

Conquering the Arctic

The hard lessons learned at the world's most northerly wind farm will help open up the world's cold regions to development, writes **Darius Snieckus** from Havøysund



In January on the northern Norwegian island of Høy, day is like night. Here, deep inside the Arctic Circle, the last of the sunlight is seen in late November and the first rays won't reappear until mid-February.

The weather is similar to the rest of the country's long, stunning coast — changeable and wet — with the distinction that the mercury can drop as low as -25°C . And that is before the wind chill.

Yet a decade ago, 16 wind turbines were erected on the bluff above the island's only town, Høy, a remote fishing and shipbuilding outpost that wasn't connected to the mainland until a bridge was opened by King Olav V in 1988.

Isolated Arctic locations such as this may seem strange places to build wind farms, yet 20GW of turbines are currently turning in cold-climate regions around the world — in Scandinavia, North America, Europe and Asia — and there is potential for up to 60GW, according to International Energy Agency outfit IEA Wind.

And Høy, the planet's most northerly wind farm, has proved to be a valuable testing ground for such sites. Gusts roar in from every direction, travelling along the jagged coast, up the cliff face and over the bluff at average speeds of about eight metres per second (m/s).

Colder air is denser too, meaning



HØY, NORWAY



Finnmark projects

The knowledge gained at Havøygavlen may prove indispensable for a series of large wind farms being planned across Norway's northernmost region of Finnmark.

Havøygavlen owner Finnmark Kraft is developing more than 800MW over six sites, partly in conjunction with Fred Olsen Renewables and Vindkraft Nord. The first project, the 120MW Hamnefjell, is due to be completed in 2015.

"We see ourselves as being well placed to be the driver and operator for the new wind farms," says Havøygavlen boss Egon Leonhardsen. "After ten years — and it has been a steep, long learning curve — we know how to run a wind farm in this environment."

that turbines here should theoretically capture more energy from the same wind speeds.

Not fit for purpose

Yet the wind farm's first years were far from a success. Buffeted by salt-laden seaborne blasts swirling unpredictably from north and south — often at speeds greater than 50m/s — the German-built Nordex N80s twice had rotor blades sheared clean off, and once, in early operation, a turbine collapsed to the ground in a storm — with the crash resonating throughout the town.

The 2.5MW turbines — then the most powerful on the market — were simply not up to the task.

Production levels at the 40MW wind farm were dishearteningly low for years. Joint developers Nuon, Norsk Hydro and Norsk Miljøkraft had forecast annual output of 120GWh, but only achieved 80GWh.

"The turbine technology in the beginning was not fit for purpose, the control systems weren't good enough," says Egon Leonhardsen, chief executive of Arctic Wind, which operates the site for current owner Finnmark Kraft.

"But then, there is nowhere in the world like Havøygavlen," he explains. "When the winds come up from the south, it is in a smooth stream, perfect for large-scale wind turbines."

"But when they're from the north you have a polar lower-pressure system which creates winds that are very unstable in speed and direction."

"The wind comes up the cliff from every direction and into the wind farm — very turbulent and with negative wind shear and other problematic wind phenomena. The conditions can be very harsh."

These gusts place extraordinary loads on both the yaw



COLD COMFORT:

Clockwise from top left: An old Lincoln Continental on the streets of Havøysund; Bernth Sjørnsen, manager of Havøysund Patentslipp; fishing boats docked in Havøysund; and the town's curiously designed tourist rest stop



ARCTIC WIND



mechanisms — which keep the rotor hubs facing the wind — and the pitch systems that adjust the blades to capture the most energy.

The turbines installed in 2002 were among the first N80s made in serial production, and the problems mounted quickly. By 2004, it was already clear that the bearings were not coping with the blustery conditions and that all the original gearboxes would have to be replaced.

"It was a very negative experience in the beginning, that's for sure," says Alexander Michel, Nordex's head of European service and sales.

"But we learned our lessons. The reality is that the conditions [at Havøygavlen] are way outside the specification of the turbine."

The story between 2002 and 2008, he says, was one of "shifting components and constant modifications", with pitch and yaw systems being replaced as each new generation of wind farm was rolled out by Nordex.

"We fed back all the learnings to our engineering department so that we could make the most of the wind farm in terms of production and technology development," notes Michel.

Technology overhaul

The years of making-do and mending were rewarded, when, in 2009, Statoil bought the site, setting in motion a re-evaluation of the facility and its taxing winds.

It proved to be a turning point.

"In 2009, it really started to change," says Leonhardsen. "The wind farm had been run as a commercial operation since 2002, but it had been really hard to get a return

on the investment. So when Statoil took over, it was decided it would be a development park for turbine technology and operations models."

Step by step, the turbines have been overhauled from top to bottom. From the outside, the N80s look the same as when they were installed. But the technology inside has been radically altered.

The rotor blades' pitch motors have been upgraded several times, a "master-follower" system now spreads the loads over multiple yaw drives, and the climate-controlled nacelle can "track" the wind flow with high-torque brakes that keep it facing windward.

The renovation work stretched to the blade tips. In 2009, Statoil sent out a 55-man crew that worked around the clock in the midnight sun of summer to repair cracks and delamination on every 38-metre LM blade.

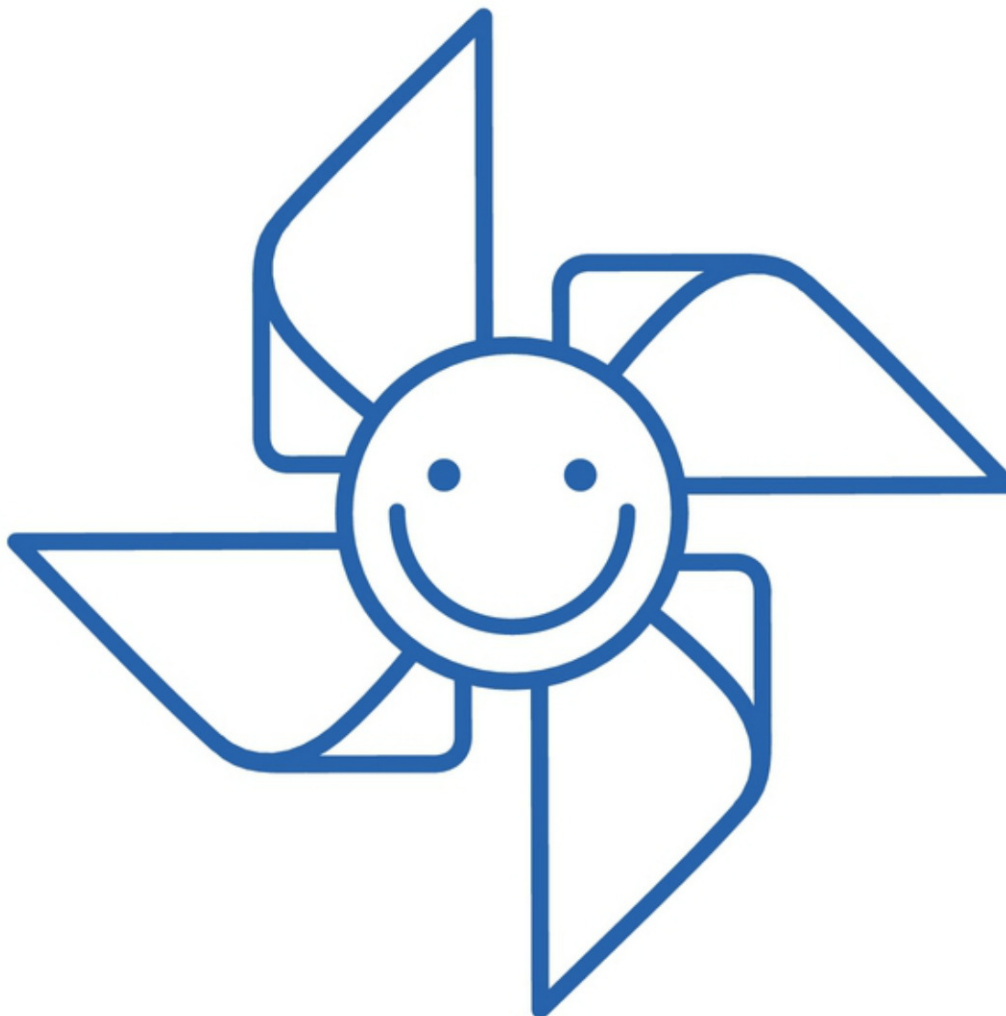
The turbines' software systems have also been re-engineered for the extreme environment.

"We are now quite relaxed about how the turbines are operating — they need well-planned and regular maintenance but they are performing much as we would like," says Nordex product manager Günter Steininger.

Back in 2004, turbine uptime was as low as 72%, and averaged under 85% in the project's first ten years. In 2012, however, the rate was above 95%, close to the industry benchmark of 97%.

"Havøygavlen does abnormal things to wind turbines. It is like an accelerated lifetime test," says Leonhardsen. "You

The German-built Nordex N80s twice had rotor blades sheared clean off, and once, a turbine collapsed in a storm



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After frosty reception, town warms to project

Local people's initial coldness towards the Havøygavlen project has thawed over the years, as environmental concerns were not borne out.

"Our objection was on the grounds of its impact on nature, and the wildlife," says Mayor of Havøysund Gudlief Kristiansen. "That and the visual aspect — it seemed a big construction for a small island."

The wind farm was built quickly, "without much consultation" with the residents, he adds. Development plans discussed with developers Nuon, Norsk Hydro and Norsk Miljøkraft seemed "already decided" before meetings with the town council.

"Now it is more or less accepted and people have come to see it as a positive thing," he says.

Svein Mathiesen, a representative of the local fisheries industry — a fleet of 30 vessels that lands 30-40 million kilograms of cod, pollock and herring each year — was also won over. "I was sceptical to start, because of the effect I thought it would have on the scenery," he says. "But then when it was erected and I looked at it for some time, I decided it wouldn't be so bad."

"Still, many people would like to see more benefit from the wind farm though, such as a [special] tax paid to the regional government [to pay] for different types of amenities."

Havøysund Patentslipp, a ship repair and engineering company established in 1935, has been an early beneficiary of work on the turbines, being contracted to carry out various jobs including coating the 80-metre towers with anti-corrosion paint.

"There is a new business potential for our guys," notes manager Bernth Sjørnsen. "We see new wind farms under development in the area that we have skills to work on."

Another business that has been helped by the wind farm is the 93-bed Havøysund Hotel, which relies largely on custom from the fishing boats — some of which come from as far away as Canada and West Africa.

According to hotel director Logan Karthigesan, a Sri Lankan, 35% of trade has been "Havøygavlen-related" — which has made the difference in a tough business climate.

"I have never closed the hotel in the winter," he says. "But there is no doubt to my mind that without the wind farm, we would have gone bankrupt some time ago."



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find problems on these turbines after five to seven years where you'd find them on other turbines after 15-20 years. Getting high uptime here is a challenge."

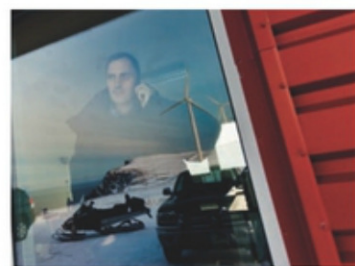
Repair logistics play a large part. With weather as hostile and changeable as on Havøya, the operations team here has set up a rapid-reaction-force approach — where parts are kept close to hand and repairs are carried out with military precision.

"We work on the turbines most every day," says Nordex's site manager, Hans Litfin. "The weather can be very bad — very windy, very cold, very wet — and we work in the darkness a lot of the year. But, you know, we get the work done."

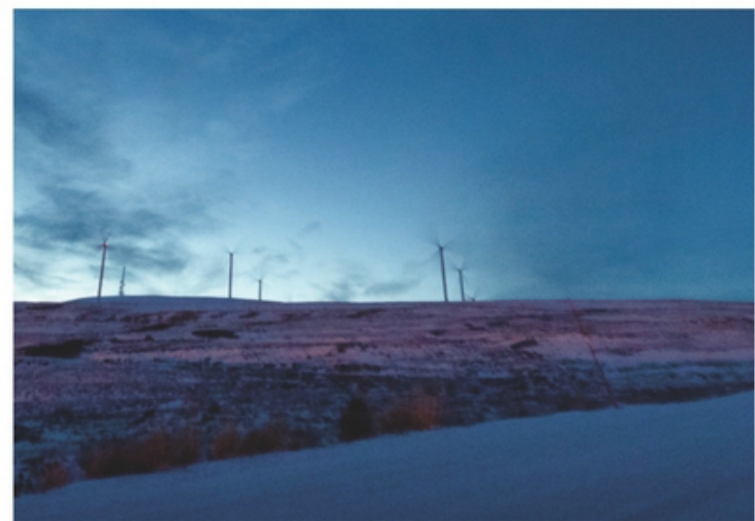
Bright future

The future at Havøygavlen looks much sunnier than it once did. With a 30-year concession, the development is a good candidate for a "repowering" project, says Leonhardsen.

Although no decisions have been taken, the performance of the Siemens SWT-3.0-101 turbine installed in late



A COOL HEAD:
Top and bottom:
Egon Leonhardsen,
chief executive
of Havøygavlen
operator Arctic Wind



Havøygavlen resonates with the saying, 'that which doesn't kill you makes you stronger'

SNOWED UNDER: Left and centre right: Hans Litfin, Nordex's Havøygavlen site manager; top right: snowmobiles are used to get around the site; and bottom right: the wind farm at night

2010 — using the foundation vacated by the felled Nordex turbine — has been inspiring to Arctic Wind.

This turbine, surprisingly, is a standard unit, containing none of the special technologies developed for Arctic environments.

While this may seem counterintuitive, monitoring the performance of this "unprotected" SWT-3.0-101 direct-drive turbine offers valuable information. By discovering how the standard components fare in hostile conditions, and comparing their performance with that of their cold-climate equivalents, the strengths and weaknesses of the latter can be more accurately determined.

Though still early days, the machine — a prototype featuring a 101-metre-diameter rotor meant for the "toughest conditions and iciest winds" — is performing

"very well" in terms of both uptime and production, says Siemens chief technology officer Henrik Stiesdal.

Havøygavlen resonates with the saying, "that which doesn't kill you makes you stronger". Not only has the wind farm proved its detractors wrong, but the extreme environment has been an education for both the developers and the turbine makers. Nordex has incorporated much of the technology refined here into its Gamma and Delta turbine platforms and is retrofitting its entire fleet of cold-climate turbines with new component packages.

"Now, whenever we have a subcomponent that needs extreme testing, our engineers say, 'Okay, let's test it at Havøygavlen,'" notes Steininger.

As Leonhardsen adds: "If it works at Havøygavlen, it will work anywhere." ■

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