The 600kW Wind Turbine at CAT

In May 1997 a large new wind turbine appeared on the hill behind CAT. It is a new design with features that meet some of the objections of those opposing wind farms...

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CAT has been experimenting with wind turbines for twenty years. Thanks to a collaboration with the Wind Energy Group and support from the Non Fossil Fuel Obligation, we are helping to test a revolutionary new design. This tipsheet explains both the reasoning and the technology behind the MS4-600kW wind turbine.

Background

The strength of the renewable energy sector in Britain to date has been largely determined by a piece of Government legislation known as the Non Fossil Fuel Obligation (NFFO). This legislation has required English and Welsh Regional Electricity Companies (RECs) to buy at least some of their power from sources other than coal, gas and oil-fired power stations.

The legislation was originally intended to protect the nuclear power industry following electricity privatisation (nuclear is still more expensive than all the fossil fuels and wind), but NFFO has become the main targeted subsidy for renewables.

Approximately every two years the Government allows power producers to submit applications for new power schemes. The whole process is known as a tranche. The Government then agrees to pay the difference between the unit cost of electricity generated by the supported schemes and the price the RECs are willing to pay (which is always an average price determined by the general state of the market). Until 1998 nuclear power received most of this subsidy, but with each successive tranche a number of new renewable projects are given life. All the money comes from a levy on consumers' bills, which amounts to 10%. On an average bill of £300 the levy will be £30 and renewables will get about £2. Separate rules apply to Scotland and N. Ireland. There have been four tranches in England and Wales.

History of the CAT wind turbine

Following tranche no.1, in 1990, two of the first commercial windfarms in the UK were built in Wales within a few miles of CAT: at Cemmaes and Llandinam. Ex-CAT employees helped to set up the new schemes. It seemed appropriate therefore that there be at least one large, windfarm-scale turbine sited within range of the Centre, both for the interest of the casual visitor and for educational purposes, to complement CAT's existing range of small and medium sized wind turbines.

CAT had no capital to invest in such a scheme, but during the next few years several options were explored, involving various joint financing packages, to erect between one and four turbines on the hills adjacent to the Centre. However, none of these projects reached fruition.

The MS4-600, erected in April 1997, now owned and controlled by CAT Energy Ltd.

When NFFO-3 was announced, CAT decided to put in a bid for its own project, and received approval in December 1994 for a single machine on Mynydd Glandulas, a 260m hill above the Centre opposite the existing 15kW Polenko wind machine (which now seems minute in comparison!). Carter Wind Turbines (now no longer trading) offered to donate an innovative 300kW machine in return for a percentage of the profits.

Subsequently this machine became unavailable, and other collaborators were sought. In 1996 discussions were begun with the Wind Energy Group Ltd (WEG), at that time a wholly owned subsidiary of Taylor Woodrow and the sole British manufacturer of large turbines, who were looking for a site for an innovative new 600kW downwind machine - the MS4-600. Planning permission was given in July 1996, with no written objections. Approval for the

change of machine was gained from NFPA (the Non Fossil Purchasing Agency), who administer the NFFO contracts, and work began in the autumn of 1996.

The electricity

The energy generated will go directly into the National Grid, and will be equivalent to the electricity demand of the Dulas Valley (the valley in which the Centre is situated). CAT and WEG believe that local communities should benefit from windfarms, and so a proportion of the income from the turbine will be put into a trust. This will be used to fund energy efficiency projects in the immediate locality of the machine, thus making the link between the need to generate energy from non-polluting sources and the need to reduce our energy demand.

The MS4-600

The MS4-600 has been developed by WEG with finance from the UK DTI and the EU's Joule II programme as a successor to their 400kW MS3. The aim was to build a low-weight, three-bladed, 600kW machine, with state-of-the-art low noise levels and a self-erect capability, suitable for sites with poor access. Conventional wisdom suggests that a downwind, free yaw (yawing is explained below) machine would satisfy these criteria, but that potential problems with yaw stability and noise from 'tower thump' (the sound made as the blades pass behind the tower) would need to be overcome.

Yawing is the term for swivelling on the tower top as the rotor turns to 'find the wind'. On a two bladed machine the rotor shudders when it yaws, particularly when in the horizontal position.

Experiments with scale models showed that flexible blades should overcome the yaw problem, as the ability of the blades to alter their plane of rotation under skewed winds produces a thrust that opposes the skew. It was also estimated that tower thump should be eliminated by giving the rotor a clearance from the tower of between five and six tower diameters.

Both of these solutions cut down the noise from the turbine, which would please anyone living very near to one.

The basic features of the machine are as follows.

Performance

The machine has a nominal rated output of 600kW at 12m/s and an extreme windspeed of 70m/s. Its predicted output with a AMWS of 8.5m/s at hub height is 2,130MWh/yr.

Rotor

The rotor is 41m in diameter and comprises three glass/epoxy resin composite blades, attached to flexible 5m spars of laminated pultrusions. The blade shell forming the aerofoil also gives flexibility. In addition to increasing yaw stability, the flexibility reduces 70m/s storm loads by 50%, allowing a more slender tower and smaller foundations than is usual for a machine of this size. The rotor turns at 29rpm and has a nominal tip speed of 63m/s.

Nacelle

The nacelle is the box which you can see supported by the tower. It houses the gearbox, which cranks up the turning speed of the generator, so that it can produce electricity of the right frequency.

To reduce bending loads on the tower the nacelle has been elongated, with the gearbox and generator at the back balancing the rotor. This gives it a pleasing, streamlined appearance. The connection between the nacelle and tower can flex, which reduces any gyroscopic loads (these produce intense pressures on the rotor hub when it yaws to find the wind). The nacelle is also set slightly off-centre from the tower, which both aids installation and reduces blade tower wake interference. The damped nacelle yawing means that the rotor can follow rapid wind direction changes smoothly.

Tower

The tower is a 40m high tapered steel tube in two sections.

Gearbox

The gearbox is a three stage planetary/parallel/parallel type with a 51.7:1 ratio. It has a three point mounting to the nacelle, the two rear mountings being soft rubber to reduce noise.

Generator

The generator is a three phase induction generator rated at 600kW, at 660V and 50Hz.

Brake

All wind turbines need a brake, both to allow the blades to be stopped manually for maintenance tasks to be completed and to cut-in automatically to prevent damage during storm conditions. Braking on the MS4-600 is by means of a spring-applied calliper brake on the high speed shaft disc. It is released by hydraulics and by whole-blade pitching towards stall.

Installation

The intention is to manufacture the rotor and nacelle of future production models to weigh in at around 25 tonnes (for technical reasons this prototype weighs somewhat more). This is light for a turbine of this output. It is therefore possible to erect the machine using a small off-load crane, rather than the 100-500 tonne capacity normally required. With more conventional installations, the crane is the largest vehicle needing access to the site, and determines the quality and size of the access road needed. With this machine financial savings can be made on road works, and environmental damage is also minimised. The ability to erect without a large crane makes the turbine particularly suitable for hard-to-access sites, which is especially useful for applications in 'developing' countries.

The tower is raised by an A-frame and winch. The nacelle, with the blades attached, is then pulled up the tower using the same winch.

The machine at CAT

The machine here was erected in April 1997. The annual mean windspeed at the exact site is around 7m/s, giving an estimated annual output from the machine of 1,196MWh/yr less 3%. This is enough to meet the electricity demands of around 200 homes. At present the machine does not operate at windspeeds in excess of 14m/s due to a resonance in the shafts, blades and generator which causes current output to be reduced. This is the subject of ongoing research.

The MS4-600 is now owned and controlled by CAT Energy Ltd. Performance data from the machine is used by the Centre for educational purposes.

Access

The turbine is on private land and there is no public access to it, although a public footpath, clearly indicated on OS Map Landranger 135, passes close by.

Now that the machine is operational there is a viewing platform at CAT.

Further information on windpower

It's A Breeze! A Guide to Choosing Windpower
Windpower Workshop: Building Your Own Wind Turbine
Windpower Teachers' Guide
Windpower Pupils' Guide

Please ring for prices. Add 20% to the total order value for post and packing (minimum £3.00) and send to the Mail Order Department or phone credit card orders to 01654 705959.

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