Rewarding Learning

AS LEVEL

Environmental Technology

Energy from the Wind (3)

For first teaching from September 2013

For first award in Summer 2014

FACT FILE

environmental technology

FACT FILE

environmental technology

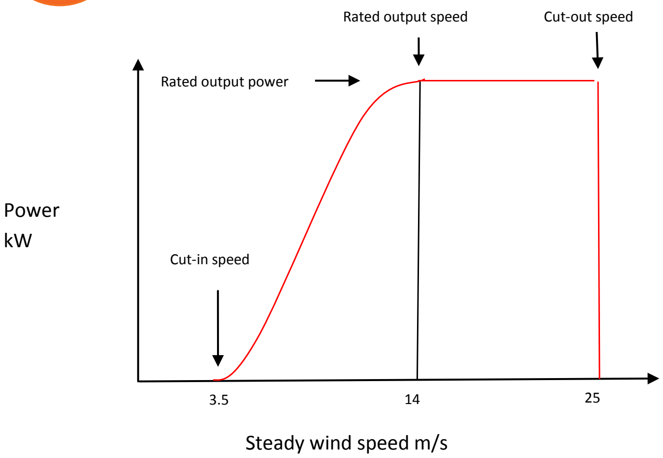
Energy from the Wind (3)

Specification Content

Students should be able to:

- define wind survival speed as the maximum wind speed that a turbine is designed to withstand before sustaining damage;
- understand that all wind turbines are designed with some element of power control;
- explain how 'yawing' ensures that the turbine faces on-coming wind; and
- discuss how commercial wind farm ventures seek to optimise the location for their turbines by considering energy output, costs, environmental and social issues.

Course Content



The typical power curve for a wind turbine as shown above, and in the Energy from the Wind Fact File 2, has three important speeds – **cut-in**, **rated output** and **cut-out**. A typical wind turbine system will produce maximum power at a range of wind speeds from rated output to cut-out speed. In addition to these three speeds there is another important speed measurement which is not shown on the power curve. This is known as the survival speed. It is the maximum speed above which the system would not be able to survive. In other words the maximum speed that the turbine can withstand before sustaining damage. For this reason it does not and cannot appear on the power curve. Typical values for survival speeds for commercial wind turbines range from 40 m/s to 72 m/s. The most common survival speed is typically in the region of 60 m/s.

For this reason there needs to be some form of **power control** in a wind turbine system which is designed to ensure the safety of the device. Above a certain wind speed, the turbine will effectively shut down. There are a range of **power control** systems which can be used to turn off a turbine if wind speeds threaten the structure.

A system which can be used for power control in a turbine must activate when the wind speed is above a certain limit. This is similar to the braking system in a car except that it uses different methods to slow down or stop the rotation of the turbine blades, indeed, some use forms of mechanical and electrical brakes. Some use a power control system that slows down the rotation of the rotor when wind speeds get too high and then produce an opposite effect when the wind is back below the prescribed limit. There are several

iStock / Thinkstock.com

iStock / Thinkstock.com

types of braking systems used;

- **Pitch control** – This system alters the pitch, or angle between the blade of the rotor and the wind, to slow down the blade rotation. The turbine's controller monitors the turbine's power output. At wind speeds over a certain limit, the power output will be too high, at which point the controller alters the pitch of the blades so that they become less aligned with the wind. This slows the rotation of the blades. Pitch controlled systems obviously require the angle at which the blades are attached to the rotor to be adjustable.
- **Passive stall control** – In this system the blades are attached to the rotor at a fixed angle but are designed so that the twists in the shape of the blades themselves will apply the braking effect if the wind becomes too fast, making the rotor slow down (or stall being the term used). The blades are angled so that winds above a certain speed will cause turbulence on the upwind side of the blade, slowing them down.
- **Active stall control** - The blades in this type of power control system are of variable pitch, similar to the blades in a pitch controlled system. An active stall system reads the power output in the way that a pitch controlled system does, but instead of pitching the blades out of alignment with the wind, it pitches them to produce stall.

iStock / Thinkstock.com

Another form of control used for wind turbines involves ensuring that the rotor faces into the wind at all times for differing wind directions.

This is known as controlling yaw which is a term used in marine and aeronautical applications to describe direction. Some small scale wind turbines use a simple vane on the rear of the turbine hub to control the position of the rotor blades relative to the wind.

A more sophisticated system for controlling yaw on larger scale wind turbines uses an anemometer on the rear of the hub to measure wind direction and a system known as the yaw drive turns gears within the hub of the rotor to align the blades with the wind.

iStock / Thinkstock.com

By minimising the misalignment between the wind direction and the direction in which the turbine is pointing the power output is maximised. However, as the wind can change direction quickly and continuously there can always be deviation between the wind and the turbine.

Yaw control is only employed in horizontal axis turbines.

Commercial Wind Farms

These are becoming increasingly common and the operators of these wind farms as they are known have a variety of factors to take into consideration when choosing a location such as;

- **Energy output** – which will be dependent on the location and the technology being used,
- **Costs** – the costs of installing and maintaining the equipment and subsequent connection to the electrical grid system,
- **Environmental issues** – the impact on the local environment in terms of effect on land use and the natural habitat,

iStock / Thinkstock.com

- **Social issues** – the possible impact on local residents who may object to large wind turbines impacting on the visual nature of the location and possible noise effects

Activity

Use the case studies to be found at the link

https://www.greencatrenewables.co.uk/case-studies-and -capability-statements/

to produce a summary of the key issues considered by commercial companies in the development of commercial wind farms paying particular attention to the points outlined above.

COUNCIL FOR THE **CURRICULUM, EXAMINATIONS** AND **ASSESSMENT**
29 Clarendon Road, Clarendon Dock, Belfast BT1 3BG
Tel: +44 (0)28 9026 1200   Fax: +44 (0)28 9026 1234
Email: info@ccea.org.uk   Web: www.ccea.org.uk