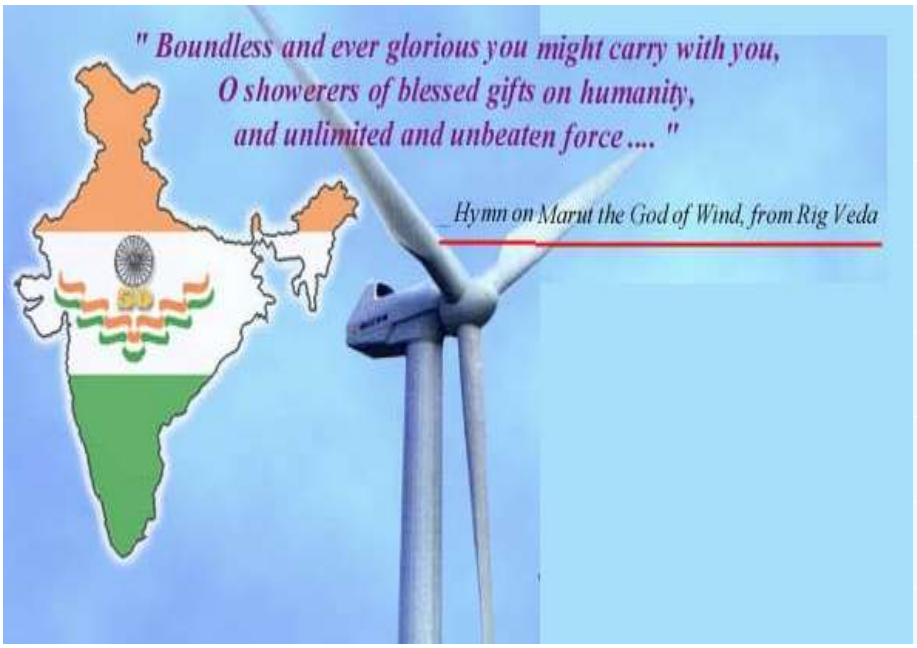
Wind Energy – Potential & Global Scenario



MOHAMMED KABIRUDDIN

MS – Energy Systems, UPES

5/13/2008

Contents

Executive Summary

The global market for wind power has been expanding faster than any other source of renewable energy. From just 4,800 MW in 1995 the world total has multiplied more than twelve-fold to reach over 59,000 MW at the end of 2005.

The international market is expected to have an annual turnover in 2006 of more than € 13 billion, with an estimated 150,000 people employed around the world. The success of the industry has attracted investors from the mainstream finance and traditional energy sectors. In a number of countries the proportion of electricity generated by wind power is now challenging conventional fuels. In Denmark, 20% of the country's electricity is currently supplied by the wind. In Spain, the contribution has reached 8%, and is set to rise to 15% by the end of the decade.

These figures show that wind power is already able to provide a significant input of carbon-free electricity. In 2005, the global wind energy sector registered another record year, with a total of 11,531 MW of new capacity installed. This represented a 40.5% increase on an annual basis and a 24% cumulative growth.

Wind power is now established as an energy source in over 50 countries around the world. Those with the highest totals in 2005 were Germany (18,428 MW), Spain (10,027 MW), the USA (9,149 MW), India (4,430 MW) and Denmark (3,122 MW). A number of other countries, including Italy, the UK, the Netherlands, China, Japan and Portugal, have reached the 1,000 MW mark.

Drivers for Wind Energy

The growth of the market for wind energy is being driven by a number of factors. These have combined in a number of regions of the world to encourage political support for the industry's development.

1. Security of supply:

In the absence of committed energy efficiency measures, the International Energy Agency (IEA) predicts that by 2030, the world's energy needs will be almost 60% higher than now. At the same time, supplies of fossil fuels are dwindling. Some of the major economies of the world are having to rely increasingly on imported fuel, sometimes from regions of the world where conflict and political instability threaten the security of that supply.

By contrast, wind energy is a massive indigenous power source which is permanently available, with no fuel costs, in virtually every country in the world.

2. Environmental concerns:

The impetus behind wind power expansion has come increasingly from the urgent need to combat global climate change. This is now accepted to be the greatest environmental threat facing the world. Under the 1997 Kyoto Protocol, OECD member states are committed to cut their CO_2 emissions by an average of 5.2%. In the developing world, more immediate concern comes from the direct environmental effects of burning fossil fuels, particularly air pollution.

Other environmental effects resulting from the range of fuels currently used to generate electricity include the dangers of fossil fuel exploration and mining, pollution caused by accidental oil spills and the health risks associated with radiation. Exploiting renewable sources of energy such as wind power avoids these risks and hazards.

3. Economics:

As the global market has grown, wind power has seen a dramatic fall in cost. A modern wind turbine annually produces 180 times more electricity at less than half the cost per unit (kWh) than its equivalent twenty years ago. At good locations wind can compete with the cost of both coal and gas-fired power. The competitiveness of wind power has been further enhanced by the recent rise in the price of fossil fuels.

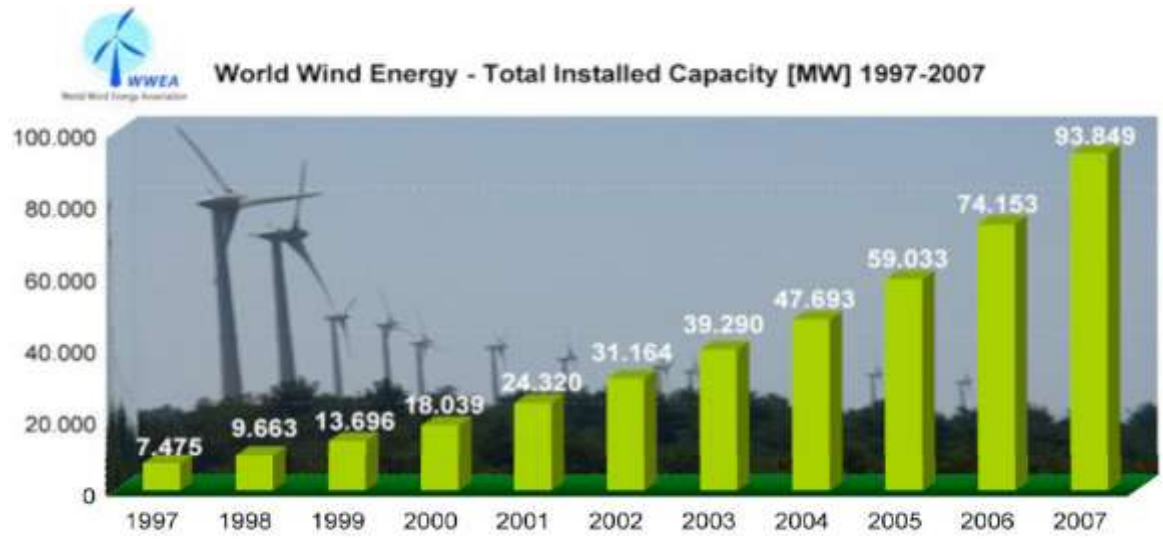
If the “external costs” associated with the pollution and health effects resulting from fossil fuel and nuclear generation were fully taken into account, wind power would work out even cheaper.

THE GLOBAL STATUS OF WIND POWER

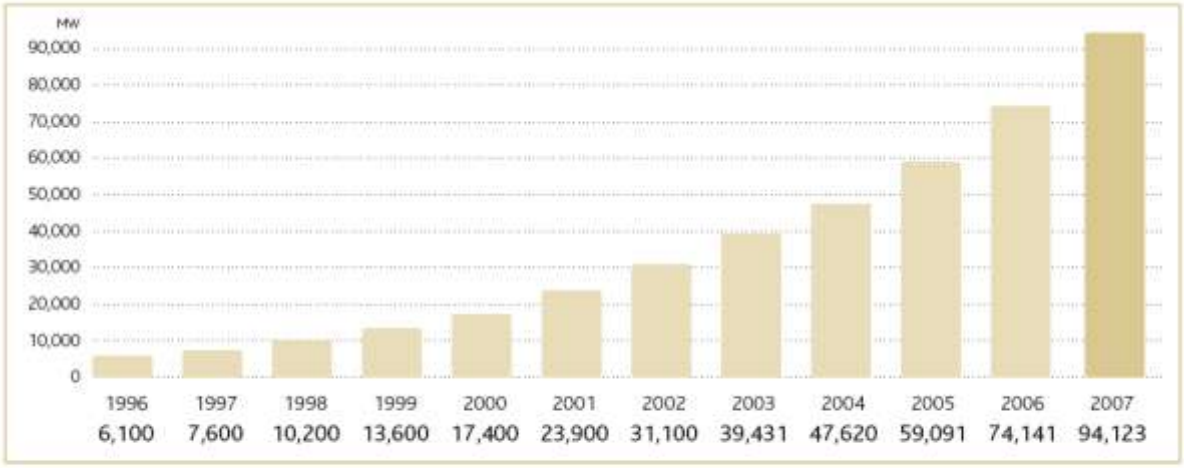
- Wind turbines generate more than 1 % of the global electricity
- Worldwide Capacity at 93,8 GW– 19,7 GW added in 2007
- Wind energy is used in more than 70 countries – USA, Spain, India and China take the worldwide lead.

Dr Anil Kane, President of the World Wind Energy Association*: "The year 2007, all in all, was a very successful year for the wind industry worldwide. However, there are several developments that make us feel concerned: 20 out of the top 40 markets have decreased the volume of additional capacity and only 18 countries have been able to increase their size.*

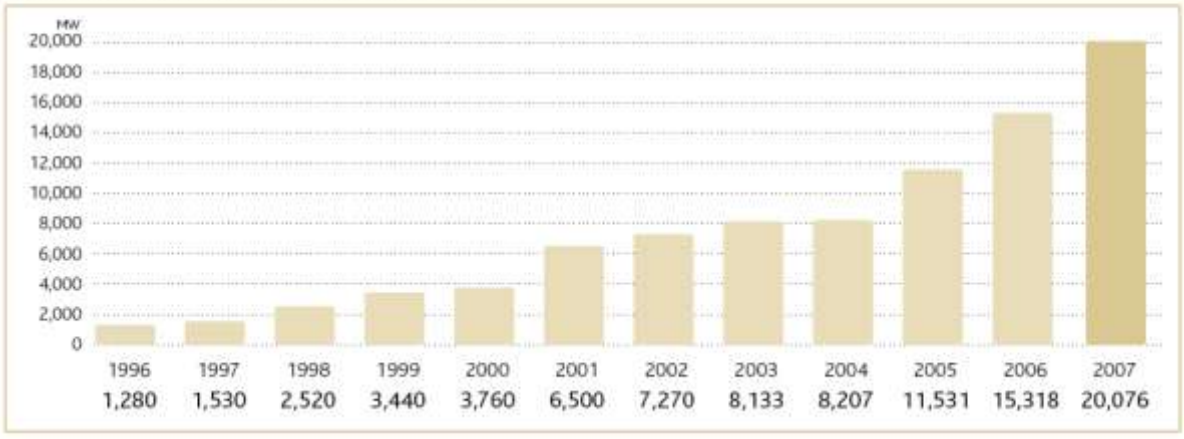
Another concern is that most of the developing countries are far behind the development of the leading wind energy countries. With today the emerging countries India and China amongst the top five wind markets, there should be sufficient motivation for the governments as well as for international donor organisations to launch effective and substantial international deployment programmes. We need a stronger support for investment in renewable energies like wind especially in the developing countries in order to ensure a truly sustainable development."



GLOBAL CUMULATIVE INSTALLED CAPACITY 1996-2007



GLOBAL ANNUAL INSTALLED CAPACITY 1996-2007



Source: GWEC

Wind power is now established as an energy source in over 50 countries around the world. Those countries with the highest total installed capacity are Germany (18,428 MW), Spain (10,027 MW), the USA (9,149 MW), India (4,430 MW) and Denmark (3,122 MW). A number of other countries, including Italy, the UK, the Netherlands, China, Japan and Portugal, have reached the 1,000 MW mark.

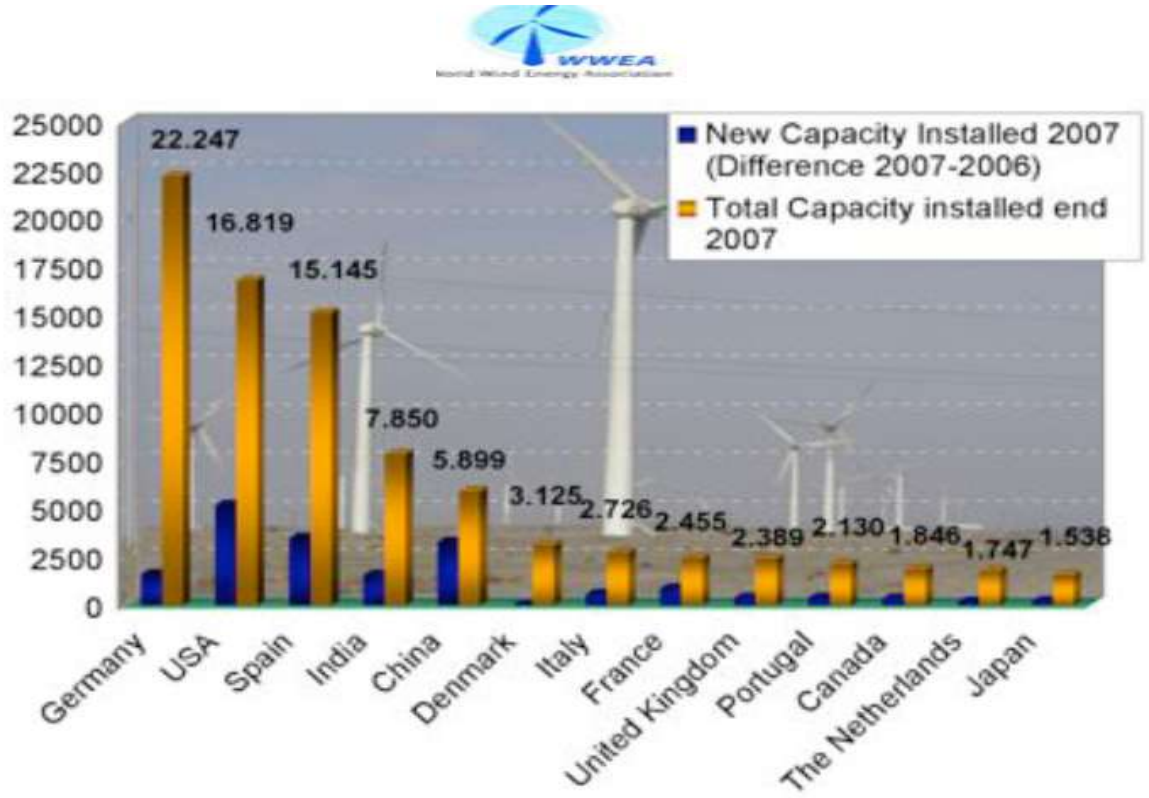
	MW	%
Germany	22,247	23.6
US	16,818	17.9
Spain	15,145	16.1
India	8,000	8.5
China	6,050	6.4
Denmark	3,125	3.3
Italy	2,726	2.9
France	2,454	2.6
UK	2,389	2.5
Portugal	2,150	2.3
Rest of world	13,019	13.8
Total top 10	**81,104**	**86.2**
Total	**94,123**	**100.0**

Source: GWEC

I. Europe

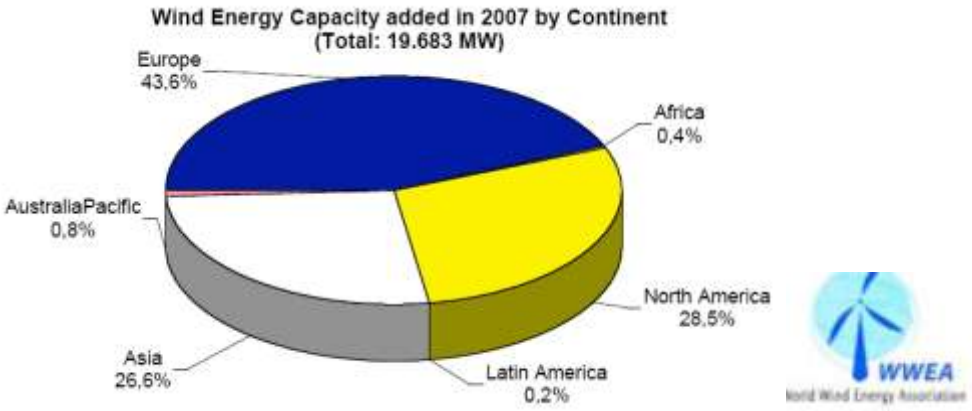
The European Union still leads the world, with over 40,500 MW of installed wind capacity at the end of 2005, representing 69% of the global total. This has already achieved, five years ahead of time, the target set by the European Commission for 40,000 MW by 2010. Wind energy expansion in the EU has been driven by individual member states' policies to encourage renewable energy.

These incorporate a range of financial incentives, including investment grants and premium tariffs, with the aim of making a contribution towards the reduction of greenhouse gas emissions. In 2001 an EU directive on renewable energy set each member state a target for the proportion of renewable energy it should achieve by 2010. The overall European target is for 21% of electricity supply. **The European Wind Energy Association (EWEA) predicts that by 2010, wind energy alone will save enough greenhouse gas emissions to meet one third of the European Union's Kyoto obligation**. EWEA's current targets are for 75,000 MW of wind capacity in Europe by 2010, 180,000 MW by 2020 and 300,000 MW by 2030.



The leading country for wind energy in Europe is Germany. Encouraged by successive laws, most recently the 2000 Renewable Energy Sources Act (updated in 2004), generators of wind power have been paid a premium tariff for their output, gradually reducing over a 20 year contract period. This policy mechanism has proved extremely successful, attracting a large number of

small business investors, and resulting in double digit annual growth rates since the 1990s.



II. North America

In 2006, nearly a quarter of new global capacity was installed in North America, where the total increased by 37%. Wind energy gained momentum in both the United States and Canada. The birthplace of large scale wind power deployment in California during the 1980s and early 1990s, the United States is experiencing a revival which could soon see it match the success of the European market leaders. With large open spaces available for development, many US states have an excellent wind regime and a growing demand for energy that avoids the volatility of fossil fuel prices.

The US industry shattered all previous annual records in 2006 to install nearly 2,500 MW of new capacity. This brought the country's total wind generating capacity up to more than 9,100 MW. The industry is expected to turn in an even better performance in 2006, with new installations likely to top 3,000 MW.

Spreading out from its Californian base, there are now utility scale developments across 31 US states. New wind farms completed in 2007 include twelve projects of 100 MW or more, ranging geographically from the 140 MW Maple Ridge project in New York to the 150 MW Hopkins Ridge project in Washington State, in the Pacific Northwest. The largest single project completed last year was the 210 MW Horse Hollow wind energy centre in Texas. Texas added some 700 MW of wind in 2005 – the largest amount of any state – bringing it close to long-time national leader California.

- ✓ Growth in the US market is largely due to the current three year window of stability provided by the federal incentive for wind energy, the Production Tax Credit (PTC). For the first time in the credit's history, the US Congress extended the PTC before it expired, taking it through to the end of 2007. As a result, the wind industry is looking forward to several record-breaking years in a row.

III. Asia

The Asian continent is developing into one of the main powerhouses of wind energy development, accounting for 19% of new installations in 2006. *With a growth rate of over 46%, total capacity in the region reached nearly 7,000 MW. The strongest Asian market remains India, with the installation of over 1,430 MW of new capacity last year taking its total to 4,430 MW. This pushed it into fourth position in the international wind power league table.* **The**

Indian Wind Turbine Manufacturers Association (IWTMA) expects between 1,500 and 1,800 MW to be commissioned every year for the next three years.

Incentives are provided to the wind energy sector by the Indian government in the form of tax breaks and tax reductions. The 2003 Electricity Act also established State Electricity Regulatory Commissions in most states with a mandate to promote renewable energy through preferential tariffs and a minimum obligation on distribution companies to source a certain share of their electricity supply from renewable's. Tariffs for grid connected wind farms vary from state to state.

Over the past few years, both the government and the wind power industry have succeeded in injecting greater stability into the Indian market. This has encouraged larger private and public sector enterprises to invest. It has also stimulated a stronger domestic manufacturing sector; some companies now source more than 80% of the components for their turbines in India. This has resulted in both more cost effective production and additional local employment. The geographical spread of Indian wind power has so far been concentrated in a few regions, especially the southern state of Tamil Nadu and Karnataka, which accounts for more than half of all installations. This is beginning to change, with other states, including Maharashtra, Gujarat, Rajasthan and Andhra Pradesh, starting to catch up. With the potential for up to 65,000 MW of wind capacity across the country (IWTMA estimate), progress in India should be further accelerated over the next decade.

With its large land mass and long coastline, China is rich in wind energy potential. The Chinese Meteorology Research Institute estimates the land-based exploitable wind resource to have the potential for 253 GW of capacity. A further 750 GW could be provided by offshore projects.

The current goal for wind power in China is to reach 5,000 MW by the end of 2010. Looking further ahead, 30 GW of wind power has been proposed by the Chinese government in its long term planning up to 2020. By the end of that year it is estimated that, in order to satisfy growing demand, total power capacity in China will have reached 1,000 GW. Wind generated electricity would by then represent 1.5% of total power production.

The wind energy industry in Japan has also been expanding, partly spurred by a government requirement for electricity companies to source an increasing percentage of their supply from renewables (Renewable Portfolio Standard-type law), partly by the introduction of market incentives. These include both a premium price for the output from renewable plants and capital grants towards clean energy projects. The result has been an increase in Japan's installed capacity from 461 MW at the end of fiscal year 2002 to more than1,000 MW by March 2006. The official government target for wind power in Japan is 3,000 MW by 2010. The main factors which could delay this being achieved are the relatively low level of the percentage target and the difficulties encountered by some wind projects because of turbulent and unstable weather conditions, especially in mountainous regions.

South Korea and Taiwan have also experienced strong growth in 2005, with close to 100 MW of installed capacity each by the end of the year. The

Philippines are estimated to have the highest wind energy potential in the Southeast Asian region, although only one wind farm of 25 MW had been installed by December 2005. The Philippines government has set a target of 417 MW within ten years, while the US-based National Renewable energy Laboratory has concluded that the country could support over 70,000 MW of installed capacity, delivering more than 195 billion kWh per year.

IV. Australia

Australia enjoys one of the best wind resources in the world, resulting in phenomenal capacity factors in many regions with predominantly open farmland. **Growth of the country's installed capacity almost doubled in 2006, with the addition of 328 MW, taking the total to 708 MW. At the same time approximately 6,000 MW of projects are in various stages of pre-construction development.**

The main national incentive for wind energy is the Mandatory Renewable Energy Target, which has a modest goal for 9,500 GWh of renewables generation by 2010 – a little over 1% of Australia's electricity demand. The Australian Wind Energy Association (Auswind) has called for this to be increased to 10%.

Although some individual states are planning to introduce more ambitious incentive schemes, such as the Victoria state government's target for 10% of renewable energy capacity by 2010, Auswind argues that federal policy needs to recognise that wind energy is a mature technology which

requires specific mechanisms to address the price gap between it and that of conventional fossil fuel generation. The industry believes that nationally, at least 600 MW of new annual capacity is required for the renewable energy industry to continue growing and for Australia to maintain a wind energy manufacturing base.

Although only 168 MW of wind capacity was installed by the end of 2005, New Zealand is equally poised to become a dynamic market. After a quiet period, almost 1,000 MW of projects have consent to start construction, with the potential for 2,000 MW of future capacity to follow on.

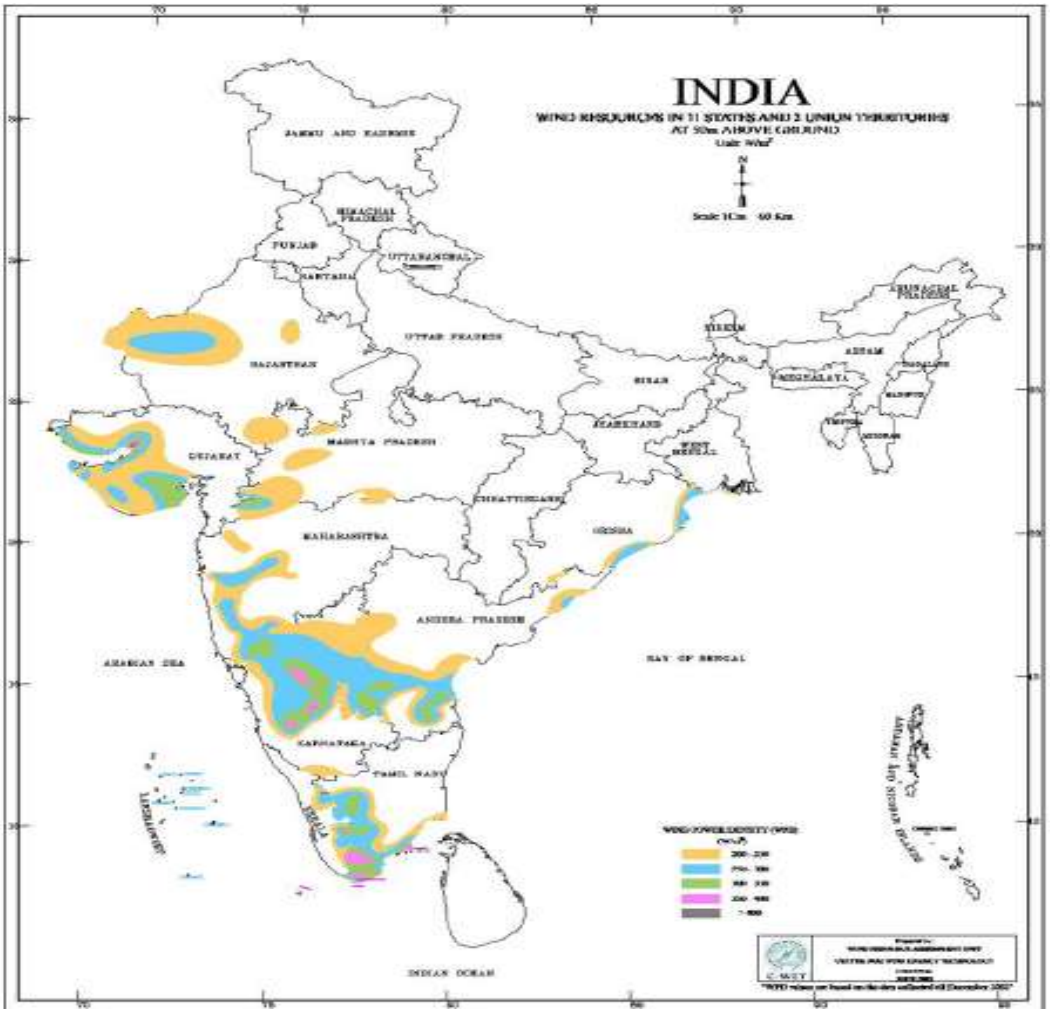
V. Africa

The potential for large scale wind power development in Africa is concentrated in the north and the south, with relatively low wind speeds experienced in the central belt. In the north, there has been development in Morocco, with 64 MW installed and a national action plan to install 600 MW by 2010, whilst Tunisia is waiting for its first 60 MW project to come to fruition.

The most successful country has been Egypt, where several large wind farms have been constructed within an 80 km2 designated zone at Zafarana on the Gulf of Suez. Most of these have been completed with the support of European government aid agencies. A further area of 700 km2 at Gabal El-Zayt on the Gulf has now been earmarked to host a 3,000 MW wind farm. This site enjoys an excellent average wind speed of 10.5 metres/sec.

From a current level of 145 MW, the Egyptian government's New and Renewable Energy Authority is looking for the country to install 850 MW by 2010. By 2020-25 the total could have reached 2,750 MW. In the south, South Africa saw its first small installation in2002, but larger projects have yet to be encouraged by the right market incentives.

VI. Indian Scenario



Source : http://www.cwet.tn.nic.in/html/departments_wpdmap.html#

In India the largest capacity wind turbine of 1650 kW has been recently installed in Tamil Nadu by one of the manufacturers.

MNRE(Ministry of New and Renewable Energy) are implementing the world's largest wind resource assessment programme, which forms the backbone of their wind exploitation efforts. Preliminary estimates indicate a potential of about 45,000 MW. Scientific surveys are being intensified to identify specific viable and potential sites. A recent study undertaken to re-assess the potential, places it at about 60,000 MW. Assuming a grid penetration of 20%, a technical potential of about 15192 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.

Today, we have a wind power installed capacity of 7320 MW in the country, out of which about 7250 MW is accounted for by commercial installations. About 33.5 billion units of electricity have been fed to the grid so far. A good local production base for wind turbines now exists in the country, with 8 manufacturing companies active in this sector.

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 government has introduced a package of incentives which includes tax concessions such as 80% accelerated depreciation, tax holidays for power

generation projects, soft loans, customs and excise duty reliefs, liberalised foreign investment procedures, etc.

Wind Potential and State Government Approval

Wind power installations world-wide have crossed 86.3 GW, producing over 52 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 a ecologically driven scenario.

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
3	Karnataka	6620	1180	847
4	Kerala	875	605	2.0
5	Madhya Pradesh	5500	845	58
6.	Maharashtra	3650	3040	1485
7	Orissa	1700	780	2
8	Rajasthan	5400	910	470
9.	Tamilnadu	3050	1880	3460
10	West Bengal	450	450	1.6
11.	Other States	-	-	0.5
	Total	45195 MW	13390	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

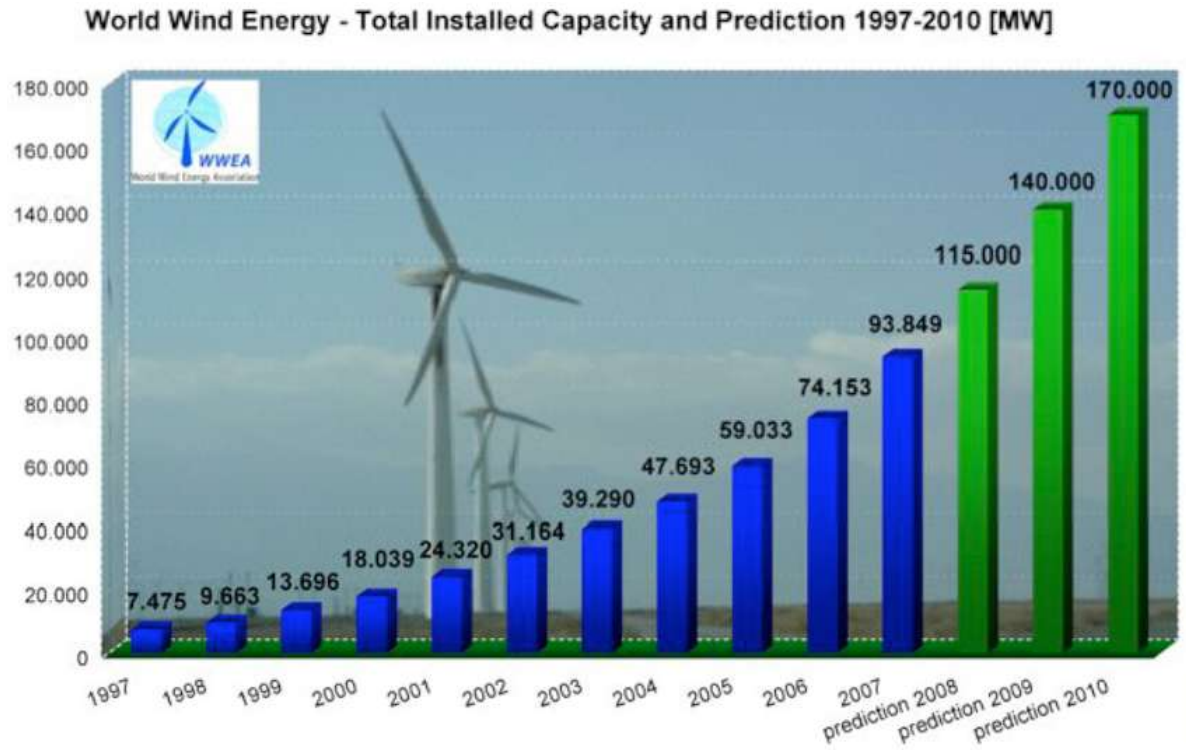
IREDA and other financial institutes mostly in the private sector are playing a significant role in promoting Renewable Energy Projects, in general and Wind Energy Projects in particular

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**

DRIVERS FOR WIND ENERGY

❖ Security of Supply

Global demand for energy is increasing at a breathtaking pace. The International Energy Agency (IEA) predicts that by 2030, the world's energy needs will be almost 60% higher than now. ***Two-thirds of this increase will occur in China, India and other rapidly developing economies; these countries will account for almost half of global energy consumption by 2030****.*



If this sharp increase in world energy demand actually takes place, it would require significant investment in new generating capacity and grid infrastructure, especially in the developing world. **The IEA estimates that the global power sector will need to build some 4,800 GW of new capacity between now and 2030.** This will require investment of approximately US$2 trillion (€1.7 trillion) in power generation and US$1.8 trillion in transmission and distribution networks. Industrialised countries face a different but parallel situation. Whilst demand is increasing, the days of overcapacity in electricity production are coming to an end. Many older power plants will soon reach the end of their working lives.

The IEA predicts that by 2030, over 2,000 GW of power generation capacity will need to be built in the OECD countries, including the replacement of retiring plants. Without energy efficiency measures, electricity demand in the European Union is expected to increase by 51% between 2000 and 2030, requiring investments in power generation of around €625 billion (US$ 760 billion). About half of this is needed for the replacement of existing power plants.

❖ *Environmental Concerns*

The impetus behind wind power expansion has come increasingly from the urgent need to combat global climate change. This is now accepted to be the greatest environmental threat facing the world. The UN's Intergovernmental Panel on Climate Change projects that average temperatures around the world will increase by up to 5.8°C over the coming century.

This is predicted to result in a wide range of climate shifts, including melting of the polar ice caps, flooding of low-lying land, storms, droughts and violent changes in weather patterns. Responsibility for climate change lies with the excessive build-up of greenhouse gases in the atmosphere, a trend encouraged by the world's growing industrialisation. Within energy use, the main culprit is fossil fuels, whose combustion produces carbon dioxide, one of the main greenhouse gases.

A shift in the way the world produces and consumes energy is therefore essential. Alongside more efficient use of energy, renewable sources of energy offer the potential for deep cuts in carbon dioxide emissions.

The main international driver for combating climate change has been the 1997 Kyoto Protocol. This set national targets for OECD member states to cut their CO_2 emissions by an average of 5.2% from their 1990 levels by 2012. Combating climate change is only a secondary driver for wind energy in the developing world.

More immediate concern comes from the direct environmental effects of burning fossil fuels, particularly air pollution. This is a major issue in countries like India and China, which use large quantities of coal for power generation.

❖ Economics

As the global market has grown, wind power has seen a dramatic fall in cost. A modern wind turbine annually produces 180 times more electricity and at less than half the cost per unit (kWh) than its equivalent twenty years ago. At good locations wind can compete with the cost of both coal and gas-fired power.

The cost of wind power generation falls as the average wind speed rises. Analysis by industry magazine Wind Power Monthly (Jan 2006) shows that at a site with an average wind speed of more than 7 metres per second, and a **capital cost per installed kilowatt of approximately € 1,000 (64000 INR),** wind is already cheaper than gas, coal and nuclear.

A typical 1 MW wind turbine would generate about 28 to 30 lakhs units of electricity which costs Rs 4.5 to 5.0 Crores. With the present power cost, the simple payback period would be about 3 – 4 years.

RENEWABLE SOURCES COST OF GENERATION		
SOURCE	*CAPITAL COST (Rs. Crores/MW)*	*GENERATION COST (Rs./KWH)*
WIND POWER	3.5	2.25
SMALL HYDRO	3.5 -6.0	1.50 -3.50
CO-GENERATION	2.0-2.5	2.00-2.50
SOLAR	30.0	15.00-20.00
PHOTOVOLTAIC	9.0	5.80
SEA WAVE	2.4	1.10
BIOMASS GASIFIER		

Source: TNEB (Nov.'98)

The competitiveness of wind power has been further enhanced by the recent rise in the price of fossil fuels, in particular the gas used to fuel power stations. In the United States, this has made wind generated electricity an increasingly attractive option for power utilities faced with rising costs. Against the volatility of conventional electricity costs, wind offers an energy source which has no fuel element and is unaffected by world trade issues.

Direct cost comparisons between wind power and other generation technologies are misleading, however, because they do not account for the "external costs" to society and the environment derived from burning fossil fuels or from nuclear generation. These external costs, including the effects of air pollution and radiation emissions, are not included in electricity prices.

❖ Advantages of Wind Power:

- It is one of the most environment friendly, clean and safe energy resources.
- It has the lowest gestation period as compared to conventional energy.
- Equipment erection and commissioning involve only a few months.
- There is no fuel consumption, hence low operating costs.
- Maintenance costs are low.
- The capital cost is comparable with conventional power plants. For a wind farm, the capital cost ranges between 4.5 crores to 5.5 crores, depending on the site and the wind electric generator (WEG) selected for installation.

Comparison between Fossil Fuels and Wind

	Wind	Fossil Fuel
Availability	Usable as it exists	Have to be procured and made usable through laborious and environmentally damaging processes
Limitation on availability	Inexhaustible resource	Limited in reserves, expected to be completely exhausted in the coming 60 years
Transportation	Used where it is available or transported where needed	Has to be transported from its source site for further processing, exposing the environment to pollution from accidents
Environmental effect of use	Zero emission	Used in producing electricity, releasing green house gasses
Geo-political implications	Reduces our reliance on oil, safeguarding national security. Allows for self sufficiency. There is no adverse effect on global environment. The whole system is pollution free and environment friendly.	Over-reliance on oil as a resource has undermined India's energy security, e.g. OPEC crises of 1973, Gulf War of 1991 and the Iraq War of 2003.

❖ *The pollution saving from a WEG*

With an average output of 4,000 kWh per year, savings have been estimated as follows:

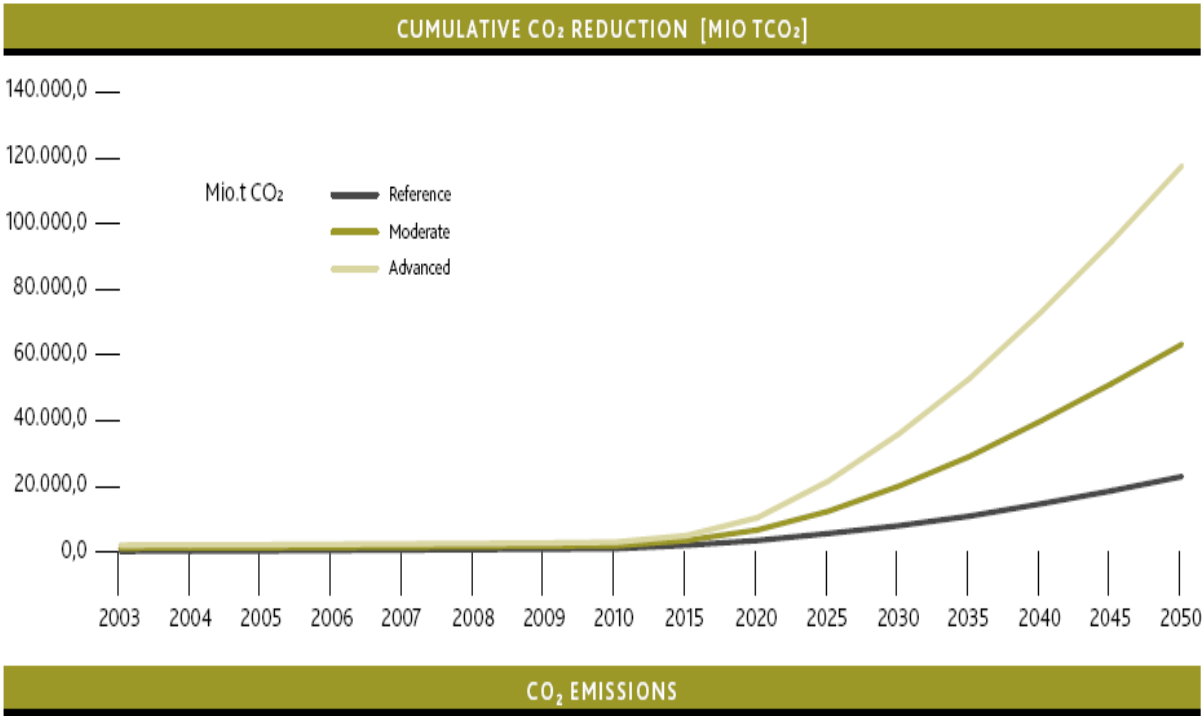
- Sulphur - dioxide (SO2): 2 to 3.2 tonnes
- Nitrogen - oxide (NO) ; 1.2 to 2.4 tonnes
- Carbon - dioxide (CO2) : 300 to 500 tonnes
- Particulates: 150 to 280 kg.

❖ Carbon Dioxide Savings

A reduction in the levels of carbon dioxide being emitted into the global atmosphere is the most important environmental benefit from wind power generation. Carbon dioxide is the gas largely responsible for exacerbating the greenhouse effect, leading to the disastrous consequences of global climate change.

At the same time, modern wind technology has an extremely good energy balance. The CO_2 emissions related to the manufacture, installation and servicing over the average 20 year lifecycle of a wind turbine are “paid back” after the first three to six months of operation.

The benefit to be obtained from carbon dioxide reductions is dependent on which other fuel, or combination of fuels, any increased generation from wind power will displace. Calculations by the World Energy Council show a range of carbon dioxide emission levels for different fossil fuels. On the assumption that coal and gas will still account for the majority of electricity generation in 20 years’ time – with a continued trend for gas to take over from coal – it makes sense to use a figure of 600 tonnes per GWh as an average value for the carbon dioxide reduction to be obtained from wind generation.



This assumption is further justified by the fact that more than 50 % of the cumulative wind generation capacity expected by 2020 will be installed in the OECD regions (North America, Europe and the Pacific). The trend in these countries is for a significant shift from coal to gas. In other regions the CO_2 reduction will be higher due to the widespread use of inefficient coal burning power stations.

Taking account of these assumptions, the expected annual saving in CO_2 will be 339 million tonnes in 2020, rising to 910 million tonnes in 2050. The cumulative saving over the whole scenario period would be 22,800 million tonnes.

❖ The essential requirements for a Wind farm

An area where a number of wind electric generators are installed is known as a wind farm. The essential requirements for establishment of a wind farm for optimal exploitation of the wind are the following:

- High wind resource at particular site.
- Adequate land availability
- Suitable terrain and good soil condition
- Maintenance access to site
- Suitable power grid nearby
- Techno-economic selection of specific turbines
- Scientifically prepared layout

❖ Limitation of a Wind farm

- Wind machines must be located where strong, dependable winds are available most of the time.
- Because winds do not blow strongly enough to produce power all the time.

- Energy from wind machines is considered "intermittent," that is, it comes and goes. Therefore, electricity from wind farms must have a back-up supply from another source.
- As wind power is "intermittent," utility companies can use it for only part of their total energy needs.
- Wind towers and turbine blades are subject to damage from high winds and lighting. Rotating parts, which are located high off the ground can be difficult and expensive to repair.
- Electricity produced by wind power sometimes fluctuates in voltage and power factor, which can cause difficulties in linking its power to a utility system.
- The noise made by rotating wind machine blades can be annoying to nearby neighbours.
- Some environmental groups have complained about aesthetics and avian mortality from wind machines

❖ Noise

Generally speaking, the sound output of wind turbines can be subdivided into mechanical and aerodynamic noise. The components emitting the highest sound level are the generator, the yaw drive which turns the nacelle of the turbine to face the wind, the gearbox and the blades. Some of the sound generated by these components is regular and some of it irregular, but all of it (except, that generated by the yaw mechanism) is present only while the turbine is actually operating. Even then, compared to road traffic, trains, construction activities and many other sources of industrial noise, the

sound generated by wind turbines in operation is comparatively low (see table).

COMPARATIVE NOISE LEVELS FROM DIFFERENT SOURCES	
Source/activity	**Indicative noise level dB(A)**
Threshold of pain	140
Jet aircraft at 250m	105
Pneumatic drill at 7m	95
Truck at 48 kph at 100m	65
Busy general office	60
Car at 64 kph at 100m	55
Wind development at 350m	35-45
Quiet bedroom	35
Rural night-time background	20-40

Source: "Wind Power in the UK", Sustainable Development Commission, 2005

Better design and better insulation have made more recent wind turbine models much quieter than their predecessors. The approach of regulatory authorities to the issue of noise and wind farms has generally been to firstly calculate the ambient (existing) sound level at any nearby houses and then to ensure that the turbines are positioned far enough away to avoid unacceptable disturbance.

❖ Wildlife – Birds

Birds can be affected by wind energy development through loss of habitat, disturbance to their breeding and foraging areas and by death or injury caused by the rotating turbine blades. Compared to other causes of mortality among birds, however (see table), the effect of wind power is relatively minor. One estimate from the United States is that commercial wind

turbines cause the direct deaths of only 0.01 - 0.02% of all of the birds killed annually by collisions with man-made structures and activities.

MAIN CAUSES OF BIRD DEATHS IN THE UNITED STATES	
Cause	Estimated deaths per year
Utility transmission and distribution lines	130-174 million
Collision with road vehicles	60-80 million
Collision with buildings	100-1,000 million
Telecommunications towers	40-50 million
Agricultural pesticides	67 million
Cats	39 million

Source: American Wind Energy Association

In Germany, records of bird deaths from the National Environmental office Brandenburg showed a total of 278 casualties at wind farms over the period 1989 to 2004. Only ten of the birds were species protected by European Union legislation.

By the end of the period Germany had over 16,500 wind turbines in operation1. The UK's leading bird protection body, the *Royal Society for the Protection of Birds, says that the most significant long term threat to birds comes from climate change.* Changes in the climate will in turn change the pattern of indigenous plant species and their attendant insect life, making once attractive areas uninhabitable by birds.

***According to the RSPB, "recent scientific research indicates that, as early as the middle of this century, climate change could commit one third or more of land-based plants and animals to extinction, including some species of British birds."* Compared to this threat, "the available evidence suggests**

that appropriately positioned wind farms do not pose a significant hazard for birds," it concludes.

References

1. www.greenpeace.org
2. www.gwec.net

3. CII-Sohrabji Godrej Green Business Centre
4. www.greenbusinesscentre.com
5. www.geni.org
6. http://mnes.nic.in/
7. Centre for Wind Energy Technology www.cwet.tn.nic.in
8. Maps of India http://www.mapsofindia.com
9. The Energy & Resources Institute (TERI) http://www.teriin.org/
10. www.ewea.org
11. http://www.ieawind.org/
12. http://www.awea.org (American Wind Energy Association)
13. www.wwindea.org
14. www.world-wind-energy.info
15. Indian Wind Turbine Manufacturers Association