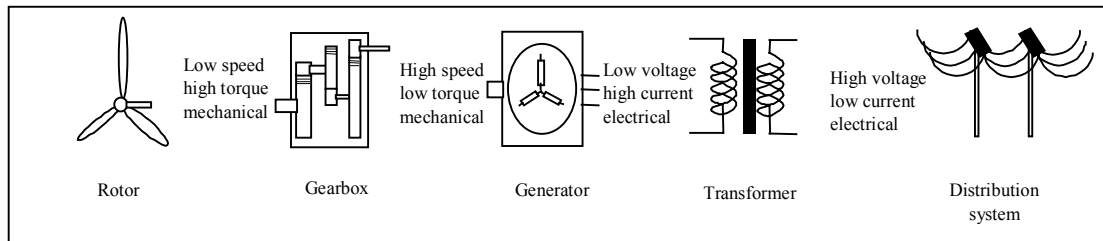


ONSHORE WIND ENERGY

TECHNOLOGY DESCRIPTION

Most wind turbine designs are now broadly similar. The designs are mature and are sometimes referred to as of “Danish” concept. They comprise a three-bladed, horizontal-axis, upwind turbine driving an electrical generator through a speed-increasing gearbox.



The conventional design

The wind turbine has three main components and several ancillaries.

Rotor

The rotor converts the wind power to low-speed, rotational mechanical power. Its blades are generally made from glass reinforced polyester (GRP) or laminated wood.

Gearbox

The low-speed mechanical power is converted into high rotational speed, low torque mechanical power by a gearbox.

Generator

The high-speed mechanical power is converted into low-voltage, high current electrical power by an electrical generator. Most machines use induction generators – sometimes more than one per turbine. These generate electricity at a relatively low voltage. Although the cost of high-voltage generators is excessive, a few turbine models use variable-speed generators and require power converters to synchronise with the grid.

Ancillaries

- **Brakes** There are two broad classes of brake. *Aerodynamic brakes* operate by pitching either the whole blade or the end section (tip brake) out of the wind. *Mechanical brakes* act more like vehicle brakes, absorbing energy either from the low-speed shaft or, more commonly, from the high-speed shaft.

- ***Pitch mechanism*** Pitch-regulated machines continuously change the angle of the rotor blades to optimise energy capture and to limit the loads on the machine. Some of the larger stall-regulated machines also incorporate a slow-rate pitching capability to optimise stall characteristics (this facility is known as active stall or combi-stall).
- ***Yaw mechanism*** The yaw mechanism is the device that keeps the turbine facing into the wind and therefore capturing the maximum possible energy.
- ***Control and safety systems*** The control system monitors wind, network and turbine conditions and ensures that all the systems are working together to capture the maximum amount of energy.
- ***Power factor correction*** Wind turbines that use induction generators generally employ some form of power factor correction. This is usually achieved using a bank of capacitors installed in the wind turbine controller cabinet within the tower.

MARKET

Onshore wind energy is used primarily to generate electricity for the grid. Installed global capacity has now exceeded 20,000MW, about 75% of which is in Europe. Growth has been slower in the UK, although the UK is recognised as having one of the best wind resources in Europe and now has almost 500MW of installed wind capacity.

The global market for wind power was estimated to be worth more than £2000 million in 2000. This market has been growing steadily at around 30% in recent years, and continued growth is expected.

There are several secondary, or consequential, markets:

- the design and manufacture of equipment (turbine and infrastructure components)
- project development
- wind farm civil engineering and installation
- operation, maintenance and services
- off-grid electricity generation
- water pumping.

BENEFITS

Wind energy offers several benefits:

- very low lifetime CO₂ emissions per unit of electricity generated
- a very large technical resource, with energy production costs potentially approaching those for existing thermal plant
- increased diversity and security of electricity supply

- elimination of the cost uncertainties associated with fuel supply price fluctuations
- an opportunity for industry – component supply and assembly, turbine provision and installation, and infrastructure development.
- increased levels of sustainability in energy resource use.

TECHNOLOGY STATUS

Onshore wind energy is an extensively deployed and commercially developed technology. It has a proven product, an established manufacturing base and a development and services infrastructure. The market place, however, remains substantially dependent upon government – on incentive mechanisms for wind energy and on policies towards other power supply technologies.

Overall, the global market has become larger and more stable and is now entering the full-scale industrialisation phase that will drive costs down further. Wind energy is approaching competitiveness with conventional thermal plant, with further cost reductions expected with technology and production improvements.

In the UK, the price of the electricity generated from wind energy has fallen over time. In 1994, the price during the third round of the Non Fossil Fuel Obligation (NFFO) was 4.32p/kWh (the capacity-weighted, index-linked average price for projects of more than 1.6MW). The price during the fifth round of NFFO (the capacity-weighted average price for projects of more than 0.995MW, index linked from issue in 1998) was 2.88p/kWh.

TARGETS FOR COMMERCIAL COMPETITIVENESS

Electricity from wind energy should be competitive with generation from all conventional sources by 2010.

NB The new electricity trading arrangements (NETA) disadvantage unpredictable generation sources such as wind energy. This will affect the economics of future wind farms.

RESEARCH AND DEVELOPMENT ISSUES

Onshore wind energy has overcome the technological barriers and has become established as a viable option for power generation. There are no outstanding R&D issues that prevent exploitation of the technology or an understanding of its prospects. Both the technology and the market have reached a level of maturity that allows improvements to be made and R&D to continue as part of the normal commercial development process.

There are, however, a number of generic issues that still affect the deployment of wind power:

- the effect on defence and civil aviation
- visual impact assessment
- the effect on birds
- output forecasting
- noise.

These issues are very important given the increased level of deployment required to meet current government targets. Furthermore, although they are deployment issues and, as such, are discussed below, they may require technology solutions. It is in this area that the wind energy Programme can make a continued contribution.

NB Grid integration is also an important issue and is recognised as such across all technologies implemented as embedded generation.

There continues to be a steady interest both in small/autonomous wind systems and in building-integrated wind systems. The prospects for both technologies are unclear, and it is recognised that reviews are needed to evaluate their status and potential and to determine whether there are R&D issues that it is appropriate for the Programme to address.

NON-TECHNICAL ISSUES

The deployment issues for specific onshore wind energy schemes are evaluated within the planning process, and planning applications must consider the visual and environmental acceptability of turbines.

The effect on defence and civil aviation

It is widely acknowledged that the effects of wind turbines, particularly on radar, are an important consideration in defence and civil aviation safety but, currently, are poorly understood. Low-fly and, in particular, tactical training areas also affect deployment.

Visual impact assessment

Historically, lack of visual acceptability has been the reason cited for most wind farm/turbine planning refusals, and this remains a very important issue in the development of wind energy in the UK. While it is not possible to alter turbine form to bring about substantial changes in appearance, the size and number of machines, individual turbine siting and the cumulative effects of wind farms do have an overall effect. The subjective nature of this subject has, to date, made it difficult to develop assessment methods that all parties find acceptable.

The effect on birds

Some information exists as to the effect of wind turbines on birds, and additional studies are ongoing. The effects are specific to individual species and, therefore, to each location. While

some developments have been refused on the grounds of their possible effect on local species, many parties believe there is still a lack of scientific information.

Output forecasting

The value of the electricity from wind under NETA can be maximised by accurately forecasting the output of one or several wind farms. Research combining weather system data with the operational information gathered by wind farm operators may be used to improve prediction models.

Noise

While noise will remain a consideration in the development of wind farms, methodologies have now been developed to measure and assess the acceptability of noise from wind turbines. These have proved successful in eliminating noise as a problem in almost all cases.

Public opinion

It is also important to be aware of public opinion and attitudes towards wind energy in order to understand what influences its acceptability. The provision of accurate and objective information can be helpful in achieving this.

UK INDUSTRY STRENGTHS

As a result of implementing the NFFO, the UK has successfully acquired the skills and resources for developing commercial wind farms in a highly cost-effective manner. The country has world class developers and consultants who are active across the globe.

However, the sector does have its weaknesses. The UK has little manufacturing industry in the wind sector. There are no established UK turbine manufacturers and very few companies successfully exporting components to the major overseas manufacturers.

One exception to this is the manufacture of turbine blades. There are two blade factories in the UK, both owned by overseas companies that offer technical expertise and sell principally into the European market. One factory manufactures wood-composite blades, for which the UK is the world leader. The other manufactures blades from GRP. Although the market share of both factories remains limited to date, they have the capability to manufacture several hundred blade sets per year.

RATIONALE FOR A DTI PROGRAMME

- Wind energy offers considerable environmental advantages, notably very low emission levels for pollutants such as carbon dioxide (CO₂) and oxides of sulphur (SO_x) and nitrogen (NO_x). The deployment of wind energy is, therefore, an essential component of government initiatives to ensure that the UK meets its greenhouse gas commitments.
- The continued development of wind energy can enhance the diversity and security of energy supply in the UK.

- Onshore wind energy is expected to play an important role in meeting the UK Government's target for 10% of electricity to be generated from renewable sources by 2010.
- Although onshore wind energy is commercially developed technology, there are issues relating to deployment and public acceptability that need to be addressed if the UK market for this technology is not to remain uncertain.
- Although the UK wind energy industry (manufacturers and developers) is not best placed to address these broader issues, part of the solution may be technology-based, and the industry may be expected to make a contribution.

In conclusion, onshore wind energy could make a major contribution to the production of sustainable energy in the UK. It also presents a significant potential opportunity for industry.

Any DTI programme should address the various deployment issues to:

- ensure a full understanding and evaluation of these issues
- provide all stakeholders with appropriate information
- enable solutions, wherever possible and appropriate
- improve prospects for the future deployment of wind energy, thereby ensuring that wind energy makes an appropriate contribution to the power supply mix.

TECHNOLOGY ROUTE MAP FOR THE DTI PROGRAMME

Onshore wind energy is considered to be a commercially developed technology that is entering the large-scale industrialisation phase. Manufacturing industry is now responsible for its own product development without the need for further government-funded R&D. However, the UK market remains uncertain because certain issues relating to deployment and public acceptability still need to be addressed.

The biggest issue facing onshore wind development between now and 2010 is likely to be planning consent. In recognition of this, the Government has started an initiative to conduct resource studies and produce regional targets for the development of renewables. The DTI Programme can complement this initiative by understanding and informing the consents process.

The activities and targets listed below may form a part of the Programme to aid deployment by 2010.

Activity	Target date
Conduct a technology status review that will: <ul style="list-style-type: none"> • evaluate small/autonomous wind systems • evaluate the building of integrated wind systems. 	2002
Establish public attitudes to wind energy by conducting a survey.	End 2002
Continue to provide relevant objective information to those involved in the planning process. This will involve: <ul style="list-style-type: none"> • completion of the existing project to establish the information needs of planners • providing planners with the appropriate information in the right form. 	Early 2002
Conclude initial projects to evaluate the options for prediction models. Assess output forecasting benefits.	Mid 2002
Improve understanding of the effects of wind turbines on MOD and civil aviation interests, and disseminate information. This will involve: <ul style="list-style-type: none"> • Developing initial guidelines for wind energy, civil and military aviation interests • Conducting research to enable revision of the guidelines, providing improved clarity and reliability of assessment methods, management and mitigation of effects. 	Autumn 2002.