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An Arctic Wind Turbine in Northern Sweden

Highlights

- **1,710 MWh production in the first year of operation**
- **95% availability during 1999**
- **Operation at temperatures down to -20ºC**
- **Energy demand for de-icing less than 3% of generated energy**

Summary

Good wind conditions make areas of northern Sweden and Finland attractive sites for wind turbine installations. However, to work successfully in the prevailing arctic conditions, wind turbine designs need to be modified to withstand low operating temperatures and ice accumulation on the rotor blades.

The 600 kW wind turbine at Suorva produced 1,710 MWh of electricity during its first year of operation. During 1999, availability was 95%, with only 9–10 days when extreme temperatures led to the turbine being shut down. The system is designed to operate at temperatures down to 20ºC below zero, with the lowest temperature so far being -37ºC.

Project Background

In early August 1998, the Swedish utility Vattenfall AB contracted Bonus Energy A/S to deliver one 600 kW Mk IV wind turbine, equipped for arctic conditions, to Suorva in northern Sweden. Construction work began later that month and the turbine was delivered to the site at the beginning of October.

Turbine performance is being monitored from 1999 to 2001 to evaluate the following:

- operation and maintenance;
- public acceptance;
- environmental impact;
- power performance;
- ice-loads/stresses;
- acoustics.

The Project

Suorva is located 100 km north of the Arctic circle, near the source of the Stora Lule river. The area is surrounded by mountains with peaks 1,400–1,500 m above sea level. Although over 100 km from the nearest village, the site is only 300 m from the road and from the existing local 10 kV grid. The turbine stands on a small ridge in the valley at 470 m above sea level.

Wind conditions during the turbine's first year of operation were measured and analysed as follows:

- mean annual wind speed, at a height of 35 m, was 7.5 m/s, with the highest observed wind speed being 32 m/s;
- channelling effects in wind distribution were observed in the direction of the valley.
- icing conditions, defined as occasions when relative humidity exceeds 95% and temperatures drop below 0ºC, were experienced 2–4% of the time.

Wind speed is measured on a 50 m high mast, located 900 m above sea level on a mountain, 7–8 km south-east of the turbine. In December 1997, one-minute average wind speeds exceeding 50 m/s were measured during a five-hour period before the anemometer broke down.

Inhabitants and visitors to the area include reindeer herders, tourists and service personnel from two nearby hydro power stations. Their opinions about the wind turbine are being assessed through interviews.

Plant Data

The turbine is a three-bladed Bonus Mk IV, specially equipped for arctic conditions. The rotor is an upwind model with a 44 m diameter and 1,520 m^2 of swept area. Rotor speed is variable at 27 or 18 rpm, depending on wind speed. The output is 600 kW from an asynchronous generator at 690 V; this is transmitted by a 20 m cable to an 800 kVA transformer with an output of 12 kV. The transformer housing is grey to minimise visual impact and is anchored to the rocks with steel wires.

The three 19 m blades have a blade heating system comprising a carbon-fibre surface on the outer part of the blades and on the leading edge. Heating is regulated by a control system triggered by signals from an ice detector and thermistors between the carbon-fibre and the original glass-fibre surface. If ice is detected and the wind speed is below 11 m/s, the heating is 9 kW on each blade; above 11 m/s, heating is increased to 15 kW. The arctic equipment also includes a heated wind vane and anemometer, heated gearbox and control system. The low-viscosity lubricants are suitable for low temperatures.

Two telephone channels control the site – one for the meteorological mast system and the other for the data acquisition, control, energy measurement and separate fault alarm systems.

Wind speed and direction, temperature, output, blade distortion and torque on the main shaft are measured. Readings from the anti-ice system and extended meteorological measurements from within a 10 km radius of the turbine are also taken.

Performance

The Suorva turbine began delivering electricity to the grid for the first time in October 1998. In its first year of operation, it produced 1,710 MWh, with 95% availability. Extreme temperatures led to the turbine being shut down on only 9–10 days during the year. The anti-ice features have performed successfully and no problems with the turbine's operation have so far been identified. The energy demand for de-icing has so far been less than 3% of the energy generated.

Preparing to raise the blade assembly into position.

Economics

The project comprises both building and evaluation phases and is financed by Vattenfall and the Swedish National Energy Administration, Energimyndigheten. It has a budget of SEK 6 million (where SEK is the Swedish krona), 30% of which is a grant from Energimyndigheten. Vattenfall is responsible for overall project management, for which it uses both its own and external experts.

The tax on electricity production, (currently SEK 0.181/kWh), is rebated. This is the case for all wind turbines in Sweden in recognition of the environmental benefits of clean energy.

Environment

In 1999, the Suorva wind turbine produced 1,806 MWh of electricity – the third largest output from a turbine in Sweden. This output, representing an annual carbon dioxide (CO_2) saving of 90.3 tonnes, may, however, have been due to an unusually long period of high wind speeds experienced during the year.

The Suorva project aims to increase knowledge of, and experience in, building and operating a wind turbine in arctic conditions, where specialist equipment is required. Information gathered from Suorva will help to address public concern about environmental sensitivity, which will in turn affect attitudes towards the future use of wind technology in Scandinavia.

The Arctic wind turbine at Suorva, Sweden.

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