Preparation of road map for mainstreaming wind energy in India

Prepared for **Indian Wind Energy Association, New Delhi**

TERI Project Report No. 2002RT66

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Executive summary

The wind power sector in India has reached a juncture where few strategic impetuses would catapult it in to the mainstream of country's power sector. The goals of the study were to revisit the potential market for wind power projects in light of ever-growing power shortages and increased consciousness about the impact of electricity generation; evaluate socio-environmental benefits of wind power vis-à-vis conventional power; develop a better understanding of the current state of the technology; analyse the international initiatives for promoting power from renewables; and to develop a plan for advancing the penetration-levels of wind power technology. Key observations of the study are summarised below.

Power situation

The magnitude of energy consumption has always been taken as an indicator of development status of an economy. India's projected economic growth rate is pegged at 7.4% in the period 1997-2012 (Planning Commission). This would necessitate commensurate growth of energy resources, most of which is expected to be from fossil fuels and electricity, in the business as usual scenario.

The power position in March 2002 indicates the energy shortage of 7.5% and peak deficit 12.6%. A look at the past track records shows that though capacity addition of 40,245 MW was envisaged between 1997-98 and 2001-02, the actual capacity addition during Ninth Plan was 19,015 MW i.e. 47% of the targeted addition. Again, as against gross energy generation target of 606.7 BU for the utilities by 2001-02, the actual energy generation has been 515.3 billion units only. These facts underline the necessity for tapping alternative supplies of electricity.

In the Indian scenario, brown outs and black outs had become a way of life due to peaking as well as general energy shortage, especially in non-metro and rural areas. In such a scenario, it is possible to absorb every unit of wind power, irrespective of its quantum and the time of delivery.

The environmental impacts

Coal is the mainstay of electricity generation in India. Coal is also the dirtiest fossil fuel in terms of harmful emissions and negative impacts on environment, human health, flora, and fauna. If the current expansion of power generation based on coal continues, the Indian power system will pose a serious threat to the environment in the coming years. Even at the Sixteenth EPS estimates of the total energy requirement to reach 975 billion units by 2012, at the current fuel-mix, the total emissions could reach levels of 780 million tons of CO_2, 4.7 million tons of SO_2 and 1.3 million tons of NOx. This means that utilization of environmentally sound technologies must increase substantially to counter these negative impacts.

Total emissions in 2001-02 from power generation in India were about 415 million tonne of CO_2, 2.5 million tonne of SO_2, and 1.3 million tonne of NO_x. The Mahatrashtra case study brings out the fact that wind power, through generation of 1505 million units (till August 2003) has saved 1324400 MT of CO_2 as well as 7525 MT of SO_2 and 3010 MT of NO_x.

Indeed, were all of 45,000 MW of wind power potential in the country to be exploited, then on the basis of MNES estimates of environmental benefits of wind power, it would result in mitigation of 90,000-128,000 tons of SO_2; 45,000-109,000 tons of NOx; 6400-12,800 million tons of total suspended particulates; and 22 million tons of CO_2 annually.

Potential of wind power in India

A re-assessment carried out by MNES puts gross potential of wind power in the country as 45,000 MW. Taking in to consideration the grid availability, the technical potential is estimated to be 13,000 MW out of which not even 20% has been realised so far. One way of increasing the penetration of wind power in the power sector is to change the perception of wind power as ‘infirm power’ arising out of unpredictability involved with wind electricity generation. Thus, if the quantity of power that would be available is predicted, say, 12 hours in advance, it will have several positive implications. Firstly, in such a scenario, wind power would be considered more as ‘firm power’ i.e. equivalent to conventional power. Secondly, it will also help in dispelling the main argument against wind power, especially among the utilities.

Wind power and energy security

Normally, energy security is conceptualized in terms of the risks of fuel supply *disruption*. However, fuel *price volatility* probably represents a more important aspect of energy security. At times price volatility may well have more profound effects on economic well-being than temporary supply disruptions. Wind energy offers a direct mean of dealing with it. Indeed, wind energy represents a form of 'insurance' against high fossil prices”.

Estimations and planning exercises do not take in to account the possible escalation in the prices of coal. The cost of coal could rise abnormally in future on account of (i) mining has to be undertaken much deeper when all the surface coal is finished, (ii) new coal fields are situated on thickly populated areas, and (iii) more land for mining is either not available or is forest land.

Wind power and socio-economic development

Wind energy is also a key potential source of sustainable jobs that are created without adding to air pollution, greenhouse gases, or other types of pollution and environmental damage such as mining or oil spills. The human health costs of air pollution (rising rates of asthma in many areas) and the cleanup costs of pollution are part of the hidden price tag of fossil fuels that reduce economic growth. Communities in rural areas near wind farms are finding today that wind can be a good neighbour, providing a source of jobs and income to sometimes hard-pressed populace.

Indeed, the wind farms, most of which are situated on remote rural locations, have been able to bring about a sea-change in socio-economic conditions of those rural areas. By way of generating income through land sales, through employment generation, and through other economic activities built around wind farms, wind power has contributed significantly to the rural development.

It has been estimated that a wind farm provides 4 times more jobs in operation and maintenance than the conventional power plants. The setting up of 338 MW wind park at Satara, Maharashtra created about 600 jobs at the factory and 2000 indirect jobs at the ancillary units. It is further estimated that Satara wind park has resulted in around Rs.12 crore pumped in to local economy through personal income. Moreover, the *local* job creation also helps in minimizing the rural-to-urban migration.

Why more wind power in India

Apart from the aforementioned points, the rationale for mainstreaming wind power in the country gets further buttressed because of the following reasons:

- Wind power is one of those renewables based power generation technologies that have demonstrated sufficiently low risk to gain the attention of the financial community and independent power developers for near-term projects.

- Significant technology advances have occurred since the first wind power plant was installed in the country in early eighties.
- Industrial learning curve theory suggests that costs decrease by about 20% each time the number of units produced doubles. Thus, the costs of wind turbines could be brought down by increasing the market volume.
- Insofar as impacts on the power systems are concerned, it is an established fact that addition of wind power results in (a) reduction in technical losses and (b) strengthening of voltage levels.
- In case of Maharashtra, 70% of the total wind electricity generation is during high-demand slots and 30% of total wind generation takes place during morning and evening peak hours, in both, high wind and low wind seasons. As such wind electricity could be awarded premium in line with those prescribed under Time of Day (ToD) tariff structure of MSEB.
- The detailed analysis shows that the levelized annual cost of wind power is less than that of a new thermal power station.
- Comparing the costs, it has to be noted that while the cost of energy from a thermal power station is initially low, it continues to increase with increases in the cost of fuel. On the other hand, the cost of wind energy is initially high and reduces as loans are repaid as no variable cost is involved.

These points, in essence, create a backdrop that underscores the rationale for promoting accelerated exploitation of wind resources in India for power generation. Before proceeding further, it is pertinent to analyse the emerging international and domestic scenarios.

The international scenario

A lot of development is taking place internationally, both in the context of technology as well as in policy and regulatory regimes. To summarize:

- Internationally, rapid wind power development is driven by increasing interest in greenhouse gas reduction, the expanding global power market, and a growing interest in “green” power.
- Many countries have adopted ‘Renewable Portfolio Standards’ mandating a certain percentage of power generation to be met from renewable sources of energy like wind energy.
- All over the world wind generated electricity is treated preferentially by means of production credits and incentives.
- The policies in New Jersey, USA specifically mentions that ‘tradable emission credits’ or ‘tradable renewable energy certificates’ or ‘attributes’

which result from projects funded through New Jersey Clean Energy will be the property of the project developer.

- Internationally, the cost of a kilowatt-hour of wind power has fallen by 20% over the past five years.

National scenario

There are several direct and indirect implications on wind power development arising out of Electricity Act 2003 (EA 2003). EA 2003 clearly mandates SERCs to promote cogeneration and renewables. The scenario that emerges out of EA 2003, therefore, points towards a number of possibilities for wind power. These include state-level quota for renewables, generating companies supplying power to consumers directly, and intrastate/inter-state/inter-regional trading. The conversion of these possibilities into business, however, would largely depend on decisions taken by the state regulators with regard to nature of quota (whether a floor limit or a ceiling), quantum and kind of tariffs (short-term or long-term), and wheeling charges and surcharge on them, and enabling actual grid-access to traders.

Plan of action

The plan articulated below is devised to address those issues and aspects that are pivotal to accelerated growth of wind power sector in the country. The plan, therefore, suggests concrete steps that allow wind power to mature to the point where it can compete directly with conventional power in the regions, rich in wind energy resources. These steps include:

1. *Technical assistance for SERC*
   Detailed studies on the matters such as grid absorption capacity; intermittency issue of wind power; reactive power; scheduling of conventional power plants; fluctuations; time of day tariff; and hybridisation of available resources should be commissioned by the MNES and state nodal agencies.
2. *Renewable Portfolio Standards (RPS)*
   On the basis of detailed assessment of renewable energy resources in the state, the SERC should come out with RPS, outlining share of each mature/near commercialization renewable energy technology. This should also include framework for trading of green power/certificates.
3. *Preferential tariff*
   Considering the fact that cost of externalities is not included in the electricity tariff in the country, a preferential tariff needs to be awarded to the wind

power in view of its environmental and societal benefits. The higher tariff is also justified in view of the perceived risks associated with financing of new technologies like wind energy in the country. Thus, the tariff should be firm and long-term so that it sends positive signals to the investors and developers. The tariff could be higher during the initial years when loan has to be repaid. Thereafter, it can be reduced in phased manner. Different studies on the subject suggest that the incremental benefit could be in the range of Rs.0.30 - Rs.0.60/kWh.

Any 'tradable emission credits' or 'tradable renewable energy certificates' resulting from wind power projects getting any financial/fiscal benefits will be the property of the project developer.

4. *Competitive bidding*
   The competitive bidding should be introduced to bring about a steady convergence between the price paid for wind power in successive years and the market price of the conventional electricity.
5. *The Climate Change Levy or Carbon Tax*
   The Climate Change Levy or Carbon Tax should be levied on the fossil fuels and conventional electricity to create a fund for (i) meeting incremental portion of tariff for wind power, (ii) technology upgradation and up-scaling of manufacturing facilities, and (iii) easy financing of infrastructural requirements.
6. *Wind Power Bonds*
   To finance the wind power development, tax-free Wind Power Bonds may be issued by the designated institution with full guarantee from the Government of India.
7. *Grid mapping and strengthening*
   In order to facilitate large wind farms, EHV grid master plans for the potential areas should be prepared along with strengthening of the grid network, in step with identification of potential sites for wind installations.
8. *Sensitization of the decision/policy makers*
   To cater to the need expressed at various fora by the policy makers, regulators, and the utility managers about getting to know the nuances of wind power development and its characteristics, sensitization workshops should be organized in the resource-rich states.
9. *Awareness creation*
   The exercise of awareness creation has to be carried out at different levels, comprising school children; parliamentarians and legislators; the potential investors and/or developers; and financiers.

10. *Media strategy*
It is important to put forward wind power sector's views and needs to potential users, law makers, as well as public at large in an effective manner. Essentially, the aim should be to focus on strategic mainstream groups rather than the renewable energy community. For this a variety of information tools - such as regular publications, news releases, briefing documents, statistics and market data, and presentations could be used.

1 Introduction

The Indian power sector is witnessing transformation through enactment of the Electricity Act 2003, the reform process, characterised by the unbundling of functions, ownership changes, the emergence of competitive markets, and the establishment of regulatory commissions. In such a changing scenario, with increasing commercial orientation to the functioning of the power sector, government policies and regulatory approaches would have a significant influence in the development of various forms of renewable energy sources, grid-connected wind power in particular, which is closest to commercialization in real terms. While internationally, RE is being pushed on account of the environment protection, in India, there is the added issue of energy security.

Lately it is observed that although MNES has issued comprehensive guidelines, various state governments are interpreting them differently and formulating their state-level policies, which do not always conform to MNES guidelines. There has also been a lack of consistency in policies. In the case of Tamil Nadu, for example, certain decisions have had a negative impact on the development of wind power. Steps like lower power purchase rates for electricity and unreasonable power wheeling and banking charges for new wind power generation have effectively retarded the growth of wind power sector in the state.

In a number of countries, the utilities purchase renewable energy based electricity at prices higher than conventional electricity due to the fact that RE power is environmentally benign. Essentially power generation involves a process in which the impacts may not be appropriately reflected in the market prices. True costs, therefore, should include both, namely, the costs incurred to provide power and the external costs of damage (or deterioration in quality) to the environment and health caused by power generation. Because of this market failure, the price charged for electric power is lower than it would be if the costs of externalities were internalized, i.e., included in the price charged to consumers for electric power. Externalities attributable to electric power generation may be classified in the following categories.

- Air pollutants including sulfur dioxide, nitrogen oxides, particulates, and heavy metals with impacts on human health, flora and fauna, building materials, and on other social assets like recreation and visibility.
- Greenhouse gases including carbon dioxide, methane, and chlorofluorocarbons, contributing to global climate change and thus to potential impacts on agriculture and human health.
- Water use and water quality affected by electricity production, principally through thermal pollution or hydroelectric projects that affect aquatic populations.
- Land use values affected by power plant sitings and by waste disposal including solid, liquid, and nuclear wastes.

Examples of upstream and downstream externalities can be cited for nearly all conventional fuels, i.e. coal, oil, natural gas, nuclear, and hydroelectric power. Upstream externalities for coal include mining and surface reclamation. Oil and natural gas use have issues associated with drilling, pipelines, and spills. Hydroelectric power is associated with flooding, erosion, and loss of aquatic life in addition to possible curtailment of aesthetics and a loss of habitat for certain species. Downstream externalities are associated with landfills/ash disposal, climate change (or global warming potential), acid rain, and silting. Nuclear power generation has the potential for serious accidents, besides problems with waste disposal.

Characterised by the non-internalisation of external costs of energy production, costs of RET based power tend to be significantly higher than that of conventional power. But the cost of *delivered* power should be measured in terms of overall benefits associated with that form of power, and their implications. In such a scenario, RET based power outweigh the conventional power - on account of their environment-friendliness and positive impact on the social development. The promotion of wind power, therefore, has to be viewed against the aforementioned backdrop. Indeed it is vitally important to capture all the externalities and due weight is given to reduction in T&D losses and grid support provided by wind power.

Against this backdrop, InWEA (Indian Wind Energy Association) asked TERI to carry out a study to analyse the aforementioned issues and suggest the solutions by (a) detailing out the benefits associated with wind power vis-à-vis implications of the conventional electricity and (b) detailing a roadmap for accelerated mainstreaming of the wind power.

2 Power scenario in India

The magnitude of energy consumption has always been taken as an indicator of development status of an economy. India's projected economic growth rate is pegged at 7.4% in the period 1997-2012 (Planning Commission)[1]. This would necessitate commensurate growth of energy resources, most of which is expected to be from fossil fuels and electricity, in the business as usual (BAU) scenario. With 15% of the world's population, India's energy consumption is 3% of the global total. The per capita annual energy consumption in the US is 8.55 TOE (tonnes oil equivalent). The global average is 1.68 TOE. The figure for India is 0.32 TOE. Thus, the goal is of providing clean, reliable, economic energy at 25 times the current availability to one billion people.

Development of the energy sector in India needs to be analyzed from the point of view of several aspects, including (i) impact on economic growth, (ii) energy security, and (iii) environmental impact. The following section looks into rationale for enhancement of utilization of renewable energy technologies like wind power.

Present scenario

The total installed capacity in India, as on March 2002 was about 1,02,620 MW, with thermal power plants constituting a major share at 71% of the total capacity, followed by hydro (26%) and nuclear (3%). The total generation for the year 2001-2002 was about 515.27 billion units with about 81%, coming from thermal power plants. The power position in March 2002 indicates the energy shortage of 7.5% and peak deficit 12.6% (TEDDY 2003). Region-wise distribution of installed capacity with type of generation is given in Table 2.1 below.

Table 2.1 Region-wise installed capacity

Region\type	*Thermal (no. of plants)*	*power MW*	*Hydro MW*	*Nuclear MW*	*Total MW*
Western	25637.5	(41)	4321.8	760	30719.3
Northern	17430.6	(28)	8575.8	1230	27236.4
Southern	16000.5	(37)	10102.0	780	26882.5

[1] Energy Policy Committee Report (draft), Planning Commission, July 2000.

Region\type	Thermal (no. of power plants) MW	Hydro MW	Nuclear MW	Total MW
Eastern	13267.5 (27)	2362.4	0	15629.9
North-Eastern	1096.1 (10)	1055.7	0	2151.8
Total	73432.2(143)	26417.7	2770	102619.9

Table 2.2 Region-wise generation

Region\type	Thermal GWh	Hydro	Nuclear	Total
Western	105069	29138	7092	141299
Northern	138859	7764	5461	152084
Southern	89273	26739	4597	120609
Eastern	49673	7786	0	57460
North-Eastern	2886	2148	0	5034
Total	385761	73576	17149	476486

It is evident from the above table that the power generation is heavily dependent on the thermal generation. Coal is the main fuel used for power generation with 60% of the total generation capacity and almost 71% of the total generation in 2001-02 being coal based. There are about 143 thermal power stations in India, out of which 90 are coal based and remaining use other fuels like gas, diesel, naphtha, etc. As per TERI estimates, based on the heat rates and the fuel consumption figures, the total emissions in the year 2001-02 from the power generation activity are about 415 million tons of CO_2, 2.5 million tons of SO_2 and 1.3 million tons of NOx.

Projected capacity additions

Plans for capacity additions, based on future demand projects have been prepared by CEA and these plans are revised time to time according to the demand projections. Detailed projections are available for the tenth plan period, i.e. from 2003 till 2007. The blue print for power sector developed by the Ministry of Power, projects 1,00,000 MW of capacity addition during 2002–2012. The region-wise capacity additions for period 2002–07, as identified in the Tenth Plan, are shown in Table 2.3.

Table 2.3 Planned capacity additions during tenth plan (2002-2006)

Region	Hydro	Thermal	Nuclear	Total
Northern	7274.0	5011.00	0	12285.00

Western	3752.0	6103.62.00	1080	10935.62
Southern	1158.20	5998.00	220	7376.20
Eastern	1860.0	7075.00	0	8935.00
North - Eastern	349.0	1088.00	0	1437.00
Total	14393.2	25275.62	1300	40968.82

Here it would be pertinent to look at the past track records. Capacity addition of 40,245 MW was envisaged between 1997-98 and 2001-02. As against this, the actual capacity addition during Ninth Plan was 19,015 MW, which works out to be 47% of the targeted addition (TEDDY 2003). The gross energy generation from power utilities at the beginning of the Ninth Plan was 394.5 billion units. A gross energy generation target of 606.7 BU was set for the utilities by 2001-02. As against this, the actual energy generation has been 515.3 billion units only (ASEAN, 2003).

Energy resources, supply, and security concerns

The demand for energy in the country has been growing rapidly and India continues to be net importer of energy. Indian fossil fuel reserves profile is dominated by coal with proved reserves of 75 billion tonnes. In comparison to coal, oil and gas reserves are limited at 727 million tonnes of oil and 640 bcm of natural gas. The important fuel resources for power generation in India are coal and hydrocarbons. The electricity sector consumed about 76.2% of coal (2000-01) making it the largest consumer.

To bridge India's peak power shortages of 13% and average shortages of around 8%, in the BAU scenario, nearly 100,000 MW of fresh capacity addition would be required by 2012, more than 75% of which is likely to be coal based. The Sixteenth EPS (Electric Power Survey) estimates the all-India peak demand to reach 157 GW by 2012, and the total energy requirement to reach 975 billion units. At current compound annual growth rate of 5.5% (ASEAN 2003), there may be a shortfall of about 95 billion units. By the end of the Tenth Five-year Plan period, domestic coal production is estimated to be around 405 MT, resulting in supply deficit of 55 MT (TEDDY, 2003). This gap is expected to be bridged through imports.

Coal being a non renewable commodity, the demand-supply dynamics has to be viewed against the backdrop of diminishing coal reserves, obsolete mining technology, fall in quality, and an overburdened transport network between mines and the power plants.

The coal resources in the country have been assessed at 240.78 billion tonnes up to a depth of 1200 m, of which 90 billion tonnes (about 37.42%) are proved reserves (TEDDY, 2003). Three quarters of the total coal reserves in India are concentrated in Bihar, Madhya Pradesh, and West Bengal. About 63% of the coal resources occur within a depth of 300 metres, a major share, of which are amenable to open-cast mining. The non-coking coal (steam coal) resources are about 85% of the total resource, of which only 12% are of superior grade (used in industries) and the balance 73% is inferior grade and is available for power generation. The share of open cast mining in the country is likely to increase from 26% in 1974-75 to 81.37% in 2002-03. Open cast mining, though less expensive, requires significantly more land area and results in much higher degradation of the environment of the surrounding areas. The quality of Indian coal has been steadily falling owing to this preference to open cast mining. Much of the domestically produced coal finds it difficult to meet the norms, for power stations in urban locations and in environmentally fragile areas, set by the Ministry of Environment and Forests (MoEF) imposed standard.

While there are plans for the developing new coalfields, they face stringent social and environmental pressures as also the problem of the land acquisition. Many potential coalfields fall within forested area. The use of forestland is becoming tougher due to the stringent clearances required for utilizing the land. Furthermore, the rehabilitation and resettlement of displaced communities is expected to be closely monitored in the future and will be required to be a part of the planning process for mine development.

On the other hand, MoEF is becoming increasingly strict with regard to emissions from coal based power plants, forcing many thermal power stations to look for alternatives (including imported coal) since the quality of the domestic coal is very poor and it often has a very high ash content. Indeed, thermal power plants, in order to meet norms for permissible fly ash in sensitive areas, have started blending high-grade imported coal with domestic coal. The pressure is also to employ improved technologies and implement coal beneficiation to ensure compliance with quality criteria. But all this will come at a cost.

Further, the large gap between production and demand of petroleum products makes India uncomfortably dependent on imports, which eats up nearly 25% of export earnings to the tune of US $12.7 billion. The World Energy

Outlook 2002 projects a 94% oil import dependency for the country in the year 2030. Such a trend obviously militates against the energy security, apart from adversely affecting the overall economy.

In the year 2011, India will have a total population of about 1.2 billion people. With India aiming for growth rates of 7-8% over the next two decades, its per capita energy consumption would also rise accordingly. It was earlier estimated that coal has a reserves-to-production ratio of over 200 years. However, more recent and reliable estimates have attempted to examine the depletion of coal reserves assuming that production would plateau 10 years from now. Based on this, Central Mine Planning and Design Institute Ltd. (CMPDI) estimated in 2001 that India's coal reserves would only last for another 40 years or so. It is estimated that the oil and gas reserves have a remaining life of about 20 years (TERI, 2002).

Environmental concerns in the context of energy usage

India's rapidly growing population, along with increased economic development, has placed a strain on country's infrastructure, and ultimately on its environment. If the current expansion of power generation based on coal continues, the Indian power system will pose a serious threat to the environment in the coming years. Even at the Sixteenth EPS estimates of the total energy requirement to reach 975 billion units, by 2012, at the current fuel-mix, the total emissions could reach levels of 780 million tons of CO_2, 4.7 million tons of SO_2 and 1.3 million tons of NOx.

This means that utilization of environmentally sound technologies must increase substantially to counter these negative impacts. Fortunately, the country has an abundance of renewable energy sources e.g. the solar, wind, biomass, and hydropower.

Apart from limiting GHG emissions, such technologies will also help in reducing the large fuel import bill for the country. Thus, it is evident that if the overall development of the country has to be made sustainable in real terms, a shift towards an energy-mix that is rich in renewable energy is a must.

Therefore, a paradigm shift in approach to energy policy issues - a shift from supply domination to an integrated approach - a judicious mix of investment in supply conversion, operational efficiency improvement, T&D losses reduction, end use efficiency, and renewable technologies - is needed.

Wind power in India

Recognizing the importance of tapping renewable energy sources for power generation, India has been working in this direction for more than two decades. The Government of India realized the importance of private sector participation in the wind power sector as early as 1983-84. Accordingly, a national programme was initiated to tap the then estimated potential of 20000 MW by adopting a market-oriented strategy. This ultimately led to successful commercial development of wind power technology and substantial additions to power generation capacity in the country. Significant progress made in this sphere was the result of a range of policy support measures and incentives announced by the government for inducting state-of-the-art wind energy technologies on the one hand, while encouraging private entrepreneurs to take up commercial projects on the other hand.

Though incentives and market-oriented policies existed during the late 1980s, the spurt in private sector participation started only in 1992, after the announcement of the 'private power policy' of 1991. This, along with a booming economy and the attractive fiscal incentives, provided the impetus for accelerated growth of the wind power sector. Since 1999, the main factors that contributed to the positive growth of the wind sectors are:

- Technological maturity and introduction of machines, suitable for the Indian conditions (e.g. wind turbines designed for low wind regimes) that resulted in overall higher capacity utilization. This factor helped in attracting more investments from the private sector.
- Introduction of bigger capacity and more cost-effective wind turbines.
- Better site selection due to more sophisticated and rigorous wind resource assessment and micro siting.
- Conducive policy regime introduced by some states (Maharashtra was one such state that came out with an investor friendly package, including attractive power purchase prices).

The drivers of this growth engine were those investors who were interested in *performance* of their wind farms so as to (i) enhance their profitability and (ii) minimize dependence on the utilities (about 80% of the wind power has been used for captive consumption). The fact that some manufacturers/developers started giving guarantee for certain minimum level of electricity generation, also helped in building up the confidence of the investor community. This period also saw transition from smaller capacity machines to bigger ones, represented graphically in Figure 2.1.

These technological strides have helped in reducing the cost of electricity generation in the country. As per a recent study conducted by IEA, "Medium cost reduction potential can be identified among those technologies that are (a) in the low to medium cost range and (b) relatively recent in development. They tend to have a learning curve with a progress ratio of around 90%, meaning that every doubling of the volume manufactured leads to a cost reduction of around 10%. Globally, wind is expected to reduce its costs by some 25% for each of the next two decades (IEA, 2003)". In India, though the cost of wind turbines has not reduced *per se*, the increased market volumes have resulted in better and bigger capacity machines (as shown above), thereby *lower cost per unit of electricity generated*.

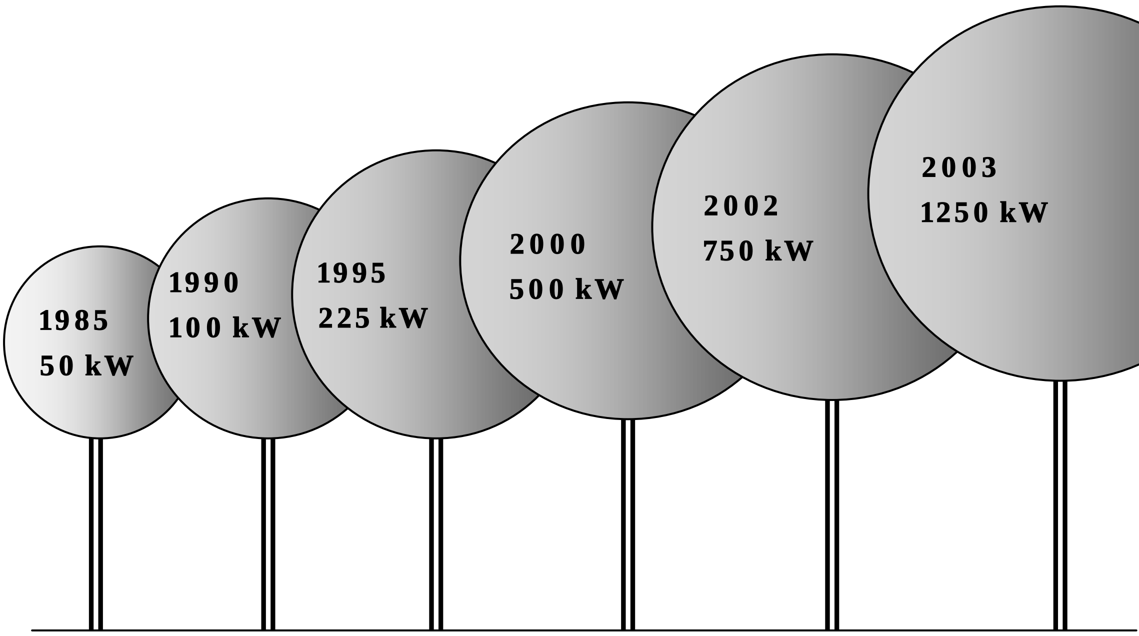

Figure 2.1 Wind turbine development in India

With an installed capacity of 2110 MW (as on September 30, 2003)[2] India is now recognized as a leading country in the world in the development and utilization of renewable energy, in general, and particularly in the development of wind power. 12.7 billion kWh of wind-generated electricity had been fed to the grid so far. As a matter of fact, power generation from wind has emerged as one of the most successful programmes in the renewable energy sector and has started making significant contributions to the overall power requirements of wind-rich states. Figure 2.2 depicts the status of wind power installations in various states in India.

[2] www.windpowerindia.com

So far as domestic industry is concerned, there are 8 major companies that are manufacturing wind turbines and components. Out of these, 5 are ISO certified. This manufacturing base not only meets domestic needs but also caters to emerging export markets, including the US and Europe. The annual production capacity is of the order of 500 MW, which can be increased to 750 MW. Large capacity wind turbines in the range of 1 to 1.25 MW are being produced in the country and it is expected that shortly, 1.65 MW wind turbine would be launched in India[2]. For testing and certification, Centre for Wind Energy Technology (C-WET) has been established that is also the focal point for wind related research and development activities.

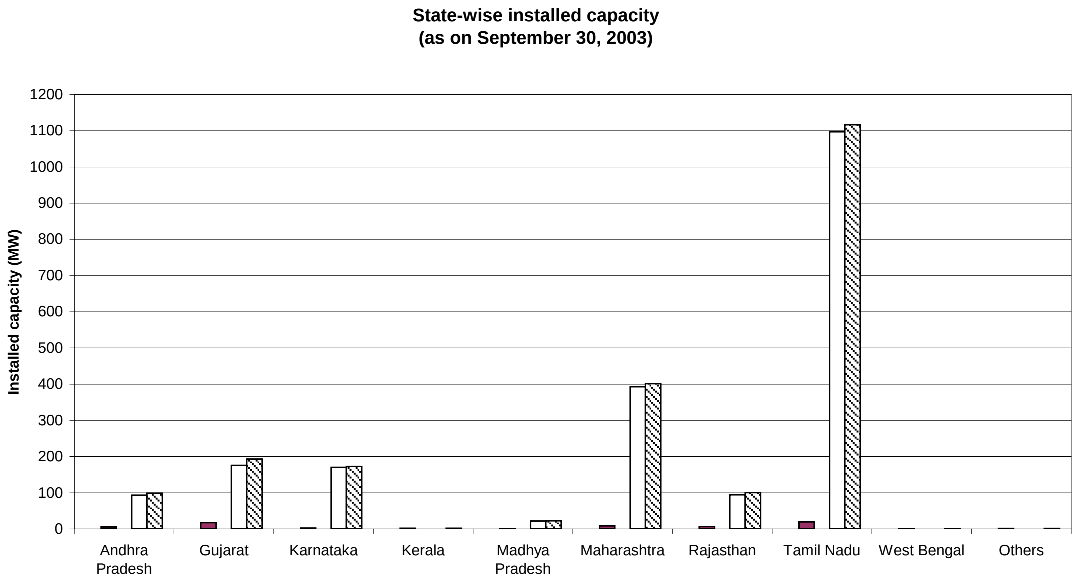

Figure 2.2 Wind power installation status in India

Potential of wind power

A re-assessment carried out by MNES puts gross potential of wind power in the country as 45,000 MW. Taking in to consideration the grid availability, the technical potential is estimated to be 13,000 MW out of which not even 20% has been realised so far. One way of increasing the penetration of wind power in the power sector is to change the perception of wind power as 'infirm power' arising out of unpredictability involved with wind electricity generation. Thus, if the quantity of power that would be available is predicted, say, 12 hours in advance, it will have several positive implications. Firstly, in such a scenario, wind power would be considered more as 'firm power' i.e. equivalent to conventional power. Secondly, it will also help in dispelling the main argument against wind power, especially among the utilities.

Indian power sector: real picture

In order to keep Indian power sector in right perspective, it is essential to analyse its dynamics. A detailed analysis brings the following aspects to fore:

1. The very first and obvious fact is that it is the public funding (whether in central sector or state sector) which is fuelling the growth. As shown in Tables 2.4 & 2.5, cumulatively out of 1,04,917.50 MW at the end of the Ninth Plan, 93,788.12 MW (i.e. 89.4%) was through public funding. In the Ninth Plan period itself (1997-2002), share of public funded capacity was 73.4%. Contrast this with wind capacity where out of 1,507.46 MW, public funded projects amounted to 62.86 MW (or 4.2%) only. Again, in case of nuclear power, 100% of 2720 MW installed comes from public funding (Planning Commission, 2002).

Table 2.4 Additions to installed capacity during the Ninth Plan (1997-2002)

Type	*Targets*				*Achievement (MW)*			
	Central sector	*State sector*	*Private sector*	*Total*	*Central sector*	*State Sector*	*Private sector*	*Total*
Hydro	3,455	5,815	550	9,820	540	3,912	86	4,538
Thermal	7,574	4,933	17,038	29,545	3,084	5,538	4,975	13,597
Nuclear	880	-	-	880	880	-	-	880
Total	11,909	10,748	17,588	40,245	4,504	9,450	5,061	19,015

Source: 10th Five Year Plan 2002-2007 Vol-II, Chapter 8.2 Power, Table 8.2.2, page 901

Table 2.5 All India cumulative capacity addition (MW)

	Hydro	*Thermal*	*Nuclear*	*Total*
Centre	3,049.00	25,836.51	2,720.00	31,605.51
State/UTs	22,636.02	39,546.59	0.00	62,182.61
Private	576.20	9,045	0.00	9,621.92
TOTAL	26,261.22	74,428.82	2,720.00	1,03,410.04*

* excludes the capacity of 1,507.46 MW from wind (state-62.86 MW; Private-1,444.60 MW)

Source: 10th Five Year Plan 2002-2007 Vol-II, Chapter 8.2 Power, Table 8.2.3, page 901

2. While it was expected that in the Ninth Plan, an additional capacity of 17,588 MW would come up through private investment, the actual achievement, however, was only 5,061 MW i.e. 29% of the target.

   Contrast this scenario with that of wind power development in the country where 96.5% of total installed capacity (1870 MW) has come from private investment (MNES, 2003)**.**
3. Total plan allocation in the Ninth Year Plan, for the conventional power sector stood at 14.5% of total plan outlay against mere 0.44% for the whole of the renewable energy sector (MNES, 2001).
4. The estimated domestic budgetary support under central sector during the Ninth Plan was Rs.14,381 crore for 4,504 MW. This works out to be Rs.3.19 crore/MW.

   The proposed budgetary support to wind power in Tenth Five Year Plan was Rs.246 crore in the central sector and Rs. 75 crore in the state sector, for an addition of 2000 MW or **Rs. 0.16 crore/MW**. As a result of 100% depreciation for renewables, the Governing of India was foregoing the tax revenue e.g. in the year 2002-03, revenue of Rs.350 crore was not received as a result of 240 MW of wind power installation.
5. The State Electricity Boards (SEBs) owed Rs.41.47 billion to central public sector undertakings and the Indian Railways. The outstanding dues of SEBs are being securitized by the concerned state governments (TEDDY, 2003). **In effect this tantamount to providing a subsidy of Rs.41.47 billion to the state owned conventional power sector.**
6. The average (all India) cost of power supply was 350.30 paise/kWh in 2001-02. Compared to this, average tariff was only 240.30 paise/kWh. **Thus, on an average, conventional power carries a subsidy of Rs.1.10/kWh**. In case of Maharashtra, these figures were 357.50 paise/kWh and 270.02 paise/kWh (TEDDY, 2003). Thus every unit of electricity in Maharashtra is subsidized to the tune of 87 paise.
7. The net subsidy involved on account of sale of electricity to agriculture and domestic sectors was projected at 30,855.36 crore for 2002-03. After taking into account surplus generated by sale to other sectors, the uncovered subsidy still amounts to Rs. 23,356.37 crore (Planning Commission, 2002).
8. Under Accelerated Generation & Supply Programme, interest subsidy is provided to SEB/States & central power utilities. *This is in spite of the fact that (a) conventional power generating technologies being technologically*

mature, there is no financial risk involved and (b) utilities are well established in this field for last so many decades.

9. The atomic energy is being fully supported by the Government of India because it feels that "Atomic energy has environmental advantages and is also likely to be economical in the longer run". Indeed, Tenth Five Year Plan states: "Levelised costs over the life of the project compare quite favorably with those for new thermal power plants located away from coal mining areas..... Aggressive nuclear power development is essential in the context of energy security, environmental advantages .... Improvements in nuclear technology are likely to make nuclear power more economical and total life cycle costs more competitive in comparison to other fuels. Therefore, India needs to aggressively build capabilities and capacity in nuclear power to progressively raise its share in India's fuel mix" (Planning Commission, 2002).

    However, even though the same logics apply to wind power also (in fact more so, considering that wind energy is truly environmentally benign), the substantial budgetary support is not forthcoming for wind power capacity additions.

The points brought forward in the preceding sections underline the fact that even though:

a. fossil fuels based power generation is not in a position to bridge electricity demand-supply gap of the nation;
b. Indian coal is of very poor quality insofar as power generation is concerned;
c. increasing import of coal and petroleum products is threatening the energy security;
d. usage of coal is environmentally hazardous as well as detrimental to human health;
e. private sector investment in conventional power generation is very small;
f. nuclear power is neither environment-friendly nor cheap;
g. wind power is environmentally benign;
h. about 96% of wind power installations in the country have come up through private investments; and
i. wind farms have supplied over 12 billions units to the grid-network across the country;

there has been marked reluctance on part of governments, utilities, and, regulatory institutions to encourage the propagation of wind power on a truly large-scale.

3 Impact of electricity generation

While electricity is essential to modern life and to economic development, the production of electricity does have serious consequences for the global, regional and local environment. Three inter-linked areas, which require consideration while discussing the environmental impacts of fossil fuels used for power generation are:

- The in-plant environment affected by the fossil fuel combustion characteristics and their impact on boiler availability and the handling requirements for gaseous and solid emissions produced from the combustion process.
- The atmospheric or global environment, as influenced by stack emissions of SO_x, NO_x, greenhouse gases, air toxins and particulate matter, most of which are subject to control by legislation.
- The local plant environment, which involves the delivery, handling and storage of the fuel and the handling of solid and liquid effluents from the flue gas cleaning process.

The generation of electricity from fuel by combustion releases carbon dioxide that contributes to global warming and climate change. India is already a major producer of carbon dioxide in aggregate, although its production per capita is small.

Fossil fuels also contain small amounts of sulphur and nitrogen, which when burnt produce acid rain causing gases. Combination of nitrogen and oxygen in air at high temperatures forms oxides of nitrogen. Particulate matters get generated from ash in the fuel, from pyrolysis and from recombination of carbon atoms during combustion process. Though all of these are dispersed by high stacks, eventually they reach the ground, and damaging health and property. Acid gases can be transported long distances across frontiers and are eventually precipitated as acid rain. Oxides of nitrogen are also precursors of tropospheric ozone, so high local concentrations of ozone can originate from remote sources.

Of the three fossil fuels used for power generation (coal, gas, and oil), coal is the most complex and the most variable in its properties. India has large reserves of coal, but generally inferior grades of non-coking coal are used for power generation in the country. The properties of the coal used for power generation are listed below:

- Ash content is in the range of 27 to 42%
- Moisture content ranges from 7 to 20%
- Volatile matter content ranges from 20-30%
- Gross calorific values range from 3200 kcal/kg to 4800 kcal/kg.
- Sulphur content is generally very low (<1%).
- Nitrogen content is generally low (<1%).

The properties of Indian coals from selected coal fields used for power generation are given in Table 3.1.

Table 3.1 Coal properties from selected coal fields (air-dried basis)

Parameters	*Korba*	*Singrauli*	*Talcher*
Moisture	7.00	6.2.00	5.70
Ash	29.30	35.10	32.60
VM	26.80	22.50	29.60
FC	36.90	36.20	33.00
GCV	4655	4185	4630
C	48.0	45.00	47.7
H_2	3.10	2.60	3.30
N_2	0.90	0.90	1.10
S	0.60	0.30	0.40

The problems associated in combustion with inferior coal are briefly discussed below:

a) With higher throughput of inferior coal vis-à-vis ash in the furnace for equivalent quantum of heat, deterioration in heat transfer takes place in the form of erosion of pressure parts, dust deposition on convection surfaces, deposit build-up and uneven heat recovery calling for more frequent soot blowing.

b) For high ash coal, design requirement of electrostatic precipitator (ESPs) calls for larger sectional area of flow path and high efficiency of collection to contain suspended particulate matter (SPM) emission at the inlet to the chimney to prescribed value of Central Pollution Control Board (CPCB) norm. Enlargement of dust separation unit would thus have a direct bearing on equipment cost.
c) To meet the higher excess air requirement for inferior grade coal the sizing of draft fans would need upward revisions in capacity and rating.
d) With requirement of handling larger volume of coal for the same effective plant capacity in case of higher ash coal, both bunker size and milling plant would need capacity enhancement. Quartz and pyrite particles with larger diameter cause substantial damage in the moving parts of the mills as well as in the ducts.
e) With increased ash content in coal, the plant size for both bottom ash and fly ash plants would be higher. This would include enhancement of capacity for both bottom and fly ash extraction systems. This will have a direct impact on land requirement for dumping ash.
f) The capital cost of the power plant increases due to the following factors:
   - requirement of larger furnace volume and heat transfer surfaces
   - requirement of larger sized electrostatic precipitators
   - requirement of higher capacity coal bunkers and milling plant
   - higher capacity coal and ash handling plants
   - larger ash dump area
   - larger coal receipt and storage area
g) On revenue account high ash content in coal would have adverse effect due to:
   - Increased transportation cost of coal
   - higher auxiliary power consumption for handling additional quantum of coal and ash
   - higher maintenance requirement of main plant, milling plants and other auxiliaries
   - higher spares requirement
   - more outage of plant leading to poorer plant availability
   - higher cost of ash management in ash dump

Besides, the poor quality of coal results in higher consumption of coal per unit of electricity generated, leading to (i) higher emissions/kWh and (ii) increased problems of ash disposal.

Impacts of coal loading/unloading, transportation and storage

During unloading, there is a huge amount of fugitive dust emission due to free-fall of coal. The coal fines form a cloud even if there is no wind. The amount of dust released depends upon the coal flow rate, particle size, and moisture content. In general, fugitive coal dust released during loading and unloading operations is 200 tonnes of particulate per million tonnes of coal (Bertram et al., 1980), or 0.2 per cent of the coal transferred (Chadwick and Lindman, 1982). Lower rank coals (bituminous, sub bituminous, and lignite) oxidise and slack (weather and disintegrate) more quickly than higher ranked coals and may lead to greater fugitive dust emissions when stored. Leachate from coal piles is the major source of water pollution. The specific characteristics of coal storage pile leachate depends on the volume of coal stored, coal particle size, surface area of the pile, degree of compaction of the surface, amount and duration of precipitation and pyritic sulphur content.

Transportation of coal for power generation has been based mainly on the rail network. In recent years, unit trains for coal movement have been adopted for pithead power stations. The rail-cum-sea route is also being used for supplies to certain power stations in South India. The share of movement of coal by rail and unit trains together is about 77%, which may go up to 80% in the future. The rail network is already stressed in certain corridors and to move large quantities of coal in the future, the rail network also needs expansion and considerable investment.

Emissions from thermal power plants

When considering impact of coal based thermal power plant, one has to include all activities from mining the coal through delivering the energy at the load-centers. The four principal elements of this system are coal mining, coal preparation, coal transport, and generation through coal combustion. Coal preparation generally takes place at or very near the mine. The coal storage is done at the power plant.

The principal residuals generated in the coal-based thermal power plant are:

1. Acid mine drainage from underground mining (in case coal is mined from underground mines)
2. Overburden from strip mining (in case of open cast mining, which is mostly the case in India nowadays)
3. Suspended solids in the wash water of the coal preparation plant

4. Particulates from air-flow cleaners and thermal driers at coal preparation plants
5. Particulates in gaseous emissions from power generation process
6. Sulfur oxides in power plant gaseous emissions
7. Water-borne heat from the power plant

Environmental impacts associated with the different stages of the coal life-cycle

The impacts of coal-based thermal power generation are carried through land, air, and water. Approximately 5000 ha of coal mining; 1200 ha for structures and roads, 200 ha for disposal of combustion wastes are required for a 100 MW thermal power plant. This involves displacement of population, transfer of forest and cultivable land for non-forest and non-agricultural use, besides other public inconveniences and ecological disturbances. The coal handling and transportation aspects of coal-based power plants were ignored as their environmental impact was considered to be quite negligible. But with the increase in coal-based power generation, the proportionate impact would be on the rise. Impacts due to coal transportation include air pollution resulting from coal dust and noise pollution near the tracks, besides increase in loads and traffic density. Another serious environmental problem is caused at the preparation of plants, with respect to coal-slurry pipelines, requiring water. The impacts at different stages are listed in Table 3.2.

Table 3.2 Impact of coal based power generation

Sl. No.	Stages in coal life-cycle	*Impact mediated through*		
		Land	*Air*	*Water*
1.	Extraction	Deforestation, disturbed land soil erosion, reclamation.	Coal dust, Occupational hazards.	Chemical mine drainage, siltation
2.	Transport & Processing.	Land requirements for roads and rails, creating water sources.	Coal dust, Noise, Diesel exhaust, damage to public roads and accidents.	Effluent of washeries.
3.	Combustion	Combustion products fall-out rain, reduction in plant	Particulates (Trace elements, Radio nuclides,	Thermal discharge, combustion

		productivity	polycyclic organic matter) and gases (SO_x, NO_x, Co_x).	products fall-out including acid rain, reduction in aquatic productivity.
4.	Transmission	Land-requirements reduction of tree cover.	Corona discharge (generation of NO_x and O_3 important in the smog and reduction of visibility	--
5.	Ash Disposal	Land required, deforestation.	--	Possibility of leachates especially toxic trace and radio-nuclides.

Environmental issues in coal mining

The environmental impacts of coal mining may be regarded as a chain reaction where the initial effect of coal extraction, in turn, produces other impacts. For example, the initial effect of opencast mining is the removal and deposition of waste overburden material causing land degradation at the surface. Damage to land adversely affects water courses, vegetation, animal communities and man-made structures. The magnitude and significance of the environmental degradation depends on the method of mining and beneficiation, scale and concentration of mining activity, geological and geomorphologic setting of the area, nature of deposits, and use pattern before the commencement of the mining operations, and the natural resources existing in the area, etc. Some of the potential impacts of mining projects on environment are as below:

- Disturbance of land surface due to excavation, stacking of waste dumps, tailing ponds, workshop, haul roads, etc.
- Disturbance of ecosystem which includes flora, fauna and aquatic life.
- Destruction of water sources including springs, wells, water reservoirs, etc.
- Disruption in water regime and drainage system.
- Pollution of land and water courses due to erosion from waste dumps, tailing ponds; wash off from workshop and domestic effluents.
- Silting of water stream and water reservoir.
- Dust pollution due to blasting, excavation, crushing transportation, stockpiles, and tailing ponds.

- Noise pollution and land vibration due to blasting, movement of heavy earth moving machinery, crushers and beneficiation plants.
- Destruction of aesthetic and recreation value of land.

Land degradation due to coal mining

Perhaps the most serious impact of mining operations is on the land environment. The extent of land degradation however varies, and is influenced by topography of the area, geology of the area, nature of soil and method of mining.

Opencast mining

Opencast mining pollutes the environment much more severely that the underground mining. With prominent emphasis on opencast coal production in India, large tracts of land were left degraded. There are three phases in opencast mining operation. First phase is the stripping of the overburden above the coal, the next is removal of coal itself and the third and final phase is filling up of the void with overburden material.

The major land requirement in case of opencast mines is for mine excavation, and in case of underground mines for the underground mining operations. Land used for residential and infrastructure facilities form a small proportion of the total land requirements. A rough estimate of land requirements for the opencast technology is as follows.

Mine excavation	50%
Infrastructural (including land for facilities external dumping)	40%
Other	10%

Ground vibration

Ground vibration is another hazard particularly associated with opencast mining operations. Large-scale opencast mining calls for massive blasting operations.

Impact on forest land

In most of the coalfields, forest land is required for mining, more so in case opencast mining. Over the years, there has been degradation of forest in most of the mining areas due to mining as well as other activities. Such degradation was compounded by erosion of the top soil and sub-soil. Though Ministry of Environment and Forests' guidelines stipulate that the coal companies are required to undertake compensatory afforestation over an equivalent area in non-forest land or twice the area in degraded forest land (in case of non-forest land not being made available); in real sense, deforestation and afforestation are not equal because of the fact the a whole generation of mature trees is completely lost.

In opencast mines, forest land is totally destroyed by mining excavation.

Occupational hazards

There are many operations, which contribute to the high SPM burden, including blasting and drilling operations, handling and loading of coal, the dumping of reject and overburden and the gaseous emissions caused by blasting. In Bihar coalfields, SPM typically ranges from 200-600 $\mu g/m^3$, causing concentrations in nearby residential areas of between 50-200 $\mu g/m^3$ i.e. between 25% and 100% of the permissible standards in these areas (The World Bank). A further problem at the mine itself is the production of significant amounts of PM_{10} particles, which are linked to pneumochoneosis. These cause many respiratory diseases, including deadly *pneumoconiosis*. Besides, diesel powered equipment are common in mechanised opencast mining. They produce emissions that are known to be hazardous and detrimental to lungs (Hills & Ramani, 1990).

Emissions

The main emissions from coal combustion at thermal power plants are Carbon dioxide (CO_2), Nitrogen oxides (NOx), Sulfur oxides (SOx), Chlorofluorocarbons (CFCs), and air-borne inorganic particles such as fly ash, carbonaceous material (soot), suspended particulate matter (SPM) and other trace gas species. Carbon dioxide, nitrous oxide, and chlorofluorocarbons are greenhouse gases.

Oxides of nitrogen and sulfur play an important role in atmospheric chemistry and are largely responsible for atmospheric acidity. Particulates and black carbon (soot) have a significant negative impact on human health causing lung tissue irritation and are linked to cancer and other serious diseases.

Carbon dioxide emissions

The most predominant combustible material in all fossil fuels is carbon. Burning of carbon produces carbon dioxide (CO_2) whereas the incomplete combustion of the fuel produces carbon monoxide (CO). This can happen due to improper mixing of the fuel and the air (which supplies oxygen), insufficient supply of air, inadequate residence time, faulty firing design, etc. Coal is pulverized to fine sizes for better mixing of coal with air to ensure complete combustion. Excess air is used to ensure complete combustion of the fuel irrespective of the type of fuel used. Use of excess air varies with the type of fuel and combustion process. Thus CO should normally not be a major pollutant at the thermal power plant.

While CO_2 does not affect the human health, it has been observed that increased CO_2 levels in the atmosphere have serious implications in terms of rise in the global temperature due to the 'greenhouse effect'. CO_2, therefore, is considered to be major offender among all Green House Gases (GHG) and major global initiatives for GHG mitigation essentially focus on reducing CO_2 emission. However, the fact remains that CO_2 emission cannot be avoided in fossil fuel combustion process. Table 3.3 gives some typical values of CO_2 emission-intensity from the combustion of different fuels for electricity generation.

Table 3.3 CO_2 emissions from fossil fuelled electricity generation

Coal (various technologies)	751-962 tonnes per GWh
Oil	726 tonnes per GWh
Gas	428 tonnes per GWh
Average	600 tonnes per GWh

Source: WEC statistics cited in "Wind Energy – The Facts". Vol.4. 1998. EWEA/European Commission

Sulfur dioxide emissions

The Indian coals, in general, have low sulphur content. Acid rain due to sulfur dioxide emissions is presently not monitored, but is projected to become a problem in future. A study has shown (Boudry, et. al.) that India would exceed critical thresholds of acidification by the year 2020.

Table 3.4 Emissions projections for All India

Year/Scenario	*SO_2 (k tonnes)*	*Multiplier Ref: 1990*	*Annual increase (%)*
1990	4471	1.00	-
2020/BAU	18549	4.15	4.9

Year/Scenario	SO_2 (k tonnes)	Multiplier Ref: 1990	Annual increase (%)
2020/Basic Control Technologies	13054	2.92	3.6
2020/Advanced Control Technologies	10522	2.35	2.9

Source: RAINS-ASIA: An Assessment Model for Air Pollution in Asia. Final Report for the World Bank Sponsored Project "Acid Rain and Emission Reductions in Asia". December 1995.

It has been observed that so far as SO_2 emissions are concerned, the thermal power plants are able to cost-effectively meet the norms using high stacks. Rather than installing flue gas desulfurization (FGD) equipment (as required by the World Bank, to meet its norms), ambient SO_2 standards are often met by constructing high stacks, which is cheaper than installing FGD technology. However, high stacks only shift the ground level concentration of SO_2 to a higher elevation rather than reducing the emissions per se. (ADB, 1998).

Oxides of Nitrogen (NO_x)

NO_x is produced during combustion from two sources. The fuel contains some nitrogen and a part of this nitrogen reacts with the combustion air to produce NO_x. This is called fuel NO_x. Generation of fuel NO_x is dependent on a series of complex reactions controlled by fuel characteristics, air-fuel mixing and furnace design. Depending on nitrogen content, the fuel NO_x can constitute 10 to 70% of total NO_x emission. As coal contains more nitrogenous compounds, fuel NO_x generation is high in coal-fired process, whereas in gas-fired process fuel NO_x generation is very low. During combustion process excess air is used to ensure complete combustion of fuel and nitrogen present in the combustion air reacts with excess oxygen to produce NO_x. This is called thermal NO_x and its generation is dependent on the temperature of the burning process.

India does not yet have any NO_x emission limit for power generation, except for gas-based power plants. As such, no major steps have so far been taken by conventional thermal power plants for controlling NO_x emissions, although many of the new conventional TPPs are going in for low-NO_x burners. For combined- cycle power plants (natural gas, LNG, and naphtha) both low NOx burners and water/steam injection are used.

Particulate matter

Incomplete and/or inefficient combustion processes of fossil fuel generate carbonaceous material, known as soot. (i.e. less than one micron). Emission levels of the soot particles are estimated to be around 0.061 gm/kWh per unit of electricity from Indian thermal power plants. (1997).

The vast bulk of coal based generating capacity in India consists of units of 210 MW and 500 MW sizes. All these units are based on sub-critical pulverised coal technology and utilise high ash (35-40%), and low grade (4000 kcal/kg GCV) coal. This coal-TPS technology combination results in high levels of particulate emissions. All these plants are provided with ESPs but the effectiveness of ESP is affected by high resistivity ash, unburnt carbon particles and high excess air ingress.

Ash

In a coal-fired plant pulverised coal is used instead of lump coal for greater efficiency of boiler. The pulverised coal on combustion produce fine residue known as ash. The ash content in Indian coals ranges between 25% to 40% and even more. The ash produced in thermal power plants can cause all three environmental risks - air, surface water and groundwater pollution. The pathways of pollutant movement through all these modes are schematically represented in Figure 3.1.

The ash produced as a result of burning of coal is further categorised as fly-ash and bottom-ash. Out of the total ash, 20% is bottom-ash, stored in the ‘ash ponds’ within the premises of the plant and the remaining is fly-ash. Ash residues and the dust removed from exhaust gases may contain significant levels of heavy metals and some organic compounds in addition to inert materials. The fly-ash immediately gets scattered over a wide area. This adversely affects the atmosphere and aesthetics of the nearby plant area. As per the thumb rule calculation suggested by the Central Pollution Control Board, the required area for a 10 m deep ash pond for 1 MW installed capacity of coal based thermal power plant works out to be about 1.5 acres. The World Bank has cautioned India that by 2015, disposal of coal ash would require 1000 square kilometres (The Business Line, 22 December 1999). The volume of solid wastes may be substantially higher if environmental measures such as flue-gas desulphurisation (FGD) are adopted.

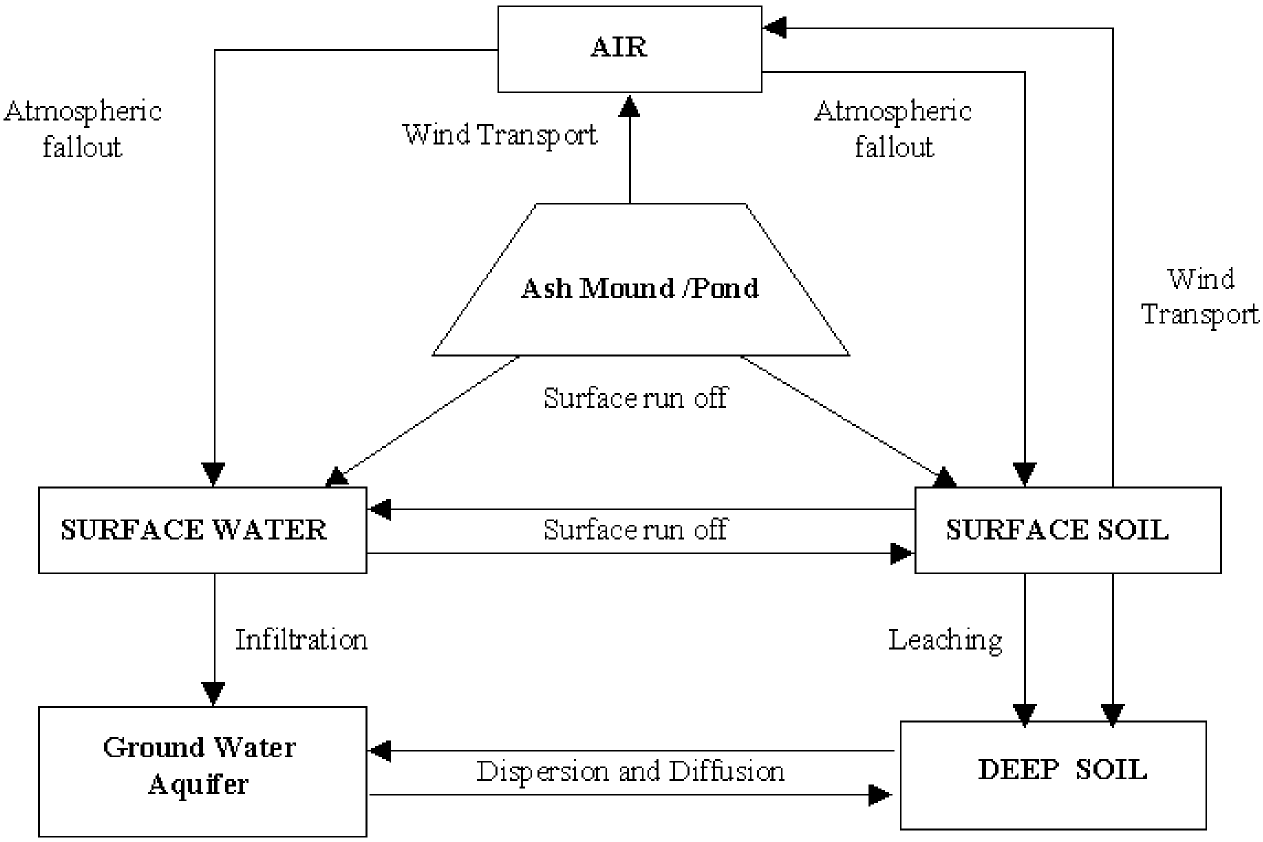

Figure 3.1 The pathways of pollutant movement through all these modes

Wind-blown ash dust from ash mound/pond causes air pollution. Besides, the air-borne dust can fall in surface water system or soil and may contaminate the water/soil system. In the wet system of disposal, flyash collected in ESP is normally sluiced with water to ash ponds for disposal. The ash settles in ponds and clean water is discharged into adjacent natural water bodies. In well-designed and managed ash disposal systems, the pollution is minimal. Current environmental standards imposed by CPCB are adequate. In practice, at most power plants in India, ash ponds are not properly designed or operated and do not comply with CPCB standards. Large quantities of fly ash are transported to reservoirs, streams and rivers; the turbidity increases causing changes in the aquatic ecosystem. Some of the ash settles down causing siltation. Dissolved ash releases toxic elements; part of the water from the ash pond leaches into the subsurface and mixes with the groundwater, which also gets contaminated. Fly ash is reported to cause ailments like allergic bronchitis, silicosis, and asthma. Besides, fly ash contaminates surface water and may also have an effect on underground water, affects the aquatic life, is harmful for plants, and corrodes exposed metallic structures in its vicinity.

Box 3.1: Flyash and pollution

Ropar, October 8

Fly ash continued to flow into the Sutlej in the international wetland here for the second day from the breached dyke of the Guru Gobind Singh Super Thermal Plant (GGSSTP). Sources said the fly ash flowing into the wetland would adversely affect its flora and fauna. The fly ash was reducing the oxygen content in water in the wetland, threatening the fish species. The Department of Fisheries, Ropar, has collected samples of water from the wetland to assess the oxygen content in it. The District Fisheries Officer, Mr Dogra, said due to persistent pollution from fly ash dykes, the number of fish species in the wetland had reduced from 35 to 17.

The fly ash would adversely affect the food chain in the wetland. The photosynthesis of hydrophytes in the wetland was being affected due to the pollution. The hydrophytes are the major food of fish and snails that further feed migratory birds coming to the wetland. *(The Tribune, October 9, 2003)*

Box 3.2: Impact of coal ash

A study was conducted in Delhi, India, to determine the impacts of coal ash effluent on the chemistry and biology of the River Yamuna. The study examined chemistry changes, measuring a suite of physic-chemical parameters at two sites upstream and downstream of a large power station. The station had a total generation capacity of 225 MW, and daily used about 4,000 tons of bituminous coal. The station produced 1,600 tons of waste ash daily, 80% of which was fly ash. The ash was sluiced into a series of settling ponds and the overrun flowed into the river Yamuna. Significant differences between the sites were observed for a number of water quality parameters including conductivity, TDS, dissolved oxygen, total hardness, sulfate, and nitrite, all of which had higher values downstream of the effluent over the two year sampling period. Free carbon dioxide, total alkalinity and phosphate were significantly lower downstream of the effluent.

Elemental metal analysis also was conducted on water samples collected upstream and downstream of the coal ash effluent. A number of toxic metals had higher concentrations (ppm or mg/L) downstream of the effluent including Al (0.39 vs 0.78 ppm), Cd (0.044 vs 0.071 ppm), Cr (0.017 vs 0.034 ppm), and Zn (0.195 vs 0.275 ppm). *(Biology Department, Virginia Tech, Virginia, USA. March 2000)*

Box 3.3: Fly ash related diseases

A large number of people at Santhaldih, in Purulia district of West Bengal, are victims of lung infections and skin disease, caused by fly ash contamination of air and water. The power plant, first commissioned in 1973, with a total of 480 MW capacity, produces 0.6 MT of fly ash every year. The authorities had built two ash tanks at Santhaldih, which have now been filled up. And the fly ash, now that it cannot be stored in these ash ponds, is getting scattered over 25 villages in the neighbourhood. The effect of the ash is found on local animals and vegetation, too. The cattle feeding on contaminated vegetation are victims of skin diseases and dental disorders. The population of birds and water animals is also decreasing. (*The Financial Express, 22 August 1999*).

The coal-ash pollutes the air as well as water too and requires a huge land area for its disposal, the value of which cannot be compensated by money specially for a country like India, where land-population ratio is much less as compared to other countries. Disposal of this ash apart from space problem causes air, land and surface water pollution also. The chemical reaction of ash with emitted gases like SO_2, NO_x and hydrocarbons results in to degeneration of flora and fauna in the adjoining region. Dust bowl conditions are invariably created in dry weather around the power plant, which adversely impacts the nearby aquatic bodies (Kumar S, 1999).

Impact on the land use

Sites for hydro and thermal power stations as well as that for ash disposal require large areas of land. While hydro power stations are built on the rivers, since thermal power stations also require cooling water, they are located on sites where water is available in abundance. This implies that the necessary land is generally of economic value, but the impact of the construction of power plants on economic activities that could have taken place there, and social impacts of them is not taken into account while calculating the cost of power.

Hydrological impacts

Significant impacts on the hydrological environment are caused by conventional thermal power generation. All thermal power requires large quantities of water for cooling and other purposes. Water is also required for auxiliary station equipment, ash handling and flue gas desulfurisaton (FGD) systems. In most cases, such supplies are drawn from existing reservoirs, or dams and reservoirs are specifically constructed to cater to the need of the plant. In case of the former, the plants access the water on payment of a nominal cess. Besides, water exploitation takes place from ground water sources too, for which neither is appropriate costing done, nor any cess levied. Thus, the environmental impact of ground water remains unaccounted for.

The characteristics of the waste waters generated depend upon the ways in which water has been used. Contamination arises from demineralizers, lubricating and auxilliary fuel oils, chlorine, and other chemicals used to manage the quality of water in cooling systems. Once-through cooling systems increase the temperature of the receiving water.

Due to low efficiencies of thermal power plants, a large amount of heat is wasted. This waste heat is removed in the condensers through circulating cooling water. The heated effluent leaving the condensers is often disposed off by discharging it to a nearby natural body of water such as a river, lake, or coastal waters. For wet cooling towers, a water source is required to compensate the evaporation losses as well as water lost during blowdown. Blowdown is the periodic flushing of cooling system to remove solids and chemicals, accumulated in the cooling water circuit. This may cause water pollution. Besides, thermal discharges affect the water-based ecosystem to various degrees (El-Hinnawi, 1981).

Thermal power generation thus causes two kinds of impacts on water resources of an area, first, it places heavy demands on water supplies to meet the cooling water requirements, and second, it causes thermal pollution of natural water systems due to the addition of waste heat.

Emission norms

The World Bank has proposed some environmental guidelines for new thermal plant. The guidelines are based on the concept of air-sheds and they distinguish air-sheds of good, moderate and poor quality. The guidelines state maximum plant emission levels which should be followed in achieving the site specific emission guidelines. The guidelines also distinguish between power plants greater or less than 500 MW (World Bank).

Current Indian emission standards for Total Solid Particles (TSP) are 150 mg/m^3 for power generation units of capacity above 200MW and 350 mg/m^3 for units less than 200 MW. The proposed World Bank standards are much lower at 50 mg/m^3. According to the proposed standards, many air-sheds in India would be classified as poor with respect to TSP. The annual average concentrations of TSP permitted by present Indian standards (360 µg/m^3) substantially exceed the limit in the World Bank alternative (80 µg/m^3 for moderate and 160 µg/m^3 for poor).

There are no fixed emission standards for SO_2 in India at present. The World Bank has prescribed the emission standard for SO_2 to be 2000 mg/m³. Present Indian ambient quality standards for SO_2 in residential areas (60 µg/m³) correspond roughly to moderate quality air-sheds and industrial areas (80 µg/m³) correspond to poor.

Table 3.5 Existing Indian MoEF standards

	Residential / rural areas			*Industrial / mixed area*		
Air quality standard, (µg/m³)	*SO_2*	*NOx*	*SPM*	*SO_2*	*NOx*	*SPM*
24 hour average	80 (3)	80 (30)	200 (100)	120	120	500
Annual average	60 (15)	60 (15)	140 (70)	80	80	360

(Figures in brackets are for sensitive areas)

Table 3.6 World Bank proposed air quality standards

	*Moderate ** quality*	
Air quality standard, (µg/m³)	*SO_2*	*SPM**
24 hour average	150	230 (130)
Annual average	*50*	80 (50)

(*Figures in brackets indicate limit for PM10
**N.B. Air quality is categorised as 'Poor' under these standards when either the annual mean value is more than twice the standard for an airshed with moderate air quality or when the 95th percentile of the 24 hour mean value of a year exceeds the trigger value for peak exposure levels in an airshed with moderate air quality.)

Current Indian standards and those proposed by the World Bank are shown in Tables 3.5 and 3.6. The World Bank standards are significantly more severe; a 'good' quality air shed requires annual average concentrations to be less than 50µg/m³ for SO_2 and 80µg/m³ for SPM. These are respectively 17% and 43% lower than the current Indian standards for residential/rural areas and 38% and 78% lower than the current Indian standards for Industrial/Mixed areas. Were the World Bank proposals to be implemented, these reductions could significantly constrain the siting possibilities for new plant.

The World Bank standards for emissions have also been expressed in terms of total emissions from power plants during a day, for plant emitting to good quality airsheds. The limits are:

- Plant up to 500 MWe: Maximum Emissions of SO_2=0.2 ton/MWe/day
- Part of Plant >500 MWe: Maximum Emissions of SO_2=0.1 ton/MWe/day

As per modelling exercise carried out by the World Bank, SO_2 concentrations around a 500 MW power plant burning Indian coal would contribute 9-17 µg/m^3 to ambient annual average. With present India standards it may well be possible to site several plants in a region without exceeding the prescribed annual limit of 80 µg/m^3. The World Bank alternative standard (50 µg/m^3) for moderate quality air-sheds would make it more difficult to comply by careful siting and control technologies may be necessary.

The World Bank study used data from several sources to estimate typical effects on air quality due to emissions from power plant alone. It observed that the majority of existing power plants exceed stack gas concentration limits for SPM, often by large amounts. This is due to several factors, including, (i) mineral content of coals used is higher than designed, (ii) poor maintenance and operating procedures, and (iii) flue temperatures are not within the range needed for optimal ESP operation.

Case study: Emissions from a 500 MW power plant

For comparative evaluation of the air pollution impact due to use of different fuels i.e., coal, fuel oil, natural gas, naphtha and LNG, emissions of different pollutants from a typical 500 MW plant are calculated (TERI, 1998). The assumptions made for the various parameters are given below:

1. Some of the important parameters having an impact on air emissions are listed in Table 3.7.

Table 3.7 Important parameters of fuels used in thermal power plant

Fuel	*Calorific value (kcal/kg)*	*Ash %*	*S %*
Coal	4000	40.00	0.350
Fuel Oil (LSHS)	10500	0.10	0.800
Fuel Oil (High S)	10500	0.06	2.100
Natural gas	8500 (kcal/Nm^3)	0	0.010
LNG	11500	0	0
Naphtha	11300	0	0.017

2. For coal and fuel oil, conventional boilers have been considered. However, in case of natural gas, LNG and naphtha, combined cycle combustion turbine (CCCT) generating stations have been considered. Thus, in case of combined cycle operation, for a typical 500 MW plant, the pollutants emitted would correspond to only about 330 MW capacity (2 × 165 MW GT) while the remaining capacity (1 × 170 MW ST) would not have impact on the emissions.
3. The emissions of various pollutants have been calculated without any control measures as well as with the application of different control devices. In the case of coal, ESPs have been considered for control of particulate matter. No control measures are considered for fuel oil (low sulphur) based power plants. It may also be noted that the power plants using natural gas, LNG and naphtha, generally have low NOx burners or water/steam injection for control of oxides of nitrogen.
4. The heat rates used for coal, fuel oil, natural gas, LNG, and naphtha are 2400, 2375, 1900, 1900, and 1900, and kcal/kg respectively. For the purpose of inter comparison of emissions, a uniform PLF of 75% is assumed for power plants using different fuels.
5. The emission factors for various pollutants are based on studies conducted on Indian Power plants. The corresponding emissions from a 500 MW unit using these emission factors are given in Table 3.8.

Table 3.8 Annual emissions from a typical power plant (500MW) using different fuels

Fuel	*Total fuel consumed (tonnes)*	*Emission factor source*	*SPM, (tonnes) Uncontrolled*	*Controlled*	*SO_2 (tonnes) Uncontrolled*	*NO_x (tonnes) Uncontrolled*	*VOCs (tonnes)*
Coal	1971000	CPCB	630720	2365	11452	5203	--
		WHO93	394200	26017	13452	14783	108
LSHS (Oil)	743036	WHO93	1082	108	11889	3938	94 67 (with ESP)
Fuel Oil (High S)	743036	WHO93	2357	236	31208	3938	94 67 (with ESP)
Natural gas	383199	WHO93	23	--	77	1680	14
LNG	358208	WHO93	22	--	0	1570	13

Fuel	Total fuel consumed (tonnes)	Emission factor source	SPM, (tonnes) Uncontrolled	SPM, (tonnes) Controlled	SO_2 (tonnes) Uncontrolled	NO_x (tonnes) Uncontrolled	VOCs (tonnes)
Naphtha	364548	WHO93	22	--	124	1598	13

Note. A = Percentage ash content by weight; S= Percentage sulphur content by weight; Typical value of f=0.7829
The NO_x emission factors quoted for WHO (1993) are those for tangentially fired boilers; Emission factor for LNG and naphtha are assumed to be same as those for natural gas.
Sources: CPCB, 1994; WHO, 1993

Some of the important inferences are as follows:

1. Overall, in respect of SPM, the cleanest fuels for power generation are natural gas, LNG, and naphtha, followed by LSHS. Coal has significantly higher particulate emissions compared to these fuels.
2. Table 3.9 shows the total CO_2 emissions per annum from a 500 MW unit using different fuels.

Table 3.9 Carbon dioxide emissions from a 500 MW power plant

Fuel	*Emission factor*	*Total CO_2 emissions (MT/year)*
Coal	94600 g/GJ energy input (WB 1997)	3.12
Fuel oil/LSHS	77350 g/GJ energy input (WB 1997)	2.53
Natural gas	56100 g/GJ energy input (WB 1997)	0.96

*- The CO_2 emissions work out to be 3.51 MT/year using Indian emission factors (Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS): India, Asian Development Bank, Manila, October 1998)

3. Overall, in respect of SO_2, the cleanest fuels are natural gas, LNG, naphtha, followed by coal and LSHS.

4. The uncontrolled emissions of nitrogen oxides per annum are maximum in case of coal (15000 tonnes). In comparison, the emissions from other fuels, i.e., natural gas (1700 tonnes) and LNG/naphtha (1600 tonnes) are lower but not insignificant as was the case earlier with SPM and SO_2 emissions.

   Overall, in respect of NO_x, the cleanest fuels are LNG, naphtha, natural gas, LSHS, followed by coal on the assumption that all of them use NO_x control measures. However, not all coal-based power plants have NO_x control measures and their emissions are likely to be higher.
5. In case of 'Volatile Organic Compounds' (VOC), total VOC emissions per annum are maximum in case of coal (108 tonnes), followed by fuel oil/LSHS (94 tonnes; 67 tonnes with ESP), and the other fuels like natural gas/LNG/naphtha (13 -14 tonnes). Overall, in respect of VOC's, the cleanest fuels are LNG/naphtha/natural gas, and LSHS, followed by coal.
6. During the combustion of fossil fuels, emissions of potentially toxic pollutants can result from the trace impurities in the fuel. These impurities (Hazardous Air Pollutants) can be emitted as particulate matter or gaseous compounds.
7. For a 500 MW power plant using indigenous coal (40% ash) approximately 0.76 MT of ash (0.6 MT of fly ash + 0.16 MT of bottom ash) is generated annually. This is presently discharged into ash ponds. For every megawatt of installed capacity, approximately 1 acre of land is required for disposal of fly ash for 30 years, provided the material is allowed to accumulate to a height of 8 to 10 m. Therefore, the estimated land requirement for a 500 MW unit over its life would be about 500 acres (200 hectares).
8. From a 500 MW unit about 130000 tonnes of gypsum would be produced annually. Gypsum sludge from the treatment of the waste water from the FGD unit contains the metals that escape from the ESP as ash or in the form of gas.

Environmental impacts of hydro power generation

Hydropower projects could be broadly categorized in three categories, namely, (i) located at large water reservoirs/dams, (ii) run-of-the river plant with or without some pondage, and (iii) small-head power plants on canals. Out of these, large reservoirs based hydropower projects cause major impacts on the environment and have human-angle attached to them. Some of the major impacts are indicated in Table 3.10.

Table 3.10 Impacts of large hydro power plants

1. Catchment area	a) Effect on river regime upstream b) Soil erosion and degradation of land necessitating integrated solid and moisture conservation measures in the agricultural area, common lands, waste-lands, etc. c) Conservation and improvement of existing natural forests and plantations over new areas as an integrated package along with soil conservation d) Wild-life protection.
2. Reservoir	a) Submergence of mines and minerals b) Clearance of forest c) Fisheries and other aquatic habitats d) Wild Life e) Flora and Fauna f) Cultural and Archaeological places g) Water quality h) Water weeds i) Resettlement of oustees j) Fore-shore cultivation k) Health hazards etc.
3. Dam	a) Induced seismicity b) Dam safety measures c) Operating arrangements - Gated and un-gated spillways d) Fish migration arrangements e) Flushing doses for maintenance of river regime f) Provision for releases to maintain the minimum and required supplies from the river g) Provision for releases required for pollution control, etc.
4. River Regime Downstream	a) Bank and bed erosion b) Degradation in river regime c) Likely increase in flood damages d) Navigation e) Pisciculture, etc.

Source: A study on cost of Electricity Generation and Environmental Aspects. Metaplanners and Management Consultants, Patna. 1989.

The adverse environmental impacts of man-made reservoirs are detailed out in the following section (Metaplanners Consultants, 1989):

Physical effects

These effects include:

- Change in the river direction

- Erosion of the reservoir banks
- Siltation of the reservoir
- Rise in the nearby water table
- Reservoir induced earthquake

Chemical change

These include the changes in reservoir water quality which may affect the health of flora and fauna dependent on that source of water, decomposition of organic material in the lake bottom resulting in the production of methane and hydrogen sulphide, waterlogging and consequent salinity in the surrounding regions and finally oxygen depletion.

Essentially, damming the rivers can alter the amount and quality of water in the river downstream of the dam, affecting the aquatic life. Alterations in the flow rate and other parameters of the water body in the river are considered to be of primary importance in the analysis of environmental externalities. Impacts on agriculture, on natural ecosystems and on wildlife, are some of the most significant impacts due to the new hydrological conditions. Additionally, the new hydrological balance in the wider area affects the quantity and quality of the underground and surface water resources (ExternE).

Biological effects

These include the submergence of flora and fauna and consequent reduction in species diversity, which may affect the ecological balance, possible extinction of some rare species, possible barriers to fish migration, breeding grounds for disease vector like of malaria, and proliferation of weeds.

A few recent studies of large reservoirs created behind hydro dams have suggested that decaying vegetation, which is caused because of flooding, may be giving off quantities of greenhouse gasses that are the same as those that are given off from other sources of electricity. If these studies turn out to be true, than some of the hydroelectric facilities that flood large areas of land may be large contributors to global warming.

Social and cultural changes

These include uprooting of the local inhabitants whose ancestral homes and farms are inundated, possible loss of archeological remains, loss of scientific information due to loss of species, possible increase in disease and finally possible gap in communication within adjacent areas.

Socio-environment impact

The most obvious impact of hydroelectric dams is the flooding. Construction of a large dam involves flooding of land area. Most of this land was previously forested or used for agriculture. Indeed, in many cases, large hydro projects have flooded the homelands of native peoples, destroying their way of life and displacing them from their habitats. Loss of agricultural land, alterations of vegetation and biodiversity are only some of other negative consequences of large hydro projects.

Environmental impact of nuclear power

In case of nuclear power plants, even during normal operation, radioactive materials are regularly discharged into the air and water. One of the biggest problems pertains to *safe* disposal of radioactive waste generated in a nuclear reactor. Nuclear waste is produced at every stage of the nuclear fuel cycle, from uranium mining and reactors to reprocessing irradiated nuclear fuel. Much of this nuclear waste will remain hazardous for thousands or even millions of years, leaving a poisonous legacy to future generations.

When a nuclear reactor is shut down or decommissioned, many of its component parts have become radioactive. They have to be treated as nuclear waste. Vast sums of money will have to be spent on nuclear waste disposal, decommissioning, nuclear transports and the clean-up after radioactive accidents.

Rationale for the wind power

The main advantage of wind power vis-à-vis other supply options are as follows:

1. Since wind electric generators can be installed rapidly, gestation period of a wind power project is much shorter compared to that of thermal or hydro power projects.
2. Fuel (wind) being free, the wind power can help stabilize energy prices far into the future. In comparison, fossil fuels based power projects can be subject to rapid price fluctuations and supply problems.
3. The electricity generated by wind plants can displace costly gas-fired generation since gas-fired units are flexible and can be adjusted quickly to respond to changes in the level of generation from wind.

4. Wind farms consist of a number of wind turbines, which can be installed in a very short time (and in tune with the power demand) compared to large centralised power stations. Therefore, wind farms obviate the need for large initial investments in big power projects with uncertain sales projections.
5. Being modular in nature, each wind turbine can start to operate as soon as it is installed on site, independent of the status of the other turbines.
6. Similarly, in case a wind turbine fails, the other machines are not affected at all.
7. As each wind turbine is small compared to the unit size of large centralised power stations, the effect of wind turbine failures on the total available power output is considerably smaller.
8. It can increase diversity of supply and power system reliability.
9. Wind farms offer grid-side benefits, such as:
   - T&D deferrals
   - Reduced T&D losses
   - Voltage support
10. The high inertia of wind turbines is a crucial factor in overall power balance of the network (Ackermann, 1999). If network frequency drops, the rotational speed of the wind turbine equipped with an induction generator wants to decrease, but the high inertia of the rotor will lead to a brief increase in the generator power output. This additional power will help to improve the power balance. But if the network frequency increases, the rotational speed of the wind turbine generator wants to increase but, due to the high inertia of the rotor, the power output will briefly decrease until the rotor speed increases. Hence, the reduced power output will improve the power balance. (This inertia effect of wind turbines, however, does not work with variable speed turbines, as generator and rotor have no fixed coupling).
11. Embedded generation (such as that from wind farms) leads to a reduced transformer load at the substations (Ackermann, 1999), when the embedded generation is generating active power. This reduced transformer load results in decreased transformer temperatures. A reduced transformer temperature leads to:
   - a higher transformer efficiency
   - a longer life time of a transformer
   - extended equipment maintenance intervals.
12. Even compared to other renewable energy technologies, especially compared to solar and geothermal, wind energy is more benign environmentally as shown in Table 3.11.

Table 3.11 Life cycle emissions from renewable (in g/kWh)

	Energy crops Current practice	*Energy crops Future practice*	*Hydro Small-scale*	*Hydro Large-scale*	*Solar PV*	*Solar Thermal electric*	*Wind*	*Geotherm*
CO_2	17-27	15-18	9.00	3.6-11.6	98-167	26-38	7-9	79
SO_2	0.07-0.16	0.06-0.08	0.03	0.009-0.024	0.20-0.34	0.13-0.27	0.02-0.09	0.02
NOx	1.1-2.5	0.35-0.51	0.07	0.003-0.006	0.18-0.30	0.06-0.13	0.02-0.06	0.28

Source: IEA, Benign Energy? The environmental implications of renewables, OECD, Paris, 1998, p45.

13. Electricity from wind can also reduce the risk of power outages, which can be important for many industries ranging from manufacturing to tourism.

Box 3.4: Power system outage and green power

The Canadian Association for Renewable Energies in its comments on the interim report of the Canada - U.S. Power System Outage Task Force, investigating the causes of the August outage said that:

- Greater reliance on green power and distributed generation technologies would have reduced transmission peaks and variances on the grid, which appear to be a contributing factor to the collapse.
- Greater use of renewable energy technologies would have facilitated a more rapid resumption of generation and transmission following corrective action, beyond the ability of fossil fuel and nuclear facilities to respond.

14. The oft-repeated issue of fluctuating power output from a wind turbine, due to the variability of the wind speed, can be sorted out to a large extent through installing a number of wind turbines in a wind farm. The studies had established that in a wind farm, consisting of a large number of wind turbines, short-term fluctuations in the overall output are reduced due to the effect that gusts do not hit all wind turbines at the same time (Ackermann, 1999).

Indeed, the recent studies show that in contrast to high frequency power level fluctuations from a single wind farm, two or more wind farms tend to *smoothen out* these fluctuations. Thus, any detrimental effect of wind power on system regulation gets reduced considerably as more and more wind farms come in to the network (Wan et. al., 2003).

Wind power and socio-economic development

Wind energy is also a key potential source of sustainable jobs that are created without adding to air pollution, greenhouse gases, or other types of pollution and environmental damage such as mining or oil spills. The human health costs of air pollution (rising rates of asthma in many areas) and the cleanup costs of pollution are part of the hidden price tag of fossil fuels that reduce economic growth.

Communities in rural areas near wind farms are finding today that wind can be a good neighbour, providing a source of jobs and income to sometimes hard-pressed populace.

Box 3.6: Wind Energy Transforms Village

Aralvoimozhy, a little-known village in Nagercoil district of Tamil Nadu is finding its place on the energy map of the world. A few kilometres north of Kanyakumari, against the backdrop of the rugged hills, the landscape is dotted as far as the eye can see with three-bladed wind turbines rising above the coconut plantations. It's an out-of-the-world experience in a world of centralised power generation with large coal-based power plants. No pollution, no noise, no displacement! Nearly three thousand wind turbines work in unison (with grid frequency) to generate millions of units of electricity.

One of the largest wind farms in the world, Aralvoimozhy is a major success story today of not only renewable energy technologies but also the manner in which distributed generation can transform the economy of a place. Indeed between 1990 and now, an investment of nearly Rs 2,000 crore can be seen in the form of economic development that has taken place in Aralvoimozhy, Nagercoil district and the Tirunelvelli district.

A small sleepy place has been transformed in a short period of ten years. Gone are the hutments and kachcha dwellings. In their place are fine bungalows and several colleges and institutions offering professional courses in engineering and medicine.

The residents of Aralvoimozhy benefited immensely by the wind rush as they got employed, took up subcontracts and sold land at good prices to industrial units that set up the windmills. And it shows. ....

Due to the high average annual wind speeds and high energy content in the wind, land for setting up wind farms in Aralvoimozhy became a prized commodity and in addition to that came opportunities of income generation and employment in the projects, transforming the life and lifestyles in this village.

Source: 'Power problems? An answer is blowing in the wind'. Business Standard (Delhi). May 20, 2002.

Indeed, the wind farms, most of which are situated on remote rural locations, have been able to bring about a sea-change in socio-economic conditions of those rural areas. By way of generating income through land sales, through employment generation, and through other economic activities built around wind farms, wind power has contributed significantly to the rural development.

Box 3.6: Clean Energy Brings Windfall to Village

November 01, 2003 8:58:00 PM ET

MUPPANDAL, India (Reuters) - On the southern tip of India, the once-impoverished people of Muppandal village are thanking Varuna, the Hindu god of the wind, for blowing unexpected good fortune their way. In the decade since the first giant power-producing windmill, towering above the palm trees with its whirring 80-foot blades, their lives have changed dramatically. Incomes have risen and thousands of new jobs have been created as dozens of wind energy producers swarmed the village, the showcase of a $2 billion clean energy program in India, the world's fifth-largest producer of wind energy.

"In 10 years, my daily income has gone up to 450 rupees ($10) from 45 rupees", says Koilpillai Gopal, a barber who has been able to convert his modest roadside kiosk into a glittering shop. "It is all because of the windmills".

In Muppandal, a hilly region where the wind races in from the Arabian Sea through gaps between the mountains, the price of land for a windmill has soared to $6,620 from about $880 in the early 1990s.

Nineteen-year old Raju Palavoor, a watchman at a wind farm, pays his college fees and flaunts a flashy watch........"Thanks to the windmills, I can be a graduate.

Source: http://energy.surfwax.com/files/Windmills.html © 2003 Reuters

Price fluctuation and energy security

Although energy security is generally conceptualized in terms of the risks of fuel supply *disruption*, fuel *price volatility* probably represents a more important aspect of energy security. At times price volatility may well have more profound effects on economic well-being than temporary supply disruptions. The real risk of volatile energy prices is not simply that they are unpredictable, but that they cause economic activity to decline. The effect of fossil fuel on economic performance needs to be explicitly recognized for its importance as an aspect of energy security.

The relationship between oil price movements and economic activity has been studied in most western countries. These studies bring it out clearly that oil prices have profound negative effects on employment, output and stock market performance. This is what is known as 'fossil price risk'. "This risk is systematic and not diversifiable, it affects everyone more or less and produces the worst possible set of circumstances for businesses and households: high fuel prices hit people when they are already feeling recessionary pressures - low incomes, layoffs and depressed property values - thereby exacerbating their economic situation. Fossil price risk cannot be diversified. Wind energy offers a direct mean of dealing with it. Indeed, wind energy represents a form of 'insurance' against high fossil prices" (Awerbuch, 2003).

The negative relationship between fossil fuel prices and economic activity has powerful implications for the valuation of fossil-based generating alternatives. In this context it clearly implies that traditional electricity cost estimates significantly understate the present-value magnitude of projected fossil fuel outlays for generating electricity.

As per IEA document, titled 'Renewable Energy... into the Mainstream' (IEA, 2002):

"The inherent characteristics of renewable energy technologies reduce or eliminate a number of risks and this adds to their overall value. Renewable energy is a domestic resource and thus less subject to transportation or supply disruptions. Renewable energy technologies can generally be sited closer to the end-use. Renewables-based generating capacity closer to the end-user minimises both transmission losses and costs. *While there are relatively high capital costs, for most renewable energy technologies the fuel input has minimal cost. This means that the electricity or heat supplied is not prone to price fluctuations, as fossil fuels are.* Supply swings, in terms of shortages or large inventories, can also create even greater swings in end-use prices, which can have economic and social repercussions that in turn can affect energy supply industries as well as all categories of end-users. This is also an energy security concern, although of a different nature.

Accordingly, by providing an important contribution to energy supply, renewable energy also reduces risk. This is why renewable energy technologies provide inherent important financial benefits that challenge traditional analysis, once the basic financial fluxes have been implemented. Indeed, engineering cost models that are currently used for financial analysis in the energy sector work reasonably well in an environment characterised by technological stasis and homogeneity – i.e. in an environment where all technology alternatives have similar financial characteristics and a similar mix of operating and capital costs. However, the current energy system is changing radically and the old environment no longer exists. ***Rather, in today's environment, the variety of resources options is broad and ranges from traditional, risky fossil alternatives to low-risk, passive, capital-intensive renewables with minimal operating cost risk.*** Renewables offer unique cost-risk choices as well as valuable flexibility and modularity attributes that traditional valuation models cannot assess because they were designed for a different technological era. Properly understood and exploited, the attributes of renewables could undoubtedly form the basis for re-engineering the electricity production and delivery process to create cost reductions in ways that cannot yet be imagined.

When correctly evaluated using modern financial analysis techniques, renewables are considerably more cost-effective relative to traditional fossil-based generation than widely believed, even without taking account of the avoided external environmental costs. This requires evaluating the technologies based on their contribution to overall financial risk. Passive, capital-intensive renewables, such as photovoltaics and wind, are essentially risk-free because their year-to-year costs remain unchanged and, even if there are some minor variations due to variable maintenance costs, these are not related to price variations of fossil fuels. Even though, on a stand-alone basis, renewables are often seen as expensive, modern financial analysis techniques, which focus on the medium-term evolution of the energy-based portfolio, show that a certain percentage of renewables in the overall fuel mix of a utility reduces the overall risk and the overall portfolio cost.

Any portfolio should include some proportion of fixed-price power. Building optimal generation portfolios that include renewables is one alternative to dealing with price risk."

Indeed, wind energy is indigenous, not only at the national level but also at the local level, thus minimising energy supply disruptions ***at the state level***. Therefore, in states rich in wind resource, reliance on energy imports (e.g. import of coal from other states) is reduced.

Conclusions

Two things become amply clear from the preceding sections, (i) generation of electricity through fossil fuels definitely leave its foot prints on the environment having significant negative consequences and (ii) wind power is not only environment friendly but it also ranks positive insofar as energy security dimension is concerned.

Indeed, were all of 45,000 MW of wind power potential in the country to be exploited, then on the basis of MNES estimates of environmental benefits of wind power (MNES, 2001), it would result in mitigation of 90,000-128,000 tons of SO_2; 45,000-109,000 tons of NOx; 6400-12,800 million tons of total suspended particulates; and 22 million tons of CO_2 annually.

4 Case study: Maharashtra

Energy scenario

Maharashtra accounts for nearly one-fourth of the gross value of the output of India's registered industrial sector. It is one of the few states in the country to achieve 100% electrification of its towns and villages. The annual average consumption of electricity per person in the state is considerably higher than the national average, and is growing constantly. As of August 2003, the total installed power capacity in Maharashtra was 13,733 MW[1].

The Maharashtra State Electricity Board (MSEB), a statutory body constituted under the Electricity (Supply) Act, 1948 is responsible for generation, transmission and distribution of power in the state. Besides MSEB, there are some licensees like Tata Power, BSES and BEST, which distribute the power in individual franchise areas. The MSEB is further supported by captive generation from some of the industrial units within the state. Of the total installed capacity of 15,214 MW[2], thermal capacity accounts for 76%, Hydro 18%, Nuclear 2% and renewables based power 4%.

The T&D losses in the state are expected to be around 16.5% by 2004-05. The energy demand requirement (at the bus bar) in the state is expected to be around 106892 million kWh, and 142911 million kWh by the end of the 10th and 11th plan periods respectively. The growth in peak load at power stations bus bars has been projected at 6% by the end of the 10th and 11th plan periods respectively.

Power generation in Maharashtra

The following tables present the complete picture of power generation in the state.

[1] http://cea.nic.in & www.npcil.org
[2] Included share from the central sector

Table 4.1 Installed capacity in Maharashtra

	MSEB	*Private*	*Central Sector**	*Total*
Coal	6396	1650	1339	9385
Gas	180	1652	386	2218
Hydro	2394	426		2820
Nuclear			367	367
Wind	8.4	392.8		401.2
Co-generation		23		23
	8970	3728	2092	15214.2

* Maharashtra's share

The installed capacity is dominated by coal, with 61% share, as shown in Figure 4.1.

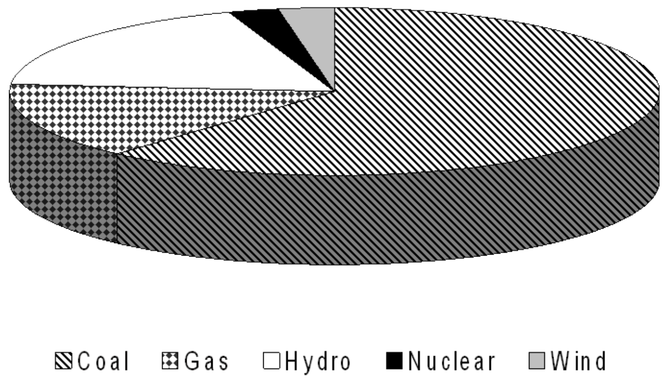

Figure 4.1 Installed capacity

Share of different source in actual generation is shown in Figure 4.2 below. Dependence on coal is evident from the fact that about 80% of total generation is coming from coal based power plants.

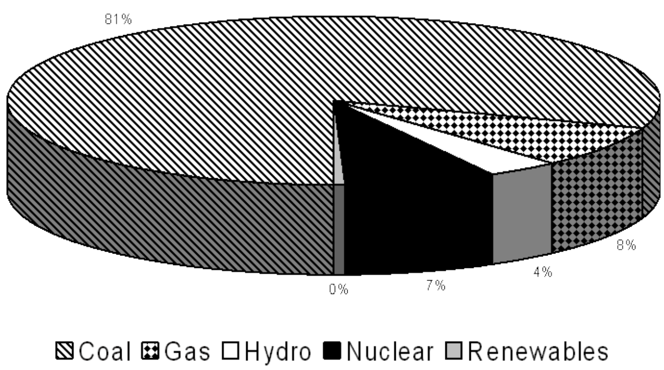

Figure 4.2 Generation from various sources

The following figure depicts the month-wise generation of thermal power plants in Maharashtra in 2000-01.

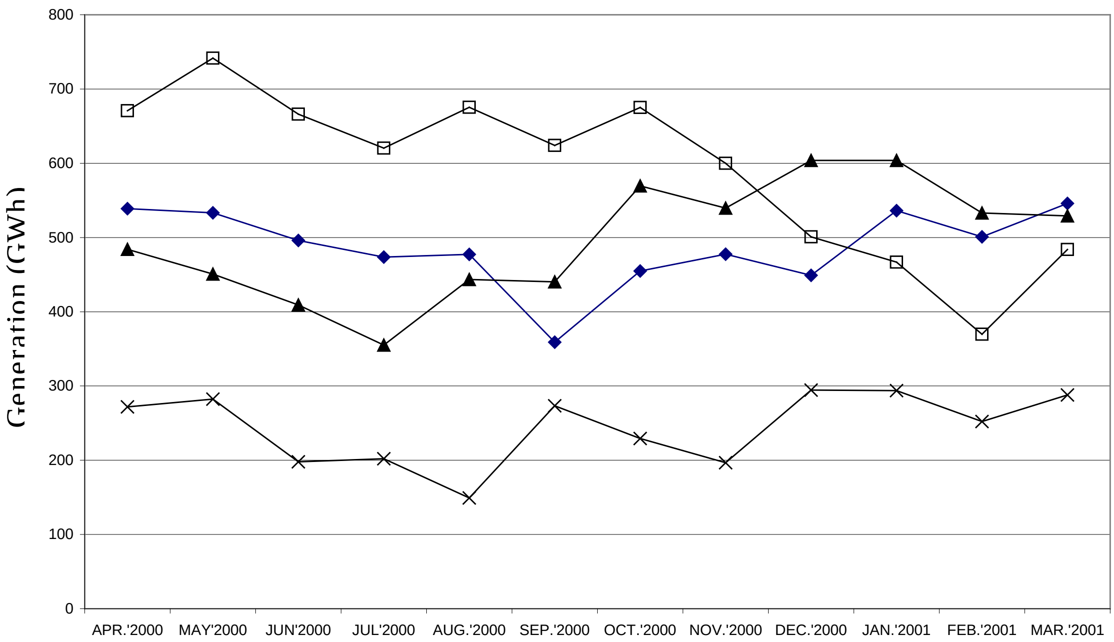

Figure 4.3 Month-wise generation of thermal power plants in Maharashtra (2000-01)

(Source: Annual report of the Western regional electricity board 2000-2001)

Future demand

The energy demand in Maharashtra was 79593 million kWh in the year 2001-02 while as the total energy available was 74218 million kWh[3]. There was marginal increase of 0.6% in the power generation during the year 2002-03 till December 2002 (*Economic survey of Maharashtra 2002-03*). As per the demand forecasts made in the Sixteenth Electric Power Survey, the energy requirement in Maharashtra would be growing at the rate of about 6% during next decade. The increase in demand and present level of generation is shown in the Figure 4.4 below.

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3 Includes energy received from central sector

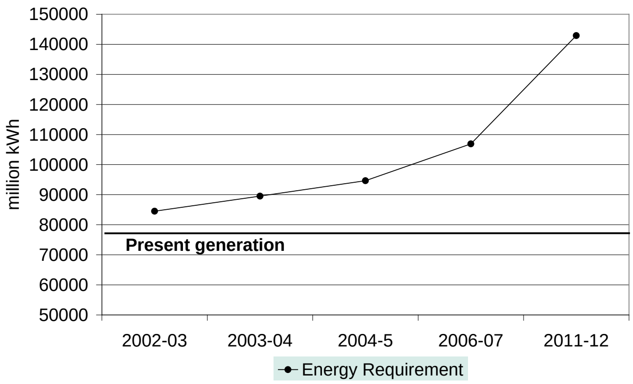

Figure 4.4 Increase in demand and present level of generation

> **Box 4.1: The energy deficit of Maharashtra**
> The available installed capacity of electricity generation for MSEB during 2002-03 is 12,235 MW (excluding DPC-I). The peak on line capacity is in the range of 8500-9000 MW, while the off-peak availability is around 7,200 MW. The peak demand varies in the range of 9,000 MW to 10,500 MW. Day off-peak demand is of the order of 7500-7600 MW. Thus, the system is facing power deficit during the entire period of the day except the night off-peak hours (from 2200 hrs to 0600 hrs.). Therefore, MSEB has to resort to load shedding. The load shedding has been 1000-1200 MW during the evening peak hours, 800-1000 MW during morning peak hours, and 400-500 MW during the day off-peak hours (from 1100 hrs. to 1800 hrs).
> *The Economic Survey of Maharashtra 2002-03*

Emissions from electricity generation

The table below gives the plant-wise energy generation, for MSEB and private power plants in Maharashtra, for the year 2001-02. Based on the heat rate for different power plants, CO_2, SO_x, and NO_x emissions have been calculated.

Table 4.2 Power generation related emissions in Maharashtra

Power plant	*Installed capacity (MW)*	*Fuel type*	*Net heat rate (kCal/kg)*	*Net generation (GWh) 2001-0₂*	*CO_2 emissions (ton)*	*SO_2 emissions (ton)*	*NOx emissions (ton)*
Maharashtra Region							
Nasik	910	Coal	2777.4073	5153.8	5414135.001	36076	16678

Power plant	*Installed capacity (MW)*	*Fuel type*	*Net heat rate (kCal/kg)*	*Net generation (GWh) 2001-02*	*CO_2 emissions (ton)*	*SO_2 emissions (ton)*	*NOx emissions (ton)*
Koradi	1080	Coal	3028.7195	5508.0	6309834.623	38556	20233
Paras	58	Coal	3499.5842	327.7	433824.0326	2294	1175
Bhusawal	478	Coal	2854.6882	2999.6	3238847.309	20997	10363
Parli	690	Coal	2963.1095	3994.4	4476791.504	27961	13974
Chandrapur	2340	Coal	2560.4628	14985.5	14512856.56	104898	51770
K'kheda-II	840	Coal	2788.9735	5050.6	5327887.926	35355	16786
T'bay TH	1150	Coal	2717	6883.5	7397769.921	48185	18362
Dahanu TH	500	Coal	2717	3531.2	3790960.266	24719	9574
T'bay GT&ST	180	Gas	2062	1208.7	588216.7945	0	2
Uran CCGT	912	Gas	2062	3585.5	1744937.105	0	5
Dabhol PVT	740	LNG	2062	292.1	142131.1374	0	0
Tarapur nuc	320	NUC		2281.2		0	0
Thermal	9878.0		52140.72	53520.7164	53378192.18	302965	142243
Nuclear	320.0		2195.57	2281.2000	0	0	0
Hydro	2819.8		4798.27	4891.0000	0	0	0
Total	13017.8		59134.56	60692.9000	53378192.20	302965	142243

Source: Generation Report, 2001-02, Central Electricity Authority, Government of India.

The average emissions from power generation in Maharashtra are 0.88 kg/kWh of CO_2, 0.005 kg/kWh of SO2 and 0.002 kg/kWh of NOx.

Power sector reforms in Maharashtra

Maharashtra has initiated electricity reforms by formulation of Electricity Regulatory Commission and rationalisation of tariff. The initiation of reforms has led to the emergence of merit order dispatch of electricity to the MSEB, related to the least cost options. Based on the recently enacted Electricity Act 2003, unbundling of the MSEB is scheduled by the year 2004. Maharashtra Electricity Regulatory Commission (MERC) was constituted in August 1999 and has been instrumental in bringing about the participatory approach and transparency in the power sector in Maharashtra. The regulatory process has also provided an impetus to an exercise for reducing T & D losses in the state. As per MoUs signed with the Centre, Government of Maharashtra has given an undertaking of (i) having 100% metering of all consumers by September 2002, (ii) computerised billing by March 2003, and (iii) achieving breakeven in distribution by March 31, 2003, and positive returns thereafter. This aim obviously could not be achieved within stipulated time but 97 %[4] of metering of the 11 kV and above feeders has been completed till June 2003 but T&D loss reduction has not been significant primarily due to non-metering of agricultural load.

Development of wind generation capacity in Maharashtra

Maharashtra has a total gross wind energy potential of 3650 MW. Considering an average plant load factor of 18%, wind energy can deliver about 5755 million units The Government of Maharashtra (GoM) first issued a policy for wind power projects in March 1998, to encourage investment in the wind energy sector. This policy was modified in October 1999, May 2000, July 2001 and January 2002 so far as fiscal incentives were concerned. Throughout this period, the tariff payable by Maharashtra State Electricity Board (MSEB) for wind power procurement remained in line with the MNES guidelines. The salient features of the GoM policy for wind power generation were (InWEA-1, 2002):

- The MSEB will purchase power from the wind power projects at a rate of Rs. 2.25 per kWh (for the base year of 1994-95); to be escalated at a compound rate of 5% per annum (for the first 10 years); no escalation for the next 3 years; and 5% escalation for the balance life of the project (7 years).
- Banking of power is permitted during the financial year.
- The Power Purchase Agreement will be executed for a period of 20 years.
- MSEB will charge reactive power consumption by the wind power project at the rate of Rs. 0.25 per kWh.
- Wind power projects are entitled to a sales tax incentive of Rs. 5 crore per MW, which can be availed either as a deferment or a waiver for a period of six consecutive years. For every year, the benefit will be limited to 1/6th of the

[4] MSEB Tariff Revision Proposal 2003-2004 Volume II P.1-20

qualifying investment. Investments in plant and machinery, new building, land development, technical development and design in a wind power project would be considered as qualifying investment.

- The developer can change from sales tax deferment to sales tax exemption or vice versa, only once in six years.
- The sales tax incentive will be available only to those wind power projects approved by the GoM prior to 31 December 1999, amounting to 443 MW, provided they are commissioned and synchronised with the MSEB grid prior to March 31, 2002.
- The sales tax incentive can be transferred to a party other than the third party sale consumer.
- The sales tax incentive can be transferred to a different party every year.
- The sales tax benefit can be availed on the finished product as well as on the raw materials used.
- The promoter will not be eligible for sales tax benefit for use of second hand machinery and old wind electric generator.
- The sites approved by MNES will be eligible for sales tax benefit.
- The entire sales tax incentive will be available only for those projects that have minimum annual Plant Load Factor of 17%. For PLF below 17%, the Sales Tax incentive is available in the following proportion:

PLF	Sales tax benefit equivalent of 1/6th of Qualifying Investment	
	Without Bank Guarantee	With Bank Guarantee
12%	60%	50%
13%	70%	60%
14%	80%	70%
15%	90%	80%
16%	100%	90%
17%	100%	100%

- While determining the PLF, the availability of the transmission lines during the months from May to September, of that financial year, shall be taken into consideration and this percentage will be increased proportionately to 100% and then the PLF will be determined. The availability of the transmission lines during the months from May to September of that financial year will be decided by Maharashtra Energy Development Agency (MEDA).

- No payment guarantee such as Escrow or Letter of Credit will be provided by the MSEB.
- The MSEB will pay the power purchase bills within 45 days, and in case of non-payment within 45 days, the MSEB will pay interest at the Reserve Bank of India rate for the delay in payment.
- The MSEB will issue No Objection Certificate (NOC) to all such wind power projects (up to 443 MW) that have received GoM approval prior to 31 December 1999, provided they can be commissioned before March 31, 2002.
- In line with MNES policy, the GoM policy shall also provide for 10% generation from non-conventional sources out of the total generation capacity in the State.
- MEDA shall recover 50% of the expenditure for erection of high-tension sub-station and transmission infrastructure and will give it to the MSEB. Developers shall bear the cost of transmission lines from the sub-station to the project and all other related equipment.
- MEDA shall bear the cost of construction of roads to the project sites. MEDA would be entitled for availing Government grants to meet this expenditure.
- MEDA shall give a subsidy up to 30% of the fixed capital investment (limited to Rs. 20 lakh) to the promoters subject to a condition that wind power plant has successfully operated with a minimum 12% PLF for at least one year.
- Entry tax/Octroi as paid by promoters while making capital expenditure will be reimbursed by MEDA.

This favourable policy regime led to large investments in wind power projects in the state. As a result, substantial wind generation capacity was added during this period. In Maharashtra, the wind turbines were installed primarily at two locations, namely Vankuswade (Satara district) and Supa (Ahmednagar district). The total installed capacity of wind turbines in Maharashtra is 395 MW (as on March 31, 2002). The wind farm at Vankuswade with installed capacity of around 350 MW is the largest single location wind farm in the country. The entire capacity (barring demonstration projects) has been developed by private developers and more than Rs. 2000 crore had been invested in these projects.

The Maharashtra Electricity Regulatory Commission (MERC) has recently come out with new tariff for wind electricity, applicable till March 2007. As per this order, wind power will fetch a price of Rs.3.50 per kWh with an annual escalation of Rs.0.15 per kWh for next 13 years. With such an encouraging tariff policy, wind power development in Maharashtra is definitely getting a big boost.

Likewise, the GoM is also thinking of levying a cess on power consumption for accelerating the development of renewable energy power projects in the state.

Satara wind park

A wind power capacity of about 350 MW has been established at Vankusawade, Thosegarh and Chalkewadi locations in Satara district with an investment of about Rs. 1400 crores. The area comprises a plateau of about 10,000 acres. The Vankusawade Wind Park is located on a high mountain plateau at 1150 m above mean sea level, running north to south above the Koyna reservoir in the Satara District of Maharashtra. It is approximately 40 kms from the town of Satara and approximately 80 kms from India's west coast.

The site has a mean annual wind speed of 23.35 kmph at 30 m height, highest in the State of Maharashtra. Suzlon Energy Ltd. alone has installed a total of 250 MW of wind power here, on behalf of a wide spectrum of investors like Bajaj Auto, Bajaj Electricals, and Tata Power Ltd. etc.

At Satara, low voltage problems have been taken care of thanks to windmill energy generation. Transformation of this area through the utilization of barren and unproductive land for wind power development has brought about considerable social-economic development and employment generation in this area.

Positive impacts

Impact on environment

Unlike conventional power generating technologies (thermal and large hydro), wind power technology does not leave any footprints on the environment, locally or globally. The process of wind power generation neither emit particulate matters, SOx, NOx, GHG nor it pollutes water, forests, and land as coal based power plants do. There is no large-scale resettlement and rehabilitation or deforestation involved in wind farms as is the case with large hydro power plants and coal mining. In fact, since the actual area required for erection of wind turbines is small, rest of the land can be used for any agricultural or non-agricultural purpose. Even on life-cycle analysis basis, negative impacts of wind power (mostly related to manufacturing, noise, and visual pollution) are very minimal. In any case, in India, wind farms being established away from densely populated areas, there have not been any complaints regarding noise pollution or visual impact. The perception among the populace is that wind turbines add to the scenic beauty of the surroundings.

It has been estimated that in Maharashtra by August 2003 wind power has helped in mitigating GHG emissions to the tune of 1324400 MT and local emissions comprising SO_2 (7525 MT) and NOx (3010 MT) emissions

Impact on local economy

This study found that a total of about 50[5] jobs and over Rs.2 lakh in personal income in 338 MW wind park at Satara were supported during the construction phase of the project (this does not include jobs created during infrastructure development like construction of roads). Another 1690[6] jobs and over Rs.67 lakh in personal income are supported annually through the operation and maintenance of the project. ***Drawing a comparative picture in Maharashtra, it is seen that a wind farm provides 4 times more jobs in operation and maintenance than the conventional power plants[7].*** In addition, the creation of 338 MW also entails about 600[8] jobs at the factory and 2000[9] indirect jobs at the ancillary units.

The servicing of daily needs of permanently stationed manpower along with that of the visiting officials has also resulted in sources of steady income to many households engaged in retail activities such as tea shops and grocery. Indeed this created new opportunities for livelihood generation for many a people. This whole scenario of *local* job creation has to be viewed against prevailing conditions in rural areas. As such there are not many job opportunities available in rural areas and this induces rural-to-urban migration of the working youth. However, wind park activities create such opportunities right at the door-step, thereby helping in minimizing this migration (which in turns relieves pressure on adjoining urban centres). Another multiplier economic aspect relates to the fact that new jobs increase business and household income, which in turn creates more jobs which further increase business and household income, and so on.

Land is one of the main requirements for setting up a wind farm and sale of land has an important economic effect on local areas, as sale proceeds go to local residents and adds to local household incomes. In case of Satara wind park, (i) the land was rocky and (ii) site being at an elevation of 1100 m above sea level,

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[5] Study of Coimbatore, Tirunelveli, & Kanyakumari carried out for IREDA in 2001.

[6] 5 persons/MW (source: Suzlon/InWEA)

[7] Manpower engaged in MSEB (excluding managerial and technical executives and officers) is about 2 persons/GWh (CEA, General Review 2000-01) as against 8 persons/GWh in case of wind.

[8] ~2 persons/MW (source: Suzlon/InWEA)

[9] 6 persons/MW (source: Suzlon/InWEA)

there was no habitation present before the work on the wind park started. Thus, this land was of no market value to the locals but it started fetching premium once the wind farm developers started acquiring the land. It is estimated that Satara wind park has resulted in around Rs.12 crore[10] pumped in to local economy through personal income. Thus, establishment of wind park has positive economic impacts on two important sectors, namely, the household sector and the retail trade sector. This is apart from impacts on sectors such as manufacturing and commercial, and national economy as a whole. From pure economy point of view, for those areas with suitable wind resources and links to electric power transmission facilities, wind power may offer an opportunity to create some long-term jobs and long-term income from wind power development.

Impact on the power system

Recently Indian Institute of Technology, Mumbai carried out a study to gauge the impact of wind generation on Western Region Electricity Board (WREB) system (InWEA, 2003). In WREB network, the wind generators are placed at Ahmednagar and Satara district in Maharashtra. Satara district accounts for 300 MW of wind power generation. The injection of electricity is at Vankuswadi 33 kV bus, Malharpeth 33 kV bus, Atit 33 kV bus, and Satara 33 kV bus, and the localized loads are 0 MW, 20 MW, 10 MW, and 30 MW at these buses respectively.

Brief data and assumptions:

i. The steady state analysis of complete network including wind generation is done.
ii. In WREB system, the loads are lumped at 220 kV level and in order to incorporate the wind generation at 33 kV level, the loads at respective buses are segregated. The values of the loads at 33 kV buses were obtained from Indian Wind Energy Association, Pune.
iii. The wind generators are modelled as negative loads (-P and -Q).
iv. Total load of 162 MW is considered for the local network where wind generators are installed.
v. Load flow analysis is carried out to find line power flows, voltages at various buses, and technical losses.
vi. 100 MVA of base MVA is considered in the load flow.

[10] 15 acres/MW and Rs.20,000/acre (source: Suzlon/InWEA)

vii. Karad 220 kV, Oglewadi 110 kV, and Lonand 110 kV are considered as load buses.

viii. Vankuswadi 33 kV bus is purely meant for wind generation without any localized load and accordingly it is modelled as negative load.

ix. Malharpeth 33 kV, Atit 33 kV, and Satara 33 kV are the three buses with localized generation as well as localized load and hence the real and reactive powers injected at these buses are decided by deducting the value of localized load at respective buses. For example at Malharpeth 33 kV, but the wind generation is around 64 MW and the local load is 20 MW, hence the actual real power injection at this bus is - 44 MW.

x. The reactive power fed to the grid is estimated by using the reactive power characteristics of the wind machines with power factor of the load assumed as 0.85.

Case 1: Effect on technical losses

a) **Losses and line flows without wind generation:** Initially the load flow is carried out for exact quantification of technical losses without any localized generation and then it is compared with the system with rated wind generation at above mentioned 33 kV buses.

Total Technical Losses = 0.04245 pu
= 4.245 MW (2.6% of total load of 162 MW)

b) **Losses and line flows with 100% of wind generation**

Total Technical Losses = 0.02051 pu
= 2.051 MW
(1.3% of total load of 162 MW)

Hence, due to availability of extra generation in terms of wind generation, the technical losses are reduced from 2.6% to 1.3% expressed as a percentage of total load of the local network.

Case 2: Effect on Voltage profile at various buses

In the old WREB system without wind generation, one of the 220 kV lines from Karad 400 kV substation is connected to Malharpeth 220 kV substation and from Malharpeth to KDPH 220 kV substation. Here Malharpeth 220 kV station is 'Line In Line Out' (LILO) type substation. In the existing system with wind generation, the additional 220 kV substation is installed between Malharpeth and KDPH i.e. at Vankuswadi, so as to take the generation, which is maximum of the order of 144 MW.

Accordingly the load flow of both the systems is studied and the voltage at 220 kV Karad bus without any localized generation is 0.9609 pu and with wind generation it comes around 0.9827 pu.

Case 3: Availability of wind power in various time slots

The wind availability in a year can be broadly classified into high wind season and low wind season. The seasonal variation in the load is not considered in this study. The high wind season is normally from April to September and low wind season is from October to March. The monthly generation in terms of MWh units is as per the data given by InWEA.

The time slots considered are same as per the MSEB Time of Day (TOD) tariff i.e. 'A' Zone from 22 hrs to 6 hrs, 'B' Zone from 6 hrs to 9 hrs and 12 hrs to 18 hrs, 'C' Zone from 9 hrs to 12 hrs and 'C' from 18 hrs to 22 hrs.

The following generation trends were observed at Satara wind farm:

Table 4.3 Average wind generation (percentage of total generation)

	High wind season						*Average*	*Low wind season*						*Average*
	Apr	*May*	*June*	*July*	*Aug*	*Sept*		*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	
A (2200-600)	25%	27%	32%	34%	31%	30%	30%	28%	26%	32%	26%	22%	24%	26
B (600-900) + (1200+1800)	48%	45%	38%	37%	38%	40%	41%	43%	39%	39%	47%	51%	48%	45%
C (900-1200) Morning peak	3%	8%	11%	12%	10%	11%	9%	21%	31%	23%	21%	16%	9%	20%
D(1800-2200) Evening peak	24%	20%	19%	16%	20%	19%	20%	7%	3%	6%	5%	11%	20%	9%

From this analysis, following inferences can be made:

- 70% of the total wind electricity generation is during high-demand slots
- 30% of total wind generation takes place during morning and evening peak hours, in both, high wind and low wind seasons. As such wind electricity could be awarded premium in line with those prescribed under Time of Day (ToD) tariff structure of MSEB.
- As the localized generation increases, the real power flow increases over the 220 kV lines from Vankuswadi to Malharpeth and Malharpeth to Karad, due

to the fact that the injection of generation is quite high as compared to local load at Vankuswadi and Malharpeth 33 kV buses.

Case 4: Availability of wind power to bridge power shortages

That the state of Maharashtra is short of power, more acutely in the rural areas, is clearly evident from the load shedding programme proposed by MSEB. For example, the load shedding quota in Satara is 90 MW with total load shedding quota in rural area in Kolhapur zone as 530 MW. Here, by optimal utilization of high wind potential sites, power deficit could be bridged through localized generation, without having to resort to transmitting power from far-flung areas.

Table 4.4 MSEB's proposed load shedding programme (from March 1, 2003 till date)

Name of Dist.	*Load shedding quota for rural area in MW* 0600 to 1100/1200 to 1700/1700 to 2200 hrs	*Load shedding quota for urban area in MW* 0800 to 1200/1100 to 1500/1400 to 1800 hrs
Kolhapur	120	
Solapur	140	
Sangli	060	
Satara	090	
Pune[R]	120	
Total for Kolhapur Zone	530	150

Source: http//www. msebindia.com/consumer/load_rel.shtm

In its order on tariff for wind power, MERC draws attention to the current situation in the State, "**where rolling shutdowns are being forced on all consumers due to peaking as well as general energy shortage. In such a scenario, it is possible to absorb every unit of wind power, irrespective of its quantum and the time of delivery**" (MERC, 2003).

Analysing the month-wise generation data, as shown in Figure 4.3, it is evident that level of power generation is generally lower in the monsoon months, owing to the lower generation in coal based power plants. But this is precisely the same period when electricity generation from the wind farms is at its maximum. Thus, wind power could be effectively utilized to tide over shortfall in generation from thermal power stations. Moreover, taking advantage of high wind power generation, annual maintenance of thermal power plants could be scheduled around this time.

Case 5: Comparison of tariff

This comparison is worked out on the basis of MERC's new tariff order for wind wherein, it has proposed a tariff of Rs.3.50/kWh for wind plants installed after April 1, 2003, with an escalation of Rs.0.15/kWh/year till 13th year of operation. This is compared with tariff for new super thermal power station considering an escalation of 7% per annum. It has to be noted that while the cost of energy from a Thermal Power Station is initially low, it continues to increase with increases in the cost of fuel. On the other hand, the cost of wind energy is initially high and reduces as loans are repaid as no variable cost is involved. The comparative picture is given in Table 4.5.

Table 4.5 Comparison of energy cost (Rs./kWh)

Year	*MERC tariff for wind power*	*New T.P.S. (Average cost tariff @7%escalation p.a. (generation cost + transmission loss in EHV System only)*
03-04	3.50	2.83
04-05	3.65	3.03
05-06	3.80	3.24
06-07	3.95	3.47
07-08	4.10	3.71
08-09	4.25	3.97
09-10	4.40	4.25
10-11	4.55	4.54
11-12	4.70	4.86
12-13	4.85	5.20
13-14	5.00	5.57
14-15	5.15	5.96
15-16	5.30	6.37
16-17	5.30	6.82
17-18	5.30	7.30
18-19	5.30	7.81
19-20	5.30	8.35
20-21	5.30	8.94
21-22	5.30	9.57
22-23	5.30	10.23
23-24	5.30	10.95
24-25	5.30	11.72
25-26	5.30	12.54

Source: MERC Order, November 24, 2003

The analysis shows that the levelized annual cost of wind power is less than that of a new thermal power station for a range of discount rates (till the discount rate reaches a value of 18% when both become same).

Conclusion

The analysis of the electricity sector of Maharashtra makes it very clear that the state is facing power deficit throughout the day (except during off-peak hours in night time) and the load-shedding is a way of life. Thus, there is an urgent need to complement the generation through other means. Considering that (a) 80% of total generation is coal based, which not only impacts the environment negatively but has to be imported from other states and (b) wind resource is available in abundance, there is a firm basis for exploiting wind power. This development will improve the power situation in the state, without compromising the environment's health and strengthening the energy security at the same time.

5 Externalities in electricity cost

Definition of external costs

As per the ExternE Project of the European Commission, "*An external cost, also known as an externality, arises when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group. Thus a power station that generates emissions of SO_2, causing damage to building materials or human health, imposes an external cost. This is because the impact on the owners of the buildings or on those who suffer damage to their health is not taken into account by the generator of the electricity when deciding on the activities causing the damage. In this example, the environmental costs are 'external' because, although they are real costs to these members of society, the owner of the power station is not taking them into account when making decisions.*"

The assessment of social and environmental externalities can be categorized as (i) assessment of environmental externalities (damages to society) and (ii) assessment of social effects (benefits to the society).

There are several ways of taking account of the cost to the environment and health, i.e. for 'internalising' external costs. One possibility would be via eco-taxes, i.e. by taxing damaging fuels and technologies a according to the external costs caused.

Another solution would be to provide suitable incentives to cleaner technologies thus avoiding socio-environmental costs.

In the following sections, outcome of different studies on the externalities and cost implications of higher emission norms is discussed.

Extern E study

The categories of major damages considered in the ExternE project include human health (fatal and non-fatal effects), and effects on crops and materials. Moreover, damages caused by global warming provoked by green house gases have been assessed on a global level. Table 5.1 gives an overview of the health and environmental effects currently included in the analysis.

Table 5.1 Impact pathways of health & environmental effect

Impact category	*Pollutant / burden*	*Effects*
Human health	PM_{10}[a], SO_2	Reduction in life expectancy
- mortality	NO_x, O_3	
	Bensene, Benso-	Cancers
	[a]-pyrene 1, 3-	
	butadiene	Loss of amenity, impact on health
	Diesel particles	Fatality risk from traffic and
	Noise	workplace accidents
	Accident risk	
Human health	PM_{10}, O_3, SO_2	Respiratory hospital admissions
- morbidity	PM_{10}, O_3	Restricted activity days
	PM_{10}, CO	Congestive heart failure
	Benxene, Benzo-	
	[a]-pyrene 1, 3-	Cancers
	butadiene	
	Diesel particles	Cerebro-vascular hospital admissions
	PM_{10}	Cases of chronic bronchitis
		Cases of chronic cough in children
		Cough in asthmatics
		Lower respiratory symptoms
		Asthma attacks
		Symptom days
	O_3	Myocardial infarction
		Angina pectoris
	Noise	Hypertension
		Sleep disturbance
	Accident risk	Risk of injuries from traffic &
		workplace accidents
Building	SO_2	Ageing of galvanised steel,
material	Acid deposition	limestone, mortar, sand-stone, paint,
		rendering, and zinc for utilitarian
	Combustion	buildings
	particles	Soiling of buildings
Crops	NO_x, SO_2	Yield change for wheat, barley, eye,
		oats, potato, sugar beet
	O_3	Yield change for wheat, barley, rye,
	Acid deposition	oats, potato, rice, tobacco,
		sunflower seed increased need for
		liming
Global	CO_2, CH_4, N_2O	World-wide effects on mortality,

warming	N,S	morbidity, coastal impacts, agriculture, energy demand, and economic impacts due to temperature change and sea level rise
Amenity losses	Noise	Amenity losses due to noise exposure
Ecosystems	Acid deposition, nitrogen deposition	Acidity & eutrophication (avoidance costs for reducing areas where critical loads are exceeded)

Source: External Costs. Research results on socio-environmental damages due to electricity & transport. The European Commission. 2003
ExternE study: Comparison of damage costs per kWh for coal, gas, nuclear and wind electricity

In general, wind technologies are very environmental friendly with respect to emissions of "classical" pollutants (SO_2, NO_x, and dust particles) and with respect to greenhouse gas emissions. Wind gets a favourable rating for both impact categories. Gas-fired technologies are quite clean, with respect to classical pollutants, but their impact on climate change depends strongly on the efficiency of the technology. Newer combined-cycle technologies can also be categorised as generating average to low greenhouse gas impacts. Coal technologies carry the burden of their very high CO_2 emissions, even for new, more efficient technologies, and in addition cause quite high impacts due to the primary-secondary aerosols. Old coal-fired power plants are also very high emitters of classical pollutants, making them overall the worst available technology.

Table 5.2 gives the costs of externalities for different fuels, for various European countries. Table 5.3, on the other hand details out the costs of different externalities for Germany.

Table 5.2 External cost figures for electricity production in the EU for existing technologies[1] (in Euro cent per kWh*)

Country	*Coal & Lignite*	*Peat*	*Oil*	*Gas*	*Nuclear*	*Biomass*	*Hydro*	*PV*	*Wind*
AT				1-3		2-3	0.1		
BE	4-15			1-2	0.5				
DE	3-6		5-8	1-2	0.2	3		0.6	0.05
DK	4-7			2-3		1			0.1
ES	5-8			1-2		3-5**			0.2

[1] Global warming is valued with a range of estimates from Euro 18–46 per ton of CO_2

FI	2-4	2-5				1		
FR	7-10		8-11	2-4	0.3	1	1	
GR	5-8		3-5	1		0-0.8	1	0.25
IE	6-8	3-4						
IT			3-6	2-3			0.3	
NL	3-4			1-2	0.7	0.5		
NO				1-2		0.2	0.2	0-0.25
PT	4-7			1-2		1-2	0.03	
SE	2-4					0.3	0-0.7	
UK	4-7		3-5	1-2	0.25	1		0.15

* sub-total of quantifiable externalities (such as global warming, public health, occupational health, mental damage)
** biomass co-fired with lignite

Table 5.3 Quantified marginal external costs of electricity production in Germany[2] (in Euro cent per kWh)

	Coal	*Lignite*	*Gas*	*Nuclear*	*PV*	*Wind*	*Hydro*
Damage costs							
Noise	0	0	0	0	0	0.005	0
Health	0.73	0.99	0.34	0.17	0.45	0.072	0.051
Material	0.015	0.020	0.007	0.002	0.012	0.002	0.001
Crops	0	0	0	0.0008	0	0.0007	0.0002
Total	0.75	1.01	0.35	0.17	0.46	0.08	0.05
Avoidance costs							
Ecosystems	0.20	0.78	0.04	0.05	0.04	0.04	0.03
Global Warming	1.60	2.00	0.73	0.03	0.33	0.04	0.03

Thailand study

In a study carried out in Thailand (CEERD, Asian Institute of Technology, 1998), different international studies on environmental externalities were evaluated in order to arrive at values for Thailand. In the PACE study, Ottinger et. al. at Pace University estimated the ranges of externality costs per kWh as follows (in USD91/kWh):

Coal-fired	\$ 0.025 - \$ 0.058
Oil-fired	\$ 0.025 - \$ 0.067
Natural gas-fired	\$ 0.007 - \$ 0.010
Solar	\$ 0.000 - \$ 0.004
Wind	\$ 0.000 - \$ 0.001
Biomass	\$ 0.000 - \$ 0.007

In the New York State Environmental Externalities Cost Study (Rowe et al 1995), biomass energy is also included together with coal, oil and natural gas fuels. The estimates of Rowe et al are as follows (in USD92 per kWh):

Coal-fired	\$ 0.0020 - \$ 0.0032
Oil-fired	\$ 0.0011 - \$ 0.0016
Natural gas-fired	\$ 0.00017 - \$0.00024

[2] Median estimates; current technologies; CO_2 emissions are valued with avoidance costs of Euro 19 per ton of CO_2

Biomass (wood) $ 0.0025 - $ 0.0036

The ExternE study gives estimates for coal, oil, natural gas and biomass fuel cycles as follows (in USD 95 per kWh, converted from ECU95 to USD95 by using the factor:
1 ECU95 = 1.24 USD 95)

Coal -fired	$ 0.046
Oil-fired	$ 0.027
Natural gas-fired	$ 0.011
Biomass	$ 0.0012 - $ 0.012

Values cited in the three studies listed above do not include damage due to global warming.

Taking an average inflation rate between 1991 and 1997 equal to 3.3 % [IMF, 1998] the external costs of these three studies have been recalculated to convert into USD97/kWh. The results are tabulated in Table 5.4

Table 5.4 Central values of environmental externalities for different fuels

Fuel type	*Environmental Externalities USD97/kWh*	
	Range	*Mean value*
Coal	0.0022 - 0.046	0.024
Oil	0.0012-0.027	0.014
Natural gas	0.0002 - 0.011	0.0056

Source: Combined by the author, based on Rowe et al 1995 & ExternE 1997

These values were then adjusted to Thailand values. The assumption in making adjustment of environmental externality values from the US and European countries to Thailand is *that the Willingness to Pay (WTP) to avoid damages is proportional to the per capita income.* The approximate formulae to estimate WTP is as follows:

$$WTP_{Thailand} = WTP_{US} \times PERCAP\text{-}GDP(PPP)_{Thailand} / PERCAP\text{-}GDP(PPP)_{US}$$

If GDP per capita (PPP) $_{Thailand}$ = USD 8,165 and
GDP per capita (PPP) $_{US}$ = USD 28,645
Then the ratio between $WTP_{Thailand}/WTP_{US} = 0.285$

This ratio is called "Income Elasticity of Willingness to Pay" and can be used to approximate the externality values for Thailand knowing corresponding values elsewhere. This approximation method is used in several analyses e.g., Pearce 1997, Makandya 1997, and World Bank 1995.

Based on income elasticity of WTP adjustment, the values of environmental externalities applicable for Thailand are tabulated in Table 5.5.

Table 5.5 Environmental Externalities of fuels in Thailand

Fuel type	*Externalities USD97/kWh* *Range*	*Mean value*
Coal	0.000627 - 0.0131	0.00684
Oil	0.00034 – 0.0077	0.00399
Natural gas	0.00006 – 0.00316	0.001596

Adopting the same approach, "income elasticity of Willingness to Pay" is calculated for India in the following manner:

WTP_{India} = WTP_{US} x PERCAP-GDP $(PPP)_{India}$ / PERCAP-GDP$(PPP)_{US}$

If GDP per capita (PPP) $_{India}$ = USD 2,136 and
GDP per capita (PPP) $_{US}$ = USD 35831 (in USD_{2002}
(Source: http://www.mrdowling.com/800gdppercapita.html)

Then the ratio between WTP_{India}/WTP_{US} = 0.06

Thus, cost environmental externalities in case of India works out to be:

Table 5.6 Environmental Externalities of fuels in India (without CO_2 emissions)

Fuel type	*Externalities USD2002/kWh* *Range*	*Mean value*	*Externalities Rupees/kWh @ USD1 = Rs.45* *Mean value*
Coal	0.000132 - 0.000276	0.0014	0.06
Oil	0.000072 - 0.000162	0.0008	0.04
Natural gas	0.000012 - 0.00066	0.0003	0.01

Source: Indian study of the environmental cost assessment

TERI study

The cost calculation in this study (TERI, 2000) is carried out on the basis of certain broad headings, covering the following components:

Table 5.7 Environment cost components (coal based plants)

S.N.	*Item description*
1	Electrostatic precipitator
2	Chimney
3	Cooling towers incl. Civil works
4	Ash handling civil works
5	Ash handling mechanical works
6	Ash dyke
7	Ash water recalculation (incl. In ETS. i.e. component 5)
8	Effluent treatment plant
9	Dust extraction & suppression systems
10	Control of fire & explosion hazards
11	DM plant waste treatment systems
12	Sewerage collection, treatment & disposal
13	Environmental laboratory equipment
14	Rehabilitation & resettlement
15	Green belt
16	Afforestation
17	Liquid fuel handling system

Table 5.8 Environmental cost components addressed for cost calculation

Categories	*Cost components*
Air pollution	
SPM	Electrostatic precipitators
SO_2, NO_x	Chimney with Stack height:
SO_2	Flue gas desulphurisation unit
	Dust extraction & suppression systems
	Equipment to monitor environment
	Equipment to monitor ambient air quality
Water pollution	
	Effluent treatment facility
	Condensate cooling water including Reservoir, Tube wells, etc. & sanitation
	DM plant waste treatment system
Land	
	Rehabilitation & resettlement of displaced persons
	Restoration of land in construction area

Categories	*Cost components*
Ash disposal	
	Ash handling system – Civil Works and Mechanical Works
	Treatment of ash pond effluent
	Ash Dykes
Forest	
	Environmental losses (when compensatory afforestation is not done) or afforestation
	Cost of supplying free fuel wood to workers during construction
Noise	
	Measures to control noise impact (ear muffs)
Visual	
	Green belt development
Other costs	
	Control of fire & explosion hazards (safety measures)
	Loss of value of timber, fuel wood and minor forest produce and manhours lost on annual basis
	Loss of animal husbandry, productivity, fodder, agriculture produce, public facilities
	Social cost for suffering to oustees

The scenarios thus developed as provided in the table, assumes two plant sizes (PS) namely 1000 MW (PS1) and 750 MW (PS2) with locations (LT) either in a cleared forest area (LT1) requiring afforestation or in a non-forest area (LT2). Moreover, from the data available, the other major component in a thermal plant with a wide cost variation is 'construction of ash dykes' (AD). The range obtained is 2.5 (AD1) to 7.5 (AD2) per cent of total cost of plant construction. For scenario purpose the two bound values are only considered. The different scenarios are studied for both Indian as well as WB norms. Thus ultimately 8 scenarios are developed as provided in Table 5.9.

Table 5.9 Environmental cost comparison (Rs. in Crore)

	LT1/AD1		*LT2/AD1*		*LT2/AD2*		*LT1/AD2*	
	Indian norm	*WB norm*	*Indian norm*	*WB norm*	*Indian norm*	*WB norm*	*Indian norm*	*WB norm*
PS1	689.33	760.28	410.91	481.86	585.91	656.86	864.33	935.28
PS2	589.83	643.04	277.63	330.84	408.88	462.09	721.08	774.29

Note: PS1-1000MW LT1-Afforestation done AD1-2.5 per cent
PS2- 750 MW LT2-No Afforestation AD2-7.5 per cent

An analysis of the cost shows that incorporation of forest area and cost of ash dyke construction can change the total environmental cost from 12 to 25% of total cost for the same plant size. The cost rises further to 27% of total cost for adherence to WB norms, which involves only an additional expenditure on ESP.

At the average (all India) cost of power supply was 350.30 paise/kWh in 2001-02, total environmental costs range from Rs.0.42/kWh to Rs.0.87/kWh.

NPCL study

Another analysis carried out at the Nagarjuna Power Corporation Ltd (NPCL) shows that if more stringent environmental norms like those proposed by the World Bank are followed, the cost of environmental equipment/ facility required to meet such additional requirements is over 9% of capital expenditure. Thus, the increase in tariff on account of such additional capital expenditure is estimated to be over 17 paise/kWh (Balachandra and Sharma, 2002).

InWEA analysis

The Indian Wind Energy Association (InWEA, 2002) did an analysis to compute the financial burden imposed on the cost of generation of thermal power plants, on account of adhering to environmental norms. The following routes were considered for the incremental costs calculations:

- Conventional coal based thermal power generation
- Combined cycle gas turbine (CCGT) based power generation using naphtha/natural gas as fuel

The parameters considered were suspended particulate matter (SPM), Sulfur Oxides (SO_x), and Nitrogen Oxides (NO_x). The current level of SPM emissions with or without abatement is given in the following Table 5.10.

Table 5.10 Summary of SPM emission using various fuel cycle technologies

Power generation technology	*Conventional Thermal*	*CCGT*
Fuel	Coal	Naphtha / NG
Emission levels	1250 mg/Nm^3 (without any abatement) 150 mg/Nm^3 (with abatement)	negligible

The efficacy of different abatement options is given below.

Table 5.11 Summary of SPM abatement technologies

Power generation	*Conventional coal*	*Incremental capital cost*	*Levels of mitigation*

technology		*thermal*		
Technologies for abatement	Option 1	Washing / beneficiation of coal	US$ 25 – 35/kW	~ 40% reduction in ash content
	Option 2	Fluidised Bed Combustion (FBC)	US$ 50 – 75/kW	~ 10% reduction in PIC (products of incomplete combustion)
	Option 3	Cyclones	0.5-1% of total capital cost	Typically 70% or < 90% and excluding particulate matter less than 10 micron (PM_{10})
	Option 4	Baghouses	1-2% of total capital cost	~ 99% with sorbent injection, dry scrubbing
	Option 5	ESPs	2-4% of total capital cost	~99.9% for all particle sizes

Table 5.12 Summary of SOx abatement technologies

Power generation technology		*Conventional coal thermal*	*Incremental capital cost*	*Levels of mitigation*
Technologies for abatement	Option 1	Pre-ESP sorbent injection	US$ 50 – 100/kW	30% to 70%
	Option 2	Post-ESP sorbent injection	US$ 80 – 170/kW	70% to 90%
	Option 3	FGD units (dry or wet)	US$ 80 – 170/kW	70% to 95%

Table 5.13 Summary of NOx Abatement technologies

Conventional coal thermal			*CCGT (Naphtha/natural gas)*		
Options	*Capital cost*	*Levels of abatement*	*Options*	*Capital cost*	*Levels of abatement*
Low NOx burners	US$ 20 – 25/kW	40% to 60%	Low NOx burners	US$ 20 – 25/kW	40% to 60%
Low excess air (LEA) combustion	US$ 25/kW	10% to 30%	Water or steam injection	US$ 20/kW	~ 80%
Staged combustion	US$ 5 – 10/kW	20% to 50%	-	-	-

Based on the details of the abatement technologies and associated capital costs outlined in tables above, the additional cost of generation is computed. Both, conventional coal thermal power plants and CCGT, are assumed to be of 400 MW capacity. Other assumptions are given in Table 5.14.

Table 5.14 Assumptions for cost computation

Power generation technology		*Conventional thermal*	*CCGT*
Fuel		Coal	Naphtha / NG
Installed Plant Capacity	MW	400	400
Aux. power consumption	%	9%	3%
Operating PLF	%	70%	85%
Gross energy units	Million kWh	2453	2978
Net energy units	Million kWh	2232	2889
Additional capital cost for abatement		Based on selection of technology considered for abatement of SPM, SOx and NOx	
Capital cost recovery	Yrs/%	10 yrs/20%	10 yrs/20%
O&M cost as % additional capital cost	%	3.5%	3%
Escalation	% per annum	5%	5%

For the computation purposes, the following combinations have been taken.

Table 5.15 Abatements options for cost computation

Power generation technology	*Conventional coal thermal*	*CCGT*
SPM abatement technology	Washing and beneficiation of coal	
SOx abatement technology	Pre-ESP sorbent injection	
NOx abatement technology	Low NOx burners	Low NOx burners

The summary of levelized costs of generation for the aforementioned combinations is given below.

Table 5.16 Levelized incremental cost of generation (Rs./kWh)

Power generation technology	*Conventional coal thermal*	*CCGT*
SPM abatement technology	0.05	
SOx abatement technology	0.19	

NOx abatement technology	0.05	0.04
Total levelized incremental cost of generation	0.28	0.04

Thus, in case of coal based thermal power station, the cost of generation of electricity gets increased by Rs.0.28/kWh on account of abatement of air pollution, without taking in to account mitigation of GHG like CO_2. If one considers the mitigation cost of CO_2 , it works out to be around Rs.0.11/kWh (taking national average of CO_2 emission for thermal power plants as 1.07 kg/kWh; international price of CER at US$3/ton of CO_2, and transaction cost of 20%). The total cost of conventional electricity thus, increases by Rs.0.39/kWh.

Conclusion

If one considers various studies detailed out earlier, the incremental monetary benefit accrued to wind power ranges between Rs.0.17 to Rs.1.40/kWh as listed in Table 5.17.

Table 5.17 Costs of externalities abatement from various studies

Study	*Cost of externalities (including GHG mitigation @ US$ 3/t) in Rs./kWh*
Thailand, 1998	0.17
Balachandra, 2002	0.28
TERI, 2000	0.43
	0.98
ExternE, 2001	1.40
InWEA, 2002	0.39
Average	**0.60**

Therefore, wind power may be given a benefit in the range of Rs.0.30–0.60/kWh on account of the fact that it does not adversely impact environment and human health.

6 International scenario

Global scene of wind power development

Over the past five years, global wind power capacity has continued to grow at an average cumulative rate of 33% (Table 6.1). During 2002 alone, more than 7,200 MW of new capacity, an investment worth more than Euro 7 billion, was added to electricity grids worldwide. By the end of 2002, the capacity of wind turbines installed globally had reached a level of over 32,000 MW. This is enough power to satisfy the needs of 40 million people. Almost 50 countries around the world now contribute to the global total and the number of people employed by the industry worldwide is estimated to be around 100,000. The impetus behind wind power expansion has come increasingly from the urgent need to combat global climate change. Most countries now accept that greenhouse gas emissions must be drastically slashed in order to limit the resulting environmental catastrophe.

Table 6.1 Growth in world wind power market 1997-2002

Year	*Installed capacity (MW)*	*Increase*	*Cumulative capacity (MW)*	*Increase*
1997	1.568		7,636	
1998	2,597	66%	10,153	33%
1999	3,922	51%	13,932	37%
2000	4,495	15%	18,449	32%
2001	6,824	52%	24,927	36%
2002	7,227	6%	32,037	29%
	Average growth over 5 years		35.7%	33.2%

Source: Wind Force 12, May 2003

Within Europe, Germany is the clear market leader. During 2002, German wind capacity grew by a record 3,247 MW, taking the country's total up to almost 12,000 MW. This represents 4.7% of national electricity demand, a proportion expected to increase to 8% by 2010.

Denmark and Spain have also continued to expand, the latter by almost 15000 MW during 2002. Denmark has meanwhile succeeded in being able to satisfy 18% of its electricity demand from the wind, the highest contribution of any country in the world. Eight other members of the European Union – France, Greece, Ireland, Italy, the Netherlands, Portugal, Sweden and the UK –now each have more that 150 MW installed, and have all effectively reached the take-off stage. The UK, Italy and the Netherlands have all pushed through the 500 MW barriers.

North America

In the Americas, the United States market has experienced a major revival, although still handicapped by lack of continuity in federal policies, In a volatile power market, large utilities are increasingly looking to wind power as a source of low- priced, stable electricity. Total US capacity has now reached 4, 674 MW.

Rest of the world

New Markets are also opening up in other continents, Australia doubled its capacity in 2002 to reach 189 MW, and with a further 1,700 MW in the pipeline in Asia, the Indian market has revived after a quiet period in the late 1990s, pushing beyond 1,700 MW by the end of 2002. China is looking to increase its capacity to 1,200 MW by 2005, whilst Japan continues to steadily expand, In Africa, both Egypt and Morocco have shown what is possible with national planning and the backing of European developers. Morecco already gets 2% of its electricity from a 50MW wind farm and has plans for a further 460 MW.

Table 6.2 Top wind energy markets in 2002 (MW)

Country	*New capacity*	*Total capacity end 2002*
Germany	3,247	11,968
Spain	1,493	5,043
Denmark	530	2,880
USA	429	4,674
India	220	1,702
Netherlands	219	727
Japan	129	486

Australia	119	189
Italy	106	806
Greece	104	462
Others	632	3,100
World total	7,227	32,037

Source: Wind Force 12, May 2003

Table 6.3 Growth rates in top ten wind energy markets

Country	*MW end 1999*	*MW end 2000*	*MW end 2001*	*MW end 2002*	*Growth rate 2001-2*	*3 years average growth*
Germany	4,442	6,107	8,734	11,968	37.0%	39.2%
Spain	1,812	2,836	3,550	5.043	42.1%	40.7%
USA	2,445	2,610	4,245	4,674	10.1%	24.1%
Denmark	1,738	2,341	2,456	2,880	17.3%	18.3%
India	1,035	1,220	1,456	1,702	16.9%	18.0%
Italy	277	424	700	806	15.1%	42.7%
Netherlands	433	473	523	727	39.0%	18.9%
UK	362	425	525	570	8.7%	16.4%
Japan	68	142	357	486	36.1%	92.7%
China	262	352	406	473	16.5%	21.8%
World total	12.874	16.929	22,952	29,329	27,8%	31.6%

Source: Wind Force 12, May 2003

Technology status

Continuing improvements are being made in the ability of the machines to capture as much energy as possible form the wind at the lowest cost. These include more powerful rotors, larger blades, improved power electronics, better use of composite materials and taller towers.

The most dramatic improvement has been in the increasing size and performance of wind turbines. From machines of just 25 kW twenty years ago, the commercial range sold today is typically from 600 up to 2,500 kW. In 2002 the average capacity of new turbines installed in Germany rose to 1,390 kW. Besides, the new 2,000 kW turbine also produces more energy than 200 of the old 1980s vintage machines.

The largest machines commercially available today are of 2.5 MW capacity, with 80 metre diameter rotors placed on 70–100 metre high towers, One result is that fewer turbines are required to achieve the same power output, saving land use in the process.

In the future, even larger turbines will be produced to service the new offshore market. Machines in a range from 3 MW up to 5 MW are currently under development. In 2003, Enercon erected the first prototype of its 4.5 MW turbine with a rotor diameter of 112 metres (European Wind Energy Association/Greenpeace, 2003).

Table 6.4 shows the rapid growth of wind turbine size in the commercial market over the past six years. From this it can be seen that in the leading markets, especially Germany, Denmark and Spain, the average size of turbine being installed has more than double since 1997.

In the scenario created by the European Wind Energy Association / Greenpeace for Wind Force 12, it is expected that the average size of new wind turbines being installed would be 1.5 MW.

Table 6.4 Average size of wind turbines installed in selected markets (kW)

Year	*Denmark*	*Germany*	*India*
1997	560	623	279
1998	687	783	283
1999	750	919	283
2000	931	1,101	401
2001	850	1,281	441
2002	1,443	1,397	553

The variability of the wind has produced far fewer problems for electricity grid management than anticipated. The quantity of wind-powered electricity which can be readily integrated into a country's electricity grid depends mainly on the system's ability to respond to fluctuations in supply. Numerous assessments involving modern European grids have shown that no technical problems will occur by running wind capacity together with the grid system up to a penetration level of 20%.

In Denmark, peak levels of up to 50% wind power have been successfully incorporated by grid managers in the western part of the country during very windy periods. The Danish Energy Plan includes a goal to consistently cover 50% of the country's electricity consumption from wind energy by 2030 by balancing imports and exports. This includes the use of interconnects to neighbouring countries, especially Germany, Norway and Sweden. The two latter countries have large capacities of hydro power that complements wind power extremely well as hydro can serve as an efficient and cheap energy storage method.

Employment potential

The Danish Wind Turbine Manufacturers Association (DWTMA) did a comprehensive study in 1996. DWTMA broke down the manufacturing activities involved in the wind turbine industry into different segments viz. metalwork, and electronics etc. and then added together the individual employment contributions. The results cover three areas – the direct and indirect employment from wind turbine manufacturing, the direct and indirect employment effects of installing wind turbines, and the global employment effects of the Danish industry's exports business.

The study shows that 17 man-years are created for every MW of wind power manufactured and 5 jobs-years for the installation of every MW. With the average price per kW of installed wind power at $1,000 in 1998, these employment figures can then be related to monetary value, showing that 22 job-years (17+5) are created by every $1 million in sales.

Based on this study, it is estimated that a total of 1.8 million jobs will be created around the work by 2020 in manufacturing, installation and other work associated with the wind power industry.

Wind Force 12

A detailed feasibility study was carried out by BTM Consult for the European Wind Energy Association and Greenpeace. This study (European Wind Energy Association/Greenpeace, 2003) established the feasibility of 12% of worldwide demand for electricity by 2020 being supplied by wind power.

This feasibility study takes off from the figures for cumulative wind power at the end of 2002 when the total installed capacity around the world was just over 32,000 MW. New installations during 2002 were of the order of 7,227 MW. The growth rate of new annual installation during the period 2003 to 2008 is estimated to be 25% per annum, ending up with installation of 133,746 MW by the end of 2008. This is the highest growth rate during the period. From 2009 onwards the rates steadily decline, although the continued growth of wind power will clearly take place at a new high level of annual installation. The report says:

"By the year 2020, an installed capacity of 1,231 GW will have been achieved, with an annual production capable of matching 12% of the world's demand for electricity, as projected by the IEA.

Beyond 2020, development continues with an annual installation rate of about 151,500 MW. Market penetration is expected to follow a typical S-curve, with a "saturation" point reached in some 30–40 years, when a global level of roughly 3,000 GW of wind power will be maintained.

Over time, an increasing share of new capacity would be used for replacement of old wind power plants assuming a 20 year average lifetime for a wind turbine. Replacement or "re-powering" of turbines will become increasingly important in the later years of the scenario. Replacement activity will pick up considerable speed from 2025 onwards, and by 2040 will account for all new installed capacity.

The expected geographical distribution of the roughly 1,200 GW of wind power available by the end of 2020 is shown in Table 6.5.

Table 6.5 2% wind power in 2020 – Regional breakdown

Region (IEA definitions)	*Share of 1,200 GW of wind power in 2020 (GW)*	*Share of 1,200 GW of wind power in 2020*	*Total electricity production in 2020 (TWh)*
OECD – Europe	230	19.2%	4,339
OECD – North America USA (250,000) Canada (60,000)	310	25.8%	6,702
OECD Pacific	90	7.5%	2,317
Latin America	100	8.3%	1,566
East ASIA	70	5.8%	1,461
South ASIA	50	4.2%	1,505
China	170	14.2%	3,461
Middle East	25	2.1%	899
Transition Economies	130	10.8%	2,238
Africa	25	2.1%	1,091
World	1,200	100%	25,579

"Based on market and industry experience, this study has taken the following reference figures for "state of the art" wind turbines in 2002 under optimum conditions:

- Investment cost: Euro 823/$kW_{installed}$
- Unit cost for electricity: Euro cents 4.04/kWh

The report further says that:
"The general conclusion from industrial learning curves theory is that costs decrease by some 20% each time the number of units produced doubles. A 20% decline is equivalent to a progress ratio of 0.80%. Studies of the past development of the wind power industry show that progress through R&D efforts and by learning resulted in a 15-20% price reduction – equivalent to a progress ration of 0.85 to 0.80"

The European Directive

The Directive 2001/77/EC of the European Parliament requires national indicative targets to be consistent with meeting 22.1% of total Community electricity consumption with renewable energy sources by 2010 (The European Communities, 2001). The Directive further says:

"It should also promote the use of renewable energy sources in an effective way, and be simple and at the same time as efficient as possible, particularly in terms of cost, and **include sufficient transitional periods of at least seven years, maintain investors' confidence** and avoid stranded costs.....

When favouring the development of a market for renewable energy sources, it is necessary to take into account the positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities, especially as concerns small and medium-sized undertakings as well as independent power producers...........

The costs of connecting new producers of electricity from renewable energy sources should be objective, transparent and non-discriminatory and due account should be taken of the benefit embedded generators bring to the grid."

The Directive further mandates:
"Member States or the competent bodies appointed by the Member States shall evaluate the existing legislative and regulatory framework with regard to authorisation procedures or the other procedures laid down in Article 4 of Directive 96/92/EC, which are applicable to production plants for electricity produced from renewable energy sources, with a view to:

- reducing the regulatory and non-regulatory barriers to the increase in electricity production from renewable energy sources,

- streamlining and expediting procedures at the appropriate administrative level, and ensuring that the rules are objective, transparent and nondiscriminatory, and take fully into account the particularities of the various renewable energy source technologies.

Without prejudice to the maintenance of the reliability and safety of the grid, Member States shall take the necessary measures to ensure that transmission system operators and distribution system operators in their territory guarantee the transmission and distribution of electricity produced from renewable energy sources. **They may also provide for priority access to the grid system of electricity produced from renewable energy sources.** When dispatching generating installations, transmission system operators shall give priority to generating installations using renewable energy sources insofar as the operation of the national electricity system permits...........

Member States shall put into place a legal framework or require transmission system operators and distribution system operators to set up and publish their standard rules relating to the bearing of costs of technical adaptations, such as grid connections and grid reinforcements, which are necessary in order to integrate new producers feeding electricity produced from renewable energy sources into the interconnected grid.

Where appropriate, **Member States may require transmission system operators and distribution system operators to bear, in full or in part, the costs referred to in the above paragraph**."

Against this backdrop, the European Wind Energy Association (EWEA) has announced that a target of 75 GW of wind power by 2010 will deliver one third of all new electricity generation capacity and meet one third of the EU's total Kyoto commitment by 2010.

The wind power, thus, would provide electricity equal to the needs of 86 million Europeans. The 75 GW target will ensure the industry continues to advance the technology, further reduce costs, create thousands of jobs and export opportunities and contribute substantially to security of supply. Currently 24,626 MW of wind power is installed in the 15 EU countries[1].

In order to achieve the ambitious targets for wind power deployment, the countries in the Union European and elsewhere have adopted a variety of policy mechanisms. These range from simple premium payments per unit of electricity produced by renewable power plants to more complex mechanisms which place

[1] http://www.ewea.org/documents/07010375gw%20launch%20FINAL.pdf

an obligation on power suppliers to source a rising percentage of their supply from renewables.

Legislative instruments in the European countries

Power purchase

As per the study conducted by the European Environment Agency (EEA) a guaranteed market for power sales was consistently identified as a success factor. During the six year period (1993-1999) covered by this study, two principal legislative options were available for power generators, (i) feed-in arrangements and (ii) competitive tendering.

Feed-in laws

One of the most effective support measures for encouraging increased renewables generation is the feed-in law, which provides guaranteed power purchase agreements at fixed prices. The most favourable rates and conditions, and consequently some of the greatest rates of increased penetration, especially of wind energy, are to be found in Germany and Spain. In both countries, utilities are obliged to purchase renewable electricity. The prices paid are guaranteed and at a preferential rate.

The success of the feed-in law is clearly visible in the rapid increase in output from wind. Output in Germany rose by over 700 % between 1993 and 1999 (from 674 to 5528 GWh), and in Spain by 2266 % over the same period (from 116 to 2744 GWh). Denmark also achieved a long and sustained growth in wind power installation during the 1990s, again due to the fact that the developers were being able to sell their power at a known and economically favourable rate.

The scheme is simple, and provides guaranteed and known power prices, over a number of years. The arrangement removes the uncertainty and risk associated with the development of a renewable energy scheme.

Competitive bidding

A competitive bidding is the main alternative to the feed-in system. It provides a guaranteed market through access to contracts and competitive prices for renewable energy. Competitive tendering has been operated in France, Ireland and the UK. Ireland established the Alternative Energy Requirement (AER) as a support mechanism for a range of renewable energy technologies, based on the system in place in the UK since 1990 called the Non-Fossil Fuel Obligation (NFFO). Both the AER and the NFFO are competitive bidding systems whereby developers respond to calls for tender to provide electricity from a range of renewable energy sources. If they are successful, they get a guaranteed power price, at the level of their bidding price, and a long-term (e.g. 15 year) contract for power sales from their renewable energy projects. Each type of renewable energy project is grouped with other similar technologies, which ensures that there is competition between applications.

Access to the grid

Another factor, found to be critical to success of renewable energy power programmes in Europe, is access to the necessary grid infrastructure. Renewable energy is generally small scale, decentralised, and may be located in remote locations where grid connections are limited. In addition, renewable energy like wind is intermittent in nature. Renewable energy electricity generation, therefore, faces problems of grid access that are not faced by the larger generators of the conventional power. Member States that took the biggest steps to address problems of grid access achieved the greatest levels of renewable electricity penetration. Denmark, Germany and Sweden all have policies that oblige utilities to allow straightforward access to the grid for renewable energy producers. They also have transparent and economically fair charging systems for grid access, so that developers know the charges that they are likely to face, in advance.

Fiscal instruments

Fiscal measures may be implemented in the form of environmental taxes, which penalise the use of fossil fuel (and hence benefit renewable energy use) or as a positive form of tax incentive for environmentally beneficial investment, such as a tax exemption or reduction. Both forms of fiscal support measure are increasingly being used by EU countries to encourage renewable energy and other environmentally beneficial activities, or for penalising fossil generation or other environmentally damaging activities.

Environmental taxes

Denmark was one of the first countries to implement an environmental tax regime. Energy consumers were charged a CO_2 tax from 1992, with some of the revenue given to generators of electricity from renewable sources. Other member States, including Austria, Denmark, Finland, Italy, the Netherlands and Sweden, have now implemented various forms of environmental tax. They have introduced energy or environmental taxes as part of their overall energy policy to more accurately reflect the total costs (including costs to the environment) of generating heat or power from fossil sources.

The types of environmental taxes implemented vary widely; they may be levied on energy use (both heat and electricity), power or heat generation, CO_2, or SO_2. In all cases, renewable energy generation for power and heat benefits through either exemptions or refunds. In some cases (as in Austria and Italy), some or all of the revenues received from energy taxes are recycled to benefit renewable energy, energy efficiency, or other environmental projects.

Tax incentives for investment

Fiscal arrangements can also be used to encourage investment in renewable energy projects. Tax exemptions or reductions can encourage private individuals and companies to consider investing in renewable energy projects as an attractive financial option. For example, in Germany and Sweden, investment in wind schemes can be offset against tax for individuals, while in Ireland, the Netherlands and Spain, companies receive tax relief if they invest in renewable energy projects. In the Netherlands, companies and firms which invest in renewable energy projects can benefit from claiming accelerated depreciation of investment in equipment for such projects.

Financial instruments

Structural Funds

Support for renewable energy has also been provided through non-energy European Community programmes, especially the Structural Funds. These funds provide support for project development, training and other key measures.

Favourable loans

Low-interest loans for the development of renewable energy projects may be provided by banks or other private sector financial institutions. Some German and Dutch financing institutions in particular are able to offer low interest loans for environmental projects.

State financial institutions are often more proactive in the development of renewable energy in their regions. In the Navarre (Spain), the regional bank is a shareholder in the public–private company established to develop the region's wind energy resources.

Box 6.1

A recent report by the Lawrence Berkeley National Laboratory, USA examined case studies in the United States of the impacts and effectiveness of “clean energy funds” on utility scale projects. The mechanisms examined included upfront grants (actual support for projects), forgivable loans (to support early expenses and paid back only if the project is completed), production incentives (payments per kWh of actual production), power-purchase agreements, and renewable portfolio standards. They concluded that long-term power purchase agreements (at least ten years) for the outputs of renewable energy systems are critical, but investor confidence to support those agreements comes *first* from stable long term policies, such as renewable energy standards, supplemented, but to a lesser extent, by green power markets.

Source: REFOCUS, Jan/Feb. 2003

The different member states have adopted one or combination of above mentioned measures. Table 6.6 gives details about the policy instruments used by different EU member and accession countries.

Table 6.6 Instruments for promoting renewable energy in the EU and its Accession States in mid-2003

Country	*Feed-in tariff*	*Quota obligation + certificate trading*	*Tenders*	*CO_2- or energy-tax*	*Environmental funds (subsidies, soft loans, etc.)*	*Tax relief / exemption / deduction*
Austria	•1				•	•
Belgium	•	•		•	•	•
Bulgaria					•	•
Cyprus						•
Czech Republic	•				•	•
Denmark	•	♣				
Estonia	•				•	•
Finland	•			•	•	•
France	•		•2		•	•
Germany	•			•	•	•
Greece	•				•	•
Hungary	•				•	•
Ireland			•		•	•
Italy		•			•	•
Latvia	•		•		•	•
Lithuania					•	•
Luxembourg	•				•	
Malta						•

Netherlands	•		•	•	•
Poland		•		•	•
Portugal	•			•	•
Romania					•
Slovenia	•		•	•	•
Slovakia				•	•
Spain	•			•	•
Sweden		•	•	•	•
United Kingdom		•	•	•	•
Turkey					•

• = deployed promotion instrument; ♣ = introduction is planned; [1]only in the Flanders region and only for photovoltaic; [2]foreseen only for wind farms over 12 MW capacity

Source: RE in EU-28 Renewable energy policies in enlarged European union, REFOCUS, the international Renewable Energy magazine, Sep/Oct 2003.

The regulatory and policy regime in the three major EU countries, which are having larger installations of renewable systems or high targets, Germany, Denmark and the UK, is discussed below.

Denmark

Denmark introduced the ‘feed in tariff’ system, for electrical generation form renewable energy systems, in 1996. The tariffs have been revised in 1999 and 2001. It was anticipated in 2001 that the system for trading of green certificates will be fully operational in 2003 and appropriate revisions were made in the feed in tariffs. Thus the feed in tariff offered for plants installed after 2001 were offered lower tariff, since it was expected that they will have additional revenue form trading of green certificates. Denmark also have specific policy for ‘repowering for wind’. The repowering scheme consists of two measures: a lower price for electricity produced by turbines older than 10 years, and a favorable electricity price when turbines below 100 kW (and in some cases 150 kW) are replaced by new turbines with a capacity up to 3 times as large. The scheme entitles new wind turbines that replace small turbines to an additional production subsidy. There is fiscal incentive, i.e. income tax benefit, for individuals who participate in the ‘wind energy co-operatives’. In addition, investment subsidies are also available for certain RE projects. The subsidy varies in the range of 15–30% of equipment cost with an upper limit. However, many investment subsidies were cut in 2002, with the change in the government.

Germany

The 'Electricity feed in Law', which was introduced in 1990, replaced by the 'Renewable Energy Sources Act' on 1st of April 2000. The grid operators pay the feed-in tariffs under this new law and cover their costs by an additional fee to be paid by all consumers. Under the new act of 2000, the utilities have the legal obligation to take off the electricity produced from RES. The grid operator whose grid is closest to the location of the RES installation has the obligation to pay the tariffs. The act states that the electricity from renewable energy must be transported and charged to the final customer.

The prices paid under the act are based on a fixed price scheme combined with a decreasing price element. From 2002 on, new installations of biomass (minus 1%), wind (minus 1.5%) and PV (minus 5%) receive lower tariffs. From 2003 on, new installations of these types receive tariffs lowered by a further, 1, 1.5 or 5%, and so on for the next following years. For every installation, the expiry date is in 20 years time from the installation. For example the tariff for onshore wind installed in the year 2001 is 9.1 Euro cents/kWh for first 5 years, and 6.17euro cents/kWh in the following years. In case of installation in the year 2002 the tariff is 9 Euro cents/kWh for first 5 years, 6.17 Euro cents/kWh in the following years.

There are investment subsidies in Germany, specifically photovoltaics, under the 100,000 Roof Photovoltaic Programme. Apart from the national level programmes the states also have support programmes for renewables. For instance, the Bremen and Saarland states have up to 30% subsidy for wind.

The UK

The National Fossil Fuel Obligations (NFFO), which were introduced in 1989, were replaced by the Renewables Obligations in the year 2002. Under the Renewables Obligations the distributors of electricity will have to supply certain percentage from renewables. In return they will receive Renewable Obligation Certificates (ROCs), which can be traded domestically. The percentages are decided on annual basis. For 2003-04 it is 4.3%, and increases gradually to 10% in the year 2010-11. A penalty is set for non-compliance: 30 GBP/MWh (approximately Euro cent 4.5 / kWh). This penalty is set annually in line with the retail prices.

In addition to the obligations, UK also introduced climate change levy on the sales of electricity, coal, natural gas and liquefied petroleum gas to the business and public sectors. Supply of renewable electricity is exempt from the levy in order to stimulate demand for the renewable energy.

USA

Federal incentives[2]

Renewable Electricity Production Credit

The Renewable Electricity Production Credit (REPC), also called the Production Tax Credit (PTC), is a per kilowatt-hour tax credit for electricity generated by qualified energy resources - defined as wind, closed-loop biomass, or poultry waste. Available during the first 10 years of operation, the REPC provides a 1.5 cents per kWh credit adjusted annually for inflation. The adjusted credit amount for 2003 is 1.8 cents per kWh.

Renewable Energy Production Incentive (REPI)

The Renewable Energy Production Incentive (REPI) provides financial incentive payments for electricity produced and sold by new qualifying renewable energy generation facilities. Eligible electric production facilities include publicly-owned electric utilities, rural electric cooperatives, and local or state governments that sell the project's electricity to someone else. Qualifying facilities are eligible for annual incentive payments of 1.5 cents per kWh (1993 dollars and indexed for inflation) for the first ten-year period of their operation, subject to the availability of annual appropriations in each Federal fiscal year of operation. The period for payment under this program ends with fiscal year 2013.

Solar and Geothermal Business Energy Tax Credit

The federal business energy tax credit is a 10% tax credit available to commercial businesses that invest in or purchase energy property in the United States. Credit may not be taken if financing for the project is subsidized or from tax-exempt private activity bonds. The tax credit is limited to $25,000 per year, plus 25% of the total tax remaining after the credit is taken. Remaining credit may be carried back to the three preceding years and then carried forward for 15 years.

State incentives

[2] www.dsireusa.org

Massachusetts

As part of its 1997 electric utility restructuring legislation, Massachusetts created the outlines for a renewable portfolio standard (RPS). In April 2002, the Massachusetts Division of Energy Resources (DOER) released its final regulations for the RPS which require all retail electricity providers in the state to utilize new renewable energy sources for at least 1% of their power supply in 2003, increasing to 4% by 2009.

Mainstay Energy Rewards Program - Green Tag Purchase Program

- Mainstay Energy is a private company offering customers who install, or have installed, renewable energy systems the opportunity to sell the green tags (also known as renewable energy credits, or RECs) associated with the energy generated by these systems. These green tags will be brought to market as state or Green-e* certified products. Through the Mainstay Energy Rewards Program, participating customers receive a one-time payment for five years' worth of green tags.

  The amount of the payments depends on the type of renewable energy technology, and the capacity of the system. Payments are as follows:
  Solar PV: $100/kW
  Wind: $50/kW
  Biomass/biofuel electric: Call for quotation.
  Geothermal/Low-impact hydro: Call for quotation.

Solar and wind energy system deduction

Businesses may deduct from net income, for state tax purposes, costs incurred from the installation of any "solar or wind powered climatic control unit and any solar or wind powered water heating unit or any other type unit or system powered thereby". The installation must be located in Massachusetts and used exclusively in the trade or business of the corporation.

Businesses that qualify for this deduction may also qualify for the the corporate excise tax exemption on solar or wind powered devices. This exemption is available for the length of the equipment's depreciation period.

Nevada

As part of its 1997 restructuring legislation, the Nevada legislature established a renewable energy portfolio standard. Under the standard, the state's two investor-owned utilities, Nevada Power and Sierra Pacific Power, must derive a minimum percentage of the total electricity they sell from renewable energy resources. In 2001, the legislature revised the minimum amounts to increase by 2% every 2 years, starting with a 5% renewable energy requirement in 2003 and achieving a 15% requirement by 2013 and each year thereafter.

Renewable energy credits

Nevada's Renewable Energy Portfolio Standard requires the state's two investor-owned utilities to derive a minimum percentage of the electricity they sell from renewable energy resources. Included in the standard is a Renewable Energy Credit (REC) program. One REC will represent a kilowatt-hour of electricity generated from a renewable energy system. Nevada's renewable energy producers can earn RECs, which can then be sold to utilities that are required to meet Nevada's portfolio standard.

New Jersey

As part of its 1999 electric utility restructuring legislation, New Jersey mandates the disclosure of fuel mixes and emissions information by each electricity supplier or basic generation service provider serving retail customers (residential, commercial and industrial). The environmental information to be disclosed to the customer includes the following:

- fuel mix, including categories for coal, gas, hydroelectric (large), nuclear, oil and renewable energy, or regional average default values as determined by the New Jersey Board of Public Utilities;
- air emissions, in pounds/MWh, of sulfur dioxide, carbon dioxide, oxides of nitrogen; and
- the electricity supplier's support of energy efficiency, as reflected in the number of discrete emission reduction credits.

New Jersey’s 2001 restructuring legislation requires all retail electric suppliers to provide 0.5% of their energy from Class I renewable resources by September 1, 2001(plus another 2.5% from Class I or II), 1% by January 1, 2006 and an additional 0.5% per year until it reaches 4% by 2012. Beginning in 2001, an additional 2.5% of retail electricity in the retail electricity portfolios must come from Class I or Class II, or any combination thereof. Class I renewables include wind, solar, fuel cells, ocean energy, landfill methane and biomass, if the biomass is "cultivated and harvested in a sustainable manner," and Class II renewables, include hydro and waste-to-energy facilities that meet the "highest environmental standards." In April 2003, the Governor's Renewable Energy Task Force called for doubling the Class I requirements from 2% in 2008 to 4%

in 2008. The total RPS in 2008 including the 2.5% Class I or Class II will be 6.5%. The rule proposal also includes a provision establishing a renewable energy certificate and a solar renewable energy certificate that can be traded separately from the electric generation for compliance with the RPS.

Renewable energy advanced power program

The New Jersey Board of Public Utilities has issued a request for proposals for a competitive incentive and financing program -- The Renewable Energy Advanced Power Program -- to encourage development of distributive renewable electricity generation projects in the state. This is one of several renewable energy programs funded by the state's Societal Benefits Charge and administered by the Office of Clean Energy, a division of the New Jersey Board of Public Utilities.

Projects will be expected to supply electricity to the PJM Power Pool, or to large power users, by installing a minimum of 1 Megawatt (MW) power generation at their facility or by aggregating a minimum of 1 MW of renewable electricity generation systems into one proposal. This Solicitation is designed to provide seed grants and access to capital in order to make renewably-powered electricity cost competitive with conventional power plants.

The funds awarded to successful proposals will include a grant award of up to 20% of the total construction costs and other qualifying costs, as well as guaranteed long-term financing for the incremental cost of construction of the project.

Note that tradable emission credits or tradable renewable energy certificates or attributes which result from projects funded through New Jersey Clean Energy programs will be the property of the project developer, unless the developer defaults on their financing commitment in which case the ownership of the credits will revert to the New Jersey Clean Energy Program until such time as the project financing provided through this program is fully recovered including any fees, penalties or interest; unless otherwise negotiated.

Vermont

In 2002 Vermont's Governor signed into law a bill (S.138) authorizing the Vermont Public Service Board (PSB) to prescribe standards for electricity suppliers to disclose information on fuel sources and the environmental impacts of electricity generation.

Solar & wind incentive program

Renewable energy legislation enacted in June 2003 authorizes the use of a portion of Vermont's petroleum violation escrow fund to provide incentives for qualifying solar electric, solar hot water, and small wind systems. A total of $522,900 is available for incentives. For wind systems, incentive amounts are determined based on manufacturer's total rated turbine output with a hub-height wind speed of 11 m/s.

Oklahoma

Oklahoma Gas & Electric - Wind power

Oklahoma Gas & Electric (OG&E) offers customers the opportunity to support renewable energy through the wind power program. Residential, commercial and industrial customers may participate by paying an additional amount per 100-kWh unit of renewable energy per month. Customers may purchase a minimum of 1 to a maximum of 20 units per month. Customers pay an additional 2 cents per kWh which is offset by a credit from the fuel adjustment charge which is currently 1.5 cents. Therefore, customers are currently paying 1/2 cent per kWh or 50 cents per 100-kWh unit.

Mississippi

Energy investment program

The Energy Division of Mississippi's Development Authority administers this program, which makes low-interest loans for a wide variety of renewable and non-renewable energy projects. Eligible technologies include solar thermal, solar space heat, solar process heat, photovoltaics, alternative fuels, geothermal, biomass, hydropower, and recycling facilities. All projects must demonstrate that they will reduce energy costs. The interest rate is 3% below the prime rate with up to a seven-year repayment period. This $7 million revolving loan fund was established through federal oil overcharge funds.

California

As a result of Senate Bill 1305 (1997), California's energy suppliers must disclose to all customers the energy resource mix used in generation. Providers must use a standard label created by the California Energy Commission (CEC), and this information must be provided to end-use customers at least four times per year.

Energy Financing Industrial Development Bond Program

The California Consumer Power and Conservation Financing Authority (the California Power Authority or CPA) is offering below-market rate loans to manufacturing companies that will use the loan for the purchase and installation of renewable energy systems, energy-efficient equipment, or clean distributed generation systems on their own facilities, or manufacturers of renewable energy and/or clean distributed generation systems or components establishing or expanding the manufacturer's California production facilities. Eligible renewable energy technologies include photovoltaics, solar thermal electric, fuel cells, small and large wind turbines, biogas, landfill gas, biomass, and geothermal electric technologies. Funding for the program includes $30 million of tax-exempt industrial development bonds.

Conclusions

The above-cited programmes and incentives give a fairly consistent picture of the progressive steps taken by the developed countries (and even states and counties) for mainstreaming the renewable energy technologies. The commonalities among them could be summarised as:

- Most of the countries/states have 'Renewable Portfolio Standards' mandating a certain percentage of total capacity to come from renewables. Not only that, this percentage increases in phased manner.
- There is a provision of issuance and trading of 'green certificates'.
- The power from renewable energy sources fetch a 'premium' that may or may not be paid by the end-consumer.
- In many places, it is mandatory for the distribution companies to disclose (a) details regarding sources of power supplied and (b) environmental impacts of the same.
- The policy in New Jersey specifically mentions that 'tradable emission credits' or 'tradable renewable energy certificates' or 'attributes' which result from projects funded through New Jersey Clean Energy will be the property of the project developer.

7 Policy and regulatory scenario in India

Policy scenario

Central and state governments' policies related to renewable energy

Central and state governments' renewable energy policies have always been instrumental in state-wise capacity additions in RE power. On both the fronts, the major objective was to attract private investment for accelerated penetration of RE power.

Combined with these positive policies (prevalent during a given period), RE resources and technology providers also played an equally important role in achieving such heights. The growth of wind sector in the state of Tamil Nadu is an illustrating example. The capacity addition in wind power sector grew from about 110 MW to nearly 750 MW between 1994 and 1996. With the wind resource assessment showing huge wind power potential in the southern region of Tamil Nadu, the state government framed favourable power purchase policies, captive use and third party sale being the most attractive features of the policy.

Indeed, the impact of taxes and duties on overall renewable energy sector is far reaching, be it technology acquisition, import of components, or in country manufacturing itself. Unless there is a favourable and balanced regime of taxation and duties, the viability of RETs becomes uncertain. Not only this, the taxation (or lack of it) on conventional energy too has a bearing on effective propagation of RETs.

In the Central Government, Ministry of Non-conventional Energy Sources (MNES) is the nodal ministry for development of energy from renewable resources. In 1993, MNES formulated guidelines for promotional and fiscal incentives by state governments for power generation from non-conventional energy sources, to be followed by the state governments. These guidelines were designed to bring about a more level playing field for grid connected power generation from renewable energy sources. The salient features of the MNES guidelines are as follows.

- Grid interfacing to be either carried out by the project promoter or SEB and cost to be borne by the project promoter.
- SEB to carry out the augmentation of the sub-station capacity and lay higher capacity transmission lines based upon the project generation capacity.
- Two separate meters for power export and import to and from the grid to be installed by the project promoter.
- Current limiting devices to be installed by the project promoter. Power factor to be always maintained above 0.8.
- SEB to allow captive use and third party sale (i.e. H.T. consumer of the SEB)
- SEB to charge uniform 2% wheeling charges irrespective of the distance from the generating station.
- SEB to permit banking of power up to one year
- SEB to purchase power at a minimum rate of Rs 2.25 /unit with no restriction on time or quantum of electricity supplied. This rate to be reviewed annually and linked to standard criteria such as wholesale price index.
- Transactions between SEB and project promoter to be settled on monthly basis.
- Consumption of electricity generated by the project promoter to be exempted from electricity duty.
- SEB to provide exemption from demand cut to the extent of 30% of the installed capacity of the project promoter.
- Sales tax benefits to be made available to the promoter who owns the project
- Incentives normally available to any other industry be made available for renewable energy power projects including concessions available in industrially backward areas.
- Infrastructural facilities to be provided for such projects on the lines of industrial estates.
- Project clearance to be provided within 2 months from the date of application
- Agreement to be signed within a period of 1 month from the date of clearance.

Initially, the state governments rather than following MNES guidelines in *Toto*, incorporated only certain elements in their policies. The state governments were then urged by MNES to amend their policies in consonance with the MNES guidelines. MNES further suggested implementation of Empowered Institutional Mechanism (EIM) with sufficient funding be created to deal with all aspects of non-conventional energy power projects at the state level. MNES also recommended an interim separate and distinct *cell* for non-conventional energy power projects within the SEBs.

In 1996 MNES issued the following guidelines for fixation of purchase price of power produced from renewable energy power projects:

- SEB to announce a base power purchase price every year.
- The base power purchase price for the year 1994-95 is Rs. 2.25 /unit. This price shall be escalated at a minimum rate of 5 % every year. This price to be applicable for all renewable energy based power projects.
- The base price of Rs.2.25/unit with an annual escalation of 5% to be available for the power producer for a period of 10 years. From the end of the 10th year onwards, the power purchase price may be equivalent to that of the 10th year ***or*** equivalent to the high tension (H.T.) tariff prevalent in the state, whichever is higher.
- SEB to make payments to the power producer within one month
- SEB to provide escrow account or an irrevocable, transferable, divisible and confirmed standby letter of credit issued by State Bank of India or another nationalised bank. The amount of the letter of credit shall be equal to the expected total of two years payment by the SEB.
- SEB to issue ***Credit notes*** to the power producer in case of non-payment of dues within the stipulated period with a validity of 6 months. These credit notes shall be transferable with SEB's H.T. consumers who in turn can adjust their bills with SEB.
- The duration of the power purchase agreement shall be 20 years, which could be extended to another 10 years through mutual agreement.

Though MNES initiated several commendable efforts to promote effective implementation of its programme and policy guidelines, its vision of bringing about uniform policy among all the states for grid connected RE power did not materialise as expected. The underlying reason was that while the Central Government can mainly act as a catalyst and facilitator, the actual policy enforcement was to be carried out only by the States. It was observed that there was a lack of uniformity in SEBs' approach to concessional tariffs, wheeling, banking, third party sale and power evacuation facilities.

State policies for wind power sector

Few states, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Rajasthan have been proactive in propagating RE in their respective states.

Especially these states have been identified by MNES to have good wind power potential based on their wind resource assessment studies.

The state governments and regulators, having critically analysed the techno-economics of wind power projects, have rationalised their stance on tariff and other incentives. The following table summarizes the prevalent practices in various states with regard to wind energy propagation.

Table 7.1 State-level Practices for Wind Power

Items	Andhra Pradesh	Gujarat	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Rajasthan	Tamil Nadu	West Bengal
Wheeling	Rs.0.50 per kWh as network charges & 28.4% of energy as system loss	4% of energy	6-12% of energy	5% of energy	2% of energy	2% of Energy as wheeling + 5% as T&D loss.	10% of energy	5% of energy	2% of energy
Banking	12 Months	6 Months	2% per month for 12 Months + 1 Month as grace period.	12 Months, drawl 9 months (Jun. - Feb.)	-	12 Months	12 Months (Jan. - Dec.)	5% (Financial year April to March)	6 Months
Buy-back	Rs.2.25 per kWh (5% escalation, 1994-95)	Rs.2.60 per kWh (2002-03) (escalation of 5 paise per year for 10yrs)	Rs. 3.25 per kWh for power projects already commissioned and to be commissioned on or before 31st August 2003 and Rs. 3.10 per kWh for power projects to be commissioned after 31st August 2003 with an annual escalation of 2% on the base tariff of Rs.3.10 per kWh.	Rs.2.80 per kWh (5% escalation, 2000-01)	Rs.2.25 per kWh (no escalation)	Rs.3.32/kWh (2% escalation, 2003-04).	Rs.3.32 per kWh (5% escalation for 10 yrs, base year 2003 - 2004)	Rs.2.70 per kWh (no escalat-ion)	To be decided on case to case basis
Third Party	Not Allowed	Not Allow	Allowed	Not Allowed	Allowed	Allowed	Allowed	Not Allowed	Not Allowe

Items	Andhra Pradesh	Gujarat	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Rajasthan	Tamil Nadu	West Bengal
Sale		ed							d
Capital Subsidy	20% (max Rs.25 lakh)	-		-	Same as for Other industries	-	-	-	-
Other In-centives	Industry Status	Exemption of E.D. & demand cut to the extent 30% of installed capacity	No electricity Duty for 5 yrs	Industry Status, Exemption from entry tax & octroi	-	-	No electricity Duty for 5 yrs	-	-
Penalty on kVArh consumption	10 paise per kVArh	Nil	40 paise per kVArh	Nil	27 paise per kVArh	25 paise per kVArh	Nil	Nil for average power factor between 0.85 and 1.0 based on import power and Rs.0.30/- to Re.1/- per KVArh depending on Consumption.	

Source: www.windpowerindia.com

In Maharashtra, MERC came out with a tariff order for wind power projects during the month of September 2003. The tariff for wind power has been set for three categories of projects as follows.

- Tariff as per the Government of Maharashtra guidelines (which endorsed MNES guidelines) for projects commissioned before the formulation of

MERC (till 26th Dec 1999) viz., Rs 3.34/kWh with 5 % annual escalation on compounded basis (Category I)

- Tariff for projects commissioned between 27th Dec 199 and 1st April 2003 @ Rs.2.5 /kWh for the first year with annual increment of 10 paise/kWh for the first ten years (Category II)
- Tariff for projects to be commissioned after 1st April 2003 till 31st march 2007 @ Rs.3.5 /kWh for the first year with annual increment of 15 paise/kWh for the first thirteen years (Category III)

However for the third category, MERC has mentioned that the new wind power capacities to be permitted for sale to utilities shall not be more than 750 MW during the balance period of 4 years of 10th Plan Period ending 31.03.2007. MERC has further mentioned in their order that benefits such as sales tax, accelerated depreciation, CDM etc. availed shall be shared by the developer with the MSEB and a formula to share these benefits need to be worked out. On the positive note, MERC has stated that the future wind power projects may be provided front-loaded tariff with a suggestion to the Government of Maharashtra to provide infrastructural support for such environment friendly power.

Present scenario

In pre-reforms period, when the state regulatory commissions were not there, the state governments were taking policy decisions encompassing incentives, buy-back tariff, and any other benefits. However, after the formulation of the state regulatory commissions, except for incentives, infrastructural benefits, and imposition of cess/surcharge, rest everything comes under the purview of SERCs. Indeed, the Electricity Act 2003 has vested SERCs with powers for promoting and governing RE power.

Electricity Act 2003 and its implications

Electricity Act 2003 and Renewable Energy

The much awaited Electricity Act 2003 (EA 2003) was notified on 10th June 2003. This new act has several enabling provisions, with a view to promote accelerated development of non-conventional energy based power generation. They are summarised below.

1. General

- Government of India (GoI) shall, from time to time, prepare the National Electricity Policy and Tariff Policy, *in consultation with the State Governments* for developing the power system based on optimal utilisation of resources such as coal, natural gas, nuclear, hydro, and renewable sources of energy *[Section 3(1)]*.
- The Central Electricity Authority (CEA) shall prepare a National Electricity Plan in accordance with the National Electricity Policy and notify such Plan every 5 years *[Section 3 (4)]*.
- GoI shall, *after consultation with the State Governments*, prepare a national policy, permitting stand-alone systems (including those based on renewable sources of energy) for rural areas *[Section 4]*.
- GoI shall also formulate a national policy, *in consultation with the State Governments* and *the State Commissions (SERCs)*, for rural electrification and for bulk purchase of power and management of local distribution in rural areas through Panchayti Raj Institutions, co-operative societies, and NGOs *[Section 5]* .

2. Generation

- Any generating company may establish, operate, and maintain a generating station, *without* obtaining a licence[1] under this Act, provided it complies with the technical standards regarding connectivity with the grid *[Section 7]*.
- A person may construct, operate, and maintain a captive generating plant and dedicated transmission lines .Such persons shall have right to open access to the transmission facilities, for carrying electricity from the captive plant to the destination of their own use. *[Section 9 (1&2)]*.

3. Distribution and transmission of electricity

- The State Electricity Regulatory Commission (SERC) shall introduce open access in such phases and subject to such conditions (including the cross subsidies and other operational constraints) as may be specified within one year of the appointed date by it. *[Section 42 (1 & 2)]*
  - SERC shall specify extent of open access in successive phases
  - SERC shall determine the wheeling charges

[1] Except in case of large hydro projects *(Section 8)*

– SERC shall decide the surcharge *in addition* to the wheeling charges to meet current level of cross-subsidy (e.g. the industrial consumer cross-subsidizes the domestic ones)
– SERC shall specify the manner in which such surcharge and cross-subsidies is progressively reduced and eliminated

Such surcharge shall not be levied in case of electricity being carried from captive power plant to the destination of own use.

Private companies have been allowed to own stakes in transmission companies along with generation and distribution. A distribution licensee can take up generation and vice versa.

4. Tariff

- SERC shall be guided in specifying the terms and conditions for determination of tariff by the following *[Section 61]*:
  – Promotion of co-generation and generation of electricity from renewable sources of energy
  – The National Electricity Policy and tariff policy
  – The principles and methodologies specified by the Central Electricity Regulatory Commission (CERC)

5. Trading

Trading has been recognised as a distinct activity. The provision of open access is likely to facilitate trading. While trading can be an independent activity, a distribution licensee or a generator can be a trader. However, a transmission licensee cannot be a trader.

There can be interstate/intrastate trading or interregional trading.

6. SERC

– SERC shall specify, for purchase of electricity from such sources, a percentage of the total electricity consumption in the area, from cogeneration and renewable sources of energy.

Besides the aforementioned provisions, EA 2003 also provides for:

– Exemption from License for generation and distribution in notified rural areas *(Section 12 and but one para of Section 14)*.

Implications on wind power development

There are several direct and indirect implications on wind power development arising out of EA 2003. Most of them can be considered to be positive for overall development of wind sector. They are discussed below.

SERC mandate for promoting RE

EA 2003 clearly mandates SERCs to promote cogeneration and renewables. This provision, therefore, would have a positive impact insofar as mainstreaming of electricity from renewable energy is concerned. Even prior to the EA2003, most of the SERCs from the wind power potential states (namely Maharashtra, Karnataka, Rajasthan, Andhra Pradesh) were critically analysing and evaluating the techno-economics and operational features of the wind power projects. Especially MERC and KERC have carried out detailed financial evaluation of wind power projects and have analysed all the relevant aspects of the current status and future growth of wind sector. Based on these evaluations and analysis they have arrived at a rationalised tariff for already commissioned and new projects. SERCs are cognized of the fact that there is a need for the economies of scale in order to bring about reduction in capital cost of wind turbines. This highlights the growing involvement and understanding of SERC in the wind sector.

While, on the one hand, SERCs are confronted with issues in promoting wind power such as PLF and pattern of availability; on the other hand they need to consider internalization of cost of externalities (quantification of environmental impacts of conventional power and socio-economic benefits of wind power) in the cost of conventional power. It is hoped, therefore, that the SERCs in the wind power potential states will earnestly evaluate all the aspects of wind power projects before arriving at the tariff for wind electricity. for wind power.

Captive power benefits

As no licence is required for electricity generation and open access is also being provided to captive power plants without any surcharge, wind farms installed for captive purpose may benefit to a greater extent besides sale of surplus power to any third party. However these favourable conditions are subject to reasonable wheeling charges to be decided by SERC.

Direct sale to consumers

As per the provisions of EA 2003, generators can sell power directly to consumers, without having to sell its power to the utilities. Generators can negotiate terms with consumers. This is further facilitated by the open access assured under EA 2003. However major concerns on the open access are that it may not come into force immediately and the surcharge and wheeling charges if decided at a higher range, will not benefit such wind power projects.

SERC and Renewables Portfolio Standard (RPS)

As SERCs are required to specify a percentage on purchase of RE power, wind power sector gain advantage as compared to other RE sectors due to its low gestation period. Further the wind sector has minimal external impacts (viz., fuel availability, labour issues, downtime of auxiliary equipments etc.) on its performance. As wind projects are being installed after extensive wind resource assessment, the power generation estimated/projected is quite reliable and further guaranteed by few suppliers in the market too. This minimizes the risk associated with wind power plants.

However the impact/influence of this RPS may not be realised immediately. Though the Electricity Act 2003 has set no time limit/deadline for SERCs to specify this percentage, Consultation Paper on National Tariff Policy states, *"The Appropriate Commission may fix a minimum percentage for purchase of energy from such sources ……. Such percentage for purchase of power from renewable sources should be made applicable for the tariffs to be determined by the SERCs from April 1, 2005".*

Further SERCs also need to enlighten themselves with all the aspects of the RE sector before declaring the RPS. On the other hand SERCs have other pressing matters like operationalising open access, to deal with. Hence the issue of RPS may be tackled once SERCs have adequately addressed the priority issues. At the same time, SERCs may also prefer to examine the impact of their current tariff order in wind sector on its annual growth before deciding the RPS.

Competition, bidding etc.

Under the open access scenario, de-licensing and trading are likely to result in more competition among the power producers and hence RE power will need to be competitive. EA 2003 also enables the SERC to fix the maximum ceiling for tariff to promote competition [62 1(a)] for retail sale of electricity in an area of more than one distributions licensee. EA 2003 further allows SERCs to adopt tariff arising out of transparent bidding process as per the Central Government guidelines.

KERC has already indicated in their discussion paper, several options for setting the tariff for RE power including competitive bidding process. Hence despite the SERC setting a preferential tariff, state government and central government providing incentives; a competitive RE power market is likely to emerge. The fact that (a) major private utilities like Reliance Energy Ltd. are entering the wind power sector and (b) wind power generators are trying to venture in to trading may also result in competitive prices of wind power.

Preferential tariff

As it is evident, wind power projects need front loaded tariff and hence the initial tariff to be provided will be higher. EA 2003 has provisions for the state government to provide financial support (grant of subsidy) in advance for any (preferential) tariff recommended by SERC *(Section 65)*. The National Electricity Policy and Tariff Policy will be developed through consultative process among Central and State governments.

Consultation Paper on National Tariff Policy states, *"A separate policy would be notified on issues relating to tariffs in respect to non-conventional energy sources …"*. The tariff policy on renewables, being developed by Government of India, therefore, *should* go in to this consultative process. As of now it is not clear whether the Tariff Policy to be brought out by the Ministry of Power is going to be prescriptive, recommendatory, or a mix of both.

Conclusions

The scenario that emerges out of Electricity Act 2003, therefore, points towards a number of possibilities for wind power. These include state-level quota for renewables, generating companies supplying power to consumers directly, and intrastate/inter-state/inter-regional trading. The conversion of these possibilities into business, however, would largely depend on decisions taken by the state regulators with regard to nature of quota (whether a floor limit or a ceiling), quantum and kind of tariffs (short-term or long-term), and wheeling charges and surcharge on them, and enabling actual grid-access to traders. While on one hand, the demand and supply gaps can provide an impetus to the trading market, there could be possible constraints in terms of availability of transmission capacity and the extent of surcharge levied on the wheeling of electricity. Nonetheless, if they are competitive then wind power generators might not be that much dependent on utilities as they had to be in pre-EA 2003 period.

8 Road map

The impacts of conventional power generation and benefits of wind power in that context have been discussed in detail in the preceding sections. Having established the fact that it is indeed desirable to increase the share of wind power in overall energy-mix, i.e. having dealt with issue of ‘why wind power’; the next step pertains to ‘how’. And that is where it becomes essential to revisit the past and identify the main aspects that need to be tackled upfront if wind power has to be accorded importance which it deserves. Indian Wind Energy Association (InWEA) took an initiative and organised a Roundtable “Wind Power: 5000 MW by 2007! Why not” on June 27, 2003 with the support of MNES. This roundtable discussed the barriers faced by wind power sector in India. The following discussion also draws from the document that emerged from this roundtable (InWEA, 2003).

This concluding section thus deals with the main aspects that have bearing on accelerated mainstreaming of wind power in India and which form the foundation of the roadmap. These aspects have been categorised in the following manner:

1. Policy and regulatory aspects
2. Institutional and state level aspects
3. Technological and resource assessment related aspects
4. Financing aspects

Policy and regulatory aspects

Renewable portfolio standards

As per the provisions of the Electricity Act 2003, the State Electricity Regulatory Commission (SERC) has to specify a percentage of the total electricity consumption in the in the area of a distribution licensee, from cogeneration and renewable sources of energy. Thus, in each state, SERC has to device *Portfolio for Power Purchase*, for which the following issues need to be resolved:

- Resource availability for each technological option in a given area

- Specifying portfolio in power purchase by licensees based on the resource availability in the distribution area. Another issue is that whether this percentage is 'a minimum' or 'a maximum'
- How to integrate seasonal variations in power output (in case of wind, solar, and small hydro)
- Pricing strategies & principles
- Whether or not this quota be excluded from merit order despatch
- Connectivity conditions
- How to deal with variations between different licensing zones
- Trading of green power certificates between licensees

Grid access

The Electricity Act 2003 mandates SERCs to notify conditions of introducing open access to transmission/distribution facilities within one year. However, this may be done in a phased manner. Secondly, SERC will decide quantum of wheeling charges and surcharge. Surcharge being linked to cross-subsidisation, it may take quite a time before it is withdrawn totally (as abolishment of cross subsidies will take a long time). *Therefore, even if third party sales is allowed, in reality it may not be a viable option if wheeling charges and surcharge is kept at very high levels (e.g. 20% wheeling charges in Karnataka).* Thus, the Regulator need to decide principles for transmission pricing as well terms for renewables based power (whether to have preferential rates for surcharge and additional surcharge).

So far as connectivity is concerned, the issues before the Regulator pertain to:

- Adequacy of provisions in the grid code
- Metering arrangements
- Conditions for banking
- How to deal with intermittency
- How to deal with reactive power

Tariff and incentive policies

It is a known fact that wind power development is highly capital intensive. Another fact is that in view of uncertainties in the policy regime, wind power development is considered to be a risky venture by the investors as well as by the financial institutions/banks. However, since there is virtually no recurring fuel cost, in ultimate analysis, the cost of wind generated electricity is lower than that from any fossil fuel. Besides, there are a host of environmental and socio-economic benefits associated with the wind power, as discussed in the preceding chapters. Against this background, it is completely justified to award a preferential tariff to wind electricity. Indeed, the tariff could be higher for the initial few years till the loan is being repaid and thereafter it could be brought down. In essence, while fixing the tariff, it is important to dwell on two essential elements, (i) a price support mechanism that enables wind power producers to enter the market and make a reasonable profit (ii) a stable regulatory environment that encourages wind based IPPs.

An additional feature in such a scenario could be the introduction of the concept of 'competitive bidding'. In this scheme, the regulator can decide on a threshold price and the power-producers bid against each other, thereby reaching a minimum price. In a time-bound programme, the base price could be lowered every year. The pre-requisite for this to happen is to get cost-benchmarking done.

In addition, to maintain transparency, the SERC needs to be assisted in terms of detailed studies on the grid absorption capacity; intermittency issue of wind power; reactive power; scheduling of conventional power plants; fluctuations; time of day tariff; and hybridisation of available resources. Indeed, many of these aspects can be taken care of through *Integrated Resource Planning*.

Regarding the fiscal/financial incentives, they should be linked to the performance of the projects rather than the capital cost. Generation based financial incentives are the most effective means of promoting and sustaining grid connected wind power projects. As detailed out in the earlier sections, the major countries in the *European Communities and states in the United States of America have their programme structured around some sort of preferential tariff and/or production credit.*

In the forthcoming carbon trading regime (such as Clean development Mechanism or CDM), wind farms are likely to have some revenues accruing on account of sale of Certified Emission Reductions (CERs) by virtue of mitigating GHG emissions. Recently few SEBs have staked claims on a share of this revenue stream. However, it may be noted that the CDM initiative has been taken by the promoter only and he has borne the associated risks and transaction costs alone. Therefore, any 'tradable emission credits' or 'tradable renewable energy certificates' resulting from wind power projects getting any financial/fiscal benefits will be the property of the project developer.

Agreements with the utilities

The inconsistent stance taken by many State Electricity Boards vis-à-vis power purchase prices for wind power had dealt a heavy blow on the development of the sector. Essentially it is imperative to have long term Power Purchase Agreements (PPAs) if potential investors are to be motivated to invest in the wind sector. Only guaranteed revenues from the sale of power, over a long term, can generate confidence among investors and developers. The investors are wary of the frequent change in the renewable energy policies by the state government and indifferent attitude by the state utilities. Wherever the state government has in principle agreed to the MNES policy guidelines and state utilities agreed for the same in the PPAs, the wind sector development has grown multi folds.

The PPAs with the state utilities for the sale of wind power is a crucial instrument on which the success of the project depends. Therefore, PPAs should be made for long term, without any ambiguity. There should be clear provision of cost escalation, to ensure financial viability of the venture. Similarly, there should be in-built safeguards against revocation of PPA.

Institutional and state level aspects

Infrastructural facilitation and project clearance

For wind power projects that require land acquisition and other institutional/environmental clearances, there should be provisions that ensure that these are done automatically and expeditiously. Costly time overruns could be avoided if all the mandatory clearances are dealt with through a *Single Window System*.

Secondly, so far as infrastructural requirements are concerned, these should be accorded a priority over there. This issue acquires greater urgency because of the trends towards larger-sized turbines that require heavy load-bearing roads. This need, if effectively addressed, shall provide the impetus to implement wind power sector on a larger scale. For instance, Tamil Nadu facilitated the site development and power evacuation facilities and attracted a record investment in the wind sector to the tune of Rs.45000 million[1].

Grid strengthening and extension

Many a times full capacity utilization of wind power projects is not possible, not because any fault in the wind turbines, but on account of erratic and weak grids. Thus, there is a need to upgrade the power evacuation network. Keeping in view

[1] 1000 MW of installed wind power capacity at an average rate of Rs.45 million per MW.

of the fact that sites having high wind resource are often remote, there has to be a continuous process of enlargement of the grid network in tandem with identification of potential sites for wind installations.

Since the electricity generated at the large wind farms may not be consumed locally, it has to be fed in to high voltage grid system. In view of this, EHV grid master plans for the potential areas should be prepared.

State level wind power development plan

To move forward in a pre-determined manner, comprehensive plan of action for development of wind power should be developed for those states that are rich in resources. These plans can dovetail with portfolio standards to be determined by the SERCs.

Such plans should also include modalities for exporting bulk power from one state to the other. Entities such as Power Trading Corporation can be involved in designing such an endeavour.

Capacity building

For decision makers to appreciate the need for exploiting wind resources present in their states, it is vitally important to first of all equip them with complete knowledge and state-of-the art technological developments. Thus, suitable modules can be prepared for different categories of utility-engineers, SERC members, and other policy makers in the state government/concerned government agencies.

Technological and resource assessment related aspects

Wind resource assessment and micro-siting

Keeping in pace with the technological developments that are taking place in the field of wind energy in the country, there is an urgent need of the following:

- Enlarging the scope of wind resource assessment programme to include wind measurements at 50 m and 70 m heights.
- Development of high resolution wind atlas on GIS platform, incorporating demographic and infrastructural information.
- Extensive micro-siting around the priority sites.
- Enlarging human resources' base for carrying out micro-surveys utilising state-of-the-art tools.

Intermittency and reliability

In addition to cost, intermittency and reliability are two of the major barriers to wind power growth. These issues are intertwined. When wind power provides either too much or too less power, the reliability of the grid is affected. Since electricity cannot be stored economically, wind farms are not as able to dispatch power on demand as a conventional power plant can. Since utilities must supply power in close balance to demand, intermittency can limit the amount of capacity of highly intermittent technologies like wind that can be readily incorporated in the energy mix.

Short-term strategies to cope with wind intermittency on the grid include improving wind prediction, using variable speed turbines, electricity flow controls, and supplemental generation. The long-term solution, however, is "hybridising" the wind machines with a more dispatchable generator or adding energy storage. One way of doing this is to have hybrid or ***'conjunctive'*** wind farm and hydro power generation (e.g. Satara wind farm with Koyna hydro power station as explained in Box 8.2).

Box 8.1: Photovoltaic – Hydro power conjunctive use study
The concept is analysed by Lahmeyer International and Solar-Institut Jülich in UNEP/GEF sponsored report titled 'Photovoltaic – Hydro Power Conjunctive Use Study'. The objective of the study was to explore the possibility of installing MW-scale PV generation capacity connected to the grid and operated in conjunction with hydro plants, which are water-constrained. The underlying idea is to convert intermittent, non-dispatchable and thus low-value renewable power into higher-value one through an appropriate re-scheduling of the hydro units using the unused storage capacities as a virtual battery. The conjunctive use of renewable plants and hydro-electric facilities would thereby increase the amount of firm energy available (Lehmeyer, 2001).

It has been observed that during monsoon, when the hydro reservoirs are getting filled up, due to favourable wind conditions, the adjoining wind farm provides maximum output. Later on also, whenever wind resource is available, wind power could be utilized thereby conserving water as storage for (a) power generation during lean-wind period and (b) meeting irrigation needs of the region if the hydro project is for dual applications. Through this complementarity of wind and hydro resources, while intermittency aspect of wind power is taken care of, ultimately availability of electricity is prolonged.

In its order on tariff for wind power, MERC states that "the wind power and hydropower are complementary generating options. Generation from both sources of power could be varied at short notice. In case of windy periods, hydro generation could be reduced while it could be increased if wind generation is not enough. The MSEB system contains some hydro plants, which could be conveniently rescheduled" (MERC, 2003).

Box 8.2: InWEA study

The generation of wind energy during May to September is in the range of 75-80% of the total annual electricity generation of wind farm. The installed capacity of wind farm projects in Maharashtra by March 31, 2002 is around 396 MW. Expected generation during this season could be around 470 million units (million kWh) at 17% Plant Load Factor. It is therefore possible to conserve Koyna water that would be equivalent to 18% additional westward diversion (17.5 TMC).

Similarly, for example in Maharashtra, from April to September, when it is high wind season, capacity utilization of wind machines goes up to 50 to 60%. Thereafter, from October to April bagasse based co-generation plants start pumping power in to grid. Therefore, by integrating such renewable technologies, round-the-year electricity needs could be effectively catered.

Technology and production upgradation

For true commercialization of wind power, a continuous process for the product/technology upgradation is essential. Upgradation is required for a variety of reasons such as the performance enhancement, cost reduction, and reliability enhancement. Worldwide it is the technological innovations that are responsible of bringing down cost of electricity from wind, apart from enabling more and more wind power to be captured at any site. Besides, the scope could also include (i) making manufacturing processes more cost-effective and energy efficient and (ii) dematerialisation. Also, in view of enlarging share of wind power in the renewables portfolio, the indigenous manufacturing capacity will have to be scaled-up considerably.

To kick-start the process, a central pool or an *Upgradation Fund* could be created, which can be accessed by the turbine manufacturers based on their proposed plans and collaborations with the relevant entities, if any.

Renovation and modernisation

Renovation and modernisation of the old windfarms with outdated technology needs to be taken up in right earnest, similar to R&M programme for the conventional power plants. This would lead to optimal resource utilisation at prime sites besides providing additional generation capacity.

Financing aspects

Non-recourse financing

A wind power project is a project with high capital cost and low plant load factor, requiring larger amortization period for debt. Presently Balance sheet financing is used in India where the promoter's balance sheet is treated as indicator for repayments, exposure, and financing. This is followed mainly because the project cash flows are not secure (in absence of consistent policies and long-term PPAs). The main disadvantage of balance sheet financing is that since the repayment of loan is not linked with the project cash-flows, there is no incentive for the project proponent to enhance and maintain the performance level. Moreover, there is no incentive for bringing down cost/MW and cost/kWh.

As against this, in the Non-recourse financing, the project is primarily evaluated on the basis of its projected cash flows. Thus, in order to maintain and improve the cash flows, it becomes imperative for the project to not only perform adequately but strive for better generational levels. This, in turn, will lead to lower cost of electricity generation. Some of the requirements for promoting project financing are:

- Employing high-end technologies and O&M practices
- Better planning of wind farm project
- Front loaded tariff (considering repayment period of six years)
- Secure, long-term PPA, to lower the risk
- If there are incentives like 'Production Tax Credits' (prevalent in countries like US), available to wind power generation, the same would provide a degree of comfort to the financial institutions because of the fact that at least a part of revenue is assured in the event utilities default on the payments.

Mega wind farms

Under the ambit of the Electricity Act 2003, policies of wheeling the electricity and power purchase agreements are likely to undergo a major change. In such a scenario, mega wind farms can answer the situation and pave the way to mainstreaming wind energy. The advantage with such an approach is that the mega wind farms can be planned in a better fashion, thereby reducing the cost per MW. There would be an incentive to generate more as the profits are entirely based on energy generation. Besides, this would also help in shifting the focus from balance sheet financing to project financing.

Resource mobilization

The draft renewable energy policy envisages an addition of 5000 MW through wind by 2012. This translates in to an investment of the order of Rs.20,000 crores. This calls for augmentation of private investments through other sources and for that a multi-pronged approach has to be adopted. It includes funds requisition from not only domestic governments and agencies, but also from overseas institutions, organisations, and agencies. In order to increase the fund-size for wind beyond the normal budgetary support, it is essential that energy components of the budgets of other ministries should also be utilized for this purpose. The Accelerated Generation & Supply Programme of the Ministry of Power could be expanded to include wind power as well.

Apart from arranging finances through the government supported mechanisms, another avenue could be based on commercial banks, NBFCs (non-banking financial companies), and other financial institutions. So far as banks are concerned, renewable energy should be included in the priority sector lending norms. Similarly, it should be made mandatory for institutions like PFC, REC, IDBI, and NABARD to earmark a certain portion of their overall budgets for financing wind power, possibly at softer terms. NABARD has set up the RIDF (Rural Infrastructure Development Fund) for the development of rural infrastructure. As most of the wind farms are situated in remote and rural areas, the utilisation of RIDF may be extended to cover wind farm development. In addition, public sector companies, especially Navratnas and Mini-navratnas should be actively pursued to invest in wind power in a big way.

Another source of resource generation could be through tax free '*wind power bonds*'. IREDA, designated SNAs, and/or public sector undertakings should be allowed to float such bonds backed by Central government guarantee. Indeed, recently the Cabinet Committee on Security has approved (i) creation of the crude oil storage equivalent to 15-days requirement and (ii) resource mobilisation through bonds to be floated by the Indian Oil Corporation. These bonds would be backed by Central Government guarantee. Considering that wind power development contributes positively towards self-sufficiency (and hence, the energy security), there is no reason as to why such steps cannot be taken for propagation of wind power also.

Recommendations

On the basis of a variety of issues discussed in the previous section and the practices followed internationally, the following recommendations are made for accelerating the deployment of wind power in the country.

1. SERC need to play a decisive role in promoting RE based power projects in the state. This may be achieved by way of the following steps:
   - Devising a framework to assess RE potential in the respective state and develop strategy to realise the potential.
   - Introducing 'Renewable Portfolio Standards' specifying share for each (mature/near commercialisation) renewable energy technology.
   - Introducing 'Green Power Trading' among the states enabling export of wind power to those states that are poor in wind resource.
   - Introducing tariff policy that
     - takes in to consideration environmental and socio-economic benefits of wind power;
     - encourages private investors and developers to enter the wind power market;
     - ensures that the investors/developers make a reasonable profit, especially considering the risks involved;
     - induces financial institutions and banks in financing the wind power ventures in a big way
     - puts premium on the performance levels of the wind farm
     - Introducing a healthy competition among the market forces through competitive bidding process, thereby bringing down the cost in each successive year.
     - Formulating framework for providing wind power projects access to grid at nominal (or preferential) wheeling charges.
     - Exempting wind power from the Merit Order Dispatch mechanism, in view of its marginal share within overall generation scenario and national endeavour to promote clean energy sources.
2. MNES is currently preparing guidelines for tariff fixation for renewable projects that would form the basis for renewable resources based electricity under the National Tariff Policy. This process should be expedited so that all the SERCs have one uniform set of methodology for tariff-setting.
3. The resource rich states should take up development of infrastructure facilities required for increased investment in the wind sector.
4. Rather than having different approaches for conventional power and power from renewables, approach of 'Integrated Resource Planning' would be more

useful as it will have a holistic look at all the resources available in a region/state and then allocate the relative share for generation. This would also help in identifying the share of renewable based power that may have to be procured from elsewhere.

6. RBI needs to declare financing of wind power projects (including other renewable energy projects RE projects) under it's 'priority sector lending' programme.
7. Wind power development should be accorded the status of infrastructure project and all the benefits available for other infrastructure projects should be made available to wind power projects also.
8. In line with 100% custom duty exemption granted to infrastructure equipment by the Union Finance Minister on January 8, 2004, custom duty on raw material, components, and equipment for wind power projects should also be abolished completely.
9. For resource mobilisation, IREDA, designated SNAs, and/or public sector undertakings should be allowed to float 'wind power bonds' backed by Central government guarantee.
10. The government should explore the possibility of attracting FDI (Foreign Direct Investment) in the wind sector. To facilitate this (i) the policies would have to be made more conducive and long-term in nature and (ii) infrastructural development would have to be undertaken on priority enabling establishment of mega wind farms.
11. In order to attract Greenfield projects and to ensure higher performance levels, non-recourse financing should be adopted as against the current practice of balance sheet financing.
12. To facilitate (i) rapid product-upgradation, (ii) up-scaling of manufacturing facilities, and (iii) infrastructure development, an *Upgradation & Infrastructure Development Fund* may be created through imposition of a nominal (i) surcharge on sales tax on coal and petroleum products and (ii) duty on consumption of conventional electricity.
13. Looking at potential of generation of extra revenues through sale of CERs under CDM, a special purpose vehicle (SPV) is suggested to be set-up for developing the wind farm projects under CDM. The benefits arising out of such CDM projects may be distributed by the SPV among the project promoters (and wind turbine manufacturer/developer who provide annual operation and maintenance) after adjusting the expenses incurred for operating the wind farm under CDM.

14. Based on the recommendations of the 'Extractive Industries Review' commissioned by the World Bank Group (WBG) (see Box 8.3), concerted efforts should be mounted to pursue WBG to (i) stop investing in coal sector and (ii) support transition to greater renewable energy utilisation.

Box 8.3: Extractive Industries Review by the World Bank Group

The World Bank Group (WBG) in July 2001 launched the 'Extractive Industries Review' to discuss its future role in the extractive industries (the oil, gas and mining sectors) with concerned stakeholders. The extraction of oil, gas, and coal here is primarily meant for electricity generation. Consultations with the stakeholders in this regard led to a broad consensus (World Bank Group, 2003):

- The climate change is important and that the extractive industries are large contributors to the problem.
- Several regional workshops recommended that the WBG assume a greater role in improving the policy environment for tackling climate change and should be working (a) to accurately reflect the costs of climate change, through internalizing external costs relating to emissions and (b) to remove perverse subsidies for fossil fuels.
- The study concluded that civil society wanted the WBG to support a transition to renewable energy through:

– Encouraging the phasing out of subsidies for fossil fuels, to be replaced by an energy tax
– Subsidies for renewables
– Increased investment in renewable energy projects
– Promotion of renewable technologies.
– The WBG should also withdraw from investment in coal-related projects.

Plan of action

The mainstreaming of wind power in country's power sector requires some concrete steps to be initiated in a time bound and on priority basis. Essentially, these action-points are distilled out of detailed discussion in the preceding sections and reiteration of some of the recommendations.

The plan of action has been prepared with an express view of increasing the installation of the wind turbines multifold, thereby bringing in the economy of scale and better technology i.e. lower cost per kWh of electricity generated. This is how a nascent wind power will become competitive to the conventional power generating technologies -the technologies that have been nurtured along many decades through huge investment of resources, at an enormous environmental cost.

- ***Technical assistance for SERC***

Detailed studies on the matters such as grid absorption capacity; intermittency issue of wind power; reactive power; scheduling of conventional power plants; fluctuations; time of day tariff; and hybridisation of available resources should be commissioned by the MNES and state nodal agencies. These studies will provide analytical insights in to many contentious issues and equip the SERC with the relevant and precise information.

- ***Renewable Portfolio Standards (RPS)***

On the basis of detailed assessment of renewable energy resources in the state and realizable potential against a set of well-defined criteria, the SERC should come out with RPS, outlining share of each mature/near commercialization renewable energy technology such as wind, biomass, and small hydro at an appropriate level (state/district/region/circle).

This should also include framework for trading of green power/certificates between those with surplus wind power and those in deficit. The Power Trading Corporation had already expressed its desire for inter-state green power trading. A mechanism therefore, should evolve to facilitate such transactions.

However, the transaction cost involved in certification, trading, and counter trading should not be loaded on wind power cost but should be met through a centralized fund.

- ***Preferential tariff***

Considering the fact that cost of externalities is not included in the electricity tariff in the country, a preferential tariff needs to be awarded to the wind power in view of its environmental and societal benefits. The higher tariff is also justified in view of the perceived risks associated with financing of new technologies like wind energy in the country. Thus, the tariff should be firm and long-term so that it sends positive signals to the investors and developers. Keeping 'certainty of the tariff' as paramount guiding principle will mean that tariff may not be linked with the merit order despatch, which is very dynamic in nature. The incremental benefit could be in the range of Rs.0.30 - Rs.0.60/kWh. The tariff could be set in such a fashion that it is higher during the initial years when loan has to be repaid. Thereafter, it can be reduced in phased manner.

Box 8.4: Cess – The precedents

Levying cess or surcharge on petroleum products to generate a pool of funds, to finance a specific task is a usual practice. Some examples:

- Haryana and Punjab levied a *road cess* of Rs.1000/kiloliters on petrol and diesel in year 2000. Punjab had an additional cess of 1% on petroleum products as *infrastructural cess*.
- In the union budget for 2002-03, an additional cess of 50 paise/liter was imposed on petrol and diesel to raise Rs.2,600 crore for the *road development*.
- In Bangalore, a cess is levied on petrol and diesel to raise *funds for mass rapid transit system*.
- It is proposed to impose an additional cess on petrol and diesel (to the tune of 50 paise/liter) to meet *capital cost of the Strategic oil Reserve*.

A process of competitiveness has to be brought in to picture so that (i) the schemes are not open-ended; (ii) there are incentives for bringing down the cost of wind power; and (iii) there is a clear signal for importance being attached to the performance of the wind farm. Towards this, competitive bidding should be introduced to bring about a steady convergence between the price paid for wind power in successive years and the market price of the conventional electricity.

- ***The Climate Change Levy or Carbon Tax***

The Climate Change Levy or Carbon Tax is levied on supplies of electricity, fossil fuels, and any other commodities, which can be used as a fuel and which add to the GHG emissions. In India also, such kind of tax or cess should be introduced. It has been estimated that in a state like Maharashtra, a cess of mere 1 paise would meet preferential tariff of Rs.1.00 for the existing level of generation from wind energy. A special purpose fund should be created out of these proceeds. This fund can be used for (i) meeting incremental portion of tariff for wind power, (ii) technology upgradation and up-scaling of manufacturing facilities, and (iii) easy financing of infrastructural requirements.

- ***Wind power bonds***

Since massive investments are required if set target of 5000 MW by 2012 has to be achieved, among variety of avenues being pursued for resource mobilization, one way could be to issue tax-free Wind Power Bonds by designated institution with full guarantee from the Government of India.

- ***Grid mapping and strengthening***

In order to facilitate large wind farms, EHV grid master plans for the potential areas should be prepared. Enlargement and strengthening of the grid network must be undertaken by the concerned authority in tandem with identification of potential sites for wind installations.

- ***Fund for up-gradation and infrastructural development***

To partially finance the costs of the technology up-gradation as well as enhancement of manufacturing facilities at easy terms and conditions, a dedicated fund should be created. This fund would be accessible to the wind turbine manufacturers.

- ***Sensitization of the decision/policy makers***

Looking at the need expressed at various fora by the policy makers, regulators, and the utility managers about getting to know the nuances of wind power development and its characteristics, sensitization workshops should be organized in all those states where there is exploitable wind potential.

- ***Awareness creation***

The awareness creation in case of wind power is a multi-level activity. At very basic level it involves making public aware about many facets and benefits of wind power. Herein, targeting citizens of tomorrow i.e. school-children could pay rich dividends in long run. Similarly, it is vitally important to make law makers – parliamentarians and legislators- realize the advantages of exploiting wind energy. On another level, the potential investors and/or developers need to be made aware of option of wind powered that may be availed by them. To start with, big private and public sector entities, especially those who are already dealing in some form of energy (whether electricity, oil, or gas) may be targeted. At yet another level are financiers and here the aim must be to change their risk perceptions about wind power. At global level, making appropriate stake holders in countries (that are rich in wind resources) aware of capabilities of Indian wind industry can significantly increase the market size.

- ***Media strategy***

Many of the aforementioned activities involve careful media planning and a variety of information tools - such as regular publications, news releases, briefing documents, statistics and market data, and presentations could be used. On print side a quality publication on wind energy, which presents latest in wind energy with some well researched articles in easy to follow language (e.g. *Wind Generation* monthly of the European Wind Energy Association or *Wind Energy Weekly* of American Wind Energy Association), could very well fill the long-felt gap. Besides, at critical junctures, comprehensive documents like *Wind Force 12* could be brought out and widely circulated. Indeed, for extending the reach of such efforts, internet should be used extensively. Moreover, dedicated supplements on wind power could be published in leading business, trade, and technical magazines/papers such as Business Today, Business India, Power Line, and the Economic Times. Organizing regular press conferences could be another way of putting forward wind sector's point of view with maximum outreach. Essentially, the aim should be to focus on strategic *mainstream* groups rather than the renewable energy community.

Conclusion

Demand for electricity in India is increasing exponentially with the growing population and agro-industrial activities. Conventional sources of power supply have been unable to cope up with this rising demand. On the other hand there are renewable technologies like wind that have proved that they can successfully complement conventional power in meeting the electricity demand, without having to degrade the environment or human health, without resorting to fuel imports, and without compromising on country's energy security. Moreover, on the global front also, although India has no commitment for limiting its GHG emissions *today*, the time is not very far off when it will have to give a commitment for reducing its GHG emission levels. And to prepare for that eventuality, without having to sacrifice its developmental goals, *investment in wind power now* provides a viable and attractive option.

Under the circumstances, it is necessary to bring more and more of wind power in to the system. The biggest impediment faced by the wind power pertains to its unfavourable competitiveness with the conventional power generation technologies and the preferential tariff that it seeks. However, if cost of conventional power were to include the costs of damages inflicted on the environment, wind power too would become competitive. Besides, the cost of conventional electricity which one sees today is outcome of so many years of continued development and public support – both on technology front as well as on fuel supply front. Contrast this with wind power, which only recently came in to being, largely through private initiatives and it becomes obvious that playing field is not leveled. So, the preferential tariff being asked for is nothing but a mechanism that is recognition of positive aspects of wind power, a token of encouragement, and a way to create an atmosphere that is more conducive to investment in wind power sector. In developed countries also (viz. Germany, Denmark, UK, and USA) wind power is being propagated aggressively through supportive policies and legislations like RPS, feed-in-law, production credits, and climate change levy etc. And the examples of these countries show that it is possible to bring down the cost of wind power through technological advances and economy of scale, direct outcomes of increased market volumes.

So there is no reason as to why wind power in India being not propagated that aggressively or similar incentives are not offered in India as well. What is required, however, is to develop a frame work (i) that ensures total transparency, (ii) which is not open-ended, and (iii) which encourages competitiveness so as to bring down the costs in a specified time-frame. As the international experiences establish, it is not sufficient to specify the targets unless such targets are backed by an affirmative and stable policy framework and a political will to achieve them.

The government has recently taken a decision to invest Rs.1600 crore in creating the infrastructure for the Strategic Petroleum Reserve (plus additional investment of Rs.4,500–5,000 crore for the crude) for hedging against physical disruption of supplies. To move towards a secure energy future, the same kind of importance and investments need to be placed on diversifying sources of energy supply, wind energy being foremost of them.

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