CERC/FOR may take coordinated action to persuade those SERCs who have not set the RPO targets as per the national objective to revise their RPO regulations	CERC/FOR
	Transmission planning and development should be institutionalised at the level of the CEA, state electricity utilities, and state nodal agencies.	Ministry of Power/CEA
Financing (From Govt.)	The National Clean Energy Fund (NCEF) should be utilised for top-priority funding of clean energy development to achieve 15% RE by 2020.	Ministry of Finance
	Adequate funding may be provided in advance for developing transmission infrastructure for RE .	Ministry of Power
	Scaling up RE to 15% would result in significant impact on APPC. In order to assuage financial difficulties of utilities by bringing down tariffs, indirect or direct support mechanisms like interest subsidies, generation-based incentives, soft loans, etc., should be provided to RE projects.	Planning Commission & MNRE
	States should be persuaded to create state-level clean energy funds by levying “green cess”, so that the proceeds can be utilized for part-funding RE transmission infrastructure, providing credit guarantees, equity funding, etc.	MNRE
	Ways and means should be evolved to provide soft loans to RE projects, because the high interest rates make most RE projects unviable.	Ministry of Finance / PC/ RBI

Area	Critical action needed	Responsibility
Debt Financing	Providing interest subsidy or allowing banks/FIs to raise tax-free bonds to provide soft loans to RE projects may be considered.	MNRE / Ministry of Finance
	Allowing IREDA (or the proposed Green Bank) to raise low-interest finance from abroad and on-lending the same to RE development in India at 8%-9% would go a long way in achieving national RE targets.	MNRE /IREDA
	A government/RBI decision to give the status of priority sector lending to RE would send the right signal to the banks.	Ministry of Finance / RBI
Policy	Lack of cohesion in GOI policies should be addressed. The IEP should be revised (or a new IEP prepared) to align it with new realities and the NAPCC objectives. Similarly, the low-carbon growth strategy should follow the national objective of 15% RE.	Planning Commission
	Fossil fuel subsidies should be phased out. Subsidy shifting in favour of clean energy may be considered.	Planning Commission
Policy	MNRE's stand (Strategic Plan for RE 2011-17, Feb 2011) that renewables can contribute only 6% of the energy mix of the total energy mix by 2022 (and 10% contribution to total electricity mix) sends the wrong signals and contradicts the national policy. MNRE should align its strategic plan with the NAPCC objective.	MNRE
	A separate law for renewable energy development may be enacted. The decision already taken by the government to do so should be implemented.	MNRE
	As declared in the JNNSM, an incentive package for CSP manufacturing in India should be announced to create a strong CSP manufacturing base in India.	MNRE
	All states should be persuaded to bring out comprehensive RE policies.	MNRE
	The cost of externalities of conventional power generation should be quantified and the same should be internalized in the pricing of fossil-fuel-based electricity.	CERC
Regulation	SERCs who have not declared RPOs in line with the NAPCC target should do so.	FOR / SERCs
	Homogeneity in inter-connectivity norms should be brought about across different states. Similarly, OA charges should be rationalised and state grid codes enacted to provide RE.	FOR
	The regulators may consider overhauling the cost-plus methodology	CERC/FOR

Area	Critical action needed	Responsibility
	for tariff determination by factoring-in the cost externalities of fossil-fuel-based generation, considering multiple cost and efficiency curves and risk-adjusted pricing.	
	The REC mechanism should be strengthened through capacity building of nodal agencies in states, bringing out smaller denomination RECs, and allowing banking of RECs, etc.	CERC
Capacity Building	Systematic capacity building should be undertaken in various central and state level organisations and utilities involved in RE development.	MNRE
	A national programme for capacity building of SNAs should be undertaken on priority during the 12th Plan.	MNRE
	Capacity building of banks and financial institutions is also critical to ease financing to RE projects.	MNRE / Planning Commission
	The R&D institutions in the RE sector need to be strengthened. They should be given autonomy, adequate financing, and time bound targets.	MNRE
Human Resources	A national programme for curriculum revision, new curriculum development, beginning new RE courses and training of technical institution faculty should be undertaken.	MNRE
	A study to assess the potential of green technologies to create jobs should be undertaken, as is being done in many other developed countries.	MNRE
Other Areas	Public sector investment in manufacture of silicon ingots and wafers should be done to make this basic infrastructure available at reasonable prices.	MNRE
	Quick measures for global technology access and adaptation should be put in place in the short- and medium-term. For the long-term, we should focus on R&D for developing indigenous technology in critical areas	MNRE / Planning Commission
	Reliable information and data on RE resources should be available in the public domain so that industries, investors, etc., can access the same. On the other hand, information devices, technologies, policies, incentives, financing, etc., should be made available to the public.	MNRE

***

1

Evolution of the Policy Environment for Renewables in India

Development of renewables in India has witnessed various ups and downs. The beginning was the set of promotional guidelines issued by the then Ministry of Non Conventional Energy Sources (MNES) during the year 1993–94. For the first time, an indicative tariff for renewable energy (RE) based electricity was announced; besides, RE project proponents were also allowed to bank and consume energy from the grid as per their supply-demand pattern within a particular financial year. The ministry's guidelines and state-level incentives like sales tax exemption, infrastructure assistance, etc, resulted in commendable capacity addition during the following decade (1993–2002). However, the next transition in the policy and regulatory framework governing RE was the enactment of the Electricity Act in 2003. Some of the major post-EA, 2003, policy and regulatory initiatives responsible for promotion of RE are chronicled in this chapter.

1.1 RECENT LEGAL AND POLICY ENVIRONMENT FOR RE

In the last few years, a set of conducive policies facilitating accelerated RE development have been put in place. These relate to legal provisions and policy pronouncement.

1.1.1. Legal and Policy Initiatives

Electricity Act 2003: The Electricity Act, (EA), 2003, introduced some enabling provisions that were conducive for accelerated development of grid connected renewables.

Under Section **61(h)**, promotion of cogeneration and generation of electricity from renewable sources of energy has been made the explicit responsibility of state electricity regulatory commissions (SERCs), who are taking these considerations into account while drafting their terms and conditions for tariff regulations. Nearly all SERCs have issued their tariff regulations/orders incorporating suitable clauses which will enable the SERCs to provide a preferential treatment to renewable energy during the tariff determination process.

Under Section **86 (1)(e),** SERC is also made responsible for the following:

i. Ensuring suitable measures for connectivity of renewable power to the grid;

ii. Sale of renewable energy electricity to any person;

iii. Mandating purchase of a certain percentage of total energy consumption from renewables.

As mandated under section 86 1(e) of EA, 2003, almost 24 SERCs have fixed certain quota (in terms of percentage of electricity being handled by the power utility) to procure renewable energy. The mandate termed as Renewable Purchase Obligation (RPO) or Renewable Purchase Specification (RPS) varies from 0.5% to 14% in various states. Few states have come out with technology-specific RPO or RPS. Besides, the state regulators determine the tariff for all RE projects in the states and ensure connectivity to the grid through extension of power evacuation from the RE project sites which are generally at remote locations and away from major load centres.

National Electricity Policy: Clause **5.12** of the National Electricity Policy stipulates several conditions for promotion and harnessing of renewable energy sources. The salient features of the said provisions of NEP are reproduced below.

5.12.1: Non-conventional sources of energy being the most environment-friendly, there is an urgent need to promote generation of electricity based on such sources of energy. For this purpose, efforts need to be made to reduce the capital cost of projects based on non-conventional and renewable sources of energy. Cost of energy can also be reduced by promoting competition within such projects. At the same time, adequate promotional measures would also have to be taken for development of technologies and a sustained growth of these sources.

5.12.2: The Electricity Act, 2003, provides that co-generation and generation of electricity from non-conventional sources would be promoted by the SERCs by providing suitable measures for connectivity with the grid and sale of electricity to any person and also by specifying, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee. Such percentage for purchase of power from non-conventional sources should be made applicable for the tariffs to be determined by the SERCs at the earliest. Progressively, the share of electricity from non-conventional sources would need to be increased as prescribed by state electricity regulatory commissions. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the Commission may determine an appropriate differential in prices to promote these technologies.

National Tariff Policy (NTP): This policy further elaborates the role of regulatory commissions, the mechanism for promoting renewable energy, the time frame for implementation, etc. Clause 6.4 of the policy addresses various aspects associated with promoting and harnessing renewable energy sources. Salient features of the provisions made by the NTP are as follows.

(i) Pursuant to provisions of Section 86 (1) (e) of EA, 2003, the appropriate Commission shall fix a minimum percentage for purchase of energy from such sources, taking into account availability of such resources in the region and its impact on retail tariffs. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by 1 April 2006.

It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, procurement by distribution companies shall be done at preferential tariffs determined by the appropriate Commission.

(ii) Such procurement by distribution licensees for future requirements shall be done, as far as possible, through competitive bidding process under Section 63 of the Act among suppliers offering energy from same type of non-conventional sources. In the long term, these technologies would need to compete with other sources in terms of full costs.

(iii) The Central Commission should lay down guidelines within three months for pricing non-firm power, especially from non-conventional sources, to be followed in cases where such procurement is not through competitive bidding.

Recently on 20th January 2011, clause 6.4 (1) is amended with inclusion of solar specific RPO. Now clause 6.4 (1) reads as follows: “within the percentage so made applicable, to start with, the SERCs

shall reserve a minimum percentage for purchase of solar from the date of notification of the official gazette which will go up to 0.25% by the end of 2012/13 and further upto 3% by 2022."

13th Finance Commission Incentive for RE: The 13th Finance Commission made recommendations for the period 2010–15. The Commission felt that a quantum jump in the supply of electricity is a critical requirement for future sustainable growth. Hence they made a provision for a forward looking grant of Rs.5000 crores to be paid as incentive to states who increase the share of electricity generated from renewable sources between FY 2010-11 to FY 2013-14. The entire incentive scheme is further subdivided in two parts namely, (i) 25% of incentive grant to be disbursed for achievement in installed capacity addition over unachieved potential as assessed by MNRE (due to uneven distribution of RE sources) and (ii) 75% of incentive grant to be allotted for achievement in installed capacity addition relative to the aggregate of installed capacity addition across all states (in order to ensure accelerated capacity addition). Further, a cap of Rs.1.25 crores/MW & Rs.1.50 crores/MW of installed capacity addition is proposed respectively for general and special category states. The report also recommends access to competitive power markets for RE developers. *(13th Finance Commission 2011)*

National Clean Energy Fund: In the Union Budget 2010–11, the Finance Minister proposed to levy a cess on all coal consumed in the country, the revenues from which will go towards the creation of a National Clean Energy Fund (NCEF). The clean energy cess of Rs.50 per metric tonne will be levied on all coal, lignite and peat produced in India, as also on imports from abroad. On 24 June 2010, the Union Finance Ministry issued formal orders for levy of the cess as a duty of excise w.e.f. 1 July 2010. The NCEF is proposed to be utilised for the development and deployment of clean energy technologies in India. An internal assessment by WISE shows that a corpus of Rs.50,934 crores will accumulate in the NCEF up to 2020 based on the CAGR of coal consumption in the country. It is imperative that a substantial portion of the NCEF should be made available for development of renewables.

Incentives for Solar Photovoltaic Manufacturing under Semiconductor Policy: During August 2008, Government of India announced a semiconductor policy with incentives to attract investment to the semiconductor sector. The scheme covered manufacturers of semiconductors, displays and solar photovoltaic technologies using semiconductor devices for solar cells. The government will bear 20 percent of capital expenditure in the first ten years if a unit is located within one of the Special Economic Zones (SEZs), including a major economic zone in Hyderabad called "Fab City" and 25 percent in the non-SEZ areas. The minimum investment was set at Rs.25 billion for semiconductor manufacturers and Rs.10 billion for other micro and nanotechnology organizations. The solar industry has been the chief beneficiary of these announcements and at least twelve industrial houses had their projects for solar manufacturing approved under the policy. When implemented, all these projects would increase solar PV manufacturing capacity in India from around 700 MW at present to over 4000 MW per annum.

Planning Commission sets up Expert Group on Strategy for Low Carbon Economy: To strengthen the goal of low carbon development, the Planning Commission of India in January 2010, constituted an expert committee/task force. The 26-member expert committee is headed by Dr Kirit Parikh, former Member, Planning Commission, GoI. The major objectives of the Committee are to review the existing studies on low carbon growth for India as prepared by various

organisations, conducting further analysis to assess low carbon options for the Indian economy and finally, prepare a report outlining a roadmap for India for low carbon growth. The final report/roadmap will contain an evaluation of some key alternative low carbon options with an analysis of their cost-benefits and relative merits and demerits, an action plan comprising of critical low carbon initiatives to be undertaken, including sector-specific initiatives, along with a suggested timeline and targets starting 2011 and extending to the 12th Plan period. The expert committee has now submitted an interim report to the Planning Commission *(Low carbon Economy, 2011)*.The report analyses projection of fuel mix and emissions under different scenarios for both 8% and 9% average GDP growth rate upto 2020. It is observed that the report is methodologically skewed and has not considered RE injection targets specified under the NAPCC.

National Action Plan on Climate Change (NAPCC): The National Action Plan on Climate Change (NAPCC) announced by the Prime Minister's council on Climate Change was notified in June 2008. As per NAPCC, renewable electricity injection into the national grid has to be set at 5% at the beginning of FY 2009–10 and needs to be increased at 1% per annum in the subsequent years to reach 15% at the end of FY 2019–20.

Jawaharlal Nehru National Solar Mission: As part of the eight national missions announced in the NAPCC, the Jawaharlal Nehru National Solar Mission (JNNSM) was announced in 2009. JNNSM aims to promote the development of solar energy for grid connected and off-grid power generation. The ultimate objective is to make solar power competitive with fossil based applications by 2020-2022.

The main objectives of the JNNSM are:

- Create an enabling policy framework for the deployment of 20,000 MW of grid-connected solar power by 2022.
- Create favourable conditions for establishment of indigenous solar manufacturing capacity, particularly for solar thermal power generation technologies.
- Promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022.
- Achieve 15 million sq meter solar thermal collector area by 2017 and 20 million sq meter by 2022.
- Deploy solar lightening systems for rural areas by 2022.

Three guidelines for project implementation under JNNSM have also been issued recently and through them, the JNNSM is now operational, to the extent of solar project development. To minimize the impact of high solar tariff on state electricity utilities and customers, it is envisaged that NVVN, NTPCs wholly owned subsidiary company engaged in the business of trading of power has been designated as the nodal agency for entering into a Power Purchase Agreements (PPA) with solar power developers for the first phase of the mission upto 2013. The PPAs will be valid for a period of 25 years. For each MW of solar power installed capacity for which PPA is signed by NVVN, an equivalent amount of MW capacity from the unallocated quota of NTPC stations will be allocated to them. NVVN will bundle this power and sell this bundled power at a rate fixed as per CERC regulations. In case of significant price movement in the market rate, the Government will review the situation. *(JNNSM 2009) (NVVN 2011)*

1.1.2. Incentives for RE by the Central Government

Capital Subsidy: Some technologies like small hydro, biomass and solar PV (off-grid) systems are provided support through capital subsidy based on installed capacity. An indexation method has been devised to calculate subsidy amounts for various technologies.

Accelerated Depreciation: The Government of India currently allows accelerated depreciation at the rate of up to 80% in the first year on a written-down value (WDV) basis for equipment under Section 32, Rule 5 of the Income Tax Act.

Generation Based Incentive (GBI): The Government of India had implemented a GBI scheme for grid interactive wind power projects - a GBI of Rs 0.50 per kWh, with cap of Rs.15 lakhs per MW per year, totalling Rs.62.5 lakhs per MW to be availed up to 10 years of the project life. This scheme is applicable to wind power projects not availing accelerated depreciation benefits and commissioned before 31 March 2012. However, there are no guidelines for GBI post-2012.

A similar GBI scheme was offered to solar power generation projects for small capacity of 50 MW. However, the scheme was withdrawn after the introduction of JNNSM.

Income Tax Holiday: Section 80 IA of the Income Tax Act offers a 10-year tax holiday within a block of first fifteen years during the life cycle of all infrastructure projects which also includes renewable energy power generation projects.

Excise Duty Exemption: Government of India is offering 100% exemption in Excise Duty for most renewable energy generation project components. The components that are offered such exemption are specified under List 9 of Section No. 237 of the Central Excise Tariff Act, 1985. The normal rate of Excise Duty for such components is 16%.

Customs Duty Exemption: Government of India is offering concessional Customs Duty of 5% for selected components of renewable energy generation power projects under the Customs Tariff Act, 1975 (51 of 1975). The electrical components and machinery used in renewable energy power projects attracts Customs Duty of 7.5% or 10% (depending upon components). Further, Govt. of India vide Notification No. 30/2010-Customs dated 27 February 2010 has offered concessional Customs Duty for all machinery imported for the initial setting up of a solar power generation project or facility.

Foreign Direct Investment: 100% FDI investment is allowed in renewable energy generation projects.

Deduction in Taxable Income: Under Section 10(23G) of the Income Tax Act, income from an infrastructure capital fund or company or a cooperative bank (from the assessment year 2002/03) by way of dividends, interest, or long-term capital gain from investments made in infrastructure business, etc., is exempt till 2012.

Renewable Regulatory Fund (RRF): All power generation projects are required to schedule the power. Any deviation from the schedule is liable to be penalised. However, wind and solar power projects are allowed limited deviation from their schedule. In order to compensate the applicable unscheduled interchange (UI) penalty to state utility because of default of RE power schedules within the allowed limits, it is proposed to create a renewable regulatory fund to compensate the

same. This fund is proposed to be created by the National Load Dispatch Centre (NLDC) on the lines of UI Pool Account at the regional level. Payments on account of renewable regulatory charges, as described in the Regulations, and interest, will be credited to this account.

1.1.3. Incentives for RE by State Governments

Some state governments have established clean energy funds through levy of 'green cess'. Certain other incentives have also been announced in states like Maharashtra. The initiatives in the states of Maharashtra, Karnataka and Gujarat are briefly discussed here.

Maharashtra: The Government of Maharashtra has levied Rs. 0.08 (eight paise) per kWh on energy consumption by commercial and industrial units. This cess generates around Rs.200 crore annually. The state government has formed the Urjankur Nidhi trust and appointed M/s IL & FS as fund manager for proper utilisation of the funds. The funds are being utilised for providing equity capital for bagasse co-generation projects and for funding power evacuation infrastructure required for evacuation of power generated from non-conventional energy generation projects.

The Maharashtra government has recently (3 March 2011) announced 100% exemption on sugarcane purchase tax of 3% for co-operative sugar factories which will be commissioning co-generation power projects. This tax exemption will be available for a ten year period, from the commissioning of the co-generation project, or till such tax exemption amount becomes equal to the project cost, whichever is earlier.

Gujarat: The Government of Gujarat has passed the 'Gujarat Green Cess Bill 2011' which proposes to levy a green cess of Rs. 0.02 (two paise) per kWh on generation of all kinds of electrical energy, including captive energy, but excluding solar energy, wind energy, bio-energy, geo-thermal energy, tidal energy and hydel energy. This cess could generate Rs.244 crore, which is proposed to be utilised for encouraging the use of renewable energy and for protection of the environment. *(Gujarat 2011)*

Karnataka: The Government of Karnataka has planned to impose Rs.0.05 (five paise) per kWh as green cess on commercial and industrial consumers to generate about Rs.50 to Rs.60 crore annually. This fund is proposed to be utilised for the development of renewable energy, incubation of projects, and enhance capabilities on evacuation of wind power projects in the state.

Concession in open access charges/demand charges for captive RE projects: RE projects, especially wind power projects, have low plant load factor compared to conventional power projects. However, the open access charges do not differentiate between the source of power generation. Hence, per unit of open access charges are comparatively higher for RE projects, making open access transactions unviable. Hence, to promote RE projects, some states have offered concessional open access charges for captive RE projects or waived the cross-subsidy surcharges for such transactions. States like Karnataka, Kerala, Tamil Nadu and Gujarat have offered concessional open access charges/demand charges for captive RE projects and states like Maharashtra have not imposed cross-subsidy surcharge. Some states have restricted such benefits for captive use of RE power and third party transactions are being excluded. So there is wide variation among the states in the open access charges and cross subsidy policies.

1.2 DEVELOPMENTS IN RE ELECTRICITY REGULATION

Developments in RE Tariff Regulations: Prior to the formation of regulatory commissions, the Ministry of New and Renewable Energy (MNRE) had prescribed the tariffs for purchase of power from all renewable sources of energy. As per MNRE guidelines, Rs.2.25/kWh tariff for the base year 1994-95 was set with escalation of 5% per annum for the first 10 years. Many state governments followed these guidelines. This tariff policy did not consider the RE technology, project cost, and other techno-commercial parameters.

Later, after the enactment of the Electricity Regulatory Commissions (ERC) Act, 1998, Section 22(1)(c) empowered the Commission to regulate the power purchase and procurement process, including the tariff. Further, Section 29 of the ERC Act, 1998, prescribes the specific principles of tariff fixation. Further, the Electricity Act, 2003, empowered the state electricity regulatory commissions (SERCs) to promote generation of electricity from RE sources and specify RE purchase obligation.

With this, SERCs formulated RE tariff regulations. The tariff methodologies and tariff petitions are being discussed through a public consultation process to bring in transparency, competition, as well as secure the returns on investment. Most of the SERCs adopted the cost-plus methodology for determination of RE tariff. These orders were passive as they were not considering the inflations and capital cost fluctuations during the tariff order control period. Hence, SERCs are now shifting towards the multi-year tariff regulations, where tariffs are linked to capital cost indexatation.

Renewable Purchase Obligation/Specification: Most SERCs have put significant emphasis on Section 86 (1) (e) of EA, 2003, namely specifying a percentage of electricity to be procured by the distribution licensees from renewable sources of energy. As on date (31.03.2011), twenty-four SERCs, with jurisdiction over their respective states, have issued orders or regulations under this section of EA, 2003, and have specified percentages for purchase of electricity from renewable sources of energy. These obligations are popularly referred to as 'renewable purchase specification' (RPS) or 'renewable purchase obligation' (RPO). While most SERCs have specified a single target for procurement of power from renewable energy technologies, some SERCs have specified separate targets for specific technologies.

REC Mechanism -Tradable Renewable Energy Certificates: Given the renewable purchase obligation on distribution licensees, the availability of renewable energy has to be ensured. To meet these targets, a tradable REC mechanism was put in place by the Central Electricity Regulatory Commission (CERC) in the year 2010. Under this framework, RE generators can trade Renewable Energy Certificates (one REC is equivalent to 1000 kWh) through power exchange platform that will allow market-based price discovery. However, this price range is determined again by CERC and the price discovery can happen only in this range defined between the Floor Price and the Forbearance Price. The respective price ranges are defined separately for solar and non-solar RECs (wind, biomass, small hydro) to take care of the difference in economics. The Commission has stipulated Rs.1.50/kWh and Rs.3.90/kWh as floor and forbearance price for non-solar RECs and Rs.12.00/kWh & Rs.17.00/kWh as floor and forbearance price for solar RECs, respectively.

The only requirement to make a renewable energy generator eligible for participating under RECs is that he should sell his power to the host distribution licensee at Average Power Procurement Cost (APPC) or at mutually agreed tariff to the entity other than host distribution licensee. APPC is the weighted average cost of power purchase for the utility, and in effect, represents the effective cost of grid mix. So, on the demand side, the REC framework allows the purchase obligated utilities to buy RECs through the national exchange irrespective of state potential and installed capacity. On the supply side, it allows the RE generators to get a base revenue income by selling power at the average power procurement cost and an additional market determined revenue stream through the REC trading platform.

CERC RE Tariff Notification: The Central Electricity Regulatory Commission has come out with tariff regulation 'Terms and conditions for determination of tariff for sale of electricity from renewable sources of energy' in September 2009. The SERCs can follow these guidelines while specifying the RE tariff in their states. These regulations have the following key features:

- Upfront tariff for a project for the whole of the normative debt repayment period (for useful life in case of solar and small hydro) to give certainty to the investors. There would not be any midcourse tariff modification.
- Capital cost norms and financial norms take care of all reasonable costs.
- Adequate and fixed return on equity determined right in the beginning.
- Generic tariff to be declared every year for the projects to be commissioned in the next financial year.
- Newer technologies e.g. solar and municipal waste-based generation projects have additional option of approaching the CERC for getting project-specific tariffs based on actual capital costs in deviation of norms specified in the regulations, subject to prudence check.
- Reasonable escalation has been built into the tariff framework so that tariffs for projects to be commissioned in successive years remain aligned to market realities.

Scheduling Norms for Wind and Solar Power: Recently, the CERC has notified 'The Indian Electricity Grid Code (IEGC), 2010' which has provided a special dispensation for scheduling of wind and solar generation in case of inter-state sale of electricity. The provision of inter-state sale of wind generation will come into force on 1 January 2012. However, the capacity of such plants connected to a 33 kV connection point should be 10 MW and above. The inter-state sale option is applicable for those who have not signed any PPA with states or others as on the date of coming into force of IEGC 2010 with effect from 03.05.2010.Such transaction will however attract unscheduled interchange charges as specified in IEGC, 2010, if the actual generation is beyond +/- 30% of the schedule in case of wind.

In case of solar electricity, these norms are applicable for solar projects of capacity 5 MW and above connected to 33 kV level and above. However, in case of inter-state sale of solar generation, no UI charges are to be paid or earned by the developer till 2015. *(IEGC 2010)*

Open Access to Inter-state Transmission of RE: CERC has issued 'Grant of Connectivity, Long-term Access and Medium-term Open Access in Inter-state Transmission and Related Matters (Amendment) Regulations, 2010', in September 2010. The amended regulations had included hydro and other renewable energy generation projects with aggregate capacity of 50 MW and

above for inter-state transmission of power, with the condition that the lead generator shall act on behalf of all the generators to undertake all operational and commercial responsibilities for all the collective generators connected at that point in following the provisions of the Indian Electricity Grid Code and all other regulations. Further, RE projects with aggregate capacity of 250 MW and above shall not be required to construct a dedicated transmission line to the point of connection, and such stations shall be taken into account for coordinated transmission planning by the Central Transmission Utility and Central Electricity Authority (CEA).

Notwithstanding many persisting loopholes and barriers, India now has a reasonably proactive policy and regulatory framework at the national level for facilitating RE development. However, we are missing in action. Our work plans, both at national and state levels still plough the business-as-usual path. The current course of action is insufficient to achieve the NAPCC target of 15% by 2020. We need to first discover what this 15% means in terms of capacity addition of RE and work out action plans to realise the same. In Chapter 4 and 5, we have attempted to discern these two critical aspects. In Chapter 5, we have identified the barriers and possible solutions.

***

2

Rationale for and Benefits of Increasing RE in the Energy Mix

2.1 RATIONALE

2.1.1 Rising Energy Demand: The Integrated Energy Policy (IEP) Report, 2006, estimates that India will need to increase primary energy supply by three to four times and electricity generation by five to six times to meet the lifeline per capita consumption needs of its citizens and to sustain an eight percent growth rate. The government plans to provide universal access to electricity and increase per capita consumption to 1000 kWh by 2012. The Expert Group on Low Carbon Economy has considered the same energy intensity of 0.95 kWh/Re.1 GDP for future projections as considered by IEP for projections in 2004–05 to 2011–12 period. According to the expert group report, in 2020, India will require gross electricity generation of 2104 billion kWh and 2359 billion kWh under 8% and 9% GDP growth rates respectively. The 17th Electric Power Survey of India (published by the Central Electricity Authority) under its long-term forecast has projected the electrical energy requirement as 1914 billion kWh in 2021–22. *(planning commission 2011)*

In the next 25 years, India's electricity demand is expected to grow at an average annual rate of 7.4%. Generation capacity will have to increase five-fold to keep pace with this demand growth. According to the Central Electricity Authority (CEA), as on March 2011, India had 174 GW of generation capacity, with annual conventional electricity generation of about 811 billion kWh. The gap between supply and demand is likely to increase unless adequate measures are taken to bring on new generation capacity and improve operational efficiency in the distribution and management of power utilities. *(CEA, world Bank 2010)*

2.1.2 Issues with Conventional Sources of Energy: India imports nearly 72% of its oil requirements and this share of imported oil is expected to reach 90% by 2031–32; the story of coal imports is also not very different. According to scenarios developed as part of the IEP by the Planning Commission, imports could increase to as high as 45% of the total coal requirement by 2031-32. Given this scenario, it is of paramount importance that the country develops all possible domestic energy sources. Minimizing the dependence on import of conventional fuel and providing energy to all at affordable prices should be the main concern of India's energy policy. Therefore, India must make every effort to harness indigenous renewable resources. During the last three Five Year Plan periods, the actual conventional electricity capacity addition merely reached around 50% of the targeted capacity addition planned (16,420 MW against 30,540 MW in the 8th Plan; 19,015 MW against 40,250 MW in the 9th Plan; 21,080 MW against 41,110 MW in the 10th Plan). The situation in the present plan period is not different; already the eleventh plan target for conventional power stands reduced from 78,700 MW to 62,374 MW, and even this is unlikely to be reached. The achievement in the first 3 years (FY 2007-08, 08-09, 09-10) is only 22,302 MW as against the original target of 47,220 MW. And there are problems in the conventional power sector (coal, gas, hydro). Mining and import of coal are both facing problems, especially since huge quantities are required. Logistics, transport and price issues are also emerging. Moreover, at projected usage levels, questions are also being raised as to how long India's extractable coal

reserves could last (52 billion tonnes as per Coal Vision 2025 of Ministry of Coal, 18 billion tonnes as per 10th Plan document of GoI). One of the major reasons for the shortfall in electricity supply in India over the past five years has been the shortage of coal and gas. In July 2005, 22 of 75 coal power stations (with a total capacity of 61,000 MW) faced severe coal shortages, even though all stations are required to maintain 15–30 days of coal stocks for emergencies**.** Moreover, around half of the running coal power plants in 2009 were more than 20 years old. These plants often operate at low load factors with an efficiency of only 30%. Environmental and climate change threats are getting more severe and project clearances are increasingly becoming difficult to obtain. In spite of many policy and infrastructural initiatives, it appears unlikely that the quantities required to achieve projected conventional power capacity will be available. ***(****MNRE paper, WISE database, World Bank 2010 , IEA 2011 b)*

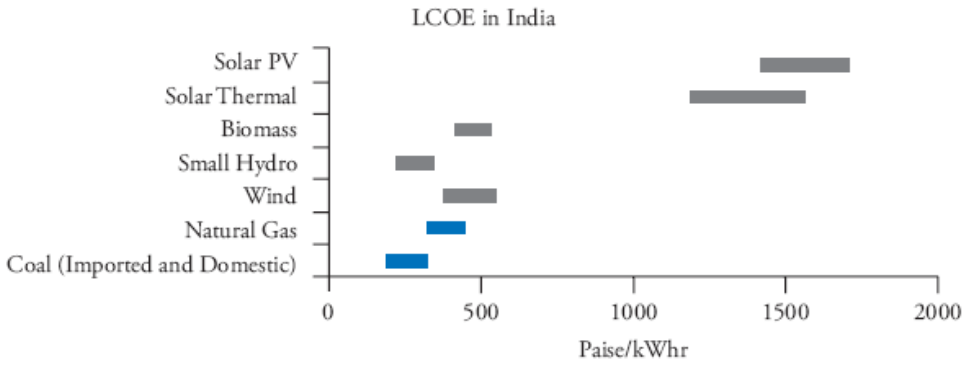
Large hydro projects are also facing problems related to environmental issues, project execution in difficult terrain, along with attendant issues of building long transmission lines. Natural gas availability and its competitive usage also do not offer much optimism. Nuclear power capacity building continues to face problems, especially with the huge targets proposed.

2.1.3 Future Cost Advantages of RE: Fuel costs constitute the largest proportion of total economic costs for conventional thermal generation, which is therefore exposed to future input inflation. Given the structural changes in global oil markets in the past decade and the accelerating global demand and shrinking supply of known fuel sources, fuel costs are projected to increase consistently in the coming decades. According to the International Energy Agency, demand for fossil fuels in the base reference scenario is expected to increase by 77% by 2030. In volume terms, coal is expected to have the largest increase: its share in primary energy demand will rise from 27% to 29% between 2007 and 2030. The average real price of coal is projected to rise from $65/tonne in 2009 to $100/tonne by 2020 and $110/tonne by 2030. Oil is expected to follow a similar trend, with the average price projected to rise from $65/barrel to $100/barrel by 2020 and $115/barrel by 2030 ($190/barrel in nominal terms).

In contrast, trends in international fuel and equipment markets are favourably inclined towards renewable energy technologies. Among the potential RE technologies in India, fuel expenses form a substantial part of total cost only for biomass. For other RE technologies, the largest cost component is the high upfront capital costs of equipment. However, in the recent past, costs of capital equipment for renewable energy have been decreasing and this is likely to continue as technology advances. The cost of solar photovoltaic generation is projected to fall from about $4/W in 2010 to $1.9/W–$2.2/W in 2020 and $1.07/W–$1.23/W in 2050. Electricity generation costs are projected to be in the range of $0.05 kWh–$0.07 kWh at sites with good irradiation. (*World Bank 2010)*

2.1.4 The Challenge of Grid Parity: India is in an advantageous position for accelerating the race towards grid parity. India has a large domestic market that can provide scale and reduce cost by being a testing ground for technologies at the inflection point of commercialization. Figure 2.1 indicates that except solar, the levelized cost of energy (LCOE) for all renewable energy technologies/options is comparable to conventional power cost.

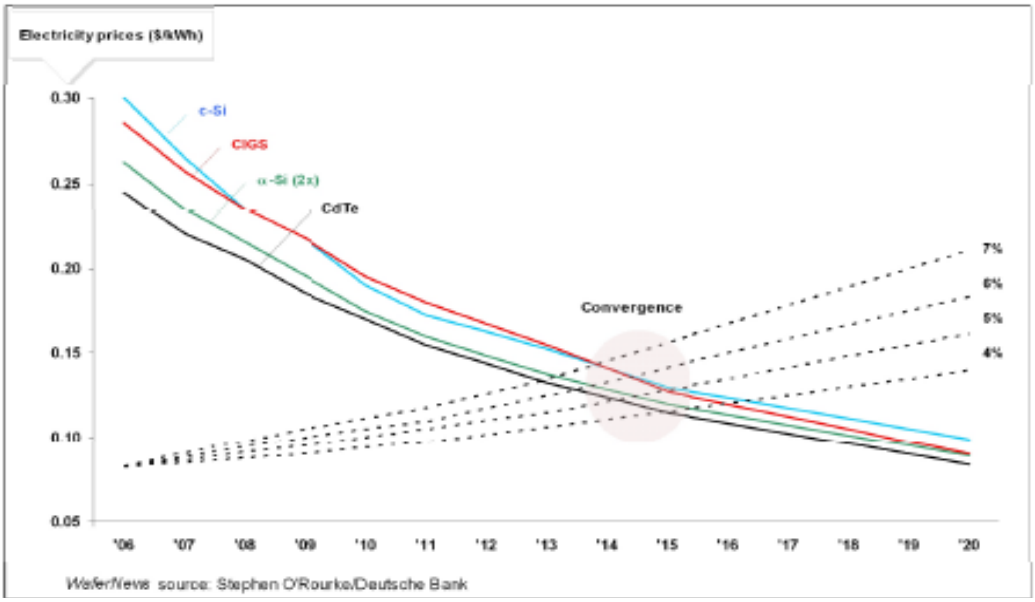
Fig 2.1: Increasing Competitiveness of RE-based Generation on LCOE basis



(Source: IIR, 2010)

The initial capital cost of all solar power generation technologies is still very high. Although prices of solar PV have been falling steeply in recent years, the ultimate goal of grid parity remains to be achieved. Most studies predict that solar grid parity will be reached during 2015–2017 in most markets, given the rising prices of fossil fuels and the falling prices of PV, growing PV markets, and a policy that favours clean energy for mitigating the adverse effect of climate change (Fig 2.2). This projection is true for high volume markets in developed countries. The JNNSM expects to bring solar cost on par with grid electricity by the year 2022, given the specific Indian conditions.

Fig 2.2: Expected Grid Parity for Solar-based Electricity



(Source : WISE 2010)

Implementing policies to bring down cost of production of basic materials required for RE equipment, providing concessional finance to RE power generation markets, together with regulatory initiatives for market expansion can help to accelerate grid parity to solar electricity in India also.

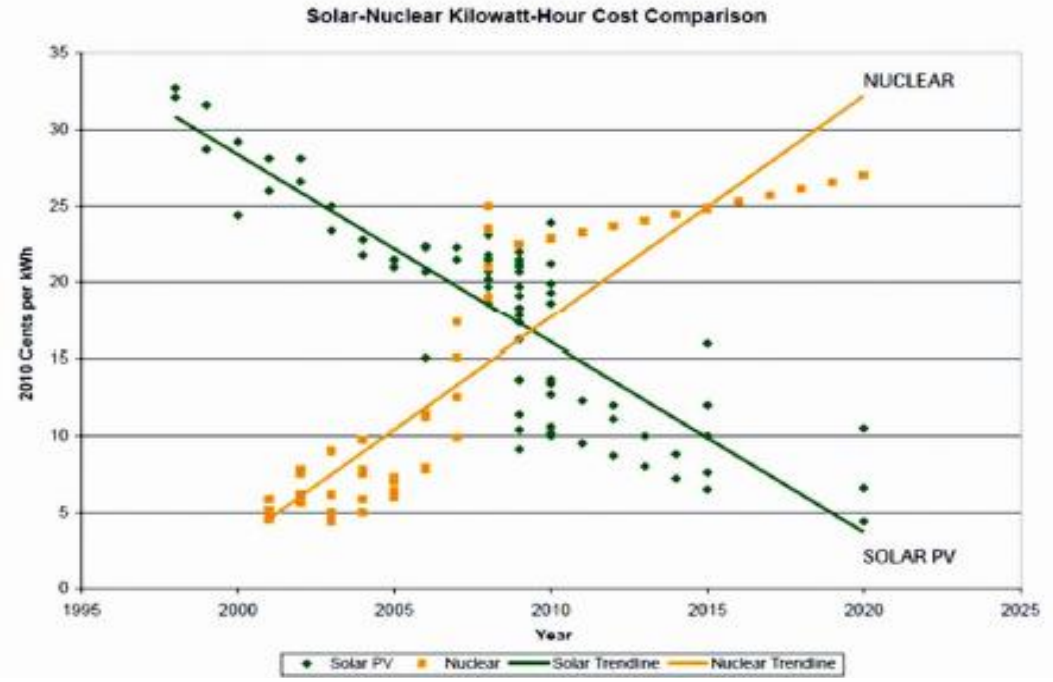
These trends in the cost of conventional and renewable power are expected to make renewable energy sources more cost-competitive than conventional sources in the not-too-distant future. Fossil fuels are also exposed to frequent market shocks and high price volatility. Although domestic

coal and gas prices are controlled by the government in India, a significant share of fuel supply is imported, which increases the risks associated with supply and price.

As per ESMAP (Energy Sector Management Assessment Programme) -World Bank Study (2010) titled 'Unleashing the potential of RE in India', our country could produce about 62 GW in an economically feasible manner, if the local and global environmental premiums of coal-based generation are brought into consideration. About 3 GW of renewable energy is economically feasible at the avoided cost of coal-based generation of Rs.3.08/kWh, all of it from small hydropower. About 59 GW of renewable energy in wind, biomass, and small hydropower is available at an avoided cost of less than Rs.5/kWh. The capacity of 68 GW in these three technologies can be harnessed at a price of less than Rs.6/kWh. About 90 percent of cumulative renewable capacity of 62 GW in wind, biomass, and small hydropower is available when the local and global environmental premiums of coal are brought into consideration. Therefore, development of a substantial volume of renewables is economically justified within the context of an aggressive low-carbon strategy in which the cost of environmental externalities is added to the alternative or avoided cost of energy generation. (*World Bank 2010)* The IPCC special report, 'Renewable Energy Sources: Summary for Policy Makers' (approved 5-8 May 2011) has identified 'non-internalization of environmental and health costs' as a market failure *.(IPCC 2011)*

2.1.5 Solar Power now Cheaper than Nuclear Energy in the US: One of the best kept secrets of the power sector is the real cost of nuclear energy. The veil of secrecy that surrounds the sector is impenetrable and it is next to impossible to find out the real cost of nuclear power. In addition, nuclear power continues to enjoy heavy hidden subsidies despite the fact that it is more than forty years old and should have been a mature industry now. However, a recent report *(Blackburn and Cunningham 2010)* from the United States suggests that solar energy is now the better buy. This report pertains to the state of North Carolina where electricity from new solar installations is now cheaper than electricity from proposed new nuclear plants. Figure 2.3 shows the historic crossover. Power from nuclear had become more expensive by 2009/10 than that from solar PV. In fact, some commercial-scale utility solar PV plants are already selling power at $0.14 per kWh. The trends indicate that nuclear power costs could climb to almost $0.32/kWh by 2020, whereas solar PV power costs would go down to below $0.04/kWh by then. The conclusions are based on a cost per kWh comparison between electricity generated by nuclear reactors and solar photovoltaic systems -both net of subsidies. The report derived a transparent method to obtain kilowatt-hour power costs from project installation costs.

Figure 2.3 Comparative Costs of Nuclear Power and Solar PV Power in cents/kWh:



(Source: Blackburn and Cunningham 2010)

It takes a minimum of six years and an average of ten years to construct a nuclear power plant. Solar power is modular and capacity can be added quickly, in a matter of months. In the distributed mode on rooftops etc., solar power also saves on transmission costs. The study finds that many US utilities are now turning to solar and wind energy which are profitable instead of risking investments in new nuclear facilities. The Indian electricity sector has much to learn from this US experience.

2.2 THE BENEFITS

2.2.1 Climate Mitigation

India is targeting an emissions intensity reduction of 20%–25% by 2020 on 2005 levels. Though there are no emissions reduction targets set for India (Non-Annex 1 Countries), India's decision is indicative of its commitment for voluntary emissions reduction. As a part of this national commitment, every state has to contribute its share. India's per capita emissions are now around 1.2 tonnes of CO_2 equivalent (CO_2 eq) and are expected to be around 2 tonnes CO_2 eq. to 2.5 tonnes CO_2 eq by 2020, and 3 tonnes CO_2 eq. to 3.5 tonnes CO_2 eq. by 2030. Hence, multi-fold efforts are required to achieve the emissions reduction targets. Power sector being the major contributor to GHG emissions, infusion of clean/renewable energy in to the power sector in a bigger way will help to achieve these targets. Energy-sector GHG emissions accounted for 57.75% of the total gross GHG emissions in 2007, with 65% of emissions generated from electricity. The energy sector GHG emissions are as shown in the Table 2.1.

Table 2.1: India: Energy Sector GHG Emissions (million tonnes of CO_2 eq) in 2007

Sector	GHG emissions
Electricity	719.31
Transport	142.04
Residential	137.84
Other energy	100.87
Energy subtotal	**1100.06**

(Source: INCCA 2010)

RE capacity addition proposed in Chapter 4 in line with NAPCC targets would reach the cumulative RE capacity of 59 GW to 63 GW at the end of 12th five year plan. A shift of this magnitude would facilitate avoidance of approximately 140 million tonnes of CO_2 emissions annually from 2017 onwards which is shown in the Table 2.2.

Table 2.2: **Annual Avoided Emissions after 2016/17 (in million tonnes of CO_2)**

RE Source	Scenario 1	Scenario 2	Scenario 3
Wind	83.07	60.75	60.75
Biomass	17.76	23.49	18.16
Small Hydro	14.46	18.50	14.68
Bagasse co-gen	19.17	22.96	19.17
Waste to Energy	0.74	0.91	0.91
Solar	6.62	16.56	28.96
Total	**141.82**	**143.16**	**142.64**

2.2.2 Energy Security

IEP has defined energy security as, "*The country is energy secure when we can supply lifeline energy to all our citizens as well as meet their effective demand for safe and convenient energy to satisfy various needs at affordable costs at all times with a prescribed confidence level considering shocks and disruptions that can be reasonably expected."* As growth of the economy is directly linked to the availability of electricity and resources, the Planning Commission of India has invited public participation and discussion on India's future energy security. This report confines itself to the electricity sector and not energy as a whole.

India's present electricity generation system is coal dominant and poses a threat towards achieving energy security. India's coal production capacity during 2009/10 was 534.33 metric tonnes, and import was 70 metric tonnes. Despite this huge coal capacity, 27 thermal power projects were operating with critical coal stock of less than 7 days in Nov 2010. This was mostly because of less receipt of local coal, delay in import of coal, and transportation issues. There are limitations on scaling up of local coal production. Further, poor quality of coal forces power projects to rely on coal imports. In order to ensure coal resources, Indian companies like Lanco, Adani, JSW, etc, are acquiring foreign coal fields to assure coal supplies for their thermal power projects. Other than coal, the countries having major oil reserves are politically unstable. Political will to acquire and hold the resources will seriously affect the fossil fuel imports and continuation of long-term supply linkages. Resource risks increase with increased dependence on fossil fuels. Hence, higher energy

penetration from RE, and diversification of power generation resources will ensure a balanced energy system.

Diversification in the use of fuels may also be important for energy security. Fuel transformation such as coal/oil to biomass can meet demand when conventional fossil fuel supplies are affected. Rather, this will reduce the dependence on coal and optimise the utilisation of renewable energy sources. Hence, usage of fuel shift technologies and applications need to be promoted.

Wind, solar and hydro resources are cost-free resources. After payback of capex, these projects will have least running costs and have the potential to supply electricity at competitive rates on a long-term basis. The fossil fuel costs are increasing because of increasing demand in diminishing reserves. With increased use of RE technologies and technology breakthrough, these projects will achieve grid parity. Continuation of RE capacity addition will help in achieving capacity additions when technology breakthrough/grid parity is achieved. Also this will help in gearing up for expansions and resolving the related issues of higher RE penetrations.

2.2.3 Foreign Exchange Savings: India imported about 84 million tonnes of coal in 2010–11 and according to the Coal Ministry, this is expected to increase to 142 million tonnes in 2011–12. *(IE 2011)* The landed cost of imported coal is almost double that of domestic coal. As per Coal India's projections, India will require to import around 200 million tonnes of coal by 2015/16 at an exorbitant price of around Rs.1,30,000 crore. Gradually moving away from coal-based projects to coal/gas–solar hybrid projects and then to CSP projects would help in saving significant amounts of foreign exchange.

2.2.4 The Green Job Bonanza: Renewable technologies are labour intensive and generate much higher employment compared to conventional power generation technologies. The thumb rule is that renewables can generate an average of 20 jobs per MW, including both direct and indirect jobs. It would be seen from Chapter 5 of this report that in the three different scenarios of capacity addition to achieve 15% RE by 2020, job creation could vary from 14.86 lakhs in Scenario 1 to 16.62 lakhs in Scenario 3.

2.2.5 Other Benefits to States: Renewable energy development can also be an important tool for regional economic development within India. Many of the states endowed with rich renewable energy potential (Arunachal Pradesh, Himachal Pradesh, Uttarakhand) lag behind in economic development. Developing renewable energy in these states can provide secure electricity supply to foster domestic industrial development, attract new investments, create employment, and generate additional state income by allowing the states to sell renewable energy certificates to other states. Investments to tap the renewable energy potential of these states would thus give a huge boost to their economies.

The 13th Finance Commission has recommended a forward-looking grant as an incentive to states who increase the share of electricity generated from renewable sources (Refer Chapter 1 also). The grant is to the tune of Rs.5000 crore for states generating grid-connected electricity (in MW) from RE sources between FY 2010-11 to FY 2013-14. In determining the level of central assistance, state performance is given a weightage of 7.5%, out of which environmental performance would account for 2%. It will be based on evaluation of five parameters—air quality, water quality, waste

management, forest cover and climate change. Thus, any efforts of the states towards promotion of RE-based power projects will be useful in obtaining maximum share of central grants in future.

2.2.6 Rural Infrastructure Development, Decentralization of Development: Conventional power projects are centralized with huge power generation capacity and long transmission lines reaching the load centres. On the other hand, the clean energy system is moving towards decentralized power generation distributed across villages, cities and the states. Except for waste-to-energy projects which are located in urban areas due to availability of the raw material, most of the RE-powered projects including wind, solar, SHP, biomass and co-generation projects are located mostly in interior rural areas. These RE projects help in creating infrastructure and developing community facilities, besides creating direct and indirect jobs in rural areas. This also leads to massive investment flow to these areas. Hence, development of renewables would be a perfect complement to decentralized development and governance.

***

3

Potential and Status of Development of Renewables in India

3.1 RENEWABLE ENERGY POTENTIAL IN INDIA

The Ministry of New and Renewable Energy, Government of India, had initiated the process of assessing the availability of renewable energy resources in India. Different studies were conducted at different points of time by MNRE to assess India's renewable energy potential. Due to changing climatic conditions, rainfall patterns, hydrology, agriculture activities, usage of RE resources and improvements in technology, the RE potential also kept changing over time. With the advent of new, state-of-the-art resource assessment techniques and technology leapfrogging, assessment of RE potential in India has further changed, with different governmental and research institutions, and policy think-tanks making their own assessments. This chapter provides a perspective of these different RE potentials, the need for further re-assessment, and the actual status of development of RE in India.

3.1.1 MNRE Estimate of RE Potential in India

The RE potential assessed by MNRE and published as the official estimate in India is tabulated in Table 3.1. A brief overview of sub-sector specific renewable assessment studies is presented subsequently.

Table 3.1: MNRE Estimate: Renewable Energy Potential in India

	Name of State	Wind Power Potential	Biomass Power Potential	Bagasse Cogeneration Potential	Small Hydro Potential	Total	% Share
1	Andhra Pradesh	5394	150.2	300	560.18	**6404.38**	**7.32**
2	Arunachal Pradesh	201			1328.68	**1529.68**	**1.75**
3	Assam	53	165.5		238.69	**457.19**	**0.52**
4	Bihar		530.3	300	213.25	**1043.55**	**1.19**
5	Chhattisgarh	23	220.9		993.11	**1237.01**	**1.41**
6	Goa		15.6		6.5	**22.1**	**0.03**
7	Gujarat	10609	1014	350	196.97	**12169.97**	**13.91**
8	Haryana		1261	350	110.05	**1721.05**	**1.97**
9	Himachal Pradesh	20	128		2267.81	**2415.81**	**2.76**
10	Jammu & Kashmir	5311	31.8		1417.8	**6760.6**	**7.73**
11	Jharkhand		66.8		208.95	**66.8**	**0.08**
12	Karnataka	8591	843.4	450	747.59	**10631.99**	**12.15**
13	Kerala	790	762.3		704.10	**1552.3**	**1.77**
14	Madhya Pradesh	920	1065.4		803.64	**1985.4**	**2.27**
15	Maharashtra	5439	1585	1250	732.63	**9006.63**	**10.29**
16	Manipur	7	4.1		109.13	**11.1**	**0.01**
17	Meghalaya	44	1.1		229.80	**45.1**	**0.05**
18	Mizoram		0		166.93	**0**	**0.00**
19	Nagaland	3	3.1		188.98	**6.1**	**0.01**
20	Orissa	910	147.3		295.47	**1352.77**	**1.55**
21	Punjab		2674.6	300	393.23	**3367.83**	**3.85**
22	Rajasthan	5005	4595		57.17	**9600**	**10.97**

	Name of State	Wind Power Potential	Biomass Power Potential	Bagasse Cogeneration Potential	Small Hydro Potential	Total	% Share
23	Sikkim	98			265.55	**363.55**	**0.42**
24	Tamil Nadu	5374	863.3	450	659.51	**7346.81**	**8.40**
25	Tripura				46.86	**0**	**0.00**
26	Uttar Pradesh	137	1477.9	1250	460.75	**3325.65**	**3.80**
27	Uttaranchal	161	6.6		1577.44	**1745.04**	**1.99**
28	West Bengal	22	368.3		396.11	**786.41**	**0.90**
29	A&N Islands	2			7.27	**9.27**	**0.01**
30	Lakshadweep	16				**16**	**0.02**
	Total	**49130**	**17981.5**	**5000**	**15384.15**	**87495.65***	**100.00**

*(*RE potential tabulated above excludes waste-to-energy, industrial waste and solar power generation potential)*

Wind Potential Assessment: Wind potential assessment was undertaken by the Centre for Wind Energy Technology (C-WET), Chennai, the nodal agency under MNRE. Earlier, C-WET had published a wind assessment report, wherein the total wind power potential in 9 states was estimated as 48,562 MW, at a hub height of 50 metres, with assumptions of 1% land availability in the identified windy region and land requirement of 12 hectares for each megawatt. Further, C-WET reassessed the wind potential and came up with a new figure of installable potential in windy states as 49,130 MW in its wind atlas, which was prepared in collaboration with Risoe, Denmark in April 2010. These estimates were based on assumptions of 2% of land availability in potential states and 9 MW installable wind power capacity per square kilometre area. Apart from this, the major off-shore potential is not yet assessed.

Solar Potential Assessment: MNRE has not yet published the state-wise power generation potential from solar energy sources. However, the India Meteorological Department, Ministry of Earth Sciences, New Delhi, has published a report 'Solar Radiant Energy Over India' in 2009. This report provides maps related to solar radiation levels in different parts of the country, global solar radiation and daily distributions of sunshine hours, etc. Potential solar states can be found from this map but exact potential have not been presented.

Biomass and Cogeneration Potential Assessment: Biomass resource assessment programme was initiated by MNRE initially at the block level. Later district level resource assessment studies were done with the help of the Indian Institute of Science, Bengaluru. The potential of power generation from surplus biomass was assessed as 18,000 MW. Apart from biomass, separate potential from bagasse cogeneration was assessed as 5000 MW.

Small Hydro Potential Assessment: Hydro projects up to 25 MW capacity have been categorized as Small Hydro Power (SHP) projects and fall under the purview of the Ministry of New and Renewable Energy. MNRE had estimated the potential of SHP as 15,384.15 MW, which includes around 5,718 potential sites.

Waste-to-Energy Potential Assessment: Urban liquid and solid waste data was collected from urban local bodies at the time of preparation of the national master plan for development of waste-to-energy in India which estimated the potential of around 462 MW by 2017 from urban liquid waste and 4566 MW by 2017 from solid waste Apart from urban local bodies, different industries also generate a lot of process waste which has a potential of 1997 MW by 2017.

Geothermal Energy Potential Assessment: Geological Survey of India (GSI) has identified 350 geothermal energy locations in the country which can generate 10,600 MW of power. Of this, 62 are distributed along the northwest Himalaya, in the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Actual resource assessment studies with the help of deep drilling have not yet been undertaken so as to explore the exact potential and commercial viability of such projects.

3.1.2 Estimate of RE Potential in India by the World Institute of Sustainable Energy (WISE)

The preliminary potential assessment study carried out by WISE (Table 3.2) indicates wind potential in the country to the extent of 100 GW, taking into consideration the technology advancement in wind energy generators, higher hub height, and expanded resource exploration. In the case of solar energy, availability of 2,08,110 sq.km of high radiation desert land for development has been the major deciding factor. The solar potential would be higher when other wasteland and rooftops are taken into consideration. However, the RE potential assessment done by WISE needs to be validated through field studies.

Table3.2: Grid-connected RE Potential in India (WISE Estimates)

Energy Source	Potential (MW)	Assumed Plant Load Factor (PLF) in %	Annual Energy Generation in Billion kWh
Wind	100,000	25	219
Small Hydro	15,000	45	46
Bagasse	5,000	60	26.3
Biomass	16,881	60	88.72
Large Hydro (existing & future)	100,000	60	525.6
Large Hydro in Bhutan	16,000	60	84.1
Waste to Energy	5,000	60	26.28
*Solar CSP based power generation	200,000	35	613.2
*Solar PV/CPV based power	200,000	20	350.4
Geothermal	10,000	80	70.1
TOTAL	**662,881**		**2049.70**
Note: Resource Potential of other RE sources including offshore wind, tidal, biogas-based power not considered.			
* India has a total suitable desert area of 208,110 sq.km for solar power generation. Only 10% utilization of the same will result in above CSP/PV potential (assuming 20 MW/sq.km)			

3.1.3 Planning Commission, GoI Assessment of Solar Potential in India

The interim report of the Expert Group of the Planning Commission, Government of India, on 'Low Carbon Strategies for Inclusive Growth', has under Section 3.1.2, 'Electricity Supply Options (Hydro and Renewable)' stated that the National Solar Mission has provided solar power the much needed thrust to make it a major contributor to India's future energy mix. It offers many advantages for both centralized and decentralized power generation, and also for powering the rural areas. Solar is presently expensive, almost 3–4 times that of coal based power. However, the industry is optimistic that with growing manufacturing capacity in the country, short-term viability gap support from the government, aggressive research and development, and large-scale deployment,

grid parity could be achieved within the coming decade or even earlier. Solar installed capacity if pursued aggressively could grow to 20,000 MW by 2020. It is one of the critical technology options for India's long term energy security**. Several parts of India are endowed with good solar radiation and deploying solar even on 1% of the land area could result in over 500,000 MW of solar power.** The coming decade is vital to validate the techno–economic viability of solar as a major contributor to the nation's future energy.

3.1.4 Wind Power Potential estimate by Lawrence Berkeley National laboratory (LBNL)

The LBNL has re-assessed the wind power potential of India using a globally accepted methodology and come to a conclusion that "the re-assessed onshore developable wind potential at 80 m hub height in India below the cost of Rs.6/kWh is 676,218 MW after assuming that farms, forests, other protected land and geographically hard terrains are not available for wind farm development. Offshore developable potential in India is about 214,304 MW. This potential is likely to be higher as better technology gets deployed. The land exclusion includes areas with slopes greater than 20 degrees, elevation greater than 1500 m, forests, snow covered areas, water bodies, and other protected areas along with crop lands." However, such meso-scale assessment of very high resource potential needs to be validated through field-level studies considering various other limiting factors.

The outcomes of various potential assessment studies underline the fact that renewable energy potential is not a constraint for meeting the NAPCC target of RE injection.

3.1.5 Need for Re-assessment of RE Potential in India

Even though such differing estimates as described above give widely varying figures of potential, one thing remains clear as of now: renewable energy potential or the supply side would not be a constraint in achieving 15% RE addition by 2020. The common concern among experts is that the present RE estimates done by MNRE are grossly under-estimated. Hence there is a need to realistically re-assess the state-wise potential of all RE sources in the country;

Wind: In the case of wind power, potential assessments done by C-WET were at 50 m mast height, where as wind turbines of 80 m and above hub height are being used. Over and above, C-WET's site developers have identified additional sites, thus increasing the assessed potential. In the case of Tamil Nadu, the present installed wind power capacity (5,903 MW) has already crossed the officially assessed technical potential (5,374 MW). Further, additional 3,000 MW of projects are in the pipeline in Tamil Nadu. Also, the revised potential assessment of C-WET has reduced the estimated potential of Andhra Pradesh, Karnataka, Kerala and Madhya Pradesh from its earlier estimates which is not rational. Also, present study doesn't cover offshore wind potential. Hence, there is a need to develop a far more refined wind map, with strong focus on assessment of offshore wind energy potential.

Solar: In the case of solar, the official potential assessment in terms of technically exploitable and economically feasible solar potential in the states is not available in the public domain. Hence, projects in the pipeline under JNNSM are a major concern for bankers and financial institutions (FIs) who are not relying on energy estimates done on the basis of weather model resource assessments and are insisting on actual ground solar resource assessments. Like in the case of

wind, ground wind resource assessment studies are undertaken by C-WET whose data is trusted by FIs and bankers. In this way, MNRE should initiate ground solar radiation resource assessments on sites identified by SNAs so that officially validated data will be available to investors and bankers.

Biomass & Cogeneration: Further, in the case of biomass and bagasse resources, surplus biomass availability for power generation is hugely affected by change in rainfall, cropping pattern, consumption by different industries and sources, etc. Hence, though India has a huge untapped potential of biomass resources, over- exploitation of biomass will have serious implications on its availability for cooking-fuel and fodder and also on its availability for existing projects. Hence, for sustainable development of RE, re-assessment of RE potential is of crucial essence.

Small Hydro: In the case of small hydro power projects, changes resulting from global warming and rising industrial usage have affected the flow of water and availability of hydro power.

Other RE: Apart from the above, renewable resources like geothermal, wave and tidal power also have huge potential. Geothermal projects have been commercially developed in other parts of the world. There are many private developers interested in venturing in to this area. However, actual resource assessment with the help of deep drilling is required. Similarly, wave and tidal power is to be assessed on priority to develop pilot scale projects and further commercial projects in the 12th plan period.

In the absence of realistic RE potential assessment figures, policy decision on power generation could be skewed in favour of conventional sources.

3.2 CURRENT STATUS OF RE DEVELOPEMENT

All India installed capacity of power generation projects is 1,75,146.36 MW as on 31 March 2011. Of this, 65% installed capacity is dominated by thermal power generation projects. Renewables contribute about 11% (19,974.48 MW) in terms of installed capacity, as shown in Figure 3.1 and 4% in terms of electricity generated as shown in Figure 3.2.

Figure 3.1: Share of RE in Overall Power Generation Capacity (MW)

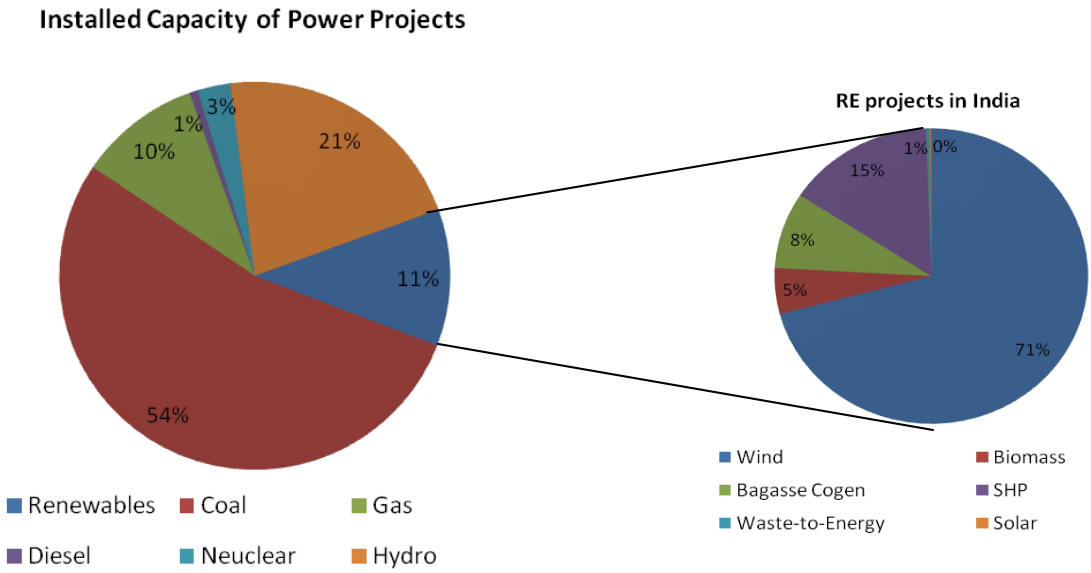
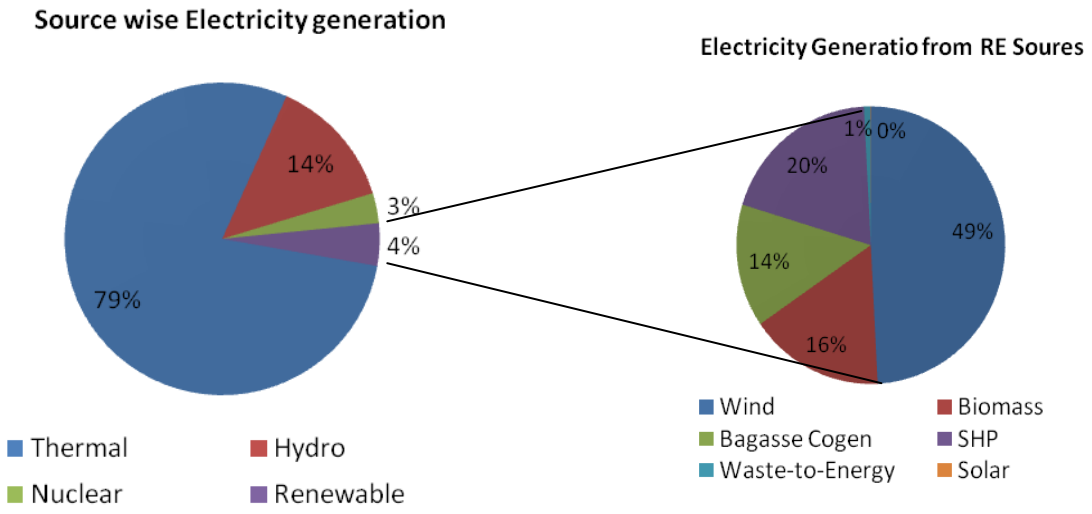


Figure 3.2: Share of RE Generation in Overall Power Generation (MU)



(Source: CEA, MNRE 2011)

Wind: Of the 19,974.48 MW of installed renewable capacity, wind power contributes 71%. This sector has received continuous state and central government support, preferential feed-in-tariff and tax sops. Wind technology is well commercialised. The sector has seen many new entrants in the recent past in the wind turbine manufacturing segment with MW class wind turbines. Most of the Class I sites have been explored, leaving behind Class II and Class III sites. Designing the project on such sites and achieving higher generation is a huge challenge. Acquisition of private land, obtaining forest clearances, development of infrastructure on complex terrains, implementation of evacuation infrastructure, identification of new sites for development and scheduling and forecasting generations are some of the challenges faced by this sector.

Small Hydro Power: Small hydro projects have achieved the cumulative capacity addition of 3042.63 MW. However, there is still huge untapped potential to be achieved out of the 15 GW assessed potential. SHP technology is also well established and commercialised and has low running cost. Development in this sector has been relatively slow because of time-consuming land acquisition and forest clearance procedures, lack of clear policy for private sector participation in some states and delay in getting project clearances.

Biomass: Biomass power projects have the highest PLF among all RE technologies. About 997.10 MW of biomass power projects and 1667.53 MW of bagasse co-generation projects have been commissioned in India. Biomass power is also unexplored to a large extent, though the technology is proven. State government support to co-operative sugar factories through the 'Urjankur Nidhi' in Maharashtra has encouraged such projects. The increased use of biomass by other industries, changing cropping pattern, and reduction in cultivable agriculture land has reduced the surplus available biomass for power generation. Thus, absence of assured supply chain, presence of multiple middlemen, the absence of well-defined agro-waste supply contracts, difficulties in acquiring wastelands for energy plantation are some of the teething problems of the sector.

Further, increased demand has inflated the biomass prices, particularly that of rice husk which is threatening the economical operation of biomass power projects.

Waste-to-Energy: Despite having Municipal Solid Waste (MSW) Management & Handling Rules 2000 in place which obligates the Municipal Corporations to scientifically dispose the waste, these projects are not picking up. As of 31 March 2011, only 72.46 MW of waste-to-energy projects have been installed in India. Success stories of running projects in Andhra Pradesh, and huge subsidies and incentives from the Central Govt could not promote this sector. Increasing waste with rising population and improved lifestyle, public agitations against open dumping, unavailability of further sites in suburbs for waste dumping and scientifically disposing such waste is a critical task in front of corporations. However, though large quantity of waste is available for power generation, there is no regular supply of processed and segregated waste for energy generation projects.

Solar Power: Government commitments through JNNSM for development of long-term solar projects has attracted a large number of investors towards this sector in a short time frame. About 37.66 MW of projects have been commissioned in India within the last two years, courtesy the semiconductor policy, solar SEZ, separate RPO for solar, feed-in-tariff, etc. Development of evacuation system, land acquisition, bankable PPA, lack of availability of measured solar data, availability of steam turbine for solar power projects are some of the major barriers for development of solar projects in India.

In 2010–11, India emerged as the third largest market for wind power after China and US. Similar potential exists in India to emerge as a world leader in solar energy development. Our country has taken the first steps in this direction by announcing JNNSM targets and beginning their implementation. A much bigger emphasis on wind and solar energy development, along with other renewables can catapult India to be a leading green power producer, thus ensuring our long-term energy security and autonomy.

(Source MNRE)

***

4

Capacity Addition Required for Achieving 12% RE by 2017 and 15% RE by 2020

As part of the preparations for launching the 12th Five Year Plan, the Planning Commission, Government of India has identified twelve 'strategy challenges' in some core areas. The Planning Commission has briefly described these 'strategy challenges' and invited responses from the public. The Commission has decided that the 12th Plan Approach Paper will be evolved through a web-based consultative process to finalise the major targets and the key challenges in meeting them, and the broad approach that must be followed to achieve the stated objectives of the Plan. This Approach Paper will then be approved by the Cabinet and the National Development Council. The twelve strategy challenges are listed below:

i. Enhancing Capacity for Growth
ii. Enhancing Skills and Faster Generation of Employment
iii. Managing the Environment
iv. Markets for Efficiency and Inclusion
v. Decentralisation, Empowerment and Information
vi. Technology and Innovation
vii. Securing the Energy Future for India
viii. Accelerated Development of Transport Infrastructure
ix. Rural Transformation and Sustained Growth of Agriculture
x. Managing Urbanization
xi. Improved Access to Quality Education
xii. Better Preventive and Curative Health Care

Out of the above twelve strategy challenges, 'Securing the Energy Future for India' encompasses the national targets for renewable energy during the 12th Five Year Plan period.

The National Action Plan on Climate Change has set a goal of a 1% annual increase in renewable energy in the national grid starting from 5% in FY 2009-10 and increasing to 15% of the energy mix of India by 2020. The share of renewable energy is currently 4% of the energy mix as on March 2011. This 15% RE by 2020 has thus effectively become a 'National RPO' though it is not legally mandated. After the announcement of the NAPCC (June 2008) and the JNNSM (November 2009), various initiatives have been taken by the government, the Central Electricity Regulatory Commission and SERCs, to set the momentum to achieve this target. However, there is no clear indication or clarity on the grid connected RE capacities that need to be added to achieve this 15%. This chapter analyses these aspects and projects three different scenarios for RE capacity addition.

4.1 THE APPROACH AND METHODOLOGY

Approach: The approach in this study is to see how this national target can be achieved (and not whether it can be achieved) and to decide the RE capacity additions required to achieve this target. The study aims to:

- Verify adequacy of the government planned capacity additions for 12th and 13th plan periods to meet 15 % RE injection by 2020 targeted under the NAPCC;
- Verify adequacy of the state-level RPO targets in meeting the national RPO;
- Review the state–wise RE potential / installed capacity and unexplored potential in order to ascertain the potential RE sources / states which could contribute substantially;
- Project likely RE capacity addition scenarios at Pan India level and at state levels to match NAPCC target;
- Assess the impact of these capacity addition scenarios on average power procurement cost (APPC) (Pan-India basis).

Adequacy of the government-planned RE capacity addition over 11th and 12th Plan periods has also been verified by comparing it with the anticipated renewable energy generation envisaged in the NAPCC. The possible renewable energy injection into the national grid due to mandatory RPO targets specified by 25 SERCs in India has been worked out considering the state-wise solar and non-solar RPO targets and state-wise future energy consumption projected by the Central Electricity Authority (CEA).

Methodology: With the broad objective of meeting the NAPCC target of 15% RE by 2020, different RE capacity addition scenarios were considered, keeping in mind the availability and commercial potential of each RE resource in India and finally three scenarios were shortlisted viz: (1) Wind dominant scenario; (2) SHP-Biomass dominant (on CAGR basis) scenario (3) Solar dominant scenario. Under each of these scenarios, a particular RE source is identified as a prominent resource for future capacity addition to meet NAPCC target. A Progressive growth rate was considered for such prominent RE source while the share of other RE sources has been defined based on their historical growth rates. By recognizing the various limitations of present officially assessed RE potential and considering the availability of vast solar resources in India, resource availability is not considered as a constraint for meeting the NAPCC target.

WISE has also specifically made a request to the state governments/State Nodal Agencies of RE potential states to share the data of capacity addition plans in their respective states. However, the response has been very poor and only a few states have responded and shared limited data about capacity addition over the next two-three years. Secondary data about state level future RE capacity addition, RE projects in pipeline, quantum RE addition proposed in the applications received for setting up the RE projects by SNAs, etc., has been collected from various sources. However, in view of availability of limited data, the RE capacity addition projections made under different scenarios are developed based on importance of RE technology from the point of energy security, present stage of development of RE technology, un- tapped RE potential, future cost reduction trends and scalability, etc. The historical annual capacity addition over the past decade,

as well as capacity addition in the recent past, has also been studied before projecting capacity addition scenarios.

Consequently, the most beneficial scenario from the three has been extended at the state level for working out possible state-wise, RE technology-wise contribution towards meeting the national RPO of 15%. The state-wise, non solar RE technology mix is determined on the basis of preparedness of the respective state in terms of policy and regulatory support as well as resource availability and past growth records. Whereas, the solar capacity allocation within the states is governed by the availability of solar radiation, total geographical area and wasteland.

4.2. THE DIFFERENT TARGETS & PLANS

4.2.1. MNRE Planned Capacity Addition for 11th, 12th, & 13th Plan periods

Prior to the recent developments like the NAPCC and JNNSM, the Working Group on New and Renewable Energy for the 11th plan had specified a targeted capacity addition for the 11th plan period and projected capacity addition for the 12th and 13th five year plans for RE technologies other than solar. Same is reproduced in the following Table 4.1.

Table 4.1: Planned capacity addition for 11th, 12th, & 13th Five Year Plan periods

Source	11th Plan (2007-12)	12 & 13th Plan (2012-22)	Total
Wind	10500 MW	22500 MW	**33000 MW**
SHP	1400 MW	3140 MW	**4540 MW**
Bio-energy	2100 MW	4363 MW	**6463 MW**
		Total	**44003 MW**

(Source : Working Group on New and Renewable Energy for the 11th five year Plan (2007-12), Planning Commission , GoI)

4.2.2. The Jawaharlal Nehru National Solar Mission Target

Under the JNNSM, ambitious targets have been announced for solar energy development. The Mission will be implemented in three stages up to 2022 leading to an installed capacity of 20,000 MW of grid-connected solar power capacity, 2000 MW of off-grid solar applications, and 20 million sq.m solar thermal collector area. The immediate aim of the Mission is to focus on setting up an enabling environment for solar based grid-connected and off-grid technologies, both at the centralised and decentralized levels. The targets are mentioned in Table 4.2.

Table 4.2 Targets specified under JNNSM

Application Segment	Target		
	Phase I (2010-13)	Phase II (2013-17)	Phase III (2017 – 22)
Solar Thermal Collector	7 million sq m	15 million sq m.	20 million sq.m
Off-grid solar Applications	200 MW	1000 MW	2000 MW
Grid power including roof top and small plants	1,100 MW	4000–10000 MW	20000 MW

4.2.3 The NAPCC Target

The NAPCC has recommended minimum share of renewable energy in the national grid to be set at 5% in 2009-10, subsequently increasing by 1% every year during the next 10 years to reach 15% by 2020. The anticipated renewable energy injection envisaged under the NAPCC has been found out by applying the National RPO targets to the all India electricity demand projections given under the '17th Electric Power Survey of India Report' published by CEA. (Table 4.3)

4.3 THE EXISTING PLANS/AND SHORTFALL VIS-À-VIS NAPCC

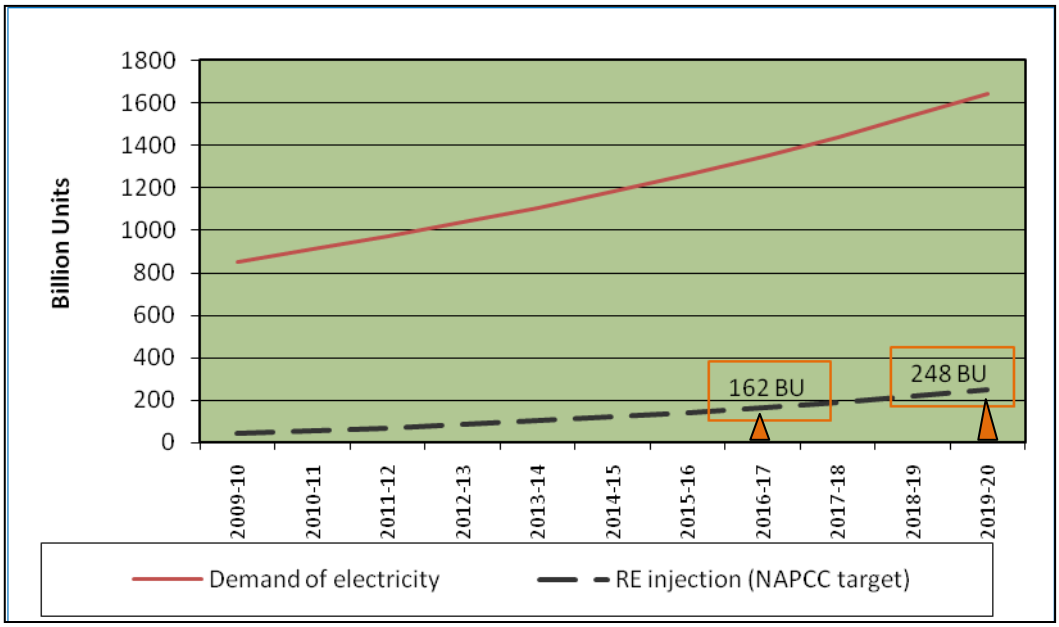
Table 4.3 and Fig 4.1 reveal that RE generation of the order of 162 BU and 248 MU need to be injected into the national grid to realize 12% and 15% share of RE in 2017 and 2020 respectively.

Table 4.3 All India electricity demand and required RE injection to meet the NAPCC target

	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Demand of electricity (BU)	848	906	969	1035	1105	1181	1262	1348	1440	1538	1643
Required RE injection (BU) (NAPCC target)	42.4	54.38	67.8	82.7	99.5	118.1	138.7	161.7	187.1	215.3	246.4

WISE working

Fig 4.1 Requirement of renewable energy to meet NAPCC target (BU)



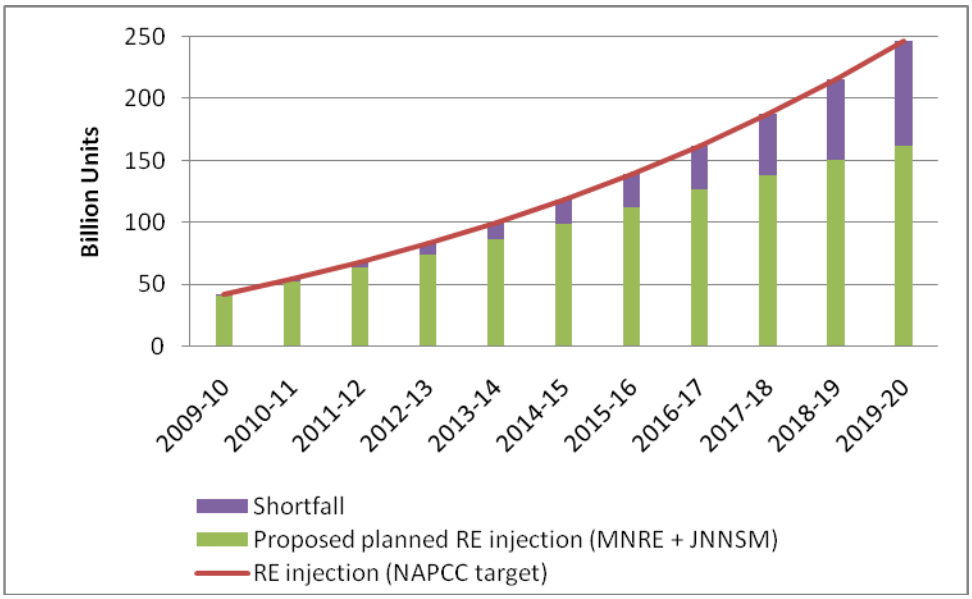
In order to find out adequacy of the government-planned capacity addition targets (MNRE & JNNSM), these targets are converted into energy terms (BU) by applying CERC specified normative RE technology-wise capacity utilization factor (CUF) and compared with the anticipated RE injection envisaged under the NAPCC. Present installed RE capacity and corresponding generation is also factored in while making such comparison. (Table 4.4)

Table 4.4 Planned RE injection and shortfall

	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Required RE injection to meet NAPCC target (BU)	42.42	54.38	67.81	82.79	99.49	118.10	138.78	161.74	187.19	215.35	246.49
Proposed planned RE injection (BU) (MNRE + JNNSM)	41.85	52.53	63.40	74.34	86.77	99.77	113.34	127.48	139.42	151.02	162.36
Shortfall (BU)	0.57	1.85	4.41	8.45	12.72	18.33	25.44	34.26	47.76	64.34	84.24

WISE working

Fig 4.2: Planned RE injection and shortfall



Assumptions:

- All India electricity demand projections as per 17th EPS Report of CEA.
- Non solar capacity addition is as set by Working Group on New and Renewable Energy for the 11th, 12th and 13th Plan.
- Solar capacity addition targets as suggested in JNNSM.
- Normative CUF: Wind (23%), Solar PV & thermal (21%), SHP (38%), Biomass & Cogen (75%) - CERC RE Tariff Regulation 2009.

Fig 4.2 reveals that the MNRE planned non-solar capacity addition for 11th and 12th Plan period together with JNNSM targeted solar capacity addition (16,000 MW) over year 2010-2020 is not sufficient to meet the NAPCC target . The shortfall in energy terms will increase to a level of 84 BU in FY 2020 from 0.57 BU in FY 2010. The planned capacity addition when realized will be able to supply 162 BU of renewable energy generation into the national grid by 2019-20, which will represent approximately 9.88 % of the energy mix in the national grid in 2020. Hence there is a shortfall of approximately 5% (84 BU) as compared to the NAPCC requirement of 15% by year 2020. Considering the average CUF of 36% representing all RE technologies, approximately

additional 26,000 MW RE capacity over and above planned RE capacity (MNRE & JNNSM) is required to overcome the shortfall by year 2020. This indicates that approximate cumulative RE capacity installation of 82,000 MW is required to be put in place by FY 2020 to meet the NAPCC target which may be subject to change, according to the proportion of different RE technologies in the energy mix.

Therefore, originally planned RE capacity addition by the working group will have to be revised to achieve the 12% and 15% RE penetration by FY 2017 and 2020 respectively. The revision in planned RE capacity in 12th and 13th Plans is still possible as the 12th plan Working Group Report on RE is yet to be finalized.

4.4. CAPACITY ADDITION SCENARIOS

In Chapter 3 of the report, we had seen that India has enough renewable energy potential to power our sustainable economic development. So overall, there is no supply side problem in achieving the targets. While working out the supply-side figures under three scenarios, the following RE technology–wise key considerations have been taken into account.

4.4.1. Key considerations

Wind: The Indian wind market grew by almost 68% on a year-on-year basis with around 2,300 MW of new wind capacity installed during FY 2010-11. This made India the third largest annual market after China and the USA for 2010. With more than 14 GW of total installed capacity at the end of FY 2010-11, India ranks fifth in the world in terms of cumulative installed capacity. During the first four years of the 11th Plan period ending March 2011, India added 7.04 GW of wind power capacity. With over a year to go before the current plan period is over, it is very likely that Indian wind power installations will meet and exceed the 11th plan-period target of 10,500 MW. Considering the fact that wind is a mature technology and there is no supply side constraint, an accelerated growth rate slightly more than advanced scenario projected by the Global Wind Energy Council (GWEC) and WISE in the 'Indian Wind Energy Outlook 2011' is considered under **Scenario 1** which is a 'wind dominant scenario'. For **Scenario 2** and **Scenario 3,** a moderate growth rate based on historical growth is considered for projecting the likely wind capacity addition during year 2010-2020. *(IWE 2011)*

Biomass: While projecting the capacity addition targets for biomass, due weightage has been given to the critical issue of the reliability of the assessed potential of biomass. The potential estimated by MNRE / Indian Institute of Science in year 2000 may not represent the real developable potential because over the past decade, the pattern of alternate usages of biomass has altered significantly, affecting the availability of surplus biomass, and in turn, the potential for biomass-based power projects. Other critical issues hampering the development of biomass-based power projects is the underdeveloped fuel supply chain and presence of multiple middle men, resulting in unprecedented hike in the fuel price.

Co-generation: A moderate growth rate below the historical growth rate has been considered in all three scenarios, since our assessment shows that the present assessed co-generation potential will be exhausted by the end of FY 2020.

SHP: Where SHP is concerned, some of the issues like long delay in getting the clearances, absence of reliable hydrological data, decrease in run-off due to ecological destruction, land acquisition problems, and lack of clear policy for private sector participation has been posing hurdles in its development since the past several years. Above limitations with regard to SHP and biomass technology has been kept in mind. Under Scenario 2, a moderate growth rate of Biomass–SHP which is more than the historical growth rate has been considered. For Scenarios 1 and 3, growth rate lower than historical growth rate has been considered.

Solar: The capacity addition targets specified under Phase I, II & III of the JNNSM are considered to be realized during the stipulated time frame in all three scenarios. However under scenario I, the solar capacity addition targets are restricted to lower limit specified under JNNSM (4000 MW) by 2017 in order to reduce the impact on pan-India APPC. The state-wise solar power development in terms of target fixation/number of applications received for setting up projects / clearances given by state government for setting the project has also been studied in detail. Considering the state /central government initiatives for solar power development, the overwhelming response received for JNNSM Phase 1 bidding, the capital cost reduction over last three years at national level, and the future cost reduction projections published by several reputed international institutions, an additional 19,490 MW capacity addition over and above JNNSM target has been considered under Scenario 3 (solar dominant).

As per an analysis carried out by WISE based on all India electricity demand projected by CEA and normative CUF of solar PV and CSP projects, total 31213 MW cumulative installed capacity needs to be put in place by 2022 in order to meet the solar RPO of 3% as specified under JNNSM and the tariff policy. This implies requirement of an additional 11213 MW solar capacity over above targets specified under JNNSM.

4.4.2. The Three Scenarios

Based on the above key considerations, the following three scenarios have been worked out.

Scenario 1 (Wind dominant): Considering the past growth rate, present stage of development and future potential availability reported under various studies, wind power has been considered to be a prominent source of generation in this particular scenario. Therefore, an accelerated growth rate slightly more than as projected under advanced scenario by the Global Wind Energy Council and WISE in the 'Indian Wind Energy Outlook 2011' has been considered, wherein an aggressive cumulative capacity addition of 45,812 MW and 74,122 MW is proposed by year 2017 and 2020 respectively. The capacity addition from SHP & biomass is presumed to be at a lower rate than historical growth rate. The solar capacity addition projections were limited up to 1000 MW, 4000 MW (lower limit for Phase II) and 10000 MW during Phase I, II and III of JNNSM respectively.

Table 4.5 RE capacity addition required as per Scenario 1 (2011-12 to 2019-20) Figures in Megawatts

Scenario 1: Wind Dominant (Annual capacities)

RE Technology	Installed capacity as on 31st March 2011	12th Five year Plan						Capacity addition in 12th Plan Period	Cumulative Capacity at the end of 12th Plan	13th Five Year Plan (first 3 years)			Capacity addition in 13th Plan Period (first 3 years)	Total capacity addition from 2011 to 2020	Cumulative Capacity by 2019-20
			Annual Capacity Addition Required							Annual Capacity Addition Required					
		FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17			FY 17/18	FY 18/19	FY 19/20			
	1	2	3	4	5	6	7	8 =(add 3 to 7)	9= (1+2+8)	10	11	12	13= (10+11+12)	14= (2+8+13)	15= (9+13)
Wind Power	14157	3343	4050	4905	5910	6293	7154	28312	45812	7479	9257	11574	28310	59965	74122
Biomass	997	293	360	450	400	450	570	2230	3520	405	510	650	1565	4088	5085
Small Hydro	3042	208	350	300	305	310	310	1575	4825	285	390	365	1040	2823	5865
Cogeneration	1667	333	400	350	350	310	390	1800	3800	400	420	380	1200	3333	5000
Waste to Energy	72	11	17	10	11	12	13	63	146	15	16	18	48	122	195
Solar power	38	262	400	500	700	900	1200	3700	4000	2000	2000	2000	6000	9962	10000
Yearly total	**19973**	**4450**	**5577**	**6515**	**7676**	**8275**	**9637**	**37680**	**62103**	**10584**	**12593**	**14987**	**38164**	**80294**	**100267**

Assumptions:

Wind: CAGR 22% for FY 11-12 to FY 14-15 and 18% For FY 15-16 to FY 19-20;
Biomass: CAGR: 19%, Co-gen: CAGR 12% (less than historical CAGR over last 10 years(24.95%); WTE: CAGR 11%; SHP: CAGR: 8% (less than historical CAGR over last 10 years(9.72%));
Solar: As per phase-wise distribution of capacities under JNNSM (lower range of achievement in Phase II)

Scenario 1: Wind Dominant (Cumulative capacities)

RE Technology	Installed capacity as on 31st March 2011	FY 11/12	12th Five year Plan					13th Five Year Plan		
			FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17	FY 17/18	FY 18/19	FY 19/20
Wind Power	14157	17500	21550	26455	32365	38658	45812	53291	62548	74122
Biomass	997	1290	1650	2100	2500	2950	3520	3925	4435	5085
Small Hydro	3042	3250	3600	3900	4205	4515	4825	5110	5500	5865
Cogeneration	1667	2000	2400	2750	3100	3410	3800	4200	4620	5000
Waste to Energy	72	83	100	110	121	133	146	161	177	195
Solar power	38	300	700	1200	1900	2800	4000	6000	8000	10000
Total	**19973**	**24423**	**30000**	**36515**	**44191**	**52466**	**62103**	**72687**	**85280**	**100267**

Table 4.5 reveals that the cumulative wind power installation will grow to **74 GW by 2020** in this scenario. During the 12th plan period on an annual average addition of 5,662 MW of wind power and 740 MW of solar power capacity needs to be set up if the 12% RE target has to be met. During first three years of the 13th Plan period, the wind and solar capacity additions need to be further accelerated to 9,436 MW and 2,000 MW (annual average basis). The combined capacity of biomass and cogeneration technologies needs to increase by 800 MW (annual average basis).

The projected annual average capacity addition in case of wind is around 5.25 times the past capacity addition. However, if the capacity addition in 2010-11 is considered as a benchmark, subsequent CAGR of 20% (which is realistic) can help to achieve this growth. Under this scenario, during the 12th five year plan, India will have to install 37,680 MW grid-connected capacity from renewables. The cumulative installed capacity of renewables would be 62,103 MW at the end of the 12th Plan. Whereas, by 2020, the cumulative installed capacity of renewables would be 100,267 MW.

Scenario 2 (Biomass-SHP dominant): Substantial untapped potential and comparative low cost of generation is the rationale behind this Biomass-SHP dominant scenario. Under this scenario, biomass and SHP are considered to be dominant irrespective of their limitations. While projecting the likely capacity addition, growth rate of past ten years was studied and slightly progressive growth rate is considered over the period 2010-2020. In this scenario wind power growth is considered in moderate terms based on historical CAGR of 16%. The solar capacity addition is limited to JNNSM targets which are considered realised.

Table 4.6 RE capacity required as per Scenario 2 (2011-12 to 2019-20) Figures in Megawatts

Scenario 2: SHP-Biomass dominant (Annual capacities)

RE Technology	Installed capacity as on 31st March 2011	12th Five year Plan						Capacity addition in 12th Plan Period	Cumulative Capacity at the end of 12th Plan	13th Five Year Plan (first 3 years)			Capacity addition in 13th Plan Period (first 3 years)	Total capacity addition from 2011 to 2020	Cumulative Capacity by 2019-20
			Annual Capacity Addition Required							Annual Capacity Addition Required					
		FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17			FY 17/18	FY 18/19	FY 19/20			
	1	2	3	4	5	6	7	8 =(add 3 to 7)	9= (1+2+8)	10	11	12	13= (10+11+12)	14= (2+8+13)	15= (9+13)
Wind Power	14157	2265	2628	3048	3536	3901	3965	**17078**	***33500***	4860	5938	6888	**17685**	**37028**	***51185***
Biomass	997	453	442	461	635	757	911	**3205**	***4655***	1057	1292	1441	**3790**	**7448**	***8445***
Small Hydro	3042	458	480	525	505	565	600	**2675**	***6175***	725	800	725	**2250**	**5383**	***8425***
Cogeneration	1667	418	417	500	548	500	500	**2465**	***4550***	450	0	0	**450**	**3333**	***5000***
Waste to Energy	72	18	14	16	18	21	24	**91**	***181***	27	42	50	**119**	**228**	***300***
Solar power	38	476	486	1500	2000	2500	3000	**9486**	***10000***	2000	2000	2000	**6000**	**15962**	***16000***
Yearly total	**19973**	**4088**	**4466**	**6050**	**7241**	**8243**	**9000**	**35000**	***59061***	**9119**	**10072**	**11104**	**30294**	**69382**	***89355***

Assumptions:
Wind: as per WISE study (CAGR 16%)
Biomass: CAGR: 26%, (more than historical CAGR over last 10 years(24.95%)),Co-gen: CAGR 13%, WTE: CAGR 17%; SHP: CAGR: 12% (more than historical CAGR over last 10 years(9.72%)); Solar: As per phase-wise distribution of capacities under JNNSM

Scenario 2: SHP- Biomass dominant (Cumulative Capacities)

RE Technology	Installed capacity as on 31st March 2011	FY 11/12	12th Five year Plan					13th Five Year Plan (first 3 years)		
			FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17	FY 17/18	FY 18/19	FY 19/20
Wind Power	14157	16422	19050	22098	25633	29535	33500	38360	44298	51185
Biomass	997	1450	1892	2352	2987	3744	4655	5711	7004	8445
Small Hydro	3042	3500	3980	4505	5010	5575	6175	6900	7700	8425
Cogeneration	1667	2085	2502	3002	3550	4050	4550	5000	5000	5000
Waste to Energy	72	90	104	119	137	157	181	208	250	300
Solar power	38	514	1000	2500	4500	7000	10000	12000	14000	16000
Yearly total	**19973**	**24061**	**28527**	**34576**	**41817**	**50061**	**59061**	**68180**	**78251**	**89355**

Table 4.6 reveals that the cumulative biomass and SHP power project installations will rise to **13.4 GW** and **8 GW** respectively by 2020. In the 12th plan period, on an annual average, 1,134 MW and 535 MW biomass and SHP capacity have to be set up if the 12% RE target has to be met. During first three years of 13th Plan period, biomass and SHP capacity addition needs to be further accelerated to 1,413 MW and 750 MW on an annual average basis.

The projected annual average capacity addition in case of biomass and SHP is around **3.5 times and 2.5 times** than the past capacity addition (on annual basis) which is difficult to achieve.

Under Scenario 2, during the 12 five-year plan, India will have to install 35,000 MW of grid-connected capacity from renewables. The cumulative installed capacity of renewables would be 59,061 MW at the end of 12th plan. Whereas, by 2020, the cumulative installed capacity of renewables would be 89,355 MW.

Scenario 3 (Solar dominant): India is located in the equatorial sunbelt of the earth. In most parts of the country, clear sunny weather is experienced 250–300 days a year. The annual global radiation varies from 1600 to 2200 kWh/m2 which is comparable with radiation received in the tropical and sub-tropical regions. The highest annual global radiation (≥ 2400kWh/m^2) is received in Rajasthan and northern Gujarat where good concentrated solar power (CSP) potential exists. Considering the abundant solar potential in the country, the past three years experience in cost reduction / international solar cost reduction projections, and the fact that the cost reduction can be achieved by facilitating mass production and R&D efforts, have been taken into account. Promoting solar energy is essential in view of energy security and for minimizing the dependence on import of conventional fuel. All the above favourable conditions underline the cause for development of the solar dominant scenario. Under this scenario, total solar capacity addition of 35,490 MW is envisaged to be realized during year 2011-2020.

Table 4.7 RE capacity addition required as per Scenario 3 (2011-12 to 2019-20) [Figures in Megawatts]

Scenario 3: Solar dominant (Annual Capacities)

RE Technology	Installed capacity as on 31st March 2011		12th Five year Plan					Capacity addition in 12th Plan Period	Cumulative Capacity at the end of 12th Plan	13th Five Year Plan (first 3 years)			Capacity addition in 13th Plan Period (first 3 years)	Total capacity addition from 2011 to 2020	Cumulative Capacity by 2019-20
			Annual Capacity Addition Required							Annual Capacity Addition Required					
		FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17			FY 17/18	FY 18/19	FY 19/20			
	1	2	3	4	5	6	7	8 =(add 3 to 7)	9= (1+2+8)	10	11	12	13= (10+11+12)	14= (2+8+13)	15= (9+13)
Wind Power	14157	2265	2628	3048	3536	3901	3965	**17078**	***33500***	4860	5938	6888	**17685**	**37028**	***51185***
Biomass	997	303	440	440	400	420	600	**2300**	***3600***	400	500	400	**1300**	**3903**	***4900***
Small Hydro	3042	233	250	345	400	330	300	**1625**	***4900***	355	295	305	**955**	**2813**	***5855***
Cogeneration	1667	333	400	350	350	310	390	**1800**	***3800***	400	420	380	**1200**	**3333**	***5000***
Waste to Energy	72	18	14	16	18	21	24	**91**	***181***	27	42	75	**144**	**253**	***325***
Solar power	38	476	1900	3000	3000	4000	5076	**16976**	***17490***	5000	6000	7000	**18000**	**35452**	***35490***
Yearly total	**19973**	**3628**	**5631**	**7198**	**7703**	**8982**	**10355**	**39870**	***63471***	**11042**	**12994**	**15248**	**39284**	**82782**	***102755***

Assumptions:

Wind: as per WISE study (CAGR 16%); Biomass: CAGR: 18%, (less than historical CAGR over last 10 years (24.95%)), Co-gen: CAGR 12%, WTE: CAGR 17%; SHP: CAGR: 7.5% (less than historical CAGR over last 10 years (9.72%)); Solar: JNNSM (16000 MW) + additional 19490 MW (69% CAGR).

Scenario 3: Solar dominant (Cumulative Capacities)

RE Technology	Installed capacity as on 31st March 2011	FY 11/12	12th Five year Plan					13th Five Year Plan (first 3 years)		
			FY 12/13	FY 13/14	FY 14/15	FY 15/16	FY 16/17	FY 17/18	FY 18/19	FY 19/20
Wind Power	14157	16422	19050	22098	25633	29535	33500	38360	44298	51185
Biomass	997	1300	1740	2180	2580	3000	3600	4000	4500	4900
Small Hydro	3042	3275	3525	3870	4270	4600	4900	5255	5550	5855
Cogeneration	1667	2000	2400	2750	3100	3410	3800	4200	4620	5000
Waste to Energy	72	90	104	119	137	157	181	208	250	325
Solar power	38	514	2414	5414	8414	12414	17490	22490	28490	35490
Yearly total	**19973**	**23601**	**29232**	**36431**	**44134**	**53116**	**63471**	**74513**	**87508**	**102755**

Table 4.7 reveals that the cumulative solar project installations will rise to **35 GW** by 2020. In the 12th plan period, on an average, annual solar power capacity of 3,395 MW has to be set up if the 12% RE target has to be met along with moderate growth of wind at an average annual capacity addition of 3,400 MW. During first three years of 13th Plan period the solar power capacity addition needs to be further accelerated to 6,000 MW (annual average basis). This differential approach is adopted because the third phase of JNNSM will begin in 2017. By then solar energy would have seen significant cost-reductions, if not grid parity. The conservative biomass projection made under Scenario 3 is based on past growth rates is more realistic and achievable. The projected solar power annual average capacity addition of 6,000 MW in the 13th plan needs special efforts for realization from all stakeholders. Under Scenario 3, during the 12th five-year plan, India will have to install 39,870 MW of grid-connected capacity from renewables. The cumulative installed capacity would be 63,471 MW at the end of the 12th Plan. Whereas by 2020, the cumulative installed capacity of renewable would be 1,02,755 MW.

4.4.3. Comparative analysis of scenario results

Table 4.8 and Fig 4.3 shows the comparison of Scenarios 1, 2 and 3. The table reveals that the wind power capacity addition on an annual average basis projected under Scenario 1 (6,662 MW) is comparatively high, but still achievable, if conducive policy environment of clear and unambiguous commitment to this leading RE source is made explicit through further policy and regulatory initiatives.

In Scenario 2 (biomass–SHP dominant), the resource limitation of the two sources may prevent the anticipated capacity addition of 1,197 MW and 598 MW on an annual average basis. Whereas the wind power capacity addition of 4,110 MW (annual average) is achievable considering the quantum jump achieved in FY 2010-11.

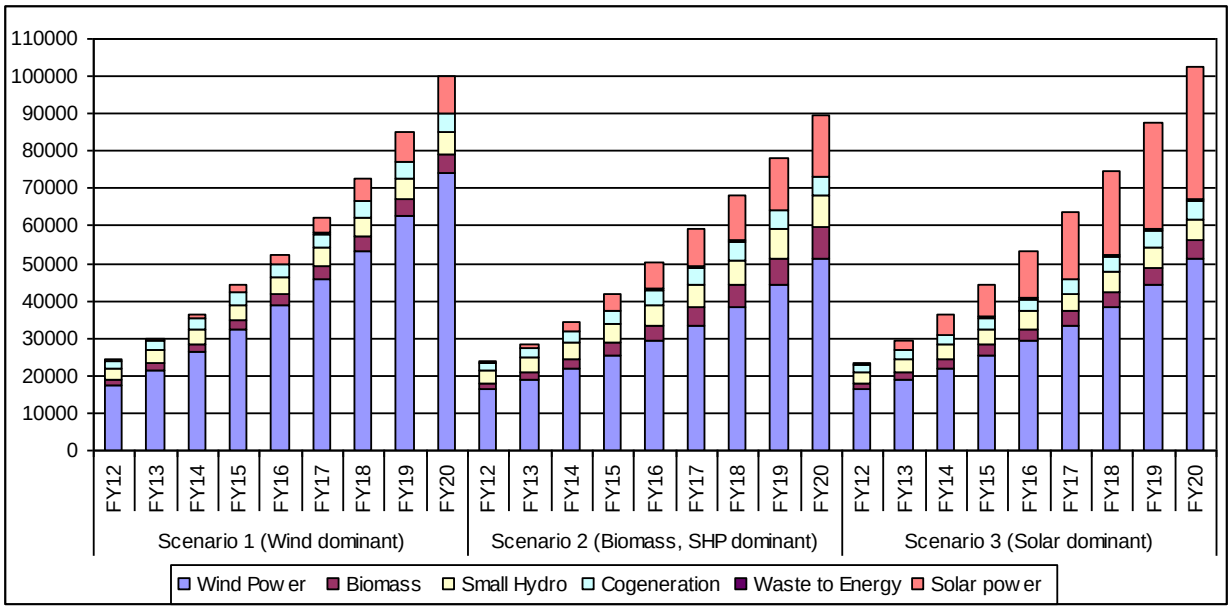
In Scenario 3 (solar dominant), biomass and SHP annual average capacity addition of 804 MW and 312 MW are achievable considering the historical trend of capacity addition. The position of wind is same as per Scenario 2 and therefore achievable. The projected solar annual average capacity addition of 3,395 MW is 1.5 times that of the JNNSM target and is achievable, considering the state level developments in non JNNSM project activities. However, the targeted capacity addition during 13th Plan period (6000 MW) needs special efforts. Considering all aspects and the importance of promoting solar power projects from the point of view of energy security, all efforts will have to be directed to meet the projected capacity addition under solar dominant scenario.

If the anticipated RE capacity addition envisaged under any of the above three scenarios is realized, then the share of RE-based generation in the Indian grid will rise to 12% and 15% by 2017 and 2020 respectively as targeted under NAPCC. However, we feel that the capacities proposed under the scenarios 1 and 3 are more realistic and feasible.

Table 4.8 : Cumulative RE capacity addition projection over 2011-12 to 2019-20 (MW) (Comparison of 3 scenarios)

		FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Scenario 1	Wind Power	17500	21550	26455	32365	38658	45812	53291	62548	74122
	Biomass	1290	1650	2100	2500	2950	3520	3925	4435	5085
	Small Hydro	3250	3600	3900	4205	4515	4825	5110	5500	5865
	Cogeneration	2000	2400	2750	3100	3410	3800	4200	4620	5000
	WTE	83	100	110	121	133	146	161	177	195
	Solar power	300	700	1200	1900	2800	4000	6000	8000	10000
	Sub-total	**24423**	**30000**	**36515**	**44191**	**52466**	**62103**	**72687**	**85280**	**100267**
Scenario 2	Wind Power	16422	19050	22098	25633	29535	33500	38360	44298	51185
	Biomass	1450	1892	2352	2987	3744	4655	5711	7004	8445
	Small Hydro	3500	3980	4505	5010	5575	6175	6900	7700	8425
	Cogeneration	2085	2502	3002	3550	4050	4550	5000	5000	5000
	WTE	90	104	119	137	157	181	208	250	300
	Solar power	514	1000	2500	4500	7000	10000	12000	14000	16000
	Sub-total	**24061**	**28527**	**34576**	**41817**	**50061**	**59061**	**68180**	**78251**	**89355**
Scenario 3	Wind Power	16422	19050	22098	25633	29535	33500	38360	44298	51185
	Biomass	1300	1740	2180	2580	3000	3600	4000	4500	4900
	Small Hydro	3275	3525	3870	4270	4600	4900	5255	5550	5855
	Cogeneration	2000	2400	2750	3100	3410	3800	4200	4620	5000
	WTE	90	104	119	137	157	181	208	250	325
	Solar power	514	2414	5414	8414	12414	17490	22490	28490	35490
	Sub-total	**23601**	**29232**	**36431**	**44134**	**53116**	**63471**	**74513**	**87508**	**102755**

Fig. 4.3 : Cumulative RE capacity addition projection over 2011-12 to 2019-20 (MW) (Comparison of 3 scenarios)



4.5. PAN INDIA IMPACT ON AVERAGE POWER PROCUREMENT COST (APPC)

For the likely three supply scenarios as suggested above, the impact on the average power procurement cost (APPC) of the utility is analyzed over the year 2010-2020 at Pan India level. The time value of the impact has been calculated taking the discount factor as 9.35%, which is the same as specified by CERC for bid evaluation for procurement of power by distribution licensees. The discounted impact on APPC cost due to purchase of renewable based energy under the three scenarios varies from 12 paisa/kWh to 21paisa per kWh. (Table 4.9).

Table 4.9: Impact on Pan India APPC due to purchase of RE

		FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20
Scenario 1	APPC with RE (Rs / kWh)	2.44	2.58	2.72	2.86	3.00	3.15	3.30	3.46	3.62
	APPC without RE (Rs / kWh)	2.27	2.39	2.50	2.63	2.76	2.90	3.04	3.20	3.36
	Impact on APPC (Rs / kWh)	0.17	0.19	0.21	0.23	0.24	0.25	0.26	0.26	0.26
	Discounted impact (Rs / kWh)	0.16	0.16	0.16	0.16	0.16	0.15	0.14	0.13	0.12
Incremental discounted impact (Rs / kWh)			0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Scenario 2	APPC with RE (Rs / kWh)	2.45	2.58	2.73	2.88	3.04	3.19	3.34	3.49	3.64
	APPC without RE (Rs / kWh)	2.27	2.39	2.50	2.63	2.76	2.90	3.04	3.20	3.36
	Impact on APPC (Rs / kWh)	0.18	0.19	0.22	0.25	0.28	0.29	0.30	0.29	0.29
	Discounted impact (Rs / kWh)	0.16	0.16	0.17	0.18	0.18	0.17	0.16	0.14	0.13
Incremental discounted impact (Rs / kWh)			0.00	0.01	0.01	0.00	0.00	-0.01	-0.02	-0.02
Scenario 3	APPC with RE (Rs / kWh)	2.44	2.60	2.76	2.92	3.08	3.25	3.41	3.56	3.72
	APPC without RE (Rs / kWh)	2.27	2.39	2.50	2.63	2.76	2.90	3.04	3.20	3.36
	Impact on APPC (Rs / kWh)	0.17	0.21	0.26	0.29	0.32	0.35	0.36	0.37	0.37
	Discounted impact (Rs / kWh)	0.16	0.18	0.20	0.20	0.21	0.20	0.19	0.18	0.16
Incremental discounted impact (Rs / kWh)			0.02	0.02	0.01	0.00	0.00	-0.01	-0.01	-0.02

Assumptions:

1. The RE penetration procurement cost is based on the likely capacity addition envisaged in the capacity addition scenario above and the CERC specified RE tariff for FY 2009-10. Factors like wind power density / size of SHP projects/ state wise biomass / bagasse fuel cost at the unexplored sites were also factored in while choosing the CERC tariff for non-solar RE technologies. In case of solar power projects, the tariff has been reduced to 8.5% per annum on the basis of past 3 years experience and the JNNSM objective of achieving grid parity by 2022.
2. The state-wise APPC for base year 2009-10 has been escalated at the rate of 5% per annum over the year 2010-2020.
3. Discount rate of 9.35% is considered for calculating the discounted impact of APPC.

The impact on the APPC is significant and it would be impossible for the utilities to absorb the same. Much of this is due to the high solar tariff. That means the government will have to exercise serious policy options to make the projects viable. These include:

a. Interest subsidies to provide softer loans;

b. Measures to accelerate grid parity;

c. Generation-based incentives, to keep tariffs low.

4.6 POSSIBLE STATE-WISE / RE TECHNOLOGY-WISE CAPACITY ADDITION PLAN TO MEET THE NAPCC TARGET (WIND and SOLAR DOMINANT SCENARIO)

As discussed in **4.4.3.** above, encouraging a solar dominant scenario is important in view of achieving energy security. However the wind dominant scenario with solar capacities restricted to lower limit projection in phase II of JNNSM may also be important from the point of view of minimal impact on Pan-India APPC. Therefore these two scenarios are considered for state-wise detailing. The possible RE technology-wise share of states in total is matched with the pan-India RE technology-wise share. While devising the state-wise/RE technology-wise share as above, a detailed study of state-wise RE potential/installed capacity and unexplored RE potential, and the past growth rate of RE capacity addition has been carried out. As the official potential assessment in terms of state-wise solar capacity is not available, the targeted solar potential is distributed in selected potential states based on the solar radiation assessment. Table 4.10 and 4.11 provide the state-wise projected RE capacity addition (cumulative basis) based on the wind and solar dominant scenarios. It would be seen that along with other policy measures, revision of RPO targets would be required in many states. This aspect has, however, been discussed in Chapter 5 on barriers and their remedies.

Table 4.10: State wise projected RE capacity addition on cumulative basis (Wind dominant scenario) Figures in MW

States	Source	Installed capacity as on March 2011 (MW)	12th Five Year Plan Period						Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
			FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	FY 16-17		FY 17-18	FY 18-19	FY 19-20		
Andhra Pradesh	Wind	199.25	120	155	200	250	270	320	1195	339	500	702	1541	2856
	SHP	189.83	4	6	6	6	6	6	30	5	7	7	19	53
	Bio energy	363.25	6	8	8	8	8	10	42	8	10	11	29	77
	Solar		38	58	73	102	131	174	538	290	290	290	870	1446
	WTE		0	2	0	0	0	0	2	2	0	2	4	6
Sub Total			**168**	**227**	**287**	**366**	**415**	**510**	**1805**	**644**	**807**	**1012**	**2463**	**4436**
Arunachal Pradesh	Wind								0				0	0
	SHP	78.84	13	22	19	19	19	19	98	18	24	23	65	176
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**13**	**22**	**19**	**19**	**19**	**19**	**98**	**18**	**24**	**23**	**65**	**176**
Assam	Wind								0				0	0
	SHP	27.11	2	4	3	3	3	3	16	3	4	4	11	29
	Bio energy		5	6	6	6	6	7	31	6	7	8	21	57
	Solar								0				0	0
	WTE						1		1				0	1
Sub Total			**7**	**10**	**9**	**9**	**9**	**10**	**47**	**9**	**11**	**12**	**32**	**86**
Bihar	Wind								0				0	0
	SHP	58.3	2	3	2	2	2	2	11	2	3	3	8	21
	Bio energy	9.5	26	31	33	31	31	39	165	33	38	42	113	304
	Solar								0				0	0
	WTE					3		2	5	0	0	3	3	8
Sub Total			**28**	**34**	**35**	**33**	**33**	**41**	**176**	**35**	**41**	**45**	**121**	**325**
Chattisgarh	Wind								0				0	0
	SHP	19.05	10	17	14	15	15	15	76	14	19	18	51	137
	Bio energy	231.19	2	2	2	2	2	2	10	2	2	3	7	19
	Solar								0				0	0

		Installed capacity as on March 2011 (MW)		12th Five Year Plan Period					Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
States	**Source**		**FY 11-12**	**FY 12-13**	**FY 13-14**	**FY 14-15**	**FY 15-16**	**FY 16-17**		**FY 17-18**	**FY 18-19**	**FY 19-20**		
	WTE						3	0	3	2	0	3	5	8
Sub Total			**12**	**19**	**16**	**17**	**17**	**17**	**86**	**16**	**21**	**21**	**58**	**156**
Goa	Wind								0				0	0
	SHP	0.05							0			1	1	1
	Bio energy		0	1	1	1	1	1	5	0	0	0	0	5
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**0**	**1**	**1**	**1**	**1**	**1**	**5**	**0**	**0**	**1**	**1**	**6**
Gujarat	Wind	2076.41	590	690	849	1021	1112	1248	4920	1259	1521	1943	4723	10233
	SHP	12.6	2	3	3	3	3	3	15	3	4	3	10	27
	Bio energy	0.5	42	51	53	50	51	64	269	54	62	69	185	496
	Solar		29	44	55	77	99	132	407	220	220	220	660	1096
	WTE		0	3	2	0	0	0	5	2	0	0	2	7
Sub Total			**663**	**791**	**962**	**1151**	**1265**	**1447**	**5616**	**1538**	**1807**	**2235**	**5580**	**11859**
Haryana	Wind								0				0	0
	SHP	70.1		0.5	0.5	0.5	0.5	1	3	1	1	1	3	6
	Bio energy	35.8	44	54	57	53	54	68	286	57	66	73	196	526
	Solar								0				0	0
	WTE						2	0	2	2	0	2	4	6
Sub Total			**44**	**54.5**	**57.5**	**53.5**	**54.5**	**69**	**289**	**58**	**67**	**74**	**199**	**532**
Himachal	Wind								0				0	0
	SHP	375.38	52	88	57	76	78	78	377	71	98	91	260	689
	Bio energy		4	4	5	4	4	5	22	5	5	6	16	42
	Solar								0				0	0
	WTE						1		1		2	2	4	5
Sub Total			**56**	**92**	**62**	**80**	**82**	**83**	**399**	**76**	**103**	**97**	**276**	**731**
Jammu & Kashmir	Wind								0				0	0
	SHP	129.33	31	53	45	46	47	47	238	43	59	55	157	426
	Bio energy		1	1	1	1	1	1	5	1	1	1	3	9
	Solar								0				0	0

		Installed capacity as on March 2011 (MW)		12th Five Year Plan Period					Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
States	**Source**		**FY 11-12**	**FY 12-13**	**FY 13-14**	**FY 14-15**	**FY 15-16**	**FY 16-17**		**FY 17-18**	**FY 18-19**	**FY 19-20**		
	WTE							2	2	0	0	2	2	4
Sub Total			**32**	**54**	**46**	**47**	**48**	**48**	**243**	**44**	**60**	**56**	**160**	**435**
Jharkhand	Wind								0				0	0
	SHP	4.05	2	4	3	2	3	3	15	3	4	4	11	28
	Bio energy		2	3	3	3	3	3	15	3	3	4	10	27
	Solar								0				0	0
	WTE					2	0	2	4	0	3	0	3	7
Sub Total			**4**	**7**	**6**	**5**	**6**	**6**	**30**	**6**	**7**	**8**	**21**	**55**
Karnataka	Wind	1726.8	490	585	734	886	971	1099	4275	1159	1425	1768	4352	9117
	SHP	723.05	2	3	2	2	2	2	11	2	3	3	8	21
	Bio energy	352.18	32	39	41	38	39	49	206	41	47	52	140	378
	Solar		22	33	41	58	74	99	305	165	165	165	495	822
	WTE		3	2	0	0	0	0	2	2	2	0	4	9
Sub Total			**549**	**662**	**818**	**984**	**1086**	**1249**	**4799**	**1369**	**1642**	**1988**	**4999**	**10347**
Kerala	Wind	32.6	21	30	49	70	70	90	309	90	110	166	366	696
	SHP	136.87	6	10	8	9	9	9	45	8	11	10	29	80
	Bio energy		22	27	28	27	27	34	143	29	33	37	99	264
	Solar								0				0	0
	WTE					2			2			2	2	4
Sub Total			**49**	**67**	**85**	**108**	**106**	**133**	**499**	**127**	**154**	**215**	**496**	**1044**
MP	Wind	275.89	65	98	130	160	160	175	723	175	243	332	750	1538
	SHP	86.16	8	13	11	11	11	11	57	10	14	13	37	102
	Bio energy	1	32	39	41	38	39	49	206	41	48	53	142	380
	Solar		37	56	70	98	126	168	518	279	279	279	837	1392
	WTE			2	2	0	0	0	4	2	0	0	2	6
Sub Total			**142**	**208**	**254**	**307**	**336**	**403**	**1508**	**507**	**584**	**677**	**1768**	**3418**
Maharashtra	Wind	2316.8	417	478	607	777	816	942	3620	1011	1287	1671	3969	8006
	SHP	1363.82	5	9	8	8	8	8	41	7	10	9	26	72
	Bio energy	322	83	100	106	99	100	127	532	106	123	136	365	980
	Solar		35	54	68	95	122	162	501	270	270	270	810	1346

States	Source	Installed capacity as on March 2011 (MW)	12th Five Year Plan Period						Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
			FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	FY 16-17		FY 17-18	FY 18-19	FY 19-20		
	WTE		3	3	0	0	2	0	5	0	2	0	2	10
Sub Total			**543**	**644**	**789**	**979**	**1048**	**1239**	**4699**	**1394**	**1692**	**2086**	**5172**	**10414**
Manipur	Wind								0				0	0
	SHP	5.45	1	2	2	2	2	2	10	1	1	2	4	15
	Bio energy								0			2	2	2
	Solar								0				0	0
	WTE								0		1		1	1
Sub Total			**1**	**2**	**2**	**2**	**2**	**2**	**10**	**1**	**1**	**4**	**6**	**17**
Meghalaya	Wind								0				0	0
	SHP	31.03	2	3	3	3	3	3	15	3	4	4	11	28
	Bio energy								0			1	1	1
	Solar								0				0	0
	WTE								0		1		1	1
Sub Total			**2**	**3**	**3**	**3**	**3**	**3**	**15**	**3**	**4**	**5**	**12**	**29**
Mizoram	Wind								0				0	0
	SHP	36.47	1	2	2	2	2	2	10	2	3	3	8	19
	Bio energy								0			1	1	1
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**1**	**2**	**2**	**2**	**2**	**2**	**10**	**2**	**3**	**4**	**9**	**20**
Nagaland	Wind								0				0	0
	SHP	28.67	2	3	2	2	2	2	11	2	3	3	8	21
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0	1			1	1
Sub Total			**2**	**3**	**2**	**2**	**2**	**2**	**11**	**2**	**3**	**3**	**8**	**21**
Orissa	Wind		60	72	80	102	105	127	486	155	210	352	717	1263
	SHP	79.62	2	4	3	3	4	4	18	3	4	4	11	31
	Bio energy		5	6	6	6	6	8	32	6	7	8	21	58
	Solar		27	42	52	73	94	125	386	208	208	208	624	1037

		Installed capacity as on March 2011 (MW)		12th Five Year Plan Period					Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
States	**Source**		**FY 11-12**	**FY 12-13**	**FY 13-14**	**FY 14-15**	**FY 15-16**	**FY 16-17**		**FY 17-18**	**FY 18-19**	**FY 19-20**		
	WTE			3		2	0	0	5	0	0	0	0	5
Sub Total			**94**	**127**	**141**	**186**	**209**	**264**	**927**	**372**	**429**	**572**	**1373**	**2394**
Punjab	Wind								0				0	0
	SHP	133.2	3	5	4	4	4	4	21	4	5	5	14	38
	Bio energy	74.5	81	98	103	97	98	124	520	104	120	133	357	958
	Solar								0				0	0
	WTE		0	2	0	0	1	2	5	0	2	0	2	7
Sub Total			**84**	**103**	**107**	**101**	**102**	**128**	**541**	**108**	**125**	**138**	**371**	**996**
Rajasthan	Wind	1525.07	630	763	959	1205	1302	1517	5746	1617	2013	2435	6065	12441
	SHP	23.85	0	0	1	1	1	0	3	1	0	1	2	5
	Bio energy	71.3	126	153	162	151	153	194	813	163	188	208	559	1498
	Solar		56	85	106	148	191	254	784	423	423	423	1269	2109
	WTE		0	0	2	0	2	0	4	0	2	0	2	6
Sub Total			**812**	**1001**	**1230**	**1505**	**1649**	**1965**	**7350**	**2204**	**2626**	**3067**	**7897**	**16059**
Sikkim	Wind								0				0	0
	SHP	47.11	2	4	3	3	3	3	16	3	4	4	11	29
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**2**	**4**	**3**	**3**	**3**	**3**	**16**	**3**	**4**	**4**	**11**	**29**
Tamil Nadu **	Wind	5904.4	950	1180	1297	1438	1487	1636	7038	1675	1947	2207	5829	13817
	SHP	94.05	6	10	8	9	9	9	45	8	11	10	29	80
	Bio energy	488.2	31	38	40	37	38	48	201	40	46	51	137	369
	Solar		19	29	36	50	64	86	265	143	143	143	429	713
	WTE		2	0	0	2	0	0	2	2	0	0	2	6
Sub Total			**1008**	**1257**	**1381**	**1536**	**1598**	**1779**	**7551**	**1868**	**2147**	**2411**	**6426**	**14985**
Tripura	Wind								0				0	0
	SHP	16.01	0	0	1	1	1	0	3	1	0	0	1	4
	Bio energy								0				0	0
	Solar								0				0	0

		Installed capacity as on March 2011 (MW)		12th Five Year Plan Period					Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
States	**Source**		**FY 11-12**	**FY 12-13**	**FY 13-14**	**FY 14-15**	**FY 15-16**	**FY 16-17**		**FY 17-18**	**FY 18-19**	**FY 19-20**		
	WTE								0				0	0
Sub Total			**0**	**0**	**1**	**1**	**1**	**0**	**3**	**1**	**0**	**0**	**1**	**4**
UP	Wind								0				0	0
	SHP	23.3	4	8	6	7	7	7	35	6	8	8	22	61
	Bio energy	581	66	80	84	79	80	101	424	85	98	108	291	781
	Solar								0				0	0
	WTE		3	0	3	0	0	3	6	0	0	2	2	11
Sub Total			**70**	**88**	**90**	**86**	**87**	**108**	**459**	**91**	**106**	**116**	**313**	**842**
Uttaranchal	Wind								0				0	0
	SHP	134.12	42	70	60	61	62	62	315	57	78	73	208	565
	Bio energy	12							0		2	2	4	4
	Solar								0				0	0
	WTE								0	0	1		1	1
Sub Total			**42**	**70**	**60**	**61**	**62**	**62**	**315**	**57**	**80**	**75**	**212**	**569**
West Bengal	Wind	4.3							0				0	0
	SHP	98.9	3	5	4	4	5	5	23	4	6	5	15	41
	Bio energy	16	16	19	20	19	19	24	101	20	23	26	69	186
	Solar								0				0	0
	WTE		0	0	1	0	0	2	3	0	0	0	0	3
Sub Total			**19**	**24**	**24**	**23**	**24**	**29**	**124**	**24**	**29**	**31**	**84**	**227**
A&N Islands	Wind								0				0	0
	SHP	5.25							0				0	0
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total									**0**				**0**	**0**
All India Total			**4450**	**5577**	**6515**	**7676**	**8275**	**9637**	**37680**	**10584**	**12593**	**14987**	**38164**	**80294**

Table 4.11: State wise projected RE capacity addition on cumulative basis (Solar dominant scenario) Figures in MW

States	Source	Installed capacity as on March 2011 (MW)*	12th Five Year Plan Period						Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
			FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	FY 16-17		FY 17-18	FY 18-19	FY 19-20		
Andhra Pradesh	Wind	199.25	60	80	125	150	180	220	755	359	563	693	1615	2430
	SHP	189.83	4	5	6	7	6	6	30	7	5	6	18	52
	Bio energy	363.25	7	9	8	8	8	10	43	8	9	8	25	75
	Solar		69	276	435	435	580	736	2462	725	870	1016	2611	5142
	WTE		0	2	2	0	3	0	7	2	3	5	10	17
Sub Total			**140**	**370**	**576**	**600**	**777**	**972**	**3295**	**1101**	**1450**	**1728**	**4279**	**7714**
Arunachal Pradesh	Wind								0				0	0
	SHP	78.84	15	16	22	25	21	19	103	22	18	19	59	177
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**15**	**16**	**22**	**25**	**21**	**19**	**103**	**22**	**18**	**19**	**59**	**177**
Assam	Wind								0				0	0
	SHP	27.11	2	3	4	4	3	3	17	4	3	3	10	29
	Bio energy		5	6	6	6	6	8	32	6	7	6	19	56
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**7**	**9**	**10**	**10**	**9**	**11**	**49**	**10**	**10**	**9**	**29**	**85**
Bihar	Wind								0				0	0
	SHP	58.3	2	2	3	3	3	2	13	3	2	2	7	22
	Bio energy	9.5	26	35	32	31	30	41	169	33	38	32	103	298
	Solar								0				0	0
	WTE					3		2	5	2	5	5	12	17
Sub Total			**28**	**37**	**35**	**34**	**33**	**43**	**182**	**36**	**40**	**34**	**110**	**320**

		Installed capacity as on March 2011 (MW)*		**12th Five Year Plan Period**					**Total Capacity addition during 12th Plan**	**13th Five Year Plan Period**			**Total Capacity addition during 13th Plan (First Three Years)**	**Total Addition During FY 11-12 to FY 19-20**
Chhattisgarh	Wind								0				0	0
	SHP	19.05	11	12	17	19	16	14	78	17	14	15	46	135
	Bio energy	231.19	2	2	2	2	2	3	11	2	2	2	6	19
	Solar								0				0	0
	WTE						3	0	3	2	0	5	7	10
Sub Total			**13**	**14**	**19**	**21**	**18**	**17**	**89**	**19**	**16**	**17**	**52**	**154**
Goa	Wind								0				0	0
	SHP	0.05							0			1	1	1
	Bio energy		0	1	1	1	0	1	4	1	1	1	3	7
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**0**	**1**	**1**	**1**	**0**	**1**	**4**	**1**	**1**	**2**	**4**	**8**
Gujarat	Wind	2076.41	310	326	377	456	498	508	2165	634	820	936	2390	4865
	SHP	12.6	2	2	3	4	3	3	15	3	3	3	9	26
	Bio energy	0.5	42	56	53	50	49	66	274	53	61	52	166	482
	Solar		53	209	331	331	441	560	1872	551	661	772	1984	3909
	WTE		2	0	2	2	0	2	6	2	2	5	9	17
Sub Total			**409**	**593**	**766**	**843**	**991**	**1139**	**4332**	**1243**	**1547**	**1768**	**4558**	**9299**
Haryana	Wind								0				0	0
	SHP	70.1		0.5	0.5	0.5	0.5	1	3	1	1	1	3	6
	Bio energy	35.8	45	60	56	53	52	70	291	57	65	55	177	513
	Solar								0				0	0
	WTE						2	0	2	2	0	5	7	9
Sub Total			**45**	**60.5**	**56.5**	**53.5**	**52.5**	**71**	**294**	**58**	**66**	**56**	**180**	**519**
Himachal Pradesh	Wind								0				0	0
	SHP	375.38	58	63	86	100	83	75	407	89	74	76	239	704
	Bio energy		4	5	4	4	4	6	23	5	5	4	14	41
	Solar								0				0	0
	WTE						1		1		2	5	7	8
Sub Total			**62**	**68**	**90**	**104**	**87**	**81**	**430**	**94**	**79**	**80**	**253**	**745**

		Installed capacity as on March 2011 (MW)*		12th Five Year Plan Period					Total Capacity addition during 12th Plan	13th Five Year Plan Period			Total Capacity addition during 13th Plan (First Three Years)	Total Addition During FY 11-12 to FY 19-20
Jammu & Kashmir	Wind								0				0	0
	SHP	129.33	35	38	52	60	50	45	245	53	44	46	143	423
	Bio energy		1	1	1	1	1	1	5	1	1	1	3	9
	Solar								0				0	0
	WTE							2	2	2	0	5	7	9
Sub Total			**36**	**39**	**53**	**61**	**51**	**46**	**250**	**54**	**45**	**47**	**146**	**432**
Jharkhand	Wind								0				0	0
	SHP	4.05	2	3	3	4	3	3	16	4	3	3	10	28
	Bio energy		2	3	3	3	3	3	15	3	3	3	9	26
	Solar								0				0	0
	WTE					2	0	2	4	0	5	5	10	14
Sub Total			**4**	**6**	**6**	**7**	**6**	**6**	**31**	**7**	**6**	**6**	**19**	**54**
Karnataka	Wind	1726.8	250	263	311	346	383	388	1691	496	626	764	1886	3827
	SHP	723.05	2	2	3	3	3	2	13	3	2	2	7	22
	Bio energy	352.18	32	43	40	38	37	50	208	41	47	40	128	368
	Solar		39	157	247	247	330	418	1399	412	495	577	1484	2922
	WTE		3	2	0	3	0	2	7	2	2	5	9	19
Sub Total			**326**	**467**	**601**	**637**	**753**	**860**	**3318**	**954**	**1172**	**1388**	**3514**	**7158**
Kerala	Wind	32.6	5	12	32	50	50	40	184	75	75	80	230	419
	SHP	136.87	7	7	10	11	9	8	45	10	8	9	27	79
	Bio energy		23	30	28	27	26	35	146	28	33	28	89	258
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**35**	**49**	**70**	**88**	**85**	**83**	**375**	**113**	**116**	**117**	**346**	**756**
Madhya Pradesh	Wind	275.89	40	42	50	70	70	60	292	125	193	212	530	862
	SHP	86.16	8	9	13	15	12	11	60	13	11	11	35	103
	Bio energy	1	33	43	40	38	37	51	209	41	47	40	128	370
	Solar		67	265	419	419	559	709	2371	699	838	978	2515	4953
	WTE			2	2	0	2	0	6	2	0	5	7	13
Sub Total			**148**	**361**	**524**	**542**	**680**	**831**	**2938**	**880**	**1089**	**1246**	**3215**	**6301**

		Installed capacity as on March 2011 (MW)*		**12th Five Year Plan Period**					**Total Capacity addition during 12th Plan**	**13th Five Year Plan Period**			**Total Capacity addition during 13th Plan (First Three Years)**	**Total Addition During FY 11-12 to FY 19-20**
Maharashtra	Wind	2316.8	217	228	284	338	370	389	1609	533	637	776	1946	3772
	SHP	1363.82	6	6	9	10	8	8	41	9	7	8	24	71
	Bio energy	322	84	111	104	99	97	131	542	106	122	103	331	957
	Solar		64	257	405	405	541	686	2294	676	811	946	2433	4791
	WTE		5	5	0	0	3	0	8	0	5	5	10	23
Sub Total			**376**	**607**	**802**	**852**	**1019**	**1214**	**4494**	**1324**	**1582**	**1838**	**4744**	**9614**
Manipur	Wind								0				0	0
	SHP	5.45	1	1	1.5	1.5	1.5	1.5	7	2	2	2	6	14
	Bio energy								0			2	2	2
	Solar								0				0	0
	WTE								0	2			2	2
Sub Total			**1**	**1**	**1.5**	**1.5**	**1.5**	**1.5**	**7**	**2**	**2**	**4**	**8**	**16**
Meghalaya	Wind								0				0	0
	SHP	31.03	2	2	3	4	3	3	15	3	3	3	9	26
	Bio energy								0			1	1	1
	Solar								0				0	0
	WTE								0	2			2	2
Sub Total			**2**	**2**	**3**	**4**	**3**	**3**	**15**	**3**	**3**	**4**	**10**	**27**
Mizoram	Wind								0				0	0
	SHP	36.47	2	2	2	3	2	2	11	2	2	2	6	19
	Bio energy								0			1	1	1
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**2**	**2**	**2**	**3**	**2**	**2**	**11**	**2**	**2**	**3**	**7**	**20**
Nagaland	Wind								0				0	0
	SHP	28.67	2	2	3	3	3	2	13	3	2	2	7	22
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0	2			2	2
Sub Total			**2**	**2**	**3**	**3**	**3**	**2**	**13**	**3**	**2**	**2**	**7**	**22**

		Installed capacity as on March 2011 (MW)*		**12th Five Year Plan Period**					**Total Capacity addition during 12th Plan**	**13th Five Year Plan Period**			**Total Capacity addition during 13th Plan (First Three Years)**	**Total Addition During FY 11-12 to FY 19-20**
Orissa	Wind		3	30	57	71	75	80	313	175	200	271	646	962
	SHP	79.62	3	3	4	5	4	3	19	4	3	3	10	32
	Bio energy		5	7	6	6	6	8	33	6	7	6	19	57
	Solar		50	198	313	313	417	529	1770	521	625	729	1875	3695
	WTE					2	0	3	5	0	4	0	4	9
Sub Total			**61**	**238**	**380**	**397**	**502**	**623**	**2140**	**706**	**839**	**1009**	**2554**	**4755**
Punjab	Wind								0				0	0
	SHP	133.2	3	3	5	5	4	4	21	5	4	4	13	37
	Bio energy	74.5	82	108	102	97	94	128	529	103	119	100	322	933
	Solar								0				0	0
	WTE		0	2	0	2	1	2	7	0	0	5	5	12
Sub Total			**85**	**111**	**107**	**102**	**98**	**132**	**550**	**108**	**123**	**104**	**335**	**970**
Rajasthan	Wind	1525.07	430	473	560	666	748	818	3265	955	1165	1331	3451	7146
	SHP	23.85	0	0	1	1	1	0	3	1	0	1	2	5
	Bio energy	71.3	128	170	160	151	147	200	828	162	186	158	506	1462
	Solar		101	402	635	635	847	1075	3594	1059	1270	1482	3811	7506
	WTE		0	0	2	2	2	3	9	0	2	5	7	16
Sub Total			**659**	**1045**	**1358**	**1455**	**1745**	**2096**	**7699**	**2177**	**2623**	**2977**	**7777**	**16135**
Sikkim	Wind								0				0	0
	SHP	47.11	3	3	4	4	4	3	18	4	3	3	10	31
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**3**	**3**	**4**	**4**	**4**	**3**	**18**	**4**	**3**	**3**	**10**	**31**
Tamil Nadu **	Wind	5904.4	950	1175	1253	1389	1526	1462	6805	1508	1659	1825	4992	12747
	SHP	94.05	7	7	10	11	9	8	45	10	8	9	27	79
	Bio energy	488.2	32	42	39	37	36	49	203	40	46	39	125	360
	Solar		34	136	214	214	286	363	1213	357	429	500	1286	2533
	WTE		3	0	3	2	2	0	7	2	2	5	9	19
Sub Total			**1026**	**1360**	**1519**	**1653**	**1859**	**1882**	**8273**	**1917**	**2144**	**2378**	**6439**	**15738**

		Installed capacity as on March 2011 (MW)*		**12th Five Year Plan Period**					**Total Capacity addition during 12th Plan**	**13th Five Year Plan Period**			**Total Capacity addition during 13th Plan (First Three Years)**	**Total Addition During FY 11-12 to FY 19-20**
Tripura	Wind								0				0	0
	SHP	16.01	0	0	1	1	1	0	3	1	0	0	1	4
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total			**0**	**0**	**1**	**1**	**1**	**0**	**3**	**1**	**0**	**0**	**1**	**4**
Uttar Pradesh	Wind								0				0	0
	SHP	23.3	5	5	7	9	7	6	34	8	6	7	21	60
	Bio energy	581	67	88	83	79	77	104	431	84	97	82	263	761
	Solar								0				0	0
	WTE		5	1	3	0	0	3	7	2	5	5	12	24
Sub Total			**72**	**93**	**90**	**88**	**84**	**110**	**465**	**92**	**103**	**89**	**284**	**821**
Uttaranchal	Wind								0				0	0
	SHP	134.12	47	50	69	80	66	60	325	71	59	61	191	563
	Bio energy	12							0		2	2	4	4
	Solar								0				0	0
	WTE							3	3				0	3
Sub Total			**47**	**50**	**69**	**80**	**66**	**60**	**325**	**71**	**61**	**63**	**195**	**567**
West Bengal	Wind	4.3							0				0	0
	SHP	98.9	3	4	5	6	5	4	24	5	4	4	13	40
	Bio energy	16	16	21	20	19	18	25	103	20	23	19	62	181
	Solar								0				0	0
	WTE		0	0	2	0	2	0	4	1	5	0	6	10
Sub Total			**19**	**25**	**25**	**25**	**23**	**29**	**127**	**25**	**27**	**23**	**75**	**221**
A&N Islands	Wind								0				0	0
	SHP	5.25							0				0	0
	Bio energy								0				0	0
	Solar								0				0	0
	WTE								0				0	0
Sub Total									**0**				**0**	**0**
All India Total			**3628**	**5631**	**7198**	**7703**	**8982**	**10355**	**39870**	**11042**	**12994**	**15248**	**39884**	**82782**

* Wind: as on 31 March 2011; Biomass & Co-gen: as on 31 Dec 2010; and SHP: as on 31 January 2011

4.7. KEY OUTCOMES

I. The government's plans for development of RE are not consistent with the policies. The RE capacity addition targeted by MNRE and that planned under the JNNSM are inadequate to meet the target generation mandated under the NAPCC. The targets originally planned by the working group will have to be revised to achieve the 12% and 15% RE penetration by year FY 2017 and 2020 respectively. The revision in planned RE capacity in 12th and 13th Plans are still possible as the 12th plan Working Group Report on RE is yet to be finalized.

II. The analysis of available RE potential, installed capacities and gaps highlights the fact that all RE sources provide an opportunity to be developed and scaled up, though wind-based power has the highest share in total RE installed capacity.

III. The preliminary studies of re-assessment of RE potential in India shows that the RE source, particularly wind, is grossly under-estimated. In case of solar, the official potential assessment in terms of technically exploitable and economically feasible capacity is not available in public domain. This calls for an urgent RE potential re-assessment study at the national level. In the absence of realistic RE potential assessment figures, policy decisions on power generation could be skewed in favour of conventional sources.

IV. The RE capacity addition projections under all three Scenarios are sufficient to raise the Pan India level RE-based generation to a level of 12% and 15% in the national grid by end of FY 2017 and 2020 respectively.

V. The capacity addition projections of non-fossil-based co-generation shown in all Scenarios reveal that the present assessed co-generation potential will be exhausted by the end of FY 2016.

VI. In order to achieve the desired RE share in the all India energy mix, the solar capacity addition targets mentioned under the three phases of JNNSM have to be realized fully, plus a substantial contribution is also required from wind power and the relatively unexplored RE technologies like SHP and biomass.

VII. The Pan India discounted impact on APPC due to purchase of RE power as suggested in Scenarios 1,2 and 3 is in the range of 12-16 paisa/kWh, 13-18 paisa/kWh, and 16-21 paisa/kWh (read in the same order). This is substantial and utilities will find it difficult to accommodate in retail tariff. Therefore, to reduce the impact to some extent, appropriate financial support in the form of soft loan to reduce the cost of generation or generation based incentives (GBI) should be considered. The adverse impact on financial health of utilities can also be minimized by reducing the transmission and distribution losses and improving the billing and collection efficiencies of the utilities, or by increasing the share of large hydro where possible.

VIII. Although all the three scenarios are capable of meeting the national RPO of 12% and 15% by year 2017 and 2020, considering the importance of scenario I and III, any one of them may be adopted at the national level.

IX. The huge untapped solar potential in the country is important from the point of view of energy security. International experience shows that cost reduction can be achieved by way of mass production and R&D efforts.

X. If capacity addition projections in Scenario 3 (solar dominant) have to be realized, then annually, on an average basis, solar capacity addition of around 3,395 MW and wind capacity addition of the order of 3,400 MW is required to be realized during the 12th five year Plan period. During first three years of the 13th Plan period, solar capacity addition needs to be further accelerated to 6,000 MW on an annual average basis. This can be achieved considering the fact that last year India has added 2,300 MW capacity wind power projects. Our neighbouring country China has increased its installed wind capacity by a factor of 21 between 2004 and 2009, from 1.2 GW to more than 25 GW. Even in India, states like Tamil Nadu have significantly developed the assessed wind potential in a very short span of time.

XI. Adoption of scenario I (wind dominant) against that of scenario III (solar dominant) at national level will reduce the impact on pan-India APPC by 4-5 paise / kWh.

XII. The state-wise RE technology wise capacity addition plan envisaged under the wind and solar dominant scenarios reveal that the individual states can share the national RPO within the available RE potential.

XIII. The state-wise RE technology mix coming out from state level analysis indicate ample scope for wind power development in the states of Tamil Nadu, Karnataka, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Orissa. The contribution of SHP can significantly come from the north and north-eastern states like Himachal Pradesh, J&K, Uttarakhand and Arunachal Pradesh. Whereas states like Tamil Nadu, Andhra Pradesh and Uttar Pradesh can still develop biomass power potential to a great extent.

XIV. Based on the analysis of solar radiation data, geographical stretch, and availability of wasteland, states like Rajasthan, Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, Orissa, Karnataka, and Tamil Nadu can play a decisive role in realizing the solar capacity addition under the solar dominant scenario.

***

5

Towards 15% RE by 2020: Removing the Barriers

5.1 FINANCIAL BARRIERS AND REMEDIES

The requirement of debt for the proposed capacity addition is massive. Banks in general are reluctant to lend to the sector because of some real and some imagined risk perceptions. The financing hurdle faced by projects under the JNNSM is a good example. Most of the lending to the wind sector is balance sheet financing. Lenders are very reluctant to provide non-recourse project finance to RE projects. Risk mitigation measures are essential if lenders' perceptions are to improve. The current interest rates are prohibitive and they are the single most important factor in making RE projects unviable. Measures to bring down the interest rates to 8%–9% level are essential if the 15% RE by 2020 target is to be achieved. Here, first the estimates of requirements of debt for all three capacity addition scenarios have been worked out and then the probable measures for risk mitigation and for providing low cost debt are analysed.

Debt Requirements for the 12th Plan Period: The funding required for the anticipated grid-connected RE capacity addition envisaged in the three scenarios given in Chapter 4 for the 12th Plan period has been worked out in Table 5.1. Standard debt: equity ratio of 70:30 has been considered for the calculation. It can be seen from the table that the debt requirement for achieving 12% RE addition during the 12th Plan period ranges from Rs.1,65,663 crore in Scenario 1 to Rs.2,59,679 crore in Scenario 3, whereas debt requirement upto 2020 ranges from Rs.3,67,359 crore in Scenario 1 to Rs.5,41,659 crore in Scenario 3 (Table 5.2).

Table 5.1: Likely Debt Requirement for RE Sector during 12th Plan Period

(amount in Rs. crore)

RE Projects	Scenario 1				Scenario 2				Scenario 3			
	Capacity Installed	*Total Cost*	*Debt*	*Equity*	*Capacity Installed*	*Total Cost*	*Debt*	*Equity*	*Capacity Installed*	*Total Cost*	*Debt*	*Equity*
Wind Power	28312	155716	109001	46715	17,078	93,928	65,750	28,179	17,078	93,928	65,750	28,179
Biomass	2230	9500	6650	2850	3,205	13,653	9,557	4,096	2,300	9,799	6,859	2,940
Small Hydro	1575	8930	6251	2679	2,675	15,167	10,617	4,550	1,625	9,214	6,450	2,764
Cogeneration	1800	7583	5308	2275	2,465	10,385	7,270	3,116	1,800	7,583	5,308	2,275
Waste-to-Energy	63	504	353	151	91	728	510	218	91	728	510	218
Solar Power	3700	54427	38099	16328	9,486	139,539	97,677	41,862	16,976	249,717	174,802	74,915
Total	**37680**	**236661**	**165663**	**70998**	**35,000**	**273,401**	**191,381**	**82,020**	**39,870**	**370,969**	**259,679**	**111,291**

Table 5.2: Likely Debt Requirement for RE by 2020

(amounts in Rs Cr.)

RE Projects	Scenario 1				Scenario 2				Scenario 3			
	Capacity Installed	*Total Cost*	*Debt*	*Equity*	*Capacity Installed*	*Total Cost*	*Debt*	*Equity*	*Capacity Installed*	*Total Cost*	*Debt*	*Equity*
Wind Power	59965	329808	230865	98942	37,028	2,03,655	1,42,559	61,097	37,028	2,03,655	1,42,559	61,097
Biomass	4088	17416	12191	5225	7,448	31,729	22,210	9,519	3,903	16,628	11,640	4,988
Small Hydro	2823	16006	11204	4802	5,383	30,522	21,365	9,156	2,813	15,950	11,165	4,785
Cogeneration	3333	14042	9829	4213	3,333	14,042	9,829	4,213	3,333	14,042	9,829	4,213
Waste to Energy	123	980	686	294	228	1,820	1,274	546	253	2,020	1,414	606
Solar Power	9962	146546	102582	43964	15,962	2,34,806	1,64,364	70,442	35,452	5,21,504	3,65,053	1,56,451
Total	**80294**	**524798**	**367359**	**157439**	**69,382**	**5,16,574**	**3,61,602**	**1,54,972**	**82,782**	**7,73,799**	**5,41,659**	**2,32,140**

*(**Assumptions:** Capital cost-5.5 Cr/MW for wind, 14.42 Cr/MW for solar PV, 15.00 Cr/MW for solar thermal, 4.213Cr/MW for biomass, 4.25Cr/MW for co-generation, 5.67 Cr/MW for SHP, 8.0 Cr/MW for waste-to-energy projects, capital costs considerations from market feedback, Debt : Equity ratio-70:30).*

Priority sector lending: Since most banks are not sensitized to the 15% RE target, including RE under the priority sector category for lending would send the right signal to the banks. At present, the priority sector broadly comprises agriculture, small-scale industries, and other activities/borrowers (such as small business, retail trade, small transport operators, professional and self-employed persons, housing and education loans, microcredit, etc.). The inclusion of RE in the priority sector will increase the availability of credit to this sector and lead to larger participation by commercial banks in this sector.

Interest subsidy: To provide viable debt financing at 8% to 9% interest rate to grid connected RE projects, a system of interest rate subsidies could be instituted. This way, with a small revenue outflow (vis-à-vis large outflows or capital subsidies), we can leverage large volumes of debt. A 4% to 5% interest rate subsidy is suggested. Funds for interest subsidy can be found from the National Clean Energy Fund.

Effective utilization of National Clean Energy Fund (NCEF): In the Union Budget for 2010/11, the Finance Minister proposed to levy a cess on coal, the revenues from which will go towards the creation of a National Clean Energy Fund. The clean energy cess (as a duty of excise) of Rs.50 per tonne will be levied on all raw coal, lignite, or peat produced in India, as also on imports. Thereafter, on 24 June 2010, the Department of Revenue, Ministry of Finance, issued a formal order levying the cess with effect from 1 July 2010. The Clean Energy Cess Rules, 2010, have also been notified. The NCEF is proposed to be used for the development and deployment of clean energy technologies in India.

At the current and projected level of coal consumption in the country, NCEF will have a cumulative collection of Rs.50,934 crore upto 2020. These resources, if effectively used, can help achieve the national target of 15% RE by 2020. The deployment of NCEF for uses other than top-priority for clean energy development should be discouraged. Besides providing interest subsidy, the NCEF can

also be used for providing credit guarantees or for funding transmission infrastructure in priority states with large potential for renewable power development.

Tax-free Green Bonds: Allowing Indian banks and financial institutions to raise low-cost capital through tax-free bonds and thereon lending the proceeds at low interest to the RE sector is another way to facilitate low cost debt for renewables. This mechanism has been adopted many times to fund the infrastructure sector; RE specific green bonds would be appropriate now.

Role of IREDA and the Green Bank: IREDA should be allowed to raise low cost funds abroad and thereon lend the same as soft loans to RE projects in India. IREDA should also be enabled to explore new instruments like green bonds, other new synthesized products with which to raise financing and enable risk sharing and mitigation in renewable energy projects. A national partial risk guarantee facility which could be managed by IREDA or private sector financial institutions, could address specific renewable energy project risks. International financial institutions could be asked to backstop such a facility if the intention is to attract global financiers and developers. It is noted that ADB is already planning such a facility in India.

The role of the proposed Green Bank is not yet clear. The Green Bank could deploy many of these innovative financing instruments. However, considering the large volumes of debt required, measures by IREDA/Green Bank would not be sufficient; it would be essential to bring in all commercial banks to RE financing.

Creation of State-Level Clean Energy Funds: In 2004, Maharashtra decided to levy a cess on conventional power to generate funds for creating a state-level Clean Energy Fund. Subsequently, Karnataka in its 2009 RE Policy announced its intention to levy a green cess; however the decision is yet to be implemented. Recently, Gujarat has levied a green cess on conventional power to create a state-level Clean Energy Fund. Some preliminary steps have been taken in Andhra Pradesh, Tamil Nadu and Bihar towards discussing the need for levying such a green cess. Even though this is a state subject, Government of India could persuade the states to set up Clean Energy Funds in all states. This state-level resource could be utilized for part-funding RE transmission infrastructure, providing credit guarantee for loans to RE projects, equity funding, offering additional incentives to RE-based off-grid or micro-grid projects, etc.

5.2 POLICY BARRIERS AND REMEDIES

India lacks a comprehensive policy statement for RE or an enabling legal framework. Different policy documents, old and new, continue to co-exist creating tremendous confusion among state-level implementers and investors.

5.2.1 Need for cohesion in GoI policy:

The contradiction with regard to share of RE in the fuel mix over the period 2010–2020 under the Government of India's major policy documents, viz the National Action Plan on Climate Change, Integrated Energy Policy, and the interim report on 'Low Carbon Strategy for Inclusive Growth in India', highlights the need for bringing cohesion in the policy of the Government of India to align the same with the NAPCC objectives.

Preparing a new Integrated Energy Policy (IEP): The Government of India approved and published its Integrated Energy Policy in August 2006. Future energy security has been assessed

through this document till the 15th Five-year Plan (year 2032). While the IEP put forth some very welcome objectives, there were some major loopholes in its detailing. The biggest stumbling blocks lie in the two main assumptions made by the policy, namely that (a) renewables may account for only 5% to 6% of India's energy mix by 2031/32; and (b) renewables would be critical to India's energy independence only beyond 2050. In view of subsequent NAPCC target of 15% RE by 2020, it is now necessary to prepare a new IEP.

Aligning the low carbon growth strategy with NAPCC: The Planning Commission, Govt. of India, had appointed a 26-member expert committee in January 2010 to prepare the report on "Low Carbon Strategies for Inclusive Growth in India." The mandate for the expert committee included preparation of a cross-sectoral study and recommendations on critical low carbon initiatives to be undertaken, including sector-specific initiatives with timelines and targets starting in 2011. The committee has submitted its interim report to the government in May 2011. The report analyses projection of fuel mix and emissions under different scenarios for both 8% and 9% average GDP growth rate up to 2020. The report is methodologically skewed in favour of fossil fuels. For example, even though the committee recognises that even if at least 1% of the land of the country is utilised for solar power generation it could generate 5,00,000 MW of power from solar, there are no proposals to accelerate solar energy deployment.

While recommending the fuel mix projections for year 2020, the report has not considered the RE injection targets specified under the NAPCC. Under the different scenarios developed for 8% and 9% GDP growth, the share of RE ranges from 35 GW to 54 GW, with maximum contribution from wind (30 GW), solar (20 GW), biomass and others (0.4 GW). The RE capacities considered in the projection can only raise the level of RE penetration to the extent of 3.76% (baseline scenario) to 5.70% (aggressive efficiency scenario) of energy mix in the grid by year 2020.

The interim report has taken cognizance of the past reduction in capital cost of solar power and considered the JNNSM recommended solar capacity in its design of the fuel mix. However, the report has totally ignored the biomass, co-generation and SHP technologies. The combined share of these technologies by 2020 is shown as 4,000 MW in all scenarios, whereas the current combined installed capacity of these technologies stood at around 6,000 MW. The assumption of a moderate 17% PLF for wind in the report against the CERC approved PLF range of 20%–30% is also not based on facts and thus underestimates the technology /efficiency improvements in wind technology. It is necessary to rectify such methodological lapses in the final report of the expert committee and align it with the NAPCC targets.

Need for a separate RE law: The Electricity Act, 2003, has some enabling provisions to promote grid connected renewable energy sources. However, there are no legally binding targets facilitating the creation, transmission, and deployment of renewable energy or provision for accelerating all round development of renewable energy. So India needs to enact a comprehensive law to facilitate renewable energy development**. Even though there is a government decision to enact such a law,** it has not been implemented yet. Many countries have enacted such RE laws with spectacular results (as in the case of China). The government decision needs to be implemented and the draft law should be presented to the Parliament in a time-bound manner.

Abolishing subsidies to fossil fuels: Conventional power continues to enjoy various hidden subsidies. A two-year research study conducted by WISE has revealed that conventional power projects in India receive subsidies to the extent of 150% of their capital cost over their lifetime (WISE, 2008). Besides, India continues to subsidise petroleum products, coal mining and transportation, keeping prices of petroleum products and coal arbitrarily low compared to international prices. Of late, there has been a welcome move to remove fossil fuel subsidies. In a world facing the threat of climate change, subsidies to expand the burning of coal and oil can no longer be justified. A recent study by the International Energy Agency titled 'Clean Energy Progress Report', has said that "fossil fuel has received USD 312 billion subsidy globally as against USD 57 billion for renewable energy in the year 2009" [IEA 2011]. Shifting these subsidies to the development of climate-benign energy sources would be appropriate.

Internalizing the Cost of Externalities: Fossil-fuel-based power generation creates huge environmental, social and economic externalities. In the EU countries, extensive research was undertaken (The ExternE Project) to determine and quantify the cost of externalities of conventional power generation. Such a scientific assessment has played a major role in evolving forward-looking policies for RE development in Europe. India also needs to undertake such a study and internalize those costs in the pricing of fossil-based electricity. Then it would be seen that even solar energy would achieve grid parity soon.

Creating a manufacturing base for CSP: Concentrating solar power (CSP) holds immense potential for India. But the biggest barrier to realizing that potential is the absence of a manufacturing base. Some start-ups are struggling to develop the technology, but they are a long way off from commercialization. The solar mission document mentions that an incentive package for CSP manufacturing on the lines of SIPs for PV mentioned earlier, is in the offing, but nothing further has been heard of the idea so far. This needs to be looked into urgently. This needs to be looked into urgently. Some foreign manufacturers such as Abengoa Solar of Spain and Infinia Corporation of USA, have opened offices in India, but have not ventured into local manufacturing. MNRE needs to take planned steps to create a local manufacturing base. Considering the huge potential for CSP-based power generation in India, CSP has the potential to be cost-effective but the recent fall in PV prices has been a setback. Indigenous manufacturing is necessary to lower CSP costs.

5.2.2. Revisions/Improvement in Policy at the State Level

Inconsistencies and lack of comprehension of the needs of the RE sector pervade many of the state-level policies published so far. They set lofty objectives but are found lacking in details. The national objectives are not considered while drafting state policies. Many state polices have contributed to more uncertainties and confusion instead of promoting RE.

Comprehensive state-specific RE policies: Development of renewable energy largely depends on multiple institutions which are empowered under different laws. These institutions include different ministries/departments of central and state governments, as well as the central and state electricity regulatory commissions. However, the progress of RE projects on the ground depends mainly on state level policies formulated by the energy/power department and the state nodal agencies. Most of the state governments have announced their state renewable energy policies in

technology-specific or fragmented forms. Multiplicity of policies and agencies governing the renewable energy sector makes integrated interventions difficult and undermines investors' confidence. Overlapping in the jurisdiction has also been noticed in some cases like in Punjab, where the state government has specified RE procurement tariff under the state policy by transgressing into the SERC's powers. Discrepancies have also been noticed in the transmission/wheeling charges and cross subsidy charges in case of third party transaction of RE. The RE targets set by many states are not in line with the national targets. The state governments should be persuaded to prepare integrated RE policies (covering all RE technologies) aimed towards a common national goal of achieving RE capacity addition.

Aligning state targets with national objectives: It is observed that the state Planning Board does not specify RE capacity addition targets while planning the energy/power sector activities. The dynamic RE target setting by the State Planning Board will have a positive impact on the RE sector as other concerned government departments will take note of it and facilitate development of RE in the state. Therefore, during preparation of the 12th Plan, the Central Planning Commission and MNRE need to co-ordinate with the State Planning Boards, Energy departments and State Nodal Agencies to ensure that states accept RE targets in line with national objectives.

Single-window clearance for RE projects (as far as possible): As per the policies and the procedure set out by the state governments, the project proponents are required to take number of permissions/approvals from the various state government departments/agencies prior to the commissioning of an RE project, resulting in delayed implementation and commissioning. For example, more than 60 percent of project cycle time in small hydropower projects is spent getting various government clearances. Clearances must be obtained from (i) wildlife, fisheries, panchayat, irrigation, public health, revenue department; (ii) SERCs (for PPAs); (iii) forest–state and centre, pollution control board, industrial license, labour permits, state transmission utilities; (iv) distribution companies' approval for interconnection and for usage of explosives for excavation; and (v) state nodal agencies (for implementation agreement, infrastructure permission), techno-economic approval from state utility and transfer of land in case land is to be procured in tribal areas. Similarly, a wind power project developer has to obtain more than 30 clearances to get a project approval.

All states may be persuaded to create Empowered Committees chaired by very few senior officials like Principal Secretary (Energy) or the Chief Secretary to accord single window clearance for setting RE projects at the state level. Admitted, such a Committee will not be able to give all clearances. For example when forest land is involved, clearance of both the state and central governments are required. Barring such clearances involving concurrent jurisdiction or exclusive central government agency jurisdiction like aviation, a state empowered committee can give clearances. Even though some states like Maharashtra, Rajasthan and Karnataka have declared single-window clearances, in practice, it doesn't happen. Rajasthan and Karnataka have set Empowered Committee of Secretaries for this purpose, whereas Maharashtra doesn't have any such institutional set-up. There is a need to institutionalise single-window clearance system to the extent possible.

An alternative would be to pilot a no-objection-based approval process. Such a process would require officials to explicitly reject an application and provide written explanations for the reasons

they did so; unless rejected, an application would automatically be considered approved. States such as Punjab have adopted a single-window clearance and fixed time limits (45 days) within which clarifications, comments, or objections to projects need to be sent to the state nodal agency failing which the state nodal agency grants all clearances to the project.

Power purchase agreement (PPA)/timely payment: In case of RE projects, the terms of the PPA and tariff period should be harmonized. At least 12 to 15-year PPAs would be required to provide confidence to developers and financiers. New technologies, such as solar thermal, may require even longer term PPAs. Mandating such PPAs would reduce regulatory uncertainty, create appropriate incentives for location and operation, and allow for efficient system operation. It is often noticed that in spite of default provisions under the PPA, the utilities often give least priority for payment to RE generators. Tamil Nadu is a typical case where payments to wind power investments have been delayed for nine months. This should be avoided and the utilities should be compelled to make regular payment to the RE project owner.

5.3 REGULATORY BARRIERS AND REMEDIES

Electricity regulators have taken many progressive and proactive measures to promote RE development in the country. The CERC and the Forum of Regulators (FOR)—though they do not have legal supervisory role over the state commissions—have in recent years tried to bring co-ordination among the SERCs to align regulatory actions with national targets and objectives. However, despite these efforts, various regulatory hurdles still remain in many states. Some of those critical barriers have been discussed here.

5.3.1 Current RPO setting insufficient to meet target: Twenty-five SERCs have fixed Renewable Purchase Obligation targets. Most of them have issued orders for RPO upto 2012-13 and some upto 2014-15. The RPO targets set by these SERCs are given in Table 5.3.

Table 5.3 RPO Targets set by SERCs

	State		RPS targets for						
		RE Source	10/11	11/12	12/13	13/14	14/15	15/16	16/17
1	Andhra Pradesh Order Dtd-31.03.09		5%	5%	5%	5%			
2	Assam Draft Notification Dtd 21.06.10		1.40% (0.05%)	2.80% (0.1%)	4.20% (0.15%)	5.60% (0.2%)	7.00% (0.25%)		
3	Bihar Notification Dtd-16.11.10	Total RE (Solar)	1.5% (0.25%)	2.5% (0.5%)	4% (0.75%)	4.5% (1%)	5% (1.25%)		
4	Chhattisgarh Regulation Dtd-09.11.10	Total RE (Solar)	5% (0.25%)	5.25% (0.25%)	5.50% (0.25%)				
5	Gujarat Notification Dtd-17.04.10	Total RE (Solar)	5% (0.25%)	6% (0.5%)	7% (1%)				
6	Goa Notification Dtd-30.11.10	Total RE (Solar)	1% (0.25%)	2% (0.3%)	3% (0.4%)				
7	Haryana Notification Dtd 03.02.11	Total RE (Solar)	1.5% (0.25%)	1.5% (0.5%)	2% (0.75%)	2% (1.0%)	2.5% (1.25%)		
8	Himachal Pradesh Notification Dtd-26.05.10	Total RE (Solar)	10% (0%)	11.1% (0.1%)	12.1% (0.1%)				
9	Jammu & Kashmir	Total RE	1%	3%	5%				

	State		RPS targets for						
		RE Source	10/11	11/12	12/13	13/14	14/15	15/16	16/17
	Notification Dtd-11.03.11	(Solar)	(0.02%)	(0.1%)	(0.25%)				
10	Jharkhand Notification Dtd - 21.07.10	Total RE (Solar)	2% (0.25%)	3% (0.5%)	4% (1.0%)				
11	Karnataka Notification Dtd– 16.03.11	BESCOM/ NESCOM/ CESE HESCOM/ GESCOM/ Hukkeri		10% (0.25%) 7% (0.25%)					
12	Kerala Notification Dtd-23.11.10	Total RE (Solar)	3% (0.25%)	3.3% (0.25%)	3.63% (0.25%)				
13	Madhya Pradesh Notification Dtd-19.11.10	Total RE (Solar)	0.8%	2.5% (0.4%)	4% (0.6%)	5.5% (0.8%)	7% (1%)		
14	Maharashtra Notification Dtd 07.06.10	Total RE (Solar)	6% (0.25%)	7% (0.25%)	8% (0.25%)	9% (0.5%)	9% (0.5%)	9% (0.5%)	
15	Manipur Notification Dtd-05.05.10	Total RE (Solar)	2% (0.25%)	3% (0.25%)	5% (0.25%)				
16	Mizoram Notification Dtd-05.05.10	Total RE (Solar)	5% (0.25%)	6% (0.25%)	7% (0.25%)				
17	Meghalaya Notification Dtd - 21.12.10	Total RE (Solar)	0.5% (0.2%)	0.75% (0.3%)	1% (0.4%)				
18	Nagaland Draft Notification Dtd 20.10.10	Total RE (Solar)	15% (0.25%)	16% (0.25%)	17% (0.25%)				
19	Orissa Order Dtd – 30.09.10	Total RE	1%	1.30% (0.10)	1.55% (0.15)	1.80% (0.20)	2.05% (0.25)	2.30% (0.30)	
20	Rajasthan Notification Dtd– 23.12.10	Total RE (Additional Solar up to 100 MW)	8.5%	9.5%					
21	Tamil Nadu Notification Dtd– 07.12.10	Total RE	14%						
22	Tripura Draft Notification Dtd 09.11.09	Total RE (Solar)	1% (0.1%)	1% (0.1%)	2% (0.1%)				
23	Uttar Pradesh Regulation Dtd 17.08.10	Total RE (Solar)	4% (0.25%)	5% (0.5%)	6% (1%)				
24	Uttarakhand Notification Dtd-03.11.10 and Dtd 06.07.10	Total RE (Solar)	4% (0%)	4.525% (0.025%)	5.05% (0.05%)				
25	West Bengal Notification Dtd-10.08.10	Total RE	2%	3%	4%				

Source : SERC 2011

FOR has conducted a study for assessment of state-wise RE potential and RPO trajectory in view of meeting the NAPCC target of 10% RE by 2015. The findings of the study were communicated to the SERCs to provide guidelines for modifying the RPO targets in the states under their jurisdiction. Some SERCs have modified the RPO targets in their states while others are continuing to follow the existing RPO targets without recognizing the realistic RE potential in the state and also the NAPCC

requirement with regard to the national RPO. To be specific, it is noticed that out of the 25 SERCs who have issued RPO regulations, the SERCs of Haryana, Meghalaya, Kerala and Orissa have set very low RPO targets, while the SERCs of Himachal Pradesh, Mizoram and Nagaland have set high RPO targets in comparison with FOR recommendations. States like Andhra Pradesh, Assam, Delhi, Nagaland, Punjab, Tripura, and West Bengal have not issued the final REC regulation as on April 2011 and hence these states have not revised their RPO target. Other SERCs have broadly followed the FOR recommendations.

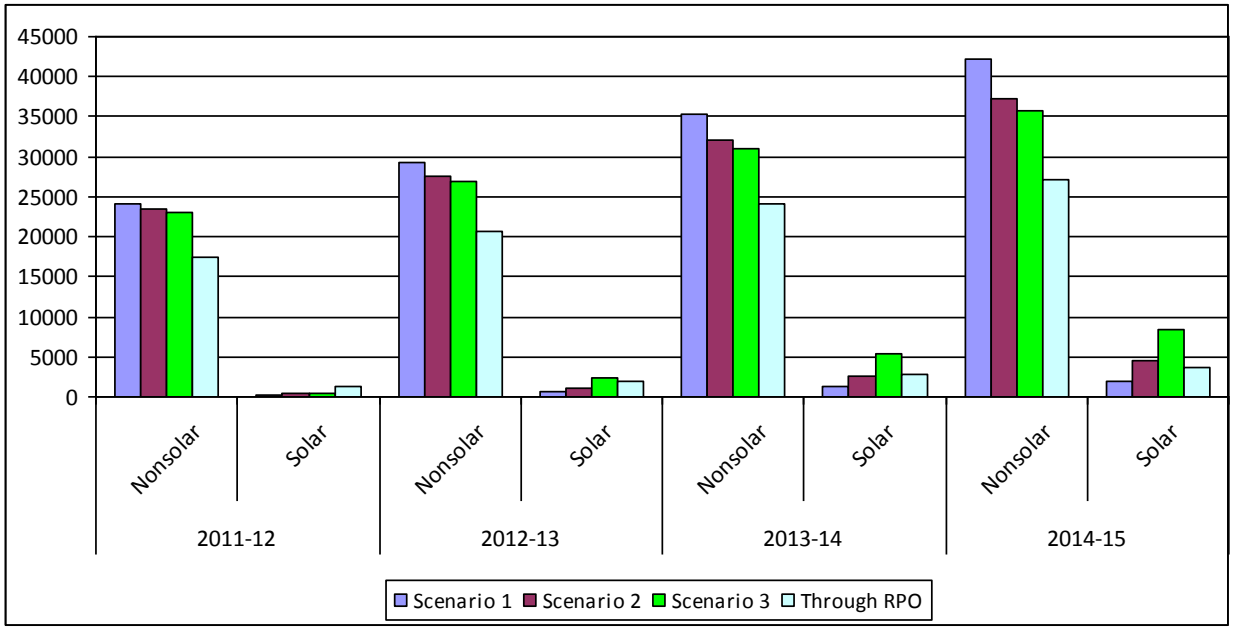
In order to know whether the existing state-wise RPO targets are in line with the national target specified under NAPCC, the RPO target set by 25 SERCs have been converted into non-solar and solar energy generation, after comparing them with state-wise future energy demand predicted by CEA. The RE generation from capacity likely to be installed as per state-wise RPO target is compared with all India electricity demand during FY 2011–12 to 2014–15. The state-wise RE capacities sufficient to meet state-wise RPO have been determined with the help of CERC-specified normative RE technology-wise CUFs. The RE capacities as determined on the basis of state-wise RPO are then compared with the likely three capacity addition scenarios. The solar RPO of 0.05% is considered for base year 2009-10 with 0.05% escalation per annum for the states who do not specify such obligation yet (3 states). Since the SERCs have specified the non-solar and solar RPO up to FY 2012–13, we have interpolated RPO targets up to FY 2014–15 on the basis of past RPO target setting in that particular state (Table 5.4).

Table 5.4 Required capacity addition vis-à-vis capacity addition through state RPO (MW)

	2011–12		**2012–13**		**2013–14**		**2014–15**	
	Non-solar	Solar	Non-solar	Solar	Non-solar	Solar	Non-solar	Solar
Scenario 1	24123	300	29300	700	35315	1200	42291	1900
Scenario 2	23547	514	27527	1000	32067	2500	37317	4500
Scenario 3	23087	514	26818	2414	31017	5414	35720	8414
Capacity addition through RPO	17499	1185	20744	1940	24017	2844	27201	3666
b. National RPO met vs NAPCC requirement								
	2011–12		**2012–13**		**2013–14**		**2014–15**	
All India Electricity demand (BU)	969		1035		1105		1181	
RE injection due to combined State level RPO targets (BU) (25 SERCs)	48.55		58.53		68.87		78.82	
National RPO met	**5.01%**		**5.66%**		**6.23%**		**6.67%**	
NAPCC requirement (%)	**7%**		**8%**		**9%**		**10%**	

Fig 5.1 and Table 5.4 indicate that the current non-solar/solar RPO targets specified by 25 SERCs taken together may not be sufficient to encourage the requisite RE capacity addition to raise the pan India solar and non-solar RE-based generation to the 10 percent level required under the NAPCC during FY 2011-12 to 2014-15. **The comparison of combined RE generation due to state-wise RPO targets with all India energy demand projections for corresponding year reveals that the current state-wise RPO can raise the pan India renewable energy share to a level of 5.01%, 5.66%, 6.23% , and 6.67%, as against required 7%, 8%, 9% and 10% in FY 2011–12, FY 12–13, FY 13–14 & FY 14–15 respectively.** Similarly, the state-wise RPO envisaged RE capacities do not match with the RE capacity addition proposed under different scenarios.

Fig 5.1 Scenario-wise RE capacity addition vis-à-vis state-wise RPO targets (MW)



5.3.2 Transmission Planning for RE development: Non-availability of evacuation infrastructure and grid integration challenges are amongst the biggest problems affecting RE project development. As per EA, 2003, development of evacuation infrastructure and providing grid connectivity for RE sources is considered as the responsibility of the transmission utility. However, in practice, in many states, it is the RE developer who has to first construct such infrastructure. The distribution licensees also have a major role to play in the evacuation of RE generation, as many RE sources are often connected at distribution voltages. The Forum of Regulators has noted that barring few utilities such as the Maharashtra State Electricity Transmission Company Ltd., Rajasthan Vidyut Prasaran Nigam, and Himachal Pradesh State Electricity Board, others have not included evacuation infrastructure for RE as part of their overall transmission or distribution capex plans.

The Indian Electricity Grid Code (IEGC), 2010, specified by CERC, mandates that transmission system planning and development should take into account the needs of renewable energy sources and the renewable capacity addition plan. To make this goal a reality, all state transmission utilities should be mandated to prepare a comprehensive five-year transmission plan linked to the capacity addition targets as per NAPCC, based on load flow studies and location of RE generation projects. State nodal agencies should take a lead role in coordinating and providing information to state transmission utilities on new renewable energy generation capacity (many of them today do not have such capability). Renewable energy evacuation should be made a high-transmission priority, and given the same focus as village electrification. It should have dedicated funding as part of existing programs like the Rajiv Gandhi Gram Vidyut Yojana (RGGVY).

In Europe and USA high priority has been accorded to RE transmission planning. The State of New Mexico in the USA (which has huge solar power potential) has established a separate Renewable Energy Transmission Authority. In India, we have the Central Electricity Authority (CEA). Perhaps a

separate coordinating division may be established within the CEA for coordinating RE transmission planning and development across India states.

5.3.3 Strengthening the REC Mechanism: The CERC has issued final regulation on REC implementation (Terms and Conditions for recognition and issuance of Renewable Energy Certificates for Renewable Energy Generation 2010) on 14 January 2010, after a detailed study of international best practices and the power sector governance in India. However, some of the critical follow-up actions and revisions required are highlighted here.

Capacity building for REC implementation in states: As per the CERC regulation on RECs, the state agencies are responsible for accreditation and recommending the renewable energy projects for registration to the Central Agency. As on date, about twenty-one SERCs have designated the SNAs as "state agency" to perform the REC implementation work specified under the renewable purchase obligation regulation. All grid-connected RE projects selling power to the utility at average power procurement cost (APPC), captive projects, merchant RE power projects selling power to third party, etc., are eligible for REC registration and trading. RE projects having small installed capacities with a huge investor base will certainly create regular workload for SNAs. Hence, to expedite the registration and facilitation process of REC accreditation, capacity building of state agencies is required.

Smaller Denomination of RECs: The present REC regulation defines the denomination of each REC to represent 1 MWh of electricity generated from an eligible renewable energy source and injected into the grid. A smaller denomination (such as 100 kWh equivalent) would facilitate participation of smaller generators and buyers across the country. This would also help in expanding the scope of voluntary markets (rather than just compliance markets) and facilitate the reach of the market to individuals and smaller organizations. The JNNSM has given special emphasis on rooftop solar PV and small scale solar power projects up to 2 MW capacity. Such projects under JNNSM will also get the benefit of a smaller denomination REC.

Allowing Banking of RECs: Under the present REC Regulation, validity of RECs is limited to 365 days from the date of issuance. Given the uncertainty involved in generation from RE based project which depend on the nature of the project, flexible mechanisms such as extended validity to facilitate banking of RECs will be beneficial for the RE developer and obligated entities. With banking provisions, obligated entities can procure additional RECs in a given year over and above their current year RPO target and seek credit for the same in a future period. In Italy and Belgium (Flanders) for instance, the validity of tradable RECs is granted up to two years and five years from the date of issuance respectively.

5.3.4 Homogeneity in Interconnectivity Norms: Interconnection of the RE projects with the grid is another important aspect where there is no consistency in the definition of 'interconnection point' across the state. The interconnection point is often left to the whims of the local utility. The CERC in its RE tariff Regulation 2009 has clearly defined the interconnection points for RE technologies. For small hydro, biomass and bagasse cogeneration projects, the interconnection point is defined as line isolator on outgoing feeder on HV side of generator transformer. Whereas the interconnection point for solar and wind power projects is specified as line isolator on outgoing feeder on HV side of the pooling sub-station. Stretching the interconnection point away from the

RE project will increase the investors expenses towards the power evacuation infrastructure. The SERCs need to follow the CERC directives while specifying the interconnection points in states.

5.3.5 Overhauling the Cost-plus Methodology: The cost-plus methodology adopted by Indian electricity regulators is a progressive and forward-looking method of determining tariffs. However, it is time to overhaul this methodology by considering the following additional factors, viz. the cost of externalities of conventional power generation, multiple cost curves, and risk-adjusted pricing of conventional fuels.

Externalities of conventional power generation: Conventional power continues to enjoy various hidden subsidies. The cost of environmental, social, and health externalities caused by these hidden subsidies is not factored into the price of conventional power. The findings of a University of Bath study indicate that the health costs alone work out to Rs.3/kWh (University of Bath, 2008). A study commissioned by the World Bank in 2001 has estimated that the global and local environmental cost of coal based generation in India is Rs.1.88/kWh. However, this is not a comprehensive estimate based on local field study covering environmental, social and economic externalities. Such a comprehensive study needs to be undertaken in India and the quantified results of such a study should be factored into the price of conventional power.

Multiple cost curves*:* It should also be recognized that when nascent renewable technologies are compared with entrenched conventional technologies, multiple futuristic cost curves come into play. First and foremost, the historical escalation in the cost of conventional power due to the variable cost of fuel should be considered. This cost escalation curve will only accelerate in future as the reserves of fossil fuels are depleted. The other cost curve of great significance is the technology and efficiency curve across renewables, which will help reduce their costs in future. Conventional power sources do not have any such advantage. Besides multiple cost curves, there is also the 'experience learning curve'. When new RE technologies are commercially developed, they go through an initial pilot learning phase. Thereafter they mature commercially. This needs to be factored-in.

Risk-adjusted pricing*:* Scientific assessments have shown that coal production will peak in India by 2015 and globally between 2020 and 2025. Thereafter, price and availability could become a problem. In fact, even today, if the approving authority and the regulators insist that project developers guarantee the supply of fuel for the 30 years of project life, many of the coal-based ultra-mega power projects (UMPP) would not qualify for approval. Electricity regulators need to consider risk differentials of technologies resulting from risks inherent in the supply and prices of fossil fuels. Today, fossil fuels invariably provide a high-risk cost stream. Like oil, coal prices have also moved into the volatile realm as supply pressures mount, carbon taxes or cess are imposed, and global demand peaks. Therefore, the cost of electricity is better understood only in terms of the risk differentials of different technologies.

5.3.6 Feed–in Tariffs: With regard to feed-in tariffs, it is preferable that the SERC should notify regulations presenting the terms and condition for determination of RE tariff before issuing the RE technology-wise tariff orders. This will bring consistency in the tariff determination process and also provide comfort to the investor, who can then envisage the possible tariff with the help of the normative parameters specified under the RE tariff regulation. SERCs of Maharashtra, Rajasthan

and Uttarakhand have followed this practice effectively. The CERC RE tariff Regulation 2009 is available for providing the guidelines for SERCs in this regard and the same may be considered for specifying methodology and normative parameters for tariff determination.

5.3.7. Open Access Regulation and State Grid Codes: System related regulations such as open access (OA) regulation, and state grid code regulations are required to be framed keeping in mind the low capacity utilization factors (CUF) and intermittent nature of RE technologies. SERCs should oversee that the stringent norms and high transmission/wheeling/cross subsidy charges under OA Regulation should not act as a barrier to the third party/captive transaction of RE. For encouraging solar power development, CERC has recently waived the inter-state transmission charges and losses for the useful life of the solar projects to be commissioned in the next 3 years (Notification dated 15.06.2010). A similar action from the SERCs at state level would boost the grid-connected solar power project development at the state level.

5.4 INSTITUTIONAL BARRIERS AND REMEDIES

Many institutional barriers involving lack of inter-agency co-ordination among and within Central and State agencies have been discussed in the previous sections. The issue of institutional bottlenecks in speedy project approvals through single-window clearance have also been addressed. The discussion here pertains to barriers resulting from lack of institutional capacity or capability**.** To facilitate accelerated development of renewable energy in India, capacity building and human resource development will have to be undertaken in a number of institutions at the central and state levels as follows.

(i) Central Sector organizations
(ii) State sector agencies
(iii) All electricity utilities
(iv) State electricity regulatory commissions
(v) Academic and research institutions
(vi) Banks and financial institutions
(vii) Civil society organizations like NGOs, etc

Of the above, the details regarding capacity building of some of the main institutions have been elaborated below.

5.4.1. Central Sector Organizations

Ministry of New and Renewable Energy (MNRE): The MNRE looks after **t**he overall development of RE in India and is responsible for resource mapping, implementing various programmes for grid connected RE as well as off-grid RE systems, providing finance for setting up demonstration RE projects in the states, conducting R&D related to RE, etc. There are many areas where the Ministry and the organizations under it will have to be strengthened.

(i) **Reliable RE resource data in the public domain**: Selection of project site and feasibility of any RE project depends on the accuracy and authenticity of resource assessment data of particular RE source. Although the MNRE has invested heavily in collecting renewable energy data, lack of good-quality data remains a big problem. Even basic data on the actual generation volume of renewable energy by technologies are not available in the public domain. Wind data

available through Centre for Wind Energy Technology (C-WET) are often inaccurate because of lack of adequate investment in improved and multi-year measurements on sites. As a result, the plant capacity factor for many wind plants is lower than what was envisaged at the design stage. Similar problems exist with hydrology data. There is also a strong need to integrate these data resources and present them to potential developers in a user-friendly way. Foremost is the need for realistic assessment of project development potential in the solar sector based on decisive factors like land availability, water availability, etc.

(ii) **Strengthening Solar R&D:** The Centre for Solar Energy needs to be strengthened, diversified and expanded considering the diversity of solar technologies. It should be made autonomous with adequate funding and time-bound targets. Under the ambit of the Centre, specialist research centres for diverse solar technologies need to be established. The Centre also needs to network with various labs across the country for advanced research into priority areas for solar research.

Indian Renewable Energy Development Agency (IREDA): IREDA's role will be critical in the future. IREDA, during FY 2010–11, has disbursed a loan of Rs.917 crore to 36 RE power projects, which is only approximately 8% of the total debt disbursed for 3156 MW of RE capacity added in 2010–11. However, if we compare the performance with that of Power Finance Corporation (PFC), it would be seen that PFC has disbursed Rs.2,22,69.5 crore to conventional power projects during the same period. PFC has also established ten to thirteen subsidiaries and JVs for business expansion out of which PFC Green Energy Ltd is dedicated for funding green energy projects. IREDA (1987) which is as old as PFC (1986) needs to be strengthened and expanded.

In order to achieve the NAPCC targets, substantial funding will be required. Therefore IREDA needs substantial equity infusion, expansion and capacity building. The aspects relating to IREDA's role in RE financing have been discussed under 'Financing Barriers.'

5.4.2 State Sector Agencies

Capacity building of SNAs-National Project required in the 12th Plan: The role of State Nodal Agencies in the development of renewable energy in the country is a critical one. The mammoth responsibility of carrying out MNRE's mandate of implementing RE programmes across the country and leading the way to a green economy lies with the SNAs. Originally, renewable energy projects and programmes were mostly centred around stand-alone devices and rural programmes. Thus, the SNAs were structured and equipped to handle such programmes only. In the last few years, grid-connected RE projects have become an important activity in many states. Consequently, new responsibilities like RE regulation, RE transmission planning, RE resource assessment, other infrastructure planning, identification of private developers to set up RE projects in the state and handling REC transactions are being shouldered by SNAs. It is time to enhance their capabilities and strengthen their functioning through capacity building and various associated activities. Recognising this fact, there is need of capacity building of SNAs through a national project to be funded and co-ordinated by the MNRE in the 12th five year plan period.

5.4.3 Capacity building of Banks/FIs

RE developers in India face numerous difficulties in obtaining debt for their projects. Many of these are related to the inherent characteristics of these projects. Some of the barriers faced by the developer in obtaining finance include the enormous paperwork and costs associated with identifying and obtaining access to finance for small and medium-scale RE projects; limited understanding of RE in financial institutions; lack of familiarity and awareness of technologies, particularly for those that have recently achieved commercialization like solar power. Further, many RE project developers are often small, independent, and newly established, lacking the institutional track record and financial strength needed to secure non-recourse project financing. Lenders often perceive them as high risk and are reluctant to provide non-recourse project finance. As the number of projects increases, it would be necessary to train bankers and financing institutions on issues such as technology awareness, risk analysis and project appraisal of the solar power projects. A national effort for this needs to be undertaken.

5.5 HUMAN RESOURCE BARRIERS AND REMEDIES

The magnitude of human resource requirement for achieving 12% RE by 2017: The manpower requirement over 12th five year plan period and upto 2020 have been assessed based on capacity addition under different scenarios for meeting the NAPCC targets. It is felt that by providing appropriate policy and regulatory framework and adequate funding the anticipated targeted RE capacity can be realized. The anticipated direct and indirect job creation for the 12th five year plan and upto 2020 are reflected in Tables 5.5 and 5.6.

Table 5.5: Job creation during 12th five year plan in RE sector (WISE Estimates)

RE project	Scenario :1		Scenario: 2		Scenario: 3	
	RE Capacity (MW) (2012-17)	Manpower requirement	RE Capacity (MW) (2012-17)	Manpower requirement	RE Capacity (MW) (2012-17)	Manpower requirement
Wind Power	28,312	424,680	17,078	256,168	17,078	256,168
Biomass	2,230	111,500	3,205	160,236	2,300	115,000
Small Hydro	1,575	14,175	2,675	24,075	1,625	14,625
Cogeneration	1,800	90,000	2,465	123,250	1,800	90,000
Waste to Energy	63	2,835	91	4,096	91	4,096
Solar power	3,700	74,000	9,486	189,720	16,976	339,520
Total	**37,680**	**717,190**	**35,000**	**757,545**	**39,870**	**819,409**

Table 5.6: Job creation in RE sector by 2020 (WISE Estimates)

RE project	Scenario :1		Scenario: 2		Scenario: 3	
	RE Capacity (MW) (2011-20)	Manpower requirement	RE Capacity (MW) (2011-20)	Manpower requirement	RE Capacity (MW) (2011-20)	Manpower requirement
Wind Power	59,965	899,475	37,028	5,55,423	37,028	5,55,423
Biomass	4,088	204,400	7,448	3,72,378	3,903	1,95,150
Small Hydro	2,823	25,407	5,383	48,447	2,813	25,317

RE project	Scenario :1		Scenario: 2		Scenario: 3	
	RE Capacity (MW) (2011-20)	Manpower requirement	RE Capacity (MW) (2011-20)	Manpower requirement	RE Capacity (MW) (2011-20)	Manpower requirement
Cogeneration	3,333	166,650	3,333	1,66,650	3,333	1,66,650
Waste to Energy	123	5,514	228	10,239	253	11,364
Solar power	9,962	199,247	15,962	3,19,247	35,452	7,09,047
Total	**80,294**	**1500,693**	**69,382**	**14,72,384**	**82,782**	**16,62,951**

(Assumptions: Direct and indirect Jobs/MW for wind: 15, biomass:50, small hydro:9, co-generation:50, waste-to-energy:45, solar:20)

Greening the academic sector: The role of academic and R&D institutions is of prime importance in developing quality manpower to cater to the required RE capacity addition targets for 12th and 13th plan period. The RE industry is experiencing huge gaps in the curricula of educational and training institutions to meet their expectations from fresh manpower. Hence, to ensure timely quality manpower to achieve RE targets, there is requirement of revision in curricula of educational and training institutions across various levels. The proposed revision is presented in Table 5.7. Along with the curricula, related laboratory infrastructure should be created to demonstrate proper practical experiments to the students. Such detailed greening of the academic sector should be undertaken through a national project for revamping curriculum and courses in technical and management institutions during the 12th plan period.

Table 5.7 Proposed revision required in the curricula of educational and training institutions

Institutions or level	Courses or programmes
Schools	Revised curriculum
Industrial Training Institutions	Technician-level programmes for skilled workers (9 months to 1 year)
Polytechnics	Diploma-level programme for supervisory staff (1 year to 2 year)
Engineering colleges and IITs	Graduate courses Postgraduate courses Doctoral-level courses
Management Institutions	Masters in Energy Management (with emphasis on RE)
Training institutes in the govt and non-govt sector	On the job training Certificate courses up to 3 months Training of trainers

To attract the best talent to this sector and to encourage students to undertake courses related to renewable energy, awareness about green jobs should be created. MNRE and industry associations should see that more and more renewable energy companies come forward for campus interviews to build confidence and ensure recruitments.

5.6 OTHER BARRIERS

Till now the major financing, policy, regulatory, institutional and human resource barriers were discussed in this chapter. However, there are many other barriers which would be briefly discussed here under the following three heads:

- Technological Barriers
- Market Barriers
- Information Barriers

5.6.1 Technological Barriers: Wind power is the most indigenously established major RE technology. Barring certain areas, the technology, though originally brought in from Europe, is today largely indigenised. Access to technology is good and implementation risks are low. However, technology obsolescence is a persistent problem because of the need and pressure to bring in new technology and adapt it to local conditions. This, combined with increase in material prices (wind being a material intensive technology), prevents significant reduction in turbine prices. India already has a local manufacturing base of over 10,000 MW annually for wind turbines and this installed manufacturing capacity will increase further in the next two years. Similarly, there is a well established annual manufacturing base of over 1000 MW in the country for solar PV panels. The investment boom in solar PV was spurred partly by the incentive package under the semi conductor policy and partly by the opening up of the Indian solar market post-JNNSM. However, there are no manufacturers of silicon crystal and wafers in the country. **Public sector investment in silicon ingot and wafer manufacturing to ensure controlled prices of this vital infrastructure for RE development would help bring down solar PV prices. China has been doing this.** A recent announcement by the Planning Commission *(Hindu, 30-4-2011)* says that the Government of India would set up two semi conductor wafer units to manufacture silicon wafers for electronic hardware production. However, it is not clear whether this includes silicon ingot production or wafer production for solar cells.

India has a large potential for generation of power from CSP. But we have no manufacturing base. Access to this technology is critical. Promotion of CSP manufacturing in India has been dealt with under 'Policy Barriers' in this chapter. CSP poses problems of technology access and implementation risks (since CSP technologies other than parabolic trough do not have a long commercial track record). Thin film PV similarly creates huge obsolescence and implementation risks. The comparatively nascent concentrated photovoltaic (CPV) technology similarly faces access problems and implementation risks.

Technology R&D is mostly the preserve of the manufacturing companies. India may take up serious long-term R&D in critical areas like efficiency increases, development of new material, and storage of renewable power. However, considering the short time at our disposal, it would be advisable to adapt imported technology to our needs, in the short-term. Technology access should not be a problem since India has a large market for these new technologies and many of the companies holding patents are from Europe where market for technologies like CSP and CPV are limited. So with a wise approach to technology adaptation and the creation of an investment friendly environment for renewable manufacturers, it would be easy for us to tide over technology barriers.

5.6.2 Market Barriers: One of the most significant market barriers is the high cost of debt and the difficulty in obtaining finance for RE projects. This has already been discussed in the 'Financing Barriers' in this chapter. Absence or inadequacy of supply chain in terms of components for technologies like wind and solar and in respect of fuel supply for technologies like biomass are problematic. Biomass projects face unreliable feedstock supply both in terms of availability and price. Some mechanism of controlling the fuel price would be appropriate. Another market barrier is the absence of manufacturing equipment suppliers for technologies like solar PV. Such manufacturing equipment base will also need to be created.

5.6.3 Information Barriers: Awareness about RE technologies are very low among policy makers, technologists, academia and the general civil society. On the other hand, availability data (like resource data) and information (like compilation of policies) to potential investors, financing institutions or the public in general is also poor. Change of mindsets at all levels through wide-spread sensitization, media campaigns, etc, is critical to the growth of the sector.

***

6
Roadmap of Actions Needed

Based on the discussions in the previous two chapters, a summary of the critical actions needed to achieve 15% RE electricity in the grid by 2020 has been attempted in this Roadmap. The actions needed are as follows:

6.1 PLANNING

- Capacity addition plans for grid-connected RE for the 12th Plan needs to be revised to ensure achievement of 15% RE electricity injection into the grid by 2020.

(Planning Commission & MNRE)

- State-wise capacity addition plans should be communicated to the State Planning Boards, energy departments, and State Nodal Agencies, for incorporation in the 12th Plan of the states.

(Planning Commission & MNRE)

- The CERC/FOR may take coordinated action to persuade those SERCs who have not set the RPO targets as per the national objective to revise their RPO regulations.

(CERC/FOR)

- Transmission planning and development should be institutionalised both at the level of the CEA, state electricity utilities, and State Nodal Agencies.

(Ministry of Power/CEA)

- Separate divisions may be created in CEA and state utilities for this purpose.

(Ministry of Power/CEA)

- A realistic re-assessment of all RE resources, considering geographical and other field issues like water availability etc., should be undertaken, to ascertain the real potential of RE in India—both grid and off-grid. Such re-assessment is essential for policy formation and realistic planning for transitioning to a post-fossil fuel world.

(MNRE)

6.2 FINANCING

6.2.1. Development Financing by Government

- The National Clean Energy Fund should be utilised for top-priority funding of clean energy development to achieve 15% RE by 2020.

(Ministry of Finance GoI)

- Adequate funding may be provided in advance for developing transmission infrastructure for RE.

(Ministry of Power)

- Since scaling up RE to 15% would result in significant impact on APPC, in order to assuage financial difficulties of utilities by bringing down tariffs, indirect or direct support mechanisms like interest subsidies, generation-based incentives, soft loans, etc., should be provided to RE projects.

(Planning Commission/MNRE)

- States should be persuaded to create state-level clean energy funds by levying "green cess", so that the proceeds can be utilized for part-funding RE transmission infrastructure, providing credit guarantees, equity funding, etc.

(MNRE)

6.2.2. Debt Financing

- Ways and means should be evolved to provide soft loans to RE projects, because the high interest rates make most RE projects unviable.

(Ministry of Finance/Planning Commission/RBI)

- Providing interest subsidy or allowing banks/FIs to raise tax-free bonds to provide soft loans to RE projects may be considered.

(MNRE/Ministry of Finance)

- Allowing IREDA (or the proposed Green Bank) to raise low-interest finance from abroad and on-lending the same to RE development in India at 8%-9% would go a long way in achieving national RE targets.

(MNRE)

- Banks/FIs/IREDA/Green Bank could evolve other innovative financing instruments or synthesized products for RE funding.

(MNRE/Planning Commission/Ministry of Finance)

- A Government/RBI decision to give the status of priority sector lending to RE would send the right signal to the banks.

(Ministry of Finance/RBI)

6.3 POLICY

- Lack of cohesion in GOI policy should be addressed. The IEP should be revised (or a new IEP prepared) to align it with new realities and the NAPCC objectives. Similarly, the low-carbon growth strategy should follow the national objective of 15% RE.

(Planning Commission)

- The stand taken in the recent document prepared by MNRE (Strategic Plan for RE 2011-17, February 2011) that renewables can contribute only 6% of the energy mix of the total energy mix by 2022 (and 10% contribution to total electricity mix) sends the wrong signals and contradicts the national policy. MNRE should align its strategic plan with the NAPCC objective.

(MNRE)

- Since the EA, 2003, is insufficient to address development concerns of RE, a separate law for renewable energy development should be enacted. The decision already taken by the government to do so should be implemented.

(MNRE)

- Fossil fuel subsidies should be phased out. Subsidy shifting in favour of clean energy may be considered.

(Planning Commission/Ministry of Finance)

- The cost of externalities of conventional power generation should be quantified (through a scientific study) and the same internalized in the pricing of fossil-fuel-based electricity.

(CERC)

- As declared in the JNNSM, an incentive package for CSP manufacturing in India should be announced to create a strong CSP manufacturing base in India. This will help bring CSP equipment price and enable large-scale power production from CSP.

(MNRE)

- All states should be persuaded to bring comprehensive RE policies.

(MNRE)

- Single window clearance (to the extent possible) should be provided to RE projects in all states.

(MNRE/State Governments)

- All states should offer long-term PPAs (12 to 15 years at least) to RE power generators.

(State Governments)

- Mechanisms should be evolved to ensure timely payment by electricity utilities to RE generators.

(State Governments)

6.4 REGULATION

- State ERCs who have not declared RPOs in line with the NAPCC should do so.

(FOR/SERCs)

- The REC mechanism should be strengthened through capacity building of nodal agencies in states, bringing out smaller denomination RECs, and allowing banking of RECs, etc.

(CERC)

- Homogeneity in inter-connectivity norms should be brought about across different states. Similarly, OA charges should be rationalised and state grid codes enacted to provide RE.

(FOR)

- The regulators may consider overhauling the cost-plus methodology for tariff determination by factoring-in the cost externalities of fossil-fuel-based generation, considering multiple curves and risk-adjusted pricing.

(CERC/FOR)

6.5. CAPACITY BUILDING

- Systematic capacity building should be undertaken in various central and state level organisations and utilities involved in RE development.

(Initiative by MNRE)

- The most important institutions which require capacity building are the State Nodal Agencies of MNRE. The Ministry had submitted a National Programme for capacity building of SNAs to the Planning Commission in 2011. But the Planning Commission advised the MNRE that the same should be taken up in the 12th Plan (since 2011-12 is the last year of the 11th Plan). This programme should be taken on priority during the 12th Plan if we have to achieve the RE deployment targets.

(MNRE/Planning Commission)

- Another priority area for capacity building is the banks and financial institutions. A programme for this is also essential.

(MNRE)

- The R&D institutions in the RE sector needs to be strengthened and new institutions need to be established to cover diverse RE targets. They should be given autonomy, adequate financing, and time-bound targets for technology development in critical futuristic areas like materials, storage, etc.

(MNRE)

6.6 HUMAN RESOURCE S

- A National Programme for curriculum revision, new curriculum development, beginning new RE courses and training of technical institution faculty should be undertaken. Providing adequately trained skilled manpower (whose requirement is very high) is critical to RE development. We have a vast educational infrastructure, but this needs to be revamped.

(MNRE)

- A focus on green jobs and awareness generation about the same is essential. A study to assess the potential of green technologies to create jobs should be undertaken, as is being done in many other developed countries.

(MNRE)

6.7 OTHER AREAS

- Public sector investment in manufacture of silicon ingots and wafers should be done, to make this basic infrastructure available at reasonable prices.

(MNRE/Planning Commission)

- Quick measures for global technology access and adaptation should be put in place in the short and medium term. For the long-term, we should focus on R&D for developing indigenous technology in critical areas.

(MNRE)

- Certain other market barriers clogging the deployment of RE technologies should be identified and remedies found.

(MNRE)

- One of the major problems in RE development is the information barrier. Reliable information and data on RE resources should be available in the public domain so that industries, investors, etc., can access the same. On the other hand, information devices, technologies, policies, incentives, financing, etc., should be made available to the public.

(MNRE)

***

References

1. **13th Finance Commission 2011**, "Report of the Thirteenth Finance Commission (2010-2015)", Chapter 12, Finance Commission India, http://fincomindia.nic.in
2. **Blackburn J O and Cunningham S, 2010**, "Solar and Nuclear Costs - the historic crossover", NCWARN (Waste Awareness and Reduction Network), Durham, North Carolina, USA.
3. **CEA 2011**, Central Electricity Authority website
4. **Gujarat 2011,**Finance Ministers Budget Speech for FY 2011-12, State Govt. of Gujarat
5. **Hindu 30-4-2011**, Centre to set up two semi-conductor wafer units, The Hindu, 3-4-2011
6. **IEA 2011 a ,** "Clean Energy Progress Report", International Energy Agency
7. **IEA 2011 b** , "Technology Development Prospect for the Indian Power Sector", International Energy Agency
10. **IEGC 2010**, Indian Electricity Grid Code, 2010, CERC.
11. **IIR 2010**, "India Infrastructure Report 2010: Infrastructure Development in A Low Carbon Economy", 3iNetwork.
12. **INCCA 2010** , "India : Greenhouse Gas Emissions 2007", Indian Network for Climate Change Assessment, Ministry of Environment and Forest, Govt. of India
13. **IPCC 2011** , "Summary for Policy Makers. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation", Cambridge University Press, Cambridge, United Kingdom and New York, USA
14. **IWE 2011** , "Indian Wind Energy Outlook 2011", published by GWEC , WISE and IWTMA
15. **JNNSM 2009**, Jawaharlal Nehru National Solar Mission document.
16. **MNRE 2010** , "Renewable Energy in India : progress, vision and strategy" , MNRE , GoI
17. **MNRE 2011**, "Strategic Plan for New and Renewable Energy Sector for the period 2011-17", Ministry of New and Renewable Energy
18. **NVVN 2011**, NTPC Vidyut Vyapar Nigam Ltd (NVVN), www.nvvn.co.in
19. **Planning Commission, 2011**, "Low Carbon Strategies for Inclusive Growth: Interim Report", May 2011, Planning Commission, Government of India.
20. **SERC 2011**, Orders of respective State Electricity Regulatory Commission,
21. **WISE 2010, "**Solar Future for India", World Institute of Sustainable Energy
22. **World Bank 2010, "**Unleashing the Potential of Renewable Energy in India", South Asia Energy Unit, Sustainable Development Department, The World Bank

***

ABOUT WISE

The World Institute of Sustainable Energy (WISE) is a not-for-profit institute set up in June 2004 to promote sustainable energy, energy conservation, and sustainable development. In particular, the institution is committed towards addressing the shortcomings existing in the sustainable energy sector in India, viz. lack of policy support and incentives, lack of legislative and research support, lack of qualified manpower, and lack of critical awareness that would lead to the transition to a sustainable energy-based economy. Since its inception, WISE has pioneered several initiatives for accelerating the development of sustainable energy in the country. Some of these include:

- Drafting a model Renewable Energy Law for India and its advocacy. This effort gained wide national and international support, and in 2008, the Government of India decided to enact a Renewable Energy Law for India.
- Undertaking major public policy initiatives for introduction of Generation-based Incentives (GBI) for wind power, development of an innovative solar energy policy for India, introduction of Renewable Energy Certificates, preparation of long-term RE vision documents for various state governments, research into repowering of old wind farms in India, etc.
- Providing consultancy support to some major state electricity regulatory commissions, and various renewable energy industries and investors, and assisting the Ministry of New and Renewable Energy, Govt of India, in certain key areas of renewable energy development in India.
- Undertaking nation-wide field level research projects on 'Comparative Public Cost of Conventional Electricity Generation in India', quantifying externalities of commercial power generation, etc.
- Conducting the first-ever study of 'Human Resource Needs of the Renewable Energy Sector upto 2015', and initiating various cutting-edge HR programmes for the renewable energy sector.
- Sensitising and training the media, financial institutions, and the academia across the country, to generate awareness among them about renewable energy, thus facilitating a conducive environment for its market expansion.
- Organising the national conference-cum-exhibition on 'wind power development in India' titled *Wind India*, India's premier conference-cum-exhibition on solar energy, *Solar India, Climate Change India,* and *RE Regulation India*, all of which were extremely successful.

The different centres and units of WISE function independently, yet work cohesively in the true tradition of inter-disciplinary learning, team spirit, and knowledge sharing. WISE is the only institution in the country to possess such expertise most essential to propel the country towards sustainability in the 21st century.

World Institute of Sustainable Energy

Plot No. 44, Hindustan Estates, Road No. 2,
Kalyani Nagar, Pune – 411 006
Tel: +91-20-2661 3832/55 **Fax:** +91-20-2661 1438
Email: cra@wisein.org **Website:** www.wisein.org