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# Sustainable Sources of Energy
## India Energy Congress 2013

**February 2013**
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"Our vision is to make India's economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on non-renewable and depleting sources of energy to renewable sources of energy. In this strategy, the sun occupies centre-stage, as it should, being literally the original source of all energy. We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people. Our success in this endeavour will change the face of India. It would also enable India to help change the destinies of people around the world."

- **Dr. Manmohan Singh, Prime Minister of India**
while launching India's National Action Plan on Climate Change (June 30, 2008)

# Contents

# 1 Introduction

## India's Energy Scenario

The Indian economy is one of the fastest growing economies in the world. The current GDP of India is estimated at USD 1.847 trillion[1] for 2011 and although growth is expected to slow down in 2012, medium to long term projections still attribute 8% to 9% per annum growth in GDP. The demand for energy during the 12th Five Year Plan is expected to increase as the economy grows, there is increased access and as access in rural areas expands. The supply of primary commercial energy is projected to increase from 710.79 mtoe in 2011-12 (Provisional) to 1219.76 mtoe by 2021-22. The annual average growth rate of the total energy requirement is expected to accelerate from 5.1 per cent per year in the Eleventh Plan to 5.7 per cent per year in the Twelfth Plan and 5.4 per cent per year in the Thirteenth Plan[2]. The availability of energy is a crucial input for sustaining the long term growth in the GDP of the country as shown on the right.

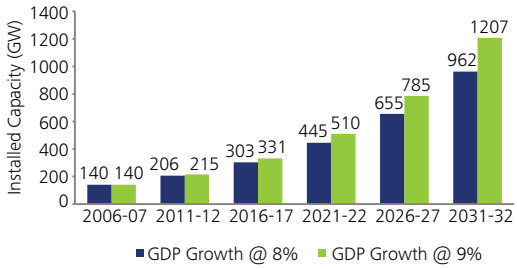
The capacity additions during the Eleventh Five Year Plan period (2007-2012) has been 54,964 MW which is 69.8 per cent of the original target and 88.1 per cent of the reduced target of 62,374 MW set in the Mid-term Appraisal (MTA). It is more than 2.5 times that of any of the earlier Plans[3]. The total installed generation capacity in the country, including renewable energy sources, as on 30 Nov 2012 is ~ 211 GW. The share of renewable energy capacity is about 12.2 per cent.

Despite the promising growth witnessed in the generation capacity additions in past few years, the electricity shortage continues to impose significant constraints to India's economic development and growth.

During the financial year 2011-12, though the total energy availability increased by 8.8% over the previous year and the peak met increased by 5.4%, the shortage conditions prevailed in the country both in terms of energy and peaking availability as shown.

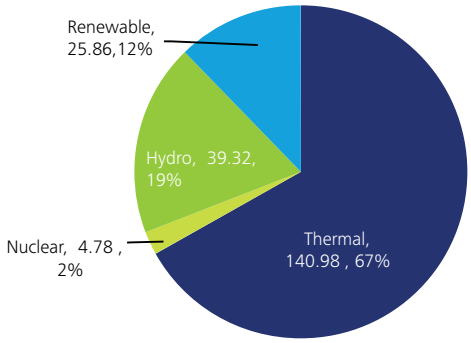
During the year 2012-13, it is anticipated that there would be energy shortage of 9.3% and peak shortage of 10.6%[4] respectively. There are certain areas where the sustainable sources of energy could play an important role.

**Figure 1 : Installed Generation Capacity – Projections till 2032**




Source: Integrated Energy Policy, 2006

**Figure 2 : Current Installed Capacity Installed Capacity (GW)**




Source: Ministry of Power

**Table 1 : Electricity demand supply gap**

| FY 2011-12 | Energy (MU) | Peak Demand (MW) |
|---|---|---|
| Requirement | 937,199 | 130,006 |
| Availability | 857,886 | 116,191 |
| Surplus/(Deficit) | (79,313) | (13,815) |
| Surplus/(Deficit) - % | (8.5%) | (10.6%) |

Source: Ministry of Power

1 International Monetary Fund , 2011
2 Planning Commission
3 Draft Twelfth Five Year Plan 2012-17
4 Load Generation Balance Report : 2012-13 (Source - CEA)

### Coal will remain the mainstay of energy supply, but the clean coal technologies could assume significance

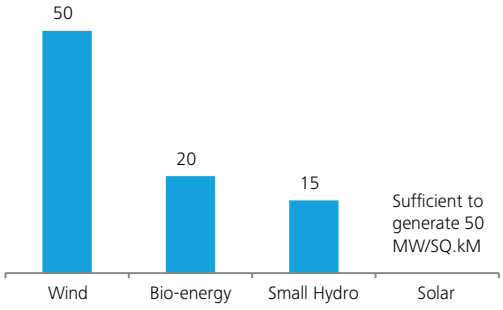
One of the key constraints in India's endeavour to supply adequate energy for the country's development is the inadequate access to primary energy resources. The domestic production of coal and lignite accounted for two-thirds of the total production of commercial energy in 2000–01 and is projected to be about the same even in 2021–22. As a percentage of total consumption of commercial energy, the share of coal and lignite is projected to increase to 57 per cent, from a level of 50 per cent in 2000–01. According to Integrated Energy Policy (IEP) estimates, India's coal reserves are likely to run out in next 45 years, assuming a 5% per annum growth in demand. India's coal reserves are characterized by low calorific value and high ash content thereby posing significant environmental challenges. With the increase in demand for coal in Asia, the availability and pricing of coal in global market would be a challenge.

In July 2008, India released its first National Action Plan on Climate Change (NAPCC), which delineated the government's current and future policies and programs to address climate mitigation and adaptation. The Plan states that India is determined that it's per capita greenhouse gas emissions "will at no point exceed that of developed countries even as we pursue our development objectives." To achieve this, India intends to develop and use new technologies, and focus on promoting understanding of climate change, adaptation and mitigation, energy efficiency, and natural resource conservation. In addition, the Plan also addressed other initiatives including "GHG Mitigation in Power Generation," with specific recommendations on more efficient, cleaner coal based power generation technologies. Specifically, the Plan stated: "Since coal based power generation will continue to play a major role in the next 30-50 years, it would be useful, wherever cost effective and otherwise suitable, to adopt supercritical boilers, which is a proven technology, in the immediate future, and ultra-supercritical boilers when their commercial viability under Indian conditions is established." Supercritical and ultra-supercritical plants can achieve efficiencies about 40% and 45%, respectively, compared to conventional subcritical plants at about 35%, and hence emit 15-30% less CO2.

### Huge untapped Renewable energy potential in India

The country possesses vast renewable energy potential. In the early 80s, India was estimated to have renewable energy potential of about 85 GW from commercially exploitable sources, namely in wind, bio-energy and small hydro. These estimates have since been revised to reflect technological advancements. Initial estimates from Centre for Wind Energy Technology (C-WET) suggest that wind energy potential at 80 metres height (with 2 per cent land availability) could be over 100 GW. Some studies have estimated even higher potential ranges up to 300 GW. The MNRE has initiated an exercise for realistic reassessment of the wind power potential, whose results are expected by the end of 2013 . A very significant part of the total Renewable Energy (RE) potential still remains to be exploited. The current installed capacity of renewable energy sources stands at around 26,368 MW (as on Nov-2012)

**Figure 3 : Renewable Energy Potential in India**
**Renewable Potential (GW)**




Source: Ministry of New and Renewable Energy (MNRE)

Wind dominates the renewable energy capacity addition with around 70% of the total renewable power capacity in MW terms. The figure shows the break-up of renewable power capacity in MW across different source.

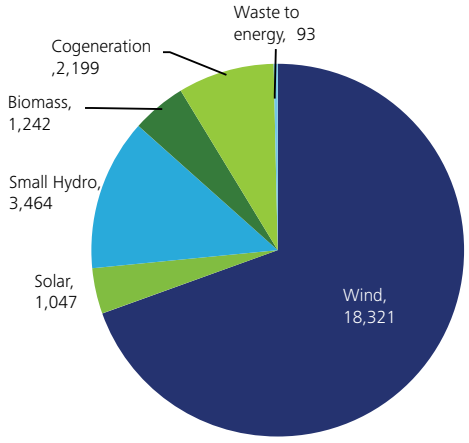
To aid the economic development, the role of the power sector becomes crucial from the perspective of meeting a large proportion of the energy requirement. The Government of India has introduced a number of policy and institutional measures, both at the Centre as well as State levels, to develop the renewable sector. State policies and legislations have successfully emulated national laws and policy guidelines to encourage the growth and restructuring of the power sector to make them more efficient, reliable and responsive.

### Renewable can also play an important role in off grid and distributed generation

Besides grid based electrification, Decentralized Distributed Generation (DDG) is the alternate option for rural electrification. DDG projects based on renewable resources are becoming the preferred option for a variety of reasons like local access to energy sources (be it water, radiation or biomass), savings on transport (of fuel) and reduction in costs of developing fuel supply chains, cleaner generation, boost to the local economy etc. DDG projects, although more expensive to commission, tougher to operate and maintain and still unable to provide continuous energy, however are increasingly being seen as viable options for long term energisation and energy security due to the availability of sustainable local energy resources. Advancements in technology is making these systems easier to install and more reliable to operate, while at the same time bringing their costs to manageable levels. The key factor promoting the use of DDG for rural electrification in India is the lack of adequate centralized energy generation available for meeting continuously growing energy demand, especially rural demand.

The state of affairs in rural electrification is making it increasingly clear that while grid extension is required, simultaneous development of large scale DDG projects based on local renewable resources is also critical keeping in view the large spikes in energy demand forecast in the coming few years.

**Figure 4 : Renewable Energy Installed Capacity Renewable Capacity (MW)**




Source: Ministry of New and Renewable Energy (MNRE)

**Table 2 : Off Grid and Captive Power – Installed Capacity**

| Off-grid/ captive power | MWeq |
|---|---|
| Waste to Energy(Urban/-Industrial) | 111 |
| Biomass(non-bagasse) Cogeneration | 423 |
| Biomass Gasifiers | |
| • Rural | 16 |
| • Industrial | 138 |
| Aero-Generators/Hybrid systems | 1.7 |
| SPV Systems (>1kW) | 103 |
| Total | 793 |

Source: Ministry of Non-conventional & Renewable Energy (MNRE)

Table 2 provides break-up of the various capacities for off grid and captive power mode across different renewable energy spectrums.

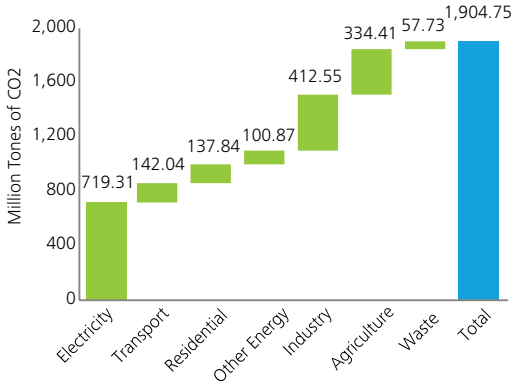
5 Source : Draft Twelfth Five Year Plan 2012-17

# 2 Issue of climate change and imperatives for India

### Green House Gas (GHG) Emissions

India, with 17 per cent of the world's population, contributes only 4 per cent of the total global greenhouse gas emissions. In terms of per capita GHG emissions, it is about 23 per cent of the global average. Around 55 per cent of India's population still does not have access to commercial energy. India's stand as a developing country is that GHG abatement in any form involves significant economic costs and can adversely impact the GDP growth as it requires a shift from cheap fossil fuels to costlier non-carbon energy sources.
The GHG emissions in India from the Energy, Industry, Agriculture and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO2 eq. emissions respectively. The sector-wise energy GHG emissions in India are shown below:

**Figure 5 : GHG emissions by sector - India**
**GHG Emissions by Sector in India**




Recognizing that climate change is a global challenge, India has been engaged actively in multilateral negotiations within the UN Framework Convention on Climate Change, in a positive, constructive and forward-looking manner. The objective has been to establish an effective, cooperative and equitable global approach based on the principle of common but differentiated responsibilities and respective capabilities, enshrined in the United Nations Framework Convention on Climate Change (UNFCCC).

India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat emanates from accumulated greenhouse gas emissions in the atmosphere, generated through long-term and intensive industrial growth and high consumption lifestyles in developed countries.
The Fourth Assessment Report of 2007 of the Working Group III of the Intergovernmental Panel on Climate Change (IPCC) states that GHG emissions have grown since pre-industrial times, with an increase of 70 per cent between 1970 and 2004. The largest growth in global GHG emissions during this period has come from the energy supply sector (an increase of 145 per cent)[6]. Efforts to address climate change adaptation and mitigation needs should not take resources away from the core development needs and growth objectives of the developing countries. Climate Change mitigation and poverty reduction efforts needs to be addressed simultaneously.

According to International Energy Agency (IEA) estimates, India's per capita CO2 in 2009 was 1.37 tonnes. The projections of India's per capita GHG emissions in 2030-31 vary from 2.77 tonnes to 5.00 tonnes of CO2, with four of the five studies estimating that India's GHG emission per capita will stay under 4 tonnes per capita. This may be compared to the 2005 global average per capita GHG emissions of 4.22 tonnes of CO2 per capita. In other words, four out of the five studies project that even two decades from now, India's per capita GHG emissions would be well below the global average 25 years earlier[7] .

While engaged with the international community to collectively and cooperatively deal with this threat, India would need to adapt to climate change and further enhance the ecological sustainability of its development path. Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected changes in climate[8] .

6 Working Paper No.2/2009-DEA : Climate Change and India- Some Major Issues and Policy Implications
7 Climate Modelling Forum, India - MOEF (2009)
8 NAPCC

## Role of Sustainable Sources of Energy

The current energy mix of India has heavy dependent on the conventional energy sources. The promotion of renewable energy is one of the key measures being taken by the Government of India to enhance energy security along with reducing GHG emissions. The promotion of renewable energy in India needs to be seen from a broader and long term perspective for its potential to positively contribute towards the India's energy security and reliability.

The National Action Plan for 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. It stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability of the impacts of climate change.

The eight Missions which form the core of the NAPCC provides multi-pronged and long term integrated strategies for achieving goals in the context of climate change. National Action Plan for Climate Change (NAPCC) is a major step towards focusing on the renewable energy generation in the country.

As part of NAPCC, the Jawaharlal Nehru National Solar Mission (JNNSM), launched in 2009, is a major initiative of the Government of India to promote development of solar power in India. The JNNSM targets to add around 20,000 MW solar power generation capacity by the year 2022. In addition, Government is now planning for a National Bioenergy Mission, proposed to be launched during the 12th Five Year Plan, with an objective to create a policy framework for attracting investment and to facilitate rapid development of commercial biomass energy market based on utilisation of surplus agro-residues and development of energy plantations.

**Figure 6 : Role of Sustainable Sources of Energy**

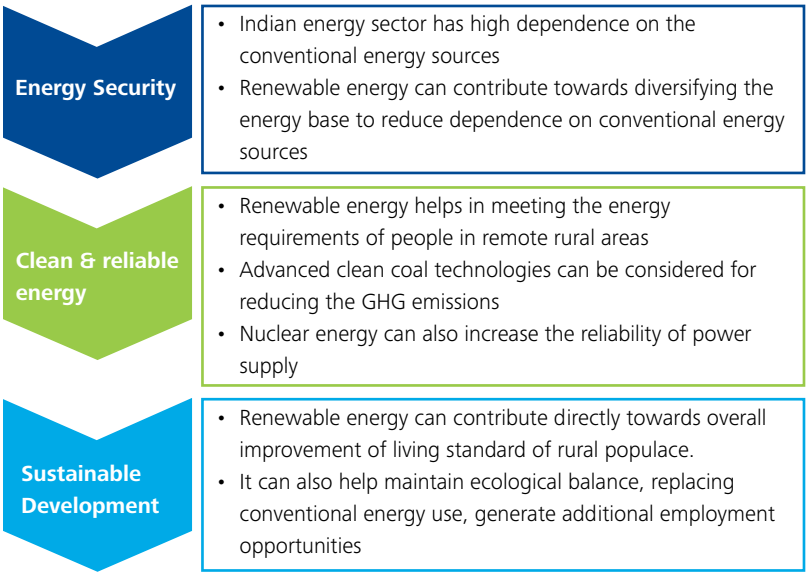



**Table 3 : NAPCC Missions**

| Eight Missions | |
|---|---|
| National Solar Mission | National Mission for Sustaining the Himalayan Eco-system |
| National Mission on Enhanced Energy Efficiency | National Mission for a Green India |
| National Mission on Sustainable Habitat | National Mission for Sustainable Agriculture |
| National Water Mission | National Mission on Strategic Knowledge for Climate Change |

Source: Ministry of New and Renewable Energy (MNRE)

# 3 Indian Renewable Energy Sector Roadmap

The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for the development of new and renewable energy. The broad aim of the Ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. India was one of the first countries to establish a separate Ministry for New and Renewable Energy (i.e. MNRE) at the central level.

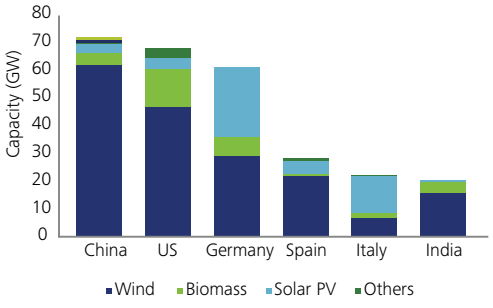
A number of institutions have been created in India for promotion of renewable energy. Institutions like Solar Energy Centre, Indian Renewable Energy Development Agency (IREDA), Centre for Wind Energy Technology (C-WET), Alternate Hydro Energy Centre (AHEC), Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) have been playing a critical role for facilitating the installation of renewable energy in the country. At the State level, State Nodal Agencies (SNAs) were set up to carry out MNRE's mandate and implement projects/ programmes.

### Performance of India in encouraging RE development

India's renewable energy installed capacity has grown at an annual rate of 23%, rising from about 3.9 GW in 2002-03 to about 26 GW in November 2012. Wind energy dominates India's renewable energy industry, accounting for 70% of installed capacity (18 GW). It is followed by small hydropower (3.4GW), biomass power (3.0 GW) and solar power (1.04 GW) that has just started registering its presence[9].

The top seven countries for non-hydro renewable electric capacity—China, the United States, Germany, Spain, Italy, India, and Japan - accounted for about 70% of total capacity worldwide. India added about 4 GW of grid-connected non-hydro renewable power capacity during 2011, mainly from wind but also from biomass and solar capacity to give a total of more than 20 GW by year-end. India is now the fifth largest wind power producer in the world, after USA, Germany, Spain and China[10] .

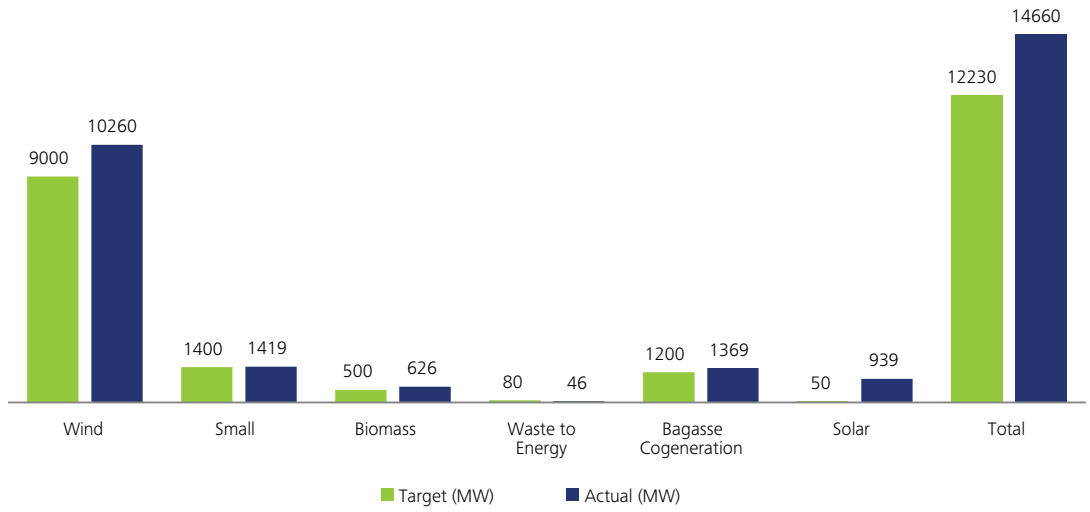
**Figure 7 : Total Renewable Energy Capacity - 2011**
**Renewable Energy Capacity (excl. Hydro) - 2011**




Source : REN21, Global Status Report, 2012

9 MNRE
10 REN21, Global Status Report,2012

**Figure 8: Renewable Sector - Eleventh Plan Period Performance**
**Capacity Additions for Grid Connected Renewable Projects - Eleventh Plan Period (2007-12)**




Source : MNRE

## Performance during Eleventh Five year Plan (Year 2007-12)

Renewable energy sector made substantial progress in the eleventh five year plan period. Wind technology had a major contribution in adding renewable energy capacity. The sector was able to surpass the overall capacity targets. The figure below details the overall as well as technology wise performance in terms of targets and actual achievement as on 31 March 2012.

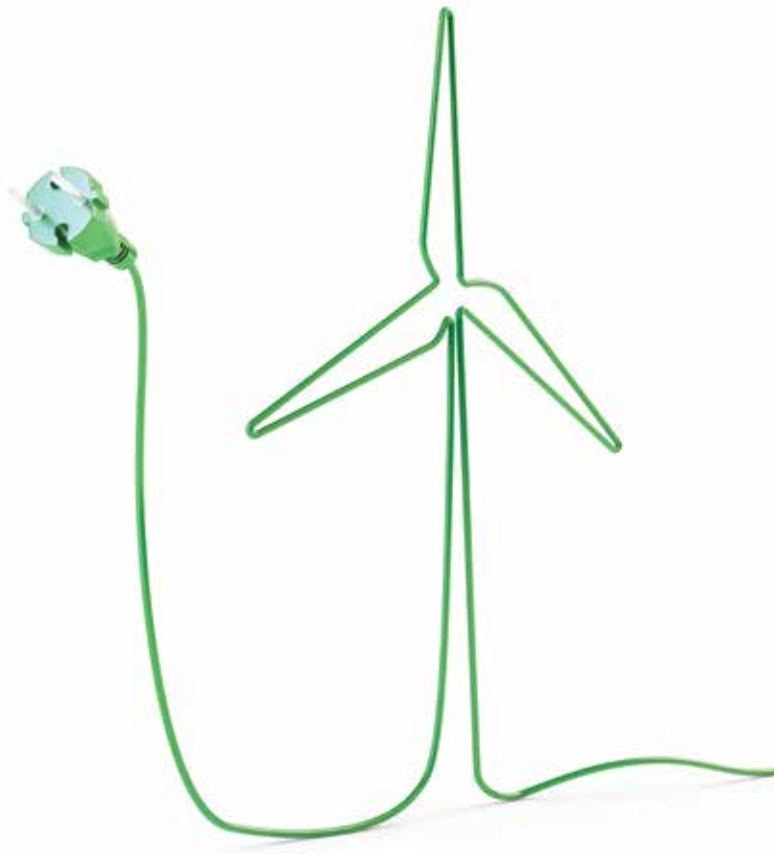
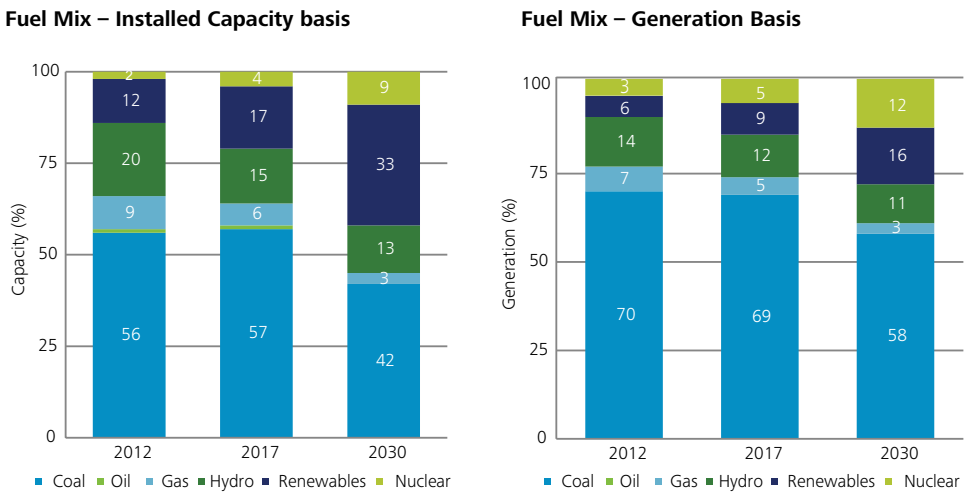


**Figure 9 : Renewable Sector - Eleventh Plan Period Performance**




Source: Draft Twelfth Five Year Plan 2012-17

## Role of renewable sector in the energy mix

Given the overall policy & regulatory push, renewable energy is envisaged to play an important role in the long term. The projected change in the mix of installed capacity & electricity generation by fuel type by the end of 2030 is shown in the figure below.

In terms of installed capacity, the share of renewable energy is expected to increase from a level of 12 per cent in year 2012 to 33 per cent in year 2030. In electricity generation terms, renewable energy is expected to rise from around 6 per cent in 2012 to 9 per cent in 2017 and 16 per cent in 2030.

The share hydro-electricity is expected to fall from 15 per cent in 2012 to 11 per cent in 2030. The share of nuclear power, another clean source from a carbon emission perspective is expected to increase from 3 per cent in 2012 to 5 per cent in 2017 and to 12 per cent in 2030. Taking all these clean energy sources together, the share of hydro, renewables plus nuclear energy is expected to increase from 26 per cent in 2012 to 39 per cent by 2030.

## Key Policy initiatives

It is well recognized globally that early commercialization of Renewable Energy (RE) technologies is highly dependent on support from the government through mix of policy and regulatory instruments. Over the years, the Government of India has introduced a number of policy and regulatory initiatives for promoting RE. Some of these initiatives have been illustrated in the table below.

Table 4 : Key Policy & Regulatory Initiatives

| Year | Instrument/Initiative | Key Features and Impact on RE Development |
|---|---|---|
| 1982 | Creation of Department of Non-conventional Energy Sources | An independent department for development, demonstration and application of RE. RE sources were recognized as potential alternative energy sources and received special consideration. |
| 1992 | Creation of MNRE | The Department of Non-Conventional energy Sources was upgraded into a full-fledged ministry. |
| 1993 | MNRE Policy and Tariff Guidelines | Introduction of RE tariff guidelines by MNRE - states to purchase RE power at Rs 2.25 per unit with 5% annual escalation on 1993 as base year. Introduction of Tariff guidelines offered relatively higher price for RE than what was prevailing, and thus triggered development of RE sector, especially wind. |
| 1993-94 | Introduction of Accelerated Depreciation | Introduction of Accelerated Depreciation (100% AD) for promotion of wind projects (altered to 80% AD in 1999). This program led to the successful commercial development by involving the private sector in wind equipment manufacturing as well as its application. |
| 1995-96 | National Wind Resource Monitoring and Demonstration Program | This programme was intended to develop a GIS platform for presenting spatial data to prepare a meso-scale modelling and a comprehensive wind power density map of potential sites. This program helped in mapping the potential wind energy sites across India which in turn induced private sector participation for commercial applications. |
| 1999 | Establishment of Center for Wind Energy Technology (C-WET) | The Center provided much needed technical support for wind resource assessment, testing, monitoring, certification and R&D. It also helped the Indian wind industry to develop large scale commercial wind farms. |
| 2002-03 | Electricity Act 2003 | Recognizes the role of RETs for supplying power to the utility grid as well as in standalone systems. Provides an overall framework for preferential tariff and quotas for RE. |
| 2004 onwards | Preferential Tariffs for RE from SERCs | Following the enactment of the EA-2003, states adopted preferential tariff mechanisms to promote RE. Since it provides differential tariffs for the development of different RETs, it brought in a balanced approach to RE development across states. |
| 2005-06 | National Tariff Policy | Directed SERCs to fix a minimum percentage of purchase of energy consumption from RE sources (RPO). This created a demand side stimulus for RE development. |
| 2005-06 | Integrated Energy Policy Report 2006 | Suggested a path to meet energy needs in an integrated manner. Recommended special focus on RE development and set specific targets for capacity addition through RE sources. |
| 2008-09 | Introduction of Generation Based Incentives (GBI) for solar and wind energy | This scheme offers fiscal incentives along with tariff on power generation from solar and wind. It shifted investment interest from installation to generation. |
| 2008 | National Action Plan on Climate Change (NAPCC) | NAPCC has advised that starting 2009-10, RPO's be set at 5% of total grids purchase, and be increased by 1% each year for 10 years. |
| 2010 | Jawaharlal Nehru National Solar Mission (JNNSM) | Targets 20,000 MW of grid-connected solar power capacity and 2,000 MW of off-grid solar power capacity by 2022. |

Source: MNRE Website & Publications

## Key Drivers for RE sector in India

### NAPCC provides guidance for promotion of renewable energy

NAPCC provides guidance on enhancements in the policy & regulatory regime to help mainstream renewables based sources in the national power system:

- A dynamic minimum renewables purchase standard (DMRPS) may be set, with escalation each year till a pre-defined level is reached, at which time the requirements may be revisited. It is suggested that starting 2009-10, the national renewables standard (excluding hydropower with storage capacity in excess of daily peaking capaci¬ty, or based on agriculture based renewables sources that are used for human food) may be set at 5% of total grids purchase, to increase by 1% each year for 10 years. SERCs may set higher per¬centages than this minimum at each point in time.
- Central and state governments may set up a ver¬ification mechanism to ensure that the renewables based power is actually procured as per the appli¬cable standard (DMRPS or SERC specified). Appropriate authorities may also issue certificates that procure renewables based power in excess of the national standard. Such certificates may be tradeable, to enable utilities falling short to meet their renewables standard obligations. In the event of some utilities still falling short, penalties as may be allowed under the Electricity Act 2003 and rules thereunder may be considered.
- Procurement of renewables based power by the SEBs/other power utilities should, in so far as the applicable renewables standard (DMRPS or SERC specified) is concerned, be based on compet¬itive bidding, without regard to scheduling, or the tariffs of conventional power (however deter¬mined). Further, renewables based power may, over and above the applicable renewables stan¬dard, be enabled to compete with conventional generation on equal basis (whether bid tariffs or cost-plus tariffs), without regard to scheduling (i.e. renewables based power supply above the renew¬ables standard should be considered as displacing the marginal conventional peaking capacity). All else being equal, in such cases, the renewables based power should be preferred to the compet¬ing conventional power.
- The NAPCC has set the right direction for the diversification of nation's energy basket, addressing the climate change issues and increasing the energy access for the population in the medium term.

### Jawaharlal Nehru National Solar Mission (JNNSM) sets ambitious target for solar promotion

The Jawaharlal Nehru National Solar Mission (JNNSM) was launched to promote power generation from solar energy in the country. The objective of the Jawaharlal Nehru National Solar Mission is to create conditions, through rapid scale-up of solar power capacity and technological innovation to drive down costs towards grid parity.

The Mission has adopted a 3-phased approach, spanning the remaining period of the 11th Plan and first year of the 12th Plan (up to 2012-13) as Phase 1, the remaining 4 years of the 12th Plan (2013-17) as Phase 2 and the 13th Plan (2017-22) as Phase 3. The mission lays down the targets that need to be achieved in the years to come so that India can tap its solar potential to the fullest. The targets set by JNNSM have been summarized in table below: Institutional Set up for

Table 5 : JNNSM Targets

| Application Segment | Target for Phase-I (2012-2013) | Cumulative Target for Phase-II (2013-2017) | Cumulative Target for Phase-III (2017-2022) |
|---|---|---|---|
| Grid Solar Power | 1,100 MW | 4,000 MW | 20,000 MW |
| Off-Grid Solar Applications | 200 MW | 1,000 MW | 2,000 MW |
| Solar Collectors | 7 million sq. mts | 15 million sq. mts | 20 million sq. mts |

### Renewable Sector

The institutional ecosystem developed under the aegis of MNRE for the RE development in the country is more focused on the research, design, development, financing and certification. The deployment of RE projects (project development, project construction, operation and maintenance) in the country is essentially taken care of by the private players. The institutional structure is further being strengthened to enable effective execution of the Ministry's policies and objectives.

The table given below highlights the different institutional functions required for the development of renewable energy sources and the existing institutions undertaking the functions:

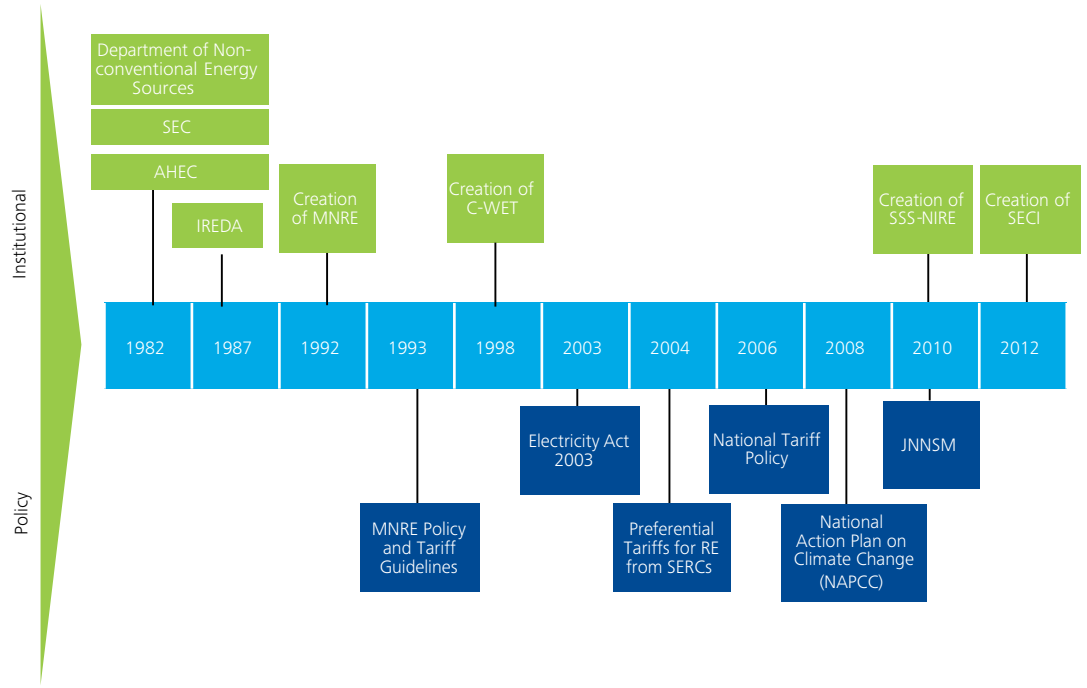
Table 6 : RE promotion & Institutional functions

| Institutional Functions | Existing Institutions |
|---|---|
| Policy and Regulatory | |
| Development of Renewable Energy Policy | MNRE |
| Policy advice and technical standards for the renewable energy generators | MNRE, CEA |
| Tariff Determination Methodology(s) | CERC, SERCs |
| Regulations on Minimum procurement, Wheeling, Open Access, Third Party Sale | SERCs |
| Promotion/Advocacy & Capacity building | |
| Resource Assessment for various renewable energy sources | MNRE, SNAs |
| Capacity building of SNAs and other institutions | MNRE |
| Facilitation | |
| • Facilitate clearances, land acquisition | SNA's |
| • Coordinate with Distribution Network Operator/ GRIDCO for connectivity | SNA's |
| • Conduct competitive bidding process/project allotment | SNA's |
| Support R&D in renewable energy technologies | MNRE & GoI |
| Promotion of decentralized distributed generation based on renewables | MNRE & SNA's |
| Creating awareness, support in financing, execution, training for O&M | MNRE, IREDA, SNA's |
| Effective utilization of IT for renewables, database management, forecasting techniques | MNRE |
| Design & implementation of Renewable Energy Certificate (REC) mechanism | MNRE,CERC, SERCs, NLDC |
| Create awareness and educate masses for adoption of renewable energy | MNRE |
| Financing | |
| • Financing of Renewable Energy Projects | IREDA |
| • Subsidy Administration | MNRE, SNA's |
| Monitoring and Evaluation | |
| • Review of implementation programs & Apply learning's and best practices | MNRE |

The institutional support and policy for renewable energy sector has evolved over the years, in order to keep up with the changes in the requirements, capacity addition and technologies.

The figure below details the evolution of Institutions & Policy Support in Indian renewable energy sector:

**Figure 10 : Evolution of Policies & Institutions**




Solar Energy Corporation of India (SECI) has been recently formed to implement the JNNSM program, identify the key opportunities in solar sector in the country and evolve solutions to problems being faced by various stakeholders in solar.

Increasing the penetration of renewable energy technologies will depend upon the ability of different renewable energy focused institutions to overcome the issues and undertake/facilitate implementation of renewable energy projects. Some of the key issues related to the current institutional structure for renewable energy sector are

- Lack of coordination/integrated effort amongst institutions (Centre as well as State) involved in promotion of renewable energy
- Neglect of certain RE sub sectors
- Issue of sustainability of select programmes - Not very well-defined implementation roadmaps for select government programmes and schemes is an issue
- Limited Capacity of State Renewable Energy Development Agencies

## RE Segment wise analysis

### Wind Energy

The wind power programme in India was initiated towards the end of the Sixth Five Year Plan, in 1983-84. The installed capacity of wind power was only 41 MW in March 1992, but through sustained and focused effort the present total installed capacity stands at 18,320 MW (MNRE). Tamil Nadu, Maharashtra, Karnataka, Rajasthan, Gujarat are the key states which have been focusing on wind energy development in India. The state wise potential & installed capacity status is given below:

The momentum of capacity addition in wind sector has gained in the recent past. Wind energy sector comprises 70% share in the renewable energy portfolio mix across all technologies.

Policy initiatives and fiscal measures like Accelerated Depreciation benefits have played as catalysts for the rapid pace of the sector.

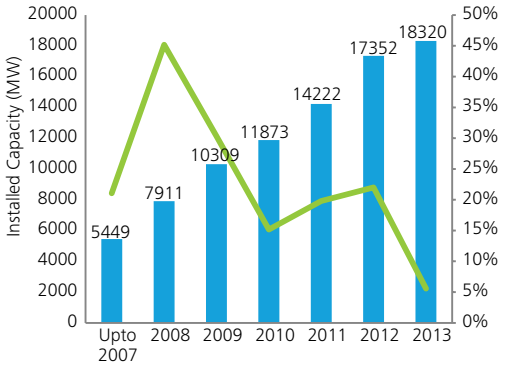
Offshore Wind Power in India

- A Steering Committee formed by the MNRE
- A subcommittee of the Steering committee assigned the task of preparing draft policy for offshore wind power development.
- Preliminary assessment done by Scottish Agency shows a potential of around 1000 (Rameshwaram) and another 1000 MW (Kanyakumari). This needs validation.

**Table 7 : State wise wind potential & installed capacity**

| State | Potential (MW) | Achievement (MW) |
|---|---|---|
| Andhra Pradesh | 5,349 | 264 |
| Gujarat | 10,609 | 3,016 |
| Karnataka | 8,591 | 2,025 |
| Madhya Pradesh | 920 | 376 |
| Maharashtra | 5,439 | 2,772 |
| Rajasthan | 5,005 | 2,079 |
| Tamil Naidu | 5,374 | 7,072 |
| Others | 7,843 | 40 |

**Figure 11 : Wind Sector Capacity Additions**
**Wind Capacity Additions**



**Solar Energy**

India receives solar energy equivalent of over 5,000 trillion kWh per year and has the potential to generate about 700 billion units annually from solar[11]. India lies in the sunny regions of the world. Most parts of India receive 4–7 kilowatt hours of solar radiation per square meter per day with 250–300 sunny days in a year.

The highest annual radiation energy is received in region comprising of Rajasthan, Gujarat while the north-eastern region of the country receives the lowest annual solar radiation. This translates to an energy generation potential of about 30-50 MW per sq.km. of shadow-free area covered with solar collectors for most parts of the country. According to MNRE, the potential of solar energy is >1,00,000 MWeq i.e. 30 -50 MW/Sq. Km. To tap this huge solar potential, India has embarked on an ambitious program under the Jawaharlal Nehru National Solar Mission (JNNSM) which is targeting an addition of 20,000 MW of solar power by 2022. The program has already received a very good response from the market under Phase I. Currently, the total installed capacity of solar energy in the country stands at 1047[12] MW[12].

Under the JNNSM phase I, Batch I, a total of 610 MW of solar projects were awarded, while batch II attracted bids for 350 MW of solar PV projects. The details of the two batches are shown in table below.

Apart from these grid connected large scale plants, small rooftop plants of capacity less than 2 MW each were also allotted under GBI scheme in Rooftop PV and small Solar Power Generation Programme (RPSSGP).
Under the State policy framework, Gujarat has been the key state which has developed around 700 MW of solar power since the announcement of Gujarat Solar Policy in July 2009.

Table 8 : Key Policy & Regulatory Initiatives

| | Capacity allocated (MW) | | Maximum size for allotment (MW) | | Lowest bid (Rs./kWh) | Benchmark tariff (Rs/ kWh) |
|---|---|---|---|---|---|---|
| | PV | Thermal | PV | Thermal | | |
| Batch I | 140 | 470 | 5 MW per bidder | 100 MW per bidder | 12 | 17.91 |
| Batch II | 350 | - | 20 MW per project | - | 7.49 | 15.39 |

11 Source : Indian Semiconductor Association Website & http://www.powermin.nic.in/whats_new/pdf/ddg_based_renewable.pdf

12 MNRE Data as on 30.11.2012

**Bio-Energy**

The current availability of biomass in India is estimated at about 500 million metric tonnes per year. MNRE has estimated surplus biomass availability at about 120 – 150 million metric tons per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW or an equivalent of 200-240 million barrels of oil. In addition to this, about 5,000 MW of additional power or an equivalent of 65 million barrels of oil could be generated through bagasse based cogeneration in the country's 550 sugar mills[13].

The current cumulative deployment of Bio-Energy based power generation is shown in table number 9.

Bioenergy segment has the highest potential for improving energy access in the rural areas. There are several benefits of focusing on bioenergy segment given the potential to generate additional rural income, reducing environmental impact of burning agri waste, scalability and employment opportunities for local population. The proposed Bioenergy Mission aims to harness the huge potential available and targets around 10,000 MW by year 2022, with emphasis on promotion of biomass based IPPs as well as decentralized systems based on bio-energy.

The development of biomass based power generation projects is dependent on the availability of resource (biomass) and development status of biomass logistics and conversion. Market for some biomass like rice husk has matured and presently almost the entire quantity is consumed in industry and power plants. On the other hand, technology for straw and stalks is at the initial stage of development. Hence states like Punjab, Haryana, Bihar, where straw is the major resource are yet to see any major development.

One of the success stories of modern India is the bagasse based Cogeneration in the sugar mills. There are more than dozen plants in operation with this higher configuration exporting over 120 MW power to the grid in the States of Tamil Nadu, Maharashtra, Karnataka, Andhra Pradesh and Uttar Pradesh. About 20 plants are under implementation in the States of Karnataka, Tamil Nadu, Maharashtra and Uttar Pradesh. Investment in high efficiency cogeneration technology can significantly improve viability of the sugar mills[14].

**Table 9 : Bio-energy Installed Capacity**

| Grid Connected | Capacities in MW |
|---|---|
| Biomass Power | 1,226 |
| Bagasse Cogeneration | 2,175 |
| Waste to Energy (Urban & Industrial) | 93 |
| Off Grid / Captive Power | MWEQ |
| Waste to Energy (Urban & Industrial) | 110 |
| Biomass(non-bagasse) Cogeneration | 416 |
| Biomass Gasifiers (Rural & Industrial) | 154 |
| Family Biogas Plants (in Lakhs) | 45.45 |
| Total | 4,174 |

13 MNRE
14 MNRE

### Small Hydro

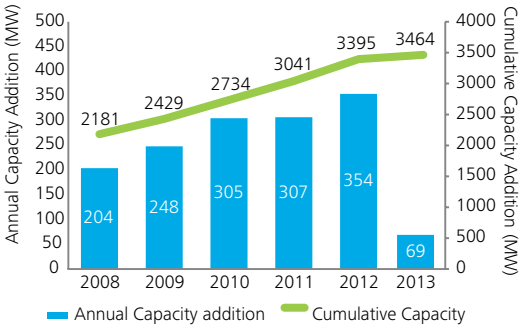
In India, the hydro power projects up to 25 MW capacities are classified as Small Hydro. The Ministry of New and Renewable Energy has been vested with the responsibility of developing Small Hydro Power (SHP) projects. The estimated potential for power generation in the country from small / mini hydel projects is 15,380 MW from 5718 identified sites.

Out of this potential, about 50% lies in the States of Himachal Pradesh, Uttarakhand, Jammu & Kashmir and Arunachal Pradesh. In the plain region Maharashtra, Chhattisgarh, Karnataka and Kerala have sizeable potential. Focused attention is given towards these States through close interaction, monitoring of projects and reviewing policy environment to attract private sector investments.

In the year 2000, the total installed capacity of small hydro projects (up to 25 MW) was 1275 MW. There has been an increase of about 150% in the installed capacity in the last 10 years. A continuous and steady growth can be seen in the SHP sector. During the 9th Five Year Plan, 269 MW of small hydro capacity was added and the same increased to 536 MW during the 10th Five Year Plan and 1,419 MW during the 11th Plan[15]. The current installed capacity for Small Hydro is around 3,451 MW installed which is around 22% of the identified small hydro potential (estimated at 15,380 MW). The figure below details the installed capacity trend from small hydro power projects in India.

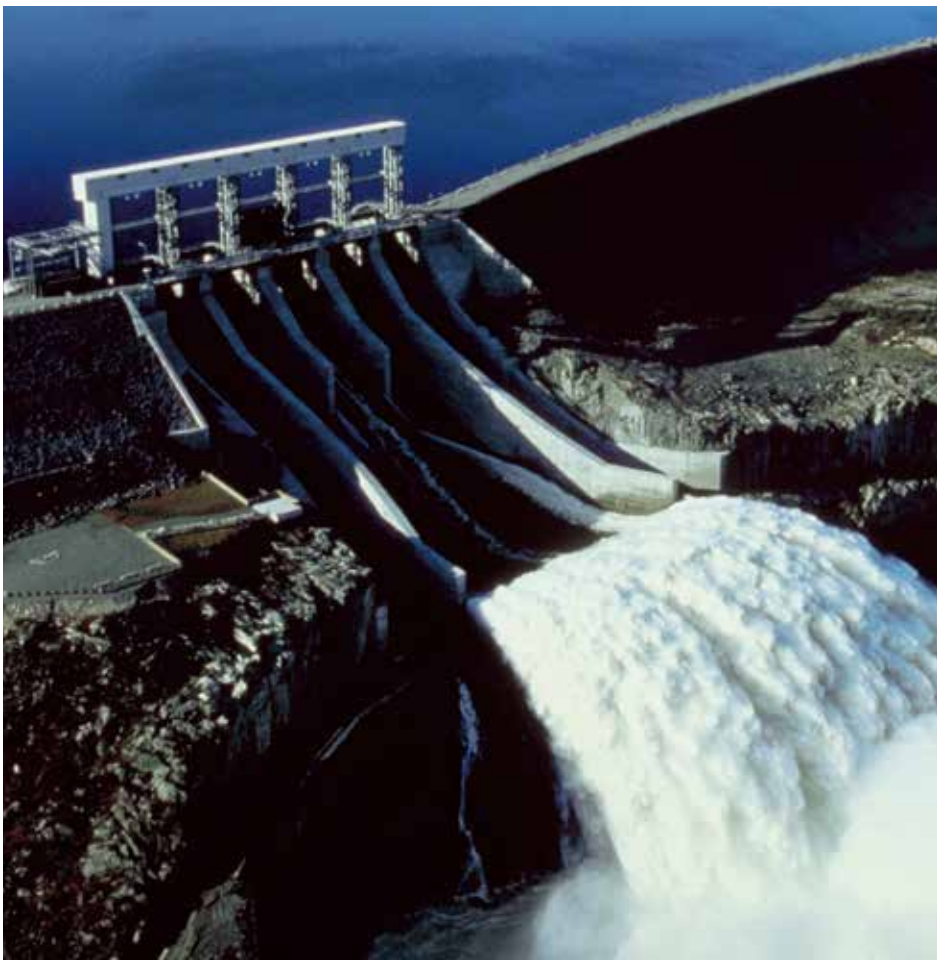
The SHP programme in India is now by and large private investment driven with 23 states having announced their policies to invite private sector to set up SHP projects. There is a renewed interest in the development of micro hydel projects & watermills during the last 3-4 years e.g. state of Uttarakhand has launched a programme for systematically developing watermills.

**Figure 12: SHP Capacity Additions**
**SHP Capacity Additions (MW)**




Source : MNRE

15 Report of the Sub-Group on Small Hydro Power (12th Plan)



## RE Outlook for 12th Five Year Plan & Ahead

A capacity addition of 30,000 MW of Grid connected renewable power is proposed of which 15,000 MW is envisaged to come from wind power, 10000 MW from solar capacity and 5000 MW from other types of renewable sources.

The supply from renewables is expected to increase rapidly from 24,503 MW by the end of the Eleventh Plan to 54,503 MW by the end of the Twelfth and 99,617 MW by the end of the Thirteenth. This fourfold increase in the next 10 years is expected to continue in subsequent years as policies provide a strong incentive for the renewables. Nevertheless the base is small and the share of renewables in total commercial energy used will remain small. It is expected to rise from about 1 per cent in 2011–12 to 1.43 per cent in 2016–17 and just under 2 per cent in 2021–22[16].

## Key Challenges for renewable sector development

The top five countries for total investment were China, which led the world for the third year running, followed closely by the United States, and by Germany, Italy, and India. India displayed the fastest expansion in investment of any large renewables market in the world, with 62% growth . India is fast becoming one of the world's most attractive markets for renewable energy investment. India's growth in the renewable energy has been mainly driven by effective national and state level government policy and institutional support for both foreign and local investment in renewable energy technologies (RETs).

The initial initiative was the establishment of a dedicated ministry (Ministry of New and Renewable Energy) and several facilitating agencies at central and state levels – e.g. Indian Renewable Energy Development Agency, Solar Energy Centre, Centre for Wind Energy Technology (C-WET), State Renewable Energy Development Agencies etc. Others included resource estimation programmes, technology development programmes, capital subsidies, generation based incentives, accelerated depreciation, feed in tariffs and Renewable Purchase Obligations (RPO).

The key enablers and challenges related to the development of renewable energy sector have been briefed in Table 10.

**Table 10 : Renewable energy - Proposed 12th Plan Targets**

| | Proposed Twelfth Plan Targets | Capacity in MW |
|---|---|---|
| 1 | Grid Connected Renewable Power | 30,000 |
| | Wind | 15,000 |
| | Solar | 10,000 |
| | Other Renewables | 5,000 |
| 2 | Off-grid/Distributed Renewable Power (MWe) | 3,400 |
| | Cogeneration from bagasse | 2,000 |
| | Solar off-grid applications | 1,000 |
| | Waste to energy | 200 |
| | Bio Gas Based Decentralised Power | 50 |
| | Others (Biomass Gasifiers, Micro-hydel) | 150 |

16 Source : Draft Twelfth Five Year Plan 2012-17 (Planning Commission)
17 REN21, Global Status Report 2012

**Renewable Purchase Obligation (RPO)**

In the interest of long term development of renewable energy sector, the Central & State Electricity Regulatory Commissions have taken the initiative to promote renewable energy by specifying minimum renewable energy procurement obligations as per the provisions of Electricity Act 2003 and other policies.

The Renewable Purchase Obligations (RPOs) ensure that the obligated entities procure a certain minimum percentage of their total power requirement from renewable energy sources. The RPO targets have been defined by a number of states in the form of Solar RPO and non-solar RPO targets for obligated entities (Distribution licensee, captive consumer, open access consumer).

After the enactment of Electricity Act 2003, several States have issued the RPO obligation but still a number of barriers were being faced in the effective implementation of RPO, enforcement of penalties in event of RPO non-compliance. State level RPOs do not add up to national objective as set under NAPCC. There is lack of cohesion between the States and the centre. Renewable resource-rich States are reluctant to take higher RPO due to various considerations while the resource-poor States have not incentive to go for higher RPO levels.

**Figure 13: RPO Framework**

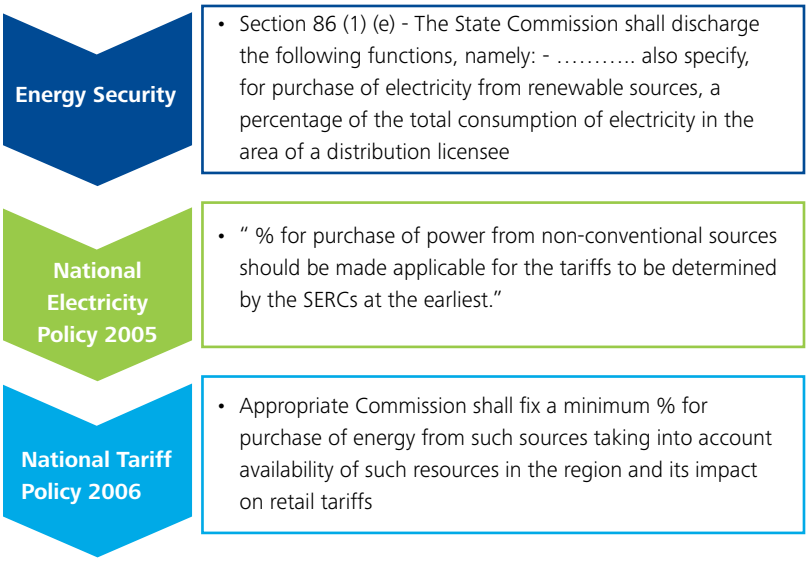


**Table 11 : RPO Targets of select States**

| State | Technology | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-17 |
|---|---|---|---|---|---|---|---|
| Andhra Pradesh | Non-Solar | 4.75% | 4.75% | 4.75% | 4.75% | 4.75% | 4.75% |
| | Solar | 0.25% | 0.25% | 0.25% | 0.25% | 0.25% | 0.25% |
| | Total | 5.00% | 5.00% | 5.00% | 5.00% | 5.00% | 5.00% |
| Gujarat | Non-Solar | 5.50% | 6.00% | | | | |
| | Solar | 0.50% | 1.00% | | | | |
| | Total | 6.00% | 7.00% | | | | |
| Himachal Pradesh | Non-Solar | 10.00% | 10.00% | 10.00% | 10.00% | 11.00% | 12.00% |
| | Solar | 0.01% | 0.25% | 0.25% | 0.25% | 0.25% | 0.25% |
| | Total | 10.01% | 10.25% | 10.25% | 10.25% | 11.25% | 12.25% |
| Madhya Pradesh | Non-Solar | 2.10% | 3.40% | 4.70% | 6.00% | | |
| | Solar | 0.40% | 0.60% | 0.80% | 1.00% | | |
| | Total | 2.50% | 4.00% | 5.50% | 7.00% | | |
| Maharashtra | Non-Solar | 6.75% | 7.75% | 8.50% | 8.50% | 8.50% | |
| | Solar | 0.25% | 0.25% | 0.50% | 0.50% | 0.50% | |
| | Total | 7.00% | 8.00% | 9.00% | 9.00% | 9.00% | |
| Rajasthan | Non-Solar | 5.50% | 6.35% | 7.00% | | | |
| | Solar | 0.50% | 0.75% | 1.00% | | | |
| | Total | 6.00% | 7.10% | 8.20% | | | |
| Tamil Nadu | Non-Solar | 8.95% | | | | | |
| | Solar | 0.05% | | | | | |
| | Total | 9.00% | | | | | |
| Uttarakhand | Non-Solar | 4.50% | 5.00% | | | | |
| | Solar | 0.03% | 0.05% | | | | |
| | Total | 4.53% | 5.05% | | | | |
| Uttar Pradesh | Non-Solar | 4.50% | 5.00% | | | | |
| | Solar | 0.50% | 1.00% | | | | |
| | Total | 5.00% | 6.00% | | | | |
| West Bengal | Non-Solar | | | 3.75% | 4.70% | 5.60% | 6.50% |
| | Solar | | | 0.25% | 0.30% | 0.40% | 0.50% |
| | Total | 3.00% | 4.00% | 4.00% | 5.00% | 6.00% | 7.00% |

Source: MNRE

**Renewable Energy Certificates (REC) Market**

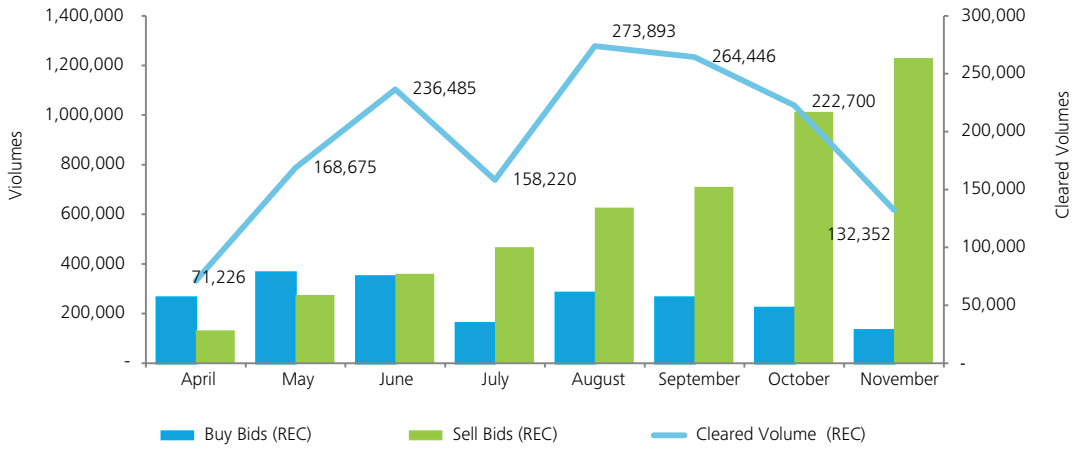
Renewable Energy Certificate (REC) mechanism is a market based instrument to promote renewable energy and facilitate compliance of renewable purchase obligations (RPO). It is aimed at addressing the mismatch between availability of RE resources in state and the requirement of the obligated entities to meet the RPO. REC market development and setting of the RPO targets by the Regulatory Commissions are two cornerstones of the development of renewable sector in India.

While most State Regulatory Commissions have set the solar and non-solar targets for the utilities under their jurisdiction, the REC market has also evolved to facilitate transactions at national level. However, as the graph below shows, there has been a marked downward trend in the demand of RECs leading to reduction in cleared volumes in the recent months. This has further led to accumulation of REC inventory.

There is policy and regulatory uncertainty for REC market which is adversely impacting the current and future REC based projects. Some of the issues relating to REC market which require immediate attention are:

- Declining trend in the REC demand due to non-enforcement of the RPO targets. There is no clear penalty mechanism which is being applied across states for non-compliance.
- CERC has determined the REC prices upto 2017 only and this has led to difficulties in financial closure of projects which are coming up solely on REC trading.
- Issues related regular monitoring (monthly/ quarterly) of RPO compliance by State agencies.

**Figure 14: REC Trading**
**Non-Solar REC Trading**




Source: IEX and PXIL

### Power Evacuation Infrastructure

The development of proper power evacuation infrastructure for the renewables has not kept pace with the additions in renewable capacity in several states. This has led to sub optimal utilization of assets and back-down of generation during peak season. This is specifically true in case of states like Tamil Nadu which has very high contribution of renewables in their energy mix. The STUs have not been able to provide the requisite focus as a result of their poor financial condition and low priority being given to renewable resources in some of the states. Given the fact that there is a high concentration of renewable energy capacity in select regions, there is a need for integrated transmission planning for evacuation of renewable generation.

The proposed Green Corridor Project which has been entrusted to POWERGRID by MNRE to identify transmission infrastructure for renewable capacity addition in the 12th Plan is an important initiative for large scale integration of RE. Under this project, the transmission systems in the states as well as at the centre is proposed to be developed in a coordinated manner while also addressing the technical issues being faced by the utilities for renewable energy evacuation. In addition, Renewable Energy Management Centers are proposed to be established in key states which would facilitate better scheduling and monitoring of RE power. The proposed project also aims to provide central assistance for financing the identified projects. In order to ensure speedy implementation, a high level of coordination with the State agencies is required.

### Framework of National Clean Energy Fund (NCEF)

Announced in the Union Budget 2010-11, the NCEF is a non-lapsable corpus under the Public Accounts of India formed through the levy of a Clean Energy Cess of Rs. 50 per tonne on coal produced domestically and imported to India. The cess came into effect from July 2010.

It is collected by the Central Board of Excise & Customs (CBEC), while Plan Finance II (PF-II) Division of the Department of Expenditure, Ministry of Finance (MoF) acts as the Secretariat for the NCEF and is the agency responsible for disbursing NCEF funds.

**Purpose of NCEF**: As per the NCEF guidelines released by the Ministry of Finance, the Fund was created for "funding research and innovative projects in clean energy technologies." The Fund is open to all. Project proposals can be submitted by individual/consortium of organizations in the Government/public sector/private sector. However, all projects must be sponsored by a Ministry/Department of the Government.

**Fund Collection**: From its inception in July 2010, the National Clean Energy Fund (NCEF) has collected revenues to the tune of Rs 1,066 Crore in FY 2010-11, an estimated Rs 3,249 Crore in FY 2011-12, and is expected to generate further Rs 3,864 Crore in FY 2012-13[18].

### Financing of Renewable Projects

Renewable energy technologies require large initial capital investments, making the levelized cost of generation higher than it is for many conventional sources. These technologies need to be supported until technology breakthroughs and market volumes generated are able to bring the tariff down at the grid parity level.

The availability of financing options shall play an important role in increasing the share of renewable energy in India. High technology and project risks perceived by financers for renewable projects make access to low-cost and long-term funding difficult. Renewable projects are capital-intensive in nature with lower O&M cost (except for Biomass based projects). The risks inherent in renewable projects are also high as the sector is in budding state in India and viability is dependent upon multiple factors like government regulatory support, technology trends etc. Higher risks reflect into higher interest rates in renewable sector lending.

Awareness amongst financial institutions is also insufficient about the sector-specific risks & opportunities. It is preventing them from adapting their standard corporate or project finance products to renewable requirements and conditions. For example, insurance products for mitigation of loss on generation are not available for renewable projects.

18 CBGA : Framework & Performance of National Clean Energy Fund (NCEF) - 2012

Solar project financing is a major issue experienced during the Phase –I of the JNNSM. Developers opted for the package of established international suppliers backed by long-term financing, which resulted in large scale thin-film domination. The Scheduled Commercial Banks (SCBs) participation has been minimal which raises concerns on scalability in future.

Worsening financial health of distribution utilities has raised a major concern amongst the financers & developers. Issues related to delayed payments for long duration is impacting the growth of renewable projects, especially in high resource potential zones.

**Resource Assessment**

Renewable power potential estimates have not been revised since early 80s. As per the initial estimates, India has an estimated renewable energy potential of about 80 GW from commercially exploitable sources viz. Wind – 45 GW, Small Hydro – 15 GW and Biomass/ Bioenergy – 17 GW. In addition, India is receiving a solar radiation sufficient to generate 35 MW/ Sq. Km. using solar photovoltaic and solar thermal energy (Source -Grid Connected Renewable Power- Draft Sub-Group report : MNRE).

Over the period with technological advancements, renewable power potential has changed. There are a number of generic estimates based on studies of various institutions that elaborates as to what proportion of technological potential could be utilized economically, based on the present economic boundary conditions. As such, renewable power potential estimates require revalidation and re-estimation. High quality resource assessments is lacking in renewable power technologies, particularly with wind & biomass. It not only hinders robust market development but increases uncertainty [19].

**Research & Development**

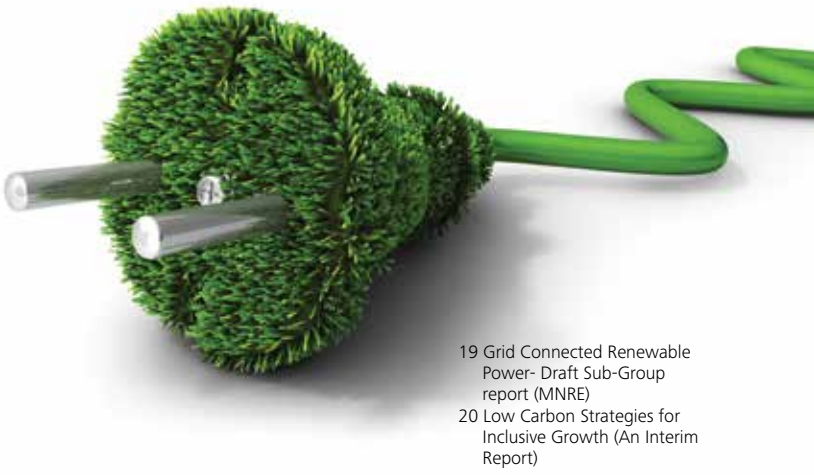
The policy framework for promotion of renewable energy provides for creating necessary environment to attract industry and project developers to invest in research, domestic manufacturing and development of renewable power generation and thus create the critical mass for a domestic renewable industry. The institutional ecosystem developed under the aegis of MNRE for the RE development in the country is more focused on the research, design, and certification. Institutions like Solar Energy Centre (SEC), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) and Alternate Hydro Energy Centre (AHEC) focus on enhancing R&D, testing & certification for RE equipment in the country. As a part of Jawaharlal Nehru National Solar Mission, a number of institutions have been formed a Centres of Excellence (COEs) for promotion of basic as well as applied research in the area of solar energy.

The R&D infrastructure for promotion of RE technologies need to be enhanced to address issues related to appropriate technology for Indian conditions, customisation of products for local needs, lack of integrated supply chain and eco-system and enhancing competitiveness of domestic manufacturing.

India needs to promote technological innovation such that efficiency continuously improves over time. The development and introduction of green technology is an essential element of any low-carbon strategy. There is an urgent need to scale up and expand investments in the research and development of such technologies. This will not only require supportive policy framework for research and development, but also interventions that facilitate adoption and absorption of new technology. Venture capital funds that take equity risk could contribute to successful commercialisation of innovations[20].

**Low level of Penetration for urban and industrial applications**

Renewable energy possesses huge potential for urban and industrial applications. However, relatively high level of cost and lack of policy & regulatory framework clarity hinders the penetration of renewable energy for urban and industrial applications.



19 Grid Connected Renewable Power- Draft Sub-Group report (MNRE)
20 Low Carbon Strategies for Inclusive Growth (An Interim Report)

# 4 Clean Coal Technologies

India faces formidable energy challenges over the next decades. It has to ensure that it adopts state-of-the-art energy technologies both on the supply side as well as on the end-use side to meet its energy needs while addressing local and global environmental problems.

Coal is fuelling more than 50% of Indian electricity and major share of the energy demand. However, coal is also one of the most unclean energy sources in the world which contribute significantly towards "Global Warming". Realizing the environmental costs of this fuel source, this has forced policy makers to take a deeper look at understanding how to manage this fuel resource environmentally and in the most energy efficient manner. Clean Coal Technologies (CCTs) are several generations of technological advances that have led to more efficient combustion and utilization of coal.

India has had considerable experience in the development of clean coal technologies especially in the development of IGCC based pilot plants. India's national laboratory the Indian Institute of Chemical Technology and BHEL (Bharat Heavy Electricals Limited) the OEM of power equipment had developed pilot facilities using both the moving bed technology and the fluidized bed technologies in Hyderabad in the early 1990's. BHEL has earlier in 1985 set-up a 6.2 MW IGCC pilot at their R&D centre in Trichy. However, these developments had not moved beyond the pilot phase. The primary barriers then were primarily technical ranging from turn down ratio of the gasification system due to variations in the power demand, hot gas clean-up systems etc. However, the technology has significantly developed mostly in the OECD countries due R&D by joint research in various organizations like EPRI and IEA as well as support from the respective governments. "Demonstration of plants for integrated gasification combined cycle (IGCC) using high-ash, low sulfur Indian coal needs to be pursued, while recognizing constraints such as high costs and availability of superior imported coal." IGCC has the potential to be more efficient than conventional power generation, especially through hybrid systems, and offers an attractive option to separate a concentrated stream of CO2 for sequestration via storage in geologic formations, which would allow coal use with near-zero emissions of CO2.

The supercritical steam cycle technologies were well demonstrated in most OECD countries since the 1970's, however, India did not explore the possibilities of introducing these for various reasons. The uptake of cleaner coal technologies has been slow due to the following reasons which primarily are non-technical. The most important being the cost-effectiveness of these technologies as most of the utilities were state owned and power supply was then seen as a social obligation. The power tariffs and low fuel costs could not justify the increased power generation and supply cost. The other major barrier was that as early as in the 1970's India decided to standardize its power plants size, which were especially designed to run on high ash Indian coals for rapid deployment (by BHEL the only utility scale power plant manufacturer) and provide electricity for rapid industrialization. It was not possible to make cleaner coal technologies cost-effective under those circumstances especially where resource efficiency was not a significant factor then.

The scenario has significantly changed after the 90's due to liberalization and after restructuring the electricity boards. This change brought in the concept of corporatization and making each segment of the power supply chain as a separate profit centre and also privatization of the distribution system. The concept now in the 21st century India is significantly different with the private sector playing a key role in all segments of the power sector including in the manufacturing of power plants. Many of global players like ABB, GE, Siemens, Toshiba and many other have set-up manufacturing facilities in supercritical and ultra-supercritical boilers and also have R&D centers. Several initiatives have also been started by the Government of India and various Industry associations in this regard. Most of the technical barriers have been addressed but major constraints still exists in the availability of skilled manpower in the operation and maintenance of the power plants. Both BHEL as well as NTPC now have a roadmap towards development and deployment of commercial scale IGCC and Ultra-supercritical plants by 2017. Indigenization of cleaner coal technologies will bring down the cost per MW not only due the lower skilled labour cost but also due to other India specific advantages in manufacturing.

Recognizing the need of indigenization and adoption of these CCTs which will enable India to harness the potential of this energy source most efficiently, a new 'Mission on Clean Coal Technologies' under National Action Plan on Climate Change has initiated in 2012. Some of the key challenges for the promotion of clean coal technologies include

- Improve the efficiency of combustion and sub systems of the power plants to increase the productivity of coal.
- Understanding economical-social-environmental benefit matrices of various technologies to make appropriate technology decisions.
- Understanding and identification of emerging superior Clean Coal Technologies practiced worldwide suitable for Indian scenario.
- Bridging the financing gaps.
- Institutionalization of the policy facilitation framework of CCTs.
- RD &D facilitation framework to overcome major technological hurdles.

# 5 Nuclear energy as an emerging alternative

Climate change is one of the most important issues facing the world today. Nuclear power can make an important contribution to reducing greenhouse gases while delivering energy in the increasingly large quantities needed for global economic development. Nuclear power plants produce virtually no greenhouse gas emissions or air pollutants during their operation and only very low emissions over their full life cycle.

The IPCC estimates that nuclear power has the largest and lowest cost GHG reduction potential in power generation. According to International Atomic Energy Agency (IAEA), GHG emissions from nuclear energy technologies will be even lower in the future due to four important trends:

- a shift from electricity intensive gaseous diffusion uranium enrichment technology to centrifuge or laser technologies that require much less electricity;
- the increased share of electricity (also for enrichment) that is based on low or non-carbon fuels;
- extended nuclear power plant lifetimes (which mean reduced emissions per kWh associated with construction); and
- increased burnup (which means reduced emissions per kWh associated with uranium mining and manufacturing fuel).

India has well recognised the role of nuclear energy as a part of its long term energy security measure. Nuclear power supplied 20 billion kWh (3.7%) of India's electricity in 2011 from 4.4 GWe (of 180 GWe total) capacities and after a dip in 2008-09 this is increasing as imported uranium becomes available and new plants come on line. Some 350 reactor-years of operation had been achieved by the end of 2011.

The current installed capacity of nuclear power plants in India stands at around 4780 MW.

Nuclear capacity additions in India have been relatively slow during the Eleventh Plan period. During the five year period, against a target of 3380 MW, only around 880 MW of capacity was added. The draft 12th Five Year Plan has targeted a capacity addition target of around 5,300 MW from nuclear energy.
In the long term, the various scenarios under the Integrated Energy Policy (IEP) envisage the nuclear capacity to be 48 GW to 63 GW by year 2030.

The share of nuclear power in India (in terms of fuel source for electricity generation) is expected to increase from 3 per cent in 2012 to 5 per cent in 2017 and to 12 per cent in 2030.

**Table 12 : Nuclear Power Installed Capacity**

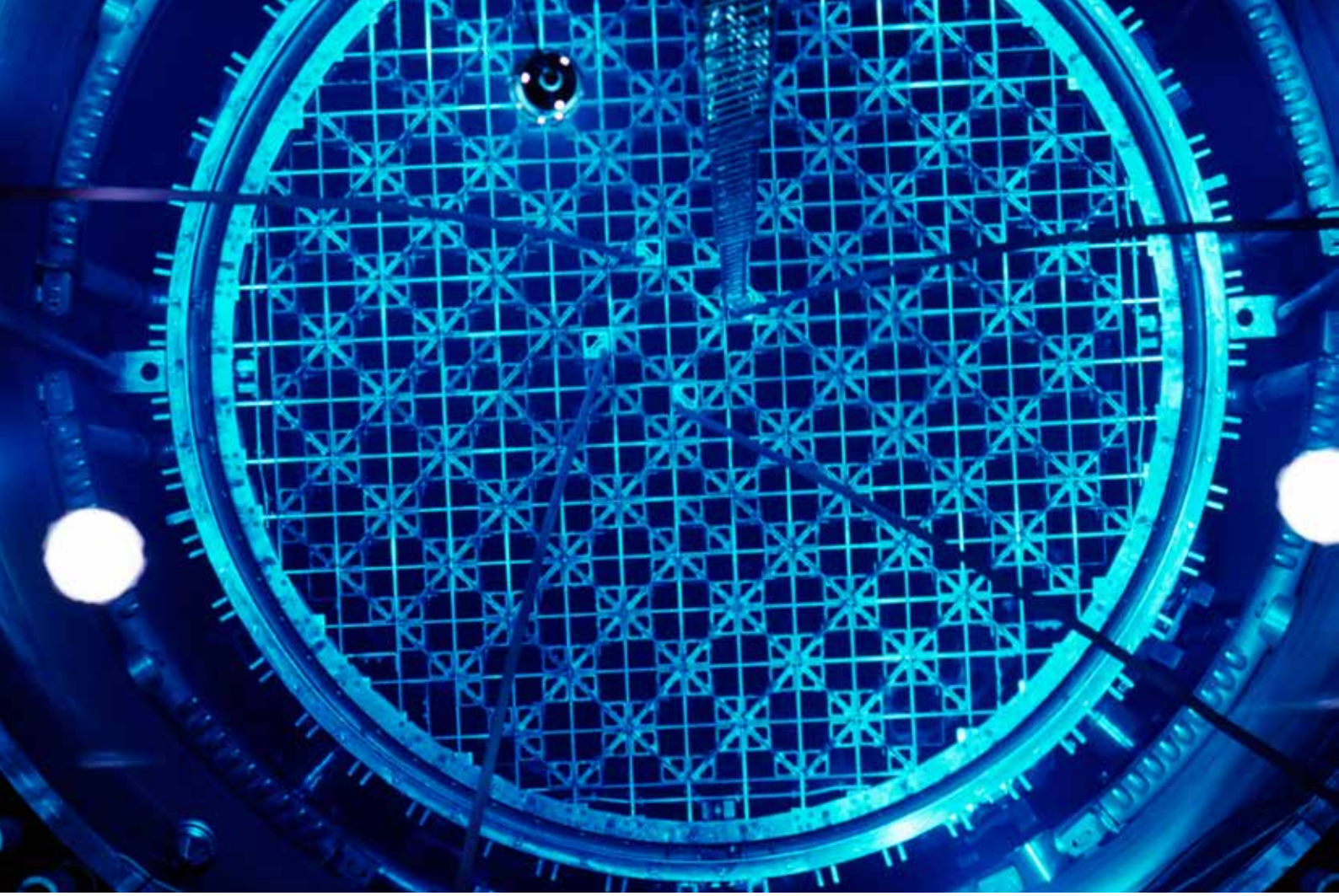
| Power station | State | Type | Units | Capacity (MW) |
|---|---|---|---|---|
| Kaiga | Karnataka | PHWR | 4 x 220 | 880 |
| Kakrapar | Gujarat | PHWR | 2 x 220 | 440 |
| Kalpakkam | Tamil Nadu | PHWR | 2 x 220 | 440 |
| Narora | Uttar Pradesh | PHWR | 2 x 220 | 440 |
| Rawatbhata | Rajasthan | PHWR | 1 x 100, 1 x 200, 4 x 220 | 1,180 |
| Tarapur | Maharashtra | BWR (PHWR) | 2 x 160, 2 x 540 | 1,400 |
| | | Total | 20 | 4,780 |

**Nuclear Cooperation agreements**

In order to encourage and support scientific, technical and commercial cooperation in the field of nuclear energy, along with ensuring sufficient fuel supplies for the nuclear power plant, India has taken a number of initiatives with different countries. The waiver given by the Nuclear Suppliers Group (NSG) to India, under which India, which has nuclear weapons and is not a signatory of the Nuclear Non-Proliferation Treaty (NPT), is allowed to buy and sell nuclear fuel only for peaceful processes from the world market, opened the gates for Civil Nuclear Agreements with various countries. The table below provides a brief list of countries India is cooperating in the field of nuclear energy.

**Table 13 : Nuclear Cooperation Agreements**

| S No | Country | Year | Agreement Name | Details |
|---|---|---|---|---|
| 1 | USA | 2008 | US-India Civil Nuclear Agreement | Cooperation between US and India towards a full civil nuclear cooperation.<br>Permits civil nuclear cooperation between those facilities that are labeled as civil and excludes the transfer of sensitive equipment and technology including civil enrichment and reprocessing items.<br>NSG granted a waiver to India and India became the only country with nuclear weapons which has not signed the NPT, while is still capable of buying and selling nuclear fuel from the rest of the world. |
| 2 | Russia | 1988, 2008, 2009 | - | Russia to set up nuclear power plants in India (2X1000 and 4X1200 MW)<br>Provisions for setting up reactors in India. Russia has also given a no objection on the transfer of sensitive technology to India.<br>India can proceed with closed cycle plants – mining, preparation of fuel and reprocessing of spent fuel |
| 3 | France | 2008 | Civil Nuclear Agreement | French company Areva to set up nuclear plants in India (2x1650 MW). Civil nuclear agreement to supply nuclear fuel for peaceful purposes. |
| 4 | Mongolia | 2009 | Civil Nuclear Agreement | Supply of Uranium to India |
| 5 | Namibia | 2009 | Civil Nuclear Agreement | Supply to Uranium to India for use in peaceful purposes. |
| 6 | Argentina | 2009 | Civil Nuclear Agreement | To encourage and support scientific, technical and commercial cooperation for mutual benefit in this field |
| 7 | Canada | 2010 | Civil Nuclear Agreement | Provides Canada's Nuclear Industry and their fuel access to Indian markets. Nuclear export agreement finalized. |
| 8 | Kazakhstan | 2009, 2011 | Agreement | Civil nuclear agreement in 2009<br>Agreement for cooperation in peaceful uses of nuclear energy.<br>Provides a legal framework for supply of fuel, construction and operation of atomic power plants, exploration and joint mining of uranium, exchange of scientific and research information, reactor safety mechanisms and use of radiation technologies for healthcare |
| 9 | South Korea | 2011 | Nuclear Agreement | Will allow South Korea with a legal foundation to participate in India's nuclear expansion program, and to bid for constructing nuclear power plants in India |



### Key Challenges in development of nuclear energy

**Safety aspect:** The recent disasters at the Fukushima NPP in Japan have raised concerns regarding the safety of nuclear power projects. The need is to revive the confidence in the technology & safety aspects w.r.t. installation of nuclear power projects and ensuring that the highest & most robust levels of nuclear safety are in place.

**Fuel supply:** While India has developed indigenous technological capability in all aspects of nuclear power, the ability to develop nuclear power is restricted by the very limited availability of Uranium. India is poorly endowed with Uranium. Available Uranium supply can fuel only 10,000 MW of the Pressurised Heavy Water Reactors (PHWR). Further, India is extracting Uranium from extremely low grade ores (as low as 0.1% Uranium) compared to ores with up to 12-14% Uranium in certain resources abroad. This makes Indian nuclear fuel 2-3 times costlier than international supplies. The substantial Thorium reserves can be used but that requires that the fertile Thorium be converted to fissile material. The pace at which we can expand nuclear power generation using indigenous fuel sources is thus severely limited even though the eventual potential for nuclear power generation is vast[21].

**Social & environmental concerns:** Issues related to social & environmental impacts needs to be addressed to encourage acceptance of the nuclear power project by all stakeholders.

21 IIntegrated Energy Policy (2006)

# 6 Discussion Points

## Renewable Energy

Renewable energy will increasingly play an important role in the overall energy mix in the country and will continue to contribute towards addressing the present and future power supply deficits as well as enhancing the energy access in remote areas. The policy makers & regulators, along with other market players, needs to play pro-active role in addressing the key issues currently faced by renewable energy sector.

**How Renewable Energy can take the centre stage for meeting India's energy requirement ?**

Need to deliberate on the strategy adopted by Govt. of India for promotion of renewable energy in India and possible way forward to strengthen the same. Are the focus areas (policy & regulatory, institutional, technology) in line with the Indian requirement for both grid as well as off-grid energy delivery? What are the missing links for renewable energy segment to attain the core focus?

**How to ensure that RPOs are implemented across states and they reflect the NAPCC targets?**

The policy & regulatory impetus will remain crucial for not only sustaining but increasing the growth rate of the renewable energy during the 12th Five Year Plan period and over the long term. The policy & regulatory framework should provide for clear RPO compliance mechanism in the long term to provide market stability & build investor confidence and aim towards achievement of targets set under the National Action Plan on Climate Change. The issue of RPO compliance and its impact on the REC market needs to be addressed to strengthen the development of renewable sector.

**How could availability of adequate financing be ensured for the development of renewable sector?**

Given the huge financing requirement for achieving the targets for the 12th Five Year Plan, the challenge for the policy makers and key stakeholders shall be to overcome the financing issues faced by the renewable energy sector and implement measures for tapping funding for the sector. The emerging technologies like solar may require preferential treatment in terms of low cost financing amongst others to develop the sector. What steps needs to be undertaken for not only increasing the availability of funds but also enhancing the viability of the renewable energy projects? Would creation of dedicated funds for the renewable sector, developing low cost financing instruments, be the options which the policy makers look at over the next five years?

**What steps needs to be undertaken to develop the REC market mechanism?**

Renewable Energy Certificates (REC) provides a market-linked alternative source of revenue for renewable based projects. The uncertainty in long term REC pricing and the increasing inventory of non-solar RECs due to non-enforcement of the RPOs could potentially derail the whole mechanism.

What would be the immediate steps which need to be taken to deepen the REC market and also provide the long term certainty for the development of REC based instruments?

**Is the institutional framework for the renewable segment strong enough to ensure coordinated develpoment of RE sector?**

The state government agencies like transmission utilities, renewable energy development agencies, etc would have to play an important role in ensuring coordinated development. For example, most of the states do not have a dedicated renewable transmission plan. While the Green Energy Corridor scheme has proposed intra/inter-state transmission system strengthening, facilities like flexible generation, establishment of Renewable Energy Management Centres, etc, but the institutional framework for coordinating such effort is not there.

Are central sector institutions required to play the role of coordination to achieve RE targets? Do some of the established institutions like Solar Energy Centre of India (SECI) have sufficient institutional capabilities to take on the bigger role of coordination and how can the same be enhanced? Similarly, what would be the key requirements for empowering the state institutions?

## Clean Coal Technologies

**What have been the key lessons from the various initiatives for clean coal technology testing and commercialization? What could be the roadmap for adoption of Advanced clean coal technologies in Indian context?**

India has to ensure that it adopts state-of-the-art energy technologies both on the supply side as well as on the end-use side to meet its energy needs. The lessons learnt from the earlier pilot projects for clean coal technologies needs to be analysed and understood for creating the policy framework around the clean coal technologies.

## Nuclear Energy

**How can various concerns with regard to safety aspects of Nuclear projects be addressed?**

The recent disasters at the Fukushima NPP in Japan have raised concerns regarding the safety of nuclear power projects. The need is to revive the confidence in the technology & safety aspects w.r.t. installation of nuclear power projects and ensuring that the highest & most robust levels of nuclear safety are in place. How can this be achieved in Indian context?

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