Potential of Wind Energy in India as a Renewable Energy Source and its Future Sustainability

Prof. Bharat Raj Singh[1*], Prof. Raghuvir Kumar[2] and **Prof. Dharmendra Singh[3]**
[1]Director General (Technical), School of Management Sciences, Lucknow
email: brsinghlko@yahoo.com; mob: +919415025825
[2]Head of Department (ME & CE), School of Management Sciences, Lucknow
email:rkumar@smslucknow.com
[3]Dean (Academic), School of Management Sciences, Lucknow
email: dr.dsingh09@gmail.com

ABSTRACT

US oil geologist Marion King Hubbert, in 1956 predicted that US oil production (Hydrocarbon) would peak in 1970 and decline thereafter. The "Hubbert Curve" illustrated practical availability of a region's oil reserves over time describes a bell-shaped curve. After exploration and initial growth in output, production plateaus and eventually declines to zero. About 150 years before Technology has generally led to a greater use of hydrocarbon fuels. The fast depletion of fossil fuel has now days become worldwide problem and making civilization vulnerable to decrease in supply. Similarly rapid use of coal, natural gases and uranium are also causing serious concern to mankind due to their limited availability & remaining stock left. On other hand, as civilization is growing use of transport becomes essential part of life and hence use of large number of vehicles for transport is contributing to about 70% of total air pollution. Now India is the fifth country, which produces higher rate of emission and creating environmental & ecological imbalance after rating to USA, China, Russia & Japan. Thereby higher rate of emission is contributing to rise in global heating due to penetration in the thickness of Ozone layer. Thus, worldwide fast depletion of conventional energy resources necessitate the search of alternatives such as Non- Conventional Energy Sources and Renewable Energy Sources for sustainability to fossil fuel and other available resources of energy. This paper deals with the non-conventional energy resource especially Wind Energy and covers past history, availability, developments and future scope towards its contribution to Energy Resource on world map as a whole and India's contribution in particular.

Five nations – Germany, USA, Denmark, Spain and India – account for 80% of the world's installed wind energy capacity. Wind energy continues to be the fastest growing renewable energy source with worldwide wind power installed capacity reaching 14,000 MW. In March'2000, India ranks 5th in the world with a total wind power capacities of 1080MW out of which 1025Mw have been established in commercial projects. In India the states of Tamilnadu and Gujarat lead in the field of wind energy. A recent study undertaken to re-assess the potential, Indian Wind Energy Association places it at about 1,00,000 MW in 2017 as against assessed 65,000 MW in 2006. Assuming a grid penetration of 20%, a technical potential of about 13,000 MW is already available for exploitation in the potential States. Today, the capital cost of wind power projects range between Rs. 4 to 5 crores per MW. This gives a levelised cost of energy generation in the range of Rs. 2.00 to Rs. 2.50 KWh, taking into consideration the fiscal benefits extended by the Government. The Indian wind energy sector had *an installed capacity of 6280 MW (as on December 31, 2006) and current installed capacity* of *32,380 MW (as on March 31, 2017).* In terms of wind power installed capacity. India is now ranked 4th in the World. Keeping in view of today's scenario, India would be a major player in the global wind energy market.

Keywords: fossil fuel, pollution, emission, wind energy, windmills, power grid etc.

1.0 INTRODUCTION

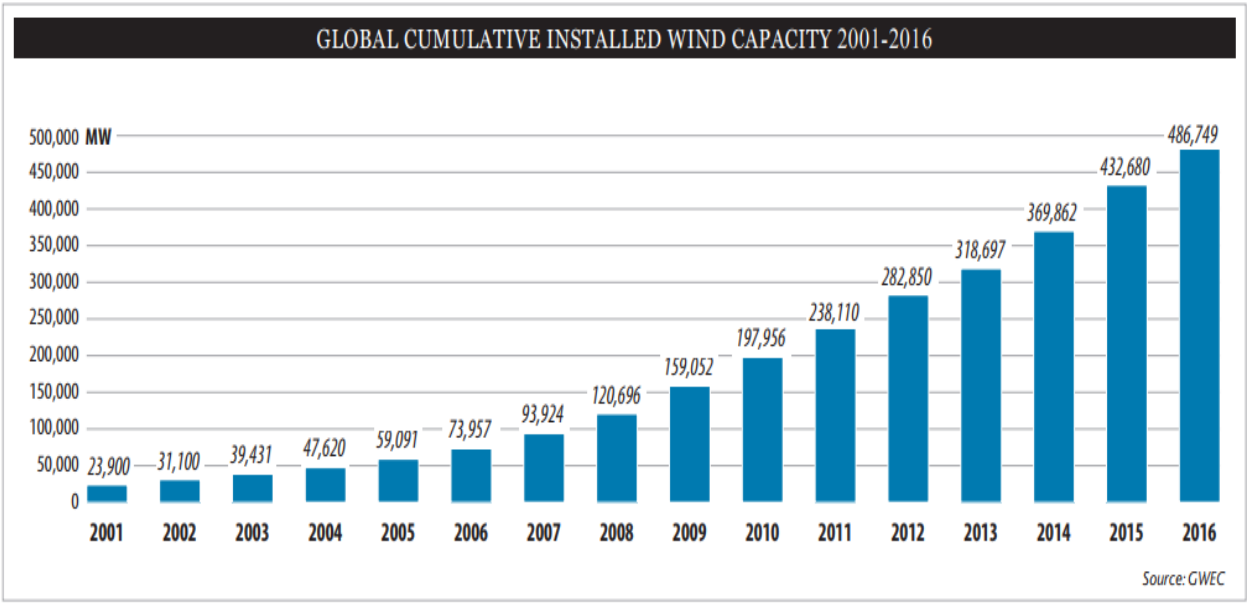
The worldwide fast depletion of conventional energy resources necessitate the search of alternatives such as Non- Conventional Energy Sources and Renewable Energy Sources for sustainability to fossil fuel and other available resources of energy. In 1956 an US oil geologist Marion King Hubbert **[1]** , predicted that US oil production (Hydrocarbon)would peak in 1970 and decline thereafter. The "Hubbert Curve" illustrated practical availability of a region's oil reserves over time describes a bell-shaped curve. After exploration and initial growth in output, production plateaus and eventually declines to zero. About 150 years before Technology has generally led to a greater use of hydrocarbon fuels. As fast depletion of fossil fuel has now days become worldwide problem and making civilization vulnerable to decrease in supply. Similarly rapid use of coal, natural gases and uranium are also causing serious concern to mankind due to their limited availability & remaining stock left. On other hand, as civilization is growing use of transport becomes essential part of life and hence use of large number of vehicles for transport is contributing to about 70% of total air pollution. India's vehicular pollution has reached 15 times than it was 25 years before. Now India is the fifth country, which produces higher rate of emission and creating environmental & ecological imbalance after rating to USA, China, Russia & Japan. The second largest

source of emission generation is use of coal in Power Plants, especially in two countries, and is causing acid rain and respiratory ailments while contributing to global warming **[2]**. China accounted for 79 percent of the world's growth in coal consumption last year and India used 7 percent more, according to statistics from BP . The latest report from the climate panel predicted that the global climate is likely to rise between 3.5 and 8 degrees Fahrenheit if the carbon dioxide concentration in the atmosphere reaches twice the level of 1750. By 2100, sea levels are likely to rise between 7 to 23 inches, it is said, and the changes now underway will continue for centuries to come.

International experts are more skeptical that wind will replace coal to a considerable extent, saying that while electricity production from wind is likely to increase rapidly, the sheer scale of energy demands suggests that coal burning will expand even more **[3].** Chinese and Indian officials are optimistic about relying much more heavily on wind.

It is estimated that "*India is ideally suited for wind energy. The cost of it works well and India has the manufacturing capability too*."

The European Wind Energy Association (EWEA) released a report **[4]** not so long ago forecasting that wind power has the potential to supply 12 per cent of the world's electricity by 2020.



EWEA claimed that they're already on the way. By the end of 2005 there were **59,091** megawatts (MW) of installed wind capacity worldwide generating clean electricity for the equivalent of 18 million homes. Now it is **4,86,749** megawatts (MW) up to Dec 2016.

Over the past decade the installed generation capacity for wind energy has increased at an average rate of 72 % as against the average rate 30% per annum up to 2006.

Source: BTM Consult ApS, March 2006 & GMEC December 2016.

Top 10 World Countries contributing Wind installed Energy

Country	MW	% Share
PR China*	168,690	34.7
USA	82,184	16.9
Germany	50,018	10.3
India	28,700	5.9
Spain	23,074	4.7
United Kingdom	14,543	3.0
France	12,066	2.5
Canada	11,900	2.4
Brazil**	10,740	2.2
Italy	9,257	1.9
Rest of the world	75,577	15.5
Total TOP 10	**411,172**	**84**
World Total	**486,749**	**100**

Source: GWEC

Five nations– Germany, Spain, USA, Denmark and India – account for 80% of the world's installed wind energy capacity **[5]** . Wind energy continues to be the fastest growing renewable energy source with worldwide wind power installed capacity reaching 14,000 MW. In March'2000, India ranks 5th in the world with a total wind power capacities of **1080**MW out of which 1025Mw have been established in commercial projects. In India the states of Tamilnadu and Gujarat lead in the field of wind energy. In December'2016, India ranks 4th in the world with a total wind power capacities of **28,700**MW.

A recent study undertaken to re-assess the potential, Indian Wind Energy Association places it at about 65,000 MW. Assuming a grid penetration of 20%, a technical potential of about 13,000 MW is already available for exploitation in the potential States. 160 sites have so far been identified in 13 States. Survey work is in progress in 24 States / UTs. The States of Rajasthan and West Bengal have also shown wind potential recently. Today, the capital cost of wind power projects range between Rs. 4 to 5 crores per MW. This gives a levelised cost of energy generation in the range of Rs. 2.00 to Rs. 2.50 KWh, taking into consideration the fiscal benefits extended by the Government. The Indian wind energy sector has an installed capacity of 6280 MW (as on December 31, 2006). In

terms of wind power installed capacity. India is now ranked 4th in the World **[6].** Keeping in view of today's scenario, India would be a major player in the global wind energy market.

This paper deals with the non-conventional /renewable energy resource especially Wind Energy and covers past history, availability, developments and future scope towards its contribution to Energy Resource on world map as a whole and India's contribution in particular.

2.0 WHAT IS WIND?

Wind is simple air in motion. It is caused by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of very different types of land and water, it absorbs the sun's heat at different rates.

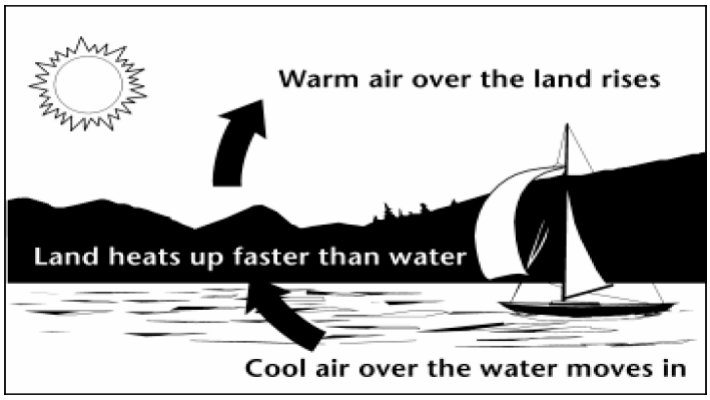


Fig. 1: Cool and Hot Air movement process

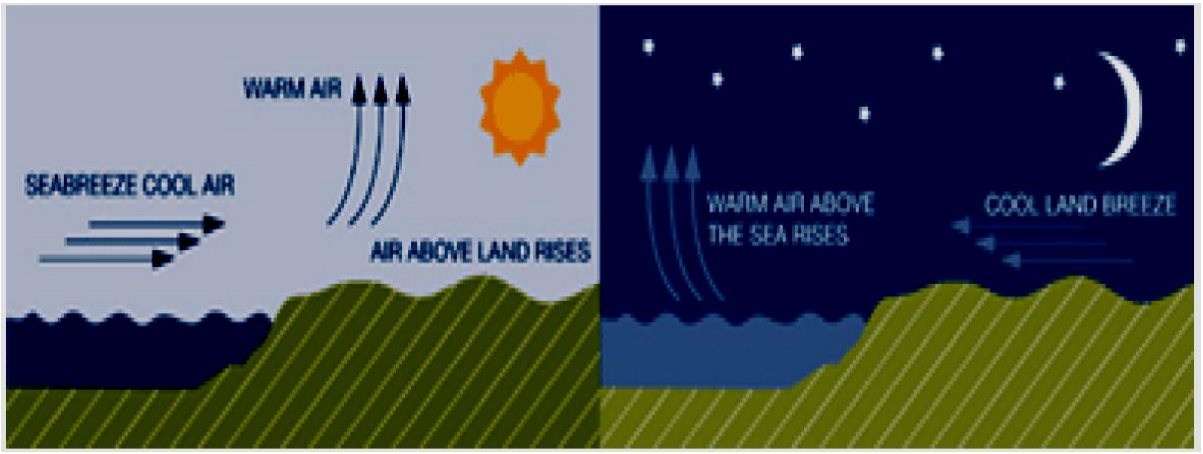


Fig. 2: Day and Night air movement

During the day, the air above the land heats up more quickly than the air over water(**Fig.1**). The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air-cools more rapidly over land than over water(**Fig.2**).

In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles.

Today, wind energy is mainly used to generate electricity. Wind is called a renewable energy source because the wind will blow as long as the sun shines.

3.0 THE HISTORY OF WIND

Since ancient times, people have harnessed the winds energy. Over 5,000 years ago, the ancient Egyptians used wind to sail ships on the Nile River. Later, people built windmills to grind wheat and other grains. The earliest known windmills were in Persia (Iran). These early windmills looked like large paddle wheels. Centuries later, the people of Holland improved the basic design of the windmill. They gave it propeller-type blades, still made with sails. Holland is famous for its windmills.

American colonists used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. As late as the 1920s, Americans used small windmills to generate electricity in rural areas without electric service. When power lines began to transport electricity to rural areas in the 1930s, local windmills were used less and less, though they can still be seen on some Western ranches.

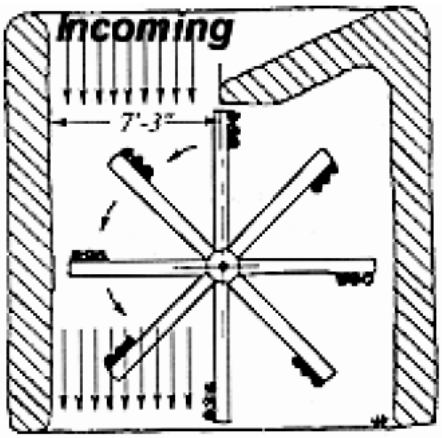


Fig.3: Wind Turbine Schematic Diagram

The oil shortages of the 1970s changed the energy picture(**Fig.3**) for the US Country and the world. It created an interest in alternative energy sources, paving the way for the re-entry of the windmill to generate electricity. In the early 1980s wind energy really took off in California, partly because of state policies that encouraged renewable energy sources.

Support for wind development has since spread to other states, but California still produces more than twice as much wind energy as any other state. The first offshore wind park in the United States is planned for an area off the coast of Cape Cod, Massachusetts (read an article about the Cape Cod Wind Project).

4.0 TYPES OF WIND MACHINES

There are two types of wind machines used today: horizontal–axis wind machines and vertical-axis wind machines(**Fig.4**). Most windmills are the horizontal-axis type. One wind machine can produce 1.5 to 4.0 million kilowatt-hours (kWh) of electricity a year. That is enough electricity for to power 150-400 homes **[7]**.

4.1 Horizontal-axis

Horizontal-axis wind machines have blades like airplane propellers. A typical horizontal wind machine stands as tall as a 20-story building and has three blades that span 200 feet across. The largest wind machines in the world have blades longer than a football field! Wind machines stand tall and wide to capture more wind.

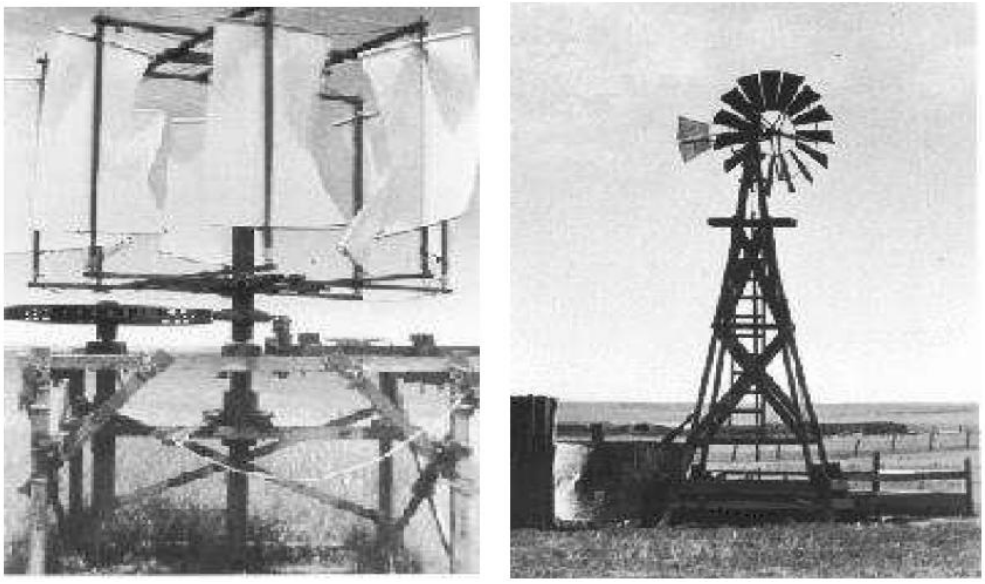


Fig. 4: Vertical and Horizontal axis Wind Turbines

4.2 Vertical-axis

Vertical–axis wind-machines have blades that go from top to bottom and look like giant egg beaters. The typical vertical wind machine stands 100 feet tall and 50 feet wide. Vertical-axis wind machines make up just five percent of the wind machines used today.

The Wind Amplified Rotor Platform (WARP) is a different kind of wind system that is designed to be more efficient and use less land than wind machines in use today. The WARP does not use large blades; instead, it looks like a stack of wheel rims. Each module has a pair of small, high capacity turbines mounted to both of its concave wind amplifier module channel surfaces. The concave surfaces channel wind toward the turbines, amplifying wind speeds by 50 percent or more. Eneco, the company that designed WARP, plans to market the technology to power offshore oil platforms and wireless telecommunications systems.

5.0 WIND POWER PLANTS

Wind power plants, or wind farms as they are sometimes called, are clusters of wind machines used to produce electricity. A wind farm usually has dozens of wind machines scattered over a large area. The Big Spring Wind Power Project in Texas has 46 wind turbines that generate enough electricity to power 7,300 homes (**Fig.5**).

Fig. 5: 200Span blades Machine and Wind Form in Texas

Unlike power plants, many wind plants are not owned by public utility companies. Instead they are owned and operated by business people who sell the electricity produced on the

wind farm to electric utilities. These private companies are known as Independent Power Producers. Operating a wind power plant is not as simple as just building a windmill in a windy place. Wind plant owners must carefully plan where to locate their machines. One important thing to consider is how fast and how much the wind blows. As a rule, wind speed increases with altitude and over open areas with no windbreaks. Good sites for wind plants are the tops of smooth, rounded hills, open plains or shorelines, and mountain gaps that produce wind funneling.

Wind speed varies throughout the country. It also varies from season to season. In Tehachapi, California, the wind blows more from April through October than it does in the winter. This is because of the extreme heating of the Mojave Desert during the summer months. The hot air over the desert rises, and the cooler, denser air above the Pacific Ocean rushes through the Tehachapi mountain pass to take its place. In a state like Montana, on the other hand, the wind blows more during the winter. Fortunately, these seasonal variations are a good match for the electricity demands of the regions. In California, people use more electricity during the summer for air conditioners. In Montana, people use more electricity during the winter months for heating.

6.0 WIND PRODUCTION

All together, wind machines in the United States generate 17 billion kWh per year of electricity, enough to serve 1.6 million households. This is enough electricity to power a city the size of Chicago, but it is only a small fraction of the nation's total electricity production, about 0.4 percent. The amount of electricity generated from wind has been growing fast in recent years, tripling since 1998. New technologies have decreased the cost of producing electricity from wind, and growth in wind power has been encouraged by tax breaks for renewable energy and green pricing programs. Many utilities around the country offer green pricing options that allow customers the choice to pay more for electricity that comes from renewable sources. Wind machines generate electricity in 30 different states. The states with the most wind production are California, Texas, Minnesota, Iowa, and Wyoming.

The United States ranks third in the world in wind power capacity, behind Germany and Spain. Most of the wind power plants in the world are located in Europe and in the United States where government programs have helped support wind power development.

7.0 WINDS AND THE ENVIRONMENT

In the 1970s, oil shortages pushed the development of alternative energy sources. In the 1990s, the push came from a renewed concern for the environment in response to

scientific studies indicating potential changes to the global climate if the use of fossil fuels continues to increase. Wind energy offers a viable, economical alternative to conventional power plants in many areas of the country. Wind is a clean fuel; wind farms produce no air or water pollution because no fuel is burned.

The most serious environmental drawbacks to wind machines may be their negative effect on wild bird populations and the visual impact on the landscape. To some, the glistening blades of windmills on the horizon are an eyesore; to others, they're a beautiful alternative to conventional power plants.

8.0 WORLD WIND POWER GENERATION

8.1 U.S. Electricity Capacity: [8]

(Winter'2005)

Fuel Type	Capacity		Generation	
	1,000 MW	Percentage	Billion KWH	Percentage
Fossil /nuclear	823	89.4	3,493	90.7
All renewables	98	10.6	359	9.3
Hydropower	79	8.6	275	7.1
Non-hydropower	**19**	**2.0**	**84**	**2.2**
Wind	7	0.7	11	0.3
Geothermal	2	0.2	13	0.3
Solar	0.5	0.1	1	0.0
Wood/MSW	9	1.0	59	1.5
Total	**920**	**100 %**	**3,852**	**100 %**

8.2 Electricity Generating Capacity in India

Installed Electricity Generation Capacity in India, 1997-2005**[9]**

Type	1997	2002	2003	2004	2005
Hydroelectric	21.65	26.26	26.76	29.50	30.94
Nuclear	2.22	2.72	2.72	2.72	2.77
Geothermal/Solar/ Wind/Biomass	1.27	1.51	1.74	1.87	3.81
Conventional Thermal	59.64	74.55	76.65	77.97	80.90
Total Capacity	85.79	105.05	107.88	112.06	118.42

Note: components may not add to total due to rounding
Source: Government of India

India is currently ranked fifth in the world in terms of total installed electricity generating capacity, and accounts for about 3.5% of the world total. Hydroelectric capacity represents about one-fourth of India's total installed capacity, and overall, India is currently ranked sixth-largest in the world in that category (accounting for about 3.7% of the world's installed hydroelectric generating capacity). There is a large amount of hydroelectric capacity in construction and planning stages, and in particular, hydropower development in the Brahmaputra river basin in eastern India is expected to result in six large power plants, which will add nearly 30,000 megawatts (MW) of generating capacity. The largest of these will be the 11,000 MW Dihang Upper project, which, when completed in about 2012, would become the world's third-largest power plant. Consumption of Electric Generation is shown in Table-1(Appendix).

8.3 INDIAN WIND POWER GENERATION

8.3.1 Wind Potential and State Government Approval

Wind power installations worldwide have crossed 44.7 GW, producing over 28 TWH of energy annually**[10].** The World Energy Council has estimated that, by 2010 A.D., the world wind power capacity can increase to 70 GW under the current policy scenario, and even 100 GW under an ecologically driven scenario. State wise positions in India are shown below:

Sl. No.	State	Gross Potential (MW) (a)	Technical Potential (MW) (b)	Installed Capacity (MW) (c)
1.	Andhra Pradesh	8275	1920	121.1
2.	Gujarat	9675	1780	337.9
3.	Karnataka	6620	1180	584.3
4.	Kerala	875	605	2.0
5.	Madhya Pradesh	5500	845	40.25
6.	Maharashtra	3650	3040	1001.15
7.	Orissa	1700	780	2
8.	Rajasthan	5400	910	358.06
9.	Tamilnadu	3050	1880	2897.34
10.	West Bengal	450	450	1.1
11.	Other States	-	-	1.6
	Total	**45195 MW**	**13390**	**5347 MW**

Source: M N E S

a. Assuming 0.5% of land availability for Wind Power generation in potential areas.
b. As on 31.03.98, assuming 20% grid penetration
c. As on 31.03.2006 achieved 4.5 % of Total Power generation 1,20,000 MW

POSSIBLE GENERATION per MW (in lacs units)	
Tamil Nadu	**16 - 20**
Maharashtra	**14 - 16**
Karnataka	**14 - 20**
Gujarat	**12 - 14**
Andhra Pradesh	**12 - 16**
Madhya Pradesh	**12 - 14**

* India's State Government Approval at **Table-2** (Appendix)

8.3.2 India Hopes to Double Wind Power Generation by 2007[12]

- India hopes to almost double its wind power generation to 10,000 megawatts by the end of 2007 to meet rising energy demand and cut its reliance on dirty coal and costly oil, a minister said on Wednesday.
- Capacity in the world's fourth-largest wind power generator rose by 45 percent in the year to March 2006, to 5,340 megawatts.
- Big industrial units like state-run Oil and Natural Gas Corp. and Indian Oil Corp. are now scrambling to set up wind farms, which attract hefty tax breaks.
- "The trend has been set. We added nearly 2,000 MW in the previous year. I am confident by next year we will have 10,000 megawatts from wind power," Vilas Muttemwar, minister for non-conventional energy sources told Reuters in an interview.
- *"Lot of people are exploring and the experience so far has been good."*
- Electricity produced from wind is currently costlier than that from gas, thermal or hydro plants, but tax breaks, lower equipment import duties, and cheap loans keep prices competitive.
- Indian allows 100 percent of investment in wind projects to be written off against tax over a period of two years.
- With the subsidies, analysts say, the cost of wind generation ranges from 2.50 to 3.50 rupees per unit, or kilowatt-hour, on par with thermal electricity generation. Power produced by old hydro-based units' costs below one rupee.

- The move to wind is not just limited to India as neighbouring China, the world's second-largest power consumer, is witnessing a investment boom in wind power due to the rise in global oil prices and a push for green energy.

8.2.3 Long Term Benefits

- Muttemwar says wind power works out cheaper than conventional energy over the long-term due to almost non-existent running costs. Farms can be set up quickly to bridge power shortfalls.

- "It pays in the long-term since there are no recurring costs unlike thermal power which requires a constant fuel supply," Muttemwar said.

- India produces more than 120,000 megawatts of power, about 12 percent less than total demand.

- The subsidies and a power-starved market have attracted foreign firms such as Danish NEG Micon, the world's biggest wind turbine maker Vestas, Germany's Enercon GmbH, and local player Suzlon.

- India has the potential to produce 65,000 Megawatts of wind power, and the government has identified 210 locations where farms can be installed, and is continuing its search for more locations, the minister said.

- Clean energy such as wind, biogas and solar energy offer an attractive option for India, which imports 70 percent of its crude oil needs at a cost of more than $40 billion a year.

- The ministry of non-conventional energy sources estimates a 200-kilowatt wind turbine replacing a thermal power plant would save 120 to 200 tonnes of coal.

- Burning that much coal would add two to three tonnes of sulphur dioxide, 1.2 to 2.4 tonnes of nitrogen oxide and 300-500 tonnes of carbon dioxide to the atmosphere.

- "Wind energy is future power. There are no emissions and no pollutants. It preserves the environment for future generations," Muttemwar said.

- From zero to 1,500 MW has taken us about 20 years in India but from 1,500 MW to 10,000 MW shall take us ten years. Wind Power has come of age and the next 20 years will see greater around 45,000 MW and enhanced deployment of Wind Electric Generators as a clean and green source of Power Generation both onshore and offshore", says Mr. Bakshi.

9.0 THE FUTURE IS NOW

9.1 WHERE DOES ELECTRICITY COME FROM?

More than 90 per cent of our electricity comes from highly polluting fossil fuels. Not only do they pollute the Earth, damaging the environment, but also they are running out, so new ways of generating electricity are required**[13]**.

9.2 WHERE COULD ELECTRICITY COME FROM?

Did you know that, according to a recent study, there are enough resources of "clean energy" like wind, solar, and bio- energy, to make up 70 percent of our required electricity supply by 2040? That would cut Australia's & many other countries greenhouse gas emissions by half. **[14-17]**

In the near future, wind energy will be the most cost effective source of electrical power. In fact, a good case can be made for saying that it already has achieved this status. The actual life cycle cost of fossil fuels (from mining and extraction to transport to use technology to environmental impact to political costs and impacts, etc.) is not really known, but it is certainly far more than the current wholesale rates. The eventual depletion of these energy sources will entail rapid escalations in price, which -- averaged over the brief period of their use -- will result in postponed actual costs that would be unacceptable by present standards. And this doesn't even consider the environmental and political costs of fossil fuels use that are silently and not so silently mounting every day.

The major technology developments enabling wind power commercialization have already been made. There will be infinite refinements and improvements, of course. One can guess (based on experience with other technologies) that the eventual push to full commercialization and deployment of the technology will happen in a manner that no one can imagine today.

10.0 CONCLUSION

From the above study, it is evident that more than 90 per cent of our electricity comes from highly polluting fossil fuels. Not only do they pollute the Earth, damaging the environment, but they are running out, so new ways of generating electricity are required. In the near future, wind energy will be the most cost effective source of electrical power. Thus following projections are drawn:-

Wind energy offers a viable, economical alternative to conventional power plants in many areas of the country.

- Wind is a clean fuel as wind farms produce no air or water pollution because no fuel is burned.
- There are enough resources of "clean energy" like wind, solar and bio- energy to make up 70 per cent of our required electricity supply by 2040 and major contribution would be of Wind Energy.
- Analysts say the cost of wind generation ranges from 2.50 to 3.50 rupees per unit, or kilowatt-hour, on par with thermal electricity generation.
- Presently Germany, USA, Denmark, India and Spain contribution is more than 80 % of World installed capacity. India's installed capacity is reached 6250 MW by Dec'2006 and ranked fourth largest producer of Wind Power Energy.
- India's installed capacity would be 45,000 MW as against world estimated 1, 20,000 MW by 2020, thereby India would play major roll in wind energy on World map.

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APPENDICES

Power Sector at a Glance ALL INDIA

1.Total Installed Capacity (As on 30.06.2017) - Source : Central Electricity Authority (CEA)

Sector	MW	% of Total
State Sector	1,03,868	31.55%
Central Sector	81,622	24.79%
Private Sector	1,43,740	43.66%
Total	3,29,231	

Fuel	MW	% of Total
Total Thermal	2,20,576	67.0%
Coal	1,94,553	59.1%
Gas	25,185	7.6%
Oil	838	0.3%
Hydro (Renewable)	44,614	13.6%
Nuclear	6,780	2.1%
RES* (MNRE)	57,260	17.4%
Total	329,231	100%

*** Installed capacity in respect of RES (MNRE) as on 31.03.2017.**

RES (Renewable Energy Sources) include Small Hydro Project, Biomass Gasifier, Biomass Power, Urban & Industrial Waste Power, Solar and Wind Energy.

2.0 Power Supply Position

The power supply position in the country during 2009-10 to 2017-18 :

Year	Requirement (MU)	Availability (MU)	% surplus / Deficit	Peak Demand (MU)	Peak Met (MU)	% surplus/ Deficit

2009-10	8,30,594	7,46,644	-10.1	1,19,166	1,04,009	-12.7
2010-11	8,61,591	7,88,355	-8.5	1,22,287	1,10,256	-9.8
2011-12	9,37,199	8,57,886	-8.5	1,30,006	1,16,191	-10.6
2012-13	9,95,557	9,08,652	-8.7	1,35,453	1,23,294	-9.0
2013-14	10,02,257	9,59,829	-4.2	1,35,918	1,29,815	-4.5
2014-15	10,68,923	10,30,785	-3.6	1,48,166	1,41,160	-4.7
2015-16	11,14,408	10,90,850	-2.1	1,53,366	1,48,463	-3.2
2016-17	11,42,929	11,35,334	-0.7	1,59,542	1,56,934	-1.6
2017-18*	3,09,680	3,07,755	-0.6	1,59,816	1,58,393	-0.9

Note: * Upto June 2017 (Provisional), Source : CEA

Generation (Billion Units)