SERIES 12

CPD fundamentals

THE CONTINUING PROFESSIONAL DEVELOPMENT PROGRAMME

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MARK THROWER MANAGING EDITOR

MODULE SEVEN

SMALL SCALE WIND TURBINES

Small wind turbines: making them work for you

By Neil Peacock, managing director Energy International

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Wind energy has a very long history- hundreds, possibly thousands of years. Wind was probably the first form of energy that man used other than elbow grease. Wind has commonly been used for milling grain and pumping water and of course as a means of propulsion. Now though, driven by the need to reduce greenhouse gas emissions and secure home-grown energy supplies, wind energy is the world's fastest growing renewable energy type. In 2011 in the UK, wind energy made a contribution of about 16TWh, which equates to around 4.5 per cent of total generation. The government's feed in tariff scheme (FITs) has had a significant impact on the economic attractiveness of small wind energy schemes and they are now quite poplar, particularly with farmers and in rural areas.

Before discussing small wind turbines it is important to define what is meant by ‘small’. Wind turbines are now available in sizes ranging from less than 1kW to 8MW. For the purposes of this article the definition provided by Renewable UK (http://www.renewableuk.com) has been adopted. This is actually the definition of small- and medium-sized wind turbines and that is, up to 50kW and up to 35M total height. Table 1 and the graphic over page (Fig 1.) expand on this definition.

There are two major distinctions in small wind turbines - vertical or horizontal axis. Horizontal axis machines are far more common than vertical axis. The claimed advantages of vertical axis machines include:-

- less intrusive visually;
- quieter;
- more bird and bat-friendly; and
- less expensive to maintain.

A number of the really small wind turbines (micro) were derived from those used commonly on navigation buoys, sailing boats and canal narrow boats for battery charging.

Choice of size is influenced by a number of factors. Probably the most significant of these is the power requirement of the site. Most small sites choose to consume the majority of the wind-generated power on site rather than to export it. Exported power normally has a much lower value than that consumed on site.

Another major consideration is space and visual impact. Love them or hate them, wind turbines are very conspicuous and difficult to hide.

Generally, the higher the hub of the turbine the better from a performance point of view. Because of this the toppling loads at the base of the turbine mast can be considerable thus significant foundations are usually required. This can involve piling and a significant mass of concrete. Some turbines use guy wires to support them which may reduce the amount of foundation work required.

Some years ago there was a spate of interest in small building-mounted turbines. DIY giant B&Q actually started to retail a turbine in their stores. David Cameron even had one mounted on his house.

An authoritative study in published in 2009 showed that most building-mounted turbines performed poorly, mainly due the turbulence caused by nearby structures. Fears were also raised regarding the potential damage that turbine induced vibration and stresses could cause to buildings.

While it would be incorrect to say that all building-mounted wind turbines are unlikely to be successful it is true to say that the problems associated with this type of installation are significant and that great care needs to be taken to overcome these.

There are some very remote areas of the UK, particularly islands where a mains electricity supply is impractical and not cost effective. In these circumstances wind turbines are often used in ‘stand-alone’ mode, possibly in conjunction with a diesel or petrol powered generator or photo voltaic panels. Here, the output is generally low voltage DC and this is usually connected via a suitable regulator to one or more storage batteries. The batteries are usually of the lead - acid type, these tending to be the most cost effective in terms of £/kWh. The output from the batteries can be used directly or more commonly through an inverter to produce 230 VAC.

Although the standalone approach is ‘green’ and to some extent provides security of supply it is still an expensive option when compared with grid supplied electricity.

Much more commonly wind turbines are operated in parallel with the grid. Here the output of the turbine is fed directly to an inverter which converts the DC output to AC and which is synchronised with the grid supply.

As with any grid-connected generator a monitoring and protection system has to be in place to prevent a dangerous situation occurring or any interference with the grid electricity quality. Design, testing and commissioning of these systems needs to be done in full consultation with the DNO and in the light of documents G83/1 and G59/1. These documents can be obtained from OFGEM at:

https://www.ofgem.gov.uk/

Table 1

Small wind systems	Power (kW)	Annual energy production (kWh)	Total height (m)	Total installed cost (£)
Micro wind	0–1.5	Up to 1,000	10-18	0.5 – 5k
Small wind	1.5–15	Up to 50,000	12-25	2 – 50k
Small-medium wind	15–100	Up to 200,000	15-50	50 – 250k

Note: The average UK domestic household consumes approximately 4,400 kWh per year.

Source: RenewableUK

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When considering small wind turbines it is likely that the site will be pre-determined. That is to say it is where the power is to be consumed.

A logical approach to determining the feasibility of a wind turbine installation is to first estimate the theoretical annual energy production using data from a reliable source and a tried and tested calculation methodology. Then, if this looks attractive move on to site monitoring.

As wind passes over land it loses energy through friction. Therefore, in general terms the further over land the wind travels the lower its velocity will be and the higher above land its velocity is measured the higher its velocity will be. Simplistically therefore the closer to the coast and / or the higher above land a wind turbine is mounted the better it is likely to perform.

There are now numerous estimation methods and sources of wind speed data available, to allow the estimated likely performance of a wind turbine installation to be determined. It is beyond the scope of this article to consider all of these in any level of detail. Two commonly used sources of information are described below.

The NOABL (Numerical Objective Analysis Boundary Layer) database was developed by the now defunct Department for Trade and Industry (DTI), passed on to the Department for Business, Enterprise and Regulatory Reform (BERR), and most recently to the Department for Energy and Climate Change (DECC). The database does not appear to have been updated for several years and is no longer supported by DECC. Despite its age and apparent abandonment by HM Government NOABL is still widely used by the small and medium size wind turbine industry.

The NOABL database web tool can be accessed at:-

http://tools.decc.gov.uk/en/windspeed/default.aspx

The Met Office draws comparisons between its own observations and analysis and concludes:-

'In summary, the Met Office UK small and medium wind databases should be used in preference to NOABL as a more reliable source of local area long term average wind speeds for site search purposes, for both the small and medium wind market sectors.'

The document from which this abstract is taken can be found out:-

http://www.metoffice.gov.uk/media/pdf/l/7/14_0058_Site_search_for_sml_med_wind_projects.pdf

Fig. 1 The graphic shows the basic components of the different connection modes.

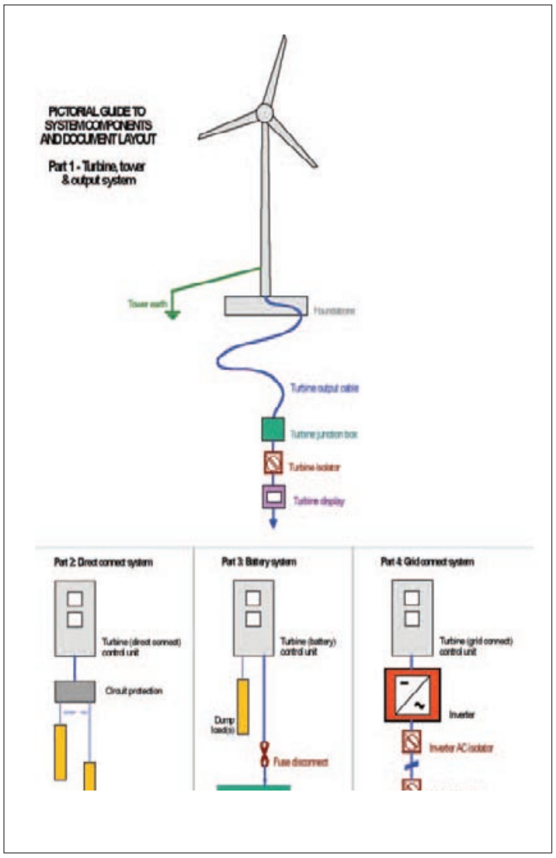
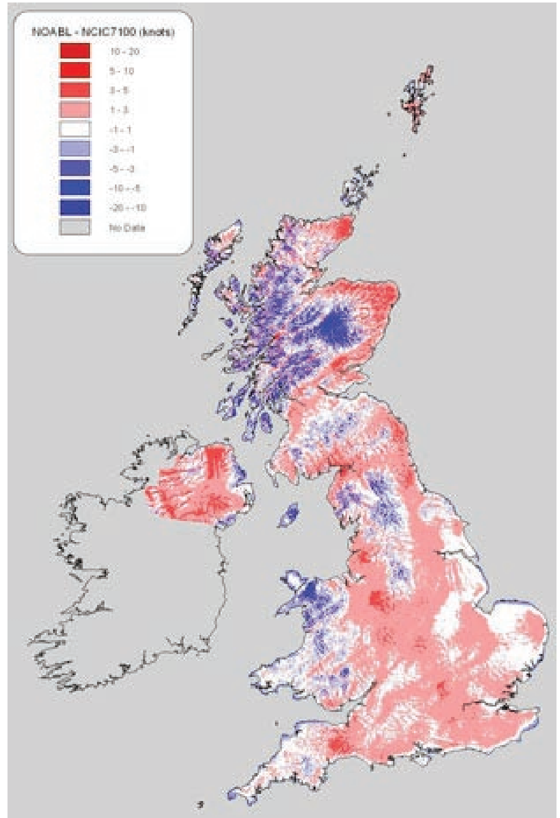


Fig. 2 The 'Wind Map' of the UK shows how the Met Office has compared its data with that found within NOABL.



Source: http://www.metoffice.gov.uk/renewables/wind-map

Above left, the performance of any wind turbine installation is crucially dependent on the average wind speed and its quality i.e. lack of shading and turbulence. Wind speed and quality is determined by geographical location and local topography.

The Met Office also has a product called Virtual Met Mast:-

http://www.metoffice.gov.uk/renewables/vmm

This appears to be an extremely useful tool for obtaining wind data for specific sites.

Local topography can have a major impact of wind turbine performance. Hills, valley, trees and buildings can shelter the turbine reducing wind speed. They can also cause turbulence which, again can have a serious effect on turbine performance.

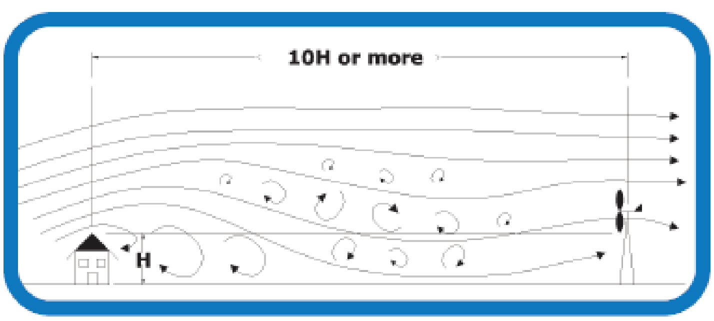
Small and medium sized wind turbine schemes are supported and incentivised by HM Governments feed in tariffs (FITs). In would be surprising and unusual for anyone to contemplate a wind turbine installation without ensuring that it would qualify for FITs. In order to qualify for FITs the turbine supplier must be accredited under the Micro Generation Certification Scheme (MCS) as must the installer. Importantly the methodology to be used to determine the likely performance of a wind turbine installation is defined by the MCS in its publication: Microgeneration Installation Standard: MIS 3003 available at:

http://www.microgenerationcertification.org/images/MIS per cent203003 per cent20- per cent20Issue per cent203.3 per cent20- per cent20Micro per cent20Wind per cent202013.12.16 per cent20FINAL.pdf

This document actually specifies that: 'An estimate of annual energy production shall be calculated using the standardised procedure detailed below.' The procedure referred to here is NOABL. There will be more discussion on MCS and FITs later.

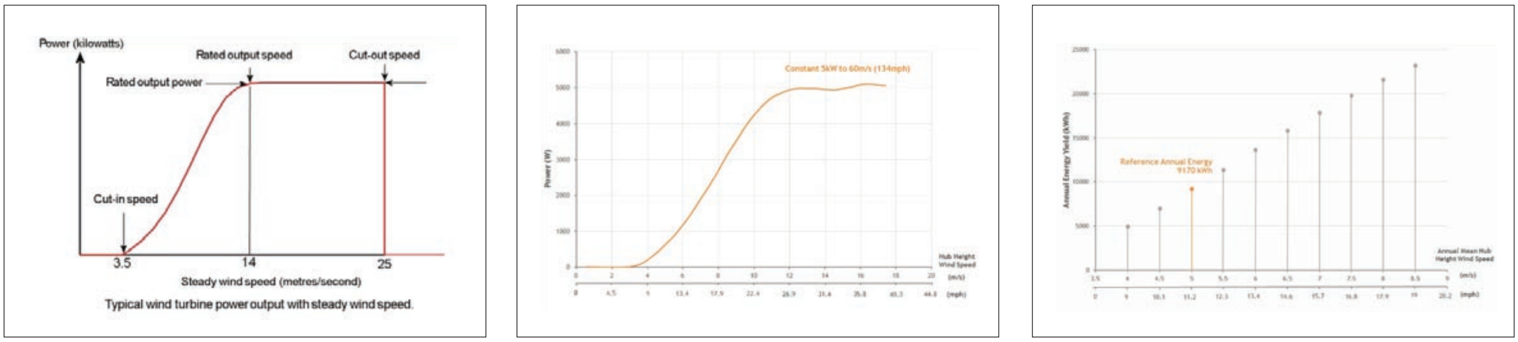
As well as estimating annual energy

Fig. 3 Ideally turbines should be sited well clear of an obstacle



Source: The Energy Saving Trust document CE72

Fig. 4 Some typical small turbine power output curves



Source: The Energy Saving Trust document CE72

Source: http://www.evancewind.com/products/10kw-solution/system-performance

production it is generally regarded as good practice to carry out some wind speed monitoring to see if theory is likely to be borne out in practice. It is worth pointing out here that the weather varies from year to year so neither the database nor monitoring is guaranteed to give a precise estimate of energy production over the life of a project.

Monitoring is usually carried out using a mast, an anemometer and a data logging system. Most suppliers, installers and specialised consultants should be able to undertake monitoring.

Ideally the monitoring mast will provide wind speed and direction at the hub height and geographical position as the proposed turbine installation.

Once a reliable estimate of the annual average wind speed that the proposed wind turbine is likely to experience has been established an estimate of annual energy production can be made.

This can be done by applying the estimated mean annual wind speed at the turbine to the wind turbine manufacturer's Annual Energy Performance Curve to obtain an estimate of the annual energy output. Discretion is required in applying further factors to reduce the estimated annual energy output, due to turbulence, underlying topography or obstructions in other directions.

It is important to note that wind turbines generate no power below a certain wind speed. Once the wind speed reaches the maximum that the turbine is designed for either it is braked, preventing the blades from rotating, the blades are feather or the blades are turned out of the wind direction (weather cocked), in all such cases no power is produced.

With a knowledge of the average wind speed and the turbine performance it is relatively straightforward to determine the likely annual energy output in kWh.

When calculating the financial return it is necessary to consider:

• the Feed in Tariff;

• how much of the power can be consumed on site; and

• any exported power

Again it is a relatively straightforward task to calculate the value of the power.

The latest feed in tariff rates are shown in the tables 3 and 4 below.

Before considering a wind turbine installation there is quite a long list of considerations which need to be addressed.

Probably the first and most important consideration for most people is 'will it work' and 'when will I get my money back'. This is hopefully well covered above.

Planning permission is required in almost every case and the issues covered below may feature in the requirements of any planning application and subsequent planning information requirements.

The height and location of the wind turbine will affect whether planning permission is needed. Generally, those with rotor diameters of more than two metres will require consent. Where a turbine is to be used purely for agricultural purposes on agricultural land, there may be a farming general consent covering the installation, nevertheless the local planning authority should still be informed.

Visual Impact – Often the requirements of a good wind turbine installation i.e. the higher the better are in direct conflict with this element.

Table. 3

Description	Period in which Tariff Date falls	Tariff (p/kWh)
Wind with total installed capacity of 1.5kW or less	1 April 2014 to 30 September 2014	17.78
	1 October 2014 to 31 March 2015	16.00
Wind with total installed capacity greater than 1.5kW but not exceeding 15kW	1 April 2014 to 30 September 2014	17.78
	1 October 2014 to 31 March 2015	16.00
Wind with total installed capacity greater than 15kW but not exceeding 100kW	1 April 2014 to 30 September 2014	17.78
	1 October 2014 to 31 March 2015	16:00

Table. 4

Annual Average Wind Speed	7	m/s		Import Rate	12	p/kWh
Turbine Power Output	1.5	kW		Value of Avoided Import	1,238	£/a
Annual Energy Output	12,900	kWh		Export Rate	4.77	p/kWh
Feed in Tariff Rate	16	p/kWh		Value of Exported Power	123.07	£/a
Value of FIT	2,064	£/a		Total Value of Power	3,425	£/a
Amount Consumed On Site	80%			Total Installed Cost	£ 44,000	
				Simple Pay Back Time	12.84	years

Typical Small Turbine Calculation

Noise – Generally the noise generated by small wind turbines emanates from two sources:

• aerodynamic noise from the rotating blades; and

• mechanical noise from the generator

Whether the noise is considered a nuisance depends to a large extent on the level of background noise. Turbine noise increases with operating duty, but background noise is also likely to increase with stronger winds. With building-mounted turbines, mechanical vibrations may also be experienced as audible noise.

Flicker – This issue is rare. In some situations due to geographical position and time of day, the sun may pass behind the rotors of a wind turbine and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as 'shadow flicker'.

Birds and Bats – Again, in rare cases particularly where the ecology is felt to be especially valuable and/or sensitive the effect of the proposed turbine may need to be assessed.

There is a wide size range of wind turbines suitable for marine, mobile and larger fixed installations such as farms. However, building mounted turbines are problematic due to turbulence.

Wind turbines can provide a 'standalone' source of power or they can be grid connected.

Considerable care is required to ensure a wind turbine installation operates effectively. There are good sources of data and estimation methodologies to facilitate this.

Annual average wind speed, turbine hub height and lack of turbulence are key features in ensuring good energy yields.

With careful installation and government incentives wind turbines are a reasonably attractive proposition.

For details on how to obtain your **Energy Institute CPD Certificate, see entry form and details on page 36**

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CPD ENTRY FORM

BEHAVIOUR CHANGE

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

QUESTIONS

1. What is the most critical factor affecting the output of a wind turbine?

- ☐ Hub height
- ☐ Wind speed
- ☐ Distance from houses
- ☐ Distance from the coast

2. What device is commonly used to convert the DC output of a turbine to AC?

- ☐ A regulator
- ☐ A rectifier
- ☐ An inverter
- ☐ A battery

3. Which body is responsible for accrediting wind turbine installations with regard to FITs?

- ☐ Microgeneration Certification Scheme
- ☐ Department of Energy and Climate Change
- ☐ Environment Agency
- ☐ Post Office

4. How is wind speed normally expressed when estimating turbine performance?

- ☐ Kilometres per hour
- ☐ Beaufort Scale
- ☐ Miles per hour
- ☐ Metres per second

5. What size range are Small and Medium Wind Turbines normally considered to be?

- ☐ >50m hub height
- ☐ >50kW
- ☐ <150kW
- ☐ 10 - 25kW

6. Which organisation is responsible for setting the Feed In Tariff rates?

- ☐ HM Treasury
- ☐ OFGEM
- ☐ Department for Energy and Climate Change
- ☐ Electricity Suppliers

7. Which piece of turbine supplier information is most important when determining the likely annual performance?

- ☐ Height of the turbine tower
- ☐ Annual Energy Performance Curve
- ☐ Turbine blade diameter
- ☐ Maximum turbine output

8. In what units is annual energy output of a turbine expressed?

- ☐ kW
- ☐ £
- ☐ kWh
- ☐ Therms

9. What device is usually used to measure wind speed and direction?

- ☐ Laser doppler
- ☐ iPhone
- ☐ Anemometer
- ☐ Gas meter

10. In 2011 in the UK what was the contribution of wind to the total electricity generation in per cent terms?

- ☐ 1 per cent
- ☐ 4.5 per cent
- ☐ 15 per cent
- ☐ 28 per cent

Please complete your details below in block capitals

Name .... (Mr. Mrs, Ms) ....

Business ....

Business Address ....

....

....

Post Code ....

email address ....

Tel No. ....

Completed answers should be mailed to:

The Education Department, Energy in Buildings & Industry, P.O. Box 825, GUILDFORD, GU4 8WQ

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CPD fundamentals

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The articles, written by a qualified member of the Energy Institute, will appeal to those new to energy management and those with more experience of the subject.

Modules from the past 11 series can be obtained free of charge. Send your request to mark.thrower@btinternet.com. Alternatively, they can be downloaded from the EiBI website: www.energyzine.co.uk

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