Wind Energy Scenario and Potential in India

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Abstract

Energy is the most essential element of socio-economic development and nation's economic growth. Renewable energy sources can play an immense role to full fill this need of energy. We see the tremendously energy gap increases, for the mitigation of this energy gap we need to some other energy sources like as renewable energy or wind energy. This paper present a states wise wind energy potential, energy scenario, installed capacities, different policy, are discussed in detail.
Keywords: energy scenario, wind potential, wind installation capacity, growth of RE

I. INTRODUCTION

India has the fifth-largest power generation portfolio worldwide. The country transitioned from being the seventh-largest energy consumer in the world a. This rapid growth of power capacity and a subsequent rise in demand can be attributed to several factors: Economic growth and increasing prosperity, growing rate of urbanization, rising per capita energy consumption, widening access to energy in the country, and also in recent years, India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development. Rapid urbanization and improving standards of living for millions of Indian households, the demand is likely to grow significantly. In order to increase the energy demand day by day. We know that electrical energy generation depend on the fusel fuel. Now a day's availability of fossil fuel is depleted from our country and as well as worldwide, for the

fulfillment of gap of electrical energy we need to some other alternatives. So we need to more generation of electrical energy by using other than fossil fuel resources. India's energy planning, which is based on the twin objectives of high economic growth and providing electricity to all, is failing to meet either [1].

The domestic power demand of India was 918 billion units in 2012. It is expected that at 9.8% annual growth the demand will reach 1,640 billion units by 2020. At this pace, India will require 390 GW in the next eight years which is almost double its current installed capacity of 210 gig watts (GW). There is growing energy inequity between rural and urban areas and also between the developed and developing states. There are millions who are yet to be benefited from electricity in rural India. The scarcity of electricity in rural areas in comparison to urban areas seems to be biased in delivery through the centralized system. While the urban-rural difference in energy supply could be reduced through renewable energy, it is more complex to overcome the widening gap between developed and not so developed states [2].

India has total energy generation target is about 1137.5 Billion Unit (BU) in 2015-2016 but we achievement only 1010.995 Billion Unit (BU) in 2015-2016. India has some amount of energy generated by renewable energy like as small hydropower, biomass, wind, solar, cogeneration, and waste-to-energy. Developing renewable energy can help India increase its energy security, reduce the adverse impacts on the local environment, lower its carbon intensity, contribute to more balanced regional development, and realize its aspirations for leadership in high-technology industries [3].

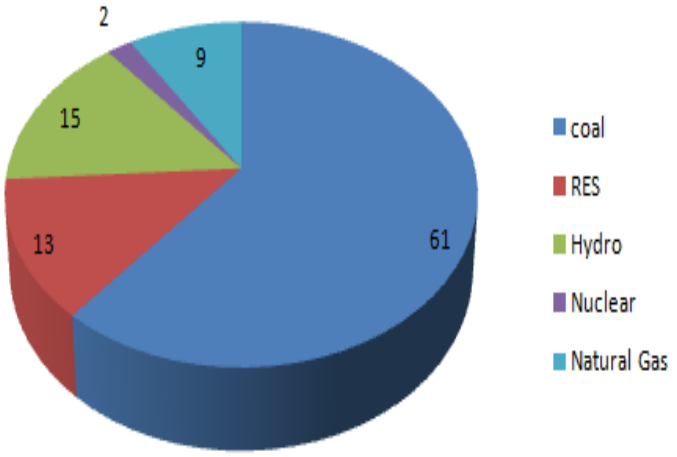
India has installed capacity of 288 GW as of 31 January 2016. Renewable Power plants constituted 28% of total installed capacity and Non-Renewable Power Plants constituted the remaining 72%. For the continuously contribution of renewable energy, India running many policy, scheme , institute and agency under the guideline of Ministry of New Renewable Energy (MNRE) such as Indian Renewable Energy Development Agency (IREDA), Solar Energy Corporation of India (SECI), National Institute of Solar Energy (NISE), National Institute of Wind Energy (NIWE), Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Decentralized Distributed Generation (DDG), and Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) [3-4]

There are huge amount of potential available in the renewable energy in our country and as well as worldwide which can be explored and harnessed to meet the energy demand. In this review paper researchers basically focused on positional of renewable energy and their scenario.

Fig. 1: Energy post-peak projection in India [8]

II. ENERGY SCENARIO

Ministry of Power (MOP) and Ministry of Non-conventional Energy Sources (MNES), Government of India, has been promoting viable renewable energy technologies including wind, small hydro and biomass power, energy conservation, demand side management etc. MNES has been promoting various sources of renewable energy since 1990 [7]. The electricity sector in India had an installed capacity of 205.34 Gig watt (GW) as of June 2012, the world fifth largest. Thermal power plants constitute 61% of the installed capacity, hydroelectric about 15% and rest being a combination of wind, small hydro, biomass, waste-to-electricity, nuclear and etc. India generated 855BU (85500MU i.e 855 TW) electricity during 2011-2015 fiscal [6].



Source of electricity in india by installed capacity

Fig. 2: electricity sector in India

Source – Govt. of India's Central Electricity Authority report dated 31-01-16

A. Wind Energy:

Electrical energy obtained from harnessing the wind with windmills or wind turbines. The development of wind power in India began in the 1986 with first wind farms being set up in coastal areas of Maharshtra (Ratnagiri), Gujarat (Okha) and Tamil Nadu (Tuticorin) with 55 kW Vestas wind turbines. Wind energy is one of the most promising alternative energy technologies of the future. During recent years, the amount of energy produced by wind-driven turbines has increased rapidly due to considerable advancement in turbine technologies, making wind power economically compatible with conventional sources of energy. The use of wind power in India has been gaining importance with rapid installation in the last few years. Wind energy makes up the majority about 68 per cent [8-9] of the total renewable energy capacity installed in India.

B. Solar energy:

Solar energy is radiant light and heat from the Sun harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture and artificial photosynthesis. With about 300 clear, sunny days in a year, India's theoretically calculated solar energy incidence on its land area alone is about 5,000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr) [10]. On 16 May 2011, India's first 5 MW of installed capacity solar power project was registered under the Clean Development Mechanism. The project is in Sivagangai Village, Sivaganga district, Tamil Nadu. January 2015, the Indian government significantly expanded its solar plans, targeting US$100 billion of investment and 100 GW of solar capacity by 2022 [11].

C. Small Hydro Power (SHP):

The estimated potential of small hydro (up to 25 MW station capacities) in India is of about 20,000 MW of which about 3632 MW has been exploited. The aim is that out of the total grid interactive power generation capacity that is being installed, 2 per cent should come from small hydro. A target of adding 1400 MW during 2007- 2012 was achieved. The use of small hydro power (SHP) in India goes way back in history, with the country's first SHP plant having come up in 1897 [9]. The current total installed capacity of small hydro power plants is 3746.75 MW [8].

D. Geothermal:

The Geothermal energy of the Earth's crust originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%). The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. At the core of the Earth, temperatures may reach over 5000 degrees Celsius [12]. Geothermal energy comes from the natural heat of the Earth primarily due to the decay of the naturally radioactive isotopes of uranium, thorium and potassium. Because of the internal heat, the Earth's surface heat flow averages 82 mW/m2 which amounts to a total heat of about 42 million megawatts [13]. The most promising geothermal fields in India are:

1) NW Himalayas: Puga-Chumathang (Ladakh district, J&K) where a 1MWe plant is planned and Parbati Valley with the Manikaran field in Himachal Pradesh where in 1992 a 5kWe geothermal binary cycle plant was successfully run.
2) Central India: Tattapani region (Madhya Pradesh) where the installation of a 20MWe binary plant has been planned [14].

E. Biomass & Biogass Energy:

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the timber industry, firewood, agricultural residues such as bagasse; crop straw, animal dung and wastes generated from agro-based industries. The main biomass sources are as listed below [9].

1) Wood and wood waste: forest wood, wood from energy plantations, saw dust, tree branches and leaves etc.
2) Agricultural residues: rice husk, bagasse, groundnut shells, coffee husk, straws, coconut shells, coconut husk, arhar stalks, jute sticks etc.

F. Tidal Energy:

Tide is periodic rise and fall of the water level of the sea. Tides occur due to the attraction of seawater by the moon. Tidal energy can be harnessed in two ways. The first, Tidal range technology uses a barrage to draw on the power of the water as it changes height between high tide and low tide in a similar way to a hydroelectric system. the same benefits of tidal energy [9]:

1) It is reliable and predictable well into the future
2) Water is 800 times denser than air, which gives it huge potential for power extraction
3) It is a renewable energy source with no harmful greenhouse emissions

G. Hydrogen fuel cell:

A fuel cell by definition is an electrical cell, which unlike storage cells can be continuously fed with a fuel so that the electrical power output is sustained indefinitely. Electrical energy is produced by converting hydrogen, or hydrogen containing fuels, directly

along with heat through the electrochemical reaction of hydrogen and oxygen into water. The process is known as electrolysis in reverse [9].Overall Reaction:

$$2H_2 \text{ gas} + O_2 \text{ gas} \rightarrow H_2O + \text{energy}$$

III. STATUS OF WIND ENERGY

Wind energy program was commenced in India by the end of the 6th five yearly plans during 1983-84 and in the last few years it has increased considerably. The main objective of the program was the commercialization of wind energy production, support research and development, provide help to wind projects and to create awareness among people. Under this program Ministry of Non Renewable Energy (MNRE) has done various modification regarding incentives, schemes and policies for wind energy. India is relatively newcomer to the wind energy sector as compared to Denmark or USA. But Indian policy support for wind energy has led India and it ranked fifth in 2011 with largest installed wind power capacity [16]. The worldwide installed capacity of wind power reached 370 GW by the end of 2014. China (114,763 MW), US (65,879 MW) and Germany (40,468 MW) are ahead of India in forth position in 2015 [17].

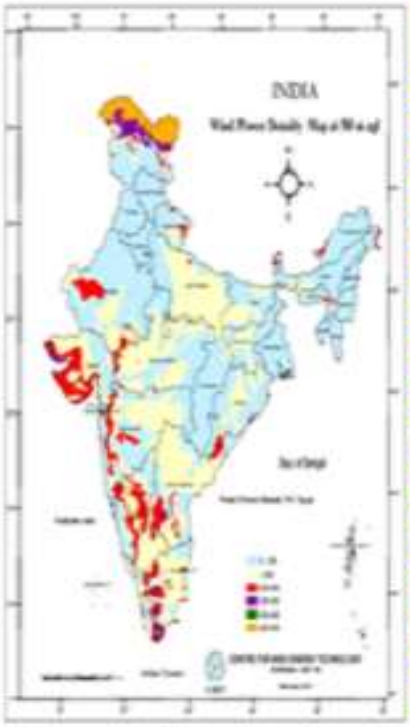
The total installed power capacity was 19,565 MW on June 30, 20136 and now India is just behind USA, China, Spain and Germany. Suzlon, an Indian-owned company, emerged on the global scene in the past decade, and by 2006 had captured almost 7.7 percent of market share in global wind turbine sales. Suzlon is currently the leading manufacturer of wind turbines for the Indian market, holding some 43 percent of market share in India. Suzlon's success has made India the developing country leader in advanced wind turbine technology [18].

In 2012, despite a slowing global economy, India's electricity demand continued to rise. Electricity shortages are common, and over 40% of the population has no access to modern energy services. India's electricity demand is projected to more than triple between 2005 and 2030. In the recently released National Electricity Plan (2012) the Central Electricity Authority projected the need for 350-360 GW of total generation capacity by 2022[1].A cumulative total of 119.5 billion units of Electricity have been fed into the state electricity grids up to 31st march, 2012. [15]

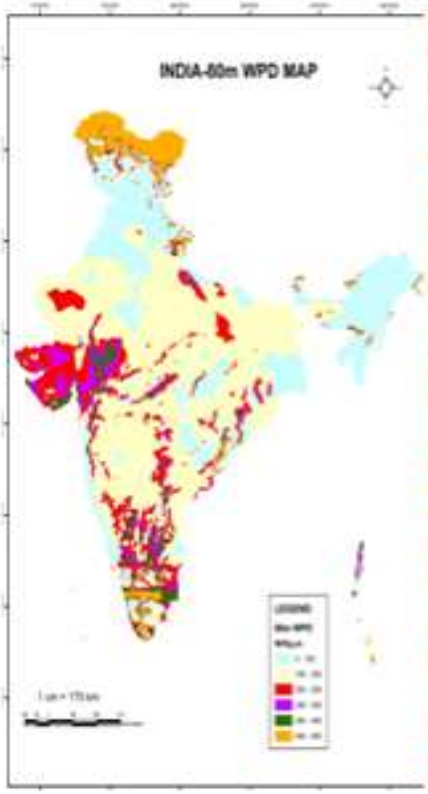
Historically, wind energy has met and often exceeded the targets set for it under both the 10th Plan (2002-2007) and 11th Plan (2007-2012) periods. During the 10th Plan period the target set was of 1,500 M W whereas the actual installations were 5,427 MW. Similarly during the 11th Plan period the revised target was for 9,000 MW and the actual installations were much higher at 10,260 MW. Wind power contributes a sizeable share of 3 to 4% to country electricity generation mix at present. The total installed capacity of wind power in India as in 31 march was 17,351.60 MW which is 8.7% of total installed capacity in India [19]

IV. WIND ENERGY POTENTIAL

Wind atlas is helpful to determine the promising sites for large scale production of energy through wind turbine. The potential for windfarms in the country was first assessed by Dr. Jami Hossain using a GIS platform at around 3000 GW in 2011. This was subsequently re-validated by Lawrence Berkley National Laboratory, US (LBNL) in an independent study in 2012. As a result, Indian wind atlas at 50 m height is As per C-WET data the total installable potential at 50 m level is 49130 MW and at 100m level is 300,000MW. The wind resource at higher Hub heights that are prevailing is possibly even more. In the year 2015, the MNRE set the target for Wind Power generation capacity by the year 2022 at 60,000 MW. As of 31 January 2016 the installed capacity of wind power in India was 25,188 MW, mainly spread across South, West and North regions [20-21-22].



States / UTs	Installable Potential (MW) 50 m Level
Andaman & Nicobar	
Andhra Pradesh	
Arunachal Pradesh*	
Assam*	
Chhattisgarh*	
Gujarat	
Himachal Pradesh *	
Jammu & Kashmir *	
Karnataka	
Kerala	
Lakshadweep	
Madhya Pradesh	
Maharashtra	
Manipur*	
Meghalaya *	
Nagaland *	
Orissa	
Rajasthan	
Sikkim *	
Tamil Nadu	
Uttarakhand *	
Uttar Pradesh *	
West Bengal*	
Total	



State Name	Installable Potential MW
Andaman &Nicobar Islands	365
Andhra Pradesh	14497
Arunachal Pradesh*	236
Assam*	112
Bihar	144
Chhattisgarh*	214
Dieu Damn	4
Gujarat	35071
Haryana	93
Himachal Pradesh *	64
Jharkhand	91
Jammu & Kashmir *	5685
Karnataka	13593
Kerala	837
Lakshadweep	16
Madhya Pradesh	2931
Maharashtra	5961
Manipur*	56
Meghalaya *	82
Nagaland *	16
Orissa	1384
Pondicherry	120
Rajasthan	5050
Sikkim *	98
Tamil Nadu	14152
Uttarakhand *	534
Uttar Pradesh *	1260
West Bengal*	22
Total	102788

Fig. 2: Wind Potential at 50mlevel in India [3]

V. STATE WISE WIND POWER INSTALLATION

The Wind power programme in India was initiated towards the end of the Sixth Plan, in 1983-84. A market-oriented strategy was adopted from inception, which has led to the successful commercial development of the technology. The broad based National programme includes wind resource assessment activities; research and development support; implementation of demonstration projects to create awareness and opening up of new sites; involvement of utilities and industry; development of infrastructure capability and capacity for manufacture, installation, operation and maintenance of wind electric generators; and policy support. The programme aims at catalyzing commercialization of wind power generation in the country. The Wind Resources Assessment

Programme is being implemented through the State Nodal Agencies, Field Research Unit of Indian Institute of Tropical Meteorology (IITM-FRU) and Center for Wind Energy Technology (C-WET).

During the last decade, the growth of wind energy sector was picked up in Indian. The pace of development was marked by formulation of right regulatory framework, incentive mechanism, flourishing component manufacturing industry, emergence of local players and coming of multinational companies as well as technology advancement [15]. Below fig.3 shown the wind energy installation across the India and generation of electricity by wind energy, the generation of maximum electrical energy from wind energy the state of Tamil Nadu is first position and second one is Maharashtra.

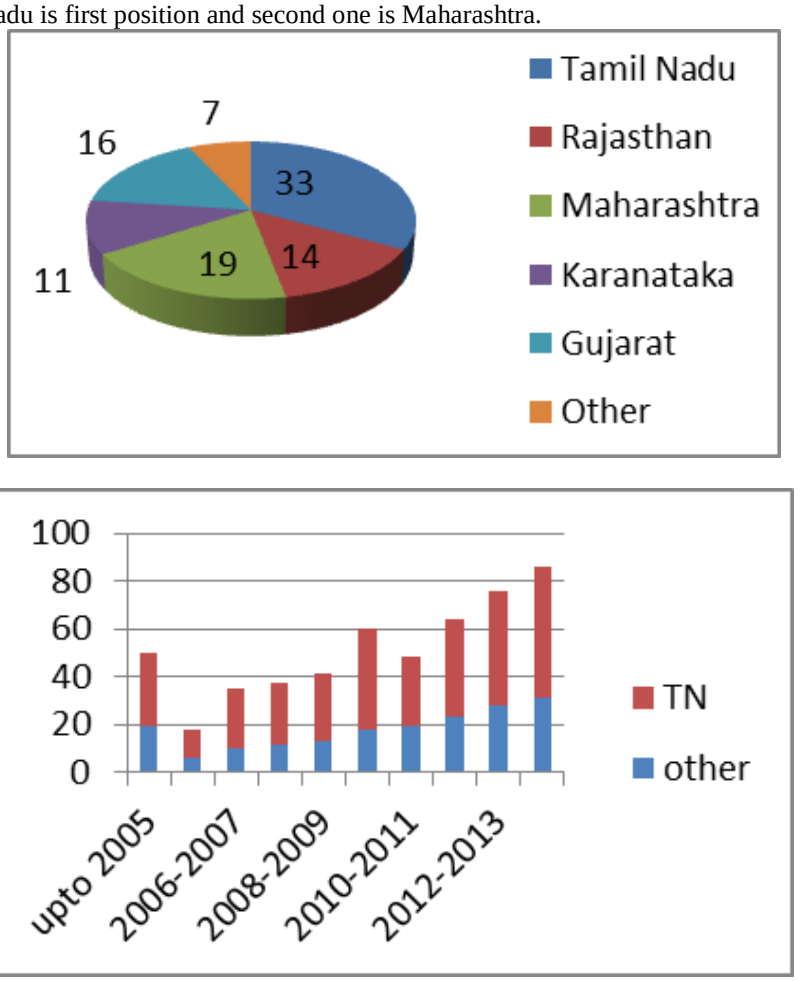


Fig. 3: Wind energy installation and electricity generation in top states India [3]

Table – 1
Installed wind power capacity per states wise

Installed Capacity per state (MW) month- Mar							
State	*15*	*14*	*13*	*12*	*11*	*10*	*09*
TN	*7456.98*	*7275.68*	*7,162.18*	*6,987.60*	*5904.4*	*4907*	*4304.5*
KA	*2639.45*	*2323.85*	*2,135.15*	*1,933.50*	*1730*	*1473*	*1327.4*
MH	*4437.9*	*4064.95*	*3,021.85*	*2,733.30*	*2310.8*	*2078*	*1938.9*
RJ	*3308.15*	*2783.45*	*2,684.65*	*2,070.70*	*1524.8*	*1088*	*738.4*
AP	*1038.15*	*783.35*	*447.65*	*245.5*	*200.2*	*236*	*122.5*
MP	*876.7*	*423.4*	*386*	*376.4*	*275.5*	*229*	*212.8*
KL	*35.1*	*35.1*	*35.1*	*35.1*	*32.8*	*28*	*27*
GJ	*3642.53*	*3447.28*	*3,174.58*	*2,966.30*	*2175.5*	*1864*	*1566.5*
Others	*4.3*	*4.3*	*4.3*	*3.2*	*0*	*4*	*1.1*
Total	*23439.26*	*21141.4*	*19,051.46*	*17365*	*14158*	*11807*	*10242.3*

Above table 1 shown the total generation of electricity from the wind turbine or wind energy and also shown their installation capacity state wise. Here also point out about the yearly cumulative capacity in MW. This table represent the growth of wind energy in subsequently. Tamil Nadu's wind power capacity is around 35% of India's total. The Government of Tamil Nadu realized the importance and need for renewable energy, and set up a separate Agency, as registered society, called the Tamil Nadu Energy Development Agency (TEDA) as early as 1985. Now, Tamil Nadu has become a leader in Wind Power in India. In Muppandal windfarm, Tamil Nadu the total capacity is 1500MW, which is the largest in India.

Table – 2
List of projects based on wind energy per states wise.

Location	*State*	*MWe*
Kanyakumari	*Tamil Nadu*	*1500*
Jaisalmer	*Rajasthan*	*1064*
Dhule	*Maharashtra*	*528*
Sangli	*Maharashtra*	*278*
Satara District.	*Maharashtra*	*259*
Vaspet	*Maharashtra*	*144*
Damanjodi	*Odisha*	*99*
Jath	*Maharashtra*	*84*
Welturi	*Maharashtra*	*75*
Kanyakumari	*Tamil Nadu*	*33*
Kayathar	*Tamil Nadu*	*30*
Jasdan	*Gujarat*	*25.2*
Ramakkalmedu	*Kerala*	*25*
Gudimangalam	*Tamil Nadu*	*21*
Puthlur	*Andhra Pradesh*	*20*
Lamba	*Gujarat*	*15*
Chennai	*Tamil Nadu*	*15*
Dewas	*Madhya Pradesh*	*14*
Chitradurga District	*Karnataka*	*14*
Perungudi	*Tamil Nadu*	*12*
Kethanur	*Tamil Nadu*	*11*
Hyderabad	*Telangana*	*10*
Muppandal	*Tamil Nadu*	*10*
Gadag	*Karnataka*	*15*
Gadag	*Karnataka*	*10.8*
Chitradurga District	*Karnataka*	*56.1*
Poolavadi	*Tamil Nadu*	*10*
Tirupur	*Tamil Nadu*	*20.4*
Jaiselmer	*Rajasthan*	*54*

Maharashtra is one of the prominent states considering the installation of wind power projects second to Tamil Nadu in India. As on 30/09/2014, installed capacity of wind energy is 4167.26 MW. All the major manufacturers of wind turbines including Suzlon, Vestas, Gamesa, Regen, Leitner Shriram have presence in Maharashtra [22].

In consideration of unique concept, Govt. of Madhya Pradesh has sanctioned another 15 MW project to Madhya Pradesh Windfarms Ltd. MPWL, Bhopal at Nagda Hills near Dewas under consultation from Consolidated Energy Consultants Ltd. CECL Bhopal. All the 25 WEGs have been commissioned on 31.03.2008 and under successful operation. 55 MW production of wind power is installed in Kerala. The first wind farm of the state was set up at Kanjikode in Palakkad district. Odisha a coastal state has higher potential for wind energy. Current installation capacity stands at 2.0 MW. Odisha has a windpower potential of 1700MW. The total installation in West Bengal is 2.10 MW till Dec 2009 at Fraserganj, Distt- South 24 Paraganas. More 0.5 MW (approx) at Ganga Sagar, Kakdwip, Distt - South 24 Paraganas. In the table 2 shown the list of power plant related to generation of electrical from wind energy.

VI. CONCLUSION

It's been observed that wind energy has achieved and repeatedly surpassed the targets set under five yearly plans. The target set during 10th five yearly plan (year 2002 to 2007) was 1,500 MW whereas the actual installations been observed were 5,427 MW. Similarly, the target set during 11th five yearly plan (year 2007 to 2012) was 9,000 MW whereas the actual installations were 10,260 MW. The proposed target for 12th five yearly plans (year 2012 to 2017) is 15,000 MW. Here in India, it is necessary to introduce long term comprehensive stable policies to support and boost the necessary investments in renewable energy. To avoid the distraction of renewable energy policies effectiveness, the policies must be carefully structured considering a harmony with existing state level mechanisms. The anticipated energy deficit in India during 2013-14 is 6.7%. To diminish the gap between demand and supply of energy we need to generate more power. India has plenty of renewable energy potential to bridge the gap between demand and supply.

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