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OPTIMAL USES OF WIND ENERGY LEADING TOWARDS A NOVEL RENEWABLE SOURCE FOR FUTURE SUSTAINABILITY

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ABSTRACT

About since last 150 years technology has led to a greater use of hydrocarbon fuels leading to fast depletion of fossil fuel which has now a day become worldwide problem and making civilization vulnerable. The rapid use of coal, natural gases and uranium are also causing serious concern to mankind due to their limited availability & small stock left. On other hand with the growth of civilization the transport has become essential part of life and use of large number of vehicles for transport is contributing to about 70% of total air pollution. India's vehicular pollution has reached 8 times than it was 20 years before and India is the fifth country in the world, which produces higher rate of emission leading to environmental & ecological imbalance after USA, China, Russia and Japan. Thereby higher rate of emission is contributing to rise in global warming due to reduction 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 / Renewable Energy Sources for sustainable substitution to fossil fuel and other available resources of energy. This paper deals with the optimal use of wind energy, its availability and future scope of development as a non-conventional energy resource for world wide scenario in general and India in particular.

Keywords: fossil fuel, pollution, emission, wind energy, windmills.

1.0 INTRODUCTION

The worldwide fast depletion of conventional energy resources necessitates the search of alternatives such as Non-Conventional Energy Sources and Renewable Energy Sources for meeting the continually increasing energy requirement in transportation sector. In 1956 an US oil geologist Marion King Hubbert [1], predicted and presented through bell shaped curve that US oil production (Hydrocarbon) would be peak in 1970 and decline thereafter. Studies show that transport sector contributes to about 70% of total air pollution, thus there is dire need of having some environmental friendly substitute to these petroleum fuel. 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. China accounted for 72 % of the world's growth in coal consumption equivalent to oil in the year 2006 and India used 16 %, according to BP Statistical

Review Report 2007[2]. The latest report from the climate panel predicted that the global climate [3] is likely to rise around 4 to 5.8 degree Centigrade, if the carbon dioxide concentration in the atmosphere reaches twice the level of 1750. By 2100, sea levels are likely to rise between 15 cm to 60 cm. 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. 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." As per survey conducted in 1998-2000 when India's contribution was 1080 MW against World installed capacity of 14000 MW, India was ranked 5th largest country in terms of installed capacity after Germany, Denmark, USA, and Spain. Since Indian wind energy sector has an installed capacity of 6480 MW as on December 31, 2006, India is now ranked 4th against the world Installed capacity of 65,000 MW[4]. Today, the capital cost of wind power projects range between Rs.4 to 5 crores per MW.

Considering the fiscal benefits extended by the Government this gives a levelised cost of energy generation in the range of Rs. 2.00 to Rs. 2.50 per KWh. Thus, looking in to current scenarios, India would be one of the major player in the global Wind Energy market by year 2020 when estimated generation may reach 45,000 MW and by year 2040, contribution of Wind Energy may lead to act as a Novel Source of future sustainability in the World.

The report [4] released in March' 2005 by Global Wind Energy Council (GWEC) forecasting that wind power has the potential to supply 12 per cent of the World's electricity by 2020 emphasizes its' potential, would result in annual reductions of 1,813 million tons of CO_2 in 2020 from 1,245,000 MW of wind energy installed.

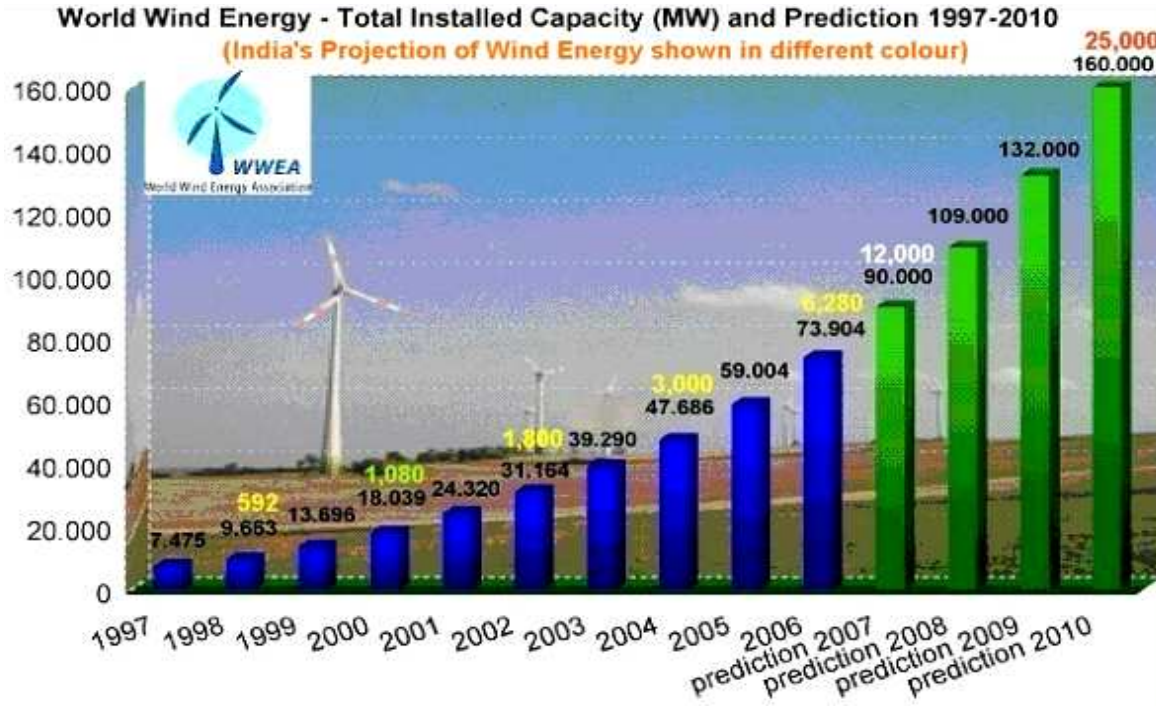

Fig.1 India's Projection of Wind Energy up to year 2010

It is claimed that at the end of 2005 there were 59,004 megawatts (MW) of installed wind capacity [Fig.1], worldwide generating enough clean electricity for the equivalent of 18 million homes. Over the past decade the installed generation

capacity for wind energy, has increased at an average rate of 30% per annum and world installed capacity will reach to 160,000 MW at the end of 2010.

2.0 WINDPOWER AND THE ENVIRONMENT

During 1970s the oil shortages pushed the development of alternative energy sources. In 1990s, the push came from a renewed concern for the environment [7] 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 near zero pollution alternatives to conventional power plants in many areas of the country. Wind is a clean fuel and the wind farms produce no air or water pollution because no fuel is burnt. The only serious drawbacks to wind machines may be their negative effect on wild bird populations and the visual impact on the landscape.

3.0 WORLD WIND POWER GENERATION

The review in Sep'2005 [5-6] shows that the 10- top wind power generation countries so called "World Leaders in Wind Capacity" are contributing about 90% of total installed capacity of world. The country wise contributions of top 10 are given in the **Table-1**(Appendix).

In the past two years some of countries have shown their progress in installed capacity from 25% to 127 % than what they were having up to 2005, see **Table-2** (Appendix). The China, United States, France, Spain, Italy and India have played leading role in enhancing their installed capacity [7-8] of wind power generation as shown in Table-2 as against their available potential. India's available capacity is about 45,000 MW which is proposed to be installed by 2020 and 65,000 MW by 2040.

4.0 ELECTRICITY GENERATING CAPACITY IN INDIA

India is currently ranked fifth in the world in terms of total installed [9] 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-3** (Appendix). The various sources of year wise power generation in India are given below in **Table-4** (Appendix).

5.0 INDIAN WIND POWER GENERATION PROGRAMME

5.1 Wind Potential and State Government Approval

Wind power installations worldwide have crossed 44.7 GW, producing over 28 TWH of energy annually. 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. In India the State wise gross and technical potentials and Installed capacities [10], State-wise Possible Generation and State Government Approvals are shown in **Table-5, Table-6** and **Table-7** respectively (Appendix).

5.2 India Hopes to Double Wind Power Generation by 2007- 08

- India hopes to almost double its wind power generation to 10,000 megawatts by the end of 2007-08 to meet rising energy demand and cut its reliance on dirty coal and costly oil.
- 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 Corporation and

Indian Oil Corporation are now scrambling to set up wind farms, which attract hefty tax breaks.

- Lot of people is 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.
- India allows 100 percent of investment in wind projects to be written off against tax over a period of two years.
- With the subsidies, 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 neighboring 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.

5.3 Long Term Benefits

- 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.
- 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.
- 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.
- It is estimated that a 200-kilowatt wind turbine replacing a thermal power plant would save 120 to 200 tones of coal.
- Burning that much coal would add two to three tones of sulphur dioxide, 1.2 to 2.4 tones of nitrogen oxide and 300-500 tones 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.
- 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 than 45,000 MW and enhanced deployment of Wind Electric Generators as a clean and green source of Power Generation both onshore and offshore [10].

6.0 FUTURE PROJECTION

More than 90 per cent of our electricity comes from highly polluting fossil fuels [11]. Not only do they pollute the Earth, damage the environment, but also they are running out, so new ways of generating electricity are required. According to a recent study, 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 [12].

6.1 progress in windmill technology

The latest technology is continuously introduced into new wind generators. A modern wind generator produces more than 100 times the annual output of a 1980 vintage generator. In the near future, wind energy will be the most cost effective source of electrical power. 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 that would be unacceptable by present standards. The major technology developments [13-19], enabling wind power commercialization have already been made. Of course there will be infinite refinements and improvements. In future, the eventual push to full commercialization and deployment of the technology including other renewable resources [20-24] will happen in big way.

7.0 CONCLUSIONS

From the above study, it is evident that more than 90 per cent of our electricity comes from highly polluting fossil fuels. They are also running out, so new ways of generating electricity are required. Thus in the near future, wind energy will be the most cost effective source of electrical power generation, thereby following conclusions 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.
- The cost of wind generation ranges from 2.50 to 3.50 rupees per unit, or kilowatt-hour, at par with thermal electricity generation.
- Presently Germany, USA, Denmark, India and Spain contribute more than 80 % of World installed capacity. India's installed capacity reached 6250 MW by Dec'2006, 7850 MW by Dec'2007 and striving hard to increase it further.
- India's installed capacity would be 45,000 to 65,000 MW as against world estimated capacity of 1, 000 GW by 2020; thereby India would contribute approximately 4.5 to 6.5%.
- Thus wind energy alone would be a novel energy source in 21st century on World Map as its contribution worldwide would be 12-15% in the total electric power requirement by 2020.

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APPENDICES

Table 1 World Total Wind Power Generation Up to December' 2004

SNo.	Country	Capacity (MW)	Percentage
1.	**Germany**	16,629	35.1
2.	**Spain**	8,263	17.5
3.	**United States**	6,740	14.2
4.	**Denmark**	3,117	6.6
5.	**India**	3,000	6.3
6.	**Italy**	1,125	2.4
7.	**Netherlands**	1,078	2.3
8.	**United Kingdom**	888	1.9
9.	**Japan**	874	1.8
10.	**China**	764	1.6
	Top Ten Total	**42,478**	**89.8**
	Rest of World Total	4,839	10.2
	WORLD TOTAL	**47,317**	**100**

Table 2 World Total Wind Power Generation in past 2007

SNo.	Country	Present Installed Capacity (in MW)	Country wise individual %ge increase in Year - 2007
1.	**Germany**	22,247.4	7.9
2.	**United States**	16,818.8	45.0
3.	**Spain**	15,145.1	30.2
4.	**India**	8,757.0	25.2
5.	**China**	5,899.0	127.0
6.	**Denmark**	3,125.0	-0.4
7.	**Italy**	2,726.1	28.4
8.	**France**	2,455.0	56.7
9.	**Britain**	2,389.0	21.7
10.	**Portugal**	2,130.0	24.1

Table 3 Electricity Generation and Consumption in India, 1995-2005
(in billions of kilowatt-hours)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1.Net Generation	396.0	412.6	411.6	470.7	504.3	529.1	548.0	563.5	556.8	558.33	587.37
2.Hydro-electric	71.9	68.2	73.9	82.2	79.9	73.7	73.0	63.5	68.5	73.77	84.50
3.Nuclear	6.5	7.2	10.4	10.6	11.4	14.1	18.2	17.8	16.4	17.77	16.84

4.Geo / solar / wind / biomass	**0.5**	**0.8**	**0.9**	**1.0**	**2.3**	**2.9**	**3.9**	**4.1**	**4.2**	**n/a**	**n/a**
5.Conventional thermal	317.2	336.1	355.8	376.8	410.7	438.5	453.0	478.2	467.7	466.82	486.03
Net Consumption	369.8	385.2	411.6	439.0	470.1	493.4	510.9	525.4	519.0	n/a	n/a
Imports	1.7	1.6	1.6	1.5	1.4	1.5	1.5	1.5	1.4	1.4	1.4
Exports	0.1	0.1	0.1	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2

n/a - not applicable
Note: generation components may not add to total due to rounding
Source: DOE/EIA and Government of India

Table 4 Installed Electricity Generation Capacities in India, 1997-2005.

Type	**1997 (MW)**	**2002 (MW)**	**2003 (MW)**	**2004 (MW)**	**2005 (MW)**
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

Table 5 Wind potential in India

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	667.0
3.	**Karnataka**	6620	1180	847.0
4.	**Kerala**	875	605	2.0
5.	**Madhya Pradesh**	5500	845	58.0
6.	**Maharashtra**	3650	3040	1485.0
7.	**Orissa**	1700	780	2.0
8.	**Rajasthan**	5400	910	470.0
9.	**Tamilnadu**	3050	1880	3460.0
10.	**West Bengal**	450	450	1.6
11.	**Other States**	-	-	0.5
	Total	**45195 MW**	**13390 MW**	**7114 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 31.03.2007 (achieved 6 % of total Electric Power Generation 1, 20,000 MW).

Table 6 Possible Generation in India

SNo.	**Possible Generation per MW** (in lacks Units)	
1.	**Tamil Nadu**	**16 - 20**
2.	**Maharashtra**	**14 - 16**
3.	**Karnataka**	**14 - 20**
4.	**Gujarat**	**12 - 14**
5.	**Andhra Pradesh**	**12 - 16**
6.	**Madhya Pradesh**	**12 - 14**

Table 7 State Government Approvals

Items	**Wheeling**	**Banking**	**Buy-back**	**Third party-sales**	**Other Incentives**	**Penalty on kVARh consumption**
Andhra Pradesh	2% of energy	-	Presently Rs.3.37 w.e.f 01.04.2004 (frozen for 5 years)	Allowed as per E.Act 2003 subject to APERC Regulations	NOT Available NEDCAP	Van Drawal 0.10p/unit. To Give 10 Lakhs / MW to APTransco 1 lakh /to NEDCAP
Tamilnadu	5% of energy	5% for 12 months	Rs. 2.90/kwh (No Escalation)	Not Allowed	NIL	No generation tax.
Karnataka	5% of energy +1.15Kwh as cross subsidy for 3rd party sale	2% every month for 12 months	Rs. 3.40 / kwh no exalation for 10 years	Allowed to HT consumers	Same as for other industries	No generating tax for 5 years Van Drawal 0.40p/unit
Kerala	To be decided by SERC	-	3.14 for 20 years	-	15% (max Rs. 5 Lakhs)	-
Uttar Pradesh	2% of energy	12 months	Rs. 2.25/kwh (5% Esc. 95-96)	Allowed	Same as for other industries	-
West Bengal	2% of energy	6 months	to be decided on case to case basis	Not Allowed	-	-
Gujarat	4% of energy	6 months	Rs. 3.37/kwh	Not Allowed	-	R.P.<10% energy 0.10 P.>10% 0.25p

Madhya Pradesh	2% of energy +Transmission charges by SERC	Not Allowed	Present Rs.3.90p/kwh	Allowed	Same as for other industries	27 paise per kVARh
Maharashtra	2% of energy +5% T&D loss	2% for 12 months	Rs. 3.50/kwh	Allowed	30% (max Rs. 20 Lakhs per project)	Sales tax (Exemption for 6 years subject to a minimum PLF of 20%)
Rajasthan	2% of Energy	2% for 12 months	Present Rs. 3.32/kwh	Allowed	-	-