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Study of Renewable Energy Development inPower Generation by Wind Power Technology in INDIA.

Atul Tripathi Mayank Tripathi
vaigyanikatul@gmail.commayanktripathi.mt@gmail.com
Department of Mechanical Engineering, Vivekanand Institute of Technology and Sciences ,
Dr.A.P.J.AbdulKalam Technical University, INDIA

Abstract-*Renewable energy resources have historically played a small role for electricity generation by Wind Power Technology in India. However, concerns such as security of energy supply, limitations and price fluctuations of fossil fuels, and threats of climate changes have encouraged Indian (MNRE-GOI) policy makers to think and debate about diversification strategy in the energy supply and promotion of renewables. The current paper discusses the role of renewable portfolio in the Indian 12Th energy action plan up to Dec 2013. A system dynamics model is constructed to evaluate different costs of renewable energy utilization by 2017. Over the last decades, the production of ''sustainable energy'' has provided a very fertile research field, involving aspects that are traditionally considered in an independent manner, namely renewable energy production, energy storage and efficient usage of available energy.*
Keywords: *Renewable energy* **,***Wind energy, Wind mills, Wind potential in INDIA*

I. Introduction

Electricity is the most important factor for fast track development in industrialization, urbanization, economic growth and quality of standard of living in society. India is the world's fifth largest producer in the electricity sector. India has an installed capacity of 2, 34,601MW as on Dec 2013.

India's electricity sector is among the world's most active players in renewable energy utilization. As of December 2013,India produces 28,067 MW electricity based on renewable technology that is beyond the total installed electricity in Austria by all technologies. India was the first country in the world to setup a Ministry of non- conventional energy resource sincerely 1980 [1,2]. The combined utilization of these renewable energy sources is therefore becoming increasingly attractive and is being widely used as an alternative for oil- produced energy [7]. With these considerations the aim of this paper is to describe in an onslaught and integrated way the major constraint hindering the development of renewable energy in India.

Energy Structure and Renewable Energy Utilization

India's foremost transmission producer POWERGRIDowns 79,556circuit km of transmission line and 132 sub stations that are found in one of India's five transmission are as, that is, Eastern region, Western region, Northern region, North Eastern region, Southern region. Regional load dispatch centre (RLDC)is a region house that organizes the use of the transmission system among these regions.

State load dispatch centre (SLDC) organizes transmission usage within the state and reports this datum to its overseeing RLDC Distribution amenitiesprovideelectricityto144millioncustomersinIndia.These amenitiesincorporatestepdownsubstationsandlinestocarrythe electricityatlowervoltagestotheelectricityconsumer.In stipulationsofThermalpowerplantfor58.7 %ofIndia's installed capacity,hydropoweraccountsfor17.6%,naturalgas8.9%, Nuclear power 2.1 %and renew ableenergyproduces12 .53%.

Region-Wise Power Supply Position

The assessment of the anticipated power supply position in the Country during the year2013-14 has been made taking into consideration the power availability from various stations in operation, fuel availability, and anticipated water availability at hydro electricstations.

State / Region	Energy			Peak		
	Requirement	Availability	Surplus (+) / Deficit (-)	Demand	Met	Surplus (+) / Deficit (-)
	MU	MU	MU	MW	MW	MW
Northem	319885	301418	-18467	47500	46879	-621
Westem	286752	283396	-3356	43456	46389	2934

Southem	309840	250583	-59257	44670	33002	-11669
Eastem	119632	131880	12248	18257	19700	1443
North-Eastem	12424	11024	-1400	2251	2025	-226
All India	1048533	978301	-70232	144225	140964	-3261

Table 1 – Region wise power supply Position of India in year 2013-2014

India's energy markets present tremendous challenges and opportunities over the next few years. Its economy, which has grown at a compounded annual growth rate (CAGR) of 10% over the last decade (in PPP terms), is expected to expand by another 11% by 2020.The country is expected to overtake China as the world's most populous nation by 2025, according to the US Census Bureau.The country already adds 16 million people to its population every year. Given the expected increase in the income and population, huge increases in electricity capacity must be installed to meet this booming demand.

With peak demand at 119 GW, and available peak supply at 104 GW, India currently has a large supply deficit of 15 GW, or 12.7%. In some northern and northwestern regions of the country, the deficit is as high as 15-18%. The lack of supply of electricity stems from low private sector investment and a low level of access to electricity. For example, only 66%, of the Indian population has access to electricity, compared with 99% in China. On a per capita basis, India's electricity consumption is at 380 kWh/ capita, compared with 987 kWh/ capita in China The issue is of particular importance in rural India, where as much as 52% of the rural population has no access to electricity. India has some of the highest levels of electricity transmission and distribution losses in the world; it was around 35% in 2003-2004, but has gradually come down to around 28% in 2008-2009 due to technological improvements.

A part of the answer to the formidable challenge of providing access to electricity is likely to come from renewable energy, where the government has put in place a number of incentives to stimulate investment. In particular, Jammu & Kashmir, Punjab, Bihar, Uttar Pradesh, and Maharashtra could benefit significantly, given their large renewable energy potential.

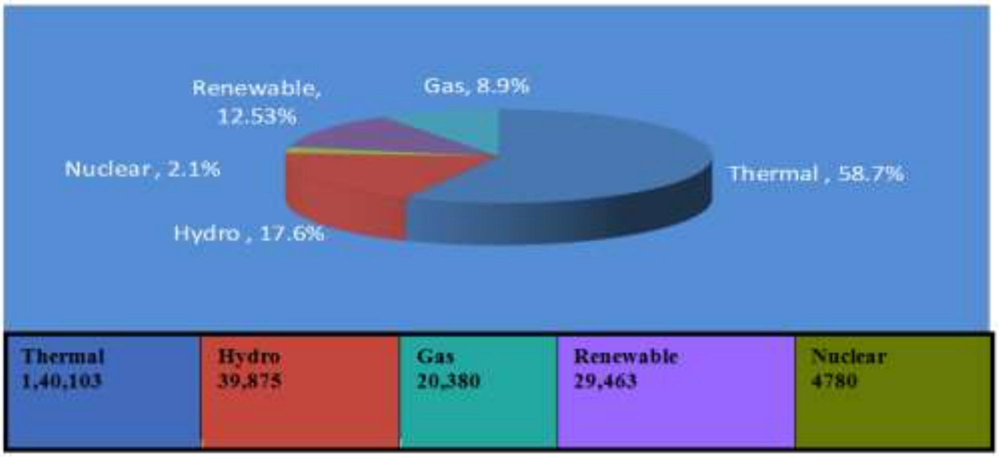


Fig 1 Indian Power Sector at a Glance (Total installed capacity : 2,34,601 MW)

Renewable Energy Potential AndDevelopment

Renewable energy is becoming an increasingly important element of India's national energy mix. The huge potentials of the country in renewable energy are recognized as an additional important energy source which can contribute to the key policy objectives of the energy sector, given the ever increasing prices and the shortages in fossil fuel supplies. By diversifying the energy mix in a climate friendly way and by increasing the energy security at the same time, the main benefits of renewable energy for India become obvious. In addition, renewable energy allows for increased energy access to the Indian people, especially in the rural and remote areas, catering to their basic energy needs.

In the early 1980s, India became the world's first nation to have a "Ministry of New and Renewable Energy (MNRE)". Due to the heavy power shortage and the ever increasing prices of fossil fuels, the nation has taken up an ambitious target of augmenting the current energy supply with renewable sources. Notable achievements have already been made in this direction with a total of 29 GW of electricity generated from renewable sources, whose total potential has been estimated by MNRE to be around 245 GW. Today India has the world's 5th largest installed capacities of renewables, including small and large hydro, solar, wind and biomass.

Opportunities exist for both grid connected and off-grid applications in residential urban and rural areas, as well as in the agricultural, commercial and industrial sectors all across the country. The Indian government has come up with favourable policies to promote renewables, namely the Electricity Act in 2003, the National Electricity Policy in 2005, the National Tariff Policy in 2006, and the latest is the National Solar Mission in 2008. The institutional structure is well suited for this, with every Indian state having its own renewable energy development agency, apart from a federal level agency (IREDA) guided by the MNRE and Ministry of Power (MOP). Innovative financing mechanisms, including Generation Based Incentives (GBI) and the Renewable Purchase Obligations (RPO) make the renewable energy sector an interesting investment opportunity and contribute to the sustainable economic growth of the country

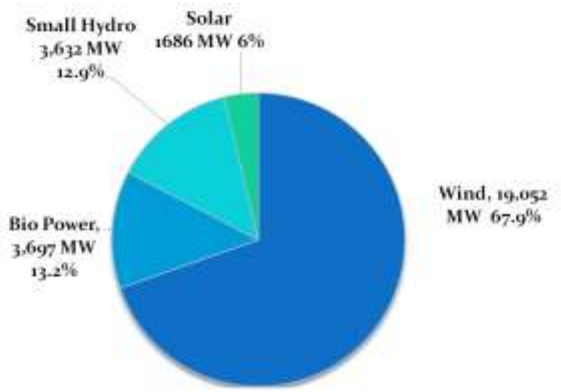


FIG -2 Indian Renewable Energy at a Glance (Total Installed capacity 28,067 MW)Renewables constitute about 12.553 % of the total power generation installed capacity in the country.

Wind Power –Potential AndDeveloment
Overview

Wind is the flow of gases on a large scale. On the surface of the Earth, wind consists of the bulk movement of air. Wind is caused by differences in atmospheric pressure. When a difference in atmospheric pressure exists, air moves from the higher to the lower pressure area, resulting in winds of various speeds. On a rotating planet, air will also be deflected by the Corioliseffect, except exactly on the equator. Globally, the two major driving factors of large-scale wind patterns (the atmospheric circulation) are the differential heating between the equator and the poles (difference in absorption of solar energy leading to buoyancy forces) and the rotation of the planet. Outside the tropics and aloft from frictional effects of the surface, the large-scale winds tend to approach geostrophic balance. Near the Earth's surface, friction causes the wind to be slower than it would be otherwise. Surface friction also causes winds to blow more inward into low pressure areas.

India, with a total of 19,565 MW as of June 30, 2013-17, has the fifth largest installed capacity of wind power in the world. She is just behind China, USA, Germany and Spain. For comparison, as of June 2013, Germany had an installed capacity of (32,422 MW) for wind power18. The targeted capacity addition in India for the period between April 2012 and March 2013 was 2,500 MW. The total capacity added during FY2012-2013 was around 1,700 MW19. Table 120 gives the state-wise, cumulative capacity installations at the end of 2012 till June 2013 as well as the semi-annual growth rate. Tamil Nadu is the southern Indian state with the highest installed capacity (7,196 MW) until June 2013, and had 8% capacity addition between 2011 and 2012. The growth can be attributed to the fact that the state was an early mover in the industry with installations dating back to the late 1990's. Many of these are now at the end of their commissioning period and are now being repowered as well. Andhra Pradesh, which had an installed capacity of just 435 MW by the end of 2012, was the state with the highest growth in installations of around 18% in the first half of 2013. This may be attributed to the high Feed-in-Tariff (FIT) of INR 4.7 (EUR 0.07) per KWh and the wind carve-out in its RPO of 5% in the state.

Table 2: State wise installed capacity and growth rate of wind in IndiaWIND: State wise installed capacity (up to June 30th 2013)

S.NO	State	Installed capacity as of December 31st 2012 (MW)	Installed capacity as of June 30th 2013 (MW)	Growth (%)
1	Tamil Nadu	7,153	7,196	1%
2	Gujarat	3,093	3,250	5%
3	Maharashtra	2,976	3,294	10%
4	Karnataka	2,113	2,170	3%
5	Rajasthan	2,355	2,717	15%
6	Madhya Pradesh	386	386	0%
7	Andhra Pradesh	435	514	18%
8	Kerala	35	35.1	0%
9	Others	4	4.3	8%

	Total	**18,550**	**19,565**	**5%**

3.2 Wind Power Technology Used

The energy that can be extracted from the wind is directly proportional to the cube of the wind speed, so an understanding of the characteristics of the wind (velocity, direction, variation) is critical to all aspects of wind energy generation, from the identification of suitable sites to predictions of the economic viability of wind farm projects to the design of wind turbines themselves, all is dependent on characteristic of wind. The most striking characteristic of the wind is its stochastic nature or randomness. The wind is highly variable, both geographically and temporally. Moreover this variability exists over a very wide range of scales, both in space and time. This is important because extractable energy from wind varies with the cube of wind velocity. This variability is due to different climatic conditions in the world also the tilt of earth on its axis and its own spinning results in different wind distributions across the world.

Major factors that have accelerated the wind-power technology development are as follows:

1. Development of high-strength fibre composites for constructing large low-cost blades.
2. Reduction in prices of the power electronics components such as converters.
3. Variable-speed operation of electrical generators to capture maximum energy.
4. Improved plant operation, pushing the availability up to 95 %.
5. Economy of scale, as the turbines and plants are getting larger in size.
6. Accumulated field experience (the learning curve effect) improving the capacity factor.

The total power generating capacity has grown to about 11087MW as of March 2010 thus placing India at fifth place in terms of installed capacity.

Power In A Wind Stream

A wind stream has total power given by **Pt = m. (K.E.w)** = 0.5**m.Vi2**

Where, m = mass flow rate of air, kg/s

Vi = incoming wind velocity, m/s

Air mass flow rate is given by

m = □AVi

Where, □= Density of incoming wind, kg/m2 = 1.226 kg/m2 at 1 atm, 15°C

A = Cross-sectional area of wind stream, m2

Substituting the above and accounting for the constants, we arrive at the following:

PW = 0.5 □ □R3Vw3CP(□, □)

Where,

Pw = extracted power from the wind,

ρ= air density, (approximately 1.2 kg/m3 at 20¤ C at sea level)

R = blade radius (in m), (it varies between 40-60 m)

Vw = wind velocity (m/s) (velocity can be controlled between 3 to 30 m/s)

Cp = the power coefficient which is a function of both tip speed ratio (λ), and blade pitch angle, (β) (deg.)

Power coefficient (Cp) is defined as the ratio of the output power produced to the power available in the wind.

Betz Limit

Betz limit is the theoretical limit assigned to efficiency of a wind turbine. It states that no turbine can convert more than 59.3 % of wind kinetic energy into shaft mechanical energy. Thus the value of Cp is limited to Betz limit. For a well designed turbine the efficiency lies in the range of 35-45 %.

Capacity Factor

Capacity factor is a term used to denote the utilization rate of a wind turbine or any power generating source for that matter. It is the ratio between power produced to the power that could have been produced if the generation source operated at 100% efficiency.

Capacity Factor = Actual amount of power produced over time / Power that would have been produced if turbine operated at maximum output 100% of the time

Wind Turbine Generator units

Turbine subsystems include:

- Rotors which convert wind energy into mechanical energy of the shaft ;
- Nacelle (enclosure) which contains all the conversion equipment, generator ,gear shaft etc.
- Tower, to increase the height of the turbine systems so that higher wind speeds are captured.
- Control equipment, Cables and other Civil works.

Internal Components of a Wind Turbine

 Anemometer: This device is used for measurement of speed. The wind speed is also fed to the controller as it is one of the variables for controlling pitch angle and yaw

 Blades: These are aerodynamically designed structures such that when wind flows over them they are lifted as in airplane wings. The blades are also slightly turned for greater aerodynamic efficiency.

 Brake: This is either a mechanical, electrical or hydraulic brake used for stopping the turbine in high wind conditions.

 Controller: This is the most important part of the turbine as it controls everything from power output to pitch angle. The controller senses wind speed, wind direction, shaft speed and torque at one or more points. Also the temp of generator and power output produced is sensed.

Gear box: This steps-up or steps down the speed of turbine and with suitable coupling transmits rotating mechanical energy at a suitable speed to the generator. Typically a gear box system steps up rotation speed from 50 to 60 rpm to 1200 to 1500 rpm

 Generator: This can be a synchronous or asynchronous Ac machine producing power at 50Hz

 High-speed shaft: Its function is to drive the generator.

 Low-speed shaft: The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

 Nacelle: The nacelle is the housing structure for high speed shaft, low speed shaft, gear box, generator, converter equipment etc. It is located atop the tower structure mostly in the shadow of the blades.

 Pitch: This is basically the angle the blades make with the wind. Changing the pitch angle changes weather the blades turn in or turn out of the wind stream.

 Rotor: The hub and the blades together compose the rotor.

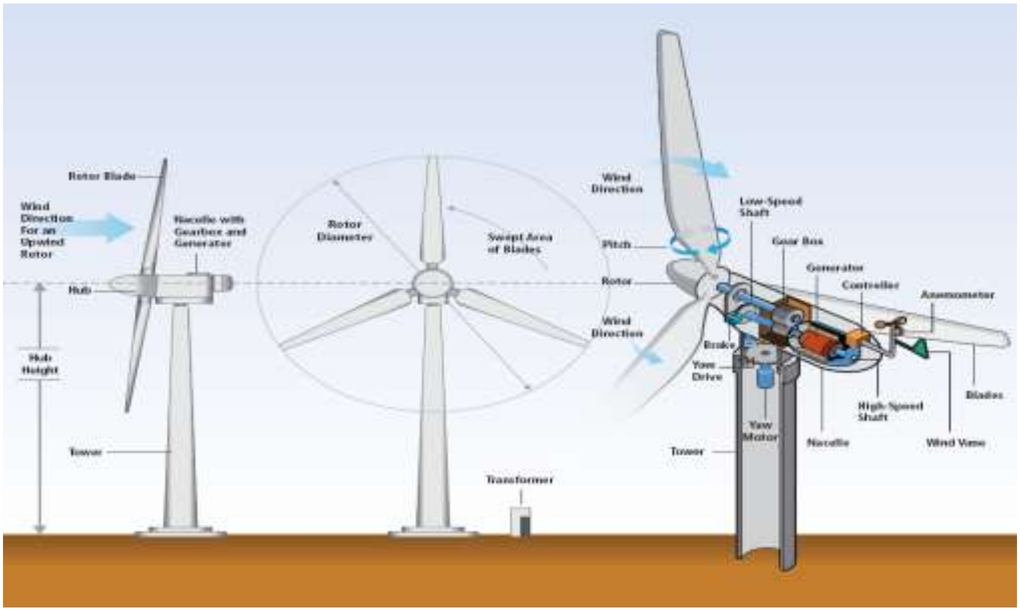
 Tower: Towers are basically made up of tubular steel or steel lattice. Taller the towers greater is the amount of power generated as the wind speed generally goes on increasing with height.

 Wind direction: Generally erratic in nature, hence the rotor is made to face into the wind by means of control systems.

 Wind vane: Basically the job of a wind sensor, measuring the wind speed and communicating the same to the yaw drive, so as to turn the turbine into the wind flow direction.

 Yaw drive: This drive controls the orientation of the blades towards the wind. In case the turbine is out of the wind, then the yaw drive rotates the turbine in the wind direction

 Yaw motor: Powers the yaw drive.



Regulatory Framework And Policies
India's Renewable Energy Policies

With the passage of India's Electricity Act of 2003, numerous policies promoting the increased usage of renewable energy have been enacted by the central government, as well as individual state governments, including:

1. Renewable purchase obligations (RPOs). The Electricity Act stipulates that State Electricity Regulatory Commissions (SERCs) specify RPOs for their own states. As of 2010, only 18 states have implemented such obligations, but future SERCs plan to put RPOs in all states.
2. Accelerated Depreciation. For wind and biomass projects, there will be an 80% deduction on the value of equipment during the first year of operation.
3. Tax Incentives. Investors in wind energy projections are given tax exemption status for up to 10 years. Specific wind devices and equipment can obtain excise duty exemptions or concessions, as well as customs duty reductions. The same applies to bioenergy projects.
4. Generation-based incentives and subsidies. Generation-based incentives include subsidies and loans to renewable energy producers according the amount of electricity produced. For example, generation-based incentives for small hydro projects are set at INR 12,000-50,000 per kW (USD 240-1,000 per kW) for projects of capacity 100-1,000 kW; and INR 2 million to 50 million per MW (USD 40,000-100,000 per MW) for larger projects of capacity 1-25 MW.
5. Feed-in tariffs. All electricity generated from renewable sources is subject to feed-in-tariffs of various rates. A feed-in tariff is not a subsidy per se, but is a premium paid by a utility to its consumers for excess power generated by alternative energy systems, and is used by governments as an incentive for consumers to adopt alternative energy sources. This is regarded as a very effective policy instrument because it is a price stabilization mechanism that makes investment returns more certain.

In India, there have been successes with the Feed-In-Tariff, but the unfavourable regulatory environment has hampered private investment in renewable development. While renewable energy capacity growth in India is high, there needs to be greater improvement if the supply-demand gap is to narrow.

Table State Specific policies for wind [Dec 31 ,2013]

STATE	WHEELING AND TRANSMISSION CHARGE	RPO			
		12-13	13-14	14-15	15-16
Andhra Pradesh	As per regulation and terms and conditions approved by Commission	5 %			
Haryana	2 % of energy Transmitted	2.75 %	4 %	N/A	N/A
Karnataka	5 % of energy Transmitted	7-10%			
West Bengal	1/3 of the wheeling charge calculated as per tariff order under tariff regulations or cost of 7.5 % of the energy fed into the grid irrespective of wheeling, whichever is higher. Transmission charge will be 2/3 of the rate of such charge applicable for open access customers for long term and short terms open access	Captive and open consumer : 5%			
Madhya Pradesh	2 % of energy transmitted + transmission charges as per the Commission	4 %	N/A	N/A	N/A
Maharashtra	As per open regulations	4 %	5.50 %	7 %	N/A
Rajhastan	Transmission charge applicable to RES power stations to be half of the transmission charges, specified by the commission for open access consumers	8 %	9%	9%	9%
Tamil Nadu	5 % energy in case of consumption of HV /EHV {hingh voltage / extra high voltage} and 7.5 % in case of low voltage	N/A	N/A	N/A	N/A
Gujarat	For 66 kV and above : Transmission charges and 4.4 % for transmission losses For below 66kV : transmission charge and 10 % transmission losses and wheeling charge	9 %			
Kerala	5 % of energy Transmitted	17 %	N/A	N/A	N/A
Punjab	2 % of energy Transmitted	3 % from 2010 with an annual increase of 10 % of 3 % per year up to a maximum of RPO of 10 %			
Odisha	Om actual basis	2.37 %	3.37 %	3.81 %	N/A

New Policy Developments

Earlier this year, the finance minister, while presenting the union budget of 2013-2014, allotted INR 8 billion (EUR 123million) to the MNRE to support the GBI incentive for wind27. Finally, in August 2013 the Union Cabinet approved the reintroduction of the GBI. A GBI of INR 0.50 (EUR 0.01)/KWh can be availed by wind power producers for a minimum of four years and a maximum of ten years, with an overall cap of INR 10m (EUR 153,846) per MW. The benefit of this incentive is applicable retrospectively for all projects launched after April 1, 2012. The total disbursement of the incentive in a year, during the first four years cannot exceed INR 2.5 million (EUR 23,076) per MW. The scheme has been designed to continue for a target of 15,000 MW during the period from 2012 to 2017. The projects have to be registered with IREDA, under this scheme.

India has so far tapped into its onshore wind potential only. It has not yet explored its offshore wind potential. The offshore wind speed is considerably higher than that the onshore wind speed and, as a result, the Capacity Utilization Factor (CUF) of offshore wind turbines is comparably higher. The MNRE established the Offshore Wind Steering Committee in August 2012 under the chairmanship of Mr. G.B. Pradhan, the then Secretary of the MNRE. The committee members consist of the various stakeholders in the wind industry in India, including ministry members, organizations and developers. The committee released a draft of the National Offshore Wind Energy Policy in May 2013. A national consultation on draft offshore policy was held in August 2013. The draft calls for the appointment of a National Offshore Wind Energy Authority (NOWA). NOWA, supported by the MNRE, will act as the nodal agency to enter into contracts with the project developers and to coordinate with other agencies for clearances. The MNRE would act as a nodal ministry and overlook the overall development of offshore wind energy in India. According to the draft, a tax holiday for the first ten years of offshore wind power generation may be available to the power producer. Concession in customs duty and exemption in excise duty may be available to the manufacturers of the offshore wind turbines. Further, exemption of service taxes for services such as conducting of Renewable Energy Resource Assessment / Environmental Impact Assessment / Oceanographic Study by third parties, utilization of survey vessels and installation vessels may be provided for. The government may also call for proposals for the development of offshore wind energy projects in specific areas. Such projects may be exempted from paying the fee for leasing the seabed area blocks and after a specified period, the ownership of the projects will be transferred to the government28.

II. Conclusions

In this paper a study on the wind potential in India has been carried. The discussions have been made on issues and challenges of renewable energy in India particularly financial and technical context. Following are the salient points of the study,Meeting an annual requirement of electrical energy is necessary, but is not enough. It is also neces-sary to meet the daily need for electricity on a continuous round-the-clock basis all over the country.

The example of India can be a very instructive one because as a developing country ithas seen both the tremendous promise of wind energy as a substitute to coal and oil andhas stumbled across real problems.coal fired generation currently provides two thirdsof the generation capacity, and hydropower supplies the other third. Yet, India is blessed with vast resources of renewable energy in solar, wind, biomass and small hydro. In fact, the technical potential of these renewables exceeds the present installed generation capacity

The government of the India must make a long-term, dedicated and highly active approach to get the technology off the ground. As we can see in the case of India, it has taken them over a decade, with consistent efforts beginning in the early 1990's, to reach where they are today. The government must make the first move in order to carry out wind mapping activities to determine the best windy sites for installation, and build private sector confidence in wind energy.The major thing that needs to occur is for the institutional infrastructure to be established as early as possible. As described before, these institutions must be responsible for the certification of wind turbines and the setting up of national standards that are appropriate to the terrain of the country, and the available local technical expertise.It is important because as seen with India, a highly subsidized approach in which foreign equipment is predominantly used is not sustainable – the technical expertise for the upkeep and maintenance of machines will not be available, forcing the project to resort to expensive foreign consultants. Also, with local production of wind equipment, and the involvement of the community that the technology will beserving, there will be a sense of ownership that is crucial to the survival of such projects. This essence lies in its decentralized natureand the ability to supply remote areas with electricity. These areas may be connected in a local area grid (LAG), much like a Local Area Network, or LAN, in computer systems, so that power lines from rural areas do not need to be constructed to the remote area. Also, wind pumps have great potential - not for electricity production but for pumping of water for irrigation or for drinking water. This is especially important in rural areas where access to clean drinking water orirrigation water is a huge public health problem.

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