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WIND POWER Facts

FREQUENTLY ASKED QUESTIONS ABOUT WIND ENERGY:

Can a wind turbine ever recover the energy spent manufacturing it?

Are land resources large enough to provide space for wind turbines?

Can wind energy ever be more than a marginal source of electricity?

Are wind turbines just old windmills converted to a modern design?

Is wind energy cheap or expensive?

What are the most economic applications?

Can wind turbines be used economically in inland areas, or located on the sea?

Is wind energy safe?

Is it reliable?

Can wind turbines fit into the landscape?

What are the siting problems?

Are wind turbines noisy?

Does wind energy affect birds and wildlife?

How can varying output from wind energy be used in the electrical grid?

Will wind energy work on a small scale?

Can wind energy be used in developing countries?

Does wind energy create jobs?

What is its popularity in countries which have many wind turbines?

What is the wind energy market like?

Why are Danish wind turbines well known around the world?

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WHY WIND ENERGY?

Wind energy is one of the most promising energy technologies for today, for the 21st century, and beyond.

Here are some short answers to frequently asked questions about wind energy:

Wind Energy is Clean

Wind turbines emit no pollutants.

A modern 600 kW wind turbine in an average location will annually displace 1,200 tonnes of carbon dioxide from other electricity sources, i.e. usually coal fired power stations.

The energy produced by a wind turbine throughout its 20 year lifetime (in an average location) is eighty times larger than the amount of energy used to build, maintain, operate, dismantle, and scrapping it again.

In other words, on average it takes only two to three months for a wind turbine to recover all the energy required to build and operate it.

Wind Energy is Abundant

The energy in the wind is a truly sustainable resource. Wind will not run out.

Already, wind energy is covering 7 per cent of Danish electricity consumption, a figure which will increase to at least 10 per cent by 2005.

The wind resources above the shallow waters in the seas around Europe could theoretically provide all of Europe's electricity supplies several times over.

Wind Energy Makes a Difference

Wind Turbines have grown dramatically in size and power output.

A typical Danish wind turbine of 1980 vintage had a 26 kW generator and a rotor diameter of 10.5 metres.

A modern wind turbine has a rotor diameter of 43 metres and a 600 kW generator. It will produce between 1 and 2 million kilowatt hours in a year.

This is equivalent to the annual electricity consumption of 300 to 500 European households.

The latest generation of wind turbines has a 1,000-1,500 kW generator and a 50-64 metre rotor diameter.

Europe's largest wind park in Carno, Wales produces the equivalent of the electricity consumption of 20,000 homes.

In Europe more than 3,000 megawatts of wind power is online as of 1997, covering the average domestic electricity consumption of five million people.

DANISH WIND TURBINE MANUFACTURERS ASSOCIATION

Wind Energy is an Advancing Technology

Technological advances in aerodynamics, structural dynamics and meteorology have contributed to a 5 per cent annual increase in the energy yield per square metre turbine rotor area (as recorded in Denmark between 1980 and 1995).

In Denmark alone, more than 60 researchers are permanently employed by the Risø National Research Laboratory, which is rapidly advancing the knowledge of global wind conditions and wind turbine technology.

The weight of Danish wind turbines per kW installed power has halved in 5 years, the sound level has halved in 3 years, and the annual energy output per turbine has increased 100-fold in 15 years.

R&D studies in Europe and the US point to a further fall in energy costs from wind of some 10 to 20 per cent around 2005.

Wind Energy is Inexpensive

Wind energy has become the least expensive renewable energy technology in existence.

Today, according to the Danish electrical power companies, the energy cost per kilowatt-hour of electricity from wind is the same as for new coal-fired power stations fitted with smoke scrubbing equipment, i.e. around 0.05 USD per kWh for an average European site.

Wind Energy is Safe

Wind energy leaves no harmful emissions or residue in the environment.

Wind Energy has a proven safety record. Fatal accidents in the wind industry have been related to construction and maintenance work only.

Wind Energy is Reliable

High quality modern wind turbines have an *availability factor* above 98 per cent, i.e. the turbines are on average operational and ready to run during some 99 per cent of the hours of the year. This availablity factor is beyond any other electricity generating technology.

Modern wind turbines only require a maintenance check every six months.

Wind Energy Uses Land Resources Sparingly

Wind turbines and access roads occupy less than one per cent of the area in a typical wind park. The remaining 99 per cent of the land can be used for farming or grazing, as usual.

Whereas a wind turbine uses 36 square metres, or 0.0036 hectares to produce between 1.2 and 1.8 million kilowatt hours per year, a typical biofuel plant would require 154 hectares of willow forest to produce 1.3 million kilowatt hours per year. Solar cells would require an area of 1.4 hectares to produce the same amount of electricity.

Wind Energy Can and Must Respect Landscape Values

Wind turbines obviously have to be highly visible, since they must be located in windy, open terrain to be economic.

Better design, careful choice of paint colours – and careful visualisation studies before siting is decided – can improve the visual impact of wind farms dramatically.

Like other man-made structures, well designed wind turbines and wind parks can give interesting perspectives and furnish the landscape with new architectural values.

Wind turbines have been a feature of the cultural landscape of Europe for more than 800 years.

Wind Projects Minimize Ecological Impact

Manufacturers and wind farm developers have by now substantial experience in minimising the ecological impact of construction work in sensitive areas such as moors, or when building wind farms in offshore locations.

Restoring the surrounding landscape to its original state after construction has become a routine task for developers.

After the useful life of a wind farm has elapsed, foundations can be reused or removed completely. The scrap value of a wind turbine can normally cover the costs of restoring its site to its initial state.

Wind Turbines Whisper Quietly, Now

Noise is no longer a major problem with advanced wind turbine technology.

Modern turbines have far better aerodynamic and mechanical engineering than designs from 10 or 15 years ago, and two-speed generators with slow moving rotors at low wind speeds have done away with the problem of noise at low wind speeds.

At distances above 200 metres, the swishing sound of rotor blades is usually masked completely by wind noise in the leaves of trees or shrubs.

The perception of noise is interestingly an extremely sub-

jective phenomenon, and it depends to a large extent on the attitude of the listener:

A Danish scientific survey shows that people who find the sight of wind turbines unpleasant, also perceive that turbines are noisy, regardless of the actual sound level.

Wind Turbines Coexist Peacefully with Wildlife

Deer and cattle habitually graze under wind turbines, and sheep seek shelter around them.

While birds tend to collide with man-made structures such as electrical power lines, masts, or buildings, they are very rarely affected directly by wind turbines.

A recent Danish study suggests that the impact of overhead power lines leading electricity away from wind farms have far greater impact on bird mortality than the wind farms themselves.

Falcons are in fact nesting and breeding in cages attached to two Danish wind turbines!

Studies from the Netherlands, Denmark, and the US show that the total impact on birds from wind farms is negligible compared to the impact from road traffic.

Wind Turbines Require Careful Siting

The energy content of the wind varies with the cube, (i.e. the third power) of the wind speed. *Twice* as much wind yields *eight* times as much energy.

Manufacturers and wind farm developers therefore take extreme care in siting wind turbines in as windy areas as possible.

The *roughness* of the terrain, i.e. the terrain surface, its contours, and even the presence of buildings, trees, plants and bushes affect the local wind speed.

Very rough terrain or nearby large obstacles may create *turbulence* which may decrease energy production and increase tear and wear on the turbines.

Calculating the annual energy production from a wind turbine is quite a complex task: It requires detailed maps of the area (up to three kilometres in the prevailing wind directions), and accurate meteorological wind measurements for at least a one year period.

Qualified advice from experienced manufacturers or consulting firms is therefore essential for the economic success of a wind project.

Wind Turbines can be Quite Economic in Inland Areas

Although wind conditions near seashores tend to be ideal for wind projects, it is indeed possible to find highly economic inland areas for wind turbines.

As the wind passes over a hill, or through a mountain pass, it becomes compressed and speeds up significantly.

Rounded hilltops with a wide view in the prevailing wind directions are therefore ideal as wind turbine sites.

Tall wind turbine towers is a way of increasing the energy yield of a wind turbine, since wind speed usually increases significantly with height.

In low wind areas, manufacturers may be able to supply special wind turbine versions with large rotors compared to the size of the electrical generator.

Such machines will reach peak production at relatively low wind speeds, although they will waste some of the energy potential of high winds. Manufacturers are increasingly optimizing their machines to local wind conditions worldwide.

Wind Energy Fits Well into the Electrical Grid

The major drawback of wind power is variability.

In large electrical grids, however, consumers' demand also varies, and electricity generating companies have to keep spare capacity running idle in case a major generating unit breaks down.

If a power company can handle varying consumer demand, it can technically also handle the »negative consumption« from wind turbines.

The more wind turbines on the grid, the more short term fluctuations from one turbine will cancel out the fluctuations from another.

In the Western part of Denmark, more than 25 per cent of the electricity supply today comes from wind during windy winter nights.

Wind Energy is a Scaleable Technology

Wind energy can be used in all sorts of applications – from small battery chargers in lighthouses or remote dwellings to industrial scale turbines capable of supplying the equivalent of the electricity consumption of one thousand families.

Other interesting and highly economic applications include wind energy used in combination with diesel powered backup generators in several small, isolated electrical grids throughout the world.

Desalination plants in island communities in the Atlantic and the Mediterranean Sea is another recent application.

Wind Energy is an Ideal Developing Country Technology

Although wind turbine design has become a high tech industry, wind turbines can easily be installed in developing countries, and serviced and maintained locally.

Turbine manufacturers provide training courses for personnel.

Wind turbines require no subsequent expensive provision of fuel, a major stumbling block for several other electricity generating technologies in developing areas.

India has become one of the large wind energy nations of the world with substantial local manufacturing.

P. R. China is presently taking the Lead in East Asia.

Wind Energy Provides Jobs

The wind industry today provides more than 30,000 jobs worldwide.

In Denmark alone, more than 9,000 people make a living from wind energy, designing and manufacturing wind turbines, components, or rendering consultancy and engineering services – an employment which is larger than e.g. the fishing industry.

The Danish production of wind turbines demands another 4,500 jobs in other countries which erect wind turbines or manufacture turbine components.

Wind Energy is Popular

Opinion polls in several European countries, Denmark, Germany, Holland, and the UK, show that more than 70 per cent of the population is in favour of using more wind energy in the electricity supply.

People who live near wind turbines are on average even more favourable towards wind energy, with a score of more than 80 per cent in favour of wind energy.

In Denmark, more than 100,000 families own shares in one of the 4,000 modern wind turbines scattered throughout the country.

Wind Energy is a Rapidly Growing Market

Since 1993, growth rates in the wind turbine market have been around 50 per cent per annum.

Currently there are some 40 wind turbine manufacturers worldwide.

The wind turbine industry is now a 1.5 billion USD industry with an extremely bright future, if environmentally friendly energy policies gain ground internationally.

The Danish Wind Turbine Industry is the World's Largest

In 1996 Danish wind turbine companies supplied more than 720 megawatts of new generating capacity, equivalent to a medium-sized nuclear power station. Danish manufacturers in 1996 held a 60 per cent share of the world market for wind turbines.

Modern Danish Wind Energy History

The reason for the Danish prominence in the wind energy market is a long tradition dating back to 1891, when the meteorologist, Paul la Cour, as the first person in the world started experimenting with electricity generation fitting a classical windmill with a DC generator.

His fundamental development work was subsequently taken over by his students.

One of them, Johannes Juul, became the first person to develop a modern alternating current (AC) wind turbine.

In 1956-57 he designed and built the now classical 200 kW Gedser wind turbine, which became a model design for all subsequent wind turbine development.

The turbine ran for 11 years without any substantial maintenance until a bearing failed.

In fact, Juul's design of a three-bladed upwind turbine with an electrically operated yaw mechanism (to turn the turbine against the wind), and an asynchronous generator has become known as *The Danish Concept*, a highly efficient design which is the equivalent of the four stroke engine of the internal combustion engine industry.

The Danish interest in wind energy waned in the late 1960ies with low energy prices.

In the late 1970ies the Danish – and subsequently the international – interest in wind energy rekindled, however,

In 1977 the Gedser wind turbine was refurbished after a request from NASA, which needed measurement results for the US wind programme.

In Denmark, machinery manufacturers opted for small machines of 11-26 kW size, which were subseqently gradually upscaled to today's sizes.

When California introduced a wind programme in the early 1980ies, the Danish manufacturers had a head start from the Danish market, and rapidly became world leaders in this field.

Søren Krohn