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Renewable Energy and Green Growth in India

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For more information

Project Monitoring Cell
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

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Introduction

Renewable energy has been an important component of India's energy planning. The importance of renewable energy sources in the transition to a sustainable energy base was recognized in the early 1970s. Modern renewable energy is being used increasingly in four distinct markets: power generation, heating and cooling, transport, and rural/off-grid energy services. The Ministry of New and Renewable Energy (MNRE) in India has been facilitating the implementation of broad spectrum programs including harnessing renewable power, renewable energy for rural areas for lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications. In addition, it supports research, design and development of new and renewable energy technologies, products and services.

The approach for deployment of new and renewable energy systems focused on a mix of subsidy, fiscal incentives, preferential tariffs, market mechanism and affirmative action such as renewable purchase obligations by way of legislation and policies. Financial support has also been extended to research and development (R&D), information & publicity and other support programs.

Renewable energy plays an important role in the long-term energy supply security, diversification of energy mix, energy access, environmental security and sustainability. Renewable energy is bound to play an increasing role in future energy systems. This chapter analyses central level policies and interventions for renewable energy applications and also recommends a set of guidelines to serve as a roadmap to accelerate the deployment of renewable energy technologies.

Status Report

Grid Power/Installed Capacity

Power generation from renewable sources is on the rise in India, with the share of renewable energy in the country's total installed capacity rising from 7.8% in 2008 to around 13% in 2014 (IREDA, 2014). India now has about 36.4 GW of installed renewable energy capacity. Of these, wind is the largest contributor and stands at around 23.7 GW of installed capacity making India the world's fifth largest wind energy producer. Small hydro power (4.1 GW), bio-energy (4.4 GW) and solar energy (4 GW) constitute the remaining capacity (MNRE, 2015). It has been reported that in terms of electricity generation, approximately 70 billion units per year is being generated from renewable sources (MNRE, 2014). Figure 1 below shows the renewable energy mix in the total installed capacity in India.

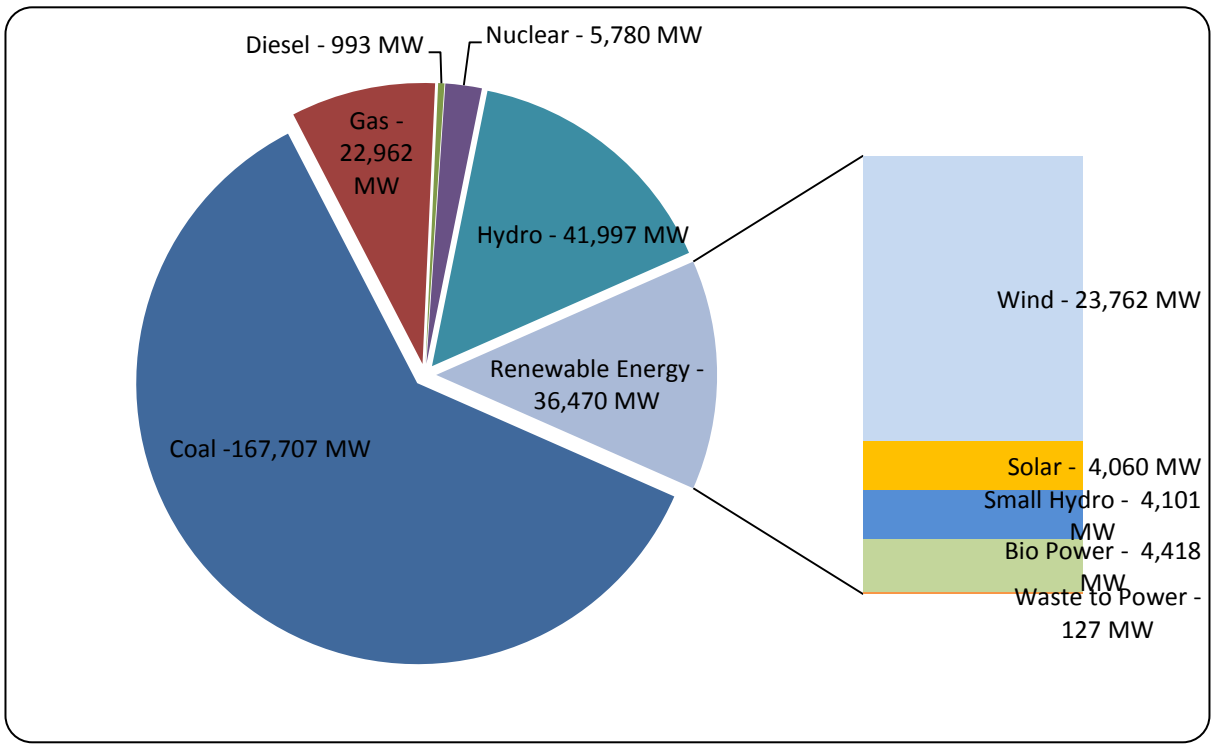

Figure 1: Share of renewables in total grid installed capacity

Source: CEA-MNRE report

Renewable energy capacity addition has always kept pace with and exceeded the targets set by India's 5 year plans. Recently the government has announced a revision of targets for renewables by 2022. Table 1 below shows installed capacities of the past along with the numbers for the targeted capacity in 2022. It is evident that this has been an unprecedented level of ambition of renewables in India.

Table 1: Past and Targeted grid connected renewable energy capacities

Renewable Energy Source	Installed capacity by end of the 11th Plan (March 2012)	Installed Capacity as on March 2015	Target as per 12th Plan (March 2017)	Revised targets by 2022
Solar Power	941	3,383	10,941	100,000
Wind Power	17,352	22,645	32,352	60,000
Biomass Power	3,225	4,183	6,125	10,000
Small Hydro	3,395	4,025	5,495	5,000
Total	**24,913**	**34,236**	**54,913**	**175,000**

Source: MNRE

Solar

The Jawaharlal Nehru National Solar Mission (JNNSM) was launched in 2010 after which the Indian SPV market has seen significant growth. Grid connected SPV mainly consists of ground mounted, rooftop and distribution grid plants. With the provision of institutional arrangements, national and local enabling mechanisms, and targeted policies, including appropriate subsidies and financing arrangements, the total installed capacity rose from 40 MW in 2010 to 2686 MW as on 30 June 2014. An aggregate capacity of 1686 MW was installed in JNNSM Phase I, and an additional capacity of 1000 MW has been added in Phase II of the programme (TERI, 2014-15). The total installed capacity of grid connected SPV as on June 2015 is 4060.65 MW (MNRE, 2015), which includes central and state level initiatives. In order to meet this target, the government is taking a number of measures which are listed below:

- Provision of renewable purchase obligation (RPO) for solar power in the National Tariff Policy
- Grant of subsidy on off-grid applications and GBI facility for bundled power and Viability Gap Funding (VGF) for grid-connected solar power projects through various interventions announced from time to time
- Setting up ultra-mega solar power projects and solar parks, 1 MW solar parks on the banks of canals, and solar power driven agricultural pump sets for energizing 1 lakh pumps.
- Concessional import duty/excise duty exemption for setting up of solar power plants, accelerated depreciation and tax holiday

The first phase of the programme provided learning experiences to the government, such as reduction in tariffs is possible if the capacity to be allotted is high, experienced companies are interested in large projects and transmission and evacuation system is still a major issue. Apart from that, timely payment and assurance of continuity is essential from the point of view of the lender, the domestic manufacturing units need more R&D support since majority of the equipment are imported increasing the overall price.

Rooftop solar has been relatively lackluster in India with no clear policy thrust so far and only about 350 MW of rooftop solar being installed (100 MW) of total rooftop capacity.

Concentrated Solar Power (CSP) in India has reached the 225 MW mark. In 2014, the world's largest linear Fresnel plant of 125 MW and equivalent to 13% of global added capacity came on line in India. The Dhursar CSP plant of 125 MW is located in Rajasthan and is Asia's largest CSP installation. Another plant of 50 MW located in Andhra Pradesh was also commissioned in 2014. (REN 21, 2015)

On Shore Wind

India currently has about 23,762 MW of installed wind power capacity and is ranked fifth in the world for total installed capacity, although the demand contracted by 26% in the previous year (REN21 2014). A steep devaluation of the rupee against the US dollar (increasing financing and import costs) and the removal of key support policies, in 2012 delayed investment in wind power. However, retroactive reinstatement of the generation-

based incentive (GBI) in late 2013 helped resurrect the market. Wind power is a mature and scalable clean energy technology in which India holds a domestic advantage. India has an annual manufacturing capacity of over 9.5 GW for wind turbines. During 2013, India installed 1.729 GW of new wind power capacity. Tamil Nadu, Karnataka, Maharashtra, Rajasthan, and Gujarat are the leading states for wind power capacity.

In 2011, the Centre for Wind Energy Technology revised India's wind power potential to 102,778 MW at 80 m height and at 2% land availability. This was a significant upward revision from the earlier estimate of approximately 49,130 MW at 50 m height and at 2% land availability. Over the past years, other research organizations have also estimated India's wind power potential using various models for mapping the wind resource. A study conducted by the Lawrence Berkeley National Laboratory, assuming a turbine density of 9 MW/km2, estimated the total wind potential in India with a minimum capacity factor of 20% to be 2006 GW at 80 m hub height and 3121 GW at 120 m hub height

Offshore Wind

India has around 7,600 km of coastline with the potential for offshore wind power development. The MNREs initiatives towards the development of offshore wind power include announcement of the Draft National Offshore Wind Energy Policy and preparation of the Draft Cabinet note on National Offshore Wind Energy Policy, which have been circulated for inter-ministerial comments. Finalization of the proposed policy is expected to provide a conducive environment for harnessing offshore wind energy, including setting up of a demonstration project to showcase technology and build investors' confidence.

A National Offshore Wind Energy Authority (NOWA) under the MNRE will be constituted, which will be the nodal agency for offshore wind projects in the country. NOWA will carry out resource assessment and surveys in the exclusive economic zones (EEZs) of the country and simultaneously enter into contract with project developers for the development of offshore wind energy project in the territorial water.***12*** The preliminary assessment along the coastline suggests that there could be a potential to develop offshore wind energy along Tamil Nadu, Gujarat, and Maharashtra coasts. With a 7600 km coastline, India is estimated to have 350 GW of offshore wind energy capacity.

This year a memorandum of understanding (MoU) has been signed for setting up a joint venture company (JVC) for undertaking the first demonstration offshore wind power project along the Gujarat coast. The MoU was signed by the MNRE, National Institute of Wind Energy, and a consortium of partners consisting of the National Thermal Power Corporation (NTPC), Power Grid Corporation of India Ltd (PGCIL), IREDA, Power Finance Corporation (PFC), Power Trading Corporation (PTC), and Gujarat Power Corporation Ltd (GPCL).

The JVC will undertake detailed feasibility study based on the inputs received from pre-feasibility studies and necessary steps for implementing the first offshore demonstration project. The first planned project along the Gujarat coast will be of 100 MW capacity. It has been proposed to provide subsidy for setting up of evacuation and transmission infrastructure of the offshore wind power to the main land, including financial support for carrying out studies such as wind resource assessment, environment impact assessment (EIA), oceanographic survey, and bathymetric studies. The MNRE would assist in obtaining clearances involved during the implementation of the project. Being the first demonstration project in the country, it will certainly provide enough learning for taking up similar viable

projects in the future, enabling India to enter the club of countries that are in the business of offshore wind power generation.

Biomass

Biomass-based power generation has been increasing in India with the installation of megawatt-scale plants processing a variety of biomass residues such as shells, husks, de-oiled cakes, and wood. According to the MNRE, 500 million tonnes (MT) of agricultural and agro-industrial residues are generated annually in the country, of which about 120–150 MT per year could be surplus for power generation.*7* Biomass power generation from agriculture and agro-industrial residues is estimated at about 17 000 MW. Rajkumar Impex Pvt. Ltd, Tuticorin, Tamil Nadu, is a leading cashew processing company in India. It has established a biomass power plant with the capacity of 6 MW using cashew nut shells as fuel, the first of its kind in India. Chanderpur Renewable Power Co Pvt. Ltd has installed 1 MW biomass gasifier-based power project in village Sohana, district Ambala, Haryana.*8* The project is financed by the Indian Renewable Energy Development Agency (IREDA) with a loan of ` 390 lakh.

Small Hydro

India has an estimated potential of about 19,750 MW of small hydropower (SHP) projects (MNRE 2012). Most of the potential is in the Himalayan states as river-based projects and in other states on irrigation canals (MNRE 2014b). The MNRE has created a database of potential sites for small hydro, and 5,415 potential sites with an aggregate capacity of 14,305.47 MW for projects up to 25 MW of capacity have been identified. So far SHP projects with an aggregate capacity of 4,101 MW have been set up, and additional capacity is under implementation. Setting up of SHP projects comes under the purview of state governments. Potential sites are either developed by the state or allotted to private developers for setting up of projects. During the Eleventh Five-year Plan, a capacity of 1419 MW was added against 536 MW during the Tenth Five-year Plan. A capacity addition of 2,100 MW from SHP projects has been planned during the Twelfth Five-year Plan. The MNRE provides central financial assistance (CFA) to set up small/micro hydro projects in both public and private sectors. Financial support is also given to state governments for identifying new potential sites, including survey and preparation of detailed project reports (DPRs), and renovation and modernization of old SHP projects. It also helps the state governments in formulating their policies for the development of SHP projects and exploitation of this potential. Under the CFA scheme of the MNRE, capital subsidy is now provided to both private and state projects and for renovation and modernization of SHP plants. Besides, technical support is being provided to SHP units through the Alternate Hydro Energy Centre (AHEC), IIT, Roorkee.

Off-Grid Renewable Energy/Power

Distributed/decentralized renewable power projects using wind energy, biomass energy, hydro power and hybrid systems are being established in the country to meet the energy requirements of isolated communities and areas which are not likely to be electrified in near future.

- Biomass based heat and power projects and industrial waste to-energy projects for meeting captive needs

- Biomass gasifies for rural and industrial energy applications
- Watermills/micro hydro projects – for meeting electricity requirement of remote villages
- Small Wind Energy & Hybrid Systems - for mechanical and electrical applications, mainly where grid electricity is not available.
- Solar PV Roof-top Systems for abatement of diesel for power generation in urban areas

The main objectives of the programme are: supporting RD&D to make such systems more reliable and cost-effective, demonstration, field testing, strengthening manufacturing base.

Table 2: Off grid, captive power and other renewable energy systems.

Renewable Energy Source	(CAPACITIES IN MW_{EQ})
Waste to Energy	154.47
Biomass (non-bagasse) Cogeneration	591.87
Biomass Gasifiers (Rural)	17.95
Biomass Gasifiers (Industrial)	152.05
Aero-Generators/Hybrid systems	2.53
SPV Systems	234.35
Water mills/micro hydel	17.21
Total	1174.50

Source: MNRE 2015

Liquid Biofuels

In 2002 the Ministry of Petroleum & Natural Gas (MoPNG), Government of India launched the Ethanol Blending Programme (EBP), making 5 percent blending of ethanol with petrol by oil marketing companies as mandatory in 9 states and 4 union territories with effect from January 2003 and gradually increased it to 10% blending and made it mandatory across the country except the Northeast, Jammu and Kashmir, and island territories. However, the target of 10% blending was never met due to various reasons such as cyclical production of sugar which increased the prices of ethanol production, failures to set an ethanol pricing

formula and procedural delays by various state governments. Even though the government fixed the price at 44/liter, the response of the ethanol market remained unsatisfactory.

In order to promote biodiesel, the Planning Comission launched the National Mission on Biodiesel based on non-edible tree-borneoils in 2003. While biodiesel production in India is predominantly focused on using jatropha, other non-edible tree-borne-oils, such as pongamia, karanja, and animal fats like fish oil are also being used. A target of blending 5% biodiesel with high speed diesel was proposed by the Planning Commission in 2006-07 which rose to 20% by 2011-12. A total of 13.4 million ha of land was made available for jetropha plantation. India deregulated the sale of biodiesel, allowing producers to sell directly to consumers in an effort to expand the biodiesel market, and India's state owned rail company, India Railways, now aims to include up to 5% biodiesel in its locomotive fuel.

Job creation

Job creation in the renewables sector takes place in three ways:

Direct employment - Employment generated directly by core activities without taking into account the intermediate inputs necessary to manufacture renewable energy equipment or construct and operate facilities. Direct employment data may be estimated on the basis of an industry survey, or data derived from representative projects and facilities for the industry in question or derived from economic data such as labour input coefficients for selected industries.

Indirect employment - includes the employment in upstream industries that supply and support the core activities of renewable energy deployment. Usually, these workers do not consider themselves as working in renewables; they produce steel, plastics or other materials, or they provide financial and other services. These industries are not directly involved in renewable energy activities but produce intermediate inputs along the value chain of each renewable energy technology (RET). A review of employment factors available in the literature indicates that the inclusion of indirect jobs typically increases overall job numbers by anywhere from 50% to 100% (Rutovitz and Harris, 2012).

Induced employment - encompasses jobs beyond the renewable energy and its upstream industries, such as jobs in the consumer goods industry. When people who are employed directly or indirectly spend their incomes on a variety of items in the broader economy (such as food, clothing, transportation and entertainment), the expenditure gives rise to induced employment effects. Similarly, changes in consumer electricity tariffs due to higher/lower costs of RETs give rise to induced employment impacts as the disposable income of the consumer changes.

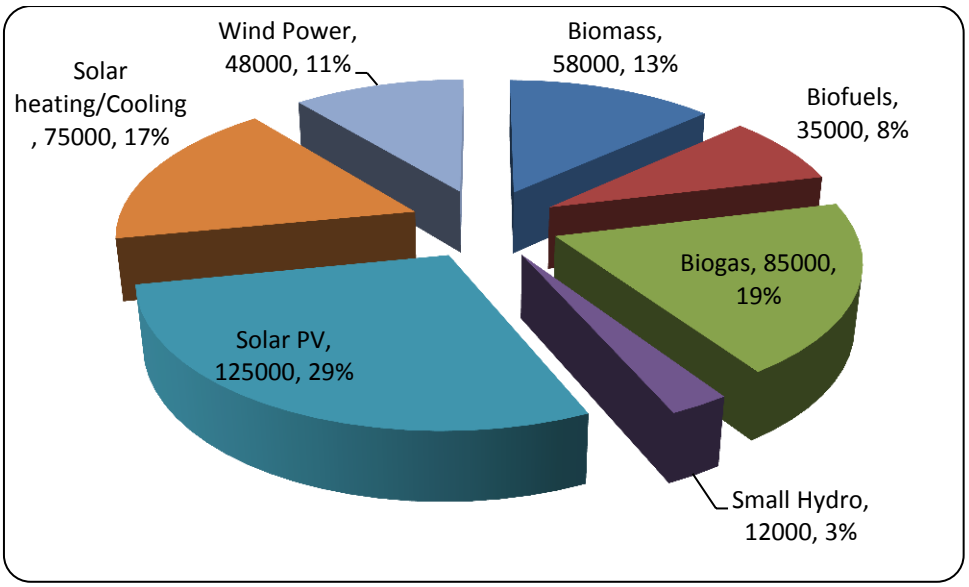

Figure 2: Job creation in the renewable energy sector in India
Source: IRENA

Legal and Institutional Framework

Electricity Act 2003: Launched in June 2003, this is the most important piece of legislation for the renewable energy sector. The act provides for policy formulation by the Government of India and mandates State Electricity Regulatory Commissions (SERCs) to take steps to promote renewable and non-conventional sources of energy within jurisdiction. It calls to promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee. Further, EA 2003 has explicitly stated the formulation of National Electricity Policy (NEP), National Tariff Policy and plan thereof for development of power systems to ensure optimal utilization of all resources including renewable sources of energy.

National Electricity Policy 2005: Aims to exploit feasible potential of renewable energy resources reduce capital costs; promote competition and private sector participation. The percentage for purchase of power from non-conventional sources should be made applicable for the tariffs to be determined by the SERCs. Progressively the share of electricity from non-conventional sources would need to be increased as prescribed by SERCs. Such purchase by distribution companies shall be through competitive bidding process.

National Tariff Policy 2006: Formulates that a minimum percentage of renewable energy procurement should be made applicable. Also, a preferential tariff should be determined by SERCs to enable renewable technologies to compete and procurement of renewable energy should be through competitive bidding.

NAPCC 2008: The National Action Plan of Climate Change by the Government of India identifies 8 core national missions running through 2017, covering several measures to

address global warming. One of the missions states that a dynamic minimum renewable purchase standard (DMRPS) be set, with escalation each year till a pre-defined level is reached. It set targets of 5% RE purchase for FY 2009-10, with an increase of 1% in target each year to reach 15% renewable energy penetration by 2020.

Jawaharlal Nehru National Solar Mission (JNNSM): As a part of the 8 National Missions announced under the NAPCC, the JNNSM (announced in 2009) aims to promote the development of solar energy for grid connected and off-grid power generation. The definitive objective is to make solar power competitive with fossil based applications by 2020-2022.

Integrated Energy Policy (IEP) 2006: The Policy recognizes and emphasizes the importance of renewable energy to meet the energy demand of the country. The broad vision behind the IEP is to consistently meet the demand for energy services of all sectors. These include the lifeline energy needs of vulnerable households in all parts of India with safe, clean and convenient energy at the least-cost.

National Clean Energy Fund (NCEF): NCEF is a fund created in 2010-11 using the carbon tax - clean energy cess - for funding research and innovative projects in clean energy technologies of public sector or private sector entities. Assistance is available as a loan or as a viability gap funding. A cess is levied on coal consumed for power generation in the country, the revenues from which go towards the creation of a fund for research and innovative projects in clean energy technology. The cess was introduced in 2011-12 and has increased from INR 50 per ton in 2010-2011 to INR 200 per ton in 2014-15. By the year 2014-15, an amount of Rs 16388.81 crore has been collected in the fund. As per estimates an amount of Rs 13118.04 crore will be collected during 2015-16. (PIB, 2015)

Renewable Purchase Obligation (RPO): SERCs set targets for distribution companies to purchase certain percentage of their total power requirement from renewable energy sources known as RPO. The states have already specified their RPOs ranging from 2% to 14% of their total energy demand to be met by renewable energy. In order to address the mismatch between availability of renewable energy sources and the requirement of the obligated entities to meet their RPO across States, the REC mechanism was introduced in 2010 to enable and recognize interstate renewable energy transactions. The REC mechanism facilitates emergence of large number of cross-border RE transactions based on non-firm renewable energy sources, while at the same time, enhancing the volume of cross-border renewable energy transactions based on firm RE sources as well. RECs serve as a motive for high potential states to further develop their renewable energy potential and for lesser potential states to develop maximum RE as they can. (RE-Invest 2015)

The government of India provides a mix of tax and non-tax benefits to promote these technologies, so as to create an enabling investment climate where these projects are taken up by market forces. The different incentives offered by central and state governments can be broadly illustrated as shown in Figure 3:

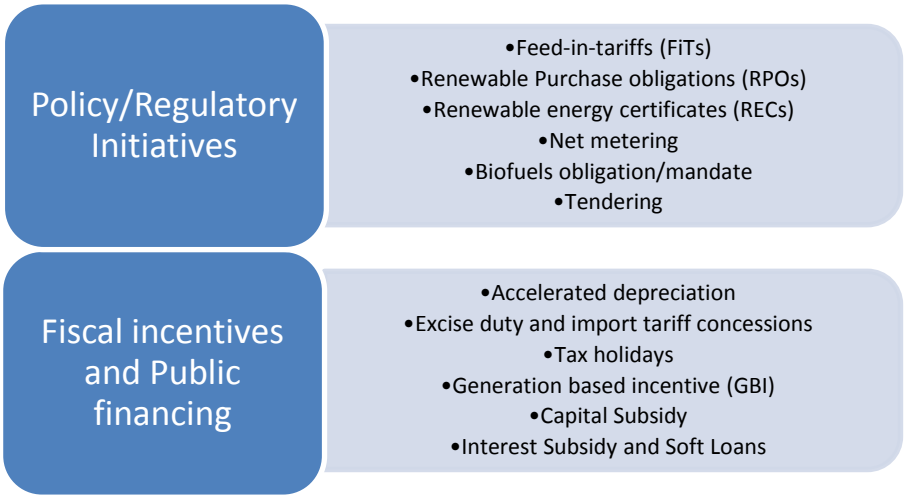

Figure 3: Broad classification of incentives available for renewable energy
Source: TERI Compilation

There are multiple agencies involved in the renewable energy sector in India. At the central level, the Ministry of New and Renewable Energy (MNRE) is the nodal ministry of the Government of India (GoI). The broad aim of the ministry is to develop and deploy new and renewable energy for supplementing the energy requirements of the country. The Ministry has set up three specialized technical institutions - National Institute of Solar Energy (NISE), National Institute of Wind Energy (NIWE), and Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE). Indian Renewable Energy Development Agency Limited (IREDA) is a government owned company, registered as a non-banking financial company functioning under the administrative control of the MNRE. Additionally RECI (Renewable Energy Corporation of India), erstwhile SECI (Solar Energy Corporation of India) will be Section 3 company under the Companies Act, 2013. The change took place for commercial purposes to facilitate growth of the company and will enable it to enlarge its scope of the activities to cover all renewable energy sources.

At the state level, there are nodal agencies and departments which operate under the purview of the respective state governments for the effective implementation of all renewable energy and cogeneration schemes. These agencies promote renewable energy deployment at the local level by channeling central-level subsidies, implementing demonstration projects, and providing assistance to interested parties. Many of the state agencies are also designated agencies for the implementation of the Energy Conservation Act, 2001. The MNRE provides grants to these agencies for their recurring and non-recurring expenditure. Financial assistance to renewable energy projects is provided through the Indian Renewable Energy Development Agency (IREDA) — the financial arm of the MNRE — which provides loans and also channels funds and other initiatives to promote renewable energy. In addition, there are a number of government institutions whose mandate encompasses the renewable energy sector. For example, the Ministry of Power (MoP) is responsible for the national electricity policy and national tariff policy, both of which play a key role in promoting procurement of renewable energy-based power. The Ministry of Environment and Forests (MoEF) is responsible for providing environmental clearances for renewable energy projects.

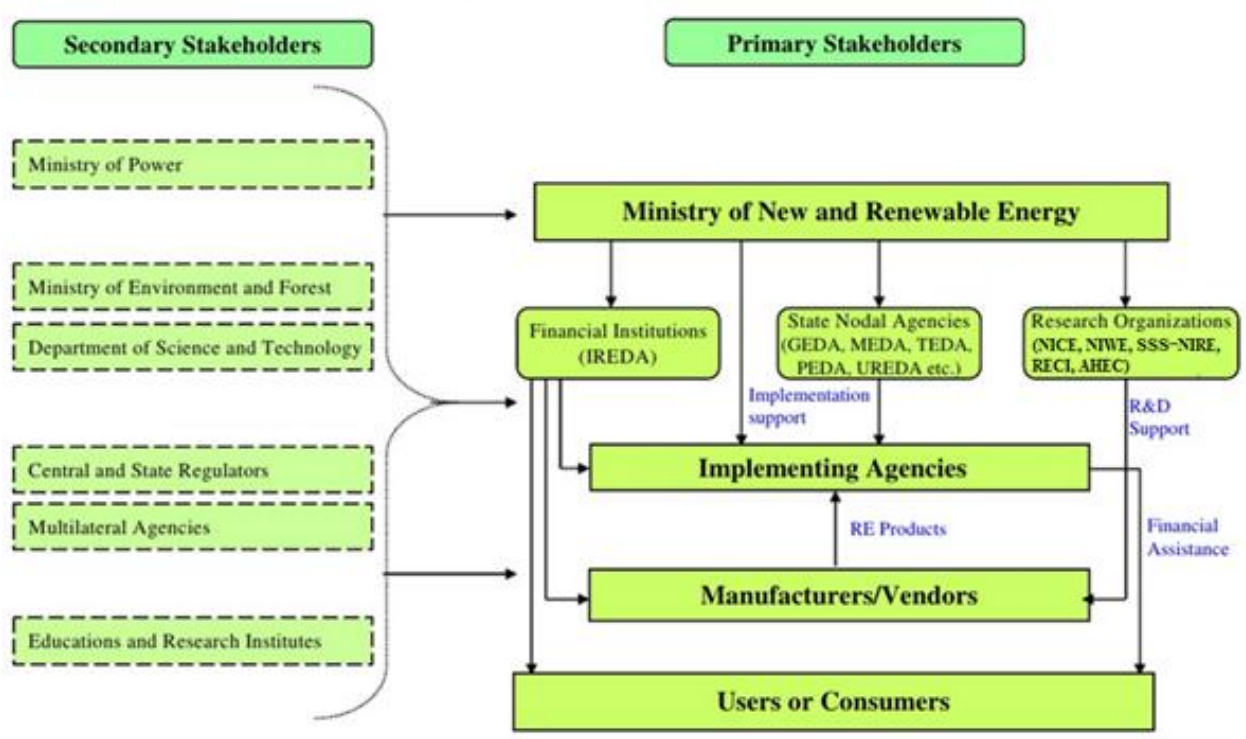

Figure 4: Governance of RE structure in India

The Renewable Energy source based power generation capacity was 18 MW in 1990 with a slow rate of growth till 2008, however, 2008 onwards the progress in the made in the sector has been considerable. This can be attributed to numerous factors which have led to this impressive growth. The driving factors for the renewable energy projects in India include demand/supply (low per capita consumption, large unelectrified areas; technology improvements and cost reduction in renewable technologies, entry of large number of players), policy (targets set under the NAPCC, JNNSM, fiscal and other incentives) and other issues (fuel challenges, and significant potential for renewable energy capacity addition) affecting conventional power generation. Against this backdrop the renewable technologies are maturing in India and their growth in India in the last decade has been commendable. The Indian growth story can be seen from the fact in the period from FY07 onwards the capacity addition from Renewable Energy based sources in India has seen a CAGR of 18.41%.

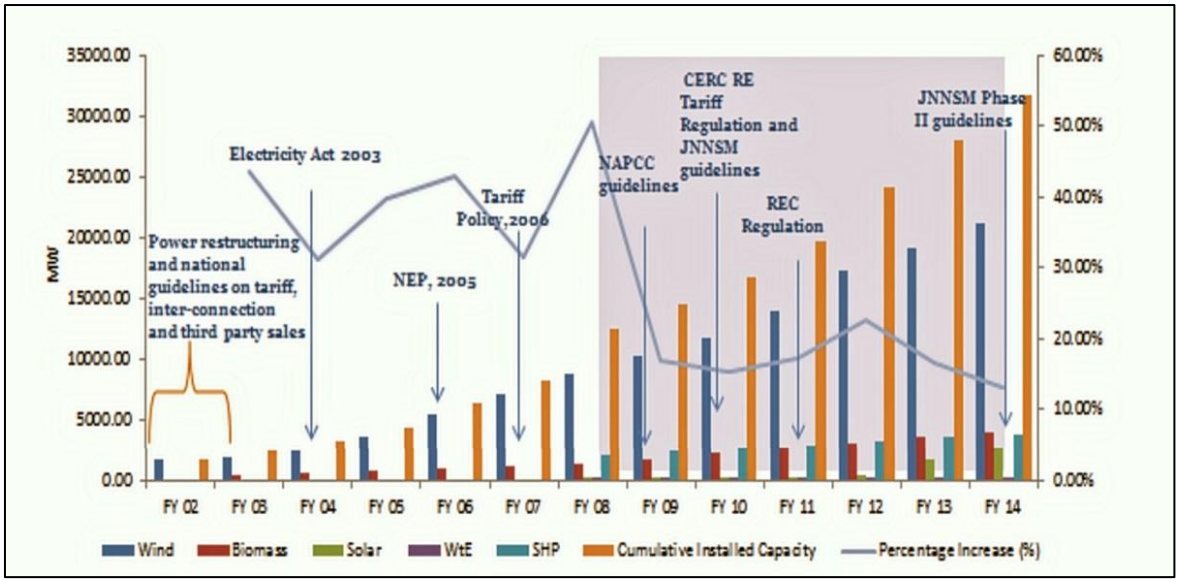

Figure 5: Renewable energy trend
Source: RE-Invest 2015

Key Barriers

High cost of financing: renewable energy technologies have high capital costs but very low operating costs spread over 25-30 years. However the cost of finance (currently ranging from 12–14%) forms a significant component of the power tariff from these sources. Reduction in interest rates would reduce tariffs and improve the competitive edge of the technology. Financing costs depends on the risk perceived by funding institutions and higher perceived risks result in more stringent financial conditions. The relatively high cost and low availability of debt in India has significantly increased the cost of renewable energy projects which is a major barrier to the expansion of the renewable sector.

Lack of enforcement of RPOs**:** The RPO is the biggest driver for the uptake of renewable energy by state utilities and captive users (obligated entities). The RPO regime is an instrument for stimulating renewable energy investments. However lack of RPO enforcement has led to concerns about the final purchase of renewable power. The state discoms will have to start taking RPOs seriously and state regulatory authorities would have to hold the discoms responsible and penalize them for failing to comply on purchase obligations. Instead of forcing defaulters to buy RECs (Renewable Energy Certificates) to cover shortfall in power purchase, states are allowing the obligated entities (such as DISCOMs and captive consumers) to 'carry forward' deficits to the next financial year. There also needs to be harmonization of the state-level RPO targets with the national targets.

Off taker risk: The creditworthiness of the distribution companies is a critical issue and plays a key role in determining the bankability of a PPA (Power Purchase Agreement). Very few discoms are in good financial health. When discoms have poor financial health, the risk of off-taker default and delayed payments is high. Weak financials of discoms will keep them from meeting commitments and affects the effectiveness of instruments that have been put in place for deployment of renewables. Recently the Electricity Regulatory Commission of Uttarakhand imposed a penalty on its discom for not complying with its renewable power obligation (RPO) target. Such actions are important for proper functioning the renewables sector.

Intermittency: Renewable energy is as an intermittent source of electricity. Characteristics of renewable power make it variable (natural variation in generation – e.g wind peaking during monsoon and reducing in availability in other seasons) and affect the degree of its predictability (e.g. sudden drop in wind power). Renewables can be integrated into the grid by taking measures like renewable energy generation forecasting; co-ordinated project development; grid planning and grid strengthening; reducing the variability and uncertainty of RE generation through aggregation over broader geographic regions; creating flexible capacity, spinning reserves and ancillary services market; and properly defining RE grid integration standards and regulations.

Inadequate evacuation infrastructure**:** Lack of adequate evacuation facilities has led to scaling back the commissioning and partial commissioning of new generation and the reduction of generation during peak periods. Banks and financial institutions are more cautious lending to renewable energy projects given the poor state of the evacuation networks. Access to grid access is a critical challenge as renewable resources are often located far away from the consumer market. Though states are required to provide the

infrastructure for evacuation of power from RE projects, in practice it is the RE developer who has to provide for such infrastructure. This has an impact on the cost of the project. Even where states provide evacuation infrastructure, such infrastructure is inadequate. Utilities have been reluctant to develop transmission lines for them due to the low utilisation of renewables during the lean period and due to delays in securing budget approvals from the government.

Permits and Land acquisition: There is a need to streamline, accelerate, and standardize the acquisition of permits, clearances, and other administrative hurdles that the developer must cross. These relate particularly to land acquisition and environmental permitting. Acquisition of land is a critical aspect for infrastructure development and the approval processes and inability of the state governments to provide an effective single-window clearance to developers has caused considerable challenges. Lack of coordination among key organization like revenue department, state pollution control board, grid operators has led to time and cost overruns resulting in high transaction costs. A robust system setting a time bound target for getting all approvals without having to follow up with different state government departments needs to be put in place for renewable energy developers.

***Financing for off grid power*:** There have been a number of barriers preventing scaling up of the subsidy mechanism for encouraging investment in the off-grid energy sector. There is a large amount of paperwork and several layers of bureaucracy before subsidies are approved. Despite this subsidies are often delayed or not disbursed at all. Such delays result in liquidity constraints for companies placing pressure on the day-to-day operations of their business. There are also many challenges in loans available to off grid companies. Companies can face interest rates of 13-18% in the domestic market which are very high and foreign loans can also only be used on a project basis according to regulations. Most banks are not willing to lend even at higher interest rates because sizes of loans are considered too small.

National Roadmap

With the above background, a roadmap is suggested for effective planning and the way ahead for renewables. The MNRE has a vision for renewable energy "*to be a significant source in furtherance of the national aim of energy security and independence*." A vision is essential as it serves as the uniting component that all stakeholders can refer to. The vision is realistic but still has the provision of novel and new ideas that add real value and push the set boundaries.

Once the vision is well established, it is necessary to translate it into more specific objectives and targets, for the different sectors in which the local authority intends to take action.

Short Term Plan: By 2020

The government of India has identified several applications and in various sectors and is encouraging development of renewables to satisfy energy demand, energy security, energy access, clean energy and environmental protection considerations. The government of India has also incorporated in its mission statement an increase in the contribution of Renewable Energy in the total energy mix of the country to 9 per cent with about 17 per cent contribution to total installed capacity of electricity by the end of 12th plan (2016-17).

The approach the MNRE has indicated on following are the principles of SMART targets (Specific, Measurable, Achievable, Realistic, Time-bound) for different renewable resources and application areas.

1. **Specific:** Well-defined, focused, detailed and concrete. Clear demarcation of procedure, timelines, activities and agencies involved along with justification of importance of the activity.
2. **Measurable:** Outcomes must be measurable to know progress against objectives. Outcomes can be in terms of units of energy, installations, and investments etc.
3. **Achievable:** Targets need to be feasible and actionable. It needs to be executed within the timeframe. Constraints and risk factors need to be understood clearly.
4. **Realistic:** Targets need to be evaluated in the context of the resources available.
5. **Time-Bound:** Targets require a defined deadline or schedule.

Thus short term focus of the government must be on deployment of renewables to reach the targets that have been set in policies. The main areas of focus need to be:

1. **Deployment of renewable energy for power production**
2. **Deployment of renewable energy meeting energy needs in rural areas**
3. **Deployment of renewable energy to supplement energy needs in urban areas**

4. Deployment of renewable energy to supplement energy needs in industrial and commercial establishments

Renewables for power production

India targets an installed renewable energy capacity of 175 GW by 2022. 100 GW of this is to come from solar power, 60 GW from wind energy, 10 GW from small hydro power, and 5 GW from biomass-based power projects. Figure 6 below is a bar chart representation of the MNRE's proposed state wise capacity that is targeted, represented zone-wise. Table for the same can be found in Annexure 1.

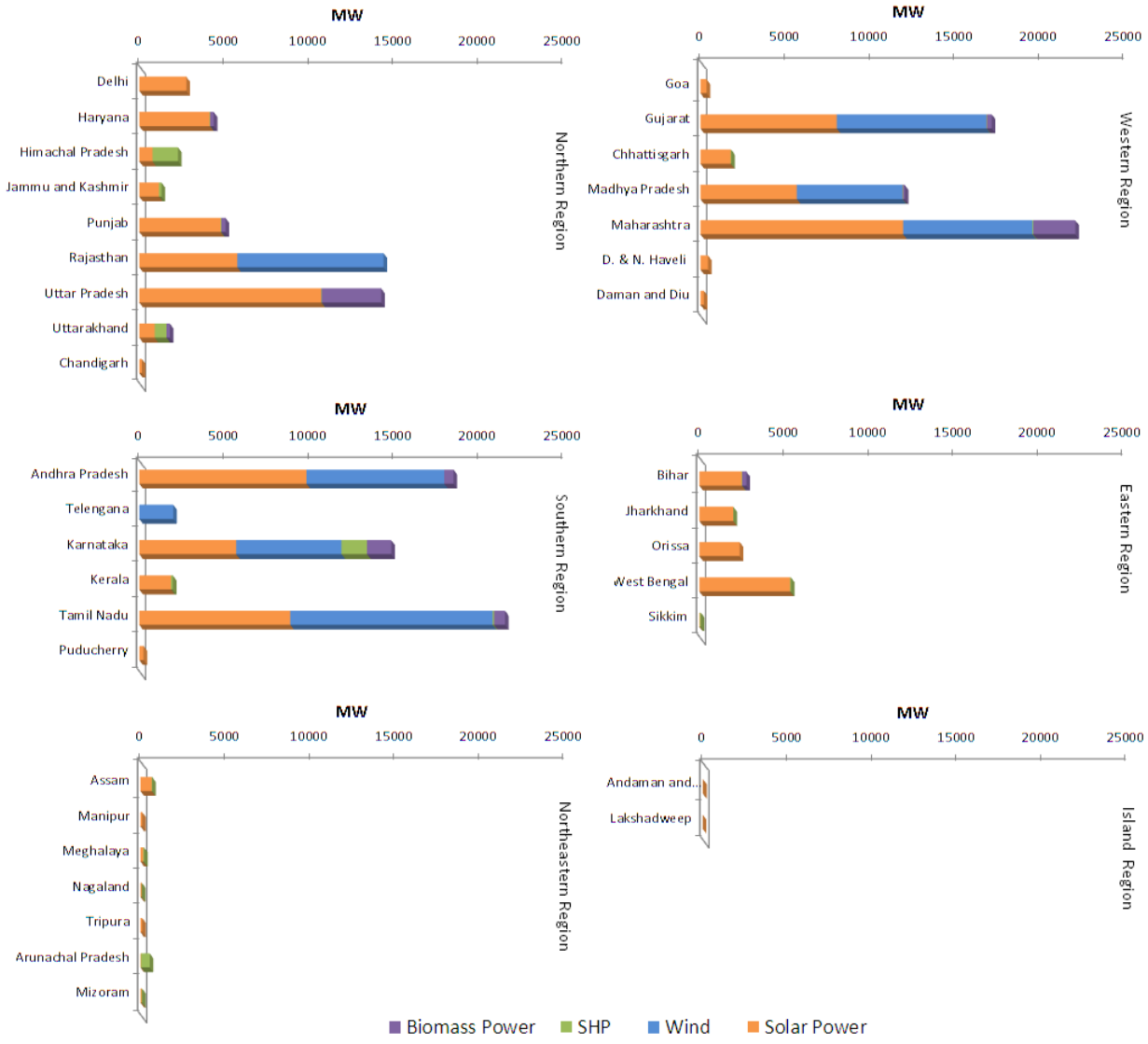

Figure 6: Revised capacity targets for renewables by 2022

Source: MNRE

Short Term Plan: By 2020 (Continued)	
Deployment of renewable energy for meeting energy needs in rural areas	Target 1 lakh family type biogas plants per year
	Target biomass gasifiers for village energy supply in 25 villages per year
	Installation of decentralized SPV systems a. 50,000 solar lighting systems and solar pumps per year b. 20,000 solar irrigation pumps can be targeted for installation in the current year.
	Target installation of 500 Micro Hydel Projects/watermills with capacity of approximately 4 MW each year
	Installation of 20 projects utilizing Aero generators and SPV-Wind hybrid systems with a cumulative capacity of 20 kW per year
	Disbursement of around 2 lakh Improved cook stoves per year
Deployment of renewable energy to supplement energy needs in urban areas	Installation of solar thermal systems in urban households/buildings covering approximately 5 lakh m^2 area
	50 MW of Rooftop SPV grid connected systems per year
	Disbursement of Solar cookers 25,000 solar cookers per year
Deployment of renewable energy to supplement energy needs in industrial and commercial establishments	Generation of Energy from Industrial waste of 10 MWeq
	Installation of 50 gasifiers for decentralized power generation in rice mills and other industries
	80 MWeq of biomass based cogeneration in other industries excluding bagasse

Medium Term Plan: By 2030

Medium Term Plan: By 2030	
Promote initiatives for increasing deployment of renewables	Set up Wind energy mission
	Promote Ultra mega solar projects and solar projects for canals
	Integrate ongoing programs such as rooftop, solar cities with smart city program
	Set up national Bio energy mission
Develop resource base for enhancing the potential of renewable energy sources	Reassessment of wind potential at 100 m hub height
	Assessment of solar potential
	Assessment of off-shore wind potential and prepare a policy on off-shore wind power
	Revaluate DNI data for Solar thermal technologies that can become the basis for project design and financial-viability calculations for all states in India
Continuing improvements in regulatory and policy initiatives to promote renewable energy technologies	Address issues relating to tariff for renewable energy technology based power projects, renewable purchase obligations and measures like renewable energy certificates and other market based mechanisms, market and grid connectivity issues, inter-state exchange of renewable energy.
	Pursue the compliance of renewable energy purchase obligations with regulatory authorities and states
	Setting up transmission systems required primarily for renewable energy projects. Assistance may also be required for Solar Parks.
	Development of strong monitoring and evaluation frameworks for the various schemes and programs. More efficient monitoring and verification is possible

	through automatic data acquisition.
Developing and deploying appropriate financial instruments	There is need for continued fiscal and subsidy support. Banking and financing community need to be engaged to support the renewable energy sector
	Exploration of alternate financial instruments such as: • Products like Risk Guarantee Fund that will address the technology risks, especially for solar • Availability of debt at a lower cost (both for grid and off-grid projects) through channels such as external borrowing or tax rebates, especially for solar technologies • Enhancing the term lending period particularly for technologies such as solar
Other interventions	Promote funding of innovative clean energy projects through the National Clean Energy Fund (NCEF)
	Promote effective systems for monitoring performance of programs/installed projects
	Promote indigenous industry in manufacturing of renewable energy. Develop large scale solar manufacturing in India (transforming India into a global solar manufacturing hub).
Human Resource Development	• Establish R&D facilities within academia, research institutions, industry, government and private entities to guide technology development.
	• Develop training programs for specific and highly specialized areas related to science & technology, and management.
	• Training for financial sector on the issues relating to project financing of renewable energy projects.
	• Small and medium scale manufacturing, industrial undertakings, services and business enterprises (SME) on development of convenient technology packages for different SME groups, technological solution awareness, best

	practices for renewable energy use, strengthening outreach of renewable energy technologies to consumers etc.

Long Term Plan: 2047

Long Term Plan: 2047	
Incubating technologies with high future potential	• Promote and target a hydrogen economy development. R&D in Hydrogen production, storage and distribution has to be strengthened.
	• Government should announce pilot projects with storage technologies to have projects on the ground to showcase performance of the technology.
	• Initiate move to electrify automotive transportation or develop electric vehicles — plug-in hybrids. Adopt nationwide charging of electric cars from solar panels on roofs and solar-powered electric vehicle charging stations around the country. These recharging connections could be deployed at highly-concentrated areas including shopping malls, motels, restaurants, and public places where vehicles are usually parked for extended periods.
	• Aggressively invest in a smart, two-way grid and micro-grid. Smart meters as well as reliable networks can accommodate the two-way flow of electricity. Such networks can be resilient enough to avoid blackouts and also accommodate the advanced power generation technologies of the future.
	• Develop large-scale solar manufacturing in India to transform India into a global solar manufacturing hub.
	• Promote and establish utility-scale Renewable Energy Zones (REZs) utilizing solar and wind generation

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A unique developing country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. TERI has grown to establish a presence in not only different corners and regions of India, but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia, and the Gulf.

TERI possesses rich and varied experience in the electricity/energy sector in India and abroad, and has been providing assistance on a range of activities to public, private, and international clients. It offers invaluable expertise in the fields of power, coal and hydrocarbons and has extensive experience on regulatory and tariff issues, policy and institutional issues. TERI has been at the forefront in providing expertise and professional services to national and international clients. TERI has been closely working with utilities, regulatory commissions, government, bilateral and multilateral organizations (The World Bank, ADB, JBIC, DFID, and USAID, among many others) in the past. This has been possible since TERI has multidisciplinary expertise comprising of economist, technical, social, environmental, and management.

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