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Small Wind Turbines – General Information

Wind Speed Information

BERR provides a wind speed database which contains estimates for the annual average wind speeds throughout the UK. You can locate it via the British Wind Energy Association website:

http://www.renew-reuse-recycle.com/noabl.pl?n=503 or

https://www.carbontrust.co.uk/publicsites/WPEstimator/Default.aspx

Each value stored in the database is the estimated average for a 1km square at heights 10m, 25m or 45m above ground level. You can use the database to estimate wind speeds in your general area for a particular mast/tower height.

This tool is insensitive to fine details of local topography. As these can dramatically change the wind conditions at any given site, you should only use the database as a rough guide. Nevertheless it can give you an idea of whether your site is in a low, medium or high wind speed area.

Wind Speed Class	Annual average wind speed
low	< 5 m/s
moderate	5-7.5 m/s
high	>7.5 m/s

If you need more certainty of wind conditions prevailing at your site you should monitor wind speeds directly with an anemometer for at least several months and ideally for a year or more.

If you are strongly dependant on the economics of a wind turbine you should consider having an independent wind speed assessment made.

Horizontal Axis Wind Turbines

Most wind turbines that you see used today are of the horizontal axis type consisting of a rotor and generator mounted on a mast or tower. Typically rotors have two or three blades. Turbines can be divided into two main groups depending on the type of generator they use.

Asynchronous (induction) generator:
In order to work, this type of wind turbine requires to be connected directly to a electrical grid of some sort. Usually this is provided by the electricity network or in remote sites by a separate diesel generator.
As wind speed increases the tendency for the rotor to turn faster is balanced by a reactive force from the grid allowing more power to be generated for a very small increase in rotational speed. This type of turbine is characterised therefore by a slow almost constant rate of turning and feeds directly to the grid without the need of an inverter. It includes a gearbox. The turbines you see on large wind farms are of this type.

Synchronous generator:
This type of wind turbine is characterised by a variable rate of rotation increasing with wind speed. The turbine output therefore has changing frequency and must first be rectified and passed through an inverter before it can feed into the electricity grid. Rotor rotational speeds are much higher than with the asynchronous type. A gearbox is normally not required.

Power and Energy

It is easy to confuse power and energy. Power is a measure of the flow of energy and is measured in kilowatts (kW). Energy is the product of power and time and is measured in kilowatt-hours(kWh). The units shown on your electricity bills are in fact kWh.

eg. a turbine generating 3 kW continuous output for 20 hours will have produced 60 kWh(units) of electrical energy.

eg. A kettle with a 2 kW rating will consume 0.2 kWh if it runs for 6 minutes(1/10th of an hour).

Wind turbines are often described in terms of the maximum power they can produce eg. 6 kW, 11 kW, 25 kW. However this figure on its own can be misleading as the actual power produced by a turbine varies with the wind speed. Manufacturers therefore normally give additional information in the form of a table or a graph called a 'power curve' showing the turbine performance for a range of wind speeds.

The annual energy yield that you can obtain from a turbine depends on the shape of its power curve and the range of wind speeds obtained at your site throughout the year. When comparing turbines therefore, it is not always the case that the turbine with the highest power rating will generate the most energy.

Wind energy capture is strongly related to the amount of air intercepted by the turbine rotor eg. a 6m radius rotor sweeps an area 4 times greater than a 3m radius rotor. Bigger rotors therefore capture more wind and generate more energy.

Site Considerations

Small wind turbines are generally linked with a property and consequently are often not located in the 'prime wind' sites such as those sought by commercial power generators. Nevertheless, if care is taken with regard to selection of the turbine and its positioning on a suitable site, a small wind turbine can be an economically attractive proposition for the owner as well as making a significant contribution to greenhouse gas reduction.

Turbine Selection

It is important to select a turbine to match your site wind speed and energy useage requirements. A turbine that performs well in a high wind speed site can be disappointing in a moderate wind speed site and vice versa. All turbines perform poorly at low wind speed sites or in very turbulent winds.

Positioning

The position of your turbine both in terms of its relation to local topography and the rotor height can significantly effect the performance of your turbine. The following rules of thumb apply:

- There should be no, or minimal, obstructions in the direction of the prevailing wind. For most sites in the UK the prevailing wind is South West.
- Obstacles such as buildings and trees degrade wind quality by producing turbulent zones in their vicinity. These can significantly reduce the output of a turbine. It is important, therefore to select a tower of sufficient height to allow the rotor to sit above any potentially turbulent zones.
- Wind speed tends to increase with height in most locations, a phenomenon known as wind shear. This variation in velocity with altitude is most dramatic near the surface. Further, the energy in the wind is proportional to the cube of the wind speed. Consequently a small change in wind speed produces a much larger change in wind energy. For example: increasing the height of a turbine rotor, from 9m to 18m will increases the expected wind speeds by 10% and the expected energy generated by 34%.

Economic Considerations

Renewable energy sources such as wind are intermittent in nature. It is therefore unlikely that a wind turbine on its own can provide a complete energy solution for a property. However when used in compliment with other energy sources it can play a key role.

A grid connected wind turbine gives the flexibility to import power from the grid when required, or to export energy when there is a surplus. These actions are performed automatically. With this type of configuration there are three potential economic benefits:

1. Cost savings: reducing your electricity bill by using your own electricity rather than buying from an electricity provider . For imported electricity typical domestic charges are currently around 11-13p/kwh(unit).

2. Selling: your electricity provider will contract to buy your surplus electricity. Current rates range from about 4p/kWh to 7.5p/kWh(unit). *Terms vary, talk to different utilities before signing a contract*

3. Greenhouse gas offsetting: by registering with Ofgem as an electricity supplier you can earn ROC's (renewable obligation certificates) for the green electricity you produce. ROC's are granted against the total energy production, even if you use the electricity yourself.These currently have a tradeable value of around £45-50/ certificate. Currently 1 ROC is awarded per MWh(1000 kWh). From April 09, this will be doubled and small wind turbines will be awarded 2 ROCs/MWh.

Due to price differentials, it is generally better to use the energy you generate to reduce your own electricity bills rather than selling it. If you have a high electricity usage you may be able to consume all the energy you produce. In practice most turbine installations use a mixture of cost savings and selling.

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Grants

A number of grants are currently available for small wind turbines.

Funding for domestic renewables projects are available from the following:

- Scottish Community and Householder Renewables Initiative (SCHRI).
    - Funding for householders is set at 30% of the installed cost of a renewable measure up to £4,000.
    - See **www.energysavingtrust.org.uk/scotland/**

- Low Carbon Buildings Programme (LCBP), UK wide.
    - **www.lowcarbonbuildings.org.uk/home/**

Funding for business purposes:

- Scotland Rural Development Programme(SRDP)
    - Project funding of up to 40%.
    - See www. www.scotland.gov.uk/Topics/Rural/SRDP
- Business Environment Partnership
    - Interest free loans for up to 4 years
    - See **www.thebep.org.uk** subsection 'Loan action scotland'

Gaia-Wind 11 kW Turbine

For this section see also accompanying file 'Data Sheet Gaia-Wind 11kW.pdf'

Gaia-Wind 11 kW Turbine Design and Use

The Gaia-Wind turbine is in the 'small wind turbine category' and has a peak rated output of 11kW. It produces an energy yield that is practical for supplying electricity to properties such as private houses, farms, offices, small businesses and public buildings where the primary goal is to reduce the amount of electricity imported rather than generate specifically for export.

The turbine has been developed according to 'Danish design'; the design basis for most of the large commercial turbines used today. Like its bigger relatives, it has a slow rotational speed (56 rpm) which is independent of the wind speed. It also incorporates many of the control and safety features from the large turbines.

The Gaia-Wind turbine is configured to give an optimal yield in moderate wind speed sites i.e. those with an annual average wind speed in the range of 4.5-7.5 m/s. As such it complements the wind conditions found in most rural areas of mainland Britain.

The turbine is usually connected to the grid at the property but can also be configured for connection to a diesel generator (wind-diesel system). With the grid connected version, the electricity provider replaces the standard meter for an import/export model allowing the turbine owner to export any excess production to the electricity grid.

NOTE: The Gaia-Wind 11 kW turbine uses an asynchronous generator to produce a grid matched output . It requires a 3 phase electrical connection. It does not require an inverter.

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Visual Presentation of a Gaia-Wind 11 kW Turbine

Tower: 18m high. Constructed from galvanised steel in either a lattice or tubular form.
The lattice open form merges into backgrounds such as trees or hills and fades with distance. The tubular form compliments modern structures.

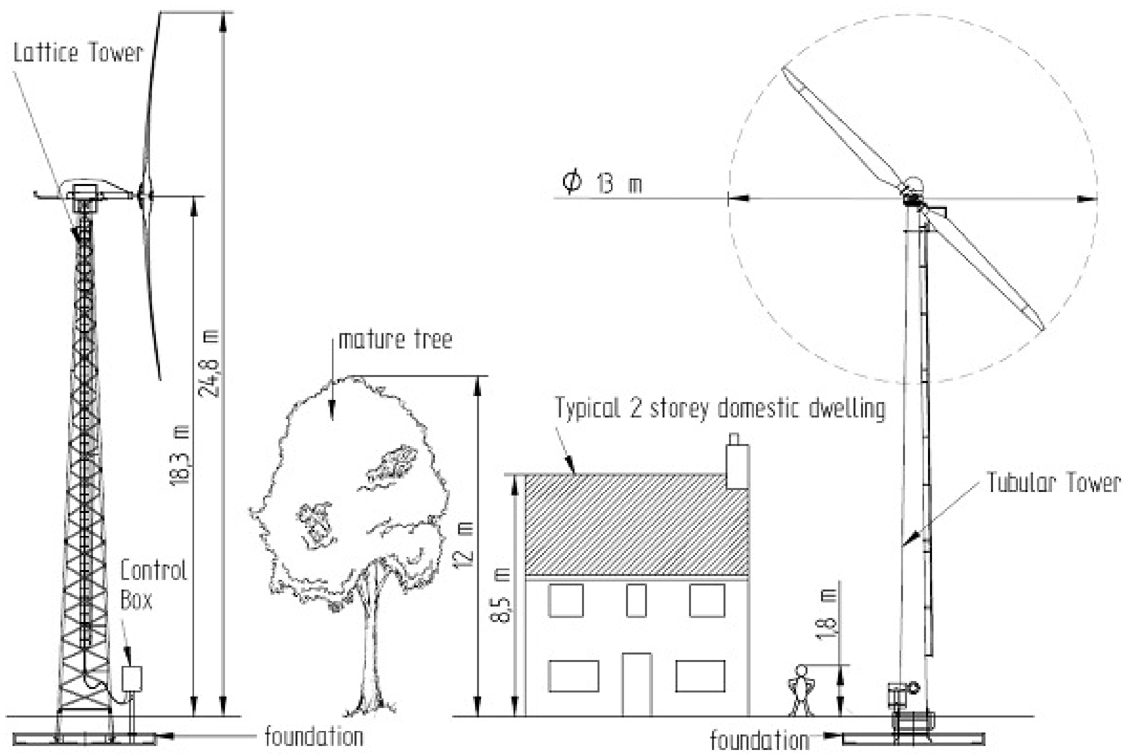
Rotor: Slow turning at nominal speed of 56 rpm (independent of wind speed). Light grey, reflection free fibreglass blades

Gaia-Wind 11 kW Turbine Footprint

Assembly Height - The turbine assembly is mounted on an 18m high tower. The hub of the rotor is at 18.3 m.The rotor is a twin blade design and is manufactured as a single composite unit 13m in diameter. When in the vertical position, the tip of the rotor extends to a height of 24.8m and the lowest point is 11.8m above the ground.
This is around 1/5th the height of a typical turbine found on a modern wind farm.

Foundation – The bottom of the tower is bolted onto a reinforced concrete base with dimensions 5 x 5 x 0.55m. This is set in a hole 1m deep with a 0.45m layer of hard packed earth on top.

Cabling- The turbine is connected to the building power supply at the main fuse box via an armoured cable buried at a depth of 0.75m.



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Gaia-Wind 11 kW Turbine Annual Energy Yield (see data sheet)

The energy production page on the accompanying data sheet shows the power curve for the turbine and gives indicative figures for the annual energy yield for different wind speed sites.

Example 1:
SimpleEconomic Calculation for Gaia-Wind Turbine(domestic use)

Large rural house in Scotland using 35,000 kWh of electricity annually.
3 phase electricity supply
Moderate wind site: annual average wind speed 6.0 m/s at a tower height of 18m
Electricity: buying rate 12p/kWh, selling rate 7p/kWh
Registered for ROCs at £50/MWh

Good clean site: Estimated Production 34,000 kWh
Able to use 60% of production onsite, exporting 40%

Year cost savings:	*34,000 kWh x 60% x £0.12 =*	*£2,448*
Year income from sales:	*34,000 kWh x 40% x £0.07 =*	*£ 952*
Year income from ROCs:	*34 MWh x 100% x 2 x £50 =*	*£3400*[1]
Gross effective income:		*£6,800*
Yearly Maintainence costs:		*£ -500*
Net yearly gain		*£6,300*

Cost of Gaia-Wind 11 kW turbine fully installed with lattice tower:
Circa £46,000
(Includes VAT at rate of 5 %)[2]

Estimated Payback period 7.3 years at current electricity prices.

Notes on simple economic calculation:

- ***Turbine design life 20 years***
- ***No provision has been made for increase in energy costs. Rising energy costs will lowers payback time.***
- ***Calculation excludes any grants that may be available.***

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Example 2:
Simple Economic Calculation for Gaia-Wind Turbine(business use)

Dairy farm with annual electricity consumption of 90,000 kWh
3 phase electricity supply
Moderate wind site-annual average wind speed 6.5 m/s at a tower height of 18m
Electricity: buying rate 11p/kWh, selling rate 7p/kWh
Registered for ROCs at £50/MWh

Good clean site: Estimated Production 40,000 kWh
Able to use 90% of production onsite, exporting 10%

Year cost savings:	*40,000 kWh x 90% x £0.11*	=	*£3,960*
Year income from sales:	*40,000 kWh x 10% x £0.07*	=	*£ 280*
Year income from ROCs:	*40 MWh x 100% x 2 x £50*	=	*£4,000*[1]
Gross effective income:			*£8,240*
Yearly Maintainence costs:			*£ -500*
Net yearly gain			*£7,740*

Cost of Gaia-Wind 11 kW turbine fully installed with lattice tower(ex VAT): Circa £44,000

Estimated Payback period 5.7 years at current electricity prices.

Notes on simple economic calculation:
- ***Turbine design life 20 years***
- ***No provision has been made for increase in energy costs. Rising energy costs will lowers payback time.***
- ***Calculation excludes any grants that may be available.***

Notes:
1. From April 09, small wind turbines will recieve 2 ROCs per MWh of electricity generated. Machines installed prior to this date will be included in the programme.

2. VAT is applied at a 5% rate for domestic renewable installations.

Greenhouse Gas Offsetting

A Gaia-Wind turbine generating around 30,000 kWh of green electricity per year, will offset around 17 tonnes of CO_2 emissions from existing energy generation . This is sufficient to bring the carbon footprint of the average four person household back to zero (household energy use + car + air travel)

Gaia-Wind 11 kW Monitoring, Control and Safety (see data sheet)

A Gaia-Wind turbine has a sophisticated monitoring and control system with three levels of system protection to ensure the rotational speed and the output power remain under control in all wind conditions. The control system is housed in a metal cabinet at the base of the tower. Data can be output to a computer on site and an internet based monitoring sytem is under development.

Gaia-Wind 11 kW Noise (see data sheet)

Due to its constant and low rotational speed, the Gaia-Wind turbine is amongst the quietest in its class (the aerodynamic noise of a turbine increases exponentially with an increase in the rotational speed).