IRISH ENERGY CENTRE
RENEWABLE ENERGY INFORMATION OFFICE

Wind Energy

General information

Wind: an Eco-Friendly Energy Source

Wind Energy has always been important for mankind. Throughout history, wind has been an indispensable resource for movement on water. The sailing ships of traders, explorers (and Vikings) were propelled by this inexhaustible energy source. Wind has also been used extensively for thousands of years for powering grain mills and to pump water by means of windmills; the importance of wind energy to us throughout the ages can easily be seen – every county in Ireland has at least one location called 'Windmill hill' or "Windmill Lane" etc.

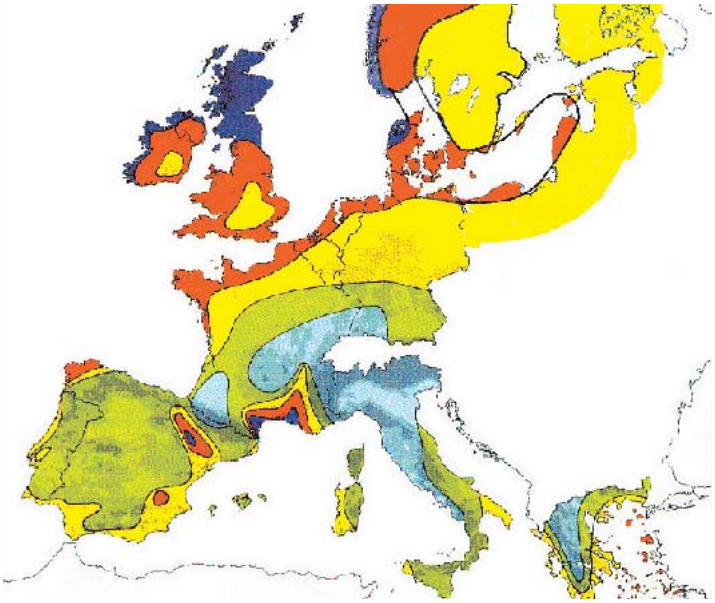
Old wind mill in Roscommon…

..and new wind turbine in Cork

The wind does not blow equally or evenly everywhere on earth. Over open sea or flat stretches of land the wind is stronger than over towns or woods. Obstacles such as trees, dwellings or buildings slow down the wind, but this effect is less noticeable at greater heights. Furthermore, the wind depends on large-scale weather systems. For example, the Gulf Stream provides Ireland with a prevailing southwesterly wind current: windy depressions develop over the Atlantic Ocean and regularly cross over our country. These weather systems, combined with our long south and western coasts, mean that Ireland is particularly suited to generating energy (in the form of electricity) from wind turbines. The importance of wind today is not in milling grain or pumping water, but in meeting modern Ireland's energy and electricity requirements in a clean, environmentally friendly and affordable way.

The Source of wind

The sun heats the earth's surface and the air above the earth. Because the earth is unequally heated, and because hot air is lighter than cold air and rises, differences in pressure are created. Air flows try and equalise these pressure differences. Together with the rotation of the earth, the differences in air pressure cause an uneven flow of air: wind.



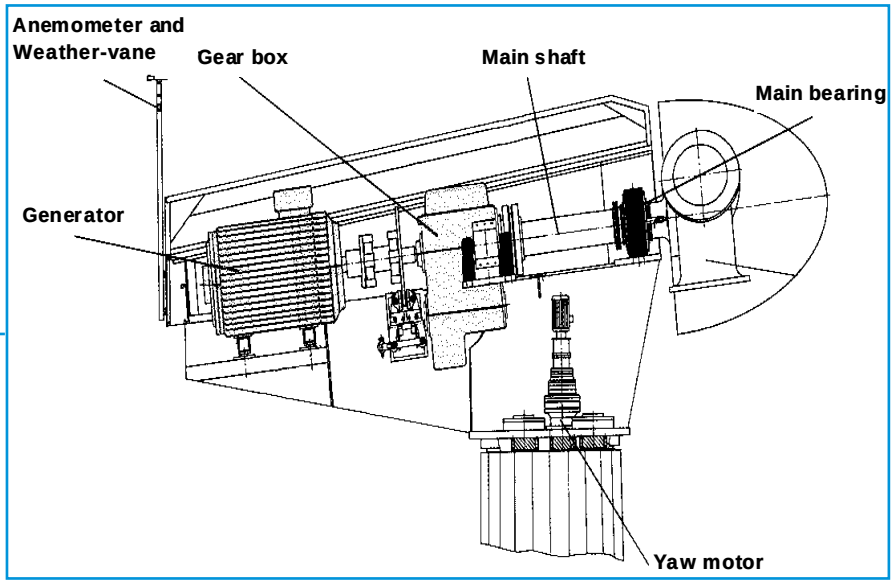
The wind in Ireland

Ireland has one of the best wind resources in the world. The red and blue areas on the European Wind Atlas show the highest wind speeds in Europe – almost the entire country of Ireland has either an excellent or very good wind energy resource.

How does a wind turbine work?

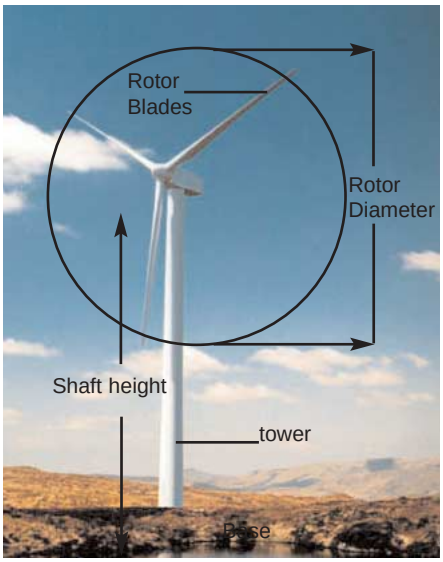
The energy of the wind airflow is efficiently converted into a rotating motion by the sophisticated shape of the rotor blades. The rotor blades are fixed to the main shaft, causing it to rotate also. This rotating motion is accelerated in a gearbox to drive a high-speed generator producing electricity – comparable to the working of a bicycle dynamo. The shaft, gearbox and generator are housed in a compartment on top of the mast, called the nacelle. Nowadays wind turbines without gearboxes are also produced using direct drive turbines with DC-generators. Special high power electronics convert from DC to AC electricity.

The Nacelle



Direction

The turbine produces maximum power when the blades are rotating in a plane perpendicular to the wind. Hence the nacelle must be able to rotate to follow the wind as the wind direction changes (this is called yawing). A weathervane on the nacelle indicates the wind direction and a yaw motor ensures that the nacelle always faces the wind.



Size

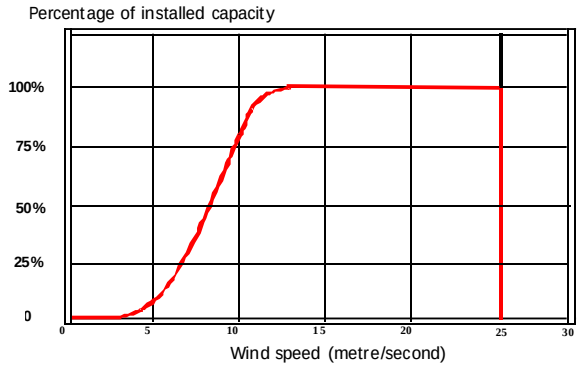
The energy production of a turbine depends on the diameter of the rotor and the wind strength. As the wind gets stronger with increasing height above ground, higher turbines produce more energy. The size of a wind turbine may be described by various characteristic dimensions such as:

* rotor diameter- the diameter of the circle that the rotating blades make.
* shaft height - the height of the main shaft or tower.
* electric generator capacity – rated electrical power of the wind turbine.

The trend nowadays is towards producing ever-larger wind turbines. This is because a small number of large wind turbines on a location of a certain area, yields more output than a large number of smaller wind turbines. In 1988 the capacity of an average wind turbine was about 100 kilowatts with a rotor diameter of 20 metres and a shaft height of 30 metres. At the moment many projects are planned in which the turbines have a capacity of about 2,000 kilowatts (= 2 MW) with rotor diameters of 60 to 70 metres and shaft heights up to 100 metres.

Electrical Output

The electricity output is very dependant on wind strength – it is proportional to the wind speed cubed. A small difference in the average wind speed causes a big difference in electrical output. Wind speeds are generally higher at the coast than further inland and rough terrain such as dense forest, hills or urban areas can also reduce wind speeds. Hence electrical power output is very dependant on the location of the Wind Farm. To prevent wind turbines in a wind farm from sheltering each other and reducing output, they should be located a certain minimum distance from each other: usually at least six times the rotor diameter.



Capacity Characteristics

The electricity output also depends on the size and type of the turbine. The output characteristics of one turbine are depicted above. At low wind speeds the turbine does not supply any electricity. From 3-4 metres per second (Beaufort 2) the turbine starts producing power and from about 12 m/s (Beaufort 6) the maximum capacity of the turbine is supplied. At wind speeds above 25 m/s (Beaufort 10) the wind turbine is stopped to avoid overloading. At a good location an average wind turbine annually supplies an electricity output of at least 850 kilowatt-hours per square metre of rotor surface. An average household uses 4,500 kilowatt-hours of electricity annually. Hence, as a rule: the number of households electricity = 0.65 times the generator capacity in kilowatts. So a 1 MW wind turbine supplies electricity for approximately 650 households.

Why wind energy?

We usually take the availability of electricity for granted. We do not take into account the permanent damage to our environment caused by the production of electricity from natural gas, peat, oil or coal. When burning these fossil fuels harmful gases are emitted, such as the greenhouse gas CO2, which leads to changes in our climate and nitrogen and sulphur oxides, which cause air pollution and acid rain. In Ireland, we import almost all of these fossil fuels and, furthermore, these fuel supplies will run out eventually. Hence dependence on these fossil fuel sources makes our energy supply vulnerable.

Wind – a clean and endless supply of energy

Wind energy can be used to displace fossil fuels in generating electricity, and hence avoid pollution. No harmful gases are emitted when generating electricity with wind turbines - it is clean. And there will always be wind; it is inexhaustible and renewable.

Costs

The cost price of wind energy is very dependant on the location of the wind turbines, as the wind speeds and the costs of connection to the electrical grid vary for each location. However, the cost price for electricity generated by wind is about the same as polluting or “brown” electricity from fossil fuels such as gas, oil and coal (2.5 to 6 Euro cents per kWh or unit). Commercial Wind Farms on particularly windy sites can already produce electricity cheaper than some fossil fuel plants – and the cost of these fossil fuels is rising. In the future, there may be a system of so-called Green Labels or Credits, which will make clean, “green” electricity from wind noticeably cheaper than “brown” electricity.

The average initial investment for a 1 MW wind turbine project is about €1.2 Million. The main costs are for the wind turbine itself, but other costs include planning development, site foundation, construction, roads, grid connection and legal fees. Ongoing costs include operation, maintenance and insurance costs, and charges for the use of the electricity grid. Local authorities usually levy rates on wind turbines.

Employment and Economic Benefits

A 5 MW wind farm will cost about €5-6 Million to build, of which €1-2 Million will be spent locally. It will typically provide 50 construction jobs for 6 months and 2 long term, sustainable jobs. The wind farm will generate about 350 GWh of electricity over 20 years, at a wholesale price of about €15 Million in today’s money. The wind farm will reduce the need to import about 60,000 tonnes of oil, reducing our imports by about €10 Million at current oil prices.

Wind Energy can provide a valuable source of employment to the locality. The main employment categories created are as follows

- *Generation, Operation and Supply - Utility companies have staff dedicated to Wind Energy. Some of the Wind Farms have their own operation and maintenance staff
- *Turbine Supply - Several Wind Turbine suppliers have staff or distributors in Ireland, and some have maintenance personnel
- *Engineering Consultants - Feasibility Studies, design and engineering /construction management
- *Environmental Services - Environmental Impact Assessments

*Construction - about 20% of the initial cost of a windfarm is spent locally on construction (roads, buildings, electrical infrastructure etc)
*Legal/Financing - Planning, Contractual and Financing
*Manufacturing – This is one main category that we do not currently have in Ireland. However, several Irish engineering companies have expressed an interest in this area (particularly tower manufacture) and some turbine manufacturers are considering establishing facilities in Ireland.

A European report predicts that 50,000 MW of Wind Energy would generate 32,000 permanent jobs. Ireland currently has about 120 MW which equates to about 60 jobs - however the industry is gearing for up to 2,000 MW by 2010, which could sustain up to 1000 full time jobs.

Policy

In response to global concern about the effects of energy consumption on our environment, the Kyoto Protocol of 1997 places a limit on the Greenhouse gas emissions that Ireland, and other countries, may produce. As a contribution towards meeting these limits, the EC Electricity Directive requires Ireland to be produce 13.2% of our electricity from Renewable Energy sources by 2010.

The Irish Government's medium term objective is to increase the installed capacity of electricity from renewable energy sources by 500 megawatts between 2000 and 2005 – most of which is expected to come from wind energy. The Dept. of the Marine and Natural Resources also has a policy for exploiting our marine resources with Offshore Wind Farms located at sea.

Financial Support

The Government has several support mechanisms to stimulate installation and exploitation of wind farms and the harnessing of wind energy. The Government continues to hold occasional competitive tendering competitions (AER schemes) for long-term Power Purchase Agreements for electricity from wind. Furthermore, the electricity market has been completely deregulated for "green" electricity. Future measures may include Tax Incentive Schemes, a "Green Certificate" scheme or a Carbon Tax from which wind energy would be exempted.

Planning Permission/Licences

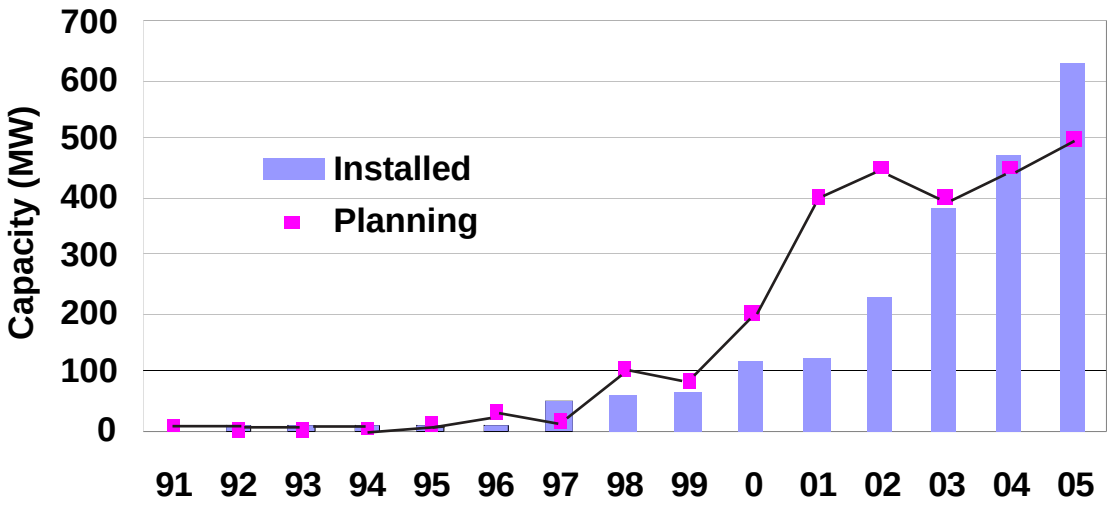
Planning Permission is required to install wind turbines, and for wind farms of greater than 5 MW, an Environmental Impact Assessment (EIA) must also be undertaken. Local authorities can have their own guidelines to Wind Farm Planning, within the framework of national policies, and so the policy with regard to granting licences and the criteria applied varies with each local authority.

Furthermore, in order for the Wind Farm to be connected to the national electrical grid, a Generating License from the Commission for Electricity Regulation is required.

Progress

The first Wind Farm opened in Bellacorrick, Co. Mayo in 1992, and by Sept 2001 there were 22 wind farms (with over 150 turbines) operating in Ireland with a total installed capacity of 125 MW, producing enough electricity to power 80,000 homes. In the summer of 2001 the government announced a scheme (AER V) which should see an additional capacity of 240 MW being built by 2003. Progress towards meeting our Kyoto targets should see installed capacity of wind energy exceed 1,500 MW by 2010.

A chart showing the possible future growth of onshore wind energy is shown below.



Offshore wind farms

Developers and planners are increasingly considering the siting of wind farms offshore. This is due to the many competing uses for onshore land, and to the higher speeds and reduced turbulence of the wind at sea. However, the cost of manufacture, construction and maintenance of offshore wind farms is considerably higher than onshore, and as such may only be viable for very large offshore wind farms. The impact on the seabed, fish, dolphins, seals, fishing, boating, shipping and birds etc.must also be taken into account. Several large wind farms are currently being considered for the relatively shallow sandbanks off the East coast of Ireland.

What happens if there's no wind?

Although Ireland has a windy climate, and wind farms are usually located in particularly windy areas, there are inevitably some calm periods. However, wind conditions are not exactly the same everywhere – if it is calm in one area it may still be windy in another. If wind farms are dispersed throughout the country there is an averaging effect with less variation, and the likelihood of no electrical output from all the wind farms is very small. Furthermore, wind farms are not the only source of electricity, but are connected into the national electricity network. Whenever the wind blows, the electricity produced by the wind farms is available to consumers. When it is calm, electricity is available from other sources, such as fossil fuel or hydro plants, or from wind farms in other parts of the country.

Local Impacts of wind energy

Harnessing energy using wind turbines can have some environmental impacts, although in comparison to conventional power plants they are relatively minor and always restricted to the immediate locality. Proper project design and site selection, appropriate planning conditions and consultation with local people and other interested parties should help reduce negative impacts. The turbines typically only use 4% of the Wind Farm land surface area (about 100 m2/MW), so that the land can usually retain its original use (livestock grazing, tillage or natural). At the end of their operating life, the wind turbines can be removed with almost no trace.

Possible impact (positive or negative) is very much dependant on the local site. Some of the main factors to be considered are:

Archaeology, Birds, Construction/Decommissioning, Electric Network, Electromagnetic Interference, Flora & Fauna, Noise, Safety, Visual Impact, Moving Shadows, Water & Air Quality, and Tourism.

Properly sited and designed wind farms take these considerations into account to minimise or eliminate any negative impact. The issues that usually need to be considered, or cause most public unease, are discussed in more detail overleaf;

Noise

Wind turbines do make some noise. The rotor makes a swishing noise and the generator and gearbox emit a mechanical sound. Carefully designed rotor blades with low rotational speed along with good noise insulation of gearboxes and generator help limit noise emission. Typically, at 200 m the sound from a modern, medium-sized wind turbine would be about 45 dB, quieter than a typical living room. At 400 m, the sound would be as loud as leaves rustling in a gentle breeze. By keeping enough distance from built-up, or other noise sensitive areas, noise pollution is avoided.

Birds

There are two potential sources of concern relating to birds. The first is that birds may fly into wind turbines or be caught by rotational flow behind the rotor. Extensive research has shown that the risk of collision is relatively small due to the low rotational speeds, although care should be taken to avoid principal migration paths. Studies in Northern Europe show an average of less than one bird casualty per turbine per year, with some wind farms recording no casualties. Traffic, hunting, oil slicks and high voltage installations each account annually for many times more birds victims than would the presence of wind turbines providing 1000 MW.

A second concern is that the birds' natural habitat may be disturbed. Many birds get used to wind turbines in their habitat, and in some cases benefit from the extra roosting provided, but attention should be paid to possible disturbance of vulnerable species of birds, particularly during construction. This should be judged separately for each site.

Safety

There is a remote chance of a damaged rotor blade being thrown from a wind turbine, or of ice flying from the blade in extremely cold conditions. The wind farm should be designed and sited such that no buildings, or populated areas lie within the possible trajectory range of the blade. This range can vary with the size, shape weight and speed of the rotor and the turbine height, but is unlikely to exceed 300 m.

Shadow

When the sun shines the rotating rotor blades make moving shadows. Normally this effect is only visible very close to the turbine. However, on a sunny winter day, with the sun low in the sky, shadows may be cast over some distance. This may be inconvenient, particularly if the shadow is cast onto a house window. Correct positioning of wind turbines, and a minimum distance from dwellings should be sufficient to avoid this problem. Alternatively, if shadows cause inconvenience for only a small number of hours a year, the wind turbine can be deactivated at those times without too much loss of production.

Visibility - Fitting into the landscape

Wind turbines are striking elements in a landscape. Whether or not you like the sight of a wind turbine installation is largely a matter of personal taste. However, there are measures that can be taken to reduce their visual impact. Care should be taken to fit them into the natural landscape. Opinion polls suggest that installations in clusters are more acceptable than isolated turbines particularly when residents understand that they yield a larger electrical output.

Interestingly, the height of turbines is not a major factor on their visual impact - the absolute height of a wind turbine in the landscape is difficult to estimate. More important to the eye is the ratio between shaft height and rotor diameter and also the rotor's speed; bigger rotors rotate more slowly and for that reason are considered to be more restful.

Currabwee Wind Farm, Co. Cork

The following measures can also help to reduce visual impact:
* areas of unique scenic beauty are not recommended as wind farm sites
* turbines should be painted off-white or light grey with a matt finish
* blades should be left to spin when the turbines are off
* the number of machines should reflect the landscape of the site
* non-linear layouts may be more suitable where the topography is uneven
* all the turbines should be of similar size and design, with blades rotating in the same direction
* on-site cabling should be underground to avoid a cluttered look
* the site should not be fenced off (except normal livestock fencing)

Summary

The local impact of wind farms must be given proper consideration, but that should always be balanced against the global benefits of avoiding greenhouse gas emissions and air pollution. Remember, a 1 MW Wind Turbine can provide enough electricity for 650 homes and will avoid 175 tonnes of slag and ash and the emission of 2,500 tonnes of the greenhouse gas CO2, 30 tonnes of Sulphur Dioxide and 10 tonnes of Nitrous Oxide per year, helping us to meet our Kyoto Protocol targets and to preserve our environment. Please support the harnessing of the energy in the wind, and from other renewable sources.

The Renewable Energy Information Office

The Renewable Energy Information Office is a service of the Irish Energy Centre. Its objective is to support the development of renewable energy in Ireland by providing independent and expert advice as well as information on related financial, environmental and technical issues.

Five ways to contact us:
WRITE: Renewable Energy Information Office
Irish Energy Centre
Shinagh House
Bandon, Co. Cork
Ireland
TELEPHONE: our hotline – 023 42193
FAX: 023 41304
EMAIL: renewables@reio.ie
VISIT OUR WEBSITE: www.irish-energy.ie/reio.htm

The Irish Energy Centre is a joint initiative of the Department of Public Enterprise and Enterprise Ireland and is supported by the EU through the Community Support Framework.

I want to know more about Wind Energy

Further reading

If you have any questions, or would like to find out more, please contact the Renewable Energy Information Office, or see the references given below:

The new series of factsheets which are available directly from us or our website:

* Renewable Energy
* Wind Energy
* Bioenergy
    - Biomass
    - Landfill Gas
* Hydropower
* Green Electricity
* Renewable Energy for Buildings & Industry:
    - Passive Solar Design
    - Heat Pumps for Your Home
    - Heat Pumps for Commercial Buildings
    - Heat Pumps for the Health Sector
    - Solar Water Heaters
    - How to Heat with Wood

Books:

Windturbines – Fundamentals, Technologies, Application, Economics.
By Erich Hau. Available from the Renewable Energy Information Office.

Bi-monthly Magazines:

Renewable Energy World	Free - Subscribe online at www.jxj.com/rew/
New Energy	Subscription Fee - Subscribe online at http://www.wind-energie.de/englischer-teil/english.htm

Websites:

Renewable Energy Information Office:	www.irish-energy.ie/reio.htm
Irish Wind Energy Association:	www.iwea.com
Danish Wind Industry Association	www.windpower.dk
(including a Guided Tour of Wind Energy at	http://www.windpower.dk/tour/index.htm
and a section for children at	http://www.windpower.dk/en/kids/index.htm)
European Wind Energy Association	www.ewea.org
RETScreenTM International:	http://retscreen.ca

(RETScreen provides software for renewable energy project analysis, including wind. The software can be downloaded free-of-charge from this Canadian government Natural Resource's website)

This list is not an accreditation by the Renewable Energy Information Office of the organizations named.