WIND AS AN ECO-FRIENDLY SOURCE TO MEET THE ELECTRICITY NEEDS OF SAARC REGION

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Abstract Increased cheap and eco-friendly electric power is vital for the development of the economy of the Third World countries. Though generation capacity has been growing at a reasonable pace, the SAARC region still face a chronic shortage of power with blackouts occurring regularly for both industry and households. The current generating capacity of the Indian sub-continent is about 150,000 MW but this needs to be doubled in the next 10-15 years to meet a situation of "power on demand". Wind power, which has entered the new millenium with a lion's roar, seems to be a promising solution. Furthermore, energy demand is likely to rise dramatically over the next two decades [Renewable Energy World, May 1999]. For developing countries, wind turbines offer an attractive source for power production. This paper reviews the economy of wind energy systems, various other factors that favour wind energy, current global status of wind energy and its future development prospects.

Keywords: *Wind energy; Renewable energy; Wind energy systems; Eco-friendly electric power*

INTRODUCTION

Today's interest in wind as an important alternative source of energy dates from the oil crisis that occurred in the mid-seventies. This interest is continuing, the basic reason for this can be found in the widespread concern about possible damage to the environment, not to mention the fear of possible shortage of the fossil fuels due to increasing exploitation of their finite reserves in the coming decades.

With the steady decrease in availability and the rising cost of natural gas and fuel oil, renewable energy resources are expected to play an increasingly important role in the future world energy scene [Fung et al., 1981].

Wind is able to compete with most conventional energy resources and the world is falling back more and more on the power of wind to energise its development. The deployment of modern wind turbines has resulted in experience in the production and use of wind turbines, which has led to improved turbines and reduced costs of wind-generated electricity.

WIND POWER ECONOMY

Energy Balance (Payback) of Wind Turbines

Wind farms have a high "energy payback" (ratio of energy produced compared to energy expended in construction and operation). Table I. shows the energy balance of different types of power plants [http://www.afm.dtu.dk/wind/].

Table 1: Primary energy payback for various types of power plants

Type of power plant	Payback (months)
Nuclear	0.7
Coal	0.7
Wind @ 4 m/s	6.3 - 22.7
Wind @5.5 m/s	3.8 - 11.4
Monocrystalline@1,000 W/m^2	87
Multicrystalline@1000 W/m^2	85
Amorphous@1,000 W/m^2	56

The energy generated by wind turbines pays for the materials used to make them in a matter of months, according to three separate European studies. In the study three different Midwestern wind farms were found to generate between 17 and 39 times as much energy as is required for their construction and operation, while coal plants generate an average 11 and nuclear plants 16 times as much [http://www.afm.dtu.dk/wind/].

Cost of Wind Energy Systems

Generating Cost

Wind energy today is one of the most cost-competitive renewable energy technologies. As can be

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seen from Table II., the cost of electricity generation by wind is comparable with that of co-generation plants and is much less than solar and photovoltaics. For wind power generation systems, the capital expenditure could range from Rs. 35 million per MW to Rs. 40 million per MW. The generation cost in a wind power unit could be as low as Rs. 2-2.5 per kWh as compared to around Rs. 4 - 4.5 per unit for liquid fuel-based power stations [Power Line, March 2001].

Table 2: Cost comparison of renewable energy products

Source	Capital cost (Rs. Million/MW)	Generation cost (Rs./kWh)
Wind power	35-40	2.25
Small hydro	35-60	1.5 - 3.5
Cogeneration	20-25	2 - 2.5
Solar	30	15 - 20
Photovoltaics	90	5.80
Sea wave	24	1.10

Capital and Operational Costs

One of the major road-blocks in the development and widespread acceptance of renewable energy technologies is the high capital costs involved. For wind power generation systems, the capital expenditure could range from Rs. 35 million per MW to Rs. 40 million per MW. As compared to the other forms of renewable energy, the capital expenditure on wind power projects is low. However, the economics can still not match with the low capital cost of liquid fuel or diesel-based power stations, which can be put up at Rs. 32 million to Rs. 35 million per MW [Power Line, March 2001].

In any case, the long term operating costs of fossil fuel-based power plants cannot be ignored. The generation costs of the fossil fuel-based systems are directly linked to the ever-increasing fuel prices. In sharp contrast to this, the unit cost of power produced by wind turbine is high in first year but comes down over a period of seven years as can be seen from the Table III [Karunanithi et al., 1999].

Table 3: Yearly reduction of unit costs of power production by wind turbines

Year	I	II	III	IV	V	VI	VII
Without depre-ciation	1.0	0.9	0.8	0.7	0.6	0.5	0.4
With depre-ciation	1.0	0.9	0.8	0.7	0.6	0.5	0.4

In the current scenario, when liquid fuel prices are highly volatile, the long term economics of power generation would most definitely favour wind power systems. The high initial investment is compensated by cost free running of wind-mill and low maintenance costs. Other than the cost of turbines, the capital costs include:

- Site costs, e.g.: Roads, Foundations, Electrical work and Electricity grid connection.
- Development costs, such as Meteorological work, Legal, Planning, Environmental-impact assessment, Interest charges during construction, Financial charges; whilst
- Operational costs include those for: Maintenance, Rates, Repairs, Land-rental charges, Site management, Insurance, Decommissioning provision [Trevor et al., 1996].

Capital costs have halved over the last decade and now average about $ 1,000 per kW. They are expected to decline further, to $ 750 to $ 850 per kW, within the next few years. Operation and maintenance costs have dropped four-fold, to 1-1.5 cent per kWh, and are also likely to drop less than 1 cent per kWh by 2005. Besides low maintenance costs, the capacity expansion in a wind-based power unit is much easier owing to its modular design [Power Line, Jan. 2000].

Other Economic Benefits

Aside from actual cost, wind energy offers other economic benefits, which make it even more competitive in the long term:

- Greater fuel diversity and less dependence on fossil fuels, which are often subject to rapid price fluctuations and supply problems. This is a significant issue around the world today.
- Greatly reduced environmental impacts per unit of energy produced, compared with conventional power plants.
- More jobs per unit of energy produced than other forms of energy. According to a 1991 study by the Worldwatch Institute, wind power technology can provide much more jobs per Terawatt-hour produced per year than any other energy technology while saving resources and avoiding future pollution of the environment.
- Long-term income to ranchers and farmers who own the land on which wind-farms are built [http://www.afm.dtu.dk/wind/].

Some Other Favourable Factors

Although wind energy is inherently intermittent, it nevertheless provides some value to utilities in offsetting generating capacity from conventional sources, other than acting as a fuel saver. The Prince Edward Island study has found out that when there are low levels of wind energy on a given power grid, they can displace a sizeable amount of conventional capacity. The reason for this is that although wind is intermittent, conventional generating systems also break down from time to time. A previous investigation, by the Tellus Institute of Boston, Mass, found that even with wind turbines providing 20 percent of the power on a utility system, their average capacity value was 23 percent. The findings were significant because in the past, some have argued that wind-farms should be viewed only as fuel savers, and given no credit for helping a utility avoid adding new power plants [http://www.afm.dtu.dk/wind/].

The other favorable factor is the relatively short gestation period of two to three years for a large fixed wind power project against five to ten years for conventional plants.

The wind plants can also be used autonomously. In places where traditional energy sources are missing or where fuel is not easily supplied (lighthouses for example, small islands and remote countries like the Antarctic continent) but where the wind velocity is high, wind machines even of small or medium sizes constitute an irreplaceable means of producing energy. They are also well suited for providing energy to rural communities in developing countries where the wind velocity is high. In these countries, grids are limited to big towns because of the scattering and low density of rural population. In this connection, it must be pointed out that in windy areas, wind is much more economical than any other source.

Wind power may prove practical for small power needs in isolated sites. But for maximum flexibility, it should be used in conjunction with other methods of power generation to ensure continuity [Nagrath and Kothari, 1994]. A complementary system like Diesel motor–generators or water turbines having a total capacity of at least five or six times the installed wind power can be used. For full utilization of the available wind power, the grid must also be capable of absorbing it at any moment. During windy periods, the excess power delivered by the wind generators can be given to the grid. On the other hand, during periods of non-productive winds, the grid can supply energy to the owners of a wind plant. Thus the network acts as a storage reservoir.

GLOBAL DEVELOPMENTS

The current global installed capacity of wind power is around 16 GW, with 2.5 GW installed in the year 2000 alone. In rupee terms the installed capacity is worth over Rs 55,700 crore. Table IV. shows the current status of wind energy over the globe [Jangamshetti, 2000].

Table 4. Current status of wind energy

Installed Capacity	End of 1996 in MW	End of 2000 in MW
World	6200	>16000
USA	1800	>2500
Europe	3400	>5500
Others (Mainly Asia)	180	>1000
India	820	>1000

Of the total installation capacity in the world, Germany, the US, Denmark and Spain account for over 80 percent. Europe accounts for the bulk of this capacity at 9,737 MW followed by North America 2,619 MW, Asia 1,376 MW, Pacific Region 116 MW, South and Central America 87 MW, and Middle East and Africa 39 MW.

Wind power has entered the new millenium with a lion's roar. The wind energy capacity around the world has grown from under 2,000 MW in 1990 to around 16,000 MW at the end of 2000. Growth in the past three years has been led by Germany, the US, Spain, Denmark and India. In 1999, the annual installation of wind power capacity increased by 51 percent. Approximately 81 percent of the new capacity was installed in Europe. In the recent years, wind power industry recorded over 40 percent growth. Germany is the industry leader with 4,445 MW operating capacity. US has an installed capacity of 2,500 MW. After Germany and US, the world's main wind energy producers are Denmark at 1,742 MW, Spain at 1,530 MW and India at 1,095 MW.

In Europe, Germany, Spain and Denmark lead the others. The Netherlands has an installed capacity of 433 MW, the UK 362 MW, Italy 277 MW, Sweden 220 MW, Greece 87 MW and Ireland 73 MW. The rest of the European countries have less than 100 MW. In America, US leads as stated above. Canada has an installed capacity of 127 MW, Mexico 2 MW and the rest of America 94 MW. In Asia, India is far ahead of its neighbours, China comes next with 262 MW, Japan 68 and the others 11 MW. The rest of the world has a total installed capacity of 151 MW. Of this Australia and New Zealand account for 45 MW, Pacific Islands 5 MW, North Africa 64 MW, West Asia 18 MW and former Soviet Union 19 MW [Power Line, March 2001; The Indian Express, July 2000].

INDIA - THE GREAT ACHIEVER

With a gross wind power potential of 20,000 MW (technically exploitable potential of about 9,000 MW), India is recognized as a "wind superpower" by the Washington-based Worldwatch Institute. However, much of the potential still remains unexploited. India can today boast of around 1,200 MW of installed capacity and is ranked fifth in the world in terms of installed capacity after USA, Germany, Denmark and Spain. Even though this comprises just over one percent of the total installed capacity in the country, the development initiative in this area of renewable energy has been noteworthy [Renewable Energy World, May 1999].

In 1985, the government of India had set up a wind monitoring and mapping program through the Ministry of Non-Conventional Energy Sources (MNES) throughout the country. This national program for the development and harnessing of power generation in a planned and phased manner was initiated with the following objectives:

- Wind resource surveys.
- Technology assessment and the adaptations required to suit Indian conditions.
- Demonstration wind farms.
- Indigenous production and commercialisation.

In the same year itself i.e. in 1985, an extensive wind resource assessment was carried out by the Indian Institute of Tropical Meteorology. It has been the world's biggest program with over 600 monitoring stations. Some new initiatives taken under this wind power program included:

- Re-assessment of gross potential.
- Preparation of master plans for 80 potential sites in ten states.
- Taking up of demonstration projects in West Bengal and Rajasthan.
- Establishment of Center for wind energy technology in Tamilnadu.
- Encouragement to Public sector companies, power utilities and large corporate houses like NHPC, NTPC, BHEL, IPCL, BSES, etc. to set up wind power projects.

This program has now emerged as an important thrust area of the development and is being carried out in 28 states/union territories of the country [Power Line, Dec. 1996]. It was during 1986, wind farm activity started in India with a boom with the installation of five wind farms at Mandvi, Okha, Devgarh, Puri and Tuticorn consisting mostly of imported machines of 55 kW capacity from Denmark. In the second phase, machines in the range of 100 kW were introduced during 1988. The installed capacity up to 1991-92 was 50 MW. The growth in India has been phenomenal after the entry of private entrepreneurs during 1992, the year, which saw the ushering of an LPG (Liberalisation, Privatisation and Globalisation) era in India. In 1992 itself 32 MW capacity was added with the installation of 247 generators at 13 locations in seven states. During 1994, higher capacity machine of 500 kW was introduced. The installed capacity in India by March 1994 was 192 MW, which had grown to 370 MW by March 1995. Thus, 178 MW was added in one year whereas the installation of first 72 MW took 8 years. In the year 1997, the installed capacity of wind generation was about 750 MW and the locations were: Okha, Madhi, Mandri, Lamba and Tuna in Gujarat; Tuticorin, Kayathar and Muppandhal in Tamilnadu; Puri in Orissa; Deogarh in Maharashtra; Thirumala in Andhra Pradesh; Kheda in Madhya Pradesh and Tala Cauvery in Karnataka. BHEL had then developed two proto-types of 55 kW grid connected Wind Electric Generators (WEGs), installed and field-tested. Based on this, the then, Department of Non conventional Energy Sources (DNES) took up a 500 kW wind farm project with indigenously developed machines. The project commissioned by BHEL at Tuna was totally indigenously planned and executed. In addition, prototype of 200 kW machine with 50 percent indigenous content was completed, installed and synchronised with the grid at Kayathar in Tamilnadu and at Lamba in Gujarat [Karunanithi et al., 1999; Krithivasan, 1996].

Today, as a result of the government's efforts, over 160 potential sites have already been identified and there are about 53 MW demonstration projects at 22 locations. About 1000 MW commercial projects are there at all these locations and over four billion units are fed to the grid. About 15 manufacturing companies are engaged in the production of wind turbine equipment. The country had 4051 wind turbines, which had the capacity to produce 1022.075 MW in March-end 1999 (MNES put the total capacity at 1155.065 MW). On March 31, 2000, the country had 4,431 installed wind turbines with a capacity to produce 1140.205 MW power, showing an increase of 118.270 MW and 380 wind turbines [Power Line, Jan. 2000].

Wind power would not have reached the present level of capacity without the incentives and promotional measures that have been put in place by the Government of India. The governments of the other countries of the SAARC region should also come forward and take some strong measures to promote and activate wind power. Since it is these countries which face a chronic shortage of power, strong will and concerted efforts are required to promote wind industry, which is destined to have very bright growth prospects in the near future. India has already set an example before the world by leading the wind power industry to new heights and glory.

FUTURE PROSPECTS

The strong belief in the continuing growth of wind power will be endorsed by an improved economy beyond the year 2004. In the revised forecast for the coming five years, growth rate of 20 percent per year is seen and the resulting annual sales by 2004 is estimated to be over 9,000 MW per year. Beyond year 2004, a more aggressive development especially in Asia is predicted. The future beyond 2004 in Asia is expected to be of rapid growth, from 1300 MW a year to almost 6000 MW a year by 2009. In Europe, there will be stable growth with about 7000-9000 MW a year; America will have strong growth from 1000 MW a year in 2005 to 3000 MW a year by 2009. In the rest of the world, it will be from 1200 MW a year to 6000 MW a year by 2009 [The Indian Express, July 2000].

Projections indicate that ten percent of the 240,000 MW (i.e. 24,000 MW) installed capacity requirement will come from renewables by 2012. Wind power is expected to contribute about 50 percent (or 12,000 MW) of this capacity. Steady technological advance will, in the view of experts, halve the cost of wind power by 2030. The February 2000 issue of "Windpower monthly" magazine states, that wind turbine costs have fallen by 15 percent with each doubling of worldwide capacity, and that capacity is doubling every three years. Going by the historical growth rate of over 25 percent for wind power generation, use of wind as an alternative source of energy is most likely to emerge as the most preferred energy option the world over [http://www.afm.dtu.dk/wind/].

World-over the price per unit of wind power has been declining. Wind power is now competitive with electricity from fossil fuel and cheaper than that from nuclear power. The price drop in wind power is expected to continue. The sources of cost reduction are design improvements and cut in the weight of WTG's, improved performance, and increased conversion efficiency and economy of scale i.e. gains from steady serial production and optimisation of logistics. In designing the wind turbines, the main priorities today are efficiency, cost effectiveness, reliability, ease of maintenance, noise reduction and the convenience with which the turbine can be transported and erected. The newer designs are more efficient, so more electricity is produced from more cost effective turbines. The cost of financing is also falling as lenders gain confidence in the technology. Wind power will become even more competitive as the cost of using fossil fuels and nuclear power rises [http://www.afm.dtu.dk/wind/; The Indian Express, July 2000; Shikha et al., 2000].

CONCLUSIONS

In comparison with previous years, the position of wind energy in the world energy market has improved. This is because not only the petroleum prices have considerably increased over the last years, but also because the technology of wind power systems has greatly improved during the time. Wind power generates electricity from an energy source that never depletes and never increases in price. The electricity produced by these systems could save several billion barrels of oil and avoid many million tons of carbon and other emissions, such as sulphur oxides and nitrogen oxides [Thomas and Urquhart, 1996]. The wind industry is destined to have very bright growth prospects in the near future. Moreover, the downward trend in wind turbine costs is no less than stunning. Costs vary between different countries but the trend everywhere is the same - wind energy is getting cheaper. Wind turbines themselves cost less as technology improves and the number being manufactured increases.

In the power-starved developing countries, especially in Bangladesh, India and China, wind power is the viable source of electricity, which can be installed and transmitted very rapidly even in remote, hilly and inaccessible areas [Shikha et al., 2000]. India has already set an example before the world by leading the wind power industry to new heights and glory. The other countries of the SAARC region which face regular blackouts throughout the year should also come forward and take some strong measures to promote and activate wind power. Strong will and concerted efforts are required to promote wind industry in this region. Thus, for developing countries, wind turbines offer an attractive source for power production.

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