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An Overview of Sustainable Energy for A Growing Indian Economy

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ABSTRACT
There is a whole gamut of challenging areas in the power sector that India needs to address on priority in order to meet its growth targets and the acute population growth, which will exceed 10 billion by the year 2050. How can a world of 10 billion people especially India be provided with adequate supplies of energy, cleanly, safely and substantially? There is a growing consensus that renewable energy sources will be a very important part of the answer. The growing interest in renewable has been prompted, in part, by increasing concern over the pollution, resource depletion and possible climate change implications of our continuing use of conventional fossil and nuclear fuels. Recent technological developments have also improved the cost-effectiveness of many of the renewable, making their economic prospects look increasingly attractive. The aim of this text is to analyse the full range of renewable energy sup-plies available for modern economies. Such renewables are recognised as vital inputs for sustainability and so encouraging their growth is significant. Subjects will include power from wind, water, biomass, sunshine and other such continuing sources, including wastes. It describes the achievement and progress made in hydropower, biomass conversion, geothermal, solar thermal technology, wind energy conversion, and the increasing usage of photovoltaics Renewable Energy Resources is a numerate and quantitative text covering subjects of proven technical and economic importance worldwide. Energy supplies from renewable are essential components of every nation's energy strategy, not least because of concerns for the environment and sustainablility.
***Index Terms*:** Biomass, Coal, Environment, Hydel project, Hydro power, Solar energy, Wind energy.

I. INTRODUCTION

Electricity is one of the basic constituents for the economic growth of a country, In India, 300 million people don't have access to electricity, power cuts are rampant and per capita power consumption is significantly lower than the world average. India is the world's fourth largest energy consumer. . Its energy needs continue to increase, but national energy shortages and an inadequate energy infrastructure could perpetuate national energy poverty. There are various initiatives taken in the country in the past few years to improve the power situation. One of the biggest concerns is the gap in the demand and supply of power in India. There are several barriers that pose a challenge to the Indian power sector. The first challenge is land acquisition; not only for the power sector but for any industry. The second challenge is speedy environmental clearance. The third challenge is availability of coal. Half of the Indian power generation depends on coal as a source and the production of coal has not increased to match the demand. And the fourth challenge is financial crisis. Because of the recent economic slowdown, financing for new projects have become tougher, especially for Independent Power Producers (IPPs). There was no order from IPPs in the last fiscal year. At present Power, Coal and New & Renewable Energy ministries are functioning under a single leadership. It means more focused and better co-ordination among these ministries and ultimately improvement in the power situation is expected. The Indian economy is in the trajectory of upward growth. To keep up the momentum of this growth, availability of uninterrupted power supply is a must. As a growing economy, India not only just requires to light bulbs, but needs electricity to fuel the growth of every industry, be it large-scale or small-scale, manufacturing, healthcare or education. All of this impacts the economic growth of the nation and it doesn't end here. It is one of those key components that facilitate our everyday life. In the current world it has a large impact on human life.

India's rising economic activities, growing population and improving living standards have led to a steady growth in her appetite for quality and quantity of energy services. As the economy expands the electricity demand is going to grow further. Considering the energy security concern for and commitment to a 'Low Carbon Growth Strategy', the 12th Five Year plan of the country included plans to ensure sustainable development of the power sector. Renewable Energy (RE) solves the sustainability problem associated with conventional fuels used for power generation as these sources are non-exhaustible and relatively clean. Further, RE is also an economical off-grid energy solution for remote locations. The 11th Five Year Plan realized the significant role of new and renewable energy to enhance the domestic energy supply options as well as the need to diversify energy sources. The 12th Five Year plan's strategy aims to develop the RE sector through capacity addition in wind power, small hydro power, solar power, and bio-power. Thus the RE space in the country is going to witness a large number of RE projects in coming years. Due to the RE impetus an increase in the development of medium to high density wind and solar farms in India is expected. In this scenario it becomes important and necessary to revisit the impacts of RE projects in the neighborhood where these projects are coming up. Thus, this study is commissioned by MNRE to assess the environmental and socio-economic impacts of RE projects in India, particularly from solar PV and on-shore wind farms. This study was carried out combining primary and secondary research. During the course of the study, solar and wind power projects sites were visited to develop understanding on the environmental externalities of the projects. Also, thorough literature review was carried out to study the RE governance and operational aspects in the country. The study analyzed the existing governance and institutional mechanism regulating the RE project development and operations. Further, micro and macro level environment and social impacts of RE projects were studied to arrive at the conclusions. The environmental and social governance system for projects in India is well established. There are institutions and processes governing every operational aspect of RE project development and local institutions, in the form of democratic bodies, to safeguard micro level ecological and social concerns. For power sector, the environmental regulations vary depending on the electricity generation capacity of the plant. Specific to RE projects (wind and solar), there has been a rigorous assessment of the projects within MoEF and after much deliberations such energy projects are kept out of the purview of stringent scrutiny considering their negligible negative impact on surrounding environment. The RE projects substitute fossil fuel, thus focus on such projects can help reduce the GHG emissions from the energy sector.

Considering the life-cycle approach, the net CO2 emissions from RE projects is significantly lower than that of coal and natural gas based energy generation facilities(summarized in table below)

LCA Emissions (g CO2 equivalent/kWh)	Wind	Solar	Nuclear	Coal CFB
Implementation	13.7	37.5	1.2	3.6
Operation	4.7	12.0	12.4	918.8
Decommissioning	0.6	0.5	0.4	52.2
Total	19.0	50.0	14.0	975.3

Table 1. Life cycle emissions from Power sources

Development of RE resources is being accorded special emphasis in view of not just its inherent advantages of cleaner power production but also the social benefit of providing energy access and energy security to remote areas. The drivers identified herein for development of renewable energy in India are – (i) Country's interest in energy security; (ii) High potential of wind and solar energy in India; (iii) Emissions reduction by shifting from polluting sources like oil and coal; (iv) Country's interest towards clean energy options. The renewable energy installed capacity in India is growing steadily. In March 2012, RE installed capacity stood at 24,914.24 MW which was 10.5% of the power mix in the country (Central Statistics Office, 2013)3. Within 15 months the RE capacity in the country has expanded by 15%, as on June 2013 this was 28708.9 MW (Source: MNRE Website4).

India's Programme Planning for Renewables

The need to increase the use of renewable energy sources for sustainable energy development was recognized in the country in the early 70s. A significant thrust has been given to the research, development and induction of renewable energy technologies in different sectors. To begin with, these Endeavours were steered and overseen by the Commission forAdditional Sources of Energy (CASE). The Department of Non-Conventional Energy Sources was created in the Ministry of Energy and entrusted with the charge of promoting non-conventional energy sources. In 1992, DNES was upgraded and it started functioning as a separate Ministry of Non-Conventional Energy Sources (MNES). The Ministry takes care of the following specific items:

1. Commission for Additional Sources of Energy (CASE);

2. Solar energy including solar photovoltaic devices and their
development, production and applications;
3. Research and development of biogas and programmes relating to biogas units.

The Ministry of New and Renewable Energy (MNRE) has taken several steps to fructify Prime Minister Shri Narendra Modi's dream of clean energy. The largest renewable capacity expansion programme in the world is being taken up by India. The government is aiming to increase share of clean energy through massive thrust in renewables. Core drivers for development and deployment of new and renewable energy in India have been Energy security, Electricity shortages, Energy Access, Climate change etc.

A capacity addition of 14.30 GW of renewable energy has been reported during the last two and half years under Grid Connected Renewable Power, which include 5.8 GW from Solar Power, 7.04 GW from Wind Power, 0.53 from Small Hydro Power and 0.93 from Bio-power. Confident by the growth rate in clean energy sector, the Government of India in its submission to the United Nations Frame Work Convention on Climate Change on Intended Nationally Determined Contribution (INDC) has stated that India will achieve 40% cumulative Electric power capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost International Finance including from Green Climate Fund. As on 31st October, 2016, Solar Energy Projects with an aggregate capacity of over 8727.62 MW has been installed in the country.

The government is playing an active role in promoting the adoption of renewable energy resources by offering various incentives, such as generation-based incentives (GBIs), capital and interest subsidies, viability gap funding, concessional finance, fiscal incentives etc. The National Solar Mission aims to promote the development and use of solar energy for power generation and other uses, with the ultimate objective of making solar energy compete with fossil-based energy options. The objective of the National Solar Mission is to reduce the cost of solar power generation in the country through long-term policy, large scale deployment goals, aggressive R&D and the domestic production of critical raw materials, components and products. Renewable energy is becoming increasingly cost-competitive as compared to fossil fuel-based generation.

In order to achieve the renewable energy target of 175 GW by the year 2022, the major programmes/ schemes on implementation of Solar Park, Solar Defence Scheme, Solar scheme for CPUs Solar PV power plants on Canal Bank and Canal Tops, Solar Pump, Solar Rooftop etc have been launched during the last two years. Various policy measures have been initiated and special steps taken in addition to providing financial support to various schemes being implemented by the Ministry of New and Renewable Energy (MNRE) for achieving the target of renewable energy capacity to 175 GW by the year 2022. These include, inter alia, suitable amendments to the Electricity Act and Tariff Policy for strong enforcement of Renewable Purchase Obligation (RPO) and for providing Renewable Generation Obligation (RGO); setting up of exclusive solar parks; development of power transmission network through Green Energy Corridor project; identification of large government complexes/ buildings for rooftop projects; provision of roof top solar and 10 percent renewable energy as mandatory under Mission Statement and Guidelines for development of smart cities; amendments in building bye-laws for mandatory provision of roof top solar for new construction or higher Floor Area Ratio; infrastructure status for solar projects; raising tax free solar bonds; providing long tenor loans; making roof top solar as a part of housing loan by banks/ NHB; incorporating measures in Integrated Power Development Scheme (IPDS) for encouraging distribution companies and making net-metering compulsory and raising funds from bilateral and international donors as also the Green Climate Fund to achieve the target.

Estimated Potential Of Renewable Energy

The increased use of indigenous renewable resources is expected to reduce India's dependence on expensive imported fossil fuels. India has an estimated renewable energy potential of about 900 GW from commercially exploitable sources viz. Wind – 102 GW (at 80 meter mast height); Small Hydro – 20 GW; Bio-energy – 25 GW; and 750 GW solar power, assuming 3% wasteland.

Targets

The Government of India has set a target of 175 GW renewable power installed capacity by the end of 2022. This includes 60 GW from wind power, 100 GW from solar power, 10 GW from biomass power and 5 GW from small hydro power.A target of 16660 MW grid renewable power (wind 4000 MW, solar 12000 MW, small hydro power 250 MW, bio-power 400 MW and waste to power 10 MW), has been set for 2016-17. Besides, under off-grid renewable system, targets of 15 MW eq. waste to energy, 60 MW eq. biomass non-bagasse cogeneration, 10 MW eq. biomass gasifiers, 1.0 MW eq. small wind/hybrid systems, 100 MW eq. solar photovoltaic systems, 1.0 MW eq. micro hydel and 100,000 nos. family size biogas plants have been set for 2016-17.

The target set for the various renewable energy sources for the next three years are:

(*Capacities in MW)

Share of renewable power in total installed capacity

Economic growth, increasing prosperity, a growing rate of urbanisation and rising per capita energy consumption has increases the energy demand of the country. In order to meet the energy demand, India has total installed power generation capacity of 307.27 GW as on 31.10.2016 from all resources. With 46.33 GW installed renewable power capacity, the renewable power has a share of about 15% to the total installed capacity.

Achievements

The details of year round initiatives and achievements of the Ministry of New and Renewable Energy are as follows:

Green Power Capacity Addition

A total of 7,518 MW of grid-connected power generation capacity from renewable energy sources has been added so far this year (January 2016 to October 2016) in the country.

A total of 7060 MW of grid-connected power generation capacity from renewable energy sources like solar (3019 MW) and wind (3423 MW), Small Hydro Power (218 MW), Bio-Power (400 MW) has been added during 2015-16 in the country against target of 4,460 MW. During 2016-17, a total 3575 MW capacity has been added till 31.10.2016, making cumulative achievement 46,327 MW.

Sector-wise highlights of achievements

- Largest ever wind power capacity addition of 3423 MW in 2015-16 exceeding target by 43%. During 2016-17, a total 1502 MW capacity has been added till 31.10.2016, making cumulative achievement 28,279 MW. Now, in terms of wind power installed capacity India is globally placed at 4th position after China, USA and Germany.
- Biggest ever solar power capacity addition of 3,019 MW in 2015-16 exceeding target by 116%. During 2016-17, a total 1750 MW capacity has been added till 31.10.2016, making cumulative achievement 8728 MW. 31,472 Solar Pumps installed in 2015-16, higher than total number of pumps installed during last 24 years i.e. since beginning of the programme in 1991. So far, 92305 Solar Pump have been installed in the Country as on 31.10.2016. Solar projects of capacity 20,904 MW were tendered in 2015-16. Of these, 11,209 MW capacity already awarded. A capacity addition of 0.53 GW has been added under Grid Connected Renewable Power since last two and half years from Small Hydro Power plants.

Biomass power includes installations from biomass combustion, biomass gasification and bagasse cogeneration. During 2016-17, against a target of 400 MW, 51 MW installations of biomass power plants has been achieved making a cumulative achievement to 4882 MW.

Source	2016-17	2017-18	2018-19
Solar Power	**12,000**	**15,000**	**16,000**
Wind	4000	4600	5200
Biomass	500	750	850
SHP	225	100	100
Grand Total	**16725***	**20450***	**22150***

Family Type Biogas Plants mainly for rural and semi-urban households are set up under the National Biogas and Manure Management Programme (NBMMP). During 2016-17, against a target of 1.00 lakh biogas plants, 0.26 lakh biogas plants installations has been achieved making a cumulative achievement to 49.35 lakh biogas plants as on 31.10.2016.

Major Initiatives taken by Ministry

Solar Power

1. Under National Solar Mission, the target for setting up solar capacity increased from 20 GW to 100 GW by 2021-22. Target of 10,500 MW, set for 2016-17 which will take the cumulative capacity to 17 GW till 31st March 2017.

2. As on date, 19,276 MW has been tendered out, of which LOIissuedfor 13,910 MW/PPA signed for 10,824 MW.

3. 34 Solar Parks of capacity 20,000 MW in 21 states have been sanctioned which are under various stages of execution.

4. As on 31.10.2016, a total of 90,710 solar pumps have been installed throughout the country. **Also,** A total amount of Rs. 67.01 crore has been sanctioned for preparation of master plans, solar city cells, promotional activities and installation of renewable energy projects and an amount of Rs. 24.16 crore has been released, so far, under **Solar City Programme.**

5. Various departments and ministries under central government have collectively committed to **deploying 5,938 MW of rooftop solar capacity** for their internal power consumption. SECI is aggregating demand for a part of this requirement and helping in procuring rooftop solar systems. **SECI has issued a tender for development of 1,000 MW rooftop solar capacity on pre-identified central government/ department owned buildings**. It is the largest such tender in India's fledgling rooftop solar market.

6. Several schemes namely (i) Defence scheme (ii) Central Public Sector Undertakings (CPSUs) scheme (iii) Bundling scheme (iv) Canal Bank/ Canal Top scheme (v) VGF Scheme (vi) Solar Park scheme (vii) Solar rooftops, have been initiated/launched by the Ministry under National Solar Mission which are un-

der implementation.
7. Under **Defence scheme** against a target of 300 MW, 347 MW sanctioned, under **Central Public Sector Undertakings (CPSUs) scheme** against a target of 1000 MW, all capacity sanctioned, under **3000 MW Bundling scheme**, Tranch-I: 3000 MW has been tendered, under **100 MW Canal Bank/ Canal Top scheme**, all capacity sanctioned, under **2000 MW & 5000 MW VGF Scheme**, tenders issued for 4785 MW, and under **20,000 MW Solar Park scheme**, 34 Solar parks have been approved in 21 States with aggregate capacity of 20,000 MW.

Solar Rooftop

A target of 40 GW grid connected solar rooftops to be achieved by 2022 has been set. So far, about 500 MW have been installed and about 3,000 MW has been sanctioned which is under installation. All major sectors i.e. Railways, Airports, Hospitals, Educational Institutions, Government Buildings of-Central/State/PSUs are being targeted besides, the private sector.

A massive Grid Connected Solar Rooftop Programme launched with 40 GW target. State Electricity Regulatory Commissions of **30 States/UTs notified regulations** for net-metering/feed-in-tariff mechanism. **Rs.5000 crore approved for solar rooftops. About 500 MW solar rooftop capacity** installed till 30.09.2016.

A total sanction of 1300 million dollars has been received from World Bank, KFW, ADB and NDB through which the SBI, PNB, Canara Bank and IREDA will be in the position to fund at the rate of less than 10%. Ministry has tied up with ISRO for Geo tagging of all the Rooftop plants using ISRO's VEDAS Portal.

Solar micro grids in Uttar Pradesh

An SMG (solar micro grid) is a flexible, modular, and reliable solar-powered micro-grid system that can provide electricity access to communities with as less as 10 households and as many as 80 households, at costs lower than their current expenses on kerosene. A typical micro-grid station can disseminate light to 40 households, for four to six hours daily using LED lamps.

Table 2. Programme/ Scheme wise Achievements in Year 2016 (January- October 2016)

Sector	Achievement (January- October 2016)	Cumulative Achievements as on 31.10.2016
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)		
Wind Power	3191.21	28279.40
Solar Power	3848.77	8727.64
Small Hydro Power	146.47	4323.37
BioPower (Biomass & Gasification and Bagasse Cogeneration)	331.78	4882.33
Waste to Power	7.50	114.08
Total	**7525.73**	**46326.82**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN $MW_{EQ)}$)		
Waste to Energy	14.61	161.12
Biomass(non-bagasse) Cogeneration	49.54	651.91
Biomass Gasifiers	0.19	18.34
-Rural -Industrial	15.58	176.30
Aero-Genrators/Hybrid systems	0.26	2.93
SPV Systems	84.98	373.99
Water mills/micro hydel	1.60	18.81
Total	**166.80**	**1403.40**
III. OTHER RENEWABLE ENERGY SYSTEMS		
Family Biogas Plants (in Lakhs)	1.014	49.354

Strategy

Considering participation at the grassroots as one of the key drivers for sustainability of decentralized generation, TERI(The Energy and Research institute) approached village-level entrepreneurs to invest and operate the SMGs. In villages where TERI has been involved, the system size ranges from 1000 Wp to 75 Wp, with majority being of 300 Wp capacity.

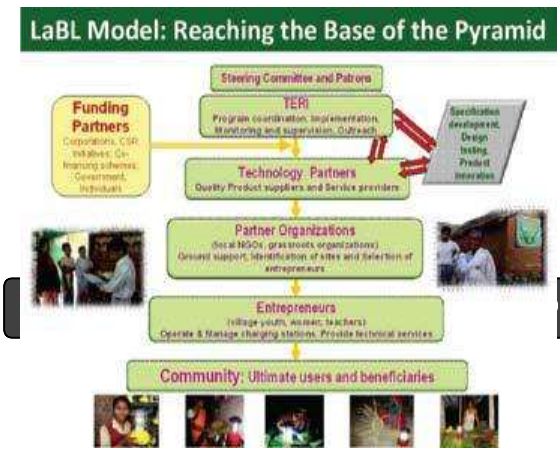
II. esults

TERI with support from the Norwegian Ministry of Foreign Affairs innovated and demonstrated SMGs in three village market places of Jagdishpur Block (CSM Nagar District) and Shivgark Block (District Rae Bareli) in Uttar Pradesh. This supplies un-interrupted power to 200 commercial establishments. The system uses

LED lights, which require less power thereby reducing the requirements of large quantities of power. The micro-grid is modular and can be set up incrementally starting with 10 connections (up to 200 connections).

The pre-installation survey indicates regular power cuts during evening hours (from 5 pm to 9 pm) and unreliable supply during other time of the day. In all, 34 micro-grids are being set up to supply clean lighting to 1400 commercial establishments and households in rural Uttar Pradesh.

The micro-grids not only help the entrepreneurs to enhance their incomes but also replace the diesel gensets and use of kerosene at comparable cost, along with providing clean and reliable power to the rural people. As this is an ongoing project, as of today, TERI has installed 17 micro-grids providing connection to 750 shops, households, poultry units and village-level processing units.



Outlook

The technology and the business model have received a lot of appreciation from the end users and implementers. *UPNEDA (Uttar Pradesh Renewable Energy Development Agency)* has adopted the model for lighting un-electrified and poorly electrified villages of Uttar Pradesh.

Lighting a billion lives

The project, Lighting a Billion Lives (LaBL), provides a flexible entrepreneurship-based energy service model in which SCS (solar charging stations) are set up in energy-poor communities. Local entrepreneurs are trained to operate and manage the charging station and rent out certified, bright, and quality solar lanterns to the community every evening for a very affordable fee. These entrepreneurs are selected and given support by local LaBL implementation partners called partner organizations. The rent is collected by the entrepreneur, a part of which is used for the operation and maintenance of the charging station and for replacement of batteries as may be required after 18–24 months of operation. TERI provides the required training support to the LaBL partner organizations and the entrepreneurs.The initiative involves a number of stakeholders with defined roles at the regional and local level, apart from product partners and energy service companies.

1486 villages across 21 states in India benefiting more than 370,000 lives through the use of 74,080 solar lanterns 1500 ‘green jobs’ created through rural entrepreneurship Trained, handheld, and partnered with more than 80 premier grassroots organizations to leverage rural entrepreneurial capacities and sustain the initiative . Working towards promoting collaborative research and development of quality off-grid lighting products together with leading industry partners.

Providing a unique platform to engage socially conscious companies to make a positive difference to communities under their CSR (corporate social responsibility) activities. Establishment of Solar Lighting Laboratory by TERI supported by the MNRE (Ministry for New and Renewable Energy) Accreditation by the MNRE as Programme Administrator for off-grid solar applications under the JNNSM (Jawaharlal Nehru National Solar Mission)

Africa advance: LaBL programme expanding to African countries through local partnerships, beginning with six charging stations in Sierra Leone and 40 solar charging stations in Mozambique and upcoming charging stations in Kenya, Ethiopia, and Uganda. • Energy for All initiative: TERI is the convener of the Lighting for All Working Group under this ADB (Asian Development Bank)-supported initiative bringing together leading players in off-grid lighting Creation of TRCs (technology resource centres) at the village level to ensure effective after-sales supply and services, handholding, local training, and capacity building.

Outlook

The LaBL initiative has been able to diversify its range of technological intervention and activities. From establishing charging stations at the village level, the intervention has lent itself to creating a support system of entrepreneurs and technicians who can maintain this by linking and synergizing with the initiatives and commitments of the governments, private sector, and donor agencies towards socio-economic development of the communities using lighting as a means for facilitating and advancing their initiatives. The user – the key stakeholder in the campaign – plays the most important role in sustaining the cause of the campaign. S/he not only uses the illumination from the solar lantern to facilitate her/his daily chores, but is also empowered to facilitate the education of her/his children, initiate livelihood activities, and have better access to health and sanitation facilities.

Solar-based village electrification

(a pilot public–private–people partnership project)

Worldwide,1.6 billion people do not have access to electricity – of those, 1.3 billion live in rural areas – and they spend large sums on dirty fuels such as kerosene and diesel for their energy needs. There are 80,000 unelectrified villages in India out of which 18,000 are remote villages. To lift millions of people out of poverty and avoid migration to cities, the development of rural economies is extremely important. Access to energy is a critical component in this regard. Even though rural electrification has been high on the political agenda for decades, the actual development taking place on the ground has been slow. Renewable energy sources provide an opportunity for electrification of remote villages and for meeting their other energy needs. This project was an attempt to demonstrate the attractiveness of solar power for those most in need of it. Scatec Solar built two pilot projects in two villages of India. Based on the experience and models used in these pilots, as well as the realization that new partnerships are needed to attract more private investments to the renewable energy sector, the Norwegian and Indian governments decided to form a PPPP (private–public–people partnership) and set up another 28 village.

SPV (solar photovoltaic) plants as a pilot project. The aim was to gain further experience with technical, financial, and organizational issues related to the scaling up of village electrification through renewable energy in rural areas.

The project involved installation and operation of CSPPs (community solar power plants) in 28 villages in four states in India: Uttar Pradesh, Madhya Pradesh, Jharkhand, and Jammu and Kashmir. A total of 290 kWp has been installed serving approximately 1300 families, with the size of each CSPP ranging from 4 kWp to 25 kWp. A variety of installation types, sizes, and models are tried out in the project, for the sake of gaining valuable information, and experience for the project proponents. The CSPPs are installed as either charging stations or mini-grid solutions comprising either a pure PV system or a hybrid configuration (PV/diesel or PV/biogas). In addition to lighting the houses, electricity was made available for commercial activities also, in certain cases. The projects in Jharkhand provided electricity to silk reeling centres.

The approach adopted for implementation of the project included the following.

Worked with local NGOs as a door opener into villages. The NGOs organized a number of meetings (over several months) for raising awareness among the villagers to participate in the project under the PPPP model and explained to them the objectives and benefits of the project. The NGOs seemed to be very competent, with a lot of experience from the areas, and also dedicated with the long-term view of supporting the villages in development.

The NGOs also carried out the needs assessment of the community – 'bottom-up approach' – and thus an estimation of the required load for different villages. The project attempted to secure proper operations and maintenance through local ownership. In all villages, VECs (village energy committees) have been formed, with varying number of members in total and varying number of female members. The VEC members were in general selected by the villagers. Similarly, the villagers appointed VO (village operators), having a minimum educational qualification, and capability of understanding and operating the systems installed. The VOs were given basic training on topics like switching the battery charging systems on and off, and the electricity supply system to the households; taking required steps during low sunshine days, like switching off supply to the households; and in general monitoring of electricity supply as per the battery charging level.
The project led to several encouraging social outcomes/impact in most of the villages. The kerosene lamps used earlier caused respiratory and eye problems. Introduction of electricity has had a clear positive health effect on the household. Children are able to do their school homework and study in the evenings. This is claimed to have resulted in better marks in school examinations.

The TV is bringing entertainment, news from the world, and educational programmes to the villagers, which is very positive. Following the commercials, some villagers now want more household appliances such as coolers and refrigerators. They have also become more aware of their own social standing as compared to people/societies seen on TV. Available electric light helps women to cook food in the evening, not during day as previously. The evening meals served are thus 'straight from the pot' meaning better quality 'fresher' food. Installation of fans makes heat more bearable and helps avoid insect and mosquitoes. The lights make it easier to spot insects inside the house at night.

Streetlights have made walking outdoor after dark safer. Streetlights have also reduced the number of thefts.As electricity has enabled pumping of water, girls do not have walk long distances to collect water. Use of water will also inevitably increase with such systems, and thus hygiene standards in the households will evidently improve.In some villages, the value of land has increased, becoming more attractive to immigrants.MNRE and Norad conducted a review of the project in late 2011 to assess the installation of projects as per plans. The review team observed that though the project contributed significantly to social outcomes, the business models were not financially viable and needed further introspectionLearning from this pilot project will be very useful to be considered while developing such projects in future. Some of these are as follows.

The local governments were not involved in the project in any way, so the implementation of the CSPPs was not coordinated with other electricity installation in the villages.

Striking the right supply/demand balance is complicated. Having stable, for example, commercial, off-take makes system dimensioning more predictable. Small systems are not bankable, hence business model innovation coupled with easily accessible support schemes is the prerequisite for success.

The operation manuals and tool kits, where applicable, should be provided in vernacular language.

Wind Power

New Delhi: India added a record 5,400 megawatts (MW) of wind power in 2016-17, exceeding its 4,000MW target.

"This year's achievement surpassed the previous higher capacity addition of 3,423MW achieved in the previous year," the ministry of new renewable energy said a statement on Sunday.

Of about 50,018MW of installed renewable power across the country, over 55% is wind power.

In India, which is the biggest greenhouse gas emitter after the US and China, renewable energy currently accounts for about 16% of the total installed capacity of 315,426MW. During 2016-17, the leading states in the wind power capacity addition were Andhra Pradesh at 2,190MW, followed by Gujarat at 1,275MW and Karnataka at 882MW. In addition, Madhya Pradesh, Rajasthan, Tamil Nadu, Maharashtra, Telangana and Kerala reported 357MW, 288MW, 262MW, 118MW, 23MW and 8MW wind power capacity addition respectively during the same period. At the Paris Climate Summit in December, India promised to achieve 175GW of renewable energy capacity by 2022. This includes 60GW from wind power, 100GW from solar power, 10GW from biomass and 5GW from small hydro projects.

It also promised to achieve 40% of its electricity generation capacity from non-fossil fuel based energy resources by 2030. In the last couple of years, India has not only seen record low tariffs for solar power but wind power too has seen a significant drop in tariffs. In February, **solar power tariffs** hit a record low of Rs2.97 per kilowatt hour (kWh)and **wind power tariff** reached Rs3.46 kWh. Even though wind leads India's renewable power sector, it has huge growth potential. According to government estimates, the onshore wind power potential alone is about 302GW. But there are several problems plaguing the sector.

For instance, the government has been concerned about squatters blocking good wind potential sites, inordinate delays in signing of power purchase agreements, timely payments and distribution firms shying away from procuring electricity generated from wind energy projects. In January, the ministry held a **meeting with the states** to sort out these issues. The ministry has also taken several other policy initiatives, including introducing bidding in the wind energy sector and drafting a wind-solar hybrid policy. It has also come out with a 'National Offshore Wind Energy Policy', aiming to harness wind power along India's 7,600 km coastline. Preliminary estimates show the Gujarat coastline has the potential to generate around 106,000MW of offshore wind energy and Tamil Nadu about 60,000MW.

- During the year 2015-16, wind power capacity addition of 3.42 GW was made, which is highest ever wind power capacity addition in the country during a single year. The present wind power installed capacity in the country is around 28.28 GW. Now, in terms of wind power installed capacity India is globally placed at 4th position after China, USA and Germany

India has a strong manufacturing base of wind power equipment in the country. Presently, there are 20 approved manufacturers with 53 models of wind turbines in the country up to a capacity of 3.00 MW single turbines. Wind turbines being manufactured in India are of international quality standards and cost-wise amongst the lowest in the world being exported to Europe, USA and other countries.

The wind power potential of the country has been reassessed by the National Institute for Wind Energy (NIWE), it has been estimated to be 302 GW at 100 meter hub-height. Online wind atlas is available on NIWE website. This will create new dimension to the wind power development in the country. India has long coastline where there is a good possibility for developing offshore wind power projects. The cabinet has cleared the National Offshore Wind Energy Policy and the same has been notified on 6th October 2015. Certain blocks near Gujarat and Tamil Nadu coast line have been identified. NIWE is in process of doing the wind resource assessment in these coastal areas.Comprehensive Guidelines for Development of On-shore Wind Power Projects in the country have been formulated and issued on 22nd October 2016.

uidelines for implementation of "**Scheme for Setting up of 1000 MW Inter-State Transmission System**

(ISTS) - connected Wind Power Projects" issued on 22nd October 2016.

The Policy for Repowering of the Wind Power Projects has been released on 5th August, 2016 to promote optimum utilization of wind energy resources by creating facilitative framework for repowering.

This wind farm is located in Bijapur district in Karnataka. It consists of twenty six of AW125/3000 Nordex-Acciona turbines, each with a rotor diameter of 125m, mounted on 120m high concrete towers. The Bannur wind farm is expected to generate about 242GWh of clean energy every year, which is equivalent to the power consumption of about 224,000 Indian homes. The wind farm can help in offsetting about 232,000 metric tons of CO_2 from entering the atmosphere. Electricity generated from the wind farm will be supplied to Bangalore Electricity Supply Company (BESCOM), after the signing of a long-term power purchase agreement (PPA).Acciona said that the wind farm is the first one to have been directly developed by the company in the Indian market.During the construction phase, the Bannur wind farm created about 600 direct jobs. The concrete towers used for the wind farm were built nearby purpose-built facility.

The turbine nacelles were mostly assembled at a plant in Chennai established by the company. Presently, Acciona owns and operates three other wind farms in India, including Anabaru (16.5 MW), Arasinagundi (13.3 MW) and Tuppadahalli (56.1 MW). All of these wind farms are located in the state of Karnataka.With the installation and commissioning of the fourth wind farm, Acciona's wind power portfolio in the country has grown to 163.8MW. The company has been operating in India since 2007.The wind sector was studied in two states of the country, Tamil Nadu and Maharashtra. In Tamil Nadu, three sites were visited in the stretch around Tirunelvelli & Kanyakumari and were studied by a rapid survey to assess environmental and social impacts from wind farms. In Maharashtra, three sites were visited and a rapid assessment of impacts from wind energy and its auxiliary infrastructure were studied.

Overall Scenario Of Wind Farms In Tamil Nadu

Area of Tirunelvelli and Kanyakumari were visited for the purpose of studying the overall impacts through a rapid survey of the area. The main impacts observed include – employment of personnel in wind farm management; change in land-use from agricultural to commercial; anecdotal stray impacts on birds; possible higher number of utility lines passing through the areas.

Case Study 1

Project Location: Vaigiakulam, Tamil Nadu, Lat: 8°42'38"N and Long: 77°43'38"E

Developmental Impacts and Sustainable Governance Aspects of Renewable Energy Projects

Observed environmental impacts	Observed social and economic impacts

Land & forest: The wind turbine was on a farmland. No trees or vegetation were observed on this site. **Auxiliary infrastructure:** The access road to turbine was not tarred. There was a security barricade around the area. **Biodiversity around the site:** No biodiversity was observed in the area. **Affect on bird and wildlife**: Very occasional loss of birdlife reported due to turbine blades or transmission lines. These observations are anecdotal in nature. **Water bodies around the site:** A pond was observed at the entrance to the farm and it appeared to be common community property. Access of community to the pond was not clear, but no barriers were in place. **Noise from wind farms:** No noise monitoring system was in place. Community living close to the wind farm didn't report noise from farm as an issue of concern. **Safety and hazard issues:** The wind mill was at an adequate safe distance from habitation and utilities. **CO2Emissions :**Wind farms operations had no SO2, NO2	**Impacts on community:** Community around the area was scarce. Use of the area around the footprint of wind-mill was restricted to wind-farm activities and community was not seen in the vicinity. **Land acquisition process:** Land was acquired by developer through a broker. Direct acquisition of land from community not undertaken. **Resettlement and rehabilitation issues:** Conflicts related to resettlement and rehabilitation were not observed and no resettlement of any person living on the land has happened as per the developer. **Impacts on tribal and vulnerable groups:** Tribal population does not reside in the vicinity of the project. **Changes in economic conditions:** Employment to technical site staff and locals for management and maintenance of wind farms.

Case Study 2:
Project location: Avurikulam village**,** Tamilnadu

Developmental Impacts and Sustainable Governance Aspects of Renewable Energy Projects

Observed Environmental Impacts	Observed social Impacts
Land: The wind turbine was on a farmland with no visible existing protected area or forest land. Some scrub and trees were observed.	**Impacts on community:** Community around the area was scarce. Use of the area around the wind-farm was restricted to wind-farm activities and community was not seen in the vicinity.
Auxiliary infrastructure: The access road to turbines was not tarred, there was a security barricade around the area, although farmers did use the area for grazing purposes.	**Land acquisition process:** Land was acquired by developer through a broker. Direct acquisition of land from community not undertaken.
Biodiversity around the site: No biodiversity was observed, no anecdotal evidence on impact of power plant on local wildlife (on deer, *neelgai* or local small and big animals) was provided by locals.	**Resettlement and rehabilitation issues:** Conflicts related to resettlement and rehabilitation were not observed and no resettlement of any person living on the land has happened as per the developer.
Affect on bird and wildlife: Occasional loss of birdlife reported from hitting transformer, turbine blades or transmission lines.	**Impacts on tribals and vulnerable groups:** Tribal population does not reside in the vicinity of the project.
Water bodies around the site: No water bodies were observed.	
Noise from wind farms: No noise monitoring system was in place. Community living close to the wind farm didn't report noise from farm as an issue of concern.	**Changes in economic conditions:** Employment to technical site staff and locals for management and maintenance of wind farms.
Safety and hazard issues: The wind mill was at an adequate safe distance from habitation and utilities like roads.	
Other emissions during operation of wind farm: Wind farms operations had no SO2, NO2 emissions and net zero carbon emissions.	

Case Study 3:
Project location: Bhimashankar Khed Taluka of Pune District, Maharashtra.
Latitude: 18°59'39.06"N, Longitude: 73°35'8.96"E
The wind farm is located at Bhimashankar in Pune District of Maharashtra. The main impacts that were observed at Bhimashankar include - land use conversion, tree felling for road construction. Forest Clearance was obtained in areas where it was relevant and only *Kutcha* road was constructed. No restriction was observed on local villagers' access to the hill and areas used for grazing.

Developmental Impacts and Sustainable Governance Aspects of Renewable Energy Projects

Observed environmental impacts	Observed social impacts
Land: The wind turbines were located on forest land, clearance was obtained from forest department for establishing the turbines. **Auxiliary infrastructure:** The access road to turbines was not tarred, there was no security barricade around the area. **Biodiversity around the site:** Usual forest biodiversity including trees & flora were observed around the site apart from the un-tarred road leading to the hilltop. **Affect on bird and wildlife**: Loss of biodiversity and fauna was not observed during operations. Tree felling was observed for development of roads and plant site. **Water bodies around the site:** No affected water bodies were observed. **Pollution from noise from wind farms:** When observed noise levels were low. No habitation was close to the wind mills, hence impacts from noise are assessed to be low. **Safety and hazard issues:** The wind mill was at an adequate safe distance from habitation and utilities like roads. There were no anticipated impacts on human health & safety. **Other emissions during operation of wind farm:** Wind farms operations had no SO2, NO2 emissions and net zero carbon emissions.	**Impacts on community:** Community around the area was at least 5km away. Use of the area around the wind-farm was restricted to wind-farm activities and community was not seen in the vicinity. However, on contact with the community, it was informed to the visiting team that there were no restrictions on accessing the hills to gather fuel wood and fodder. **Land acquisition process:** Process of land conversion from forest land to commercial was followed with permission from forest department. **Resettlement and rehabilitation issues:** Conflicts related to resettlement and rehabilitation were not observed and no resettlement of any person living on the land occurred. **Impacts on tribals and vulnerable groups:** Tribal population does not reside in the vicinity of the project. Villagers and locals were not adversely impacted as no community land was taken up for construction and access to community is allowed. Locals were allowed to freely use the forest land for the usual purposes of gathering firewood and fuel or grazing. **Changes in economic conditions:** Small employment to technical site staff and locals for management and maintenance of wind farms.

Biomass and biofuels

The material of plants and animals, including their wastes and residues, is called *biomass*. It is organic, carbon-based, material that reacts with oxygen in combustion and natural metabolic processes to release heat. Such heat, especially if at temperatures >400 C, may be used to generate work and electricity. The initial material may be transformed by chemical and biological processes to produce *biofuels*, i.e. biomass processed into a more convenient form, particularly liquid fuels for transport. Examples of biofuels include methane gas, liquid ethanol, methyl esters, oils and solid charcoal. The term *bioenergy* is sometimes used to cover biomass and biofuels together.

The dry matter mass of biological material cycling in the biosphere is about 250×10^9 t y^{-1} incorporating about 100×10^9 t y^{-1} of carbon. The associated energy bound in photosynthesis is 2×10^{21} J y^{-1} =0 7×10^{14} W . Of this, about 0.5% by weight is biomass as crops for human food. Biomass production varies with local conditions, and is about twice as great per unit surface area on land than at sea.

Biomass provides about 13% of mankind's energy consumption, includ-ing much for domestic use in developing countries but also significant amounts in mature economies; this percentage is comparable to that of fossil gas. The domestic use of biofuel as wood, dung and plant residues for cooking is of prime importance for about 50% of the world's population. The industrial use of biomass energy is currently comparatively small for most countries, except in a few sugarcane-producing countries where crop residues (bagasse) burnt for process heat may be as much as 40% of national commercial supply. Nevertheless, in some industrialised countries, the increasing use of biomass and wastes for heat and electricity generation is becoming significant, e.g. USA (about 2% of all electricity at 11 GW_e capacity); Germany (at 0 5 GW_e capacity) and in several countries for co-firing with coal.

If biomass is to be considered renewable, growth must at least keep pace with use. It is disastrous for local ecology and global climate control that firewood consumption and forest clearing is significantly outpacing tree growth in ever increasing areas of the world.

Biomass gasifier for electrification of cluster of villages* an Ankur Scientific experience

Ankur Scientific, a company founded by Dr B C Jain is situated in an eco-friendly environment in Savli, Vadodara, the industrial city of Gujarat, and is a global technology leader dealing in RETs (renewable energy technologies)for over 25 years. The company has created an enviable position for itself in the area of biomass gasification systems. Ankur Scientific, apart from having credits of ISO 9000, ISO 14000, OHSAS 18000 and CE certifications, also exports its systems to about 30 countries. It also has numerous installations within the wide cross-section of Indian industries.

The MNRE (Ministry of New and Renewable Energy), Government of India, is exploring the possibility of generating 10,000 MW of power in the next 10 years from surplus biomass, both agro and forest residues and also by way of dedicated energy plantations. In addition to this, lower capacity biomass power plants could be set up for feeding power at the tail end of the grid (11 kV line). These plants would ensure that power reaches many villages in rural India. It would also have several other benefits such as the ones listed below.

Small plants of up to 2 MW help in improving the voltage of the 11-kV grid as also the power factor. The grid frequency stabilizes and limits transmission and distribution losses to a large extent (about 7% losses are prevented)

1.Greater probability of success and long-term sustenance.

2.Creation of large-scale employment for unemployed/partially employed rural people.

3.Likely creation of a large number of small entrepreneurs in rural areas.

4.Rural 11-kVA grids become net producers of electricity thus ensuring uninterrupted power supply to rural areas. Round-the-clock/on-demand generation of electricity and hence ability to meet peak demand.

5.Very short gestation periods of a few months

Almost 80% of the cost of generation is returned to the local economy through purchase of biomass and creation of local jobs

Perennial and sustainable green power and, therefore, mitigation of global warming

Increased, long-term self sufficiency on the energy front

Potential for cogeneration through inclusion of cold chains in the power projects

Greening of barren and waste lands through production of sturdy energy species as small plants are conducive to energy plantations, leading to afforestation.

The power plant at Sankheda, Vadodara

Recognizing the above benefits, Ankur Scientific has set up a 1.2-MW grid-connected, biomass power plant based on its own gasification technology in Sankheda Taluka of Vadodara district. This project is the first of its kind in Gujarat and also the first project to be set up under the status of 'Model Investment Project' implemented by MNRE and UNDP (United Nations Development Programme) with partial financial assistance from both.

The project was commissioned in a record time of about six months, including identification of land, biomass surveys, acquiring permissions, manufacturing, and import of state-of-the-art equipment. This would not have been possible without the unstinted support of the local villagers and farmers, panchayats, the taluka offices, the collectorate and departments of land conversion and town planning, the District Industries Centre, the pollution control board, the Gujarat Energy Development Agency (the state nodal agency of MNRE), the Madhya Gujarat Vij Company Ltd, the Gujarat Energy Transmission Corporation Ltd, and MNRE.

Fuel supply linkage

The major reliance of biomass is on crop residues of the common crops available near the project site, mainly cotton, *tur*, and astor stalks, mango seeds, and corn cobs. The surrounding area of the project site is rich in cotton, *tur*, and maize cultivation. The farmers and villagers very willingly give their agri-residues, which, in turn, provides them with some added revenue for these otherwise wasted products that were generally burnt.

Development of entrepreneurs for secured and sustained fuel supply.

Ankur Scientific is also developing entrepreneurs out of these farmers and villagers for secured and sustained fuel supply. This is because the villagers and farmers are taking interest in the project and getting some additional revenue out of the waste feedstock. A few young enthusiasts amongst the villagers and the farmers have been identified and trained into becoming entrepreneurs. They then manage the supply chain on a sustainable basis Technology.

Ankur Scientific has installed two woody biomass-based gasifiers designed and manufactured by them and coupled to three units of 400-kWe each running on 100% producer gas engine gensets.

The following innovations have been included in the power plant.

The waste heat/flue gas from the exhaust of the two engines is being used for biomass drying. The flue gas is being used in the two bin dryers with a total capacity of 16 m3, which is sufficient to meet the dried biomass requirement of the two gasifiers. The bin dryers reduce the moisture content in the biomass to less than 20% as that is preferable in 'Ankur' systems.

Waste heat recovery for VAM chiller

The Ankur biomass gasification system requires chilled water for the heat exchanger to cool the producer gas and condense the moisture in the producer gas. A normal scroll-type chiller is used for this purpose wherein the power consumption of the chiller is about 45 kWh.

To reduce the power requirement for the overall auxiliaries, Ankur is recovering the waste heat/flue gas from one of the engine exhausts transferring it to hot water through a heat exchanger. This hot water is then fed into a VAM chiller to generate 36 TR chilling with a temperature profile of 13–8 0C. In this case, the total power requirement for the VAM chiller including its auxiliaries would be about 17 kWh.

Utilization of charcoal/biochar

The quantity of char produced is approximately 5% of the weight of the biomass used. Further, the char is discharged through the dry ash char removal system and collected in bags. Hence, no fly ash is generated.Char from Ankur gasifier has a reasonably high calorific value and is useful as a fuel for small-scale industries requiring thermal energy. It can also be used as filler-cum-fuel by brick kilns filler in concrete hollow bricks, or as a raw material in the manufacture of precipitate silica. Therefore, part of this is sold off to such units at a nominal price.

Char from Ankur gasifier

The char discharged from the systems is segregated as follows.

Sizes above 10 mm are partly sold and partly given to the villagers for cooking. Ankur Scientific, as a part of its corporate social responsibility, has developed a special charcoal stove and distributed the same to the local villagers for smokeless cooking.

Sizes between 1 mm and 10 mm are used for briquetting. A separate briquetting machine has been installed at the project site and the briquettes thus made are partly sold to industries for their thermal application and partly given to the local villagers for smokeless cooking.

Biochar from 'Ankur' gasifiers: a boon

Char of size less than 1 mm is used as biochar. Biochar is the carbon-rich product when biomass is heated with little or no available oxygen.
The properties of biochar and its potential impact on soil are listed below.

Has 7%–10% ash and 70%–75% fixed carbon
Calorific value ranges from 5500 kcal/kg to 6500 kcal/kg
Enhances the health of the soil.

Increases the pH of acidic soils (as biochar is typically alkaline)
Increases water and nutrient retention
Biochar carbon is chemically altered during gasification and is thus resistant to attack by micro-organisms
Biochar carbon can remain stable for long periods of time (100 to 1000 years)
It is an important way of storing carbon that has been scavenged from the atmosphere during photosynthesis.

Hydro Power

The term hydro-power is usually restricted to the generation of shaft power from falling water. The power is then used for direct mechanical purposes or, more frequently, for generating electricity. Other sources of water power are waves and tides

Hydro-power is by far the most established and widely used renew-able resource for electricity generation and commercial investment. The early generation of electricity from about 1880 often derived from hydro-turbines, and the capacity of total worldwide installations has grown at about 5% per year since. Hydro-power now accounts for about 20% of world's electric generation. Output depends on rainfall and the terrain. In about one-third of the world countries, hydro-power produces more than half the total electricity.

However, global estimates can be misleading for local hydro-power plan-ning, since small-scale (1 MW to ~10 kW) applications are often neglected, despite the sites for such installations being the most numerous. This may be because the large surveys have not recognised the benefits perceived by the site owners, such as self-sufficiency or long-term capital assets. Thus the potential for hydro generation from run-of-river schemes (i.e. with only very small dams) is often underestimated. Social and environmental factors are also important, and these too cannot be judged by global surveys but only by evaluating local conditions.

Remote village electrification through a micro-hydel project*

Arunachal Pradesh, also called the Land of the Rising Sun, lies in the north-eastern most part of the country. The state is mostly hilly and is covered with dense forests. It has got a long rainy season of almost six months. Due to its topography and a long rainy season, there are many streams and tributaries running throughout the year without drying up. Many of the villages lie near such streams and tributaries. This makes the place conducive for hydel projects ranging from pico to micro and mini. These villages are again very remote without road connectivity and located at a large distance from each other.

The MNRE (Ministry of New and Renewable Energy), Government of India, has been pioneer-has been no requirement of any kind of special or major maintenance so far. The running and maintenance of the project are being done by the villagers themselves. The concept of Village Energy Management Committee has been introduced in this project and is under assessment and monitoring at present. Technical assistance and general guidance are provided by APEDA (Arunachal Pradesh Energy Development Agency) whenever required.

No of Households
Seema-19
Gungtung-14
TOW-09
Population
Seema-220
Gungtung-130
TOW-100
Agriculture and horticulture are the main occupation of the villagers.
Accessibility
Itanagar to Sagalee by Kutcha road-100Km
Sagalee to Parang by Kutcha road-30Km
Parang to Power house through porter track-5Km

Salient features of the project

ing the electrification of such remote villages by providing subsidy for setting up hydel projects of different capacities. The Bikhi MHP (Micro Hydel Project) of 2 × 15-kW capacity, is one such project constructed under the subsidy assistance from the MNRE under the RVE (rural village electrification) programme. This project falls under the Sagalee circle of Papumpare district in Arunachal Pradesh.

Running, maintenance, and revenue collection
The project has been running successfully ever since it was commissioned. There
Benefits from the project
Three villages namely Seema, Gungtung, and Taw have been electrified through this project. A government middle school near Seema Village is also gaining benefits. The plant also provides power to a health sub-centre and the Anganwadi centres of the villages.
Three villages and one government middle school with a boarding facility for boys and girls have been electrified under this project. Details by village are given below.

Name of scheme	-	Bikhi MHP (2 × 15 kW)
Sanction No. and date	-	31/1/2003-VE-SHP (ARN-PR) dated 31March 2004
Original estimated cost	-	Rs 32.68 lakh
Revised cost	-	Rs 41.63 lakh
Installed capacity	-	30 kW
Types of turbine	-	Turbo Impulse Turbine (Jyoti make)
Type of generator	-	3 phases, 415 volt AC Syn. generator
Gross head	-	32 MTR
Design discharge	-	80 LPS each unit
Length of power channel	-	100 metres
Fund sharing		
MNRE share	-	Rs 18 lakh
State share	-	Rs 23.63 lakh
Implemented by	-	APEDA
Commissioning date	-	28 January 2008
Geographical coordinates of the power house		
Longitude	-	93029'14.09''E
Latitude	-	27020'34.13''N

Jakhana micro-hydel project*

An initiative of UREDA (Uttarakhand Renewable Energy Development Agency), the Jakhana micro-hydel project is a unique model of community-managed power supply system. The basic idea behind the project was to utilize the free flowing water of the perennial Balganga river for generating power and to supply continuous electricity to the nearby revenue villages, namely Jakhana, Bhaldgaon, Toli; their hamlets Bagi, Jamrauli, Budli, and Chauri; and the nearby market on a sustainable basis with a system of community-based operation and management. The project is located at Village Jakhana in Block Bhilangana of District Tehri Garhwal.

The uniqueness of this project is that it was planned and constructed with the participation of the community. For planning, construction, operation, and maintenance of the Jakhana project, a VEC (Village Energy Committee) has been formed. It has been registered under the Society Registration Act 1860 with registration No. 622/2005-06. This VEC has been involved from the planning of the project to its commissioning. Operators and electricians have also been provided training on operation, distribution, and safety aspects. Villagers take care of the routine and minor repairs of the civil structure of the project on their own. The VEC consists of eight members, out of which two are women.

The total power production from the project is 100 kW. It provides power supply to 295 families through a transmission network of 2.58 km and distribution network of 5.87 km. Apart from the main transformer of 80 kVA, 5 step-down 25 kVA 11 kV/415 transformers have been installed on the distribution line.

Control panel and turbines of the Jakhana micro hydel project

The project has been designed on 50 m net head and 149 LPS discharge. The project has two cross flow turbines of 50 kW, a synchronous generator of 82.5 kVA, a 150-m feeder channel, 1150-m power channel, and a penstock pipe of 150 m. Other structures such as diversion, desilting tank, forebay tank, and power house have been constructed as per the requirement of the project. The project has been insured against natural calamities. AHEC (Alternate Hydro Energy Center), IIT, Roorkee, provides the technical support like alignment at site, drawing, and maintenance manual along with training to VEC members and operators for construction and operation/maintenance of the project.

Three operators have been deputed by the VEC for the operation and maintenance of the project. A salary of Rs 18,000 per month is being paid to these operators/ electricians. Electricity charges at the rate of Rs 3 per unit from metered connection and Rs 50 per bulb/month from non-metered connection are being taken by the VEC. The VEC prepares and distributes bills on a monthly basis through the appointed electricians. The collection of electricity bill is done at the project site. Monthly bill recovery from the consumers is 93%. The amount collected is being used as honorarium to the operator and for day-to-day maintenance charges. Expenses of Rs 1000 per month are marked as miscellaneous expenses. The VEC also maintains various documents such as day book, bill collection register, log book, complaint register, stock register, and bank documents.

The total cost of the project is Rs 147.42 lakh out of which Rs 59.04 lakh has been provided by the MNRE (Ministry of New and Renewable Energy) as central financial assistance. The VEC has borne 8% of the capital cost of the project in the form of cash/labour and land for the project. The remaining funds have been provided by UREDA (Uttarakhand Renewable Energy Development Agency).

Thanks to the power supply available, the villagers are using refrigerator, washing machine, electric iron, fan, heaters, and so on. A saw mill has also been established in the area. Presently, this project is operating only for six to eight hours every day as per the requirement of electricity. The CUF (capacity utilization factor) is about 30%. To increase the CUF and obtain additional income, the VEC is now planning to provide electricity to the commercial consumers and small/cottage industries in the nearby area during the day.

The Jakhana micro-hydel project works as a self-sustained small hydro project.

Some of its key success factors are identified below.

Members of the VEC have been selected by the villagers based on population

1. The VEC has the authority to penalize defaulters
2. Regular salary is paid to operators and technicians
3. Load management in peak hours
4. Regular account audits by certified chartered accountants
5. Insurance of the project equipment.

Clean energy for Ladakh

Traditionally, Ladakh has been an energy-deficient region due to its remoteness, topography, and location. A centralized electricity distribution model is neither feasible nor viable for the region. However, the importance of energy in everyday life cannot be over-emphasized. The extreme weather conditions coupled with scarcity of natural resources render life difficult, particularly during the prolonged winter season when the temperature plummets below sub-zero. Provision of clean energy sources such as electricity or natural gas by the state agencies has not yet reached the remote and far-flung villages. Uninterrupted use of fossil fuels is polluting the serene atmosphere of Ladakh and endangering the fragile ecosystem of this high-altitude Himalayan region. The LEDeG (Ladakh Ecological Development Group) therefore encourages a decentralized approach of energy production so as to make the region self-reliant using renewable resources primarily sun and water, both of which are available in abundance in the region.

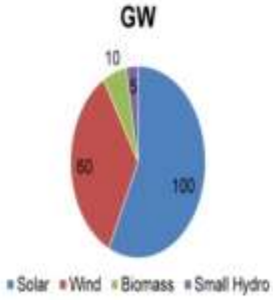
Micro-hydro power units

The villages in Ladakh are scattered and for three to four months most of the remote villages remain inaccessible during winter due to the snow and cold. In keeping with its aims and objectives, LEDeG decided to install a micro-hydro power unit in Udmaroo village of Nubra Block to improve the living conditions of the inhabitants of this remote village. Udmaroo is situated on the bank of River Shayok in Nubra valley of Leh District and is located at about 150 km from Leh. The village comprises 90 households and the total population of the village is about LEDeG – in collaboration with the EU (European Union), BORDA (Bremen Overseas Research and Development Association), GERES (Groupe Energies Renouveable, Environment et Solidarites), and SD Tata Trusts (for end-use machine) – has successfully commissioned a 30-kW micro-hydro unit during the year 2009. The unit was inaugurated by Dr Farooq Abdullah, Hon'ble Minister for New and Renewable Energy, Government of India, and Shri Omar Abdullah, Hon'ble Chief Minister of Jammu and Kashmir, on 2 September 2009. Since then, the unit has been functioning successfully and the village electricity committee is looking after and maintaining the unit efficiently. The villagers have also installed a carpentry and saw machine, a flour machine, and an oil expeller machine. These have not only reduced the drudgery but also added income to the community and provided livelihood to many families.

Technical details of the system

Capacity: 32 kVA, presently generating 20–25 kVA
Head and flow: net head 54 m, design flow 120 litres/second
Electric component: 415-V three-phase, four-wire system with electronic load governing, live load
Total transmission length: 3.3 km
Costs and funding
Total cost of micro hydro system: Rs 22,18,810
User cash contribution towards capital cost: approximately Rs 1000 per household
User in-kind contribution: unpaid labour for installation
Remaining costs covered in grant funds from EU, BORDA, and GERES under the 'Rural Electrification Component' of 'Improving the living conditions of marginalized people in remote villages of Ladakh region,' conceived and implemented by LEDeG. The fruit processing unit was funded by Sir Dorabji Tata Trust.

The Government has revised its target of renewable energy capacity to 175 GW by end of 2022, making it the largest expansion in the world and providing plenty of opportunities for investors. The target capacity is as shown below:



The UN Environment Program's (UNEP) 'Global Trends in Renewable Energy Investment 2016' report ranks India among the top ten countries in the world investing in renewable energy. The Government is also committed to Clean Energy and is driving efforts to achieve 40% power installed capacity from non-fossil-fuel-based energy resources and reducing emissions by 33- 35% of its GDP by 2030. The New & Renewable Energy sector has witnessed the highest ever-solar power and wind power capacity addition over the last two years since April 2014. Key achievements in the sector during the last 2 years are: • The world's largest 648-MW solar power plant was commissioned in Tamil Nadu on September 21, 2016. • A 140% increase in solar power capacity addition (4.13 GW) during 2014-16 as compared to 1.72 GW during 2012-14. • Highest ever wind power capacity addition of 3300 MW in 2015-16. 52% increase in wind power generation capacity from 3.8 GW during April 2012-Mar2014 to 5.7 GW during April 2014-March 2016. • 34 solar parks of aggregate capacity of 20,000 MW have been sanctioned for 21 states. INR 356.63 crores has been released to Solar Energy Corporation of India for the projects. • 31,472 solar water pumps were installed in 2015-16; this is higher than total number of pumps installed during the last 24 years since 1991. • 501 MW grid connected solar rooftop projects have been installed in the country. Capacity Addition As on February, 2016, cumulative capacity of 50 GW grid interactive renewable energy capacity has been installed in the country, which constitutes 16% of the total installed power generation capacity of 314.6 GW

Fiscal Incentives The Government has provided a whole host of financial and fiscal incentives for promoting renewable energy projects. • Fiscal incentives such as accelerated depreciation, concessional custom duty, excise duty exemption, income tax holidays for 10 years to promote renewable energy. • To promote solar roof tops, INR 5,000 crore has been approved for implementation of Grid Connected Rooftops systems over a period of five years up to 2019-20 under National Solar Mission (NSM). This will support installation of 4,200 MW Solar Rooftop systems in the country in the next five years (December 2015). – A capital subsidy of 30 percent of the project cost for general States/UTs and 70 percent for Special category States (North East including Sikkim, Uttarakhand, HP, J&K, Lakshadweep, Andaman & Nicobar) excluding industrial and commercial establishments. – Inclusion of roof top solar as part of housing loan by banks/NHB

Clean Energy Fund – Clean environment cess on coal, lignite and peat has been doubled from Rs.200 per tonne to Rs.400 per tonne, to promote use of renewable energy sources (Budget 2016-17). • Renewable energy projects included in priority sector lending norms of commercial banks (RBI, April 2015). • Renewable Generation Obligation (RGO) - New coal/lignite based thermal plants after specified date to also establish/procure/purchase renewable capacity (January 2016). • Inter-sate transmission charges and losses for Wind and Solar projects have been waived off (January 2016). • Provision of rooftop solar and 10% renewable energy is now mandatory under Mission Statement and Guidelines for development of smart cities (October 31, 2016). Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects MNRE launched the scheme for development of Solar Parks and Ultra Mega Solar Power Projects on December 12, 2014. 25 Solar Parks with capacity of 500 MW and above (smaller parks of lesser capacity for Himalayan and hilly regions) and Ultra Mega Solar Power Projects targeting over 20,000 MW of solar power installed capacity will be set up within a span of 5 years starting from 2014- 15. Scheme for Development of Solar PV Power Plants on Canal Banks/ Canal Tops “Pilot-cum-Demonstration Project for Development of Grid Connected Solar PV Power Plants on Canal Banks and Canal Tops” was approved on December 5, 2014. A target of 100 MW Grid Connected Solar PV Power Plants on Canal Banks and Canal Tops (50 MW on Canal Tops and 50 MW on Canal Banks) has been set. Some of the incentives under the scheme are: • INR 3 crore/MW or 30% of the project cost, whichever is lower, for Canal Top SPV projects and Rs. 1.5 crore/MW or 30% of the project cost, whichever is lower, for Canal Bank SPV projects • Assistance of INR 225 crore for 100 MW (50 MW on Canal Tops and 50 MW on Canal Banks) to be disbursed over a period of maximum 2 years post sanctioning of the plants. 16 MW of canal top/ canal bank solar projects have been commissioned as on December 16, 2016 under the scheme. Other Incentives to promote renewable energy projects • Various projects of total 356 MW capacity have been sanctioned and projects of 84 MW capacity have been tendered for Indian defense and para military forces using solar cells and modules manufactured in India. • A Joint Indo-US PACE Setter Fund has been established, with a contribution of USD 4 million from each side to enhance clean energy cooperation. • India has the fourth largest wind power installed capacity in the world after China, United States and Germany. To further boost this segment, the National Off-Shore Wind Energy Policy 2015 was announced to facilitate offshore wind farms in the territorial waters of India. • Government has recently approved amendments in tariff policy in Jan. 2016 which envisages long term trajectory of Renewable Purchase Obligation (RPO) prescribing purchase of solar energy to promote renewable energy with an aim to reach up to 8% of total electricity consumption by March, 2022. Department of Industrial Policy and Promotion Ministry of New and Renewable Energy 7 • Government is implementing the Green Energy Corridor Project for Strengthening interstate and intra-state transmission system along with other control infrastructure to facilitate integration of large scale renewable energy generation. Ease of Doing Business • Renewable energy has been re-classified as ‘white category.’ Previously, this sector was under ‘green category’ and the re-classification will enable ease of doing business as setting up of solar and wind power plants will be exempt from seeking environmental clearances from Ministry and consent from State Pollution Control Boards. • Wind Atlas 2015, a GIS (Geographic Information System) based software tool to help policy planners and developers was launched in September 2015. The tool identifies regional and local wind energy potential in India and contains average annual values of Wind Speed (m/s), Wind Power Density and Capacity Utilization Factor (CUF) calculated for an average 2 MW turbine at 100 m. This data is made freely available by Government on public domain. Skill Development About 98,000 people work in the four major areas of renewable energy i.e. Solar, Wind, Biomass and Small Hydro Power. Department of Industrial Policy and Promotion Ministry of New and Renewable Energy

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To meet the rising demand and manage the gaps in capacity of trained manpower, the Government in May 2015 set a target of achieving 50,000 "SuryaMitras" of skilled manpower in solar energy sector by 2019-20. 6653 SuryaMitras have been trained under the program as of February, 2017 with over 150 institutes across the country implementing the Suryamitra program and creating job opportunities for unemployed youth.

Renewable Energy projects in India can play an important role in addressing energy issues in the country, i.e., energy deficit and energy access problems. RE can contribute to both grid interactive and off grid power provisioning in India. Hence, RE deployment becomes an obvious choice for ensuring country wide energy security and access, particularly in remote areas, where off-grid applications are the preferred solution. Promoting RE will lead to both economic growth and social development in the country. The country has taken aggressive stance and has plans to derive 15% of the power from RE sources by 2020 (this is three times the activities planned by MNRE in 2008). In order to meet the country level targets, RE projects will need special encouragement. The support is also encouraged due to the low green house gas (GHG) footprint of RE projects. Since RE technologies have relatively (compared to other energy options) lower ecological footprint hence such projects should not be treated at par with conventional infrastructure projects. Further backing from the state and central government in forms of tailored subsidy support and quick project clearance will encourage investments in RE sector. Sufficient environmental and social governance mechanism in place The RE project deployment and development in the country is regulated by environmental and social governance system. The current regulatory mechanism in India is strong, involving multiple tier institutions. The mechanism is based on the perceived impacts from the project and to ensure that environmental and social governance norms are followed by the projects. Recommendations:

1. No new changes are required in the legal framework or the governance structure to mitigate or manage the environmental and social impacts. Current governance mechanisms have adequate provisions to ensure environmental & social management for the projects in the wind and solar power sector. State agencies need to be encouraged and their capacities enhanced to ensure full enforcement of the existing environmental norms.

2. In order to expedite the project clearance process, it is recommended that the wind and solar energy projects developed in environmentally non-sensitive areas. A fast channel for quick clearances from various authorities can be developed to further incentivize such projects. Environmental impacts from RE projects not significant but impact may increase in future As established by life-cycle assessment, RE projects have comparatively low environmental externalities that too are limited to project development phase. The RE projects don't generate solid or liquid effluents during operations and thereby pollution of land, surface water or ground water resources is not anticipated from such projects. During the operations phase the impacts on the surrounding environment are negligible, and are reversible in nature and can be mitigated by proper Environmental Management plan. It is helpful to observe sustainable energy management as a multivalued phenomenon, process, and operation method that complies with the sustainable development concept. In sustainable energy management, it is necessary to conduct major and multivalued changes in all society sectors and levels so that the process of sustainable energy management takes place gradually. Initializing and beginning the implementation of sustainable energy management represents numerous analyses, assessments, changes, and adjustments, and implementation of the process is linked with the implementation of numerous and various measures and activities which to a larger or lesser extent are completely different than the traditional method of energy management. ...

Institutional and economic factors

The impression may have been given in this book so far that everything can be understood by science and performed by engineering. Such an opinion is naïve in the extreme. The reality is that practical developments in energy concern about 75% 'institutional factors' and only about 25% of science and engineering. Scientists and engineers as such are minor influences, with the key parts played by others, including politicians, planners, financiers, lawyers, the media, the public and, because of ethical and cultural values, philosophers. Nevertheless when scientists and engineers themselves enter the other areas of influence, they may become more influential.

Socio-political factors

Action within society depends on many factors, including culture, traditions, political frameworks and financing. Such influences vary greatly between localities, and also change with time; they also depend on the availability and awareness of technologies.

National Energy Policy:

The key socio-political factors influencing policy on energy supply, espe-cially from renewables, include, in approximate order of importance:

Security of supply. It is the duty of politicians to secure their nation's energy supply. Having the ability to utilise indigenous supplies is therefore strategically important to guard against international disruption. Having indigenous fossil and nuclear energy supplies (which many countries have only to a limited extent) does support national security; even so, the large-scale centralisation of such resources leaves them vulnerable. Using renew-ables provides the necessary dispersed security and does not deplete finite resources. Every nation has its own set of renewable resources and there is generally common consensus, at least in principle, that these should be assessed and harnessed as a major component of energy supply. Large-scale resources concentrated at a few sites, such as large hydro power, tend to be recognised, but not, unfortunately, the sum total of widely dispersed low intensity supplies, such as rooftop photovoltaics.

Diversity of supply**:** Having 'all my eggs in one basket' is not a robust strategy. Both individuals and nations can increase security of supply by having several operational options in parallel. There is therefore perceived value in diversity, but no common method of quantifying such diversity. The accounting method of discounting allows financial optimisation, but includes no evaluation of risk and gives no credit for diversity. For energy supplies, there should be diversity in all aspects of energy supply and use, including transport, fuels, electricity generation and heating. Clearly renewables are able to give great diversity of supply in these aspects, and with geographical variation.

Economic supply is usually taken to mean 'low price to the consumer within a competitive market'. This price is heavily influenced by taxes, subsidies, monopoly influences and supplier profits, as well as the more obvious material supply costs; see below regarding economic conditions and energy markets. Evaluating what is 'economic' is attempted by various forms of analysis, usually based on 'discounting', but the actual price paid per unit tends to dominate once a supply is available. Renewables, by definition, utilise energy from the environment, which usually arrives with-out payment as with sunshine, wind and rain. The major cost of renewables is therefore the initial capital cost of the equipment, and so the method of integrating capital and operational costs is vital for economic comparisons with fossil and nuclear fuel systems.

Sustainability and climate change. As discussed beforeany envi-ronmental issues have risen in public and political consciousness in the last 50 years. In particular, global concern for sustainable development and climate change led to international concern, expressed most notably by the United Nations Framework Convention on Climate Change (FCCC 1990) and its associated Kyoto Protocol (1997). Almost all countries have agreed to accept obligations under the FCCC to reduce, or at least reduce the increase Since the principal source of greenhouse gas emissions is CO_2 from burning fossil fuels, this constitutes an incentive both to use energy more efficiently, and to substitute renewable energy for fossil energy.

Health and Safety. We all have a duty to prevent accidents to others and a desire to prevent damage to ourselves and our families. Governments and responsible organisations have many regulations to safeguard and improve the safety and health of citizens. Like other energy installations, such as nuclear power stations, oil refineries, and high-voltage transmission lines, renewable energy installations can be dangerous, with recognisable diffi-culty in maintaining safety at the many and dispersed locations. Working near rotating machinery and electrical power systems, climbing structures and handling combustible materials present dangers. In practice, many renewable installations have relatively small-scale operation, so person-nel are involved in many varied tasks; although providing interesting and responsible work, such variation presents dangers.

Pollution may be defined as negative impacts, usually chemical emissions, not present in the natural environment. Therefore, since its sources are energy flows in the natural environment, renewable energy is intrinsically pollution-free. This contrasts with fossil and nuclear energy, whose sources are intrinsically pollutants. It is the mechanisms for harnessing renewable energy that may introduce negative impacts, such as smoke and noise, not the sources themselves. Fossil and nuclear energy processes concentrate and then emit chemicals and ionising radiation whose precursors are already present in the primary materials. Therefore, in general, renewables avoid the widespread pollution hazards to health associated with brown energy sup-plies. The obvious exception is incomplete combustion of biomass, which is common from burning firewood or in poorly regulated machines using biofuels.

Legislation**.** Governments tend to have much legislation concerning energy supply to regulate security, diversity, costs and safety. Specific legislation is needed for renewables, e.g. rights to hydropower, sunshine and wind. To increase security and diversity of supply, governments may enforce (obligate) energy suppliers to include a certain proportion from renewables. Benefits may be enforced, e.g. by net metering for householders so imported electricity from the grid is offset by exporting from embedded photovoltaic, wind and hydro generation.

Planning. Governments establish planning legislation and procedures, which may vary greatly between nations and states, but are usually considered and decided upon by local authorities. However, central gov-ernment will legislate and pronounce upon on general strategy (such as the need for sustainable development) and will reserve the power to decide upon appeals. So although it may involve itself closely in large and influential developments, e.g. large-scale hydropower and offshore wind power, the decisions about medium and small developments tend to reside with local government. Therefore overall strategy and legislation can be expected from national governments, with implementation mostly regulated by local gov-ernment officials and elected representatives. Democratic rights may give individual citizens considerable influence within planning procedures, but usually only to present arguments to the decision-makers.

Structure of energy markets. Until the 1990s, most governments granted the electricity supplier in each region a regulated monopoly, in order to allow economies of scale and discourage wasteful duplication of distribution systems. By 2000, legislation in most industrialised countries encouraged a trend to allow independent generators and suppliers to compete in liber-alised markets, but under the control of a Regulator, who acts as a judge to manage prices and services within the bounds set by government. In general, this led to reductions in the price of conventional electricity and has also encouraged many new companies to set up as renewable generators and suppliers. The same governmental mechanisms have been used to obligate the supply of increasing amounts of renewable energy, usually in tandem with financial inducements to renewable energy generators paid from levies on all consumers. A particular mechanism that has been very successful in producing rapid expansion of renewable energy generation is the 'feed law' legislation whereby private generators, often individuals or cooperatives, are guaranteed attractive tariff payments for energy exported to the grid or energy network; such feed laws have been influential in Denmark, Germany and Spain especially.

Economic conditions. The relatively large capital costs and initial loans for renewables, together with low fossil fuel price competition, require relatively long payback periods (often 10–15 years and more). Settled economies with small present and predicted inflation rates (and the associated small interest rates) favour such investment. Unsettled economies with large interest rates (reflecting larger risk) discourage capital investment.

Appendix:

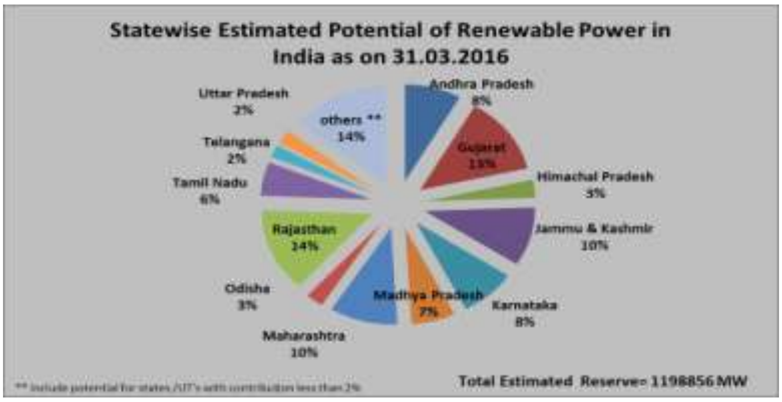
Statewise and Sourcewise Installed Capacity of Grid Interactive Renewable Power as on 31.03.2015 and 30.03.2016

	Bio-Power					
	Biomass Power		**Waste to Energy**		**Wind Power**	
States/ UTs	**31.03.15**	**31.03.16**	**31.03.15**	**31.03.16**	**31.03.15**	**31.03.16**
Andhra Pradesh	389.75	380.75	58.16	58.16	1032.00	1431.45
Arunachal Pradesh	-	-	-	-	-	-
Assam	-	-	-	-	-	-
Bihar	43.42	43.42	-	-	-	-
Chhattisgarh	264.90	279.90	-	-	-	-
Goa	-	-	-	-	-	-
Gujarat	55.90	56.30	-	-	3645.00	4037.50
Haryana	52.30	45.30	-	-	-	-
Himachal Pradesh	-	-	-	-	-	-
Jammu & Kashmir	-	-	-	-	-	-

Jharkhand	-	-	-	-	-	-
Karnataka	664.28	872.18	1.00	1.00	2638.00	2869.15
Kerala	-	-		-	35.00	43.50
Madhya Pradesh	36.00	35.00	3.90	3.90	880.00	2141.10
Maharashtra	1033.40	1220.78	12.72	12.72	4446.00	4654.15
Manipur	-	-	-	-	-	-
Meghalaya	-	-	-	-	-	-
Mizoram	-	-	-	-	-	-
Nagaland	-	-	-	-	-	-
Odisha	20.00	20.00	-	-	-	-
Punjab	140.50	155.50	10.25	10.25	-	-
Rajasthan	111.30	108.30	-	-	3309.00	3993.95
Sikkim	-	-	-	-		
Tamil Nadu	662.30	641.90	8.05	8.05	7455.00	7613.86
Telangana	-	-		-		77.70
Tripura	-	-		-	-	-
Uttar Pradesh	888.50	870.00	5.00	5.00	-	-
Uttarakhand	30.00	76.00	-	-	-	-
West Bengal	26.00	26.00	-	-	-	-
Andaman & Nicobar	-	-	-	-	-	-
Chandigarh	-	-	-	-	-	-
Dadar & Nagar Haveli	-	-	-	-	-	-
Daman & Diu	-	-	-	-	-	-
Delhi	-	-	16.00	16.00	-	-
Lakshadweep	-	-	-	-	-	-
Puducherry	-	-	-	-	-	-
Others	-	-	-	-	4.00	4.30
All India Total	**4418.55**	**4831.33**	**115.08**	**115.08**	**23444.00**	**26866.66**
Distribution (%)	**12.35**	**11.46**	**0.27**	**0.27**	**65.53**	**62.70**

*in MW

Denotes non availability or indeterminant value Source: Ministry of New and Renewable Energy



Statewise and Sourcewise Installed Capacity of Grid Interactive Renewable Power as on 31.03.2015 and 30.03.2016

							(In MW)
States/ UTs	**Small Hydro Power**		**Solar Power**		**Total**		**Growth* Rate(2014-15 to 2015-16)**
	31.03.15	**31.03.16**	**31.03.15**	**31.03.16**	**31.03.15**	**31.03.16**	
Andhra Pradesh	223.23	232.98	242.86	572.96	1946.00	2676.30	**37.53**
Arunachal Pradesh	104.61	104.61	0.03	0.27	104.63	104.87	**0.23**
Assam	34.11	34.11	-	-	34.11	34.11	**0.00**
Bihar	70.70	70.70	-	5.10	114.12	119.22	**4.47**
Chhattisgarh	52.00	52.00	7.60	93.58	324.50	425.48	**31.12**
Goa	0.05	0.05	-	0.00	0.05	0.05	**0.00**
Gujarat	16.60	16.60	1000.05	1119.17	4717.55	5229.57	**10.85**
Haryana	71.50	73.50	12.80	15.39	136.60	134.19	**-1.77**
Himachal Pradesh	723.91	793.31	-	0.20	723.91	793.51	**9.61**
Jammu & Kashmir	156.53	156.53	-	1.00	156.53	157.53	**0.64**
Jharkhand	4.05	4.05	16.00	16.19	20.05	20.24	**0.93**
Karnataka	1129.73	1217.73	77.22	145.46	4510.23	5105.52	**13.20**
Kerala	168.92	198.92	0.03	13.05	203.95	255.47	**25.26**
Madhya Pradesh	86.16	86.16	558.58	776.37	1564.64	3042.53	**94.46**
Maharashtra	335.43	339.88	360.75	385.76	6188.30	6613.28	**6.87**
Manipur	5.45	5.45	-	-	5.45	5.45	**0.00**
Meghalaya	31.03	31.03	-	-	31.03	31.03	**0.00**
Mizoram	36.47	36.47	-	0.10	36.47	36.57	**0.27**
Nagaland	29.67	30.67	-	-	29.67	30.67	**3.37**
Odisha	64.63	64.63	31.76	66.92	116.39	151.55	**30.21**
Punjab	157.40	170.90	185.27	405.06	493.42	741.71	**50.32**
Rajasthan	23.85	23.85	942.10	1269.93	4386.25	5396.03	**23.02**
Sikkim	52.11	52.11	-	-	52.11	52.11	**0.00**
Tamil Nadu	123.05	123.05	142.58	1061.82	8390.98	9448.68	**12.61**
Telangana	-	-	61.25	527.84	61.25	605.54	**888.64**
Tripura	16.01	16.01	5.00	5.00	21.01	21.01	**0.00**
Uttar Pradesh	25.10	25.10	71.26	143.50	989.86	1043.60	**5.43**
Uttaranchal	209.32	209.33	5.00	41.15	244.32	326.48	**33.63**
West Bengal	98.50	98.50	7.21	7.77	131.71	132.27	**0.43**
Andaman & Nicobar	5.25	5.25	5.10	5.10	10.35	10.35	**0.00**
Chandigarh	-	-	4.50	6.81	4.50	6.81	**51.24**
Daman & Diu	-	-	-	4.00	0.00	4.00	**-**
Delhi	-	-	5.47	14.2	21.47	30.28	**41.07**

				8			
Lakshadweep	-	-	0.75	0.75	0.75	0.75	**0.00**
Puducherry	-	-	0.03	0.03	0.03	0.03	**0.00**
Others	-	-	0.79	58.31	4.79	62.61	**1207.12**
All India Total	**4055.37**	**4273.48**	**3743.99**	**6762.87**	**35776.96**	**42849.38**	**19.77**
Distribution (%)	**11.34**	**9.97**	**10.46**	**15.78**	**100.00**	**100.00**	

III. CONCLUSION

We conclude that renewables are growth areas of development, with potential to supply much of the world's energy from millions of local and appropriate sites, but success requires knowledge, vision, experience, finance, markets and individual and collective choice. However, we caution that for a national energy system to be truly sustainable, not only must its energy sources be sustainable but also its pattern of energy consumption. That is, close attention needs to be paid to the efficiency and purposes of energy end-use. Unless this is done, even RENEWABLE ENERGY RESOURCES will not be sufficient to meet the growing demand for energy services for heat, transport, cooking, electronics, etc. recent technological developments have also improved the cost-effectiveness of many of the renewables, making their economic prospects look increasingly attractive. It describes the achievement and progress made in hydropower, biomass conversion, geothermal, solar thermal technology, wind energy conversion, in INDIA and also the increasing usage of photovoltaics. It is evident that global warming is setting in and is going to change the climate, as well as the terrain of many countries, unless drastic measures are taken. The Kyoto meeting emphasized the importance of limiting CO_2emissions and to abide by some form of agreement to reduce emissions. The present study concludes that renewable energy penetration into the energy market is much faster than was expected in recent years and by 2030, 15–20% of our prime energy will be met by renewable energy.

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