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Wind Turbine Provides Electricity for Arctic Town

Photograph: Kotzebue Electric Association

The AOC 15/50 wind turbine, Alaska.

Highlights

- First successful utility wind power project in Alaska
- Local co-operative distributes electricity through small grid
- Wind turbine designed to withstand arctic conditions
- Potential for replication in other communities

Summary

A small coastal town in Alaska is in its third year of operating the first successful utility wind power plant in the state. The installation meets the needs of about 200 homes in Kotzebue and accounts for about 6% of total electricity consumed in the town, which has 3,500 residents. A new wind turbine, developed with support from the US Department of Energy (US DOE) and designed to operate in cold climates, was chosen. The project required wintertime construction and special procedures were followed to protect the fragile arctic tundra.

Project Background

Kotzebue, like most communities in rural Alaska, uses electricity produced by small, diesel-engine-driven generators. Kotzebue Electric Association (KEA) operates six such generators with a combined rated capacity of 11.2 MW. KEA is a non-profit-making, electricity co-operative that distributes power to town residents through a small distribution grid.

During the summer, when coastal harbours are free of ice, barges carry diesel to Kotzebue from southern Alaska – a journey of more than 2,000 km. The fuel is stored in large tanks for use during the long winter. Many tanks in villages such as Kotzebue are more than 20 years old and nearing the end of their useful life. Stricter environmental regulations mean that costs for new tanks are significantly higher than they used to be. In addition, state subsidies for diesel fuel have been reduced and spread over a larger base of population.

In response to these cost increases, KEA turned to wind generation as a way of reducing diesel consumption and the cost of electricity for residents. With long-term wind speeds averaging 6 m/s, the idea of harnessing wind energy has long appealed to local people.

The Project

So far, KEA has installed 10 turbines with a combined rated capacity of 660 kW. The Kotzebue project is a joint undertaking between the US DOE, the Electric Power Research Institute (EPRI) and the Alaska Energy Authority, Alaska Industrial Development Export Authority (AEA/AIDEA).

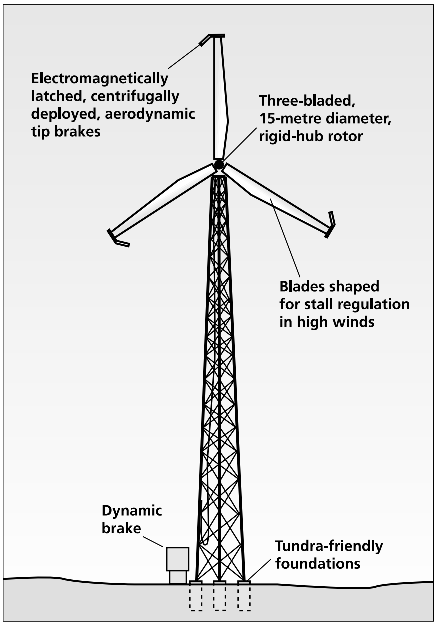
The AOC 15/50 turbines were developed with support from the US DOE's Wind Turbine Development Program and made by the Atlantic Orient Corporation (AOC) of Norwich, Vermont. They were designed to operate economically in cold climates with moderately favourable wind resources.

Several design features keep maintenance of the AOC 15/50 to a minimum – a critical requirement for machines operating in remote locations such as Kotzebue (see Figure 1). For example, the rotor spins downwind of the 24.4 m steel tower in a passive yaw arrangement. Wind-direction sensors and yaw-drive motors, which must be checked periodically, are thus not required to keep the rotor spinning perpendicular to the wind. In addition, the gearbox is directly connected to the drive train, thereby eliminating the need for maintenance-prone couplings inside the nacelle.

The shape of the blades regulates excessive power generation in high winds. In high winds, turbulent eddies of air form next to the trailing surface of the blades. These eddies cause the blades to stall, thus reducing the aerodynamic force on the rotor. Overspeed control is provided by tip brakes that deploy centrifugally at the end of the blades. The tip brakes cause a large aerodynamic drag on the rotor and slow it down. Finally, there are two types of brake – an electrodynamic brake that uses the generator, and a conventional disc brake for stopping.

Construction took place during the winter when the ground was sufficiently frozen to support the crane and other equipment without damaging the tundra. KEA and AOC trained local crews in installation and maintenance procedures. The first three turbines were commissioned in September 1997 and the remaining seven in June 1999.

Figure 1:
The AOC 15/50 wind turbine.



Performance

KEA, US DOE and EPRI are collecting data on the project, which will be made available to other utilities under the US DOE/EPRI Turbine Verification Project (TVP). The TVP evaluates wind turbines in utility operating environments in the USA with the purpose of sharing experience and data with other electric supply companies (see *CADDET Renewable Energy Newsletter*, 2/99).

Table 1: 1998 and 1999 electricity production from turbines 1–3

1998 kWh	1998 average wind speed (m/s)	1998 capacity factor	1999 kWh	1999 average wind speed (m/s)	1999 capacity factor
270,874	4.9	0.16	208,582	5.4	0.12

Table 2: First-year electricity production from turbines 4–10, 1 July 1999 to 30 June 2000

First year kWh	Average wind speed (m/s)	First year capacity factor
546,882	5.1	0.14

All TVP projects, including the one at Kotzebue, report performance and other data according to utility standards. For example, although the generator is rated by its manufacturer at 50 kW, the maximum sustained output of the wind turbine is 66 kW, so the TVP rates the turbine at 66 kW. Turbine availability is uniformly defined for all TVP projects based on the time the turbines are available to operate, whether or not the wind is blowing. Any downtime (for scheduled maintenance, unscheduled outages, interconnection or grid failures – or even public tours) is subtracted from the total. During the first two years of operation, the TVP availability of the Kotzebue wind installation was 96%, much higher than that of most diesel-engine-driven generators.

Figure 2: Power output curve of the AOC 15/50.

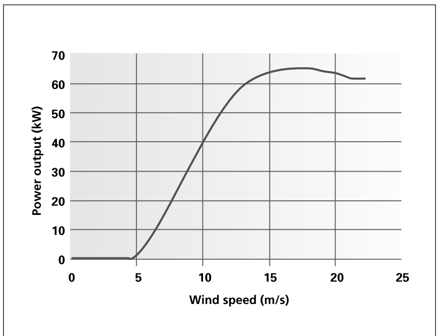


Figure 2 shows the instantaneous power output at standard conditions over the range of wind speeds that the turbine operates. Output is higher during arctic winters because of the greater density of cold air.

Economics

The first three turbines that were erected cost $2,985/kW (where $ is the US dollar) to install and commission. KEA estimates that the remaining seven turbines cost $2,200/kW. For the 1997 installation, the costs incurred, in addition to the turbine hardware, amounted to 63% of the total. For the 1999 installation, KEA reduced these costs to about 50% of the total.

Such costs are about twice the industry standard for utility-scale, wind-power plant. However, KEA believes they are reasonable, given that all construction projects in the Arctic are expensive and a learning curve was required for both KEA and AOC.

KEA's wind installation reduces annual diesel consumption by 340,000–380,000 litres. Based on the average cost of diesel in 1998, this translates into an annual saving of about $86,000. Taking this into account, the 'levelised' cost of energy from the wind turbines is estimated at $0.109/kWh.

Environment

Construction of the wind plant took place during the winter to avoid damaging the fragile arctic tundra. The tower foundations are specially designed to keep the ground continuously frozen and maintain the integrity of the tundra.

Table 3 shows the diesel-generated emissions avoided through the use of wind turbines based on emissions data reported to the US Environmental Protection Agency for KEA.

Although the project is still evolving, the town of Kotzebue has already learned a great deal about wind systems. The town hopes to use this experience to develop regional expertise in wind systems to help other communities generate electricity from wind. KEA plans to install other turbines, with up to 2 MW of capacity, at the Kotzebue site. It also hopes to support smaller installations in nearby coastal villages.

Table 3: Emissions avoided by KEA wind installation

	CO_2 (kg)	SO_2 (kg)	NO_x (kg)
1998	197,000	825	5,048
1999	342,132	1,433	8,981

Photograph: Kotzebue Electric Association

Turbine installation.

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