CRISIL Risk and Infrastructure Solutions Limited

Forum of Regulators

Assessment of achievable potential of new and renewable energy resources in different states during 12th Plan period and determination of RPO trajectory and its impact on tariff

Final Report

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Consultant's Key Team Members

Vivek Sharma	– Project Leader (vivek.sharma@crisil.com)
Vikram Madan	– Team Member (Vikram.madan@crisil.com)
Vikas Kumar	– Team Member
Radhika Bansal	– Team Member

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1. Executive Summary

India has 150 GW of known renewable energy potential, of which only about 14% has been developed. Renewable energy is considered to be an important part of the solution to India's energy shortage. The country's renewable energy potential is likely to be even greater than 150 GW, as sources with significant generation capacity have not yet been mapped. Developing renewable energy can help India increase its energy security, reduce the adverse impacts on the local environment, lower its carbon intensity, contribute to a more balanced regional development, and realize its aspirations for leadership in high-technology industries.

Pursuant to the provisions of the Electricity Act, the Forum of Regulators has stipulated that the state electricity regulatory commissions (SERCs) shall fix a minimum percentage for purchase of power from renewable energy sources taking into account the availability of renewable sources in the region and its impact on the retail tariff. As on date, 23 SERCs have specified the renewable purchase obligations (RPO) for their licensee distribution companies.

Further, the National Action Plan on Climate Change (NAPCC) has recommended increasing the share of renewable energy to 10% by 2015 and 15% by 2020. A similar target has been mentioned by the Forum of Regulators in its Policy on Renewables. In order to achieve these goals, India needs an order-of-magnitude increase in renewable energy growth in the next decade. Further, it is required to set the RPO trajectories for the coming years. Therefore, it becomes critical to assess the achievable renewable energy potential during the 12th Plan period and to address the various challenges in the development of renewable energy. .

This report presents various scenarios for the RPO trajectory based on the resource-wise supply of renewable energy sources, target suggested by NAPCC, operationalisation of renewable energy certificate mechanism, and the impact of increasing the renewable purchase obligation (RPO) on retail tariffs. It also highlights the key challenges and bottlenecks along with the enablers for the development renewable energy in India. The data used for the analysis is based on information corroborated from the Ministry of New and Renewable Energy (MNRE), SERCs, state nodal agencies, the Central Electricity Regulatory Commission (CERC), and developers on various wind, solar, biomass, and small hydro projects in potential major states as well as the information

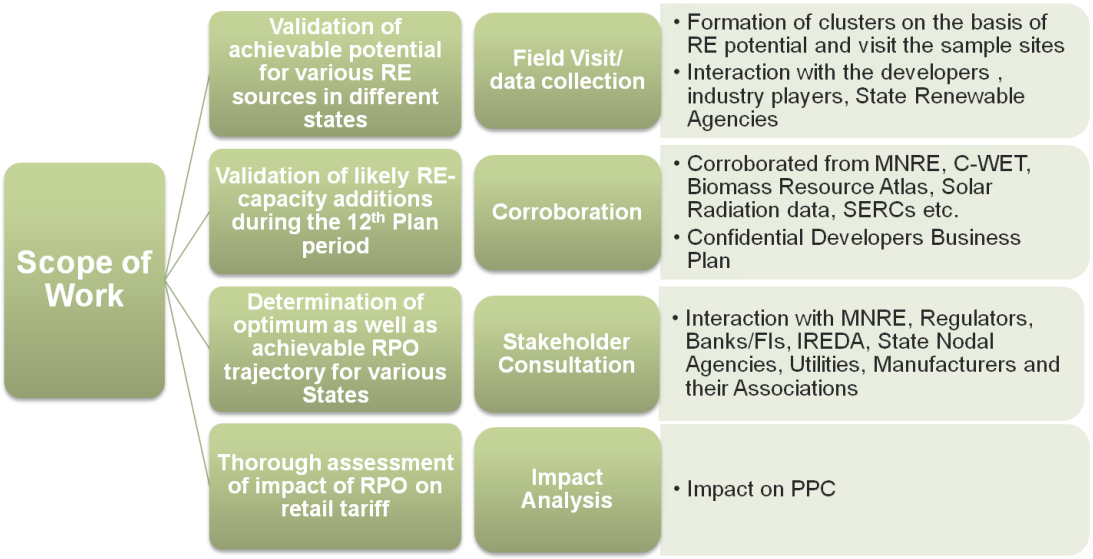
1.1 Objective of study

The objective of the study includes preparing a comprehensive report on the following:

1. Estimation of the potentials of various renewable energy sources in different states and the overall availability of renewable resource based electricity in the country;
2. Assessment of the projected demand of electricity in the area of the distribution licensee(s) in each state;
3. Determination of the possible trajectory for setting RPOs and its impact on retail tariff;
4. Recommendations, based on the above findings, on the desirable minimum RPO to be specified by respective state regulatory commission.

The brief scope of work is shown in a pictorial format below.

Figure 1: Brief scope of work



1.2 Renewable energy potential and installed capacities

As per the Annual Report of MNRE 2010–11, India has significant untapped renewable energy resources. Developing renewable energy can help in providing 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 trading certificates to other states. Investment towards the development of potential renewable energy sources of these states would thus give a huge boost to their economies.

Thus, there are advantages of placing high priority on renewable energy development specific to state and technology. Starting with the 10th Plan period (1997–2001), India accelerated the pace of renewable energy development. India's renewable energy installed capacity has grown at an annual rate of 31%, from about 2.5 GW in 2003 to about 21 GW in August 2011.

Table 1: Potential and installed capacities for various renewable energy sources

Resource	Estimated potential (MW)	Capacity addition as on 31.08.2011 (MW)	Gap (MW)
Wind Power	48,500	14,989	33,511
Small Hydro Power	15,000	3,154	11,846
Bio Power*	23,700	2,936	20,764

Resource	Estimated potential (MW)	Capacity addition as on 31.08.2011 (MW)	Gap (MW)
Solar Power	20–30 MW/sq km	46	-
Total	87,200[1]	21,125	66,121[1]

Source: MNRE Annual Report 2010–11

**Includes biomass, bagasse-based cogeneration, and waste-to-energy grid-connected projects*

1.3 MNRE estimation of RE resource supply during 12th Plan

The capacity addition targets for the 12th Plan period aim at faster, sustainable, and more inclusive growth as is evident from MNRE's Working Group Report.

Table 2: 12th Plan capacity addition through grid-connected renewable energy (MW)

Resource	2012-13	2013-14	2014-15	2015-16	2016-17	12th Plan
Wind	2,500	2,750	3,000	3,250	3,500	15,000
Solar	1,000	1,000	2,000	2,500	3,500	10,000
Biomass	350	625	825	950	1,300	4,050
Small Hydro	350	400	400	450	500	2,100
Waste-to-Energy	40	60	100	100	200	500
Tidal/Geothermal	1	2	3	4	4	14
Total (MW)	**4,241**	**4,837**	**6,328**	**7,254**	**9,004**	**31,664**

Source: Working Group Report on New and Renewable Energy for the 12th Plan

The table above indicates that the 12th Plan period targets for grid-connected renewable capacity addition are close to 32 GW. However, there are several challenges in terms of lower capacity utilization factors, high technological costs, inadequate funds, lack of transmission facilities, inter-state transmission, less robust and enforceable RPOs, etc., which need to be addressed to meet the ambitious targets. The Working Group has also proposed a budget of Rs. 43,000 crores to support the development for both grid-connected and off-grid renewable projects.

1.4 Availability of wind resource during 12th Plan

Wind power is the fastest growing power generation technology in India and accounts for around 70% of the total grid-interactive renewable capacity in the country. By the end of August 2011, the total capacity reached around 15 GW. Wind power development is focused primarily in five wind resource rich states with wind energy contributing to around 41.7% of the total capacity in Tamil Nadu (6,084 MW), followed by Maharashtra (2,345 MW), Gujarat (2,269 MW), Karnataka (1,727 MW), and

[1] *Excluding solar*

Rajasthan (1,620 MW). Andhra Pradesh and Madhya Pradesh are also wind potential States, but the progress is insignificant.

1.4.1 Wind resource assessment

As per MNRE, the total potential of wind is around 49 GW. However, Tamil Nadu has already surpassed the estimated potential, and the estimation made by individual agencies suggests that the wind potential can be much higher than the current estimated potential. The increase can be attributed to various technological advancements and the assumptions made while estimating the potential. The table below highlights the shortcomings and assumptions of the assessments[2], particularly Wind Potential Assessment (WPA) II and III.

Table 3: Assumptions for wind resource estimation

WPA II and III (J Hossain)	Changed Scenario (J Hossain)
Only a part of barren land was used	Forest land, grazing land, and cultivated and agricultural land have been used
Wind turbine of 55-250 kW rating	Wind turbine of 1,500–2,000 kW being installed
Hub height of 20-30 m	Hub height of 80-90 m
Rotor diameter 20–30 m	Rotor diameter of 80–90 m
Max rotor efficiency around 40%	Max rotor efficiency around 50%
Individual wind farm of maximum 10-15 MW capacity	Individual wind farm of maximum 25-700 MW capacity
Only existing transmission line to be used	New transmission lines required being set up
Only existing substations in rural areas are used to evacuate power	Large new and dedicated substations have been set up to evacuate power
10–15% penetration	In line with international practices
Limited experience of wind farm capacity of 100 MW capacity	Enhanced experience of wind farm capacity of up to 10,000 MW

Source: GIS-based assessment of potential for wind farms in India [Hossain, Sinha, and Kishore]

1.4.2 Achievable wind potential during 12th Plan

The wind capacity addition potential during the 12th Plan period has been estimated on the basis of the pipeline of registered projects, wind potential, and availability of land in each state. The table below gives the broad achievable wind potential (till 2020) including the re-powering potential on the

[2] *GIS-based assessment of potential for wind farms in India undertaken by Jami Hossain, Vinay Sinha, and VVN Kishore*

basis of site and land availability and utilizing Class III turbines and the business plans of wind turbine manufacturers and developers.

Table 4: State-wise achievable wind potential till 2020 (MW)

State	Incremental (MW)	Re-powering (MW)	FY 2011-12 (MW)
Tamil Nadu	7,000–8,000	1,500	1,000–1,200
Karnataka	5,000	1,000	400–500
Andhra Pradesh	7,000–8,000		350–400
Maharashtra	6,000–7,000		500–750
Gujarat	6,000–7,000		600–750
Rajasthan	4,000–5,000		500–600
Madhya Pradesh	3,000–3,500		150
Orissa	500		
Chhattisgarh	500		
Jharkhand	500		
Total	**39,000–43,000**	**2,500**	**3,500–4,200**

Source: CRIS analysis based on registered projects and pipeline of developers in various states. Above information is further corroborated by CTU through State Nodal Agencies and STUs.

1.4.3 Issues and constraints

The wind power industry in India has reached, to an extent, a stage of maturity, but still faces certain issues, which need to be addressed:

- Uncertainty and divergence in feed-in tariffs approved by SERCs
- Inadequacy of generation based incentive (GBI) and uncertainty with regard to its continuity as well as continuity of Accelerated Depreciation (AD).
- Lack of long-term RPO trajectory and its compliance
- Inadequate evacuation and transmission infrastructure
- Lack of forecasting tools and grid management
- Financial losses of distribution utilities
- Incoherent resource assessment

All the issues highlighted above have a state-specific significance. Among all, the issue of transmission and evacuation infrastructure is the most important and predominant in the states of Tamil Nadu, Gujarat, and Rajasthan. Similarly, states like Maharashtra, Andhra Pradesh, and Karnataka will also require support towards transmission evacuation and grid management. Besides, the revision of tariff in the state of Andhra Pradesh is detrimental for the development of wind power projects in the state and requires immediate attention.

1.5 Availability of solar resource during 12th Plan

The solar energy sector in India has received great impetus since the announcement of the Jawaharlal Nehru National Solar Mission (JNNSM), which was launched on 11th January 2010. The

mission seeks to kick-start solar generation capacities, drive down costs through local manufacturing, and boost research and development in order to accelerate the transition to clean and secure energy.

The key driver promoting solar power has been the solar-specific RPOs. As per the solar mission, the solar power purchase obligation for states may start with 0.25% in Phase I and to go up to 3% by 2022. Several estimates have been made on solar power potential, and most of them have identified the feasible solar power potential in India to be more than 100,000 MW. This potential coupled with the thrust from the government to develop solar power, has made investments in solar power very attractive to solar developers.

1.5.1 Solar resource assessment

The daily average solar energy incident varies in the range of 4-7 kWh per square metre of surface area depending on the location and time of the year. The solar radiation data assumes critical importance as it impacts the viability of solar power projects, which are quite capital intensive.

MNRE has also taken cognizance of the requirement and has started the augmentation of the network of solar radiation resource assessment (SRRA) stations, to begin with, by setting up such stations at sites with high potential for solar power generation in the country. The Centre for Wind Energy Technology (C-WET), Chennai, is implementing this project.

Gujarat and Rajasthan have excellent solar radiation with abundant land availability and are the most suitable states for solar energy plants. Other suitable states are Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, Maharashtra, and Orissa. However, the solar energy potential remains largely unutilized in the country.

1.5.2 Achievable solar potential during 12th Plan

The solar capacity addition potential during the 12th Plan period has been estimated on the basis of the pipeline of registered projects and favourability of solar policies in each of the states. The table below gives the broad achievable solar potential on the basis of the solar policies of the state.

Table 5: State-wise achievable solar potential during 12th Plan (MW)

State	Incremental solar potential (MW)
Andhra Pradesh	300–500
Gujarat	2,500
Karnataka	200-300
Maharashtra	500
Orissa	200
Rajasthan	3,500
Tamil Nadu	3,000
Total	**10,200–10,500**

Source: CRIS analysis based on the data provided by each SNAs and Solar policy of the state

1.5.3 Issues and constraints

Many of the solar power project developers having achieved various milestones, like identification of projects and land acquisition, are now waiting for the financial closure of the projects. Further, the bankability of the projects allotted under the competitive bidding scheme has not yet been established.

The long approval processes and the inability of the state governments to provide single-window clearance to developers has been another barrier. Further, in Tamil Nadu and Rajasthan, the absence of evacuation infrastructure is the biggest constraint towards capacity addition.

The other issues that are detrimental for the growth of solar power projects in India are:

- The viability of a project depends on the correctness of the radiation data for the site and thus unavailability of radiation data for most of the project sites act as a major hindrance.
- The state nodal agencies could be involved to a larger extent, and single-window clearance could be enabled to cut down the lead time faced by the developers at each step.

1.6 Availability of small hydro resource during 12th Plan

Hydropower represents the use of water resources towards inflation-free energy due to the absence of fuel cost, mature technology, and a high plant load factor. Most of the small hydropower projects are driven by large private investment. Generally, the projects are economically viable and the private sector is showing lot of interest in setting up small hydropower projects. These factors make small hydropower projects one of the most attractive renewable sources for grid-quality power generation.

1.6.1 Small hydro resource assessment

The estimated potential of power generation in the country from small/mini hydropower projects is about 15,500 MW. Almost 50% of the total estimated potential lies in the states of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Arunachal Pradesh. Plain regions such as Maharashtra, Chhattisgarh, Karnataka, and Kerala also have a sizeable potential.

As per the MNRE figures, Karnataka has already surpassed the estimated potential for small hydropower, which highlights the need of correct estimation of small hydro resource. Key states with abundant and unused potential are Arunachal Pradesh, Uttarakhand, Jammu and Kashmir, and Himachal Pradesh. These states could be the driver for further harnessing small hydropower in the country.

Thus, it is highlighted that a comprehensive hydro potential assessment is required. We understand that MNRE has recommended a resource assessment to be carried out during the 12th Plan period.

1.6.2 Achievable small hydro potential during 12th Plan

The achievable small hydro potential is built upon the estimates provided by MNRE and state nodal agencies.

Table 6: State-wise achievable small hydro potential during 12th Plan (MW)

State	Incremental small hydro potential (MW)
Andhra Pradesh	75

State	Incremental small hydro potential (MW)
Arunachal Pradesh	50
Assam	25
Bihar	30
Chhattisgarh	300
Himachal Pradesh	1,000
Jammu and Kashmir	30
Jharkhand	40
Karnataka	800
Kerala	70
Madhya Pradesh	50
Maharashtra	200
Orissa	140
Punjab	30
Tamil Nadu	20
Uttarakhand	350
West Bengal	100
Total	**3,300**

1.6.3 Issues and constraints

The pace of small hydropower development, which increased significantly during the first 4 years of the 11th Plan period (2008–2012), has now stabilized. The development has been relatively slow because of the following issues.

- Implementation time: The implementation of small hydro projects is governed by the state policies and the potential sites are allotted by the state governments to private developers. The process of allotment of sites and selection of developers is often time consuming and has been usually litigated. The implementation of projects is also affected due to difficult terrain and limited working season.
- Hydrological and geological uncertainties: Small hydro projects, due to their inherent scale, do not undergo a thorough hydrological and geological investigation prior to project allotment or even construction. There have been instances in the past wherein a wide variation in generation has been observed as against the envisaged generation.
- Feed-in tariff: Even though the SERCs have announced the feed-in tariff, the following issues still remain unaddressed:
  - Some states have fixed/levelised tariff, whereas other states have incorporated escalation factors.
  - The feed-in tariffs do not adequately compensate for the high resource and other operational risks investors are likely to face over the 35-year investment time horizon.
  - In order to increase attractiveness of RE-based power development and to facilitate further investments by private developers, individual states need to align their respective RE tariff to the latest CERC tariff.

- Inadequate evacuation infrastructure: Since the potential sites are located in remote areas, the lack of evacuation infrastructure acts as the biggest impediment to the cost-effective hydropower potential.
- Impact on environment: The sites allocated for small hydro projects generally have some trees or forest cover. Therefore, the projects require compulsory afforestation and also impact the aquatic life (fish etc.).

1.7 Availability of biomass resource during 12th Plan

Biomass is the most commonly used energy source for several small-scale industries and is used as fuel for independent power plants. A cumulative capacity of 2,650 MW biomass power and bagasse co-generation has so far been commissioned, which includes 1,000 MW from biomass power and 1,650 MW from bagasse cogeneration. Several states including Maharashtra and Karnataka have initiated action for setting up agro residue based projects, which aggregate to about 3,000 MW.

1.7.1 Biomass resource assessment

As per the Biomass Resource Atlas of India, prepared by the Indian Institute of Science (IISc) and facilitated by MNRE,

- Estimated biomass power potential is 18,601 MW;
- Estimated wasteland power potential is 6,239 MW.

The biomass power potential can be increased significantly by exploring the opportunity of high yield varieties and energy plantation in the wasteland. The assessment of scale-up potential has been facilitated by MNRE separately for crop residues and energy plantations. In the case of energy plantations, biomass yield has been estimated by utilization of arid lands and through plantations based on high yield woody biomass.

Further, with a view to determine realistic achievable potential, detailed analyses have been carried out to examine the state-wise agro residue based biomass potential. It has been estimated that 20% to 30% of the generated biomass is lost in harvesting and transportation when mechanized harvesting is used. States such as Punjab, Maharashtra, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, Karnataka, Tamil Nadu, Rajasthan, Kerala, Andhra Pradesh, Bihar, West Bengal, Orissa, and Assam have 18,051 MW biomass-based energy potential, which is 96% of the total potential based on biomass.

It is also highlighted that a comprehensive mapping of biomass resource needs to be carried out in order to estimate the realistic achievable biomass power potential. We understand that MNRE has already initiated various studies and has undertaken the launch of a bioenergy mission in the 12th Plan period.

1.7.2 Achievable biomass potential during 12th Plan

The achievable biomass potential during the 12th Plan period is based on the estimates of the National Bioenergy Mission.

Table 7: State-wise achievable biomass potential during 12th Plan (MW)

States	Incremental Biomass Potential (MW)
Bihar	800
Karnataka	650
Andhra Pradesh	500
Gujarat	400
Madhya Pradesh	450
Punjab	400
Rajasthan	400
Haryana	250
Maharashtra	200
Chhattisgarh	200
Tamil Nadu	100
Total	**4,350**

1.7.3 Issues and constraints

Although biomass-based power generation can be scheduled and carried out throughout the year at a much higher capacity utilization factor, this type of power generation faces several issues:

- Availability of biomass: The availability of biomass fuel has been a serious concern and reduction in the availability of biomass fuel in the state owing to its increased use by alternate/competing markets has become a matter of concern.
- Biomass price: Since biomass-based power projects are the only category of non-conventional power projects that have fuel cost therefore fuel cost has an associated impact on the viability of the projects as well. It is understood that the existing approved fuel cost (as per the tariff order of various states) has made the survival of biomass plants difficult in various states.
- Feed-in tariff: As per the feed-in tariff announced by various SERCs, there is a divergence among states on the following aspects:
  - The biomass tariff framework adopted by different states varies from each other and from CERC as well.
  - Some states have used market determined cost of biomass fuel as market determined and some have incorporated the equivalent heat rate mechanism to determine the tariff.
  - Wastage in the storage of biomass stock has not been considered by some states while calculating the tariff.
- Area reservation policy: The area reservation policy has been rendered ineffective owing to the increased alternative usage of biomass fuel. Further, coordination with state governments is required to restrict inefficient alternate usage of biomass fuel.

1.8 Likely capacity addition of RE resources during 12th Plan

The likely capacity addition for renewable energy resources during the 12th Plan period has been carried out under the two scenarios as detailed below:

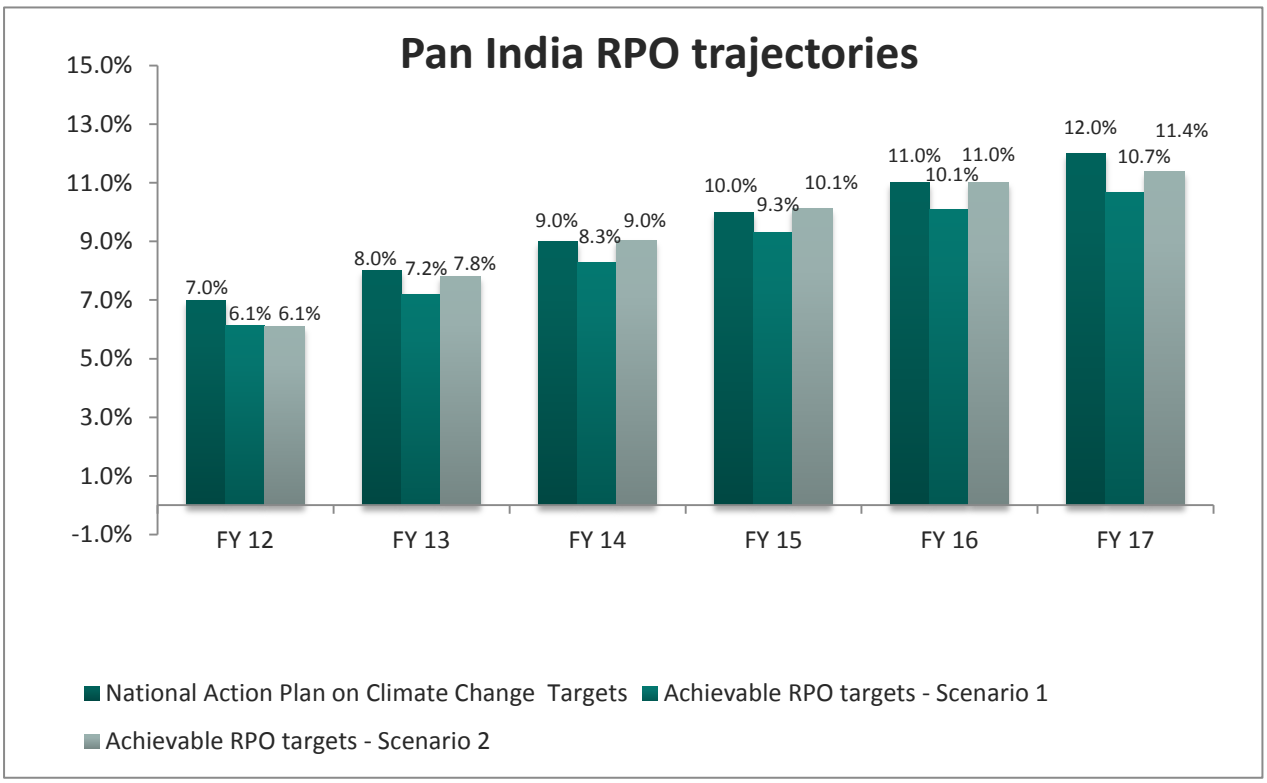
- **Scenario – 1:** The likely capacity addition for renewable energy under this scenario is as per CRIS assessment, which is based on the corroborated data from various state agencies and has been further validated by the developers. It is assumed if the existing regulatory and policy support is continued, the likely capacity addition during the 12th Plan period would be as per Scenario – 1.
- **Scenario – 2:** The likely capacity addition for renewable energy under this scenario can be achieved only if issues or the constraints highlighted are addressed. Further, the facilitation of interstate transmission of renewable energy and evacuation infrastructure is required; only then, the likely capacity addition shall be as per Scenario – 2.

Table 8: Technology-wise likely capacity addition (MW) during 12th Plan

RE Technology	Scenario – 1 (MW)	Scenario – 2 (MW)
Wind Power	19,255	23,804
Solar Power	9,410	9,410
Small Hydro Power	2,799	3,195
Biomass Power	4,250	4,250
Total RE	**35,715**	**40,659**

The national RPO trajectory is estimated based on the likely capacity additions for both the scenarios during the 12th Plan period, as follows.

Figure 2: Pan India RPO trajectories



The above graph shows the achievable RPO trajectory under Scenario – 1 and Scenario – 2 as against the RPO targets suggested by NAPCC.

1.9 Impact on power purchase cost

The incremental impacts of varying levels of RPO on the power purchase cost (PPC) has been analysed for each state as well as at the pan India level for both the mentioned scenarios. This analysis has been done using the state-specific RE tariffs for high-potential states and CERC-specified tariff for low-potential states. Thereafter, the time value of the impact has been calculated taking the discount factor as 9.35%, which is same as the tariff specified by CERC for bid evaluation for procurement of power by distribution licensees.

Table 9: Impact of proposed RPO on PPC (Scenario – 1)

Item	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Total energy (MUs)	968,659	1,053,341	1,138,023	1,222,705	1,324,812	1,435,707
RE energy (MUs)	54,787	70,907	88,153	107,331	129,831	155,382
RPO %	**5.7%**	**6.7%**	**7.7%**	**8.8%**	**9.8%**	**10.7%**
Increase in RPO		1.1%	1.0%	1.0%	1.0%	1.0%
Impact of inclusion of RE (p/unit)	7.5	9.2	11.0	12.5	13.5	14.0
Incremental impact (p/unit)		1.8	1.8	1.5	1.0	0.5

Item	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Time value of Impact of inclusion of RE (p/unit)*		8.5	9.2	9.6	9.5	9.0
Incremental impact, considering time value (p/unit)		**1.0**	**0.0**	**0.3**	**-0.1**	**-0.5**
* Discount rate = 9.35%						

Table 10: Impact of proposed RPO on PPC (Scenario – 2)

Item	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Total energy (MUs)	968,659	1,053,341	1,138,023	1,222,705	1,324,812	1,435,707
RE energy (MUs)	54787	70114	87693	107517	131776	163266
RPO %	**5.7%**	**6.7%**	**7.7%**	**8.8%**	**9.9%**	**11.4%**
Increase in RPO		1.0%	1.0%	1.1%	1.2%	1.4%
Impact of inclusion of RE (p/unit)	7.5	9.2	11.0	12.5	13.7	14.8
Incremental impact (p/unit)		1.7	1.8	1.5	1.2	1.0
Time value of Impact of inclusion of RE (p/unit)*		8.4	9.2	9.6	9.6	9.5
Incremental impact, considering time value (p/unit)		**0.9**	**0.0**	**0.4**	**0.0**	**-0.2**
* Discount rate = 9.35%						

The decrease in the PPC can be attributed to the following reasons:

1. Increased cost of conventional power, especially in the case of Tamil Nadu and Rajasthan
2. Reducing cost of RE power, typically in the case of solar energy. In the previous study, the impact was calculated at a solar tariff of Rs. 18.44 per unit, whereas for the current study, the solar tariff has been reduced from Rs. 10 to Rs. 6 (present value adjusted for inflation rate of 7%) for 2012-13 to 2016-17.

Based on detailed calculations, it is observed that the impact of proposed RPO targets on PPC is not much in the initial years and can be easily accommodated by the state utilities. Further, in the later years, the impact on tariff is itself showing a negative trend.

However, the infirm nature of wind and solar power and the implied unscheduled interchange (UI) charges, which state utilities have to bear, have been excluded while assessing the impact on PPC. The key takeaway is that if initiatives are taken for better scheduling of wind and solar power, the impact of renewable energy shall be minimal, as shown above.

2. Introduction

2.1 Background

The Forum of Regulators (FOR) has been constituted by the Government of India as per Section 166 (2) of the Electricity Act, 2003. The responsibility of promoting cogeneration and generation of electricity from renewable sources of energy has been entrusted to the appropriate commission under Section 61 and in particular to the state regulatory commissions under Section 86 (1) (e) of the Electricity Act, 2003. Accordingly, various state electricity regulatory commissions (SERCs) have specified the renewable purchase obligations (RPO) for their licensee distribution companies. These RPOs vary across the states.

In order to accelerate the large-scale deployment of renewable energy, the National Action Plan on Climate Change (NAPCC) envisages a dynamic renewable purchase obligation target of 10% at the national level for 2015 with an annual increase in the trajectory over long term so as to reach around 15% by 2020 at the national level. Further, the Ministry of New and Renewable Energy (MNRE), in its paper on 'Renewable Energy in India: Progress, Vision and Strategy', projected that the renewable energy capacities at the end of the 12th Plan, i.e., FY 2017, would be around 41,400 MW[3].

For achieving the desired targets stated under the draft 12th Plan, it is important to formulate the RPO trajectory. Against this background, CRISIL Infrastructure Advisory has been appointed to assess the achievable potential of new and renewable energy resources in different states during the 12th Plan period and determine the RPO trajectory and its impact on retail tariff as per the prescribed scope of work.

2.2 Objective of study

The objective of the study includes preparing a comprehensive report on the following:

1. Estimation of the potentials of various renewable energy sources in different states and overall availability of renewable resource based electricity in the country;
2. Assessment of the projected demand of electricity in the area of the distribution licensee(s) in each state;
3. Determination of the possible trajectory for setting RPOs and its impact on retail tariff.
4. Recommendations, based on the above findings, on the desirable minimum RPO to be specified by each state regulatory commission.

2.3 Introduction

India's significant untapped renewable energy resources can be an important contributor to alleviating power shortages. This is also important for energy security, contributing to regional development, enhancing access in remote (rural) areas, diversifying fuel sources, and providing local and global

[3] *This includes grid and off-grid potential.*

environmental benefits. Recognizing these benefits, the Government of India has given much attention to renewable energy and set up ambitious goals for the sector. Meeting these goals will require significant capital investments and a concerted action to solve the issues faced by the different renewable energy sectors.

As per MNRE, India has 150 GW of known resource potential out of which only about 14% has been developed. The country's huge energy potential is likely to be even greater than 150 GW, as sources with significant generation capacity have not yet been mapped. In sectors such as wind and small hydropower, application of the latest developments in engineering design and equipment technology, repowering, higher hub height, and size technology is also likely to increase the potential, and so are the discovery of new small hydropower sites and the development of energy plantations in the unexploited wastelands. The potential for solar power is expected to increase significantly as technology improves.

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, Orissa, and Uttarakhand) lag in economic development. Developing renewable energy in these states can help in providing 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 trading certificates to other states. Making investments to develop the renewable energy potential of these states would thus give a huge boost to their economies.

Thus, there are advantages of placing high priority on renewable energy development specific to state and technology. Starting with the 10th Plan period (1997–2001), India accelerated the pace of renewable energy development. India's renewable energy installed capacity has grown at an annual rate of 31%, from about 2.5 GW in 2003 to about 21 GW in August 2011.

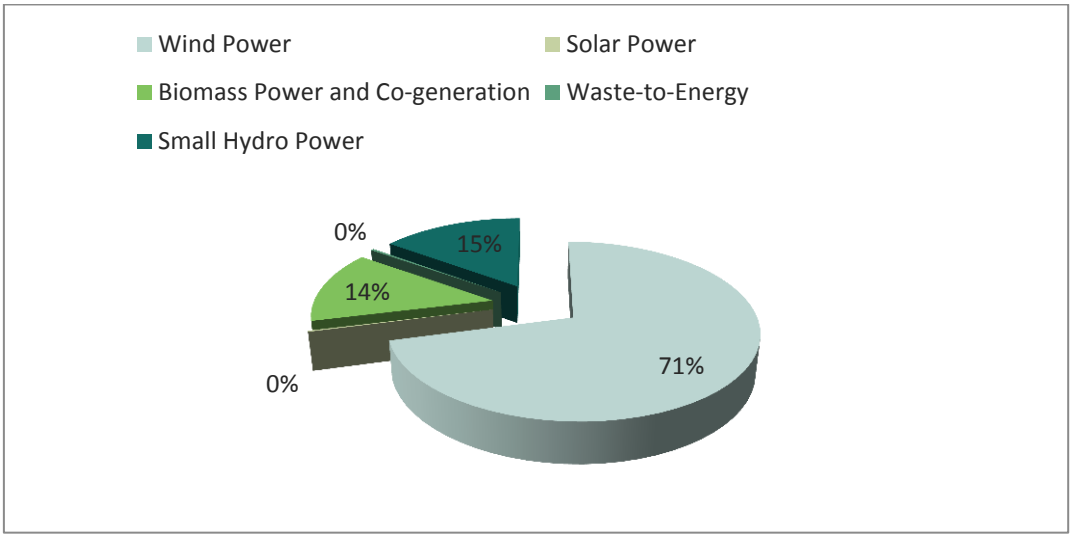
Table 11: Status of grid-connected renewable energy

Sr. No.	Technology	Installed capacity (GW) as on 31.08.2011
1	Wind Power	14.99
2	Solar Power	0.05
3	Biomass Power and Co-generation	2.86
4	Waste-to-Energy	0.07
5	Small Hydro Power	3.15
	Total	**21.13**

Wind energy dominates India's renewable energy industry, accounting for 71% of the installed potential. This sector has received more support than any other renewable energy sector to date. Wind continues to be the biggest renewable energy sector in India, in terms of both current installed capacity (15 GW) and total known potential (49 GW[4]), as per MNRE. This growth can be partially attributed to the use of accelerated depreciation, which has been the core reason for the attractiveness of the sector to the investors who buy completed turnkey projects from equipment vendors and take profits from the tax savings and feed-in tariffs.

[4] *C-WET assessment, which is under review*

Figure 3: Grid-connected renewable energy



Solar power is in the nascent stage and represents a strategic long-term solution for India. A reason behind the sluggish growth of solar energy is the high cost of generation, which has gone down over the past few years. There is a huge potential for solar energy applications in grid-interactive solar power generation plants, solar thermal industrial applications, rural electrification, roof top based applications and mobile towers in off-grid areas, and domestic water heating. The Government of India has launched the National Solar Mission, which shall be implemented in three phases—Phase I (2009–13), Phase II (2013–17), and Phase III (2017–22)—to achieve the target of deploying 20 GW of solar power by 2022.

Small hydropower although being one of the least expensive and most attractive forms of renewable energy, lies largely untapped. The development of small hydropower has been relatively slow because of long delays in getting clearances and acquiring access to evacuation infrastructure, lack of a clear policy on private sector participation in some states, and issues associated with land acquisition and rehabilitation and resettlement. Despite the advantage of being least expensive, resource utilization is very low, which calls for immediate attention.

Biomass has a huge potential in an agrarian economy like India. Like small hydropower, biomass remains largely underdeveloped. The sector is the least developed in India, with only about 3 GW of potential realized to date. Biomass plants require large quantities of fuel input for operation (biomass feedstock), which requires a well-developed fuel supply chain. The presence of multiple middlemen, difficulties in administering and enforcing agricultural contracts, and the development of wastelands have led to the underdevelopment of fuel supply chains. Further, the alternate use of biomass feedstock and the increasing cost of biomass have raised questions on the financial viability of the projects.

2.4 National Action Plan on Climate Change

NAPCC was released by the Prime Minister of India on 30th June 2008. It outlines a national strategy that aims to enable the country adapt to climate change and enhances the ecological sustainability of India's development path. The focus areas of NAPCC regarding renewables are as mentioned below.

- Promotion of efforts towards understanding of climate change, adaptation of mitigation measures, energy efficiency, and natural resource conservation. Mitigation comprises

measures to reduce the emission of greenhouse gases (GHG) by switching to renewable sources of energy.

- One of the eight National Missions outlined in NAPCC is the National Solar Mission, which lays the path of development of the solar energy sector in India. The objective of the National Solar Mission is to significantly increase the share of solar energy in the total energy mix.
- Recognition of the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy, and biomass energy.
- Specification of the dynamic minimum renewable purchase standard (DMRPS or the RPO). Mission suggests RPO to be 5% starting 2009-10 and to be increased by 1% each year for 10 years.

Although national policies enable development of renewable energy projects, the pace of development depends largely on each state's policy and regulatory support. State-level renewable energy policies, specific feed-in tariff and RPO programmes from SERCs, utility evacuation programmes, clearance mechanisms, open access policies, and capacity of state nodal agencies all have significant influence on the pace of renewable energy development.

2.5 Performance analysis of 10th and 11th Plan period

The renewable energy scenario at the start of 12th Plan is in a much stronger position than it was a few years ago. The target vis-à-vis achievement analysis of renewable energy capacity during the 10th Plan and 11th Plan would be indicative of the pace of growth of renewable energy.

Table 12: 10th and 11th Plan-wise capacity addition in grid connected renewable energy (MW)

Resource	10th Plan		11th Plan	
	Target	Achievement	Target	Achievement
Wind power	1,500	5,427	10,400	10,260
Small Hydropower	600	538	1,400	1,420
Bio power*	780	795	1,946	2,042
Solar power	145	1	416	940
Total	**3,025**	**6,761**	**12,230**	**14,660**

**Note – including biomass power, bagasse cogeneration, urban and industrial waste to energy.*

[Source: MNRE]

Table 13: 11th Plan-period-wise capacity addition in grid connected renewable energy (MW)

Resource	2007-08		2008-09		2009-10		2010-11		2011-12	

Resource	2007-08		2008-09		2009-10		2010-11		2011-12	
Wind Power	1500	1663	2000	1485	2500	1565	2000	2350	2400	3197
Small Hydro	200	205	250	249	300	305	300	307	350	353
Bio Power	250	81	300	97	400	151	455	144	450	153
Bagasse Cogeneration		185		248		297		322		312
Waste to Power - Urban	2	-	5		14		17		25	17
Waste to Power - Industrial	10	12	8	5	10			7		-
Solar Power			14		2	8	200	27	200	905
Total	**1962**	**2145**	**2577**	**2084**	**3226**	**23315**	**2972**	**3157**	**3425**	**4943**

[Source: MNRE]

The table above gives period-wise capacity addition during the 11th plan. During the last two years of the 11th plan period, renewable power capacity addition has overachieved targeted capacity addition. This performance is reflective of the strong growth prospects for the renewable energy sectors and 12th plan provides opportunity for the strong growth momentum to continue.

2.6 Working Group Report on New and Renewable Energy for the 12th Plan

Renewable energy witnessed a sea change during the 11th Plan period with the total installed capacity reaching about 23 GW with an annual growth rate of 23% from the 2002-03 level. The capacity addition targets for the 12th Plan period aims at faster, sustainable, and more inclusive growth as is evident from MNRE's Working Group Report, which highlights that one-third of the total 100 GW capacity addition requirement shall be contributed by renewable sources.

Table 14: 12th Plan capacity addition through grid-connected renewable energy (MW)

Resource	2012-13	2013-14	2014-15	2015-16	2016-17	12th Plan
Wind	2,500	2,750	3,000	3,250	3,500	15,000
Solar	1,000	1,000	2,000	2,500	3,500	10,000
Biomass	350	625	825	950	1,300	4,050
Small Hydro	350	400	400	450	500	2,100

Resource	2012-13	2013-14	2014-15	2015-16	2016-17	12th Plan
Waste-to-Energy	40	60	100	100	200	500
Tidal/Geothermal	1	2	3	4	4	14
Total	**4,241**	**4,837**	**6,328**	**7,254**	**9,004**	**31,664**

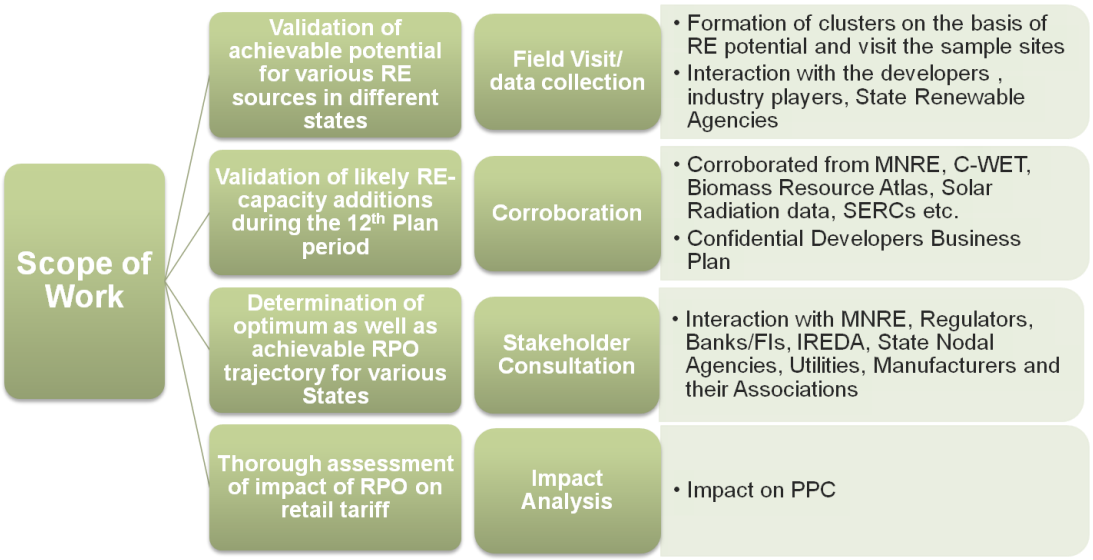
Source: Working Group Report on New and Renewable Energy for the 12th Plan

The table above indicates that the 12th Plan period targets for grid-connected renewable capacity addition are to the tune of 32 GW. However, there are several challenges in terms of lower capacity utilization factors, high technological costs, inadequate funds, lack of transmission facilities, inter-state transmission, less robust and enforceable RPOs, etc., which need to be addressed to meet the ambitious targets. The Working Group has also proposed a budget of Rs. 43,000 crores to support the development for both grid-connected and off-grid renewable projects.

2.7 Scope of work

The study was undertaken with the objective of suggesting the RPO trajectory for the states keeping in view the achievable potential of new and renewable energy resources in different states during the 12th Plan period and determining the impact of the trajectory on tariff. The scope of work is shown in a pictorial format below.

Figure 4: Scope of work – Key considerations



2.8 Approach and methodology

The proposed study is an extension of an earlier study[5] that was carried out by us on behalf of FOR. While the earlier assessment was carried out for estimating the state-level RPO required to achieve

[5] *CRIS was appointed to estimate the state-level RPO required to achieve the NAPCC targets.*

the NAPCC targets, this assessment is far more comprehensive and looks at the achievable potential based on the bottom-up approach. It is to be noted that there are some key value additions in the approach used in this study, which are as follows.

2.8.1 State-wise validation of achievable potential for each RE source

State-wise validation of achievable potential represents one of the most important components towards the determination of the RPO trajectory. The validation included a review of the assumptions considered in the stated[6] estimation of renewable energy potential by the secondary sources of information. Here, it is worth mentioning that some agencies have conducted a survey of RE potential, and as per these studies, the RE potential in India is significantly higher than that mentioned in government reports. A major reason for this difference lies in the assumptions behind the estimation of RE potential. In this assessment, the findings are corroborated through a quick technical estimation for wind potential in India (as wind constitutes the highest installed capacity among all RE sources in India and is expected to play the lead role in further growth of the RE sector in India for the next 5–10 years).

2.8.2 Validation of likely RE capacity additions during the 12th Plan period

This had been carried out by corroborating the capacity addition figures obtained from the industry players[7] and state renewable agencies through stakeholder consultation (wind manufacturers, MNRE, FOR, CERC, SERCs, state RE agencies, and research/academic institutes) so as to give a realistic picture of the likely capacity additions for RE-based power plants during the 12th Plan period. The achievable pipeline in each state is validated after considering the wind potential in the site/area, status of land, and transmission requirement. Area-wise/pocket-wise information was revalidated by the Central Transmission Utility (CTU), which had been entrusted the responsibility of assessing the optimum transmission requirement for setting up wind and solar projects in each state.

2.8.3 Assessment of impact of RPO on PPC

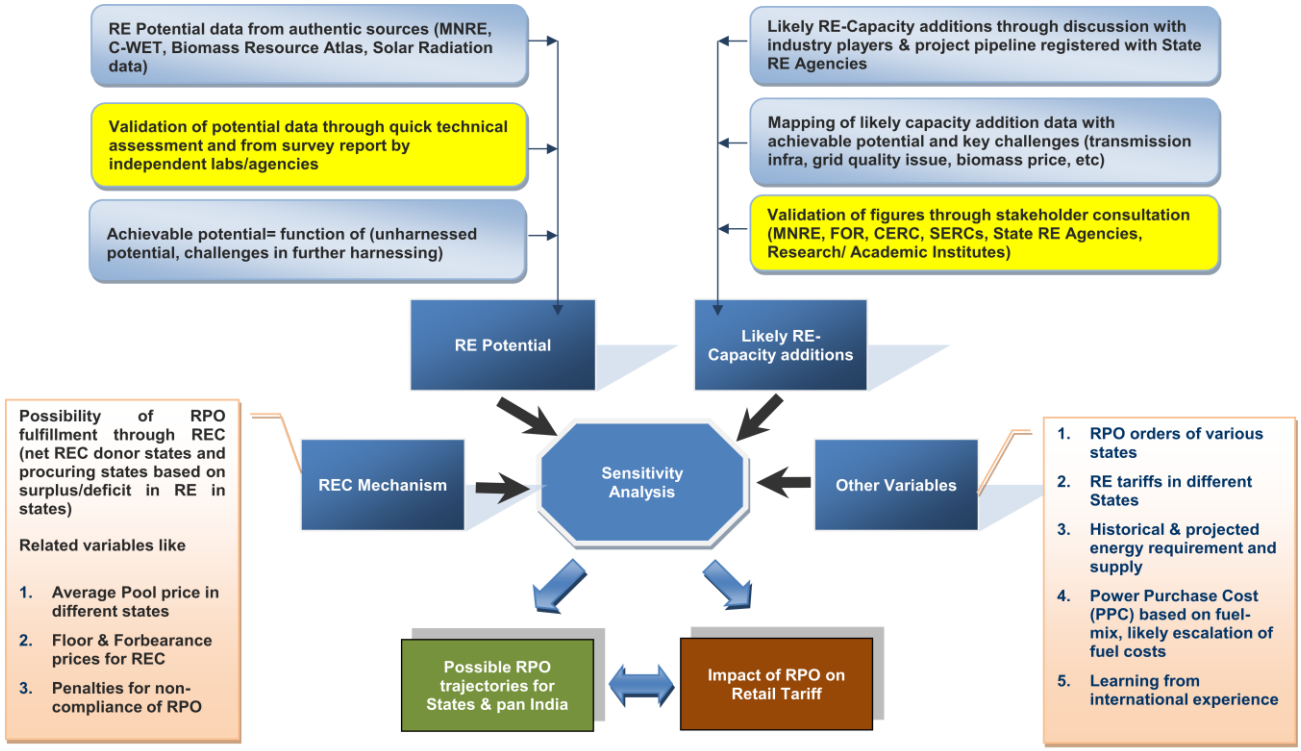
The state-specific impact on the PPC was assessed based on the quantum of RE power that will be procured under the RPO obligation. The PPC in each state was forecasted based on the past trend of escalation as well as the tariff orders issued by the SERCs.

The broad approach and methodology followed for the assessment is shown in a pictorial format below.

6 *MNRE publishes technology-wise gross and net potential. However, this potential was assessed almost two decades ago and requires revalidation.*

7 *Discussion was held with wind manufacturers to understand their business plan as well as the status of area-wise/pocket-wise pipeline of achievable wind installation in six key states in India.*

Figure 5: Broad approach and methodology



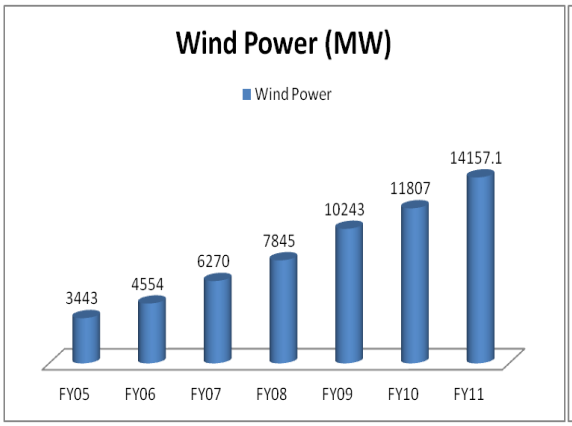
-SNA, STU, SERC and Micro level details from the confidential Business Plan of the Manufacturer
- SERC orders for RE tariffs, existing RPO levels, PPC cost and trend

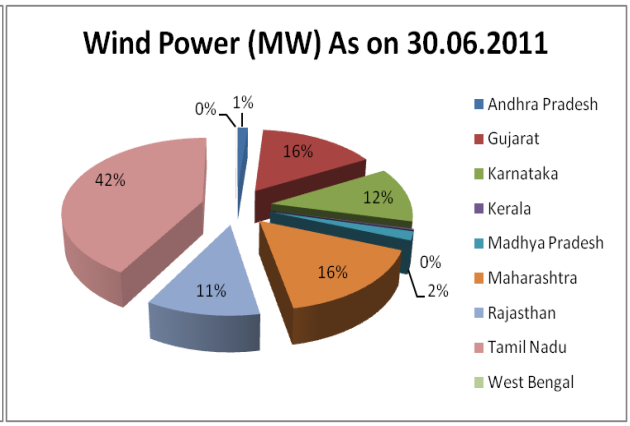
3. Assessment of wind potential and likely capacity supply scenario

This chapter primarily focuses on the assessment of the wind potential and likely capacity additions during the 12th Plan period based on broad parameters like (policy and regulations, wind potential assessment, transmission and evacuation infrastructure, and financing) and the discussions held various stakeholders (MNRE, FOR, developers, state nodal agencies, state utilities, and financing agencies).

3.1 Background

Wind power is the fastest growing power generation technology in India and accounts for around 70% of the total grid-interactive renewable capacity in the country. From an installed capacity of 41 MW in March 1992, the wind power capacity reached 7,094 MW by the end of the 10th Five Year Plan period. During the first four years of the 11th Five Year Plan period, the installed capacity was 7,063 MW.





By the end of June 2011, the total capacity reached to 14,561 MW. Wind power development is focused primarily in five wind resource rich states with wind energy contributing to around 41.7% of the total capacity in Tamil Nadu (6,084 MW), followed by Maharashtra (2,345 MW), Gujarat (2,269 MW), Karnataka (1,727 MW), and Rajasthan (1,620 MW). Andhra Pradesh and Madhya Pradesh are also wind potential states, but the progress is insignificant.

3.2 Potential assessment

As per MNRE, the total wind potential in the country estimated earlier was just 49 GW. The table below gives the state-wise wind power potential and installed capacity as on 31.06.2011.

Table 15: State-wise wind power potential and installed capacity as on 31.06.2011 (MW)

State	Potential	Installed capacity	Gap
Andhra Pradesh	8,968	198.20	8,769.80
Gujarat	10,645	2,269.43	8,375.57
Karnataka	11,531	1,727.65	9,803.35
Kerala	1,171	35.10	1,135.90

State	Potential	Installed capacity	Gap
Madhya Pradesh	1,019	275.90	743.10
Maharashtra	4,584	2,345.80	2,238.20
Orissa	255	-	255
Rajasthan	4,858	1,620.10	3,237.90
Tamil Nadu	5,530	6,084.20	
West Bengal	-	4.30	
Total	**48,561**	**14,560.68**	

Source: MNRE

The key takeaway is that Tamil Nadu has already surpassed the estimated potential for wind energy, which highlights the importance of correct estimation of wind resource. Key states with abundant and unused potential are Karnataka, Gujarat, Andhra Pradesh, and Rajasthan. These states could be the future drivers in harnessing wind-based power in the country.

Estimates made by many individual agencies suggest that wind power capacity could be at a much higher level, somewhere between 400 GW to 800 GW. Lawrence Berkeley National Laboratory, USA, has estimated a technical potential of 800 GW at 80-m mast measurement with optimum land utilization.

Similarly, the GIS-based assessment of potential for wind farms in India undertaken by Mr. Jami Hossain, Mr. Vinay Sinha, and Mr. VVN Kishore gives a wind farm potential of 2,076 GW at a plant load factor of more than 20%. However, similar attempts have been made earlier to assess the potential for harnessing wind energy for electricity generation by Hossain and Raghavan[8], referred to as Wind Potential Assessment (WPA) II and III, respectively, which have been widely quoted in all policy, regulatory, and industry documents. The table below highlights the shortcomings of these assessments, particularly WPA II, and also summarizes the assumptions for the GIS-based assessment of wind farm potential.

Table 16: Assumptions for wind resource estimation

WPA II and III Assessment (J Hossain)	Changed scenario (J Hossain)
Only a part of barren land was used	Forest land, grazing land, and cultivated and agricultural land have been used
WTG of 55-250 kW rating	WTG of 1,500–2,000 kW being installed
Hub height of 20-30 m	Hub height of 80-90 m
Rotor diameter 20–30 m	Rotor diameter of 80–90 m

[8] *Mani A. Wind Energy Resources Survey for India-II. pp 591. New Delhi: Allied Publishers, ISBN 81-7023-358-5; 1992. Mani A. Wind Energy Resources Survey for India-III. pp 637. New Delhi: Allied Publishers, ISBN 81-7023-221-X; 1994.*

WPA II and III Assessment (J Hossain)	Changed scenario (J Hossain)
Max rotor efficiency around 40%	Max rotor efficiency around 50%
Individual wind farm of maximum 10-15 MW capacity	Individual wind farm of maximum 25-700 MW capacity
Only existing transmission line to be used	New transmission lines required being set up
Only existing substations in rural areas are used to evacuate power	Large new and dedicated substations have been set up to evacuate power
10–15% penetration	In line with international practices
Limited experience of wind farm capacity of 100 MW capacity	Enhanced experience of wind farm capacity of up to 10,000 MW

Source: GIS-based assessment of potential for wind farms in India [Hossain, Sinha, and Kishore]

The wind capacity addition potential during the 12th Plan period has been estimated on the basis of the pipeline of registered projects, wind potential, and availability of land in each state. The table below gives the broad achievable wind potential (till 2020) on the basis of site and land availability and utilizing Class III turbines. The figures given below have been validated by the developers[9]. It should be noted that this information/data has also been validated by the CTU during the assessment on pocket-wise transmission requirement based on the likely capacity addition through wind sources in each state.

Table 17: State-wise achievable wind potential till 2020 (MW)

State	Incremental (MW)	Re-powering (MW)	FY 2011-12 (E)
Tamil Nadu	7,000–8,000	1,500	1,000–1,200
Karnataka	5,000	1,000	400–500
Andhra Pradesh	7,000–8,000		350–400
Maharashtra	6,000–7,000		500–750
Gujarat	6,000–7,000		600–750
Rajasthan	4,000–5,000		500–600
Madhya Pradesh	3,000–3,500		150
Orissa	500		
Chhattisgarh	500		
Jharkhand	500		
Total	**39,000–43,000**	**2,500**	**3,500–4,200**

Source: CRIS analysis

[9] *Discussion was held with wind manufacturers to understand their business plan as well as the status of area-wise/pocket-wise pipeline of achievable wind installation in six key states in India.*

The above table provides only the gross potential based on the proposed capacity addition programme; a comprehensive wind potential assessment is required. We understand that MNRE has already started the resource assessment, which shall take at least a year to firm up its findings.

3.3 Existing policy and regulatory regime for wind power

The regulatory policies for wind power sector emanated from the Electricity Act, 2003, mandating SERCs to generate renewable electricity by providing connectivity and creating purchase obligations. Besides, several other federal-level policy incentives through accelerated depreciation and other exemptions are also available to developers. These interventions have helped the wind industry to grow many folds.

The pro-wind policies adopted by the central and state governments include the following:

3.3.1.1 Tax exemption through accelerated depreciation

Investors can take advantage of the tax exemption through an accelerated depreciation of up to 80% of the project cost within the first year of commissioning of projects. This is the most significant incentive that has led to the growth of the wind industry.

3.3.1.2 Income tax exemption and import duty waivers

Wind power project owners are exempted from income tax on all earnings generated from the project for any single 10-year period during the first 15 years of the project life. Besides, import duty waivers on wind turbines and other components are available.

3.3.1.3 Soft loans from Indian Rural Energy Development Agency

MNRE and the Indian Rural Energy Development Agency (IREDA) have issued guidelines for financing wind energy projects, applicable from 3rd February 2009.

3.3.1.4 Generation-based incentives

In December 2009, MNRE announced the scheme for the implementation of generation-based incentives (GBI) for grid-interactive wind power projects. The introduction of GBI aims at attracting large IPPs and foreign direct investors to the wind power sector by giving an incentive on the generation of electricity. IREDA is the nodal agency for the implementation of GBI. The scheme provides an incentive of Rs. 0.50/kWh through IREDA with a total cap of Rs. 6.2 million/MW spread over a minimum of 4 years (i.e., an annual cap of Rs. 1.55 million/MW). The incentive is over and above the feed-in tariff specified by the respective SERCs. The scheme is not applicable for third party sale and merchant plants, but is applicable for captive power plants.

3.3.1.5 Feed-in tariff

Central and state electricity regulatory commissions have notified the wind-specific feed-in tariff for electricity generated from wind. The tariffs applicable in various states are as per the following table.

Table 18: Wind – State-wise feed-in tariff

State	Wind energy tariff (Rs. per unit)
Madhya Pradesh (Order dated 14/05/10)	Rs. 4.35 levelised for 25 years

State	Wind energy tariff (Rs. per unit)
Andhra Pradesh (Order dated 01/05/2009)	Rs. 3.50 for 10 years, next 10 years' tariff to be decided afterwards
Gujarat (Order dated 30/01/2010)	Rs. 3.56 fixed for 25 years
Karnataka (Order dated 11/12/2009)	Rs. 3.70 fixed for 10 years
Rajasthan (Order dated 14/12/2011)	Rs. 4.46: Jaisalmer, Jodhpur, and Barmer districts
	Rs. 4.69: Other districts, fixed for 20 years
Maharashtra (Order dated 21/04/2010)	Wind Zone – Energy Net Levelised Tariff (Rs./kWh) 2011–12 Wind Zone – 1 4.56 Wind Zone – 2 3.96 Wind Zone – 3 3.38 Wind Zone – 4 3.04
Kerala (Order dated 22/11/2010)	Rs. 3.64 for 20 years
Tamil Nadu (Order dated 20/03/2009)	Rs. 3.39 for 20 years
Haryana (Order dated 15/05/2007)	Rs. 4.08 applicable for 5 years with annual escalation of 1.5% from 2008-09
Punjab (Order dated 13/12/2007)	Rs. 3.49 (base year 2006-07) with annual escalations @5% up to 2011-2012
West Bengal (Notification dated 25/03/08)	Rs. 4.00 fixed for 5 years and as cap

3.3.1.6 Renewable purchase obligation

Most of the SERCs have notified the RPO regulations for which the control period is ending in either 2013 or 2014. The non-solar RPOs announced by various SERCs are mentioned in the table below.

Table 19: Non-solar/wind RPO levels specified by states

State	FY 12	FY 13	FY 14
Assam	2.7%	4.05%	5.4%
Andhra Pradesh	5%	5%	5%
Bihar	2.0%	3.25%	3.5%
Chhattisgarh	1.25%	1.50%	
Delhi	1.9%	3.25%	4.60%

State	FY 12	FY 13	FY 14
Gujarat	5.00%	5.50%	
Haryana	1.25%	1.50%	2.25%
Himachal Pradesh	10.0%	10.0%	10.0%
Jammu and Kashmir	2.9%	4.75%	-
Jharkhand	2.5%	3%	-
Goa and other UTs	1.7%	2.6%	2.6%
Karnataka	9.75%	For BESCOM, MESCOM, CESCOM	
	6.75%	For GESCOM, HESCOM, Hukeri	
Kerala	3.05%	3.35%	3.65%
Madhya Pradesh	2.1%	3.4%	4.7%
Maharashtra	6.75%	7.75%	8.5%
Manipur	2.75%	4.75%	
Mizoram	5.75%	6.75%	
Meghalaya	0.15%	0.20%	
Nagaland	6.75%	7.75%	
Orissa	1.20%	1.40%	1.60%
Punjab	2.37%	2.83%	3.37%
Rajasthan	4.5%	6.6%	7.7%
Tamil Nadu	8.95%	To be declared	
Tripura	0.9%	0.9%	1.9%
Uttar Pradesh	4.5%	5%	-
Uttaranchal	4.5%	5%	-
West Bengal	3%	4%	5%

3.3.1.7 Renewable Energy Certificate mechanism

A renewable energy certificate represents the renewable attributes of a single megawatt-hour of renewable energy. The participation of wind energy generators in the renewable energy certificate (REC) market has also been quite encouraging, totalling a registered capacity of 672 MW. The status of REC market for wind projects registered as on 31st October 2011 is as follows:

Table 20: State-wise registration status of wind projects under REC

Sr. No.	State	Wind (No. of Units)	Wind Capacity (MW)
1	Gujarat	11	92
2	Maharashtra	111	290
3	Rajasthan	4	28
4	Tamil Nadu	30	262
5	Himachal Pradesh	0	0

Sr. No.	State	Wind (No. of Units)	Wind Capacity (MW)
6	Jammu and Kashmir	0	0
7	Chhattisgarh	0	0
8	Haryana	0	0
9	Uttar Pradesh	0	0
	Total	156	672

Source: REC Registry India

3.4 Issues and constraints

The wind power industry in India has reached, to an extent, a stage of maturity, but still faces certain issues, which need to be addressed.

3.4.1 Uncertainty and divergence in feed-in tariffs approved by SERCs

The assumptions and methodology adopted by the SERCs for determining the feed-in-tariffs for wind projects are different. Because of the difference in approach, there are wide variations in the tariffs (as can be seen from Table 16), leading to uncertainty for the investors as well as non-viability of the projects[10] in certain states in India. For instance, it is observed that feed-in tariffs of Rs. 3.50/kWh in the state of Andhra Pradesh is low, leading to lack of capacity addition in the state in spite of the high wind potential in the state. It should be noted that the feed-in tariff in Andhra Pradesh based on the tariff regulation approved by CERC is Rs. 4.63/kWh as compared to Rs. 3.50/kWh approved by APERC. Therefore, harmonization of approach adopted and tariffs announced by different SERCs is critical for future growth. Further, the issue of longer control period and delay in RE tariff revisions at the state level are also a matter of concern.

3.4.2 Inadequacy of GBI and uncertainty with regard to its continuity

The GBI scheme was issued for the 11th Plan period and the response to the scheme, so far, has been modest. Total capacities of around 650 MW projects have registered with IREDA under the GBI scheme up to 15th April 2011. The reasons for of moderate success of scheme have been cited as inadequacy of incentive (Rs. 0.50 per unit), ceiling of Rs. 62 lakh per MW, and generation from captive projects not being covered under the scheme. Further, there is no clarity regarding the continuity of the scheme.

3.4.3 Lack of long-term perspective for RPO trajectory and its compliance

As per the RPOs notified by various SERCs in Table 17, there is a wide divergence in terms of the following aspects:

- Long-term perspective: The control period for RE tariff ends in 2013 or 2014. It is recommended that a long-term RPO trajectory covering a tenure of at least 10 years (up to 2022) along with the tariff should be announced across states.

[10] *Specially in the case of project finance*

- Implementation of open access and interstate sale of renewable energy: Open access and interstate sale of renewable energy is required for facilitating the higher installation in the wind major states. At this stage, states with rich wind potential are unable to sell RE power outside the state.
- Compliance of RPO: Only a few states (like Maharashtra and Rajasthan) have a shortfall clause in place. Improved frequency (monthly/quarterly) for RPO compliance monitoring and reporting is necessary prior to ensuring enforcement for non-compliance. Despite the applicability of RPO targets for captive/open access users, its compliance status is not known in many states. Automatic pass-through of RE and REC cost in retail tariffs could encourage compliance of RPO.

3.4.4 Inadequate evacuation and transmission infrastructure

The lack of adequate evacuation and transmission infrastructure is one of the biggest barriers to harnessing the renewable energy potential. For instance, attractive potential wind sites in Rajasthan, Gujarat, and coastal Tamil Nadu remain less tapped because of lack of adequate grid evacuation capacity and transmission infrastructure. The issue of evacuation and transmission infrastructure has been dealt in detail in subsequent sections on states. This particular issue is also going to be addressed in a greater detail by the CTU that is undertaking another study[11].

3.4.5 Lack of forecasting tools and grid management

In the existing regulatory framework, resource-rich states are expected to take higher wind purchase obligation and buy power at a preferential tariff, and wind power projects have been accorded the status of 'must run projects'. Although the introduction of the REC mechanism facilitates the trading of the green attribute of renewable energy across states, the mechanism doesn't deal with the infirm nature and poor predictability of wind generation. That is why states like Tamil Nadu and Rajasthan are increasingly finding it difficult to absorb higher quantum of wind power during the higher windy season and low demand period. In this regard, linking of the Southern Grid with the National Grid, freely allowing open access and third party sale within and outside the state/region, as well as improving forecasting tools will be critical for further harnessing the potential of wind power in the country. Incentives need to be provided to facilitate the implementation of robust wind forecasting tools.

3.4.6 Financial losses of distribution utilities

The regulatory framework is designed to allow the pass-through of renewable energy costs to consumers in the form of retail tariff revisions. However, in most of the states, retail tariffs don't represent the actual cost of supply. This has lead to a huge revenue gap and accumulated financial losses. As a result, utilities have limited financial capability to go out of their way to encourage renewable energy development. This also leads to a concern over the bankability of the Power Purchase Agreement (PPA) signed by the state utility.

[11] *CTU is appointed by FOR for assessing the transmission requirement for harnessing the RE potential optimally. During the course of this assignment, CRIS worked closely with CTU and provided required data regarding the likely sites/pockets. To an extent, the information has been validated by CTU after discussion with the state nodal agencies, state transmission utilities, and the distribution utilities.*

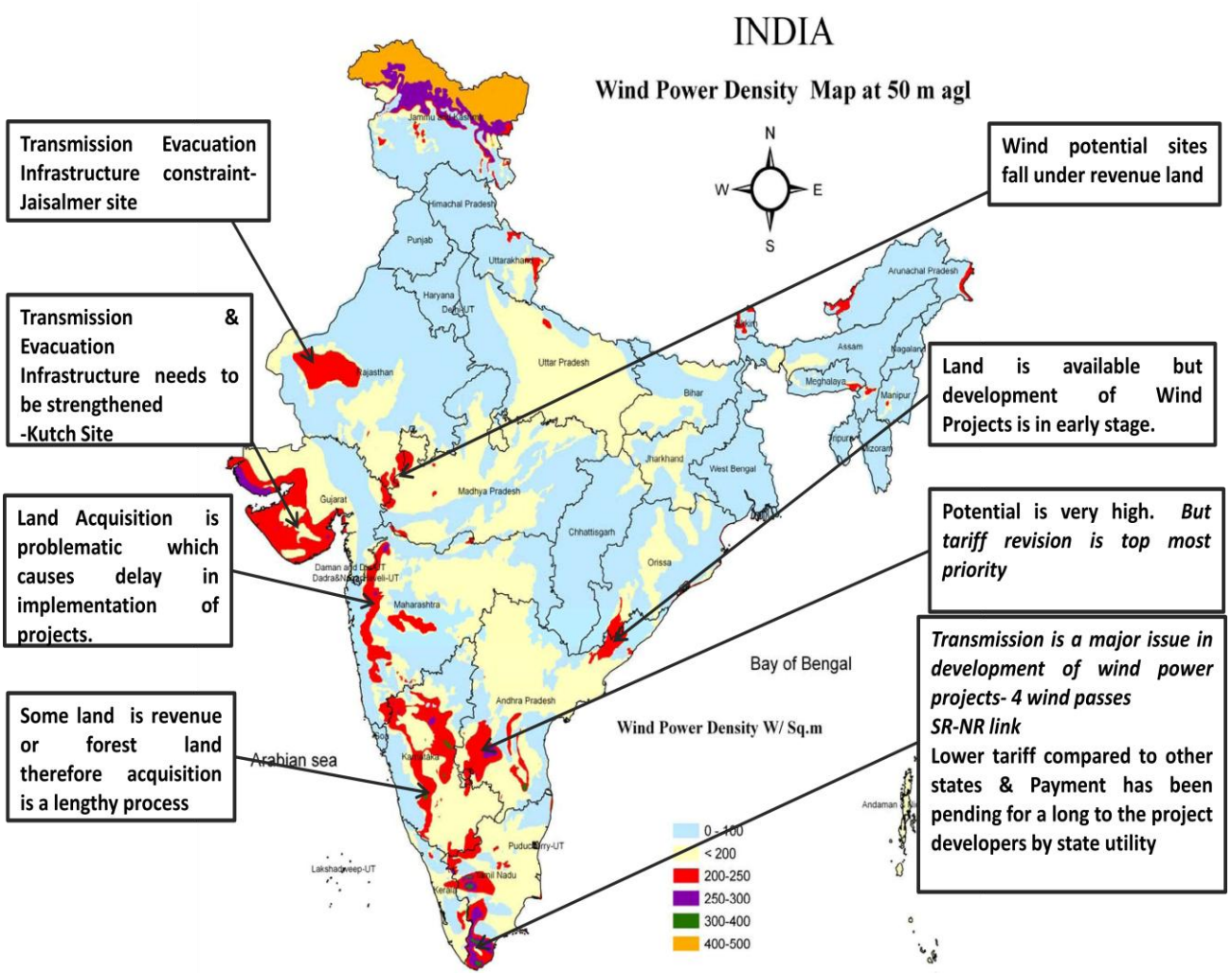
3.4.7 Incoherent resource assessment

A number of state nodal agencies are not able to establish and maintain a technical library, a data bank, or an information centre or collect and correlate information regarding renewable energy sources. There is a strong need to integrate these data resources and present them to potential developers in a user-friendly way.

In the past, the Centre for Wind Energy Technology (**C-WET**), Chennai, has undertaken a resource assessment, but the basic data on the actual generation volume of wind energy is not realistic as can be seen from the case of Tamil Nadu where the actual installed capacity has already surpassed the estimated potential. We understand that MNRE has taken the cognizance of the same and has already started the resource assessment, which shall take at least a year to firm up its findings.

All the issues highlighted above have a state-specific significance in the figure below. The issue of transmission and evacuation infrastructure is predominant in the states of Tamil Nadu, Gujarat, and Rajasthan. Similarly, states like Maharashtra, Andhra Pradesh, and Karnataka will also require support towards transmission evacuation and grid management. Besides, the revision of tariff in the state of Andhra Pradesh is detrimental for the development of wind power projects in the state and requires immediate attention.

Figure 6: Nation-wide immediate issues in harnessing wind potential

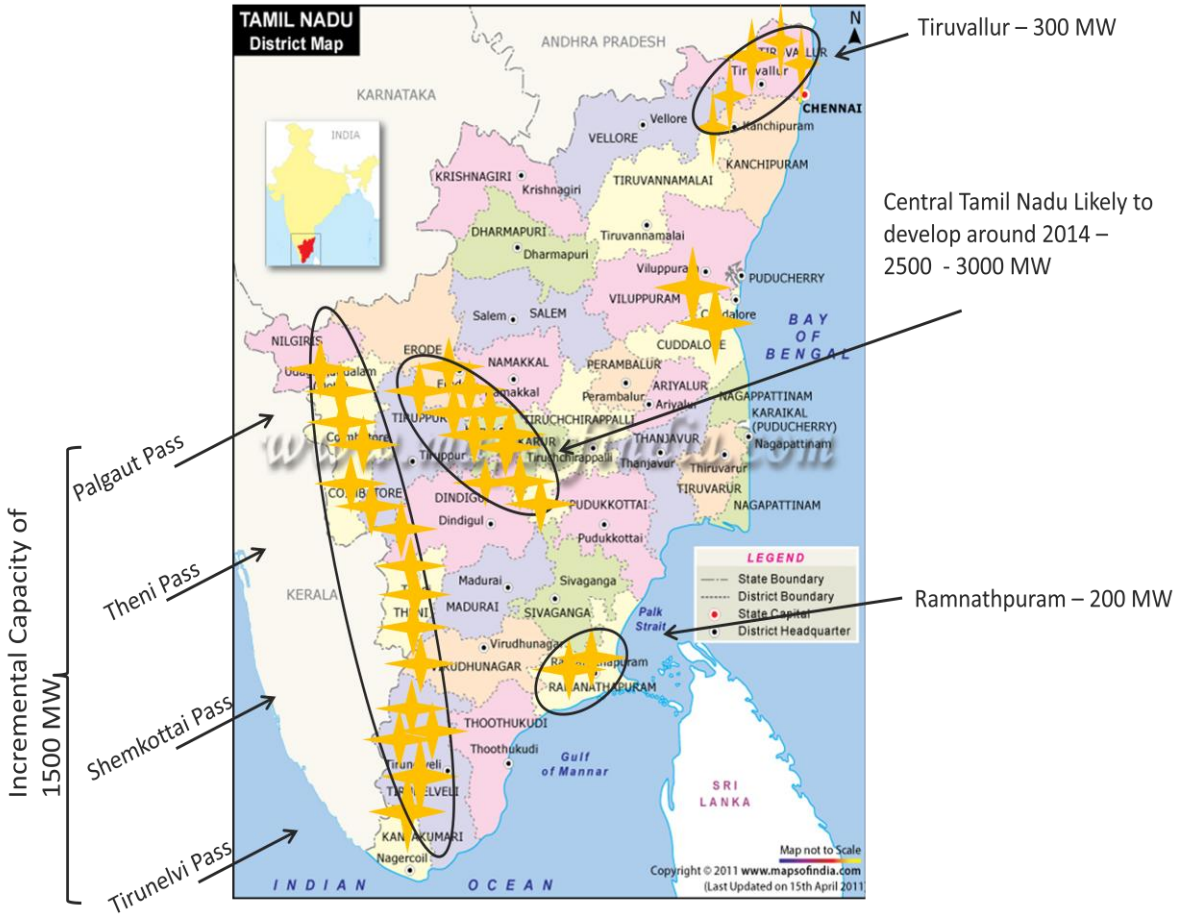


3.5 Likely capacity addition in Tamil Nadu

As per the discussions with the Tamil Nadu Electricity Board (TNEB) and Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO), wind-based power in Tamil Nadu is going to grow substantially in the coming 5 years. It is noted that around 11,000 MW of applications are registered with TNEB. This year, the state is expected to install a capacity of around 1,200–1,400 MW (653 MW already commissioned in the state as on October 2011).

Based on the intent of developers and the availability of land, the incremental capacity Tamil Nadu is estimated to be around 8,000 MW, out of which, around 5,000 MW is likely to come during the 12th Plan period. The figure below provides the information on the wind pockets available in Tamil Nadu where the likely capacity addition is envisaged.

Figure 7: Wind pockets in Tamil Nadu to be developed during 12th Plan



However, there are constraints in achieving capacity addition in the state. The key constraints identified from the discussions with Tamil Nadu Transmission Corporation Limited (TANTRANSCO) and developers are as follows:

3.5.1 Inadequate transmission capacity to evacuate additional power

The following table provides the details of transmission issues in Tamil Nadu.

Table 21: Transmission issues in Tamil Nadu

Particulars	Transmission issues in Tamil Nadu
Major wind pockets	Tirunelveli, Udumalpet, Muppandal, and Theni areas
Current capacity of evacuation infrastructure	About 3,000 MW
Transmission projects in pipeline	• Tirunelveli (TNEB) (TN wind/Kanarapatty) 400/230 kV S/S, 3 × 315 MVA • Tirunelveli (TNEB)-Tirunelveli (PG), 400 kV Quad D/C line • Five 230/33 kV wind energy substations at Marandai, Sayamalai, Vagaikulam, Kumarapuram, and Sankaralingapuram and one 230/110 kV Samugarangapuram substation with associated 230 kV

Particulars	Transmission issues in Tamil Nadu
	lines connecting with Kanarapatty 400 kV S/S • Kanaraptty (TN Wind)-Kayathar 400 kV, 400 kV D/C line • Kayathar-Karaikudi, 400 kV D/C Quad line • Karaikudi-Pugalur 400 kV D/C Quad line • Establishment of 400/230-110 kV S/S with 2 × 315 MVA 400/230 kV ICT, and 2 × 200 MVA 400/110 kV ICT at Kayathar • Pugalur–Sholinganallur (Ottiampakkam) 400 kV D/C Quad line
Remarks	At the time of planning of the above transmission system in 2007, wind generation in Tamil Nadu was about 2,900 MW. At present, wind power in Tamil Nadu has enhanced to about 6,500 MW, and therefore, the existing transmission capacity in the state is inadequate. This could further hamper the connectivity of additional wind capacity (proposed about 5,000 MW addition up to 2016-17).
Incremental capacity	Total 8,000 MW capacity addition envisaged
Status of implementation	Lagging by 4 years as reviewed in June 2011

Source: CRIS analysis based on the discussions with the nodal agency, transmission utility, and developers

3.5.2 Grid management during high-wind season

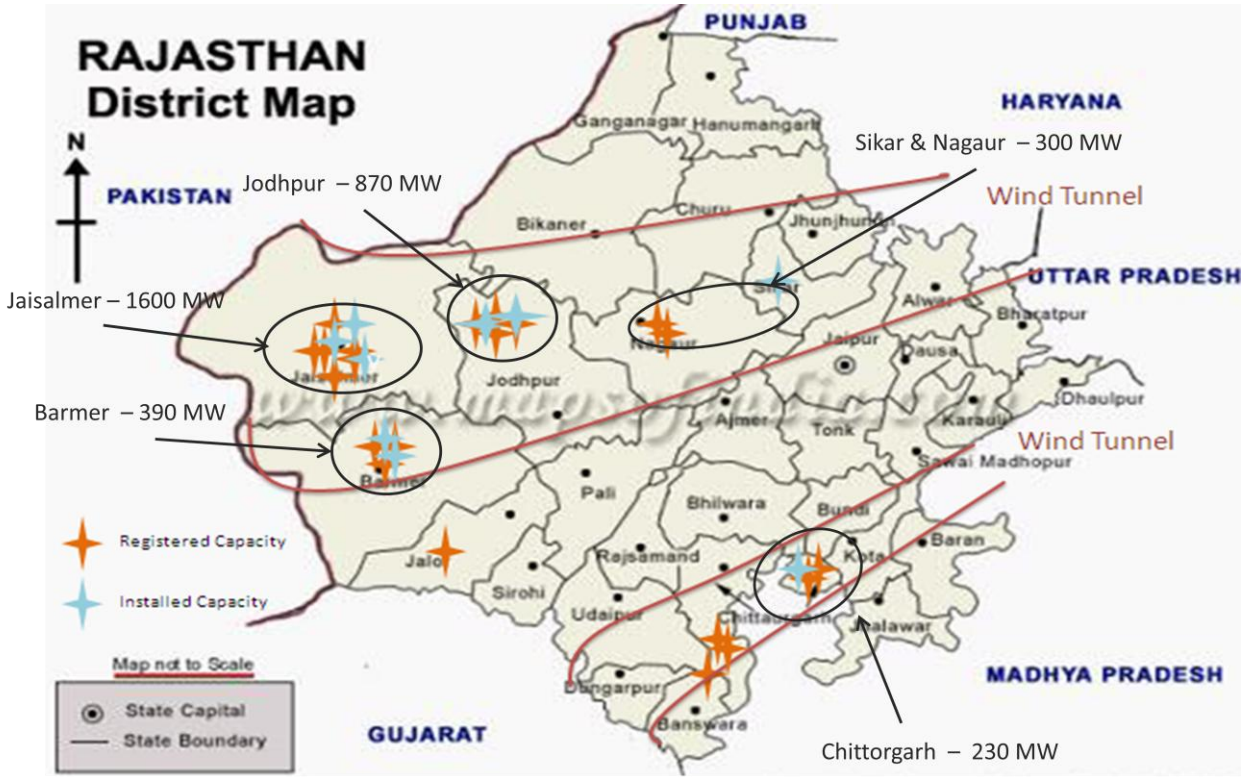
Tamil Nadu procures around 14%-15% of the total capacity from wind resources, and these wind power plants are treated as must run stations. Due to the infirm nature of wind generation and its poor predictability, during the higher windy and less demand season, Tamil Nadu is increasingly finding it difficult to absorb higher quantum of wind power. In this regard, linking of the Southern Grid with the National Grid, freely allowing open access and third party sale within and outside the state/region, as well as improving forecasting tools will be critical for further harnessing the potential of wind power in the state.

The key takeaway is that the lack of evacuation infrastructure and connectivity of the Southern Grid to the National Grid can be detrimental to the growth of wind power projects in Tamil Nadu.

3.6 Likely capacity addition in Rajasthan

As per the discussions with Rajasthan Renewable Energy Corporation Limited, the capacity addition through wind power in Rajasthan is going to grow substantially in the 12th Plan period. The figure below provides the information on the wind pockets available in the state of Rajasthan where the likely capacity addition is envisaged.

Figure 8: Wind pockets in Rajasthan to be developed during 12th Plan



The table below gives the district-wise registered capacities of the state, totalling 10,167.55 MW.

Table 22: District-wise registered capacity in Rajasthan

District	Installed capacity (As on 31.03.2011) (MW)	Registered capacity (As on Sep 2011) (MW)
Banswara	-	440.00
Barmer	9.60	253.70
Chittorgarh	2.92	55.50
Jaisalmer	1208.12	7413.80
Jalore	-	10.00
Jodhpur	288.75	1484.85
Nagaur		163.20
Pratapgarh		211.50
Sikar	12.00	-
Unidentified Sites		135.00
Total	**1521.40**	**10167.55**

Out of around 10,000 MW of projects allocated till date, land has already been identified for approximately 5,000 MW of wind projects. Thus, the 'potential' incremental capacity in Rajasthan is estimated to be at least 5,000 MW, out of which, around 4,000 MW is likely to come during the 12th Plan period. However, several challenges are envisaged in the achievement of these targets. The challenges are outlined below.

3.6.1 Inadequate transmission and evacuation infrastructure

Based on the discussions with the state nodal agency, various developers, and the transmission utility, the current evacuation capacity has been identified to be around 1,600 MW. The available 1,600 MW is required to evacuate solar power as well. Therefore, if the required evacuation infrastructure is not provided, the likely capacity addition in the state in the coming years would slow down. The table below provides details regarding transmission issues in the state.

Table 23: Transmission issues in Rajasthan

Particulars	Transmission issues in Rajasthan
Major wind pockets	Jaisalmer, Jodhpur, and Barmer areas
Current capacity of evacuation infrastructure	About 1,600 MW
Transmission projects in pipeline	25-km long, 220 kV 300 MW at Mulana-Akal, 40-km long 220 kV 300 MW Tejuwa–Ramgarh
Remarks	Rajasthan Vidyut Prasar Nigam Limited transmission projects - 400 kV Akal-Jodhpur line completion is pending for funding. It is required to expedite the 400 kV Ramgarh substation work, 400 kV Ramgarh-Bhadla, 400 kV Bhadla-Bikaner, and 400 kV Bhadla-Jodhpur transmission line work, which has been lagging behind for the past 2 years.
Incremental Capacity	5,000 MW capacity addition envisaged
Status of Implementation	Lagging by 1 to 2 years

Source: CRIS analysis based on the discussions with the nodal agency, transmission utility, and developers

Therefore, lack of evacuation infrastructure could be a deterrent to the growth of wind power projects in the state of Rajasthan. Jodhpur, Jaisalmer, and Barmer areas have significant wind potential, but lack evacuation infrastructure.

3.7 Likely capacity addition in Maharashtra

Based on the discussions with the Maharashtra Energy Development Agency (MEDA) as well as developers, the potential incremental capacity in the state of Maharashtra is estimated to be around 7,000 MW, out of which, around 1,500 MW is likely to come during the 12th Plan period. The figure below provides the information on the wind pockets available in Maharashtra where the likely capacity addition is envisaged.

Figure 9: Wind pockets in Maharashtra to be developed during 12th Plan

The challenges for the development of wind power projects in the state are as follows.

3.7.1 Land acquisition problems

Acquisition of land is the single most critical issue in Maharashtra. In the past, many projects got delayed or cancelled because of the difficultly in land acquisition. This also leads to substantial increase in the cost of land. It is noted that the cost of land (in terms of per MW) in Maharashtra is higher than that in many other states in India. A single-window clearance mechanism and a clear land acquisition policy are required for faster implementation of wind projects in the state.

3.7.2 Transmission evacuation capacity

Although the existing transmission capacity of around 2,400 MW is adequate for the evacuation of wind power of 1,500 MW considered for the 12th Plan, strengthening of the local transmission network as well as additional transmission capacity will be required. Right of way for transmission projects poses significant problems for the developers.

Table 24: Transmission issues in Maharashtra

Particulars	Transmission issues in Maharashtra
Major wind pockets	Nandurbar, Sinnar, Nagar, Satara, and Sangli areas
Current capacity of evacuation infrastructure	About 2,400 MW
Transmission projects in	65-km long 220 kV, 170 MW at Adwadi-Bableshwar, 15-km long

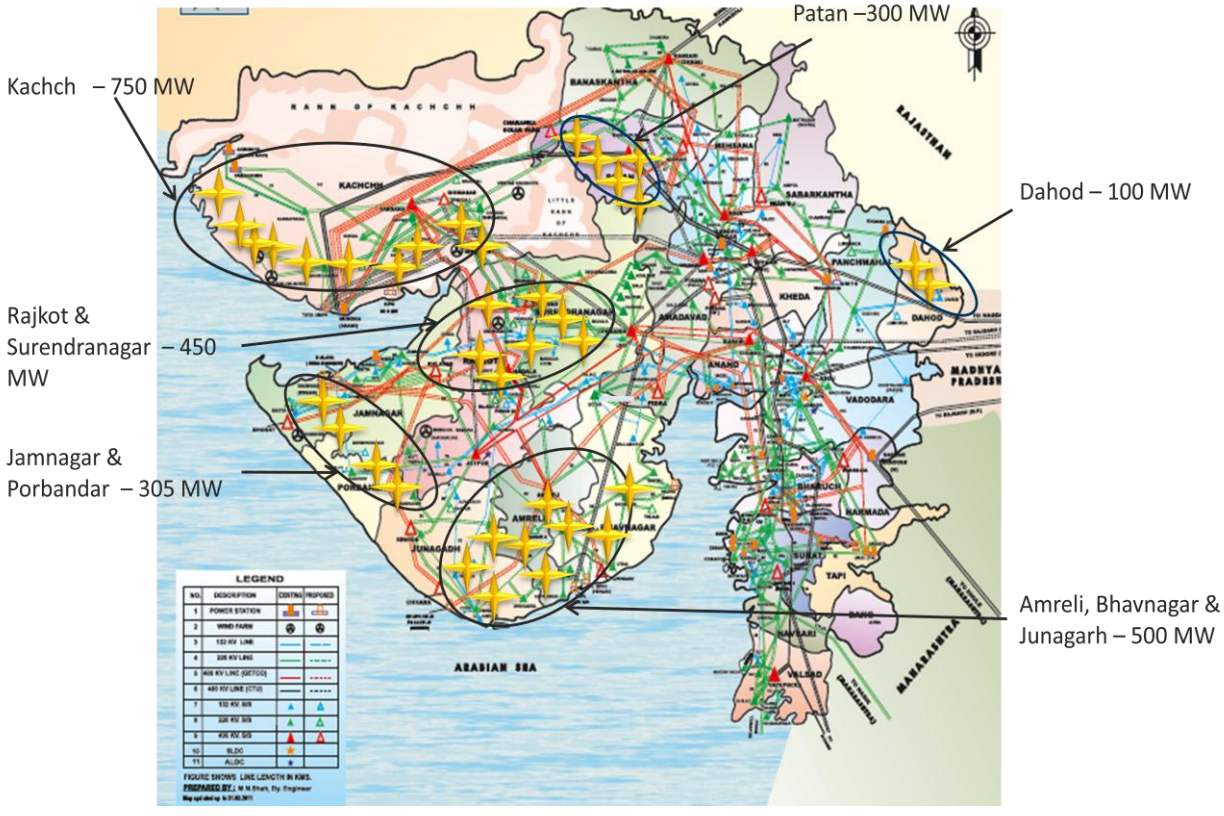
Particulars	Transmission issues in Maharashtra
pipeline	33 kV 65 MW at Supa-Nagar, 23-km long 132 kV 100 MW at Sautada-Raimoha
Remarks	220 kV S/C 570 sq mm AAAC Moose, 110-km long transmission line from Gangapur to Satara, and 220 kV S/C 570 sq mm from Gangapur to Malegaon - 110-km length have not been commissioned due to pending forest clearance. Work is held up in about 22 km of forest area. Due to this, the power flow from the wind farms is restricted. The restricted power is in the order of 170 MW and this could aggravate in future. Higher right of way issues also cause delays in the commissioning schedule.
Incremental capacity	7,000 MW capacity addition envisaged
Status of implementation	Implementation lagging by 3 years

The key takeaway is that the state has a huge incremental potential of 7,000 MW, which can be harnessed in future. But, the issues related to land acquisition and right of way have led to a staggered growth of wind power projects in the state.

3.8 Likely capacity addition in Gujarat

The figure below provides the information on the wind pockets available in the state of Gujarat where the likely capacity addition is envisaged.

Figure 10: Wind pockets in Gujarat to be developed during 12th Plan



As per the discussions with the Gujarat Energy Development Agency (GEDA) and Gujarat Electricity Transmission Company (GETCO), the applications received for evacuation of power from projects aggregate to around 10,000 MW. Out of these, approximately 70%, i.e., 7,000 MW, of the projects have been accorded clearance. Therefore, it is estimated that the potential incremental capacity in the state of Gujarat is estimated to be around 6,000 MW, out of which, around 2,500 MW is likely to come during the 12th Plan period.

The key takeaway is that the state has a huge incremental potential of 6,000 MW, which can be harnessed during the 12th Plan and subsequent plan periods. It is also noted that the state government is taking adequate measures to provide the required evacuation and transmission infrastructure. However, the state is also seeking the option of evacuating power outside the state through adequate transmission capacity in the long term as well as pro-active and progressive inter-state power evacuation and an open access policy.

3.9 Likely capacity addition in Karnataka

The immediate potential incremental capacity in the state of Karnataka is estimated to be around 5,000 MW, out of which, around 3,000 MW is likely to come during the 12th Plan period. Figure 11 provides the information on the wind pockets available in Karnataka where the likely capacity addition is envisaged in 12th Plan period based on the discussion with developers.

Figure 11: Wind pockets in Karnataka to be developed during 12th Plan (CRIS estimation)

Pockets	Estimated Capacity
Belgaum	500
Bellary	130
Chikmangalur	80
Chitradurg	200
Davanagar	240
Dharwar	150
Gadag	200
Hassan	400
Mysore	130
Raichur	160
Bijapur	300
Gulbarga	300
Shimoga	110.6
Total	2900

The target for the 12th Plan period of 3,000 MW is low as compared to the estimated potential of 11,000 MW by MNRE. Further, the state agencies have also provided the information on wind pockets to be developed in 12th plan; projecting the likely capacity addition of around 3,300 MW as provided in Figure 12 below has been considered for building up Scenario – 2.

Figure 12: Wind pockets in Karnataka to be developed during 12th Plan (State agency estimation)

Pockets	Estimated Capacity
Bagalkote	111
Belgaum	527
Bellary	230
Bijapur	197
Chikmangalur	200
Chitradurga	210
Davanagere	443
Gadag	119
Hassan	35
Haveri	446
Kolar	33
Kopal	494
Mysore	8.25
Raichur	96
Shimoga	76
Total	**3223**

The key constraints in the development of huge incremental wind power potential in the state are as follows.

3.9.1 Forest land

Karnataka has a number of good windy sites but is not able to develop them because of forest issues. It is noted that many of the land available for installation of wind projects in Karnataka is forest and revenue land. The procedure for the change of land use and other clearances is lengthy. A single-window clearance policy and usage of land patches limited to turbine/tower width could encourage faster acquisition of land.

3.9.2 Connectivity of Southern Grid

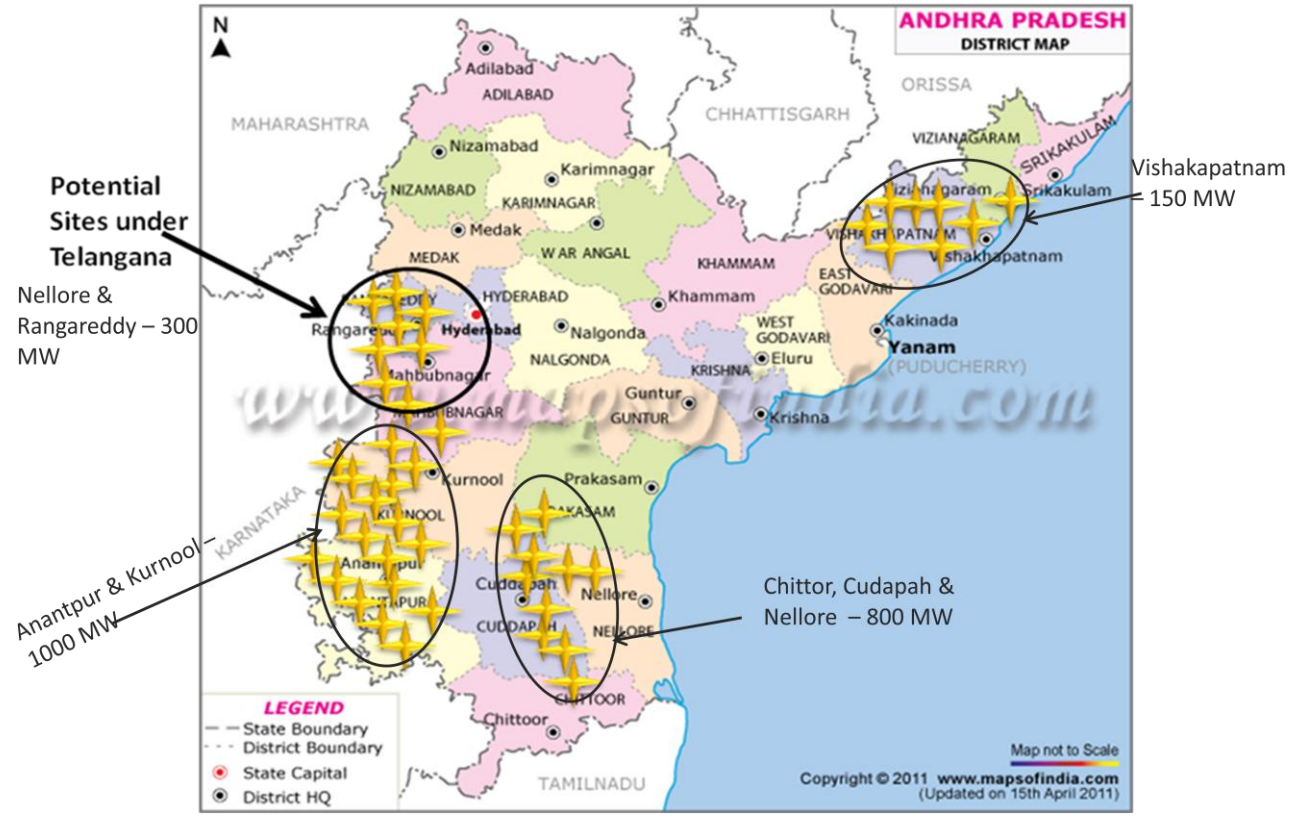
Similar to the situation of Tamil Nadu, it is very important for the Southern Grid to get connected to the National Grid. This will encourage higher capacity addition in the state of Karnataka.

The key takeaway is that the state has a huge incremental potential of 5,000 MW, which can be harnessed in future. However, if the Southern Grid is not connected to the National Grid by 2014, the capacity will be constrained from the current estimation.

3.10 Likely capacity addition in Andhra Pradesh

Andhra Pradesh has the third largest potential in the country. The incremental capacity in the state is estimated to be around 8,000 MW, out of which, around 2,000 MW is likely to come during the 12th Plan period. This figure is quite low compared to the estimated potential by MNRE of around 9,000 MW. The figure below provides the information on the wind pockets available in the state where the likely capacity addition is envisaged.

Figure 13: Wind pockets in Andhra Pradesh to be developed during 12th Plan



However, state agencies have given an optimistic estimate of around 5,000 MW during 12th Plan period, which can be achieved is as follows:

Table 25: Proposed capacity addition in Andhra Pradesh (state agency estimation) – Scenario – 2

District	Proposed capacity addition (MW)
Anantpur	3,558
Cuddapah	768
Kurnool	423
Nellore	179
Prakasam	224
Rangareddy	100
Total	**5,047**

The major bottlenecks and constraints in achieving the envisaged potential in the state are as follows.

3.10.1 Low feed-in tariffs in the state

The assumptions and methodology adopted by the Andhra Pradesh Electricity Regulatory Commission (APERC) for the determination of feed-in-tariffs for wind projects is different from CERC. Because of this difference, there are wide variations in the tariffs, leading to uncertainty for the investors as well as non-viability of the projects in the state. It is noted that the feed-in tariff in Andhra Pradesh based on the tariff regulation approved by CERC is Rs. 4.63/kWh, whereas the tariff approved by APERC is Rs. 3.50/kWh. Because of the low tariff regime in the state, capacity addition has been poor despite the huge wind potential in the state.

3.10.2 Many sites available for installation of projects under Telangana area

It is noted that many sites with high wind potential fall under the Telangana area. Decision on the proposed bifurcation of the state as well as the socio-political scenario will be critical for higher capacity in the state. In fact, Andhra Pradesh can become a leader in future capacity additions if the regulatory and political environment becomes conducive and stable.

3.11 Likely capacity addition

3.11.1 Methodology adopted

In order to estimate the pipeline of wind projects, wind projects in each state are mapped against the milestones achieved like registration of projects, transmission and land approval, and approved detailed project reports (DPR). This was done in consultation with important stakeholders involved in the implementation of grid-connected wind power projects. The brief outline of the methodology adopted is as follows:

a. The project pipeline is built state wise, to assess the likely capacity addition in the state, year on year, on the basis of land availability only till the implementation of the 12th Plan period.

b. An assessment of transmission infrastructure availability and the regulatory environment in the states, which impact the timely commissioning of projects, is made, and the likely capacity addition is projected in a constrained environment. The likely constraints in the achievement of targeted capacity addition are then mapped state wise.

c. A rough estimation of the achievable potential and the likely capacity addition during the 12th Plan is made.

3.11.2 Assumptions

The assumptions made for projecting the installed capacity includes the state wise generation and capacity utilization factors (CUF) for wind are follows:

Table 26: Installed Capacity and Generation till 2011

States	Installed Capacity (MW)*	Generation (MUs)*	CUF (%)
Tamil Nadu	5887	8720	27.15
Karnataka	1512	2842	26.50
Andhra Pradesh	177	309	24.50
Maharashtra	2310	4114	22.00
Gujarat	2094	3669	23.00
Rajasthan	1521	1552	20.00
Madhya Pradesh	100	175	22.50
Orissa		0	22.00
Chhattisgarh		0	22.00
Jharkhand		0	22.00
Total	**13601**	**21382**	

* *Till March, 2011 only*

[Source: MNRE; Discussions with State Renewable Agencies]

3.11.3 Likely capacity addition

3.11.3.1 Scenario – 1

The year-wise likely capacity addition is estimated assuming a constraint on land availability. Further, based on the discussion with state nodal agencies and developers, the likely capacity addition for wind under both the scenarios estimated, as follows.

Table 27: Year-wise capacity addition (Scenario – 1)

State	Remarks	FY 12 (E) (MW)	Year-wise capacity addition (MW)				
			FY 13	FY 14	FY 15	FY 16	FY 17
Tamil Nadu	TNEB estimate	1,200	1,000	1,000	1,000	1,000	1,000
Karnataka	KREDL estimate	530	530	599	599	599	599
Andhra Pradesh	Corroborated estimate	400	400	400	400	400	400
Maharashtra	MEDA estimate	300	300	300	300	300	300
Gujarat	GEDA estimate	503	500	500	500	500	500
Rajasthan*	Corroborated estimate	654	739	739	686	634	581
Madhya Pradesh	Corroborated estimate	150	150	150	150	150	150
Orissa	Corroborated estimate		50	100	100	100	50
Chhattisgarh	Corroborated estimate		50	100	100	100	50
Jharkhand	Corroborated estimate		50	100	100	100	50
Total		**3,734**	**3,769**	**3,988**	**3,935**	**3,883**	**3,680**

**Based on past conversion rate of registered projects into installed projects*

Table 28: Year-wise capacity addition (Scenario – 2)

State	Remarks	FY 12 (E) (MW)	Year-wise capacity addition (MW)				
			FY 13	FY 14	FY 15	FY 16	FY 17
Tamil Nadu	TNEB estimate	1,200	1,000	1,000	1,000	1,000	1,000
Karnataka	Information submitted by	530	620	600	700	780	523

State	Remarks	FY 12 (E) (MW)	Year-wise capacity addition (MW)				
	state						
Andhra Pradesh	Information submitted by state	210	1,503	1,435	257	1,202	650
Maharashtra	MEDA estimate	300	300	300	300	300	300
Gujarat	Information submitted by state	500	2,633	300	1,150	500	500
Rajasthan	Information submitted by state	579	400	400	400	400	400
Madhya Pradesh	Corroborated estimate	150	150	150	150	150	150
Orissa	Corroborated estimate		50	100	100	100	50
Chhattisgarh	Corroborated estimate		50	100	100	100	50
Jharkhand	Corroborated estimate		50	100	100	100	50
Total		**3,470**	**6,756**	**4,485**	**4,257**	**4,632**	**3,673**

**Based on past conversion rate of registered projects into installed*

It is noted that most of the state-wise constraints have been identified and are being addressed to a great extent through the intervention of entities like MNRE, CERC, and SERCs. Therefore, we expect that the capacity addition in the initial years of the 12th Plan period may be at a sluggish pace, but the growth rate would be higher during the later years.

4. Assessment of solar potential and likely capacity supply scenario

The effective utilization of India's solar potential will depend on the successful implementation of the Jawaharlal Nehru National Solar Mission (JNNSM). This chapter primarily focuses on the assessment of the solar potential and likely capacity additions during the 12th Plan period based on four broad parameters (policy and regulations, solar radiation potential, infrastructure, and financing) and the discussions held with various stakeholders (MNRE, FOR, developers, state nodal agencies, state utilities, and financing agencies).

4.1 Background

The solar energy sector in India has received great impetus since the announcement of the Gujarat Solar Policy in January 2009, which is a milestone in India's solar energy development programme. The Government of India announced the Jawaharlal Nehru National Solar Mission (JNNSM) on 23rd November 2009, which was launched on 11th January 2010. The mission seeks to kick-start solar generation capacities, drive down costs through local manufacturing, and boost research & development (R&D) in order to accelerate the transition to clean and secure energy.

The key driver promoting solar power projects has been the solar-specific RPOs. As per the solar mission, the solar power purchase obligation for states may start with 0.25% in Phase I and go up to 3% by 2022. Developers will have the option of participating in the solar-specific REC mechanism or availing benefits from the feed-in tariff. The RECs will also allow states with relatively poor solar resources to meet their RPO commitments. Several estimates have been made on solar power potential, and most of them have identified the feasible solar power potential in India to be more than 100,000 MW. This potential coupled with the thrust from the government to develop solar power, has made investments in solar power very attractive to solar developers. The key aspects related to solar power are as follows.

4.1.1 Ambitious targets of National Solar Mission

The targets for grid-connected solar power for the three phases of the mission are as follows:

- Phase 1: 1,000-2,000 MW by 2013
- Phase 2: 4,000-10,000 MW by 2017
- Phase 3: 20,000 MW by 2022

At the launch of the National Solar Mission, these targets appeared aggressive. But after the two rounds of bidding for NTPC Vidyut Vyapar Nigam Limited Phase I projects, these targets were found to be achievable considering the focus and support of the government. A moderate achievement of mission targets (4,000-10,000 MW solar power by 2017), considering a normal fructification rate of project proposals and interest of investors, could lead to a figure of 4,000-6,000 MW of solar power by 2015. Solar power developers have shown interest in setting up solar power projects in various states.

4.1.2 Pipeline of solar projects

The pipeline of solar project proposals/registration in the major states is as mentioned below.

- In Rajasthan, 16,900 MW solar power projects have been registered, out of which, 100 MW is expected to come up in 2011-12.
- In Gujarat, 968.5 MW solar power project PPAs have been signed with various developers, out of which, 250 MW is expected to come up in 2011-12.
- Tamil Nadu is likely come up with a state solar policy of 3,000 MW, out of which, a 20 MW solar power project is expected to come up during 2011-12.
- In Karnataka, 275 MW of solar projects have been allocated by the state.
- In Maharashtra, a target of 525 MW of solar power projects has been set for the 12th Five Year Plan period.

Considering the above points, about 9,000–10,000 MW solar power is likely to be achieved by 2017. The total capacity by the end of June 2011 reached 46.68 MW.

4.2 Potential assessment

The daily average solar energy incident varies from 4-7 kWh per square metre of surface area depending on the location and time of the year. Solar radiation is available at most locations in the country for about 300 days in a year.

With the launch of JNNSM, the requirement of solar radiation data gains utmost importance as it is required by

- Solar project developers to design their projects optimally to achieve competitive costs of energy generation
- Financial institutions to be convinced about the viability of solar power projects
- The government to formulate policies backed by scientific rationale
- Regulators to determine levelised tariff.

The solar radiation data assumes critical importance as it impacts the viability of solar power projects, which are quite capital intensive. As of now, the measurement of global solar radiation, diffuse solar radiation, and direct normal incidence (DNI) is being carried out only at 39, 23, and 21 locations, respectively.

MNRE has also taken cognizance of the requirement of correct estimation of radiation data and has started the augmentation of the network of solar radiation resource assessment (SRRA) stations, to begin with, by setting up such stations at sites with high potential for solar power generation in the country. C-WET is implementing this project. 51 ground-monitoring stations are being set up, where all the relevant solar radiation parameters and associated weather parameters will be monitored.

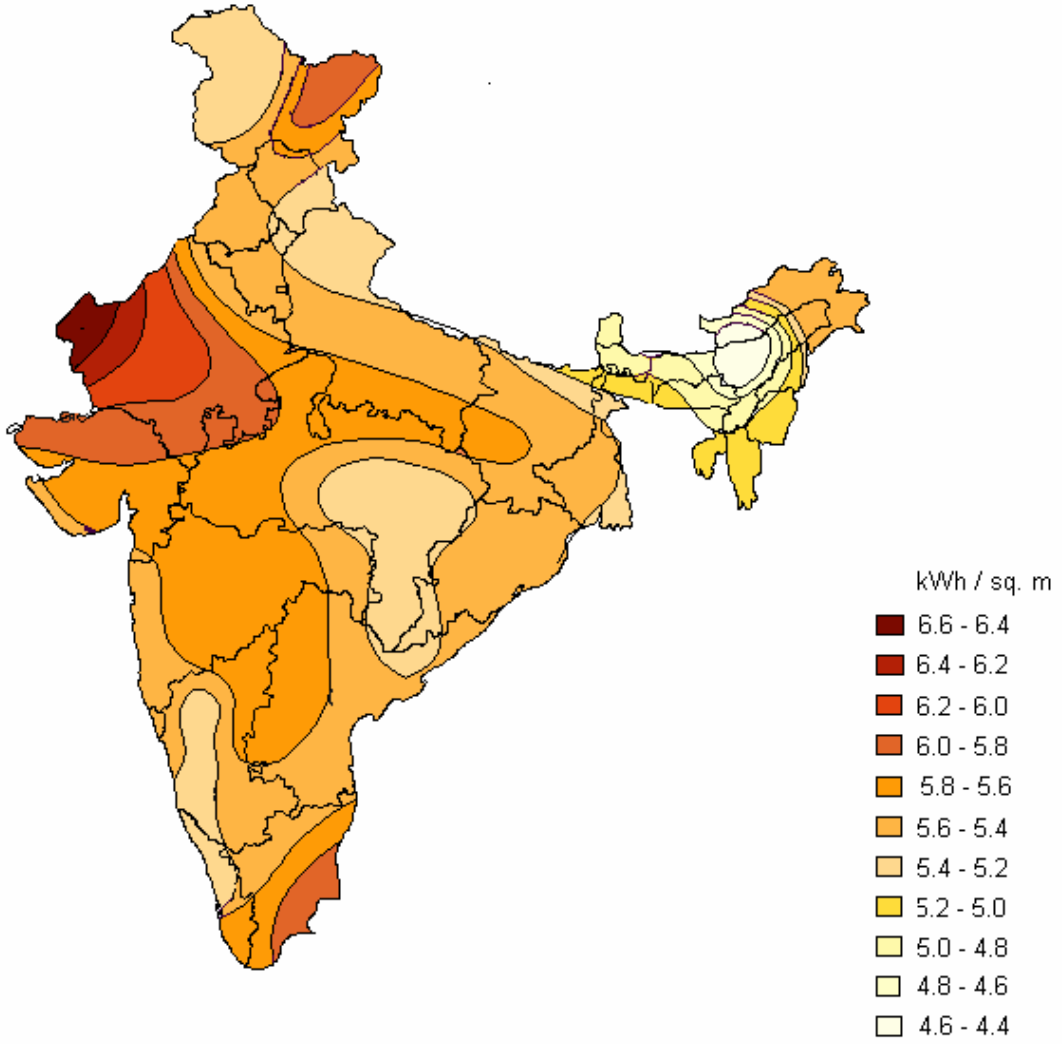
Table 29: State-wise distribution of SRRA sites

Sr. No.	State	No. of Sites
1.	Andhra Pradesh	7
2.	Chhattisgarh	1
3.	Gujarat	11
4.	Jammu and Kashmir	1
5.	Madhya Pradesh	3
6.	Maharashtra	3

Sr. No.	State	No. of Sites
7.	Karnataka	5
8.	Pondicherry	1
9.	Rajasthan	12
10.	Tamil Nadu	6

Source: MNRE

Figure 14: Solar radiation map of India



Source: TERI

The key takeaway is that the country has enormous solar energy potential. The daily average solar energy incident varies from 4-7 kWh per square metre of surface area depending on the location and time of the year. Gujarat and Rajasthan with excellent solar radiation and abundant land availability are the most suitable states for solar energy plants. Other suitable states are Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, Maharashtra, and Orissa. However, the solar energy potential in the country remains largely unutilized.

4.3 Existing policy and regulatory regime for solar power

The policy and regulatory regime emanated from the Electricity Act, 2003; the National Tariff Policy, 2006; the Gujarat Solar Policy; and the National Solar Mission as a part of NAPCC, that mandated SERCs to generate renewable electricity by providing connectivity and creating purchase obligations. The pro-solar policies adopted by the central and state governments include the following.

4.3.1.1 Tax exemption through accelerated depreciation

Investors can take advantage of tax exemption through accelerated depreciation of up to 80% of the project cost within the first year of commissioning of projects.

4.3.1.2 Income tax exemption and import duty waivers

Solar project developers are exempted from income tax on all earnings generated from the projects for any single 10-year period during the first 15 years of the project life. Besides, import duty on panels and other components is waived.

4.3.1.3 Feed-in tariff

Central and state electricity regulatory commissions have notified the feed-in tariff for electricity generated from solar sources. The tariffs applicable in various states are given in the following table.

Table 30: Solar – State-wise feed-in tariff

State	Wind energy tariff (Rs. per unit)
Gujarat	Solar PV: Rs. 15 (year 1-12), Rs. 5 (year 13-25) Solar Thermal: Rs. 11 (year 1-12), Rs. 4 (year 13-25)
Karnataka	Rs. 14.5 - Solar PV and Rs. 11.35 - Solar Thermal
Madhya Pradesh	Rs. 15.35 - Solar PV and Rs. 11.26 - Solar Thermal
Maharashtra	Rs. 13.10 - Solar PV and Rs. 12.85 - Solar Thermal
Rajasthan	Rs. 15.32 - Solar PV and Rs. 12.58 - Solar Thermal
Tamil Nadu	Rs. 14.34 (after availing the Accelerated Depreciation benefits)

4.3.1.4 RPO

Most of the SERCs have notified the solar RPO regulations for which the control period is ending in either 2013 or 2014. The solar RPOs announced by various SERCs are given in the table below.

Table 31: Solar RPO levels specified by states

State	FY 12	FY 13	FY 14
Assam	0.10%	0.15%	0.20%
Bihar	0.50%	0.75%	1.00%
Chhattisgarh	0.25%	0.5%	
Gujarat	0.5%	1%	
Haryana	0.25%	0.50%	0.75%

State	FY 12	FY 13	FY 14
Himachal Pradesh	0.01%	0.25%	0.25%
Jammu and Kashmir	0.10%	0.25%	
Jharkhand	0.50%	1.00%	
Karnataka	0.25%		
Kerala	0.25%	0.25%	0.25%
Madhya Pradesh	0.40%	0.60%	0.80%
Maharashtra	0.25%	0.25%	0.50%
Orissa	0.10%	0.15%	0.20%
Punjab	0.03%	0.07%	0.13%
Rajasthan	0.5%	0.5%	0.5%
Tamil Nadu	0.05%	To be declared	
Uttar Pradesh	0.50%	1.00%	
Uttaranchal	0.025%	0.05%	-

4.3.1.5 REC mechanism

The implementation of the REC mechanism has facilitated the transfer of the green attribute of the electricity generated from renewable sources of energy to the states with scarce RE potential. The first solar Photo Voltaic project was registered under the REC mechanism in October 2011 only.

4.4 Issues and constraints

Many of the solar power project developers having achieved various milestones like identification of projects and land acquisition are now waiting for the financial closure of the projects. This is a major bottleneck in achieving required solar project capacity addition. Further, the bankability of the projects allotted under the competitive bidding scheme has not yet been established. A single government or semi-government financing agency could act as the focal point for all applications to be processed (after detailed technical and commercial due diligence), and then, other financing institutions could take up these projects for financing.

The long approval processes and the inability of the state governments to provide single-window clearance to developers have made infrastructure the second most important barrier. Further, in Tamil Nadu and Rajasthan, the absence of evacuation infrastructure is the biggest constraint in capacity addition.

The other issues that are detrimental for the growth of solar power projects in India are as follows:

- India needs to set up its own solar radiation data collection stations in order to accelerate the development of solar power projects in the country. The success of a solar power project depends majorly on the correct assessment of the radiation data.
- The state nodal agencies could be involved to a larger extent and single-window clearance could be enabled to cut down the lead time faced by the developers at each step.

4.5 Likely capacity addition

4.5.1 Methodology adopted

The pipeline for solar projects is estimated based on the consultation with important stakeholders including state nodal agencies, developers, and lenders. The brief outline of the methodology adopted is as follows:

a. The state-wise achievable potential for solar power projects is estimated on the basis of state policies.

b. The project pipeline is built state wise, to assess the likely capacity addition in the state, year on year, on the basis of land availability till the implementation of the 12th Plan period.

c. An assessment of transmission infrastructure availability and the regulatory environment in the states, which impact the timely commissioning of projects, is made, and the likely capacity addition is projected in a constrained environment. The likely constraints in the achievement of the targeted capacity addition are then mapped state wise.

d. A rough estimation of the achievable potential and the likely capacity addition during the 12th Plan is made.

4.5.2 Assumptions

The assumptions made for projecting the likely capacity addition includes the state wise installed capacity till March 2011 is based on data provided by MNRE, as follows:

Table 32: Installed Capacity of Solar Grid Connected Systems as of 31.03.2011

States	Installed Capacity (MW)
Andaman & Nicobar Islands	0.10
Andhra Pradesh	2.10
Arunachal Pradesh	0.03
Gujarat	11.00
Haryana	1.00
Karnataka	6.00
Kerala	0.03
Madhya Pradesh	0.10
Maharashtra	4.00

States	Installed Capacity (MW)
Orissa	1.81
Punjab	2.33
Rajasthan	7.65
Tamil Nadu	6.05
Uttar Pradesh	0.38
Uttarakhand	0.05
West Bengal	1.15
Total	**43.76**

[Source: MNRE]

The capacity utilization factors (CUF) of solar PV and thermal used for projecting the energy generated by solar systems during the 12th plan period are based on the discussions with State Nodal Agencies and interaction with Solar developers. Since the solar resource assessment is being undertaken by MNRE, therefore normative capacity utilization factors as per CERC tariff order have been used for projecting the generation from solar systems.

Table 33: Normative Capacity Utilization Factors for Solar

Solar Systems	CUF	Weightage
Solar PV	19%	75%
Solar Thermal	23%	25%
Average CUF	**20%**	

[Source: Interaction with State Nodal Agencies and Solar developers]

4.5.3 Likely capacity addition

The year-wise likely capacity addition is estimated based on the solar policies and the discussions with state nodal agencies, further validated by developers.

Table 34: Likely capacity addition for solar power for Scenario – 1 and Scenario – 2

States	Installed till 2011 (MW)	FY 12 (E) (MW)	Remarks	Year-Wise Capacity Addition (MW)				
				FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	2.1	5	Based on estimation of state nodal agencies	10	10	20	20	20

States	Installed till 2011	FY 12 (E)	Remarks	Year-Wise Capacity Addition (MW)				
Gujarat*	11	250	Based on GEDA estimates	209	331	331	441	560
			Based on figures validated by developers	300	400	400	500	550
Karnataka	6	40	Estimates provided by KREDL	40	40	40	40	40
Maharashtra	4	0	Estimates provided by MEDA	100	125	125	75	75
Orissa	1.81	5	Based on estimation of state nodal agencies	10	10	20	20	20
Rajasthan	7.65	100	Based on the comments of RRECL Capacity registered is 17000 MW, but only 3500 MW is likely to get commissioned	500	500	700	700	1000
Tamil Nadu	6.05	20	Based on discussions with TEDA and election manifesto of the state	100	500	700	700	1000
Total		**420**		**1,060**	**1,585**	**2,105**	**2,055**	**2,705**

5. Assessment of small hydro potential and likely capacity supply scenario

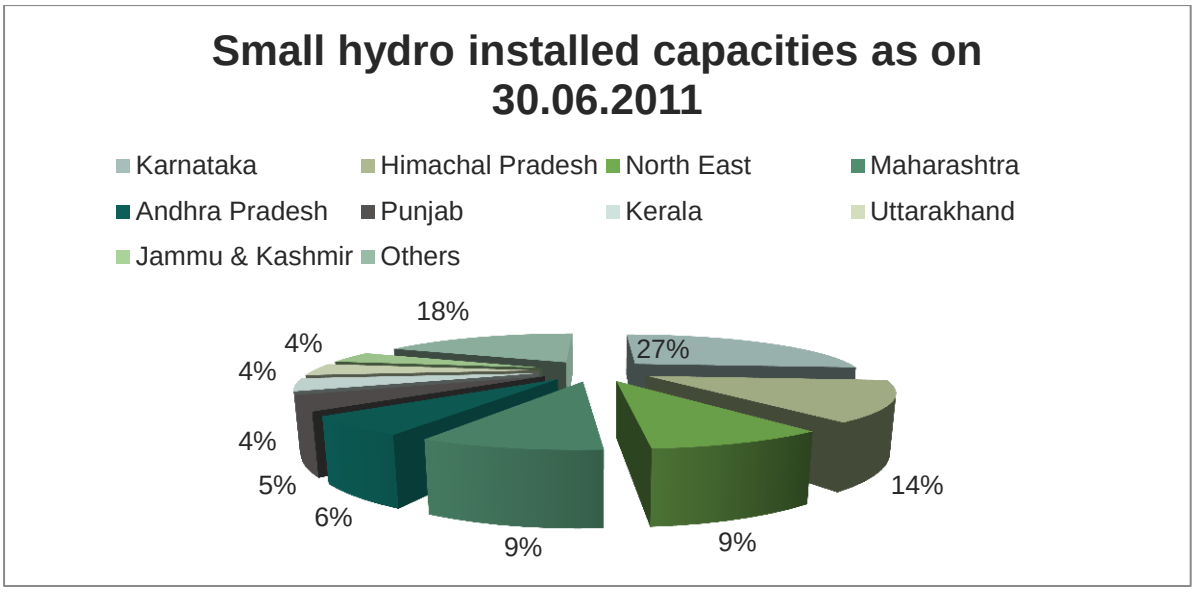
This chapter primarily focuses on the assessment of the small hydro potential and likely capacity additions during the 12th Plan period based on four broad parameters (policy and regulations, potential, infrastructure, and financing) and the discussions with various stakeholders (MNRE, FOR, developers, state nodal agencies, state utilities, and financing agencies).

5.1 Background

Hydropower represents the use of water resources towards inflation-free energy due to the absence of fuel cost, mature technology, and a high plant load factor. Out of the total installed capacity in India of 176,990 MW (June 2011), hydropower contributes about 21.5%, i.e., 38,106 MW. The total hydroelectric power potential in the country is assessed at about 150,000 MW, equivalent to 84,000 MW at 60% load factor. The potential of small hydropower projects is estimated at about 15,000 MW. While the Ministry of Power, Government of India, deals with large hydro projects, the responsibility of small hydropower development rests with MNRE.

Table 35: Small hydro – State-wise installed capacities as on 31.06.2011

State	Small hydropower (MW)
Karnataka	820.85
Himachal Pradesh	418.96
North East	275.69
Maharashtra	275.13
Andhra Pradesh	191.43
Punjab	154.50
Kerala	136.87
Uttarakhand	134.62
Jammu and Kashmir	129.33
Others	568.26
Total	**3,105.64**



Most of the small hydropower projects are driven by large private investment. Generally, the projects are economically viable and the private sector is showing lot of interest in setting up small hydropower projects. The viability of these projects improves with the increase in the capacity of the projects. These projects have the potential to meet the power requirements of remote and isolated areas. These factors make small hydropower projects one of the most attractive renewable sources for grid-quality power generation.

5.2 Potential assessment

The estimated potential of power generation in the country from small/mini hydropower projects is about 15,500 MW. Almost 50% of the total estimated potential lies in the states of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Arunachal Pradesh. In the plain region, Maharashtra, Chhattisgarh, Karnataka, and Kerala have a sizeable potential. State-wise details of the potential are given in the table below.

Table 36: Small hydro potential

State	Potential (MW)	Installed capacity (MW)	Projects under implementation (MW)	Gap (MW)
Andaman and Nicobar Islands	7.27	5.25	0	2.02
Andhra Pradesh	560.18	191.43	63.25	305.5
Arunachal Pradesh	1,328.68	78.84	47.67	1,202.18
Assam	238.69	27.11	15	196.58
Bihar	213.25	59.80	24.1	129.35
Chhattisgarh	993.11	19.05	148.2	825.86
Goa	6.5	0.05	0	6.45
Gujarat	196.97	15.60	0	181.37
Haryana	110.05	70.10	3.4	36.55

State	Potential (MW)	Installed capacity (MW)	Projects under implementation (MW)	Gap (MW)
Himachal Pradesh	2,267.81	429.46	132.25	1,706.10
Jammu and Kashmir	1,417.80	129.33	8.91	1,279.56
Jharkhand	208.95	4.05	34.85	170.05
Karnataka	747.59	851.65	141.68	
Kerala	704.10	136.87	65.55	501.68
Madhya Pradesh	803.64	86.16	4.9	712.58
Maharashtra	732.63	275.13	91.2	366.31
Manipur	109.13	5.45	2.75	100.93
Meghalaya	229.8	31.03	1.7	197.07
Mizoram	166.93	36.47	0.5	129.96
Nagaland	188.98	28.67	4.2	156.11
Orissa	295.47	64.30	3.6	227.57
Punjab	393.23	154.50	21.15	217.58
Rajasthan	57.17	23.85	0	33.32
Sikkim	265.55	52.11	0.2	213.24
Tamil Nadu	659.51	113.05	20.5	525.96
Tripura	46.86	16.01	0	30.85
Uttar Pradesh	460.75	25.1	0	435.65
Uttarakhand	1,577.44	134.62	229.45	1,213.37
West Bengal	396.11	98.4	84.25	213.46
Total	**15,384.15**	**3,163.43**	**1,149.26**	**11,317.20**

The key takeaway is that the state of Karnataka has already surpassed the estimated potential for small hydropower, which highlights the importance of correct estimation of small hydro resource. The states with abundant and unused potential are Arunachal Pradesh, Uttarakhand, Jammu and Kashmir, and Himachal Pradesh. These states could be the driver for further harnessing small hydropower in the country.

It is also highlighted that a comprehensive hydro potential assessment is required. We understand that MNRE has recommended a resource assessment to be carried out during the 12th Plan period.

5.3 Existing policy and regulatory regime for small hydropower

CERC had issued guidelines for determining tariff of power generated from small hydro projects, and SERCs, in their respective states, decide issues related to tariff and other conditions. 23 states have announced their policies to invite the private sector to set up small hydropower projects.

The enabling policies adopted by the central and state governments include the following:

- Schemes involving capital up to Rs. 5,000 millions need no prior clearance from the Central Electricity Authority. Besides, schemes involving capital up to Rs. 500 millions need no environmental clearance from the Ministry of Environment and Forests (MoEF).
- Income tax holiday is available for term loans through IREDA for capacities up to 25 MW.
- 100% income tax exemption is provided for any continuous block of 10 years in the first 15 years of operation.
- Providers of finance to such projects are exempted from tax on any income by way of dividends, interest, or long-term capital gains from investment made in such projects on or after 1st June 1998, by way of shares or long-term finance.
- Concessional customs duty @10% to 20% is available for non-captive use.
- For schemes up to 15 MW, there is no excise duty on turbines,
- Accelerated depreciation of 100% on specified renewable energy based devices or projects and accelerated depreciation of 80% in the first year of operation.
- MNRE subsidy on capital cost is extended to small hydro projects with capacity below 25 MW.

Further, for power projects with capacity ≤ 3 MW, the incentives are as follows:

- Incentives for detailed survey and investigation (DSI): 100% grant-in-aid subject to certain ceilings depending on the type of schemes
- Incentives for preparation of DPRs: Grant-in-aid of 50% of the DPR costs subject to certain ceilings depending upon the type of schemes
- Interest subsidy scheme through financial institutions
- For hilly regions (North-eastern region and Andaman and Nicobar Islands): Rs. 11.20 million/MW. Applicable project cost: Maximum Rs. 60 million/MW
- For non-hilly (other) regions: Rs. 3.83 million/MW. Applicable project cost: Maximum Rs. 40 million/MW

5.3.1 Policy incentives in various states for small hydropower projects

Table 37: Policy incentives in various states for small hydropower projects

Items	MNRE Guidelines	Himachal Pradesh	Tamil Nadu	Kerala	Karnataka
Power Wheeling	2%	2%	15%	12%	2% up to 1 MW 5% up to 3 MW 10% above 3 MW
Power Banking	1 year	Allowed with additional charges	Allowed for captive	At mutually agreed rate	Negotiable
Third Party Sale	At mutually agreed rate	Allowed	Not allowed	Allowed	Allowed
Royalty on Water	10% of electricity tariff	1-3 MW: 10% 3-15 MW: 12% Exemption for the first 5 years up to 1 MW	Included in power wheeling charges	Included in power wheeling charges	10% of prevailing electricity tariff
Capital			10% of cost	As extended to	

Items	MNRE Guidelines	Himachal Pradesh	Tamil Nadu	Kerala	Karnataka
Subsidy			of equipment Maximum Rs. 5 lakhs	other industries Maximum Rs. 5 lakhs Additional subsidy: 5% of cost of equipment Maximum Rs. 5 lakhs	
Electricity Duty Exemption	Yes	Exemption for 5 years			Exemption for 5 years for captive

5.3.2 Feed-in tariff

Central and state electricity regulatory commissions have notified the feed-in tariff for electricity generated from small hydropower projects. The tariffs applicable in various states are given in the following table.

Table 38: Small hydro projects – State-wise feed-in tariff

State	Small hydro projects tariff (Rs. per unit)
Andhra Pradesh	Rs. 2.69–1.92 (year 1-10)
Gujarat	Rs. 3.29 for FY 08 escalation @3%
Karnataka	Rs. 3.4 for 10 years
Madhya Pradesh	Rs. 5.40–3.73 (Year 1-30)
Maharashtra	Rs. 3.34
Himachal Pradesh	Rs. 2.95

5.3.3 REC mechanism

The status of small hydro projects registered as on 31st October 2011 under REC mechanism is as follows.

Table 39: State-wise registration status of small hydro projects under REC mechanism

Sr. No.	State	Small hydro (No. of units)	Small hydro (Capacity)
1	Gujarat	0	0
2	Maharashtra	9	37
3	Rajasthan	0	0
4	Tamil Nadu	0	0
5	Himachal Pradesh	3	21

Sr. No.	State	Small hydro (No. of units)	Small hydro (Capacity)
6	Jammu and Kashmir (JKSPDCL)	2	18
7	Chhattisgarh	0	0
8	Haryana	0	0
9	Uttar Pradesh	0	0
	Total	**14**	**75**

5.4 Issues and constraints

The pace of small hydropower development, which increased significantly during the first 4 years of the 11th Plan period (2008–2012), has now stabilized. Development has been relatively slow because of the following issues.

5.4.1 Implementation time

The implementation of small hydro projects is governed by the state policies, and the potential sites are allotted by the state governments to private developers. The process of allotment of sites and selection of developers is often time consuming and has been widely litigated. Delays in project development activities and in obtaining statutory clearances including land acquisition, forest clearance, and irrigation clearance also increase the gestation period.

5.4.2 Access to site

The implementation of projects is also affected due to difficult terrain and limited working season. The other problem relates to inadequate evacuation facilities and transmission links.

5.4.3 Hydrological and geological uncertainties

Small hydro projects, due to their inherent scale, do not undergo a thorough hydrological and geological investigation prior to project allotment or even construction. There have been instances in the past wherein a wide variation in generation has been observed as against the envisaged generation.

While geological uncertainties can be mitigated by employing reasonably advanced construction techniques, no such mitigation is possible in case of hydrological uncertainties, which impact the revenue generation of the projects.

In order to increase investor interest in small hydro projects, state agencies need to prepare a shelf of projects for allotment with reasonably good hydrological investigation.

In case of self-identified schemes promoted by various state governments, the risk due to such hydrological uncertainty should be borne by the developer during the stage of identification and investigation prior to allotment.

5.4.4 Feed-in tariff

Even though SERCs have announced the feed-in tariff, the following issues remain unaddressed:

- Some states have fixed/levelised tariff, whereas other states have incorporated escalation factors.
- The feed-in tariffs do not adequately compensate for the high resource and other operational risks that investors are likely to face over the 35-year investment time horizon.

5.4.5 Inadequate evacuation infrastructure

Since the potential sites are located in remote areas, the lack of evacuation infrastructure acts as the biggest impediment to cost-effective hydropower potential.

5.4.6 Impact on environment

Small hydropower projects are normally set up in hilly areas. The land required to set up the projects may have some trees or forest cover. Therefore, the projects require compulsory afforestation and hence forest clearance. Rivers/canals are diverted for a limited distance to generate electric power, which may also have some impact on the environment. The projects may also impact aquatic life (fish etc.).

5.5 Likely capacity addition

5.5.1 Methodology adopted

In order to estimate the pipeline of small hydro projects, the projects in each state are mapped against the various milestones of the projects like registered, major clearances done, under construction, and due for commissioning. This was done by in consultation with important stakeholders. The brief outline of the methodology adopted is as follows:

a. The state-wise achievable potential for small hydropower is estimated on the basis of MNRE data.

b. The project pipeline is built state wise, to assess the likely capacity addition in the state, year on year, on the basis of land availability till the implementation of the 12th Plan period.

c. An assessment of transmission infrastructure availability and the regulatory environment in the states, which impact the timely commissioning of projects, is made, and the likely capacity addition is projected in a constrained environment. The likely constraints in the achievement of the targeted capacity addition are then mapped state wise.

d. A rough estimation of the achievable potential and likely capacity addition during the 12th Plan is made.

5.5.2 Assumptions

The capacity utilization factors (CUF) of Small Hydro as per CERC tariff order have been used for projecting the generation from small hydro power projects.

Table 40: Capacity Utilization Factors for Small Hydro Projects

State	CUF	Weightage

State	CUF	Weightage
HP, Uttarakhand & North Eastern States	45%	75%
Other States	30%	25%
Overall	**41.3%**	

5.5.3 Likely capacity addition

The year-wise likely capacity addition is built upon the estimates provided by MNRE and state nodal agencies. The state of Himachal Pradesh has set the targets for the next 5 years, which is as follows.

Table 41: Small hydro capacity addition targets of Himachal Pradesh for 12th Plan

State	FY 13 (MW)	FY 14 (MW)	FY 15 (MW)	FY 16 (MW)	FY 17 (MW)	12th Plan
Himachal Pradesh	105.45	219.65	165.15	307.45	198.02	1916.98

Himachal Pradesh SERC has submitted that the identified potential of small hydro projects (up to 25 MW) in Himachal Pradesh is about 2,350 MW. Of the balance potential of about 1,900 MW, 247 projects with aggregate capacity 996 MW are planned for commissioning in 12th Plan. The proposed network connectivity for these projects has aggregate capacities of about 3,600 MW. As in the case of mountains, due to corridor, environmental, land, design, and aesthetic constraints, common lines have to be designed for evacuation and transmission of power from various capacity projects and also for near future possible capacities.

For the rest of the states, the normalization of state-wise targets given by MNRE has been undertaken to an extent of 70%. This is owing to the fact that the projects in the north-east locations are facing public opposition and lack evacuation facilities. The projected Scenario – 1 is based on the estimations of state nodal agencies and the discussions with MNRE.

Table 42: Likely capacity addition for small hydro projects (MW) – Scenario – 1

State	FY 12 (E)	12th Plan likely addition (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	15	73.4	15.8	15.8	19.2	19.2	3.4
Arunachal Pradesh	0	47.7	11.9	11.9	11.9	11.9	0.0
Assam	0	21.3	3.8	3.8	5.9	5.9	2.1
Bihar	4.7	24.1	6.0	6.0	6.0	6.0	0.0
Chhattisgarh	1.2	291.0	37.1	37.1	84.7	84.7	47.6
Haryana	3.4	3.4	0.9	0.9	0.9	0.9	0.0
Himachal Pradesh*	107.55	995.72	105.45	219.65	165.15	307.45	198.02

State	FY 12 (E)	12th Plan likely addition (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Jammu and Kashmir	3	28.5	2.2	2.2	8.8	8.8	6.5
Jharkhand	0	34.9	8.7	8.7	8.7	8.7	0.0
Karnataka	176.5	323.1	35.4	35.4	95.9	95.9	60.5
Kerala	0	71.0	16.4	16.4	18.2	18.2	1.8
Madhya Pradesh	0	36.4	1.2	1.2	11.7	11.7	10.5
Maharashtra	4.9	197.7	22.8	22.8	58.3	58.3	35.5
Manipur	0	2.8	0.7	0.7	0.7	0.7	0.0
Meghalaya	0	1.7	0.4	0.4	0.4	0.4	0.0
Mizoram	0	0.5	0.1	0.1	0.1	0.1	0.0
Nagaland	0	4.2	1.1	1.1	1.1	1.1	0.0
Orissa	20	136.7	0.9	0.9	45.3	45.3	44.4
Punjab	15	30.6	5.3	5.3	8.4	8.4	3.2
Sikkim	0	0.2	0.1	0.1	0.1	0.1	0.0
Tamil Nadu	0	20.5	5.1	5.1	5.1	5.1	0.0
Uttarakhand	22	341.2	57.4	57.4	94.6	94.6	37.2
West Bengal	10	112.8	21.1	21.1	30.6	30.6	9.5
Total	**383.25**	**2,799**	**359.70**	**473.90**	**681.63**	**823.93**	**460.25**

Table 43: Likely capacity addition for small hydro projects (MW) – Scenario – 2

State	FY 12 (E)	12th Plan likely addition (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	15	73.4	15.8	15.8	19.2	19.2	3.4
Arunachal Pradesh	0	47.7	11.9	11.9	11.9	11.9	0.0
Assam	0	21.3	3.8	3.8	5.9	5.9	2.1
Bihar	4.7	24.1	6.0	6.0	6.0	6.0	0.0
Chhattisgarh	1.2	291.0	37.1	37.1	84.7	84.7	47.6
Haryana	3.4	3.4	0.9	0.9	0.9	0.9	0.0
Himachal Pradesh*	107.55	995.72	105.45	219.65	165.15	307.45	198.02
Jammu and Kashmir	3	28.5	2.2	2.2	8.8	8.8	6.5
Jharkhand	0	34.9	8.7	8.7	8.7	8.7	0.0
Karnataka	176.5	718.6	161.2	108.5	152.8	150.8	145.3

State	FY 12 (E)	12th Plan likely addition (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Kerala	0	71.0	16.4	16.4	18.2	18.2	1.8
Madhya Pradesh	0	36.4	1.2	1.2	11.7	11.7	10.5
Maharashtra	4.9	197.7	22.8	22.8	58.3	58.3	35.5
Manipur	0	2.8	0.7	0.7	0.7	0.7	0.0
Meghalaya	0	1.7	0.4	0.4	0.4	0.4	0.0
Mizoram	0	0.5	0.1	0.1	0.1	0.1	0.0
Nagaland	0	4.2	1.1	1.1	1.1	1.1	0.0
Orissa	20	136.7	0.9	0.9	45.3	45.3	44.4
Punjab	15	30.6	5.3	5.3	8.4	8.4	3.2
Sikkim	0	0.2	0.1	0.1	0.1	0.1	0.0
Tamil Nadu	0	20.5	5.1	5.1	5.1	5.1	0.0
Uttarakhand	22	341.2	57.4	57.4	94.6	94.6	37.2
West Bengal	10	112.8	21.1	21.1	30.6	30.6	9.5
Total	**383.25**	**3,195**	**485.5**	**547.0**	**738.5**	**878.8**	**545.1**

6. Assessment of biomass potential and likely capacity supply scenario

This chapter primarily focuses on the assessment of the biomass potential and likely capacity additions during the 12th Plan period based on four broad parameters (policy and regulations, biomass potential, infrastructure, and financing) and the discussions held with various stakeholders (MNRE, FOR, developers, state nodal agencies, state utilities, and financing agencies).

6.1 Background

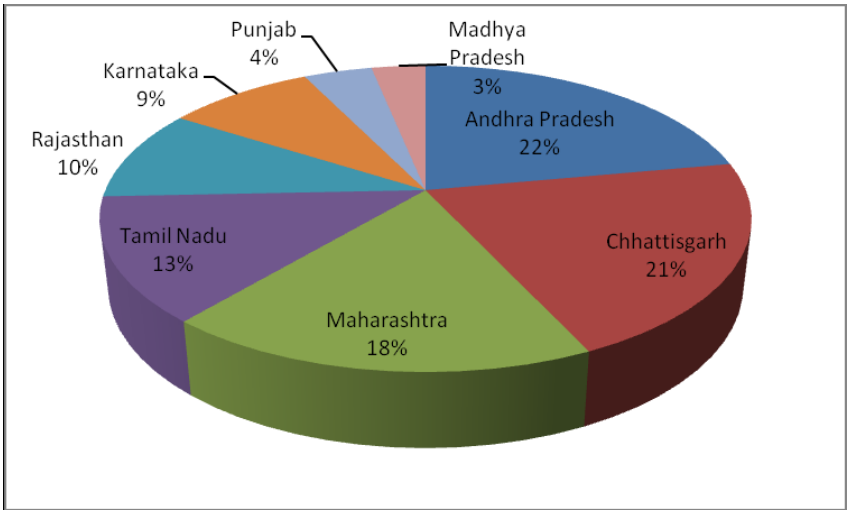
Biomass is a vital source of energy for meeting the household and industrial energy requirements in India. It is the most commonly used domestic fuel. It is also used as the energy source for several small-scale industries and as fuel for independent power plants. A cumulative capacity of 2,650 MW biomass power and bagasse co-generation has so far been commissioned, which includes 1,000 MW from biomass power and 1,650 MW from bagasse cogeneration. Several states including Maharashtra and Karnataka have initiated action for setting up agro residue based projects, which aggregate to about 3,000 MW. In addition, 300 MW non-bagasse cogeneration projects have been installed. Besides this, about 120 MW equivalent biomass gasifier systems have been installed in rice mills and other industries for captive power and thermal applications.

Table 44: State-wise installed biomass power/cogeneration projects (as on 31.03.2011) (MW)

State	Till 2003	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total
Andhra Pradesh	160.05	37.70	69.50	12.00	22.00	33.00	9.00	20.00	--	363.25
Bihar		--	--	--	--	--	--	--	9.50	9.50
Chhattisgarh	11.00	--	--	16.50	85.80	33.00	9.80	43.80	32.00	231.90
Gujarat	0.50	--	--	--	--	--	--	--	--	0.50
Haryana	4.00	--	2.00	--	--	--	--	1.8	28.00	35.80
Karnataka	109.38	26.00	16.60	72.50	29.80	8.00	31.90	42.00	29.00	365.18
Madhya Pradesh		1.00	--	--	--	--	--	--	--	1.00
Maharashtra	24.50	--	11.50	--	40.00	38.00	71.50	33	184.50	403.00
Punjab	22.00	--	--	6.00	--	--	--	34.50	12.00	74.50
Rajasthan		7.80	--	7.50	8.00	--	8.00	--	42.00	73.30
Tamil Nadu	106.00	44.50	22.50	--	42.50	75.00	43.20	62.00	92.50	488.20
Uttarakhand	--	--	--	--	--	--	--	--	10.00	10.00

State	Till 2003	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total
Uttar Pradesh	46.50	12.50	14.00	48.50	--	79.00	172.00	194.50	25.50	592.50
West Bengal		--	--	--	--	--	--	16.00	--	16.00
Total	**483.93**	**129.50**	**136.10**	**163.00**	**228.10**	**266.00**	**345.40**	**447.60**	**465.00**	**2,664.63**

Figure 15: State-wise installed capacities (Percentage of total capacities installed)



6.2 Potential assessment

As per the Biomass Resource Atlas of India, prepared by IISc and facilitated by MNRE,

Estimated biomass power potential is 18,601 MW;
Estimated wasteland power potential is 6,239 MW.

Table 45: Biomass-based power – State-wise potential (in MW)

State	Agro potential (MWe)	Forest and wasteland potential (MWe)
Andhra Pradesh	738.3	
Arunachal Pradesh	9.3	
Assam	278.7	
Bihar	645.9	
Chhattisgarh	245.6	
Goa	26.1	
Gujarat	1,226.1	1,155.2
Haryana	1,375.1	39.5
Himachal Pradesh	1,42.2	
Jammu and Kashmir	42.7	

State	Agro potential (MWe)	Forest and wasteland potential (MWe)
Jharkhand	107	
Karnataka	1,222.1	
Kerala	864.4	
Madhya Pradesh	1,386.2	2,060.6
Maharashtra	1,969.7	1,741.7
Manipur	15.3	
Meghalaya	11.4	
Mizoram	1.16	
Nagaland	10.2	
Orissa	432.8	
Punjab	3,177.6	36.8
Rajasthan	1,121.9	262.3
Sikkim	2.44	
Tamil Nadu	1,163.9	429.4
Tripura	2.96	
Uttar Pradesh	1,764.9	514.1
Uttaranchal	88.3	
West Bengal	529.2	
Sub-Total	18,601.5	6,239.6
Total	**24,841.1**	

Source: Biomass Atlas

The biomass power potential can be increased significantly by exploring the opportunity of high yield varieties and energy plantation in the wasteland areas. The assessment of scale-up potential has been facilitated by MNRE separately for crop residues and energy plantations. In the case of crop residues, the assessment focused on the market for utilization of residues such as stalk and straw, which are still at the initial stages of development, and the target potential for scale up by utilization of these resources during the 12th Five Year Plan. In the case of energy plantations, biomass yield has been estimated by utilization of arid lands and through plantations based on high yield woody biomass.

With progressively higher steam parameters and efficient project configuration in new sugar mills and the modernization of the existing ones, the potential of surplus power generation through bagasse cogeneration in sugar mills is estimated at 5,000 MW.

The potential of biomass based power could be increased substantially if linked with dedicated plantation on forest and non-forest degraded lands. It is possible to generate about 5,000-6,000 MW power by raising dedicated plantations on about 2 million hectares of forest and non-forest degraded lands.

Further, with a view to determine the realistic achievable potential, detailed analyses have been carried out to examine the state-wise agro residue based biomass potential. It has been estimated that 20% to 30% of the generated biomass is lost in harvesting and transportation when mechanized

harvesting is used. States such as Punjab, Maharashtra, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, Karnataka, Tamil Nadu, Rajasthan, Kerala, Andhra Pradesh, Bihar, West Bengal, Orissa, and Assam have 18,051 MW power potential, which is 96% of the total power potential based on biomass.

It is also highlighted that a comprehensive mapping of biomass resource needs to be carried out in order to estimate the realistic achievable biomass power potential. We understand that MNRE has already initiated various studies and has undertaken the launch of a bioenergy mission in the 12th Plan period.

6.3 Existing policy and regulatory regime for biomass and cogeneration projects

CERC had issued guidelines for determining tariff of power generated from biomass and bagasse cogeneration projects, and SERCs, in their respective states, are deciding issues relating to tariff and other conditions. The enabling policies adopted by the central and state governments include the following:

6.3.1 Central financial assistance

The central financial assistance for the establishment of biomass- and bagasse-based cogeneration projects is as per the following schemes:

Table 46: Central financial assistance – Biomass and bagasse power projects

Project type	Special category states (NE region, Sikkim, J & K, HP and Uttaranchal) – Capital subsidy	Other states – Capital subsidy
Biomass power projects	Rs. 25 lakhs × (C MW)^0.646	Rs. 20 lakhs × (C MW)^0.646
Bagasse co-generation by private sugar mills	Rs. 18 lakhs × (C MW)^0.646	Rs. 15 lakhs × (C MW)^0.646
Bagasse co-generation projects by cooperative/public sector sugar mills 40 bar and above 60 bar and above 80 bar and above	 Rs. 40 lakhs × Rs. 50 lakhs × Rs. 60 lakhs × Per MW of surplus power (maximum support: Rs. 8.0 crores per project)	 Rs. 40 lakhs × Rs. 50 lakhs × Rs. 60 lakhs × Per MW of surplus power (maximum support: Rs. 8.0 crores per project)

6.3.2 State-wise incentives

The policies and other incentives announced by various states are given in the following table.

Table 47: State-wise incentive for biomass- and bagasse-based cogeneration projects

State	Wheeling	Banking	Third party sale	Other incentives
Andhra Pradesh	28.4% + Rs.	Allowed at 2% for 8-12	Not allowed	-

State	Wheeling	Banking	Third party sale	Other incentives
	0.5/kWh	months		
Chhattisgarh			Allowed	As to other industry Electricity duty exempted for the 1st five years
Gujarat	4% of energy	Allowed for 12 months	Allowed	-
Haryana	2% of energy	Allowed for 12 months	Allowed	
Karnataka	6% to 12% of Energy	2% per month for 12 months	-	Subsidy @Rs. 25 lakhs/MW for co-gen only
Kerala	5% of energy	Allowed for 4 Months	Not allowed	50% cost of power line to be borne by KSEB
Maharashtra	7% of energy	Allowed	Allowed	50% cost of power line to be borne by MSEB
Madhya Pradesh	2% of energy	Not allowed	Allowed	-
Punjab	2% of energy	Allowed for 12 months	Allowed	-
Rajasthan	2% of energy	Allowed for 12 months	Allowed	-
Tamil Nadu	2% within 25 km, 10% beyond 25 km others	Allowed at 2% charge	Not Allowed	-
Uttar Pradesh	12.5%	Allowed for 24 months	Allowed	-

Source: SERCs' Tariff Order

6.3.3 Feed-in tariff

Central and state electricity regulatory commissions have notified the specific feed-in tariff for electricity generated from biomass- and bagasse-based power projects. The tariffs applicable in various states are given in the following table.

Table 48: State-wise tariffs for biomass- and bagasse-based cogeneration projects

State	Tariff fixed by SERCs
Andhra Pradesh	Rs. 4.28/kWh (2010-11) (Biomass) Rs. 3.48/kWh (2010-11) (Cogen)
Chhattisgarh	Rs. 3.93/kWh (2010-11) (Biomass)
Gujarat	Rs. 4.40/kWh (with AD benefits) (Biomass) Rs. 4.55/kWh (with AD benefits) for first 10 years (Cogen)
Haryana	Rs. 4.00/kWh (Biomass) Rs. 3.74/kWh (Cogen) 3% escalation (base year 2007-08)
Karnataka	Rs. 3.66/kWh (PPA signing date) Rs. 4.13/kWh (10th year) (Biomass) Rs. 3.59/kWh (PPA signing date) Rs. 4.14/kWh (10th year) (Cogen)
Kerala	Rs. 2.80/kWh (Biomass) escalated at 5% for five years (2000-01)
Maharashtra	Rs. 4.98/kWh (2010-11) (Biomass) Rs. 4.79/kWh (Commissioning year) (Cogen)
Madhya Pradesh	Rs. 3.33 to 5.14/kWh paise for 20 years, with escalation of 3-8 paise
Punjab	Rs. 5.05/kWh (2010-11) (Biomass) Rs. 4.57/kWh (2010-11) (Cogen) Escalated at 5% for cogen and biomass
Rajasthan	Rs. 4.72/kWh - water cooled (2010-11) Rs. 5.17/kWh - air cooled (2010-11) (Biomass)
Tamil Nadu	Rs. 4.50-4.74/kWh (2010-11) (Biomass) Rs. 4.37-4.49/kWh (2010-11) (Cogen) (Escalation: 2%)
Uttaranchal	Rs. 3.06/kWh (2010-11) (Biomass) Rs. 3.12/kWh (2010-11) (Cogen) (new projects)
UP	Rs. 4.29/kWh for existing projects and Rs. 4.38/kWh for new projects with escalation at 4 paise/year, base year (2006)
West Bengal	Rs. 4.36/kWh fixed for 10 years (Biomass)
Bihar	Rs. 4.17/kWh (2010-11) (Biomass) Rs. 4.25/kWh (2010-11) – existing (Cogen) Rs. 4.46/kWh (2010-11) – new (Cogen)
Orissa	Rs. 4.09/kWh

6.3.4 REC mechanism

The status of biomass and bagasse-based power projects registered under the REC mechanism as on 31st October 2011 is as follows.

Table 49: REC registration status of biomass- and bagasse-based cogeneration projects

Sr. No.	State	Biomass (Nos.)	Biomass (MW)	Cogen (Nos.)	Cogen (MW)
1	Gujarat	1	1	0	0
2	Maharashtra	2	40	6	75
3	Rajasthan	1	10	0	0
4	Tamil Nadu	4	46	0	0
5	Himachal Pradesh	0	0	0	0
6	Jammu and Kashmir (JKSPDCL)	0	0	0	0
7	Chhattisgarh	5	49	1	3
8	Haryana	3	9	0	0
9	Uttar Pradesh	12	188	28	348
	Total	**28**	**342**	**35**	**426**

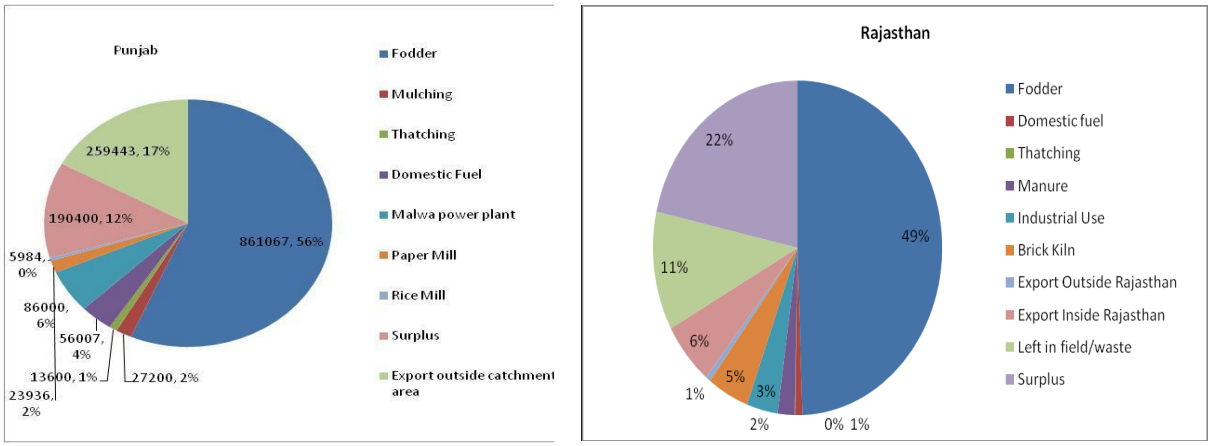
6.4 Issues and constraints

Although biomass-based power generation can be scheduled and carried out throughout the year at a much higher capacity utilization factor, this type of power generation faces several issues:

6.4.1 Availability of biomass

The availability of biomass fuel has been a serious concern, and reduction in the availability of biomass fuel in the state owing to its increased use by alternate/competing markets has become a matter of concern. Recently, the availability of biomass for power generation has gone down drastically due to its increased use in brick kilns, small and medium boilers, and captive power plants. Biomass is becoming a popular fuel in these alternate markets/usages. This is mainly due to the very high delivered price of coal in the region, which in turn is due to high transportation cost. This has resulted in the creation of competitive markets for biomass suppliers, reduced availability of biomass for power generation, and substantial rise in its price. For these alternate/competitive industries, the price of biomass is not of much significance as those industries can easily recover the same by increasing the price of their finished products. In such a scenario, the area reservation policy for biomass-based power projects is rendered meaningless.

Figure 16: Competitive use of biomass in Punjab and Rajasthan



Source: MNRE – Bioenergy Mission

6.4.2 Biomass price

Since biomass-based power projects are the only category of non-conventional power projects that have fuel cost therefore fuel cost has an associated impact on the viability of the projects as well. Therefore, it is imperative to assess the state-wise cost adopted for determining the tariff by various SERCs. As per the existing tariff/regulations, the specified prices in states are significantly lower than the prevailing market prices. The table below gives the cost of biomass adopted by various states.

Table 50: Biomass cost adopted by SERCs

State	Biomass price (Rs./MT) CERC 2011-12	Biomass price (Rs./MT) as specified by concerned SERC	Rationale considered	Biomass price (Rs./MT) CERC 2012–13
Andhra Pradesh	1,461	2,000	Date of order: 31.3.09, based on the prevailing cost of biomass	2,315
Haryana	2,434	2, 390 (2011-12)	Reviewed biomass price vide order dated 27.05.2011 as directed by APTEL after detailed analysis and in line with the CERC norm	2,635
Maharashtra	2,022	2,605 (2010-13)	MERC order dated 29.04.2011 specified based on the prevailing cost of biomass	2,116
Madhya Pradesh	1,459	1,181 (2007-08)	Equivalent heat value of coal in 50:25:25 proportion of main biomass,	1,507

State	Biomass price (Rs./MT) CERC 2011-12	Biomass price (Rs./MT) as specified by concerned SERC	Rationale considered	Biomass price (Rs./MT) CERC 2012–13
			supplement biomass, and coal	
Punjab	2,349	2,500 (2010-11)	Collected information from various sources like MPL: 2469, DDL: 2845, Apex Cooperative Institutions: 2773-3070, and IREDA: 1800-2000	2,756
Rajasthan	2,046	1,216 (2009-10)	RERC assumed such price in the absence of adequate benchmark price for biomass. Further noted that stakeholders should submit documentary evidence in support of their claim so that RERC may review the base price	2,300
Tamil Nadu	2,047	2,000 (2009-10)	Based on prevailing prices	2,277
Uttar Pradesh	1,704	1,675 (2009-10)	Equivalent heat value of coal	2,355
Other states	2,018	JSERC: 1,797	As per CERC (09-10)	2,283
		CSERC: 2,018	As per CERC (11-12)	
		BERC: 1,050	Date of order: 21.5.2009	
		KERC: 1,280	Took note of CERC specified price 1797 (09-10)	
		GERC: 1,600 (2010-11)	As suggested by state nodal agency, i.e., 1500, plus transportation/handling cost 100/MT	

Source: CERC RE Tariff Regulations, 2012

It is understood from the consultation with various stakeholders that the existing approved fuel cost will make survival of biomass plants in various states difficult.

6.4.3 Feed-in tariff

As per the feed-in tariff announced by various SERCs (given above), there is a divergence among states on the following aspects:

a) The biomass tariff framework announced by different states varies from each other.

b) Some states have used market determined cost of biomass fuel as market determined and some have incorporated the equivalent heat rate mechanism to determine the tariff.

c) Wastage in the storage of biomass stock has not been considered by some states while calculating the tariff.

6.4.4 Area reservation policy

The area reservation policy has been rendered ineffective owing to the increased alternative usage of biomass fuel. Further, coordination with state governments is required to restrict inefficient alternate usage.

6.5 Likely capacity addition

6.5.1 Methodology adopted

In order to estimate the pipeline of biomass power projects, a reconstruction of projects of biomass projects in each state as against various milestones was done. This was done in consultation with important stakeholders. The brief outline of the methodology adopted is as follows:

a. The state-wise achievable potential for biomass-based power is estimated.

b. The project pipeline is built state wise, to assess the likely capacity addition in the state, year on year, on the basis of land availability till the implementation of 12th Plan period.

c. An assessment of transmission infrastructure availability and the regulatory environment in the states, which impact the timely commissioning of projects, is made, and the likely capacity addition is projected in a constrained environment. The likely constraints in the achievement of targeted capacity addition are then mapped state wise.

d. A rough estimation of the achievable potential and likely capacity addition during the 12th Plan is made.

6.5.2 Assumptions

The plant load factors (PLF) of Biomass and Cogeneration power projects as per CERC tariff order have been used for projecting the generation from Biomass and Cogeneration small hydro power projects.

Table 51: Cogeneration plants Plant Load Factor (PLF)

State	Cogeneration
Uttar Pradesh and Andhra Pradesh	45%
Tamil Nadu and Maharashtra	60%
Other States	53%
Average for all states	**53%**

Table 52: Average Plant Load Factor (PLF) for Biomass and Cogeneration Projects

Technology	Plant Load Factor	Weightage
Biomass	80%	80%
Cogeneration	53%	20%
Average PLF	**75%**	

6.5.3 Likely capacity addition

The likely capacity addition for both Scenario – 1 and Scenario – 2 has been derived from the National Bioenergy Mission to be launched with the 12th Plan. The targets for the mission are given in the following table.

Table 53: Bioenergy mission targets

Biomass Mission	Overall target 2017					Overall target 2022				
	IPP	Tail End	Off Grid	Cogen	Total	IPP	Tail End	Off Grid	Co gen	Total
Agro Residue	2,100	550	150	325	**3,125**	3,000	2,000	250	500	**5,750**
Plantation	800	150	75	100	**1,125**	3,000	1,000	100	100	**4,200**
Total	**2,900**	**700**	**225**	**425**	**4,250**	**6,000**	**3,000**	**350**	**600**	**9,950**

Going further, assessing the pipeline of the projects in the state we understand that biomass-based power projects are being implemented as per the following proportion.

Table 54: State-wise capacity addition during 12th Plan

State-wise pipeline		Proportionate capacity addition (MW)
Bihar	17%	723
Karnataka	15%	638
Andhra Pradesh	13%	553
Gujarat	10%	425
Madhya Pradesh	10%	425
Punjab	9%	383
Rajasthan	9%	383
Haryana	6%	255
Maharashtra	5%	213

State-wise pipeline		Proportionate capacity addition (MW)
Chhattisgarh	4%	170
Tamil Nadu	2%	85

The likely capacity addition is projected on the basis of the estimations of state nodal agencies and the discussions with MNRE.

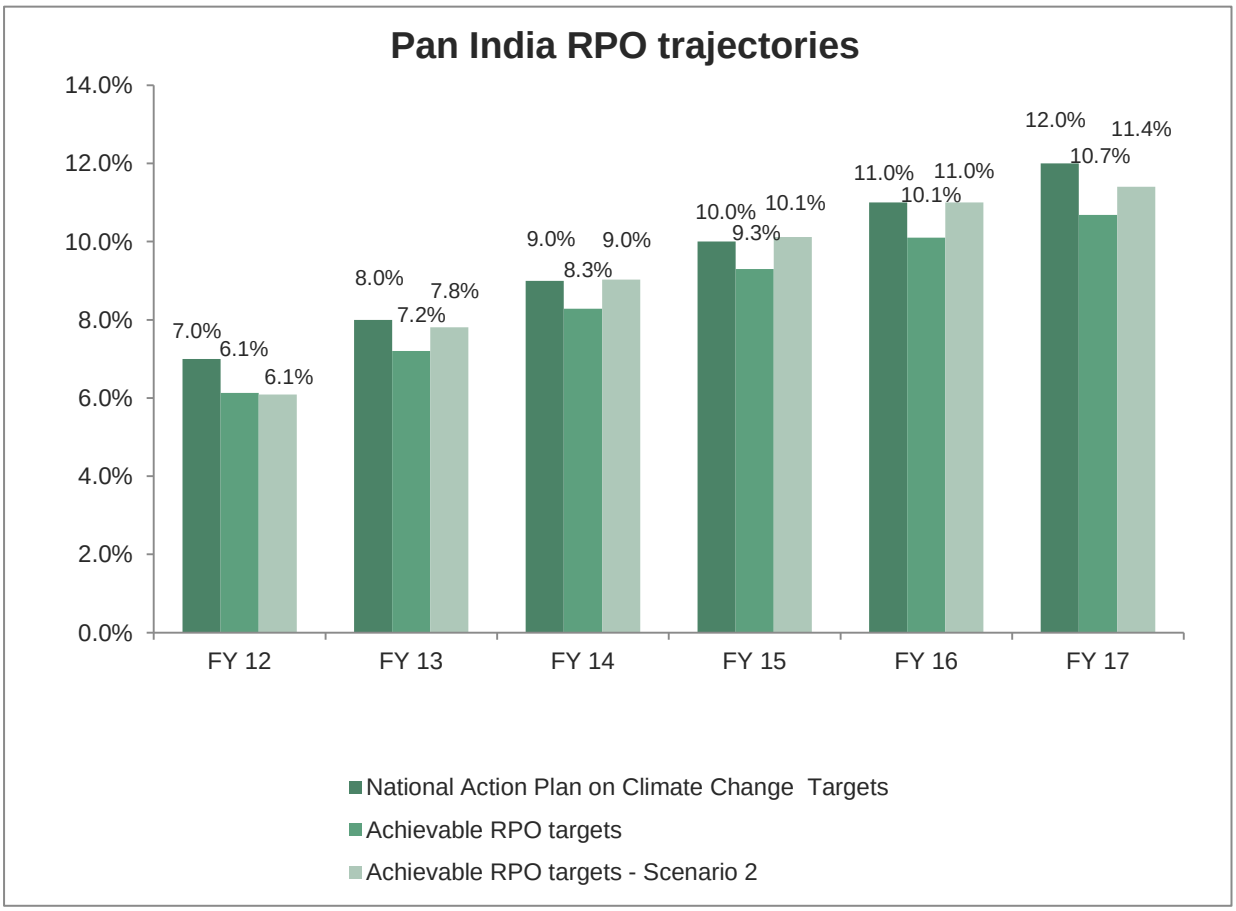
Table 55: Likely capacity addition for biomass-based projects (Scenario – 1 and Scenario – 2)

State	12th Plan likely addition (MW)	FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	553	110.50	110.50	110.50	110.50	110.50
Bihar	723	144.50	144.50	144.50	144.50	144.50
Chhattisgarh	170	34.00	34.00	34.00	34.00	34.00
Gujarat	425	85.00	85.00	85.00	85.00	85.00
Haryana	255	51.0	51.0	51.0	51.0	51.0
Karnataka	638	127.50	127.50	127.50	127.50	127.50
Madhya Pradesh	425	85	85	85	85	85
Maharashtra	213	42.5	42.5	42.5	42.5	42.5
Punjab	383	76.5	76.5	76.5	76.5	76.5
Rajasthan	383	76.5	76.5	76.5	76.5	76.5
Tamil Nadu	85	17	17	17	17	17
Total	**4,250**	**850**	**850**	**850**	**850**	**850**

7. Likely supply of renewable energy – Nationwide scenario

The national RPO trajectory is estimated based on the likely capacity additions for both the scenarios during the 12th Plan period.

Figure 17: Pan India RPO trajectories



The above graph shows the achievable RPO trajectory under Scenario – 1 and Scenario – 2 as against the RPO targets suggested by NAPCC.

7.1 Scenario – 1

The likely capacity addition for renewable energy under Scenario – 1 is as per CRIS assessment, which is based on the corroborated data from various state agencies and has been further validated by the developers. The targets given by various state agencies figures have been validated by mapping them against the business plan of the major developers for the 12th Plan period. It is assumed if the existing regulatory and policy support is continued, the likely capacity addition during the 12th Plan period would be as per Scenario – 1. The table below gives the details of Scenario – 1.

Table 56: Year-wise likely capacity addition (MW) – Scenario – 1

Year-wise Capacity Addition	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Wind Energy Projects	3,178	3,769	3,988	3,935	3,883	3,680
Solar Energy Projects	391	1,060	1,585	2,005	2,055	2,705
Small Hydro Projects	504	360	474	682	824	460
Biomass Projects	123	850	850	850	850	850
Total Renewable Energy Projects	**4,197**	**6,039**	**6,897**	**7,472**	**7,611**	**7,695**

The weighted average Capacity Utilization Factor (CUF) of all the renewable energy technologies is around 29%. The table below gives the year wise incremental renewable energy generation due to incremental capacity addition year on year.

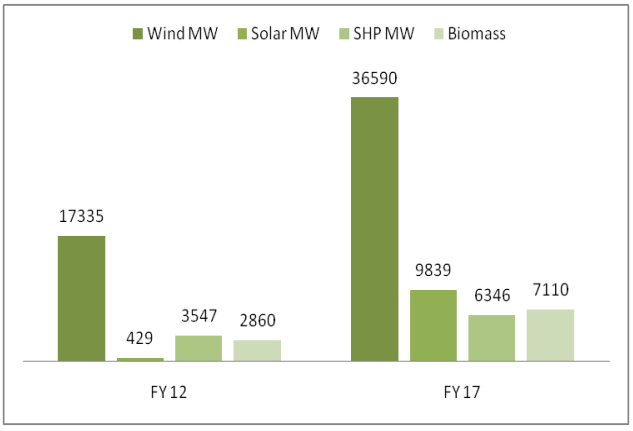
Table 57: Year-wise likely renewable energy generation (MU) – Scenario – 1

Year-wise Generation	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Wind Energy Generation	29,352	37,285	45,666	53,956	62,152	69,967
Solar Energy Generation	752	2,609	5,386	8,898	12,499	17,238
Small Hydro Generation	10,594	11,777	13,410	15,569	18,289	19,811
Biomass Generation	18,674	24,224	29,774	35,323	40,873	46,423
Total Renewable Energy Generation	**59,372**	**75,894**	**94,236**	**113,747**	**133,813**	**153,439**

The likely capacity additions during the 12th Plan for each RE technology are as per the table given below.

Table 58: Technology-wise likely capacity addition (MW) – Scenario – 1

RE technology	12th Plan capacity addition (MW)
Wind Power	19,255
Solar Power	9,410
Small Hydro Power	2,799
Biomass Power	4,250
Total RE	**35,715**



7.2 Scenario – 2

The likely capacity addition for renewable energy under this scenario can be achieved only if issues or the constraints highlighted in the previous chapters are addressed. The assessment has been done on the estimates given by the state agencies and other agencies, which are mapped against the constraints in the state. If the highlighted constraints are addressed appropriately along with providing the support required for facilitating interstate transmission of renewable energy and evacuation infrastructure, the likely capacity addition shall be as per Scenario – 2. The table below gives the details of Scenario – 2.

Table 59: Year-wise likely capacity addition (MW) – Scenario – 2

Year-wise capacity addition	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Wind Energy Projects	2,914	6,756	4,485	4,257	4,632	3,673
Solar Energy Projects	481	1,115	2,025	2,305	2,135	1,585
Small Hydro Projects	504	485	547	739	879	545
Biomass Projects	123	850	850	850	850	850
Total Renewable Energy Projects	**4,022**	**9,207**	**7,907**	**8,150**	**8,496**	**6,653**

The weighted average Capacity Utilization Factor (CUF) of all the renewable energy technologies is around 29%. The table below gives the year wise incremental renewable energy generation due to incremental capacity addition year on year.

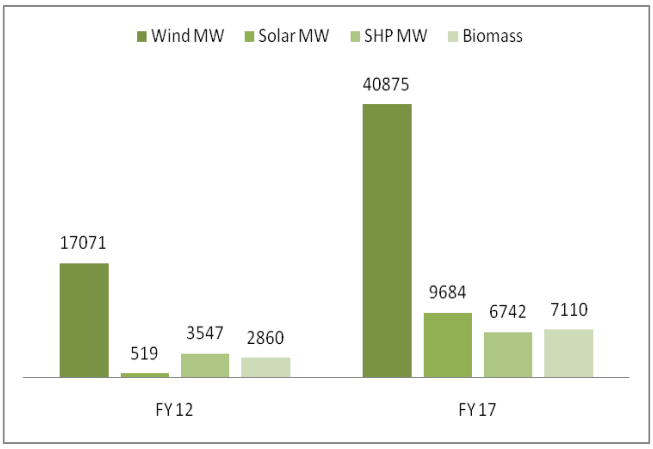
Table 60: Year-wise likely renewable energy generation (MU) – Scenario – 2

Year-wise Generation	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Wind Energy Generation	28,814	43,026	52,635	61,659	71,589	79,448
Solar Energy Generation	908	2,862	6,410	10,448	14,189	16,965
Small Hydro Generation	10,594	12,108	13,933	16,241	19,106	20,850
Biomass Generation	18,674	24,224	29,774	35,323	40,873	46,423
Total Renewable Energy Generation	**58,991**	**82,220**	**102,751**	**123,672**	**145,756**	**163,686**

The likely capacity additions during the 12th Plan for each RE technology are as per the table given below.

Table 61: Technology-wise likely capacity addition (MW) – Scenario – 2

RE technology	12th Plan capacity addition (MW)
Wind Power	23,804
Solar Power	9,165
Small Hydro Power	3,195
Biomass Power	4,250
Total RE	**40,413**



7.3 Data collected by CTU

A study is being carried out by the CTU, Power Grid Corporation of India Limited (PGCIL), for the assessment of transmission infrastructure required by states having higher RE potential, namely Gujarat, Rajasthan, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, and Himachal Pradesh. A team from PGCIL visited the states and collected data from state transmission utilities and state nodal agencies.

The table below gives a snapshot of the data collected by CTU, which further validates the information collected for the RPO assessment study.

State	Wind	Solar	Small Hydro
Gujarat	As per DPR – 3,000 MW up to 2015-16 As per data – 4,300 MW up to 2014-15	As per DPR – 1,458 MW up to 2014-15 As per data - 890 MW up to 2012-13	
Maharashtra	As per data – 4,300 MW up to 2015-16	As per data - 200 MW up to 2012-13	
Rajasthan	As per DPR - 850 MW up to 2013-14 As per data - 750 MW up to 2013-14	As per DPR – 1,400 MW up to 2013-14 As per data – 1,700 MW up to 2013-14	
Tamil Nadu	As per DPR – 5,400 MW As per data – 5,000 MW up to 2016-17		
Karnataka	As per data – 1,538 MW up to 2013-14		
Andhra Pradesh	As per data – 3,148 MW up to 2013-14		
Himachal Pradesh			Basin-wise capacity addition: 3,607.32 MW

From the RPO assessment study, we have tried to identify the pockets that are likely to be developed during the 12th Plan period. The pockets have been identified in consultation with wind turbine manufacturers and developers. The entire analysis is based on the corroboration of various sources, including the source of information that CTU has obtained, providing details on the DPRs submitted to various state agencies.

7.4 State-wise RPO targets

The pan India RPO trajectory has been further divided into state-wise RPO targets. The key considerations while deciding the state-wise RPO trajectories have been as follows:

1. The RPO targets should be achievable, i.e., the supply of RE power/RECs should be there in order to facilitate the compliance of RPO by the obligated entities.
2. Equitable distribution of RPO targets across the states. This has been done with a view of following national trajectory like NAPCC targets in future. Therefore, the states with low RPO targets (as per their current RPO target for FY 12) have been assigned an accelerated trajectory, and the states with high RPO targets (as per their current RPO target for FY 12) have been assigned a normalized trajectory.
3. The impact of proposed RPO targets on the PPC should be minimal. The state-wise impact has been dealt in a greater detail in the next chapter.
4. The interstate transmission of RE power is facilitated.
5. Invoking of Section 11[12]of Electricity Act 2003 by states: Invoking Section 11 by States and restricting export of power has deterred implementation of Open Access.
6. Solar RPO targets are assumed in line with the National Solar Mission targets giving due consideration to supply of solar RE power/ RECs.
7. Coal shortage in India: Thermal power generation which depends mainly on coal accounts for nearly 65 per cent of the electricity generated at present. Four years ago in 2007 this was at 77 per cent. With a major shortfall in the coal behemoth's production this year, a grim situation in the ailing sector has surfaced the need to move towards energy efficient alternate sources of power generation like hydro, wind, solar as well as nuclear energy. Further with the increased usage of imported coal the power purchase cost for all the distribution companies has been increasing over the past year. Therefore, these alternatives will soon be reaching grid-parity and compete with conventional costs.

The methodology adopted for designing the state-wise targets under both the scenarios is as follows:

1. Supply of renewable energy year wise has been considered as a constraint.
2. RPO target for FY 12 declared by State Electricity Regulatory Commission (SERC) of the state has been considered as a starting point.
3. RPO trajectory for the states has been designed with a view to align the targets of the states towards a National target.
4. Low potential states or states which haven't developed renewable energy potential in the state have been given an aggressive trajectory leading to higher incremental impact on power purchase cost dealt in detail in next chapter.

[12] *The Section 11 empowers state to direct generating stations to supply power as directed by state, under exceptional circumstances. However, there is a scope of misinterpretation of this section as "these circumstances" are not clearly defined and state can interpret it in a different manner. The circumstances should be clearly defined and should not be based on inability of state generators and Distribution Companies to provide power to the consumer.*

5. High potential states which are already procuring much more than the target RPO have been assigned small incremental targets due to following factors
    a. Allow sufficient capacity under the REC mechanism
    b. Already power purchase cost is higher for high potential states

The state-wise RPO details under both the scenarios are given in the table below.

Table 62: State-wise RPO targets (inclusive of solar RPO targets) – Scenario – 1

State	RPO % Scenario – 1					
Tamil Nadu*	14.0%	14.2%	14.4%	14.6%	14.8%	15.0%
Karnataka	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%
Himachal Pradesh ^	10.01%	11.0% (10.25%)	12.0% (10.25%)	13.0% (10.25%)	14.0% (11.25%)	15.0% (12.25%)
Gujarat ^	6.0%	7.2% (7.0%)	8.4%	9.6%	10.8%	12.0%
Rajasthan^	6.0%	7.2% (7.1%)	8.4%	9.6%	10.8%	12.0%
Maharashtra^	7.0%	8.0%	9.0%	10.0% (9.0%)	11.0% (9.0%)	12.0%
Andhra Pradesh^	5.0%	6.0% (5.0%)	7.5% (5.0%)	9.0% (5.0%)	10.5% (5.0%)	12.0% (5.0%)
Kerala^	3.3%	4.0% (3.6%)	5.0% (3.9%)	6.0% (4.2%)	7.5% (4.5%)	9.0% (4.8%)
Uttar Pradesh	5.0%	5.5%	6.2%	7.0%	8.0%	9.0%
Chhattisgarh^	5.25%	6.0% (5.75%)	6.8%	7.5%	8.3%	9.0%
Punjab^	2.4%	3.7% (2.9%)	5.0% (3.5%)	6.4% (4.0%)	7.7%	9.0%
Uttarakhand^	4.5%	5.8% (5.05%)	6.6%	7.4%	8.2%	9.0%
Madhya Pradesh	2.5%	4.0%	5.5%	7.0%	8.0%	9.0%
West Bengal^	3.0%	4.0%	5.0%	6.0%	7.5% (7.0%)	9.0% (8.0%)
Haryana^	1.5%	3.0% (2.0%)	4.5% (3.0%)	6.0%	7.5%	9.0%
Orissa^	5.0%	6.2% (5.5%)	6.9% (6.0%)	7.6% (6.5%)	8.3% (7.0%)	9.0%
Delhi	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%
Bihar	2.5%	4.0%	4.5%	5.0%	6.1%	7.0%
Jharkhand	3.0%	3.5%	4.3%	5.0%	6.0%	7.0%
Jammu and Kashmir	3.0%	3.5%	4.0%	4.8%	5.8%	7.0%

State	RPO % Scenario – 1					
Assam	2.8%	4.2%	5.6%	7.0%	7.0%	7.0%
Others	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%

** Includes the RPO targets for captive as well*

^ States where RPO targets announced by states are different from the proposed trajectory. Actual targets are provided in brackets for the years when RPO targets announced are lower than determined above..

Table 63: State-wise RPO targets (inclusive of solar RPO targets) – Scenario – 2

State	RPO % Scenario – 2					
Tamil Nadu*	14.0%	14.2%	14.4%	14.6%	14.8%	15.0%
Karnataka	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%
Himachal Pradesh^	10.01%	11.0% (10.25%)	12.0% (10.25%)	13.0% (10.25%)	14.0% (11.25%)	15.0% (12.25%)
Gujarat^	6.0%	7.2% (7.0%)	8.4%	9.6%	10.8%	13.0%
Rajasthan^	6.0%	7.2% (7.1%)	8.4%	9.6%	10.8%	13.0%
Maharashtra^	7.0%	8.0%	9.0%	10.0% (9.0%)	11.0% (9.0%)	13.0%
Andhra Pradesh^	5.0%	6.0% (5.0%)	7.5% (5.0%)	9.0% (5.0%)	11.0% (5.0%)	13.0% (5.0%)
Kerala^	3.3%	4.0% (3.6%)	5.0% (3.9%)	6.0% (4.2%)	7.5% (4.5%)	9.0% (4.8%)
Uttar Pradesh	5.0%	6.0%	6.8%	7.5%	8.25%	9.0%
Chhattisgarh^	5.25%	6.0% (5.75%)	6.8%	7.5%	8.3%	9.0%
Punjab^	2.4%	3.7% (2.9%)	5.0% (3.5%)	6.4% (4.0%)	7.7%	9.0%
Uttarakhand^	4.5%	5.8% (5.05%)	6.6%	7.4%	8.2%	9.0%
Madhya Pradesh	2.5%	4.0%	5.5%	7.0%	8.0%	9.0%

State	RPO % Scenario – 2					
West Bengal^	3.0%	4.0%	5.0%	6.0%	7.5% (7.0%)	9.0% (8.0%)
Haryana^	1.5%	3.0% (2.0%)	4.5% (3.0%)	6.0%	7.5%	9.0%
Orissa^	5.0%	6.2% (5.5%)	6.9% (6.0%)	7.6% (6.5%)	8.3% (7.0%)	9.0%
Delhi	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%
Bihar	2.5%	4.0%	5.0%	6.0%	7.5%	9.0%
Jharkhand	3.0%	4.0%	5.0%	6.0%	7.5%	9.0%
Jammu and Kashmir	3.0%	5.0%	5.0%	6.0%	7.5%	9.0%
Assam	2.8%	4.2%	5.6%	7.0%	8.0%	9.0%
Others	2.0%	3.0%	4.0%	5.5%	7.0%	9.0%

**Includes the RPO targets for captive as well*

^ States where RPO targets announced by states are different from the proposed trajectory. Actual targets are provided in brackets for the years where the RPO targets announced are lower than determined above.

8. Impact on Power Purchase Cost

The incremental impacts of varying levels of RPO on the PPC have been analysed for each state as well as at the pan India level for both the scenarios. This analysis has been done using the state specific RE tariffs for high potential states and CERC specified tariff for low potential states. Thereafter, the time value of the impact has been calculated taking the discount factor as 9.35%, which is same as the tariff specified by CERC for bid evaluation for procurement of power by distribution licensees.

Table 64: Impact on PPC (Scenario – 1)

Item	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Total energy (MUs)	968,659	1,053,341	1,138,023	1,222,705	1,324,812	1,435,707
RE energy (MUs)	54,787	70,907	88,153	107,331	129,831	155,382
RPO %	**5.7%**	**6.7%**	**7.7%**	**8.8%**	**9.8%**	**10.7%**
Increase in RPO		1.1%	1.0%	1.0%	1.0%	1.0%
Impact of inclusion of RE (p/unit)	7.5	9.2	11.0	12.5	13.5	14.0
Incremental impact (p/unit)		1.8	1.8	1.5	1.0	0.5
Time value of impact of inclusion of RE (p/unit)*		8.5	9.2	9.6	9.5	9.0
Incremental impact, considering time value (p/unit)		**1.0**	**0.0**	**0.3**	**-0.1**	**-0.5**
* Discount rate = 9.35%						

Table 65: Impact on PPC (Scenario – 2)

Item	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Total energy (MUs)	968,659	1,053,341	1,138,023	1,222,705	1,324,812	1,435,707
RE energy (MUs)	54787	70114	87693	107517	131776	163266
RPO %	**5.7%**	**6.7%**	**7.7%**	**8.8%**	**9.9%**	**11.4%**
Increase in RPO		1.0%	1.0%	1.1%	1.2%	1.4%
Impact of inclusion of RE (p/unit)	7.5	9.2	11.0	12.5	13.7	14.8
Incremental impact (p/unit)		1.7	1.8	1.5	1.2	1.0
Time value of Impact of inclusion of RE (p/unit)*		8.4	9.2	9.6	9.6	9.5
Incremental impact, considering time value (p/unit)		**0.9**	**0.0**	**0.4**	**0.0**	**-0.2**
* Discount rate = 9.35%						

The key take away from the impact analysis for Scenario – 1 is that the incremental impact on the PPC is 1.0 paisa per unit for the first year, which gradually decreases to negative incremental impact to the extent of 0.5 paisa per unit in FY17. This decrease in the PPC can be attributed to the following reasons:

1. Increased cost of conventional power, especially in the case of Tamil Nadu and Rajasthan
2. Reducing cost of RE power, typically in the case of solar energy. In the previous study, the impact was calculated at a solar tariff of Rs. 18.44 per unit, whereas for the current study, the impact has been assessed at a decreasing tariff of Rs. 10 to Rs. 6 (present value adjusted for inflation rate of 7%) for 2012-13 to 2016-17.

Based on detailed calculations, it is observed that the impact on PPC is not much in the initial years and can be easily accommodated by the state utilities. Further, in the later years, the impact on tariff is itself showing a negative trend. Moreover, the impact on PPC for Scenario – 2 is more as compared to Scenario – 1 owing to the higher RPO targets for the states.

However, the infirm nature of wind and solar power and the implied UI charges, which state utilities have to bear, have been excluded while assessing the impact on PPC. The key takeaway is that if initiatives are taken for better scheduling of wind and solar power, the impact of renewable energy shall be minimal, as shown above.

Further, it is noted that the impact of inclusion of RE could be relatively higher in some states than that in other states. This would be the more likely for the states where the current RPO levels are very low as against the proposed RPO trajectory.

8.1 Assumptions

The impact on power purchase cost has been projected on the basis of following assumptions:

8.1.1 Power Purchase Cost

The conventional power purchase cost for states has been projected as per the recent available tariff orders and the escalation rate has been taken on the basis of past 5 years CAGR.

State	Power Purchase Cost (Rs./kWh)	Annual Escalation (%)
Andhra Pradesh	2.50	3.52%
Bihar	2.32	4.58%
Chhattisgarh	1.62	4.92%
Delhi	2.62	6.48%
Goa North Eastern States & other UTs	2.30	4.92%
Gujarat	2.98	4.43%
Haryana	2.60	5.93%
Himachal Pradesh	2.34	5.80%
Jammu and Kashmir	2.62	3.98%
Jharkhand	2.01	3.48%

State	Power Purchase Cost (Rs./kWh)	Annual Escalation (%)
Karnataka	2.66	6.59%
Kerala	1.99	5.11%
Madhya Pradesh	2.09	7.00%
Maharashtra	2.62	4.92%
Orissa	2.03	4.92%
Punjab	2.71	6.00%
Rajasthan	2.60	6.00%
Tamil Nadu	3.38	4.92%
Uttar Pradesh	2.62	6.65%
Uttarakhand	2.34	4.92%
West Bengal	2.43	3.67%
Assam	2.40	5.27%

[Source: SERCs Tariff Orders]

8.1.2 Renewable Energy Tariff

The renewable energy tariff has been projected for the high potential states as per the state specific tariff and for low potential states the CERC determined tariff has been used to assess the impact of increased RPO targets over the 12th plan period.

8.1.2.1 Wind Energy Tariff

The wind energy tariff has been projected as per the following table:

State	Wind Energy Tariff - Rs./ kWh					Remarks
	FY13	FY14	FY15	FY16	FY17	
Andhra Pradesh	3.50	3.50	3.85	3.85	3.85	Control period ends in FY 14 after that 10% increase.
Gujarat	3.92	3.92	3.92	3.92	3.92	Control period ends in August, 2012 after that 10% increase is assumed
Karnataka	3.70	3.70	4.07	4.07	4.07	Control period ends in FY 14 after that 10% increase is assumed
Kerala	3.64	3.64	4.00	4.00	4.00	Control period ends in FY 14 after that 10% increase is assumed
Maharashtra	3.96	3.96	3.96	3.96	3.96	No increase is envisaged
Rajasthan	4.69	4.69	4.69	4.69	4.69	No increase is envisaged
Tamil Nadu	3.73	3.73	3.73	3.73	3.73	10% increase in FY 13 is assumed
Other States	4.84	4.84	4.84	4.84	4.84	CERC tariff is assumed.

[Source: ERCs tariff order; CRIS Analysis]

8.1.2.2 Solar Energy Tariff

For all the states except the state of Gujarat have signed PPAs on the basis of competitive bidding only, therefore the tariff has been projected considering CERC's view on solar energy tariff

Table 66: Solar Energy Tariff

Solar Energy Tariff (Rs./kWh)	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Present Value	10.39	10.00	9.00	8.00	7.00	6.00
Future Value (adjusted for inflation @7%)	10.39	10.70	10.30	9.80	9.18	8.42

[Source: Discussion with CERC]

8.1.2.3 Small Hydro Tariff

For the high potential states the tariffs have been considered as the state specified tariff and for low potential states the CERC specified tariff has been used.

8.1.2.4 Biomass Energy Tariff

For projecting the tariff the two part tariff has been considered wherein Fixed Cost has been kept fixed till the end of control period and variable cost is escalated at a rate of 5% annually.

Table 67: Biomass Projected Tariff (Rs/kWh)

State	Fixed Cost	Variable Cost	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Andhra Pradesh	1.90	1.88	3.78	3.87	3.97	4.08	4.19	4.30
Gujarat	1.59	2.08	3.67	3.77	3.88	4.00	4.12	4.24
Maharashtra	1.94	2.36	4.30	4.42	4.54	4.67	4.81	4.95
Punjab	1.79	2.64	4.43	4.56	4.70	4.85	5.00	5.16
Rajasthan	2.08	2.60	4.68	4.77	4.90	5.04	5.19	5.34
Tamil Nadu	1.76	1.95	3.70	3.76	3.82	3.88	3.95	4.03
Uttar Pradesh	1.92	2.13	4.61	4.06	4.06	4.06	4.06	4.06

[Source: SERC Orders; CRIS Analysis]

8.2 State-wise impact on PPC

The table below shows the state-wise impact of the inclusion of RE on PPC that would be incurred for meeting the RPO targets under Scenario – 1.

Table 68: State-wise impact of inclusion of RE (paisa/unit) – Scenario – 1

States	Impact of inclusion of RE (paisa/unit)					
	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Tamil Nadu	6.81	6.29	5.47	4.32	2.76	0.74
Karnataka	11.07	12.48	13.47	13.71	13.28	11.92
Himachal Pradesh	7.97	9.02	9.60	9.64	9.05	7.74
Gujarat	5.18	7.19	8.71	9.68	10.03	9.89
Rajasthan	13.88	16.79	19.15	20.90	21.95	23.50
Maharashtra	4.78	6.16	9.13	11.53	13.39	16.61
Andhra Pradesh	6.95	9.34	12.05	14.43	16.92	18.90
Kerala	3.83	6.98	10.44	13.48	17.27	20.40
Uttar Pradesh	8.71	10.15	11.45	12.34	12.75	12.36
Chhattisgarh	16.62	19.98	23.20	26.21	29.01	31.50
Punjab	5.33	8.49	11.11	13.12	14.45	14.99
Uttarakhand	6.94	9.59	11.32	12.67	13.55	13.92
Madhya Pradesh	6.80	10.99	14.58	17.48	18.84	19.49
West Bengal	5.21	8.51	11.46	14.04	17.30	19.95
Haryana	3.86	7.37	10.29	12.55	14.09	14.73
Orissa	12.92	16.64	18.93	20.89	22.65	23.92
Delhi	5.29	9.11	12.46	15.29	17.50	19.02
Bihar	5.66	8.61	11.20	14.03	16.23	17.73
Jharkhand	9.01	12.80	16.32	19.98	23.44	26.83
Jammu and Kashmir	5.57	7.87	10.15	12.29	14.15	15.36
Assam	4.32	6.92	9.00	10.51	11.17	11.18
Others	6.01	9.49	12.60	16.25	19.26	22.39

The table below shows the state-wise impact of the inclusion of RE on PPC that would be incurred for meeting the RPO targets under Scenario – 2.

Table 69: State-wise impact of inclusion of RE (paisa/unit) – Scenario – 2

States	Impact of inclusion of RE (paisa/unit)					
	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Tamil Nadu	6.81	6.29	5.47	4.32	2.76	0.74
Karnataka	11.07	12.48	13.47	13.71	13.28	11.92
Himachal Pradesh	7.97	9.02	9.60	9.64	9.05	7.74
Gujarat	5.18	7.19	8.71	9.68	10.03	9.89
Rajasthan	13.88	16.79	19.15	20.90	21.95	23.50
Maharashtra	4.78	6.16	9.13	11.53	13.39	16.61
Andhra Pradesh	6.95	9.34	12.05	14.43	16.92	18.90
Kerala	16.62	19.98	23.20	26.21	29.01	31.50
Uttar Pradesh	5.33	8.49	11.11	13.12	14.45	14.99
Chhattisgarh	6.94	9.59	11.32	12.67	13.55	13.92
Punjab	6.80	10.99	14.58	17.48	18.84	19.49
Uttarakhand	5.21	8.51	11.46	14.04	17.30	19.95
Madhya Pradesh	3.86	7.37	10.29	12.55	14.09	14.73
West Bengal	12.92	16.64	18.93	20.89	22.65	23.92
Haryana	5.29	9.11	12.46	15.29	17.50	19.02
Orissa	5.66	8.61	11.20	14.03	16.23	17.73
Delhi	9.01	12.80	16.32	19.98	23.44	26.83
Bihar	5.57	7.87	10.15	12.29	14.15	15.36
Jharkhand	4.32	6.92	9.00	10.51	11.17	11.18
Jammu and Kashmir	6.01	9.49	12.60	16.25	19.26	22.39
Assam	16.62	19.98	23.20	26.21	29.01	31.50
Others	5.33	8.49	11.11	13.12	14.45	14.99

The detailed calculations under both the scenarios for each state has been provided as annexure to the report.

9. Enablers of renewable energy development

This chapter provides a list of enablers for the development of renewable energy, which could create a more conducive environment to attract private investment in renewable energy, and examines how the strength of India's dynamic private sector could be better leveraged to meet its ambitious renewable energy goals and bridge the gap between the proposed RPO trajectory and the NAPCC targets.

The key takeaways from the issues highlighted in the technology specific chapters are that the major barriers that hold back the renewable energy development relate to three broad areas:

1. Financial viability of renewable energy projects
2. Lack of support infrastructure
3. Regulatory and process delays

Addressing the issues of financial viability of the projects require a long-term perspective of regulatory authorities, streamlining financial incentives, moving to a market-based approach for setting tariffs, creating new long-term funding sources, and most important, establishing the firmness of power by better scheduling and forecasting techniques.

Investments in support infrastructure need to be made to ensure timely transmission evacuation and accessibility to project sites, provide quality and easily accessible resource assessment, and catalyze the adoption of best practices in scheduling and forecasting techniques.

Policy implementation must be made effective on the ground, and the capacity and capability of state nodal agencies must be enhanced by providing single window clearances to facilitate renewable energy development and reduce the cost of business for renewable energy investors.

These efforts are interlinked with each other and therefore could be implemented in a gradual, risk-tolerant manner. Separate incentive schemes along with pilot programmes could be launched around the idea of renewable energy parks, which could create integrated infrastructure for investors in renewable energy resource rich areas.

9.1 Proposed enablers for achieving the ambitious targets

The following are the proposed enablers that shall increase the pace of development of renewable energy and enable the achievement of NAPCC targets.

9.1.1 Incentive structure for state utilities

An incentive structure should be devised which should capture the additional burden on utilities for procuring renewable energy. India could use the recently established National Clean Energy Fund, which finances research and innovative projects in clean technologies, as a vehicle to accumulate and channel renewable energy subsidies and reduce the financial burden on utilities. The existence of a fully financed national fund to subsidize RE would remove market uncertainty and make states and utilities more willing to implement renewable energy goals.

9.1.2 Open access transactions

Open access transactions of energy should be promoted. Some of the high potential states have been reluctant to allow open access to consumers and third party sales by captive generators because of concerns of losing large high-paying consumers and the resultant impact on utility finances. The high incidence of cross-subsidy surcharges and wheeling charges imposed on the direct sale of power to consumers, reduces the competitiveness of renewable energy in an otherwise potentially high-demand market. It would also put competitive pressure on utilities to improve the quality of supply. The government should promote new models for allowing renewable energy developers to recover higher generation costs directly from customers.

9.1.3 Innovative funding arrangements

IREDA, a focused renewable energy financial intermediary, should play a catalytic role in leveraging more funding from domestic and international markets. IREDA needs to explore new instruments, such as green bonds, new equity, and synthesized products, to raise financing and enable risk sharing and mitigation in renewable energy projects.

9.1.4 Risk sharing mechanism

A national partial risk guarantee facility, which could be managed by IREDA or private sector financial institutions, could address specific renewable energy project risks, such as refinancing, construction financing, off-take by utilities, resource availability, and technology.

9.1.5 Transmission and evacuation infrastructure

Renewable energy evacuation should be made a priority. It should have dedicated funding as a part of existing programmes like Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) or through new green funds. As per the mandate of the Indian Electricity Grid Code (IEGC) announced in April 2010, states are required to undertake interstate transmission system planning and development taking into account the needs of renewable energy sources and the renewable capacity addition plan. However, considering the gestation period of renewable energy technologies, all state transmission utilities should be mandated to prepare a comprehensive five-year transmission plan with appropriate consideration of renewable generation projects based on load flow studies and location of generation projects. State nodal agencies should play a lead role in coordinating and providing information to state transmission utilities on new renewable energy generation capacity.

It is also recommended that developers should allowed to set up required transmission and evacuation facilities. In this regard PPP model is required to be structured. Possibility of viability gap funding for transmission network could also be explored.

9.1.6 Capacity building of state nodal agencies

State nodal agencies are supposed to play a phenomenal role in the development of renewable energy projects, but very few have the resources, capability, and authority to do so. It is the need of the hour to bring all the state nodal agencies at the same level; therefore, a comprehensive capacity-building programme on emerging regulatory, legal, and financing issues should be structured to facilitate development of grid-connected renewable energy. International experience suggests that local agencies need help in conducting resource assessments, providing support for investment projects, developing demonstration projects, setting local standards, and creating awareness about

programmes. State nodal agencies also need resources and training to work with other state agencies to ensure speedy clearances of renewable energy projects.

9.2 Way forward

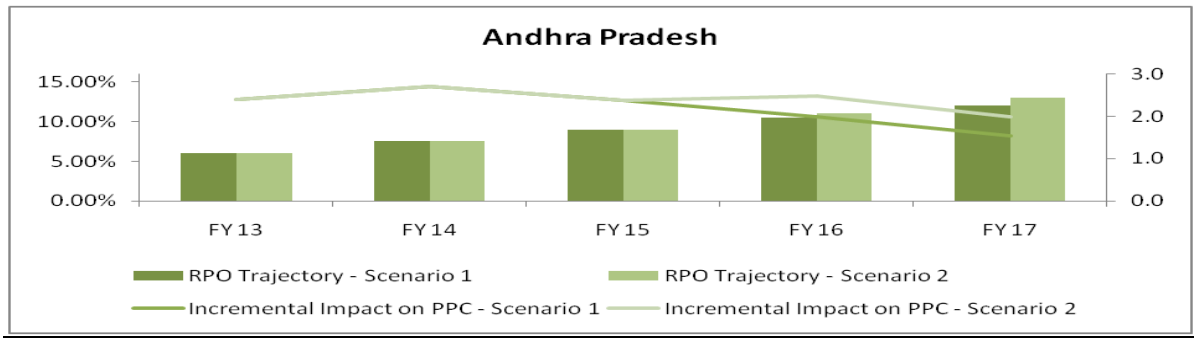
For the proposed enablers to bring about any radical change in renewable energy, we need to adopt a quick win solution, which could provide the required momentum for the implementation of high-effort, high-impact structural reforms. Some solutions take substantial time to design and implement and may require considerable resources. Achieving and demonstrating some quick results is important to gain political support for longer-term solutions. The following table shows the categorization of the enablers.

Table 70: Categorization of enablers

	Short term (0–1 years)	Medium term (1–3 years)	Long term (3–5 years)
Enablers	Enforcement of state-level RPOs	Improving financial sector capability	Transmission and evacuation plan including involvement of private sector
	Incentive structure for utilities	Capacity building	Aggregation of projects
	Connecting Southern grid to National Grid	Strengthening of state nodal agencies	Formation of supporting supply chains
		Setting up transmission facilities through PPP	Research and development
		Resource assessment	Renewable energy park through Case 2 kind of biddings
		Renewable energy park through Case 2 kind of biddings	

Annexure 1 – Andhra Pradesh

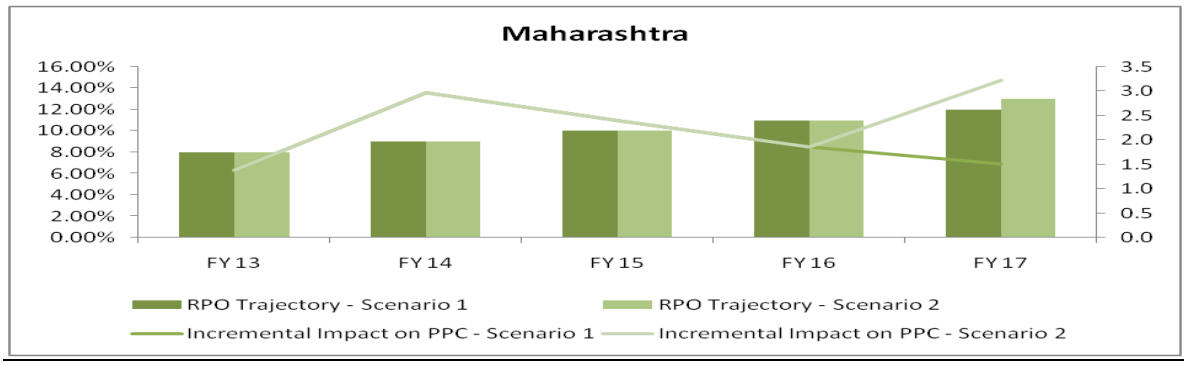
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	89,032	97,649	106,266	114,884	125,350	136,770	
PPC without RE	Rs./Unit	2.50	2.59	2.68	2.77	2.87	2.97	**3.52%**
Cost of Power Purchase, without RE	Rs. Crores	22,258	25,271	28,469	31,861	35,987	40,647	
RPO Level	**%**	**5.0%**	**6.0%**	**7.5%**	**9.0%**	**10.5%**	**12.0%**	
RPO Level - Solar (Inclusive in Overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	84,580	91,790	98,296	104,544	112,188	120,358	
Renewable Energy Purchase	MUs	4,452	5,859	7,970	10,340	13,162	16,412	
- Non-Solar	MUs	4,229	5,371	7,173	9,191	11,595	14,361	
- Solar	MUs	222.6	488.2	797.0	1,148.8	1,566.9	2,051.6	
RE (Non-Solar) Tariff	Rs./Unit	3.55	3.61	3.71	3.79	3.86	3.94	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	21,145	23,755	26,334	28,993	32,208	35,770	
Renewable Energy Purchase Costs	Rs. Crores	1,732	2,429	3,416	4,525	5,837	7,335	
Total PPC	Rs. Crores	22,877	26,184	29,750	33,518	38,045	43,105	
Per Unit Cost of Power	Rs./Unit	2.57	2.68	2.80	2.92	3.04	3.15	
Difference in PPC	Rs./Unit	0.070	0.093	0.121	0.144	0.169	0.189	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.0%	1.5%	1.5%	1.5%	1.5%
RPO level	**%**	**5.0%**	**6.0%**	**7.5%**	**9.0%**	**10.5%**	**12.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	7.0	9.3	12.1	14.4	16.4	18.0
Incremental impact on PPC	**Paisa/unit**		**2.4**	**2.7**	**2.4**	**2.0**	**1.5**
Scenario – 2	**Increase in RPO Level:**		1.0%	1.5%	1.5%	2.0%	2.0%
RPO level	**%**	**5.0%**	**6.0%**	**7.5%**	**9.0%**	**11.0%**	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	7.0	9.3	12.1	14.4	16.9	18.9
Incremental impact on PPC	**Paisa/unit**		**2.4**	**2.7**	**2.4**	**2.5**	**2.0**

Annexure 2 – Maharashtra

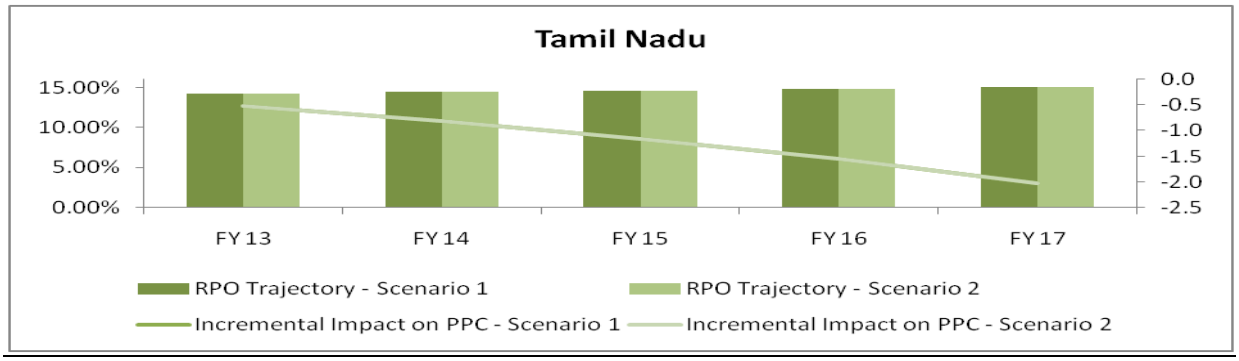
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	125,661	133,974	142,287	150,601	160,166	170,339	
PPC without RE	Rs./Unit	2.62	2.75	2.88	3.03	3.17	3.33	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	32,923	36,828	41,038	45,572	50,852	56,742	
RPO Level	**%**	**7.0%**	**8.0%**	**9.0%**	**10.0%**	**11.0%**	**12.0%**	
RPO Level - Solar (Inclusive in Overall RPO)	%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	116,865	123,256	129,482	135,541	142,548	149,898	
Renewable Energy Purchase	MUs	8,796	10,718	12,806	15,060	17,618	20,441	
- Non-Solar	MUs	8,482	10,048	11,739	13,554	15,616	17,886	
- Solar	MUs	314.2	669.9	1,067.2	1,506.0	2,002.1	2,555.1	
RE (Non-Solar) Tariff	Rs./Unit	3.04	3.10	4.80	4.80	4.80	5.04	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	30,619	33,882	37,344	41,015	45,258	49,933	
Renewable Energy Purchase Costs	Rs. Crores	2,905	3,771	4,992	6,293	7,738	9,348	
Total PPC	Rs. Crores	33,524	37,653	42,336	47,309	52,996	59,281	
Per Unit Cost of Power	Rs./Unit	2.67	2.81	2.98	3.14	3.31	3.48	
Difference in PPC	Rs./Unit	**0.048**	**0.062**	**0.091**	**0.115**	**0.134**	**0.149**	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.0%	1.0%
RPO level	**%**	7.00%	8.00%	9.00%	10.00%	11.00%	12.00%
Difference in PPC due to inclusion of RE	Paisa/unit	4.8	6.2	9.1	11.5	13.4	14.9
Incremental impact on PPC	**Paisa/unit**		**1.4**	**3.0**	**2.4**	**1.9**	**1.5**
Scenario – 2	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.0%	2.0%
RPO level	**%**	7.00%	9.00%	10.00%	11.00%	12.00%	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	4.8	6.2	9.1	11.5	13.4	16.6
Incremental impact on PPC	**Paisa/unit**		**1.4**	**3.0**	**2.4**	**1.9**	**3.2**

Annexure 3 – Tamil Nadu

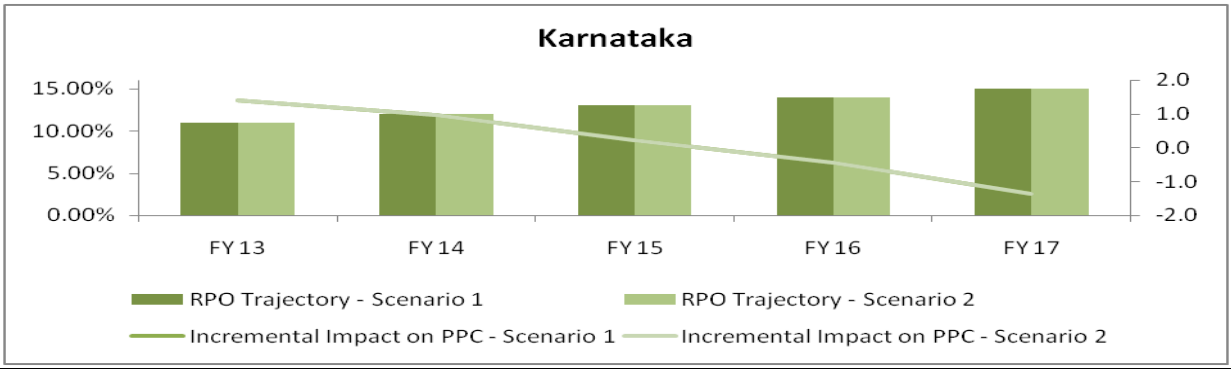
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	87,222	96,729	106,235	115,742	126,999	139,350	
PPC without RE	Rs./Unit	3.38	3.55	3.72	3.90	4.10	4.30	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	29,481	34,303	39,528	45,184	52,017	59,885	
RPO Level	**%**	**14.0%**	**14.2%**	**14.4%**	**14.6%**	**14.8%**	**15.0%**	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	75,011	82,993	90,937	98,843	108,203	118,448	
Renewable Energy Purchase	MUs	12,211	13,735	15,298	16,898	18,796	20,903	
- Non-Solar	MUs	11,993	13,252	14,501	15,741	17,208	18,812	
- Solar	MUs	218.1	483.6	796.8	1,157.4	1,587.5	2,090.3	
RE (Non-Solar) Tariff	Rs./Unit	3.75	3.76	3.77	3.79	3.81	3.82	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	25,354	29,432	33,836	38,587	44,319	50,902	
Renewable Energy Purchase Costs	Rs. Crores	4,721	5,479	6,273	7,096	8,050	9,086	
Total PPC	Rs. Crores	30,075	34,911	40,109	45,683	52,368	59,988	
Per Unit Cost of Power	Rs./Unit	3.45	3.61	3.78	3.95	4.12	4.30	
Difference in PPC	Rs./Unit	**0.068**	**0.063**	**0.055**	**0.043**	**0.028**	**0.007**	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		0.2%	0.2%	0.2%	0.2%	0.2%
RPO level	**%**	**14.0%**	**14.2%**	**14.4%**	**14.6%**	**14.8%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.8	6.3	5.5	4.3	2.8	0.7
Incremental impact on PPC	**Paisa/unit**		**-0.5**	**-0.8**	**-1.2**	**-1.6**	**-2.0**
Scenario – 2	**Increase in RPO Level:**		0.2%	0.2%	0.2%	0.2%	0.2%
RPO level	**%**	**14.0%**	**14.2%**	**14.4%**	**14.6%**	**14.8%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.8	6.3	5.5	4.3	2.8	0.7
Incremental impact on PPC	**Paisa/unit**		**-0.5**	**-0.8**	**-1.2**	**-1.6**	**-2.0**

Annexure 4 – Karnataka

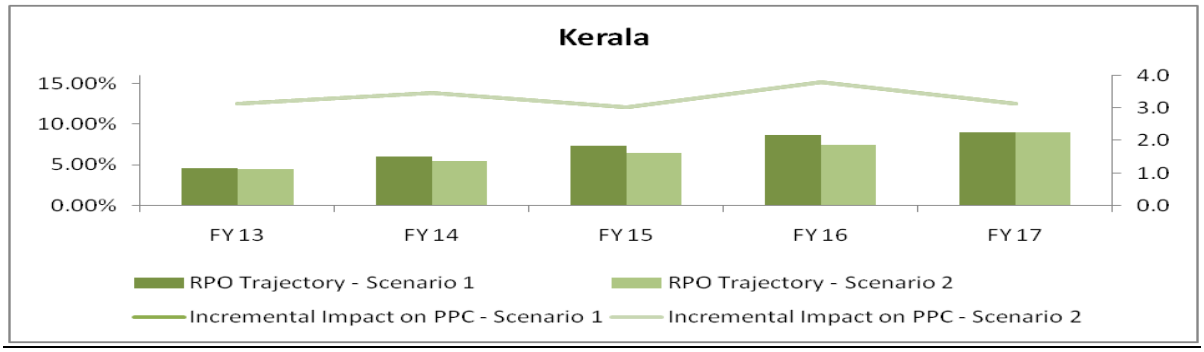
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	53,540	58,831	64,122	69,414	75,425	81,957	
PPC without RE	Rs./Unit	2.66	2.84	3.02	3.22	3.43	3.66	**6.59%**
Cost of Power Purchase, without RE	Rs. Crores	14,242	16,680	19,377	22,358	25,894	29,989	
RPO Level	**%**	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	48,186	52,360	56,428	60,390	64,865	69,663	
Renewable Energy Purchase	MUs	5,354	6,471	7,695	9,024	10,559	12,294	
- Non-Solar	MUs	5,220	6,177	7,214	8,330	9,617	11,064	
- Solar	MUs	133.9	294.2	480.9	694.1	942.8	1,229.4	
RE (Non-Solar) Tariff	Rs./Unit	3.60	3.98	4.12	4.12	4.20	4.20	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	12,817	14,845	17,052	19,451	22,269	25,491	
Renewable Energy Purchase Costs	Rs. Crores	2,017	2,569	3,189	3,858	4,627	5,476	
Total PPC	Rs. Crores	14,834	17,414	20,241	23,309	26,895	30,967	
Per Unit Cost of Power	Rs./Unit	2.77	2.96	3.16	3.36	3.57	3.78	
Difference in PPC	Rs./Unit	0.111	0.125	0.135	0.137	0.133	0.119	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.0%	1.0%
RPO level	**%**	**10.0%**	**11.0%**	**12.0%**	**13.0%**	**14.0%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	11.1	12.5	13.5	13.7	13.3	11.9
Incremental impact on PPC	**Paisa/unit**		**1.4**	**1.0**	**0.2**	**-0.4**	**-1.4**
Scenario – 2	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.0%	1.0%
RPO level	**%**	**10.0%**	**11.0%**	**12.0%**	**13.0%**	**14.0%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	11.1	12.5	13.5	13.7	13.3	11.9
Incremental impact on PPC	**Paisa/unit**		**1.4**	**1.0**	**0.2**	**-0.4**	**-1.4**

Annexure 5 – Kerala

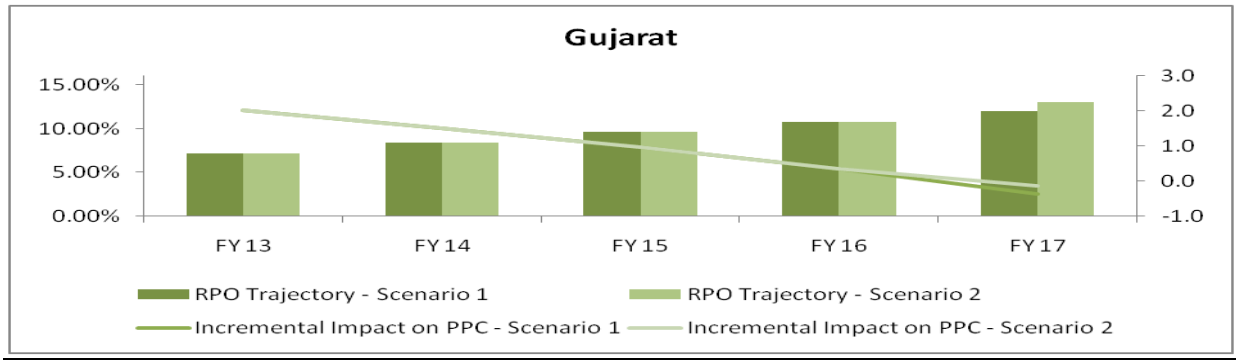
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	19,230	20,650	22,071	23,491	25,054	26,720	
PPC without RE	Rs./Unit	1.99	2.09	2.20	2.31	2.43	2.55	**5.11%**
Cost of Power Purchase, without RE	Rs. Crores	3,827	4,320	4,853	5,429	6,086	6,823	
RPO Level	**%**	3.3%	4.0%	5.0%	6.0%	7.5%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	18,595	19,692	20,751	21,772	22,884	24,315	
Renewable Energy Purchase	MUs	635	826	1,104	1,409	1,879	2,405	
- Non-Solar	MUs	587	723	938	1,175	1,566	2,004	
- Solar	MUs	48.1	103.3	165.5	234.9	313.2	400.8	
RE (Non-Solar) Tariff	Rs./Unit	2.56	4.24	4.28	4.28	4.47	4.47	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	3,700	4,119	4,563	5,032	5,559	6,209	
Renewable Energy Purchase Costs	Rs. Crores	200	317	473	642	889	1,159	
Total PPC	Rs. Crores	3,900	4,464	5,083	5,746	6,519	7,368	
Per Unit Cost of Power	Rs./Unit	2.03	2.16	2.30	2.45	2.60	2.76	
Difference in PPC	Rs./Unit	0.038	0.070	0.104	0.135	0.173	0.204	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**0.7%**	**1.0%**	**1.0%**	**1.5%**	**1.5%**
RPO level	**%**	**3.3%**	**4.0%**	**5.0%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	3.8	7.0	10.4	13.5	17.3	20.4
Incremental impact on PPC	**Paisa/unit**		**3.1**	**3.5**	**3.0**	**3.8**	**3.1**
Scenario – 2	**Increase in RPO Level:**		**0.7%**	**1.0%**	**1.0%**	**1.5%**	**1.5%**
RPO level	**%**	**3.3%**	**4.0%**	**5.0%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	3.8	7.0	10.4	13.5	17.3	20.4
Incremental impact on PPC	**Paisa/unit**		**3.1**	**3.5**	**3.0**	**3.8**	**3.1**

Annexure 6 – Gujarat

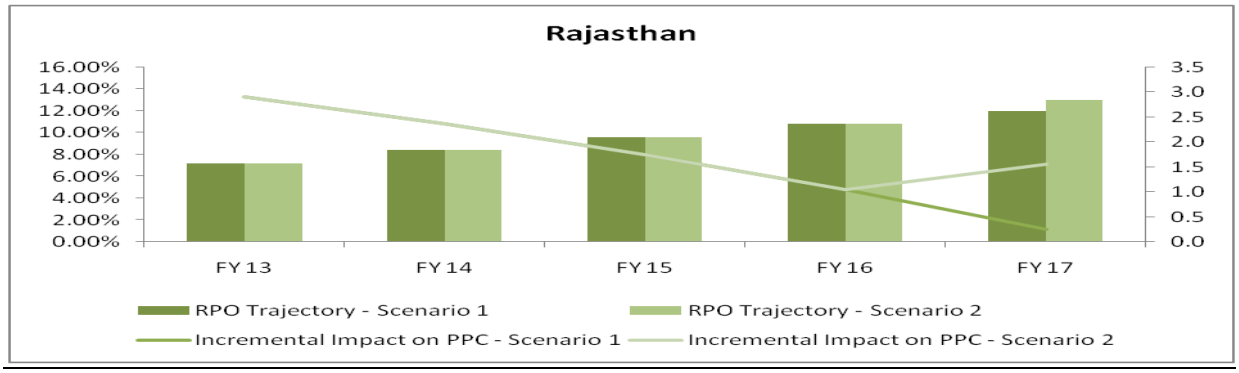
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	85,445	92,173	98,900	105,628	113,799	122,603	
PPC without RE	Rs./Unit	2.98	3.11	3.25	3.39	3.54	3.70	**4.43%**
Cost of Power Purchase, without RE	Rs. Crores	25,463	28,685	32,143	35,851	40,337	45,384	
RPO Level	**%**	6.0%	7.2%	8.4%	9.6%	10.8%	12.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	80,318	85,536	90,593	95,488	101,509	107,891	
Renewable Energy Purchase	MUs	5,127	6,636	8,308	10,140	12,290	14,712	
- Non-Solar	MUs	4,913	6,176	7,566	9,084	10,868	12,873	
- Solar	MUs	213.6	460.9	741.8	1,056.3	1,422.5	1,839.0	
RE (Non-Solar) Tariff	Rs./Unit	3.56	3.91	3.91	3.91	3.91	3.91	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	23,935	26,620	29,443	32,410	35,981	39,938	
Renewable Energy Purchase Costs	Rs. Crores	1,970	2,728	3,562	4,464	5,498	6,633	
Total PPC	Rs. Crores	25,905	29,348	33,005	36,873	41,478	46,571	
Per Unit Cost of Power	Rs./Unit	3.03	3.18	3.34	3.49	3.64	3.80	
Difference in PPC	Rs./Unit	0.052	0.072	0.087	0.097	0.100	0.097	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**1.2%**	**1.2%**	**1.2%**	**1.2%**	**1.2%**
RPO level	**%**	**6.0%**	**7.2%**	**8.4%**	**9.6%**	**10.8%**	**12.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.2	7.2	8.7	9.7	10.0	9.7
Incremental impact on PPC	**Paisa/unit**		**2.0**	**1.5**	**1.0**	**0.4**	**-0.3**
Scenario – 2	**Increase in RPO Level:**		**1.2%**	**1.2%**	**1.2%**	**1.2%**	**2.2%**
RPO level	**%**	**6.0%**	**7.2%**	**8.4%**	**9.6%**	**10.8%**	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.2	7.2	8.7	9.7	10.0	9.9
Incremental impact on PPC	**Paisa/unit**		**2.0**	**1.5**	**1.0**	**0.4**	**-0.1**

Annexure 7 – Rajasthan

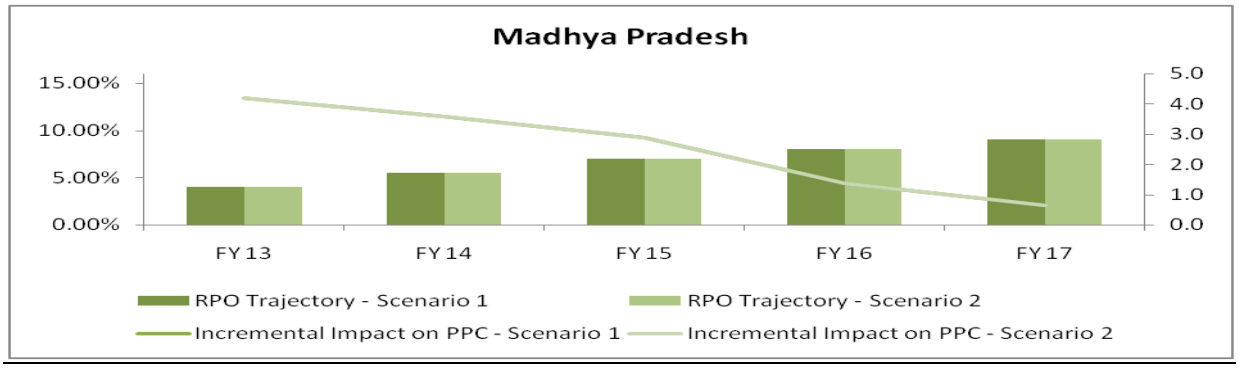
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	48,916	52,686	56,456	60,227	64,669	69,438	
PPC without RE	Rs./Unit	2.60	2.76	2.92	3.10	3.28	3.48	**6.00%**
Cost of Power Purchase, without RE	Rs. Crores	12,718	14,520	16,493	18,650	21,227	24,160	
RPO Level	**%**	6.0%	7.2%	8.4%	9.6%	10.8%	12.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	45,981	48,893	51,714	54,445	57,684	61,106	
Renewable Energy Purchase	MUs	2,935	3,793	4,742	5,782	6,984	8,333	
- Non-Solar	MUs	2,813	3,530	4,319	5,179	6,176	7,291	
- Solar	MUs	122.3	263.4	423.4	602.3	808.4	1,041.6	
RE (Non-Solar) Tariff	Rs./Unit	4.68	4.69	4.71	4.73	4.75	4.78	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	11,955	13,475	15,108	16,860	18,935	21,261	
Renewable Energy Purchase Costs	Rs. Crores	1,442	1,930	2,467	3,049	3,712	4,441	
Total PPC	Rs. Crores	13,397	15,405	17,574	19,909	22,646	25,702	
Per Unit Cost of Power	Rs./Unit	2.74	2.92	3.11	3.31	3.50	3.70	
Difference in PPC	Rs./Unit	0.139	0.168	0.191	0.209	0.219	0.222	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.2%	1.2%	1.2%	1.2%	1.2%
RPO level	**%**	**6.0%**	**7.2%**	**8.4%**	**9.6%**	**10.8%**	**12.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	13.9	16.8	19.1	20.9	21.9	22.2
Incremental impact on PPC	**Paisa/unit**		**2.9**	**2.4**	**1.7**	**1.0**	**0.3**
Scenario – 2	**Increase in RPO Level:**		1.2%	1.2%	1.2%	1.2%	2.2%
RPO level	**%**	**6.0%**	**7.2%**	**8.4%**	**9.6%**	**10.8%**	**13.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	13.9	16.8	19.1	20.9	21.9	23.5
Incremental impact on PPC	**Paisa/unit**		**2.9**	**2.4**	**1.7**	**1.0**	1.5

Annexure 8 – Madhya Pradesh

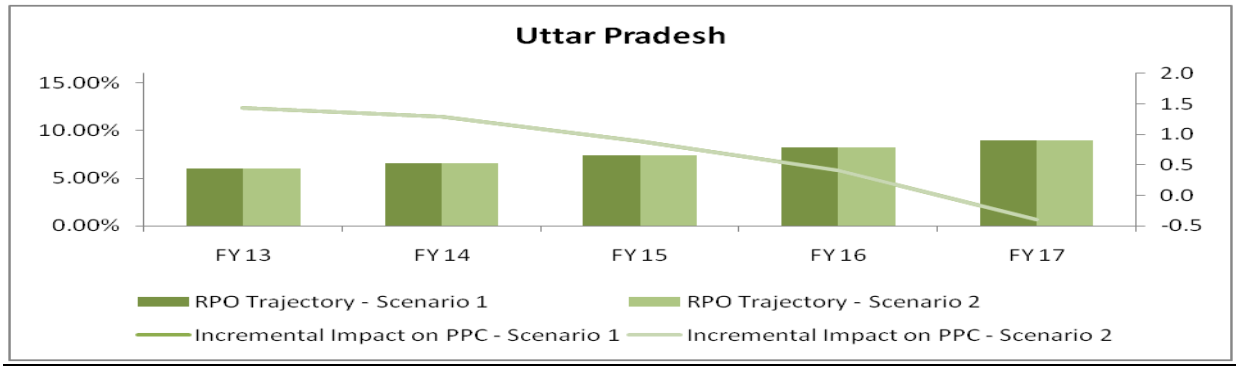
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	49,338	53,559	57,781	62,002	66,834	72,042	
PPC without RE	Rs./Unit	2.09	2.24	2.39	2.56	2.74	2.93	**7.00%**
Cost of Power Purchase, without RE	Rs. Crores	10,312	11,977	13,826	15,875	18,310	21,118	
RPO Level	**%**	2.5%	4.0%	5.5%	7.0%	8.0%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	48,105	51,417	54,603	57,662	61,487	65,558	
Renewable Energy Purchase	MUs	1,233	2,142	3,178	4,340	5,347	6,484	
- Non-Solar	MUs	1,110	1,875	2,745	3,720	4,511	5,403	
- Solar	MUs	123.3	267.8	433.4	620.0	835.4	1,080.6	
RE (Non-Solar) Tariff	Rs./Unit	4.19	4.19	4.19	4.19	4.19	4.19	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	10,054	11,498	13,066	14,763	16,845	19,217	
Renewable Energy Purchase Costs	Rs. Crores	593	1,068	1,603	2,195	2,724	3,304	
Total PPC	Rs. Crores	10,647	12,566	14,669	16,958	19,569	22,522	
Per Unit Cost of Power	Rs./Unit	2.16	2.35	2.54	2.74	2.93	3.13	
Difference in PPC	Rs./Unit	0.068	0.110	0.146	0.175	0.188	0.195	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.5%	1.5%	1.5%	1.0%	1.0%
RPO level	**%**	**2.50%**	**4.00%**	**5.50%**	**7.00%**	**8.00%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.8	11.0	14.6	17.5	18.8	19.5
Incremental impact on PPC	**Paisa/unit**		**4.2**	**3.6**	**2.9**	**1.4**	**0.6**
Scenario – 2	**Increase in RPO Level:**		1.5%	1.5%	1.5%	1.0%	1.0%
RPO level	**%**	**2.50%**	**4.00%**	**5.50%**	**7.00%**	**8.00%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.8	11.0	14.6	17.5	18.8	19.5
Incremental impact on PPC	**Paisa/unit**		**4.2**	**3.6**	**2.9**	**1.4**	**0.6**

Annexure 9 – Uttar Pradesh

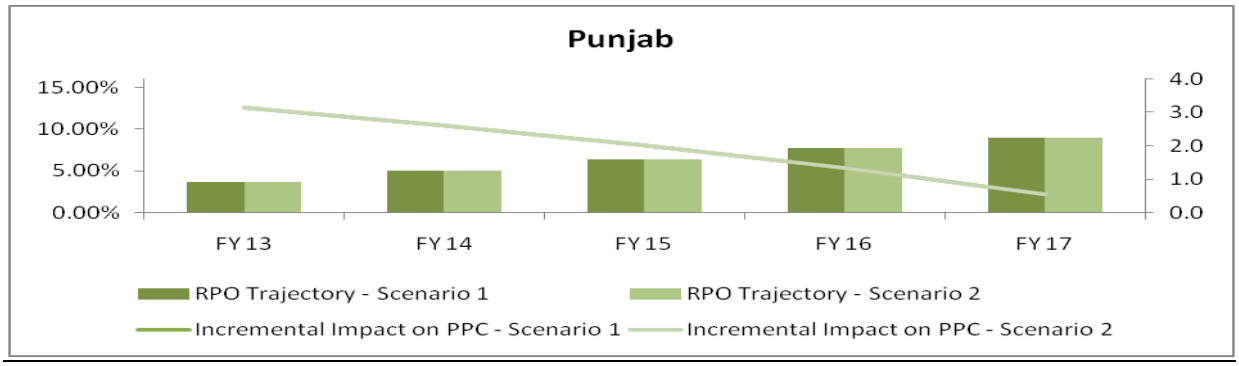
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	79,268	85,547	91,827	98,106	106,032	114,598	
PPC without RE	Rs./Unit	2.62	2.79	2.98	3.18	3.39	3.61	**6.65%**
Cost of Power Purchase, without RE	Rs. Crores	20,755	23,889	27,348	31,162	35,920	41,404	
RPO Level	**%**	5.0%	5.5%	6.2%	7.0%	8.0%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	75,305	80,842	86,134	91,239	97,549	104,284	
Renewable Energy Purchase	MUs	3,963	4,705	5,693	6,867	8,483	10,314	
- Non-Solar	MUs	3,765	4,277	5,005	5,886	7,157	8,595	
- Solar	MUs	198.2	427.7	688.7	981.1	1,325.4	1,719.0	
RE (Non-Solar) Tariff	Rs./Unit	4.04	4.07	4.07	4.07	4.07	4.07	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	19,717	22,575	25,653	28,981	33,046	37,678	
Renewable Energy Purchase Costs	Rs. Crores	1,728	2,182	2,747	3,392	4,225	5,142	
Total PPC	Rs. Crores	21,445	24,757	28,399	32,372	37,272	42,820	
Per Unit Cost of Power	Rs./Unit	2.71	2.89	3.09	3.30	3.52	3.74	
Difference in PPC	Rs./Unit	0.087	0.101	0.114	0.123	0.127	0.124	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		0.5%	0.7%	0.8%	1.0%	1.0%
RPO level	**%**	**5.0%**	**5.5%**	**6.2%**	**7.0%**	**8.0%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	8.7	10.1	11.4	12.3	12.7	12.4
Incremental impact on PPC	**Paisa/unit**		**1.4**	**1.3**	**0.9**	**0.4**	**-0.4**
Scenario – 2	**Increase in RPO Level:**		0.5%	0.7%	0.8%	1.0%	1.0%
RPO level	**%**	**5.0%**	**5.5%**	**6.2%**	**7.0%**	**8.0%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	8.7	10.1	11.4	12.3	12.7	12.4
Incremental impact on PPC	**Paisa/unit**		**1.4**	**1.3**	**0.9**	**0.4**	**-0.4**

Annexure 10 – Punjab

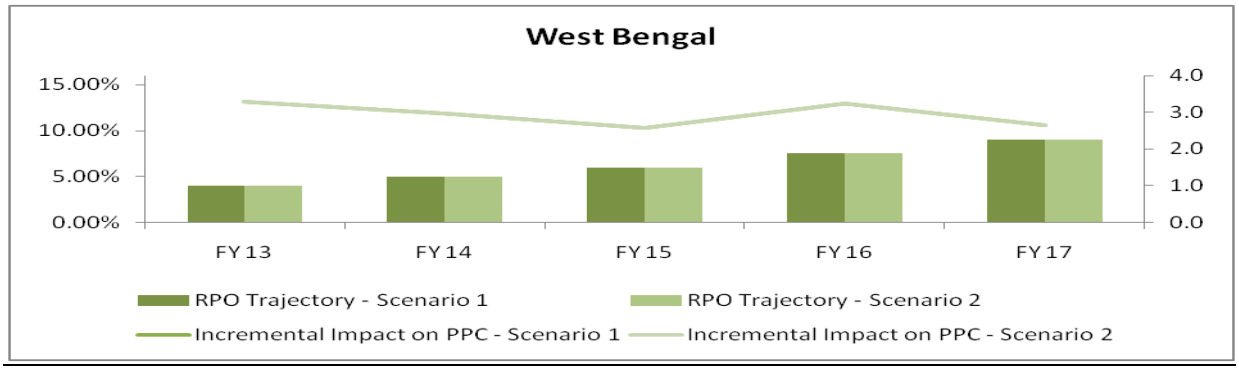
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	89,032	97,649	106,266	114,884	125,350	136,770	
PPC without RE	Rs./Unit	2.50	2.59	2.68	2.77	2.87	2.97	**6.00%**
Cost of Power Purchase, without RE	Rs. Crores	22,258	25,271	28,469	31,861	35,987	40,647	
RPO Level	**%**	2.4%	3.7%	5.0%	6.4%	7.7%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	59,037	62,491	65,828	69,049	73,273	77,739	
Renewable Energy Purchase	MUs	1,452	2,414	3,494	4,690	6,095	7,688	
- Non-Solar	MUs	1,301	2,090	2,974	3,952	5,103	6,407	
- Solar	MUs	151.2	324.5	519.9	737.4	992.1	1,281.4	
RE (Non-Solar) Tariff	Rs./Unit	4.30	4.34	4.39	4.44	4.49	4.55	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	15,999	17,951	20,044	22,287	25,069	28,193	
Renewable Energy Purchase Costs	Rs. Crores	716	1,244	1,834	2,481	3,232	4,069	
Total PPC	Rs. Crores	16,715	19,196	21,878	24,768	28,301	32,261	
Per Unit Cost of Power	Rs./Unit	2.76	2.96	3.16	3.36	3.57	3.78	
Difference in PPC	Rs./Unit	0.053	0.085	0.111	0.131	0.144	0.150	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.3%	1.3%	1.3%	1.3%	1.3%
RPO level	**%**	**2.4%**	**3.7%**	**5.0%**	**6.4%**	**7.7%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.3	8.5	11.1	13.1	14.4	15.0
Incremental impact on PPC	**Paisa/unit**		**3.2**	**2.6**	**2.0**	**1.3**	**0.5**
Scenario – 2	**Increase in RPO Level:**		1.3%	1.3%	1.3%	1.3%	1.3%
RPO level	**%**	**2.4%**	**3.7%**	**5.0%**	**6.4%**	**7.7%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.3	8.5	11.1	13.1	14.4	15.0
Incremental impact on PPC	**Paisa/unit**		**3.2**	**2.6**	**2.0**	**1.3**	**0.5**

Annexure 11 – West Bengal

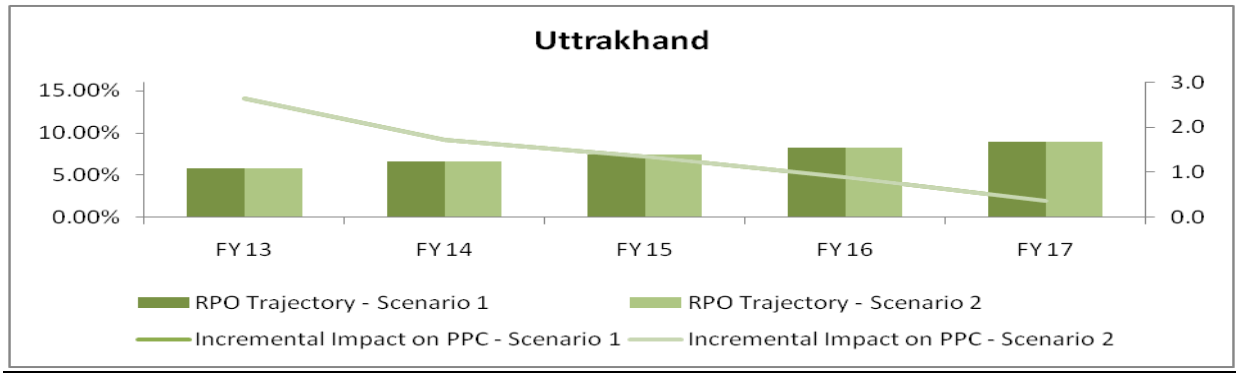
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	41,020	44,862	48,703	52,545	56,682	61,145	
PPC without RE	Rs./Unit	2.43	2.52	2.61	2.71	2.81	2.91	**3.67%**
Cost of Power Purchase, without RE	Rs. Crores	9,968	11,301	12,719	14,226	15,909	17,791	
RPO Level	**%**	3.0%	4.0%	5.0%	6.0%	7.5%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	39,789	43,067	46,268	49,392	52,431	55,642	
Renewable Energy Purchase	MUs	1,231	1,794	2,435	3,153	4,251	5,503	
- Non-Solar	MUs	1,128	1,570	2,070	2,627	3,543	4,586	
- Solar	MUs	102.6	224.3	365.3	525.4	708.5	917.2	
RE (Non-Solar) Tariff	Rs./Unit	3.60	4.31	4.31	4.31	4.52	4.52	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	9,669	10,849	12,083	13,372	14,715	16,189	
Renewable Energy Purchase Costs	Rs. Crores	513	834	1,194	1,591	2,173	2,821	
Total PPC	Rs. Crores	10,182	11,683	13,277	14,964	16,889	19,010	
Per Unit Cost of Power	Rs./Unit	2.48	2.60	2.73	2.85	2.98	3.11	
Difference in PPC	Rs./Unit	0.052	0.085	0.115	0.140	0.173	0.199	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.5%	1.5%
RPO level	**%**	**3.00%**	**4.00%**	**5.00%**	**6.00%**	**7.50%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.2	8.5	11.5	14.0	17.3	19.9
Incremental impact on PPC	**Paisa/unit**		**3.3**	**3.0**	**2.6**	**3.3**	**2.7**
Scenario – 2	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.5%	1.5%
RPO level	**%**	**3.00%**	**4.00%**	**5.00%**	**6.00%**	**7.50%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.2	8.5	11.5	14.0	17.3	19.9
Incremental impact on PPC	**Paisa/unit**		**3.3**	**3.0**	**2.6**	**3.3**	**2.7**

Annexure 12 – Uttarakhand

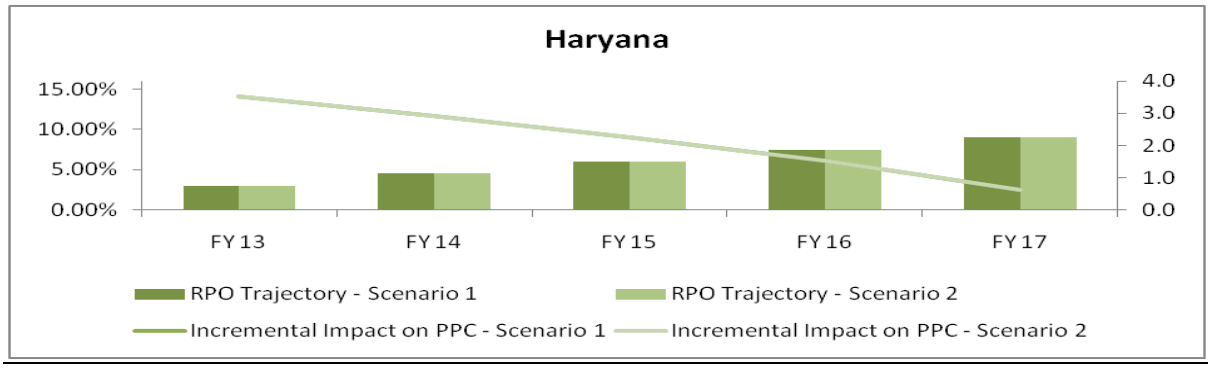
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	8,445	9,090	9,734	10,379	11,174	12,030	
PPC without RE	Rs./Unit	2.34	2.46	2.58	2.70	2.84	2.98	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	1,976	2,232	2,507	2,805	3,168	3,579	
RPO Level	**%**	4.5%	5.8%	6.6%	7.4%	8.2%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	8,065	8,562	9,092	9,611	10,258	10,947	
Renewable Energy Purchase	MUs	380	527	642	768	916	1,083	
- Non-Solar	MUs	359	482	569	664	777	902	
- Solar	MUs	21.1	45.4	73.0	103.8	139.7	180.4	
RE (Non-Solar) Tariff	Rs./Unit	3.50	3.50	3.50	3.50	3.50	3.50	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	1,887	2,102	2,342	2,597	2,909	3,257	
Renewable Energy Purchase Costs	Rs. Crores	148	217	276	339	411	490	
Total PPC	Rs. Crores	2,035	2,319	2,618	2,936	3,320	3,746	
Per Unit Cost of Power	Rs./Unit	2.41	2.55	2.69	2.83	2.97	3.11	
Difference in PPC	Rs./Unit	0.069	0.096	0.113	0.127	0.136	0.139	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**1.3%**	**0.8%**	**0.8%**	**0.8%**	**0.8%**
RPO level	**%**	**4.5%**	**5.8%**	**6.6%**	**7.4%**	**8.2%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.9	9.6	11.3	12.7	13.6	13.9
Incremental impact on PPC	**Paisa/unit**		**2.6**	**1.7**	**1.3**	**0.9**	**0.4**
Scenario – 2	**Increase in RPO Level:**		**1.3%**	**0.8%**	**0.8%**	**0.8%**	**0.8%**
RPO level	**%**	**4.5%**	**5.8%**	**6.6%**	**7.4%**	**8.2%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.9	9.6	11.3	12.7	13.6	13.9
Incremental impact on PPC	**Paisa/unit**		**2.6**	**1.7**	**1.3**	**0.9**	**0.4**

Annexure 13 – Haryana

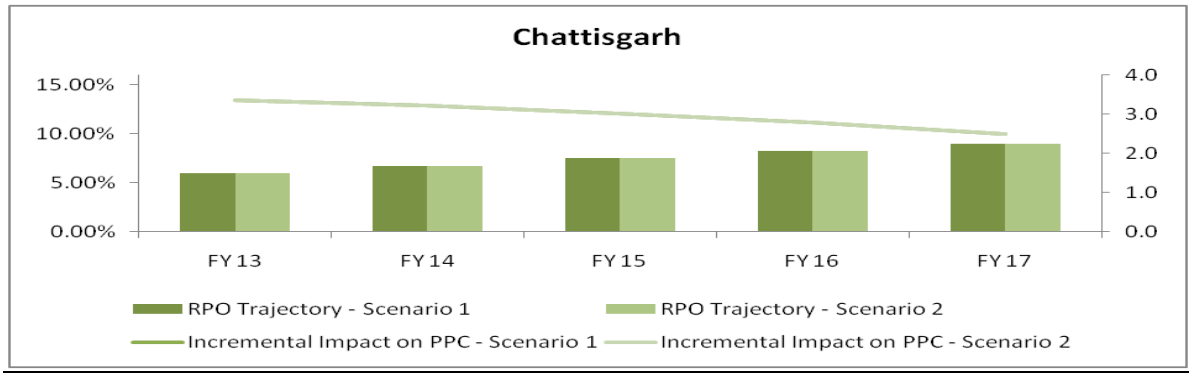
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	38,417	41,595	44,772	47,950	51,865	56,100	
PPC without RE	Rs./Unit	2.60	2.75	2.92	3.09	3.27	3.47	**5.93%**
Cost of Power Purchase, without RE	Rs. Crores	9,988	11,456	13,063	14,820	16,982	19,458	
RPO Level	**%**	1.5%	3.0%	4.5%	6.0%	7.5%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	37,841	40,347	42,757	45,073	47,975	51,051	
Renewable Energy Purchase	MUs	576	1,248	2,015	2,877	3,890	5,049	
- Non-Solar	MUs	480	1,040	1,679	2,397	3,242	4,208	
- Solar	MUs	96.0	208.0	335.8	479.5	648.3	841.5	
RE (Non-Solar) Tariff	Rs./Unit	4.13	4.15	4.17	4.20	4.25	4.25	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	9,839	11,113	12,475	13,931	15,708	17,707	
Renewable Energy Purchase Costs	Rs. Crores	298	650	1,049	1,491	2,005	2,577	
Total PPC	Rs. Crores	10,137	11,763	13,524	15,422	17,713	20,284	
Per Unit Cost of Power	Rs./Unit	2.64	2.83	3.02	3.22	3.42	3.62	
Difference in PPC	Rs./Unit	0.039	0.074	0.103	0.126	0.141	0.147	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.5%	1.5%	1.5%	1.5%	1.5%
RPO level	**%**	**1.5%**	**3.0%**	**4.5%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	3.9	7.4	10.3	12.6	14.1	14.7
Incremental impact on PPC	**Paisa/unit**		**3.5**	**2.9**	**2.3**	**1.5**	**0.6**
Scenario – 2	**Increase in RPO Level:**		1.5%	1.5%	1.5%	1.5%	1.5%
RPO level	**%**	**1.5%**	**3.0%**	**4.5%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	3.9	7.4	10.3	12.6	14.1	14.7
Incremental impact on PPC	**Paisa/unit**		**3.5**	**2.9**	**2.3**	**1.5**	**0.6**

Annexure 14 – Chhattisgarh

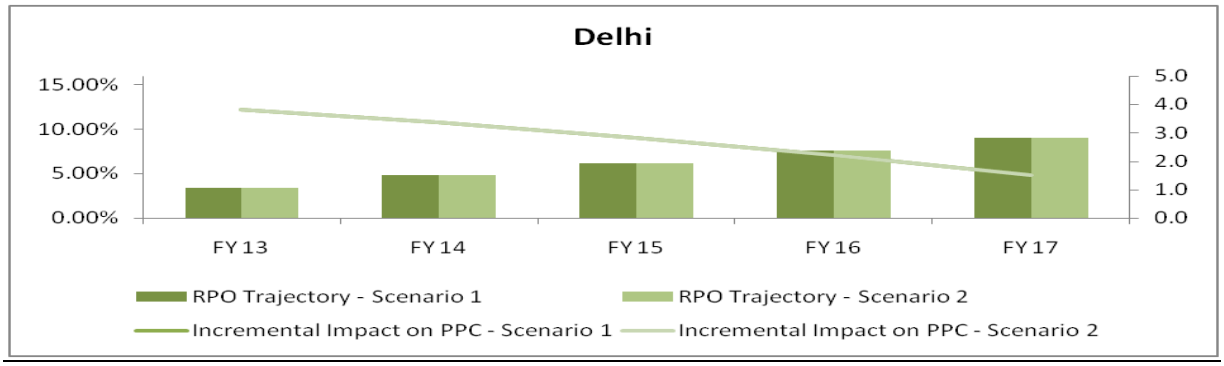
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	21,785	24,043	26,301	28,560	31,245	34,183	
PPC without RE	Rs./Unit	1.62	1.70	1.78	1.87	1.96	2.06	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	3,529	4,087	4,690	5,344	6,134	7,041	
RPO Level	**%**	5.3%	6.0%	6.8%	7.5%	8.3%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	20,641	22,601	24,526	26,418	28,667	31,107	
Renewable Energy Purchase	MUs	1,144	1,443	1,775	2,142	2,578	3,077	
- Non-Solar	MUs	1,089	1,322	1,578	1,856	2,187	2,564	
- Solar	MUs	54.5	120.2	197.3	285.6	390.6	512.8	
RE (Non-Solar) Tariff	Rs./Unit	4.51	4.63	4.76	4.89	5.04	5.19	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	3,344	3,841	4,374	4,943	5,628	6,407	
Renewable Energy Purchase Costs	Rs. Crores	547	726	927	1,149	1,412	1,711	
Total PPC	Rs. Crores	3,891	4,567	5,301	6,092	7,040	8,118	
Per Unit Cost of Power	Rs./Unit	1.79	1.90	2.02	2.13	2.25	2.37	
Difference in PPC	Rs./Unit	0.166	0.200	0.232	0.262	0.290	0.315	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		0.8%	0.8%	0.8%	0.8%	0.7%
RPO level	**%**	**5.25%**	**6.00%**	**6.75%**	**7.50%**	**8.25%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	16.6	20.0	23.2	26.2	29.0	31.5
Incremental impact on PPC	**Paisa/unit**		**3.4**	**3.2**	**3.0**	**2.8**	**2.5**
Scenario – 2	**Increase in RPO Level:**		0.8%	0.8%	0.8%	0.8%	0.7%
RPO level	**%**	**5.25%**	**6.00%**	**6.75%**	**7.50%**	**8.25%**	**9.00%**
Difference in PPC due to inclusion of RE	Paisa/unit	16.6	20.0	23.2	26.2	29.0	31.5
Incremental impact on PPC	**Paisa/unit**		**3.4**	**3.2**	**3.0**	**2.8**	**2.5**

Annexure 15 – Delhi

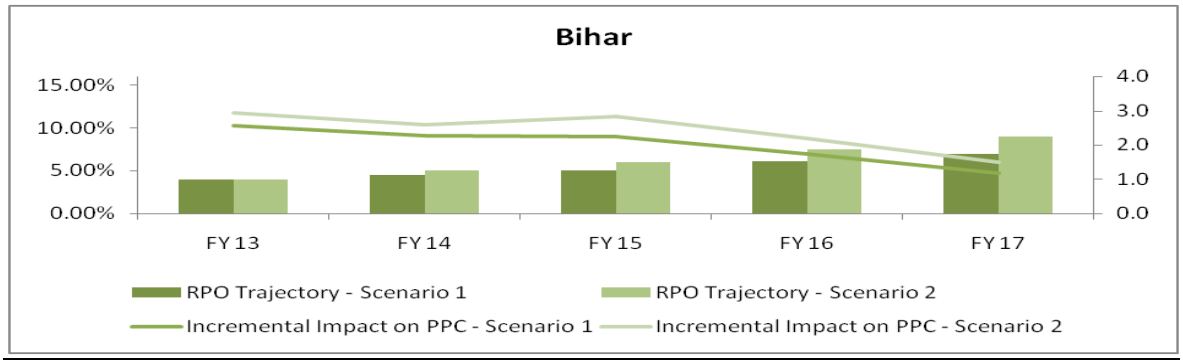
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	36,293	39,587	42,881	46,174	49,988	54,116	
PPC without RE	Rs./Unit	2.62	2.79	2.97	3.16	3.37	3.59	**6.48%**
Cost of Power Purchase, without RE	Rs. Crores	9,509	11,044	12,737	14,604	16,834	19,405	
RPO Level	**%**	2.0%	3.4%	4.8%	6.2%	7.6%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	35,567	38,241	40,822	43,312	46,189	49,246	
Renewable Energy Purchase	MUs	726	1,346	2,058	2,863	3,799	4,870	
- Non-Solar	MUs	635	1,148	1,737	2,401	3,174	4,059	
- Solar	MUs	90.7	197.9	321.6	461.7	624.8	811.7	
RE (Non-Solar) Tariff	Rs./Unit	4.53	4.66	4.80	4.94	5.09	5.25	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	9,319	10,668	12,126	13,698	15,555	17,658	
Renewable Energy Purchase Costs	Rs. Crores	382	736	1,146	1,611	2,154	2,776	
Total PPC	Rs. Crores	9,701	11,404	13,272	15,310	17,709	20,434	
Per Unit Cost of Power	Rs./Unit	2.67	2.88	3.10	3.32	3.54	3.78	
Difference in PPC	Rs./Unit	0.053	0.091	0.125	0.153	0.175	0.190	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.4%	1.4%	1.4%	1.4%	1.4%
RPO level	**%**	**2.0%**	**3.4%**	**4.8%**	**6.2%**	**7.6%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.3	9.1	12.5	15.3	17.5	19.0
Incremental impact on PPC	**Paisa/unit**		**3.8**	**3.4**	**2.8**	**2.2**	**1.5**
Scenario – 2	**Increase in RPO Level:**		1.4%	1.4%	1.4%	1.4%	1.4%
RPO level	**%**	**2.0%**	**3.4%**	**4.8%**	**6.2%**	**7.6%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.3	9.1	12.5	15.3	17.5	19.0
Incremental impact on PPC	**Paisa/unit**		**3.8**	**3.4**	**2.8**	**2.2**	**1.5**

Annexure 16 – Bihar

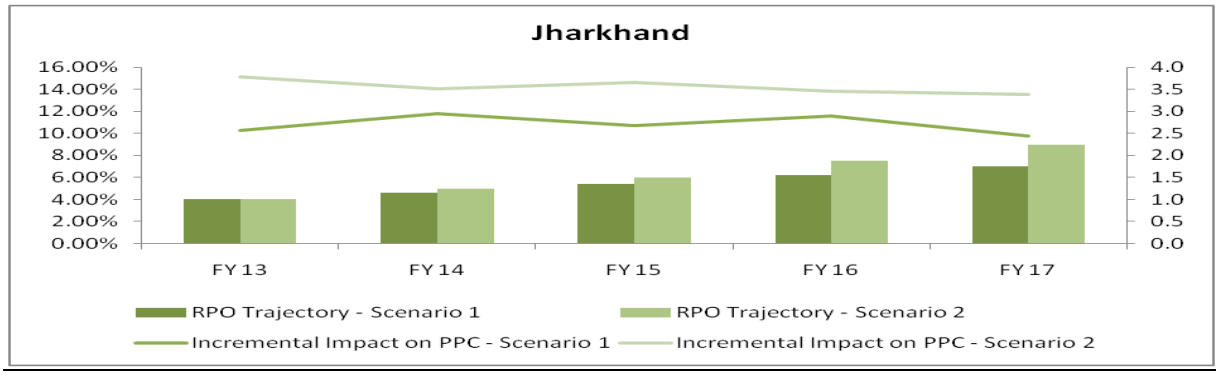
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	36,293	39,587	42,881	46,174	49,988	54,116	
PPC without RE	Rs./Unit	2.62	2.79	2.97	3.16	3.37	3.59	**6.48%**
Cost of Power Purchase, without RE	Rs. Crores	9,509	11,044	12,737	14,604	16,834	19,405	
RPO Level	**%**	2.5%	4.0%	4.5%	5.0%	6.1%	7.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	19,407	21,764	24,082	26,292	29,480	33,050	
Renewable Energy Purchase	MUs	498	731	1,003	1,384	1,882	2,488	
- Non-Solar	MUs	448	619	815	1,107	1,490	1,955	
- Solar	MUs	49.8	112.5	188.1	276.8	392.0	533.1	
RE (Non-Solar) Tariff	Rs./Unit	3.94	3.94	3.94	3.94	3.94	3.94	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	4,503	5,280	6,110	6,977	8,181	9,591	
Renewable Energy Purchase Costs	Rs. Crores	228	363	518	720	976	1,278	
Total PPC	Rs. Crores	4,731	5,643	6,628	7,696	9,157	10,869	
Per Unit Cost of Power	Rs./Unit	2.38	2.51	2.64	2.78	2.92	3.06	
Difference in PPC	Rs./Unit	0.057	0.082	0.105	0.127	0.145	0.157	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**0.8%**	**0.8%**	**1.0%**	**1.0%**	**1.0%**
RPO level	**%**	**2.5%**	**3.3%**	**4.0%**	**5.0%**	**6.0%**	**7.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.7	8.2	10.5	12.7	14.5	15.7
Incremental impact on PPC	**Paisa/unit**		**2.6**	**2.3**	**2.2**	**1.7**	**1.2**
Scenario – 2	**Increase in RPO Level:**		**1.0%**	**1.0%**	**1.5%**	**1.5%**	**1.5%**
RPO level	**%**	**2.5%**	**3.5%**	**4.5%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.7	8.6	11.2	14.0	16.2	17.7
Incremental impact on PPC	**Paisa/unit**		**2.9**	**2.6**	**2.8**	**2.2**	**1.5**

Annexure 17 – Jharkhand

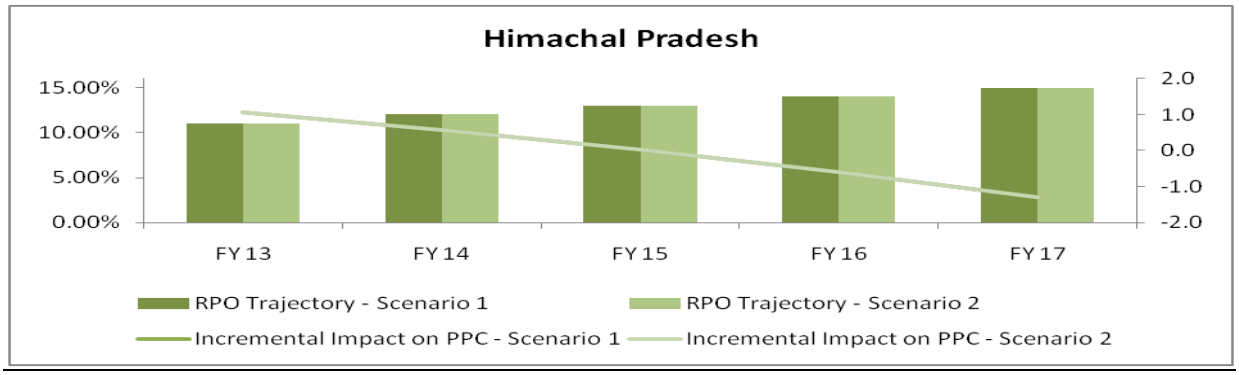
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	23,408	25,981	28,554	31,128	34,493	38,222	
PPC without RE	Rs./Unit	2.01	2.08	2.15	2.23	2.31	2.39	**3.48%**
Cost of Power Purchase, without RE	Rs. Crores	4,705	5,404	6,146	6,933	7,951	9,117	
RPO Level	**%**	3.0%	3.5%	4.3%	5.0%	6.0%	7.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	22,706	25,072	27,341	29,571	32,423	35,546	
Renewable Energy Purchase	MUs	702	909	1,214	1,556	2,070	2,676	
- Non-Solar	MUs	644	779	999	1,245	1,638	2,102	
- Solar	MUs	58.5	129.9	214.2	311.3	431.2	573.3	
RE (Non-Solar) Tariff	Rs./Unit	4.53	4.53	4.53	4.53	4.53	4.53	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	4,564	5,215	5,885	6,587	7,474	8,479	
Renewable Energy Purchase Costs	Rs. Crores	352	490	676	883	1,171	1,500	
Total PPC	Rs. Crores	4,916	5,705	6,561	7,469	8,644	9,979	
Per Unit Cost of Power	Rs./Unit	2.10	2.20	2.30	2.40	2.51	2.61	
Difference in PPC	Rs./Unit	0.090	0.116	0.145	0.172	0.201	0.226	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**0.5%**	**0.8%**	**0.8%**	**1.0%**	**1.0%**
RPO level	**%**	**3.0%**	**3.5%**	**4.3%**	**5.0%**	**6.0%**	**7.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	9.0	11.6	14.5	17.2	20.1	22.6
Incremental impact on PPC	**Paisa/unit**		**2.6**	**3.0**	**2.7**	**2.9**	**2.4**
Scenario – 2	**Increase in RPO Level:**		**1.0%**	**1.0%**	**1.2%**	**1.3%**	**1.5%**
RPO level	**%**	**3.0%**	**4.0%**	**5.0%**	**6.2%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	**9.0**	**12.8**	**16.3**	**20.0**	**23.4**	**26.8**
Incremental impact on PPC	**Paisa/unit**		**3.8**	**3.5**	**3.7**	**3.5**	**3.4**

Annexure 18 – Himachal Pradesh

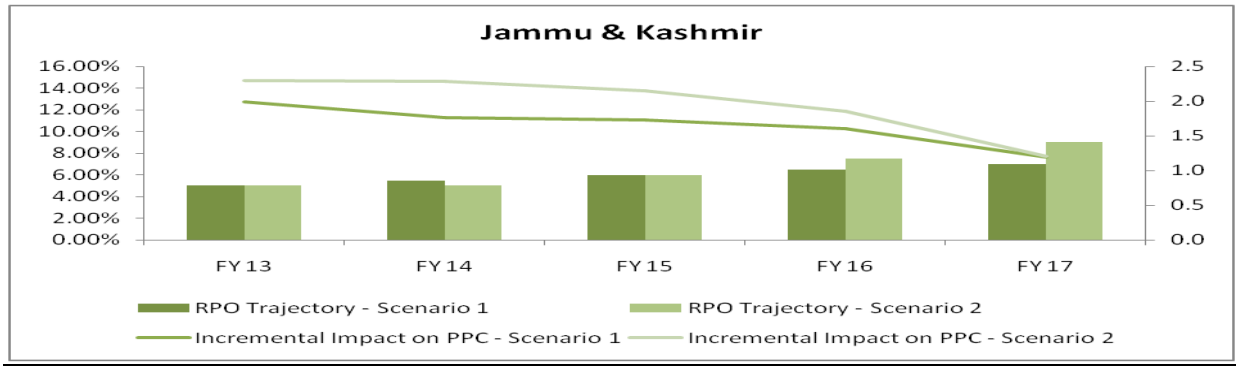
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	9,504	10,230	10,957	11,683	12,539	13,457	
PPC without RE	Rs./Unit	2.34	2.48	2.62	2.77	2.93	3.10	**5.80%**
Cost of Power Purchase, without RE	Rs. Crores	2,224	2,533	2,870	3,238	3,677	4,175	
RPO Level	**%**	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	8,553	9,105	9,642	10,164	10,783	11,438	
Renewable Energy Purchase	MUs	951	1,125	1,315	1,519	1,755	2,018	
- Non-Solar	MUs	928	1,074	1,233	1,402	1,599	1,817	
- Solar	MUs	23.8	51.2	82.2	116.8	156.7	201.8	
RE (Non-Solar) Tariff	Rs./Unit	2.95	2.95	2.95	2.95	2.95	2.95	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	2,001	2,254	2,526	2,817	3,162	3,549	
Renewable Energy Purchase Costs	Rs. Crores	298	371	450	534	628	730	
Total PPC	Rs. Crores	2,300	2,625	2,975	3,351	3,790	4,279	
Per Unit Cost of Power	Rs./Unit	2.42	2.57	2.72	2.87	3.02	3.18	
Difference in PPC	Rs./Unit	0.080	0.090	0.096	0.096	0.090	0.077	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**1.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**
RPO level	**%**	**10.0%**	**11.0%**	**12.0%**	**13.0%**	**14.0%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	8.0	9.0	9.6	9.6	9.0	7.7
Incremental impact on PPC	**Paisa/unit**		**1.1**	**0.6**	**0.0**	**-0.6**	**-1.3**
Scenario – 2	**Increase in RPO Level:**		**1.0%**	**1.0%**	**1.0%**	**1.0%**	**1.0%**
RPO level	**%**	**10.0%**	**11.0%**	**12.0%**	**13.0%**	**14.0%**	**15.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	8.0	9.0	9.6	9.6	9.0	7.7
Incremental impact on PPC	**Paisa/unit**		**1.1**	**0.6**	**0.0**	**-0.6**	**-1.3**

Annexure 19 – Jammu and Kashmir

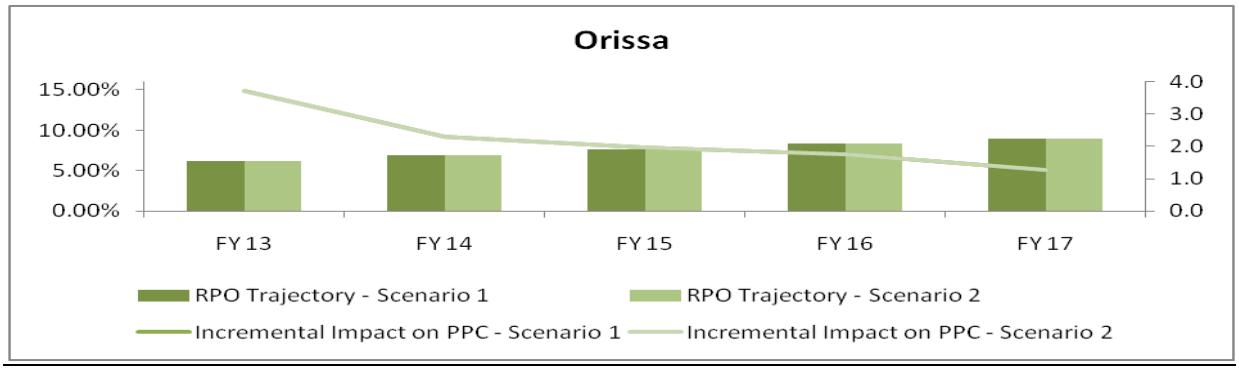
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	11,202	12,016	12,830	13,644	14,594	15,609	
PPC without RE	Rs./Unit	2.62	2.72	2.83	2.95	3.06	3.18	**3.98%**
Cost of Power Purchase, without RE	Rs. Crores	2,935	3,273	3,634	4,019	4,469	4,971	
RPO Level	**%**	3.0%	3.5%	4.0%	4.8%	5.8%	7.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	10,866	11,595	12,317	12,996	13,747	14,517	
Renewable Energy Purchase	MUs	336	421	513	648	846	1,093	
- Non-Solar	MUs	308	360	417	512	664	859	
- Solar	MUs	28.0	60.1	96.2	136.4	182.4	234.1	
RE (Non-Solar) Tariff	Rs./Unit	3.94	3.94	3.94	3.94	3.94	3.94	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	2,847	3,159	3,489	3,828	4,210	4,623	
Renewable Energy Purchase Costs	Rs. Crores	150	205	265	342	444	564	
Total PPC	Rs. Crores	2,997	3,364	3,754	4,169	4,654	5,187	
Per Unit Cost of Power	Rs./Unit	2.68	2.80	2.93	3.06	3.19	3.32	
Difference in PPC	Rs./Unit	0.056	0.076	0.093	0.111	0.127	0.138	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		**0.5%**	**0.5%**	**0.8%**	**1.1%**	**1.2%**
RPO level	**%**	**3.0%**	**3.5%**	**4.0%**	**4.8%**	**5.8%**	**7.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	5.6	7.6	9.3	11.1	12.7	13.8
Incremental impact on PPC	**Paisa/unit**		**2.0**	**1.8**	**1.7**	**1.6**	**1.2**
Scenario – 2	**Increase in RPO Level:**		**0.8%**	**1.0%**	**1.3%**	**1.5%**	**1.5%**
RPO level	**%**	**3.0%**	**3.8%**	**4.8%**	**6.0%**	**7.5%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	**5.6**	**7.9**	**10.2**	**12.3**	**14.1**	**15.4**
Incremental impact on PPC	**Paisa/unit**		**2.3**	**2.3**	**2.1**	**1.9**	**1.2**

Annexure 20 – Orissa

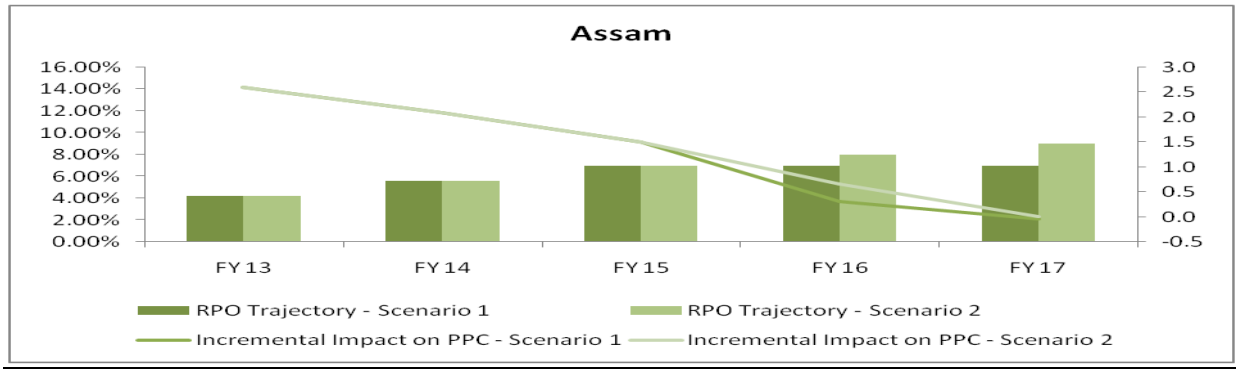
Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	27,149	29,538	31,928	34,317	37,437	40,840	
PPC without RE	Rs./Unit	2.03	2.13	2.23	2.34	2.46	2.58	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	5,511	6,291	7,135	8,046	9,209	10,541	
RPO Level	**%**	5.0%	6.2%	6.9%	7.6%	8.3%	9.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	25,792	27,707	29,725	31,709	34,330	37,165	
Renewable Energy Purchase	MUs	1,357	1,831	2,203	2,608	3,107	3,676	
- Non-Solar	MUs	1,290	1,684	1,964	2,265	2,639	3,063	
- Solar	MUs	67.9	147.7	239.5	343.2	468.0	612.6	
RE (Non-Solar) Tariff	Rs./Unit	4.31	4.31	4.31	4.31	4.53	4.53	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	5,236	5,901	6,642	7,435	8,445	9,592	
Renewable Energy Purchase Costs	Rs. Crores	626	882	1,097	1,328	1,612	1,926	
Total PPC	Rs. Crores	5,862	6,783	7,739	8,763	10,057	11,518	
Per Unit Cost of Power	Rs./Unit	2.16	2.30	2.42	2.55	2.69	2.82	
Difference in PPC	Rs./Unit	0.129	0.166	0.189	0.209	0.226	0.239	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.2%	0.7%	0.7%	0.7%	0.7%
RPO level	**%**	**5.0%**	**6.2%**	**6.9%**	**7.6%**	**8.3%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	12.9	16.6	18.9	20.9	22.6	23.9
Incremental impact on PPC	**Paisa/unit**		**3.7**	**2.3**	**2.0**	**1.8**	**1.3**
Scenario – 2	**Increase in RPO Level:**		1.2%	0.7%	0.7%	0.7%	0.7%
RPO level	**%**	**5.0%**	**6.2%**	**6.9%**	**7.6%**	**8.3%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	12.9	16.6	18.9	20.9	22.6	23.9
Incremental impact on PPC	**Paisa/unit**		**3.7**	**2.3**	**2.0**	**1.8**	**1.3**

Annexure 21 – Assam

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	7,585	8,679	9,772	10,866	12,383	14,112	
PPC without RE	Rs./Unit	2.40	2.53	2.66	2.80	2.95	3.10	**5.27%**
Cost of Power Purchase, without RE	Rs. Crores	1,820	2,193	2,599	3,042	3,649	4,378	
RPO Level	**%**	2.8%	4.2%	5.6%	7.0%	7.0%	7.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	7,373	8,314	9,225	10,105	11,516	13,124	
Renewable Energy Purchase	MUs	212	365	547	761	867	988	
- Non-Solar	MUs	193	321	474	652	712	776	
- Solar	MUs	19.0	43.4	73.3	108.7	154.8	211.7	
RE (Non-Solar) Tariff	Rs./Unit	3.31	3.31	3.31	3.31	3.31	3.31	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	1,769	2,100	2,453	2,829	3,394	4,071	
Renewable Energy Purchase Costs	Rs. Crores	84	152	234	327	389	458	
Total PPC	Rs. Crores	1,853	2,253	2,687	3,156	3,783	4,530	
Per Unit Cost of Power	Rs./Unit	2.44	2.60	2.75	2.90	3.06	3.21	
Difference in PPC	Rs./Unit	0.043	0.069	0.090	0.105	0.108	0.108	

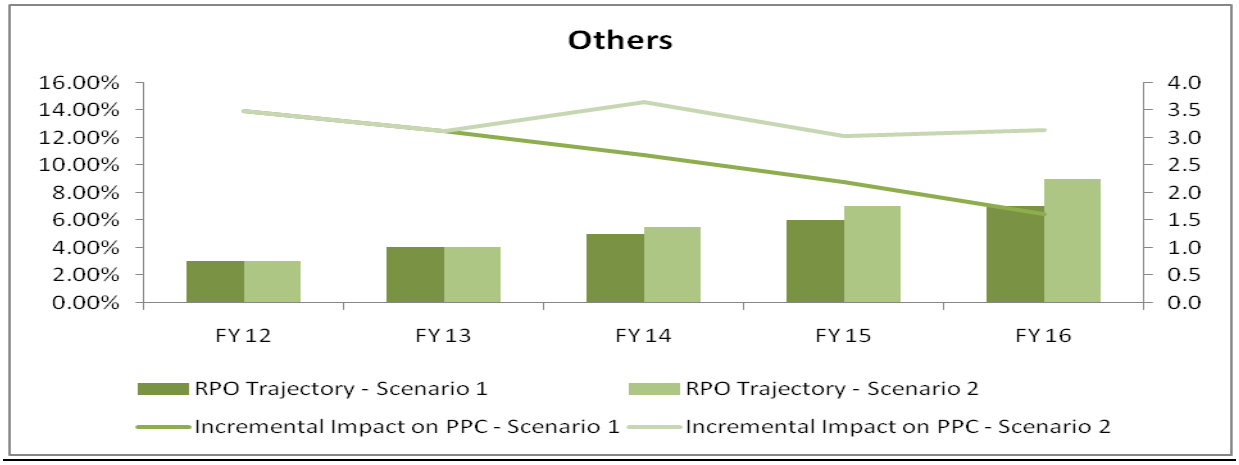


Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.4%	1.4%	1.4%	0.0%	0.0%
RPO level	**%**	**2.8%**	**4.2%**	**5.6%**	**7.0%**	**7.0%**	**7.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	4.3	6.9	9.0	10.5	10.8	10.8
Incremental impact on PPC	**Paisa/unit**		**2.6**	**2.1**	**1.5**	**0.3**	**0.0**
Scenario – 2	**Increase in RPO Level:**		**1.4%**	**1.4%**	**1.4%**	**1.0%**	**1.0%**
RPO level	**%**	**2.8%**	**4.2%**	**5.6%**	**7.0%**	**8.0%**	**9.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	4.3	6.9	9.0	10.5	11.2	11.2
Incremental impact on PPC	**Paisa/unit**		**2.6**	**2.1**	**1.5**	**0.7**	**0.0**

Annexure 22 – Others States

Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Union Territories, and Goa

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	
Total Energy Requirement	MUs	25,805	28,520	31,236	33,951	37,357	41,112	
PPC without RE	Rs./Unit	2.30	2.41	2.53	2.66	2.79	2.93	**4.92%**
Cost of Power Purchase, without RE	Rs. Crores	5,939	6,887	7,914	9,025	10,419	12,030	
RPO Level	**%**	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	
RPO Level - Solar (Inclusive in Overall RPO)	**%**	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	
Energy from Conventional Sources	MUs	25,289	27,665	29,986	32,254	35,115	38,234	
Renewable Energy Purchase	MUs	516	856	1,249	1,698	2,241	2,878	
- Non-Solar	MUs	452	713	1,015	1,358	1,774	2,261	
- Solar	MUs	64.5	142.6	234.3	339.5	467.0	616.7	
RE (Non-Solar) Tariff	Rs./Unit	4.58	4.58	4.58	4.58	4.58	4.58	
Solar Tariff	Rs./Unit	10.39	10.70	10.30	9.80	9.18	8.42	
Conventional Energy Purchase Cost	Rs. Crores	5,820	6,680	7,597	8,574	9,794	11,188	
Renewable Energy Purchase Costs	Rs. Crores	274	477	710	970	1,278	1,627	
Total PPC	Rs. Crores	6,094	7,157	8,307	9,544	11,071	12,815	
Per Unit Cost of Power	Rs./Unit	2.36	2.51	2.66	2.81	2.96	3.12	
Difference in PPC	Rs./Unit	0.060	0.095	0.126	0.153	0.175	0.191	



Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 1	**Increase in RPO Level:**		1.0%	1.0%	1.0%	1.0%	1.0%
RPO level	**%**	**2.0%**	**3.0%**	**4.0%**	**5.0%**	**6.0%**	**7.0%**
Difference in PPC due to inclusion of RE	Paisa/unit	6.0	9.5	12.6	15.3	17.5	19.1
Incremental impact on PPC	**Paisa/unit**		**3.5**	**3.1**	**2.7**	**2.2**	**1.6**

Item	Unit	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Scenario – 2	**Increase in RPO Level:**		1.0%	1.0%	1.5%	1.5%	2.0%
RPO level	**%**	2.0%	3.0%	4.0%	5.5%	7.0%	9.0%
Difference in PPC due to inclusion of RE	Paisa/unit	6.0	9.5	12.6	16.2	19.3	22.4
Incremental impact on PPC	**Paisa/unit**		3.5	3.1	3.6	3.0	3.1

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Registered Office – Mumbai

CRISIL House, Central Avenue,
Hiranandani Business Park,
Powai, Mumbai- 400 076
Phone : 91-22-3342 3000
Fax : 91-22-3342 3810

New Delhi

The Mira, G-1, 1st Floor, Plot No. 1 and 2
Ishwar Nagar, Mathura Road,
New Delhi - 110 065, India
Phone : 91-11-4250 5100
91-11-2693 0117 - 121
Fax : 91-11-2684 2213

Hyderabad

3rd Floor, Uma Chambers
Plot No. 9 and 10, Nagarjuna Hills,
Near Punjagutta Cross Road
Hyderabad - 500 082
Phone : 91-40-40328200
Fax : 91-40-2335 7507

Bengaluru

W-101, Sunrise Chambers,
22, Ulsoor Road,
Bengaluru - 560 042
Phone : 91-80-2558 0899
Fax : 91-80-2559 4801

Ahmedabad

706, Venus Atlantis,
Near Reliance Petrol Pump
Prahladnagar,
Ahmedabad
Phone : 91-79-4024 4500
Fax : 91-79-2755 9863

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