Technical Note TN683 (Revised) / May 2023

Wind Energy

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Summary

- Wind speed at your site is critical, doubling the wind speed gives an eightfold increase in power
- Choice of turbine location is critical
- Planning permission can be contentious and a considerable amount of preparation of an application will be required
- Grid capacity is constrained in many parts of the country so connection costs and timescales should be established early on
- Local use of energy to offset grid electricity will improve the viability of a project

Introduction

The wind resource in Scotland is the highest in Europe and over the last two decades there has been a huge number of turbines installed; many of them by farmers. A wind turbine can provide low carbon energy for use within a farm business or provide an additional revenue stream from export of electricity. Once installed, farming activity can continue around turbines and land take is minimal. This technical note examines the opportunities for development of new wind power projects by farms and rural businesses.

Wind resource

At any instant the power in the wind is proportional to the cube of its speed. Doubling the wind speed gives an eight-fold increase in power; a 7 m/s wind is 60% more powerful than a 6 m/s wind. As a starting point, modelled mean wind speed information can be found on-line from several websites by entering a grid reference or a postcode e.g. http://www.rensmart.com/Weather/BERR

Mean wind speed increases as height above ground increases and speeds are normally quoted for a range of heights for any given location. Published wind speed data of this type should only ever be used as a starting point and a more detailed estimate of the wind regime at the specific turbine location should be made before any investment decisions are made. The terrain over which the wind

flows as it approaches a turbine will affect not only the speed but also the level of turbulence experienced and sites with an open fetch free from buildings, trees or other obstacles should be chosen. The most accurate wind speed estimates can be made following a period of on-site measurement by erecting an anemometer on a temporary mast. Recorded data can then be correlated with long term data from a local meteorological station. An alternative is to have a site specific modelling exercise undertaken by a specialist consultant, such as a “Virtual Met Mast”. If external funding is to be obtained for a wind power project, many funders will specify the level of resource assessment that they require.

Turbines

Grid voltage wind turbines are available in a wide range of sizes with maximum outputs ranging from around 1 kW up to 10 MW (10,000 kW). At farm scale we normally consider turbines from around 5 kW up to 1 MW (1000 kW) with some farm businesses hosting windfarms with turbines up to 3 MW. Turbines above this scale are generally designed for off-shore deployment, however are becoming more common place on land as technology develops. The table below shows typical dimensions for different scales of machine;

Rated capacity (kW)	Hub height (m)	Rotor diameter (m)	Height to blade tip
6	12.0	5.5	14.75
11	18.0	13.0	24.50
50	24.0	16.5	32.25
250	30.0	29.0	44.50
800	50.0	48.0	74.00
2300	75.0	71.0	110.50
3000	78.0	82.0	119.00

Table 1: Typical dimensions for a range of turbine sizes

Turbine manufacturers will supply a **power curve** to show the turbine output at different wind speeds. At very light winds the turbine will not turn and no power will be produced until the **cut-in wind speed** is reached. As the speed increases more power is produced until the **rated power** of the turbine is reached, typically at about 12 m/s. Further increases in wind speed have little effect on output until the **shut-down speed** is reached when the turbine will shut down to prevent damage. The table below shows a typical power curve for an 800 kW turbine. The shape of the curve will be similar irrespective of the size of the turbine.

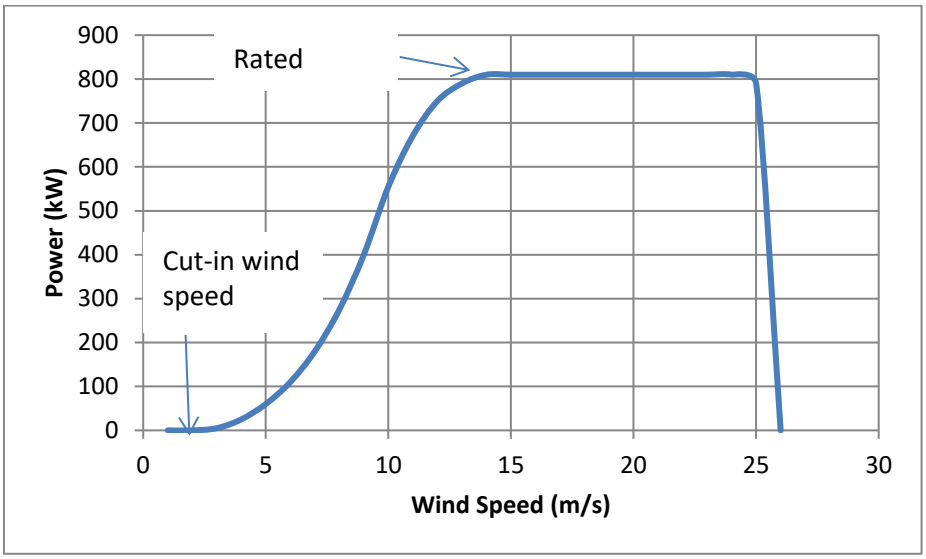

Figure 1: A typical power curve for an 800 kW wind turbine

The statistical distribution of actual speeds throughout the year around the mean will affect the output of a turbine and turbine outputs are often quoted based on a typical distribution known as the Weibull distribution. The actual distribution for a site can be calculated from long term wind data or estimated based on the type of terrain surrounding the site. Once the mean wind speed and the distribution about this mean have been estimated they can be used along with the turbine power curve to calculate the likely annual energy yield from the particular site. The estimated annual energy yields from an 800 kW turbine for a range of mean wind speeds and assuming it is erected on an open rural site free from trees or buildings is shown in Figure 2.

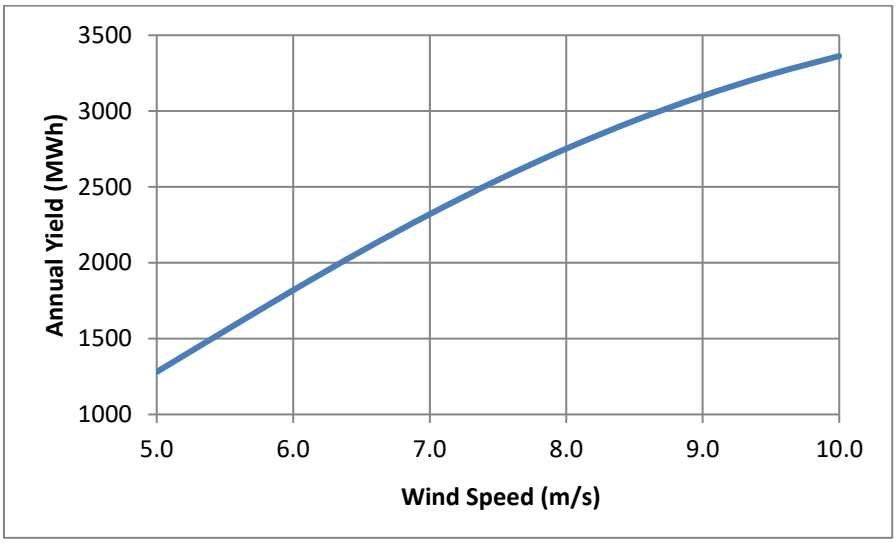

Figure 2: Annual yield from an 800 kW turbine depending on the mean wind speed at the site

Figure 2 clearly demonstrates why siting of a turbine is so important. Even a small increase in mean wind speed can make a considerable difference to the annual yield and therefore the return on investment obtained.

Planning Issues

Obtaining planning permission for a wind turbine can be contentious and as the scale of a development increases so to does the range of issues that have to be considered and the depth to which they have to be investigated. As a starting point national and local planning policy should be consulted. Most planning authorities will have specific policies relating to wind turbines and many will have undertaken a landscape capacity study which will provide guidance on where different scales of development may or may not be acceptable. Consultation with the local planning authority at an early stage is advised although they will consider each application on its own merits and will not provide a definitive decision on a proposal until a formal application has been received. For schemes including more than two turbines or where the hub height of any single turbine is greater than 15 metres a screening opinion should be sought in respect of the Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017. Many single turbine schemes may not require a full EIA unless there are site specific environmental concerns; however even where a full EIA is not deemed necessary the response received from the planning authority will provide guidance on the issues that should be covered if a planning application is taken forward. Issues that are likely to require addressing in supporting documentation with a submission include;

- **Aviation and radar –** The potential for interference with air traffic and radar installations needs to be investigated and confirmation that the proposal is acceptable to both military and civilian authorities must be shown.
- **Telecommunications –** Transmissions from radio masts and fixed microwave links will be affected where turbine blades interfere with their communication paths.
- **Landscape and visual impact –** is one of the most contentious issues with wind turbines and therefore requires careful consideration at the planning phase. Detailed plans showing the zone of theoretical visibility (ZTV) and detailed assessments of the visual appearance of the turbine from surrounding landscape types and important features will need to be included with an application along with graphical representations of the effect on the view from critical viewpoints. As turbine height increases so to does the distance from which it may be visible and hence the amount of effort required to prepare a landscape and visual impact assessment (LVIA). For turbines of 50 m or more producing an LVIA can be a costly exercise. The cumulative visual impact of the proposed turbine and any existing or other proposed turbines in the vicinity must also be considered.
- **Noise –** The intensity of any noise from a proposed turbine as received by local residences must be calculated and shown to be within acceptable limits. Where the overriding limit cannot be met a turbine can be deemed acceptable where the increase in noise level above the existing background level is kept within a reasonable limit. Measurement of existing background levels

over the full range of wind speeds will be required if this is the case. The cumulative noise effect of the proposed turbine and any existing or other proposed turbines in the vicinity must be considered.

- **Archaeological and cultural heritage –** both designated and non-designated sites in the locality should be identified and any effect of the proposed development quantified. These effects may include physical intrusion on to the sites or impacts upon their setting and surroundings.
- **Ecology -** There are many habitats and species in Scotland that are protected by legislation and potential effects on these must be properly assessed. Effects on birds from wind turbines is particularly important for obvious reasons but protected mammals such as badgers, otters, water voles and bats from turbines, access tracks, overhead lines and underground cables must also be considered.
- **Soil and hydrology –** may be affected by the construction process. Any necessary mitigation should be detailed at the planning stage.
- **Access and transport –** can be particularly problematic for larger turbines where oversized loads will have to be delivered to site. Site access and increased traffic volumes on minor roads during the construction phase need to be catered for in advance and proposed arrangements detailed in the planning submission.
- **Shadow Flicker –** can occur where the sun shines directly through a rotating turbine and directly on to a house window. This can be modelled in advance and if it is not possible to design it out then turbines can be programmed to shut down at times when this is likely to occur.
- **Decommissioning –** at the end of a turbine's design life should be considered from the outset and planning authorities will often require that a plan for removal and reinstatement is put in place at the commissioning stage.

Grid Connection

Only very small installations with a maximum system output of 3.68 kW per phase or less can be connected to your existing wiring without prior permission from the district network operator (DNO). In these cases the turbine would have to be installed by an approved installer and the DNO should be informed within 28 days.

For all other turbines permission must be obtained before a connection is made. Obtaining permission for connecting systems of up to 50 kW can be fairly straight forward in most areas provided a 3 phase supply is available although any requirement to upgrade existing transformers should be checked in advance of committing to purchase of a turbine. As turbine size increases potential connection problems will become greater. Many areas of Scotland have constrained networks already operating at their design capacity and access to the network may require extensive

upgrading to the local distribution network or the national transmission network. This can not only add huge costs to a potential project it can also result in substantial time delays (often of several years) before a new generator can be connected. Liaison with the DNO at an early stage is advised. In order to be completely sure that a connection will be available when required it is necessary to have received an offer of connection including a connection date and have paid a deposit to secure the grid capacity.

Local Demand

Where a local demand exists for energy the income gained from a wind turbine can often be enhanced by offsetting purchased electricity. Remember that energy will only be produced when the wind is blowing and in most cases energy will have to be imported from the grid to meet demand on calm days. When estimating the financial benefit of a turbine to your business careful comparison of the demand profile of the site with the estimated yield profile of the turbine is important. Smart controllers are becoming available that will switch on local loads when renewable generation is high. Examples of the type of load where this could be appropriate is water heating where the water can be stored within a thermal store until required or ice building within refrigeration plant. Battery technologies or the generation of hydrogen are also developing areas that can help to make the most use of your renewable generation.

Revenue

With the removal of incentive schemes such as the Feed-in-Tariff (FIT), the main drivers for small-medium farm scale renewables are to provide security against volatile energy markets, offsetting grid bought power and providing green opportunities from becoming more energy self-sufficient. Inflated energy prices can also help significantly lower the payback periods for farm renewables.

Income from a wind turbine can be derived from the following sources;

- Sale of exported energy – either from a power purchase agreement (PPA) or from export tariffs such as Smart Export Guarantee (SEG).
- Savings on imported energy – energy used on site to offset imported energy will normally provide a greater saving than the export rate available.

For more info on SEG and other government schemes see:
https://www.ofgem.gov.uk/environmental-and-social-schemes

Banks and financial institutions may offer favourable rates for loans on renewable and green projects. Further support may be available through schemes such as Business Energy Scotland, who offer a SME Loan and other cashback options.

More info on Business Energy Scotland can be found here: https://businessenergyscotland.org/smeloan/

Budget costs

Overall project costs for wind turbine installations will depend on the infrastructure costs associated with the particular site, the scale of turbines installed and the cost of a grid connection can be a large part of this where substantial grid upgrading is required. Construction costs will also vary over time due to changes in raw material costs and economic conditions, therefore it is advisable to shop around to get the best deal.

Business rates

Business rates in Scotland were reviewed in 2023, for the first time since 2017. Rateable value is not purely based on the size of the installation, as a number of other factors are taken into account. Once the basic parameters of a potential scheme are established it should be possible to estimate the likely rateable value. Wind turbines could be eligible for relief which can result in a reduction in rates paid. The exact rates and reliefs can be subject to changes in government policy and legislation. To obtain accurate and up-to-date information on business rates for hydro schemes in Scotland, it is recommended to contact the local assessor's office or consult with a qualified professional.

For more info on Renewable Energy Generation Relief see: https://www.mygov.scot/non-domestic-rates-relief/renewable-energy-generation-relief

Carbon Savings

The carbon saving attributable to any renewable energy generator will depend on the generation portfolio of the grid electricity that is offset. The electricity grid is becoming greener all the time as more renewables contribute to our electricity demand, but fossil fuels are still a major source. In 2022 the mean CO_2 intensity of the UK electricity grid was 182gCO_2/kWh. An 800 kW wind turbine on a site with a 7.0 m/s mean wind speed supplying an annual yield of 2320 MWh annually would therefore have resulted in CO_2 savings of 422 tonnes in 2022.

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