EWEA
WIND IS POWER

WIND POWER **ECONOMICS**

WIND ENERGY COSTS - INVESTMENT FACTORS

"Developing Europe's potential for using renewable energy will contribute to security of energy supply, reduce fuel imports and dependency, reduce greenhouse gas emissions, improve environmental protection, decouple economic growth from resource use, create jobs, and consolidate efforts towards a knowledge-based society"

- The share of renewable energy in the EU' Communication from the Commission to the Council and the European Parliament Brussels 26.5.2004

Fig. 1: The Costs of Wind Power as a Function of Wind Speed (Number of Full Load Hours) and Discount Rate

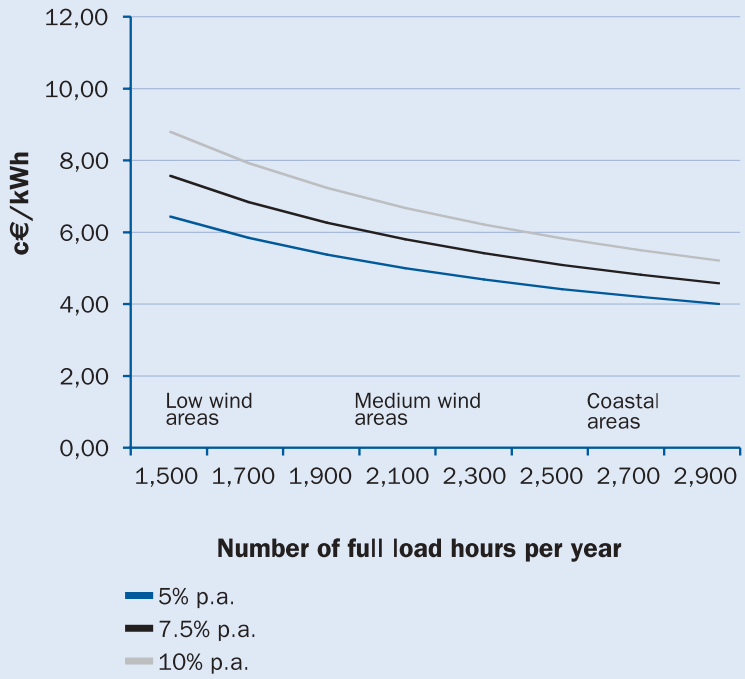
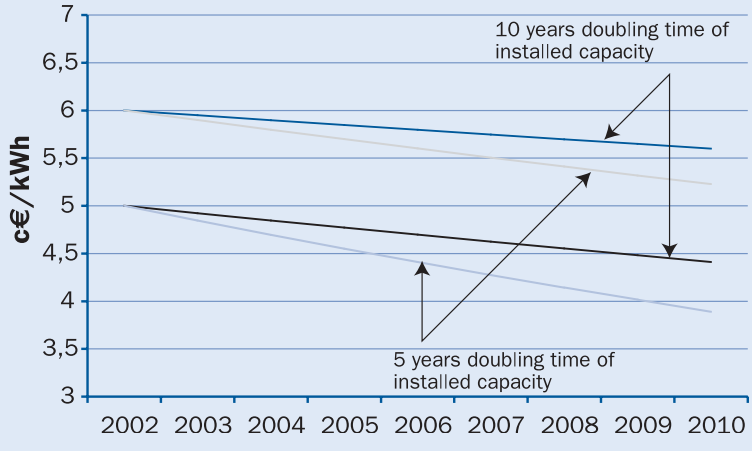


Fig. 2: Using Experience Curves to Illustrate the Future Development of Wind Turbine Economics until 2010



Costs illustrated for a turbine installed in a medium wind regime with a present day production cost of 5 to 6 c€/kWh.

"More installations exploiting wind power can help to plug the growing gap in European electricity supply and at the same time dovetail with the Lisbon Strategy providing the EU with high-tech world-class technology"

–Introduction to Wind Energy The Facts, DGTREN, European Commission, May 2004

For a new machine, O&M costs might have an average share over the lifetime of the turbine of about 20-25% of total levellised cost per kWh produced.

The main factors governing wind power economics are:

- Investment costs, including wind turbines, foundations and grid connection
- Operation and maintenance costs
- Electricity production/average wind speed
- Turbine lifetime
- Discount rate

Of these, the most important parameters are the wind turbines' electricity production and their investment costs. As electricity production is highly dependent on wind conditions, selecting the right site is critical to achieving economic viability.

Three major trends have dominated the economics of grid connected wind turbines in recent years:

• The turbines have grown larger and taller.
The average capacity of turbines installed in Germany and Denmark increased from approximately 200 kW in 1990 to almost 1.5 MW during 2002. Turbines in the 1.5 to 2.5 MW range have more than doubled their share of the global market - from 16.9% in 2001 to 35.3% in 2003.

• Turbine efficiency has increased.
A mixture of taller turbines, improved components and better siting has resulted in an overall efficiency increase of 2 - 3% annually over the last 15 years.

• Investment costs have decreased.
The average cost per kW of installed wind power capacity currently varies from 900 €/kW to 1,150 €/kW. The turbine itself comprises about 80% of this total cost. The remainder is contributed by three main items - foundations, electrical installation, grid connection – and then other costs are land, road construction, consultancy and financing costs.

Reduction of costs by swept rotor area (kWh/m2) have declined by 30%, or around 3% per year from 1989-2001.

The other principal cost element in generating electricity from wind power is operation and maintenance (O&M). Obviously, there are no fuel costs. O&M costs include regular maintenance, repairs, insurance, spare parts and administration. Because not many machines are more than 20 years old, data is not always available, or comparable. For a new machine, O&M costs might have an average share over the lifetime of the turbine of about 20-25% of total levellised cost per kWh produced.

Manufacturers are aiming to shrink these costs significantly through development of new turbine designs requiring fewer regular service visits and therefore reduced downtime. The trend towards larger wind turbines also reduces O&M costs per kWh produced.

The cost of electricity generated by wind power (2003 calculations) ranges from approximately 4 - 5 €cents/kWh at sites with very good wind speeds to 6 - 8 €cents/kWh at sites with low wind speeds.

Generating cost of wind power

When all these elements are considered together, the cost of electricity generated by wind power (2003 calculations) ranges from approximately 4 - 5 €cents/kWh at sites with very good wind speeds to 6 - 8 €cents/kWh at sites with low wind speeds. A good wind speed site is defined as a coastal location with an average wind speed of 6.9 metres per second (m/s) at a height of 50 m above ground level. Medium and low wind speed sites have average wind speeds of 6.3 and 5.4 m/s respectively. (fig. 2)

This cost calculation is based on the following assumptions:

- A new medium-sized wind turbine of 850 - 1,500 kW capacity
- Investment costs ranging from 900 to 1,100 €/kW
- O&M costs averaging 1.2 €cents/kWh over a life-time of 20 years
- A discount rate of 7.5% per annum

The cost of capital, reflected in the discount or interest rate, is a particularly important factor. Like nuclear energy and hydropower, wind power is a capital intensive technology, with about 75% of total costs required as capital up front. For a natural gas plant, by comparison, the share is typically 40 - 60%. The economic performance of a wind power project is therefore highly dependent on the level of interest rates.

The trend towards larger wind turbines also reduces O&M costs per kWh produced.

When conventional power is substituted by wind power, the avoided cost depends on the degree to which wind power substitutes each of three components – fuel cost, O&M costs and capital

Future development of costs

Power production costs of wind-generated electricity have fallen steadily as the technology has developed. The average cost for a coastal turbine has decreased from approximately 8.8 €cents/kWh (for a 95 kW turbine installed in the mid-1980s) to 4.1 €cents/kWh for a recent 1,000 kW machine A cost reduction of over 50% in the last 15 years has occurred for electricity from wind power.

As a rule of thumb, manufacturers expect the production cost of wind power to decline 3-5% for each new generation of wind turbines they add to their product portfolio.

Future cost reductions are a function of how the market grows. Looking forward, using analysis based on the "experience curve" method, it is anticipated that power production costs will continue to decrease. With a doubling of total installed capacity, the cost of production per kWh from new wind turbines will fall by between 9% and 17%.

Presently, the European market has doubled every three years. If, as Fig. 2 shows, the market takes 5, not 10 years to double, the cost would be 3.9-5.2 €cents/kWh instead of 4.4-5.6 €cents/ kWh. The EWEA target of 75GW installed in the EU by 2010 requires an annual growth rate of 16%, a doubling over 4.8 years.

A cost reduction of over 50% in the last 15 years has occurred for electricity from wind power.

External costs and subsidies

These calculations take no account of the environmental benefits to society of wind power or the "external costs" (the environmental and social costs not reflected in the market price) of conventional electricity generation.

A Commission-funded project - ExternE – estimates that the cost of producing electricity from coal or oil would double and the cost of electricity production from gas would increase by 30 %, if external costs, in the form of damage to the environment and health, were taken into account. The study further estimates that these costs amount to 1-2 % of EU GDP or between €85 billion and €170 billion, not including the cost of global warming and climate change.

If those environmental costs were levied on electricity generation according to their impact, many renewables, including wind power, would not need any support. If, at the same time, direct and indirect subsidies to fossil fuels and nuclear power were removed, the need to support renewable electricity generation would seriously diminish or cease to exist.

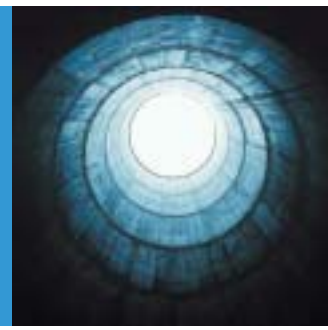
The total avoided external costs through the use of wind power amounted to nearly €1.8 billion in 2000. By 2020, taking EWEA projections for wind energy to be generating 425 TWh/a, the level of avoided external costs would have risen to an annual €25 billion.

As a rule of thumb, manufacturers expect the production cost of wind power to decline 3-5% for each new generation of wind turbines they add to their product portfolio

" Climate change is not just an environmental, but an economic threat. Swiss Re, the world's largest re-insurer, has forecast that the insurance costs from rising sea levels, more severe droughts and other results from climate change will total £265 billion per year by 2010"

UK Foreign Secretary, 28 October 2004, Launch of UK International Energy Strategy

With a doubling of total installed capacity, the cost of production per kWh from new wind turbines will fall by between 9% and 17%.



Avoided conventional energy costs

When conventional power is substituted by wind power, the avoided cost depends on the degree to which wind power substitutes each of three components – fuel cost, O&M costs and capital. It is generally accepted that implementing wind power avoids the full fuel cost and a considerable portion of the O&M costs of a displaced conventional power plant. The level of avoided capital costs depends on the extent to which wind power capacity can displace investments in new conventional power plants and is thus directly tied to the capacity credit of wind plant – the percentage of conventional capacity that a wind turbine can replace. 25% is considered to be a reasonable capacity credit for wind power when the volume of wind electricity in the grid is less than 10% of total electricity production.

The conventional power costs avoidable through use of wind electricity will vary from country to country. Fig. 4 shows the range, assuming that all conventional fuel and O&M costs are avoided and that wind power is assigned a capacity credit of 25%. This shows that in Spain, for example, for each kWh of electricity generated by wind power which displaces a kWh of gas power, approximately 5.2 €cents/kWh are saved in gas fuel, O&M costs and displaced capital costs. Therefore, if a wind turbine could be installed in Spain at an average cost below 5.2 €cents/kWh, this would make wind power economically competitive in comparison with new gas-fired plant.

The competitiveness of wind will depend on short term prediction, and specific conditions for budding into short-term forward and spot markets at the power exchange.

These calculations show that although wind power might be more expensive than conventional power today, it may nevertheless take up a significant share in investors' power plant portfolios as a hedge against volatile fossil fuel prices. The constancy of wind power costs justifies a relatively higher cost per kWh compared to the more risky future costs of conventional power due to volatile oil, coal and gas prices.

The 2002 Europe-wide survey reported that renewable energy was the most popular area for further energy-related research. 37% of respondents chose more renewable research compared with 7% for gas, 5% for nuclear fission and 3% for coal.

Wind energy prices

The price paid for electricity generated by wind turbines varies from country to country, but is often based on payment of a premium above the market price aimed at reflecting the environmental benefits of the technology. A full explanation of these pricing mechanisms is given in the Fact Sheet “Wind Power Market Development”.

"In order to achieve a 10 –20% part of the world-wide energy consumption provided by wind, major steps have to be taken...it is for this objective that there is a need for long-term R&D"

International Energy Agency

Research and development

Continuing research and development work is needed if wind power is to continue to see reductions in its generation costs. Over the past two decades, R&D programmes have been a pre-condition for the successful development of the wind power industry. In its 2001 report "Long Term Research and Development Needs for Wind Energy, 2000 to 2020", the International Energy Agency asserted that: *"Thanks in large part to successful R&D, the wind energy market is in a state of rapid development. R&D has been an essential activity in achieving cost and performance improvements in wind power generation.* [...]*".*

EU-funded research and development programmes such as those within the Fifth Framework Programme have given considerable impetus to the wind power industry over the last 15 years. The results of such programmes include the development of large MW-scale turbines, the first European wind atlas and support for demonstration projects such as the first offshore wind farm.

A principle objective of wind industry R&D is to meet the levels of wind penetration described in the EWEA scenario "Wind Force 12 – A Blueprint to Achieve 12% of the World's Electricity by 2020". To achieve this goal, the industry needs to:

- Continue making cost reductions
- Enable increased penetration of wind power
- Minimise environmental and social impacts

"In order to achieve a 10 –20% part of the world-wide energy consumption provided by wind, major steps have to be taken [...] *it is for this objective that there is a need for long-term R&D".*
International Energy Agency

The 2002 Europe-wide survey "Energy, Issues, Options and Technologies", which interviewed 16,000 people across all 15 EU member states, reported that renewable energy was the most popular area for further energy-related research. 37% of respondents chose more renewable research compared with 7% for gas, 5% for nuclear fission and 3% for coal.

Reduction of costs by swept rotor area (kWh/m²) have declined by 30%, or around 3% per year from 1989-2001.

Fig. 3: Total Costs of Wind Power (c€/kWh, Constant 2001 Prices) by Turbine Size

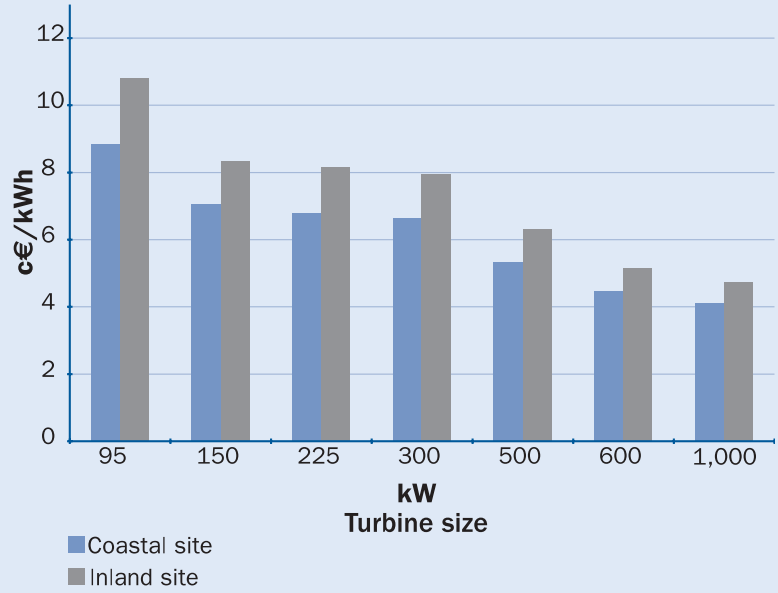
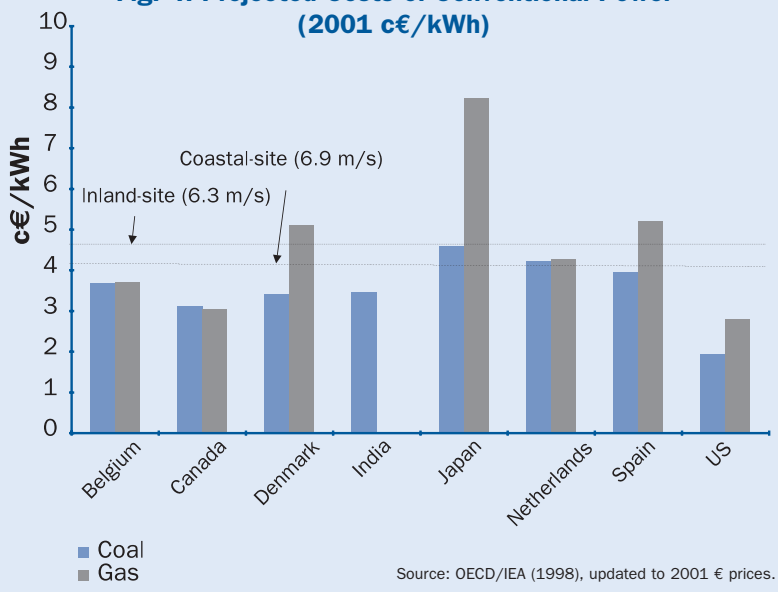


Fig. 4: Projected Costs of Conventional Power (2001 c€/kWh)



Source: OECD/IEA (1998), updated to 2001 € prices.

About EWEA

EWEA is the voice of the wind industry - promoting the best interest of the sector in Europe and worldwide.

EWEA members include manufacturers covering 98% of the global wind power market, as well as component suppliers, research institutes, national wind and renewables associations, developers, electricity providers, finance and insurance companies and consultants. The combined strength of more than 200 members from over 40 countries makes EWEA the world's largest renewable energy association.

Located in Brussels, close to key EU institutions and players, the EWEA Secretariat co-ordinate international policy, communications, research and analysis. The first stop for external enquiries about wind power from around the world, EWEA manages European programmes, hosts events and supports the needs of its members.

For further information and details of membership:
www.ewea.org

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More detailed information than this fact sheet can be found in the full version of Wind Energy the Facts