alpha ventus

Fact Sheet

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FACT-SHEET alpha ventus

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Overview

The alpha ventus offshore wind farm is a joint project of the utilities EWE, E.ON and Vattenfall. These three energy providers established the “Deutsche Offshore-Testfeld und Infrastructur GmbH & Co. KG” (DOTI) operator consortium specifically for this purpose in June 2006. The shares distribution is: EWE 47.5%; E.ON and Vattenfall each 26.25%. The total investment is Euro 250 million with the BMU (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) providing Euro 30 million of funds.

alpha ventus was commissioned as the first German offshore wind farm in April 2010. The construction phase proper was a brief 12 months, a pioneering feat in a location with a water depth of about 30 metres and a distance from the coast of 60 kilometres. The farm is controlled via the control centre in the town of Norden (Eastern Frisia). Reflecting its role as offshore test site, alpha ventus operates two types of wind turbines (WT) with two different foundation designs. The rated output of the wind farm is 60 MW.

Experience gained in construction and operation is an input into the further development and expansion of the German offshore wind power industry.

The project shows positive results: during the operating years from 2011 to 2015, alpha ventus fed an annual average of some 247.45 million kilowatt hours of power into the grid, equivalent to the annual power consumption of approximately 71,000 average households (3,500 kWh) in Germany.

Adding the power generated during the commissioning period to the five full operating years, alpha ventus has by March 2016 generated 1,5 terawatt-hours of electricity since 2009.

Offshore - particular challenges

The alpha ventus offshore wind farm is located in the open sea of the Exclusive Economic Zone (EEZ) of the Federal Republic of Germany. The prevailing wind at the site is 210-240° (south-westerly) with an average wind speed of 10 metres per second (m/s), equivalent to a force 5 wind. Under heavy weather conditions, the swell can have waves of up to 10 metres in height, on average 6 - 8 metres. The main direction of swell is 330° (north-westerly).

The location far offshore reflects the particular conditions of the German North Sea coast: offshore wind farms are only granted building permission when located beyond the Wadden Sea World Natural Heritage site and off the near-coastal shipping routes. A location in the open North Sea guarantees excellent wind yield. The original forecasts of 3,900 full load hours per annum compare with approx. 2,000 for land-based sites. 4,450 full load hours were registered during the first full year of operation, far in excess of the forecast. On the other hand, the water depths of up to 40 metres, the aggressive salt-laden air, the strong and often gusty winds and the swell together add up to extreme demands on the installation logistics, construction, operation and maintenance. The challenges driven by the environmental conditions are also factors forcing up the costs of investment and operation compared with near-coastal offshore locations and onshore wind farms.

It is a basic requirement for the wind turbines and the offshore substation that all key technical components are of redundant design. In addition, the nacelles of the wind

alpha ventus

- 6 wind turbines, type Adwen AD 5-116 (M5000), with each 5 MW nominal output, on tripod foundations
- 6 wind turbines, type Senvion 5M (REpower) each with 5 MW nominal output, on jacket foundations
- Total: 12 wind turbines with overall 60 MW rated output
- 1 offshore substation
- Directly adjacent: BMWi research platform FINO 1
- Submarine cable link via Norderney; connection to German national grid: substation Hagermarsch
- DOTI control centre in Norden
- Supply port: Norden-Norddeich
- Supply airport: Emden

Location

alpha ventus lies about 45 km north of the island of Borkum, within the Exclusive Economic Zone (EEZ) of the Federal Republic of Germany. The coordinates of the wind farm corners are:

54° 00.0’ N 6°34.4’ E
54° 01.6’ N 6°34.4’ E
54° 01.6’ N 6°37.3’ E
54° 00.0’ N 6°37.4’ E

turbines have air conditioning as an isolation from the aggressive sea air. The prevailing sea and current conditions have been considered in early design stages. The phenomenon of scour holing, i.e. the transportation of sediments by the interaction of waves and currents forming sloughs around structures embedded in the sea bed resulted in a foundation designed to be isolated from the sea bed. The foundations actually stand on pillars embedded up to 35 metres deep in the sea floor, to which they are permanently fixed. The foundations are also designed to withstand so-called freak waves.

The wind turbines are arranged on a grid formation with a mutual separation of approx. 800 metres. Four rows of each three wind turbines form a rectangle, covering a total area of four square kilometres, equivalent to around 500 soccer-fields. All general shipping and fishing vessels are prohibited from entering the entire area of the wind farm. The dimensions of the individual turbines themselves are impressive: including the rotor, Adwen wind turbines reach 148 metres above the water line, making them as high as the Cheops pyramid. The Senvion units reach 155 metres into the sky, making them almost as high as Cologne Cathedral. If considers them from the sea bed, overall heights actually add up to 178 and 185 metres.

Operation of the offshore wind farm

The alpha ventus wind farm is operated from a land-based centre. All wind turbines and the substation are monitored and controlled via the control centre in Norden. It is nonetheless necessary for personnel to go on site, i.e. offshore, on a regular basis. This includes routine servicing and maintenance work as well as the recurring testing of the 12 wind turbines. The testing takes place on a four-year cycle and covers everything from the base of the foundations to the tips of the rotor blades.

The service technicians are transported to the offshore farm either by water or air. In spring and summer the relatively calm seas mean transportation is mainly by boat, in autumn and winter when the sea is much rougher, helicopters are primarily used. The actual mode of transport depends on the weather conditions at the time: as soon as the significant (average) wave height of 1.5 metres is reached, i.e. which also includes waves of approx. 2 metres in height, it is

Technical data Senvion 5M (REpower)

- Rotor diameter: 126 m
- Hub height: 92 m
- Rated output: 5 MW
- Rotation speed: 6.9 - 12.1 rpm; generator: 670-1,170 rpm
- Cut-in wind speed: 3.5 m/s (force 3 wind)
- Rated wind speed: 13.0 m/s (force 6 wind)
- Cut-out wind speed: 30 m/s (force 11 wind)
- Blade tip speed: 80 m/s (ca. 288 km/h) at a rotor speed of 12.1 rpm
- Lifespan: 20 years
- Weight of nacelle without rotor and hub: 290 t
- Weight of nacelle with rotor and hub: 410 t
- Foundation weight: ca. 500 t; tower: ca. 210 t

Technical data Adwen AD 5-116 (AREVA Wind re. Multibrid M5000)

- Rotor diameter: 116 m
- Hub height: 90 m
- Total height above seabed: 178 m
- Total height above sea surface: 148 m
- Rated output: 5 MW
- Rotation speed: 5.9 - 14.8 rpm
- Cut-in wind speed: 3.5 m/s (force 3 wind)
- Rated wind speed: 12.5 m/s (force 6 wind)
- Cut-out wind speed: 25 m/s (force 10 wind)
- Blade tip speed: 90 m/s (324 km/h)
- Weight of nacelle without rotor and hub: 200 t
- Weight of nacelle with rotor and hub: 309 t
- Weight of steel in tripod, tower, nacelle: 1,000 t
- Tripod - weight of steel: 700 t;
- Height: 45 m; Pile length: 35-45 m

forbidden for personnel to transfer from service vessels to the offshore plant for safety reasons. On the other hand, approaching the wind turbines using helicopters is actually possible even in relatively high winds. Each wind turbine has a winching area situated on the roof of the machine house (turbine house). This winching area allows service technicians to be hoisted from a helicopter. The helicopters themselves cannot land on a wind turbine. A helicopter landing pad is located on the offshore substation for stops during maintenance operations.

Work on the high seas is subject to extremely stringent safety specifications. The wind turbines and the substation are each equipped with comprehensive safety installations. This includes full first aid kits and communication equipment including several telephones on each wind turbine. Service personnel must have certified training on all aspects of safety at sea and for helicopter flights and are given regular occupational health checks. The protection and safety concepts are based on strict, regulator-sanctioned procedures and routines including full logging of communications with the control centre. This helps ensure that all work is coordinated and also enables a quick response to any sudden changes in weather conditions. The safety measures are complemented by emergency plans which are fully approved by the public maritime traffic monitoring organisations and sea rescue services.

Technical data of substation

- Constructed in September 2008
- 30 m: elevation of helipad
- 25 m: elevation of main deck with crane, substation control and protection (I&C) / switch-gear plant / neutral earthing transformer, fire extinguishing system, MV and LV systems, emergency generator, MVAr throttle / 110 kV GIS (gas-insulated switchgear) system (AREVA)
- 21 m: cable deck with workshop, equipment room, lounge, diesel tanks, emergency generator, cable bench and oil sump
- Cable deck and main deck: 110/30 kV transformer 75 MVA (AREVA)
- Jacket foundation height: approx. 46 m
- Jacket weight: approx. 650 t
- Foundation piles: 30 m long, 2.7 m diameter, 100 t apiece
- Position: N 54°00', E 6°37.40'

Offshore: The transmission of power

Within the wind farm itself, power is transmitted from the wind turbines to the offshore substation along 33 kV sea cables. Some 16 kilometres of cable were buried at least 60 centimetres deep in the sea bed. The offshore substation steps up the voltage to 110 kV and the power is finally transmitted to the mainland along an approx. 60 km long sea cable which also crosses the island of Norderney. On the mainland the electricity is fed into the Hagermarsch substation from where it enters the German transmission-grid. The transmission grid operator TenneT TSO GmbH is responsible for operating the offshore grid feed-in. The sea cable also includes integrated optical fibre data lines to provide modern communication and monitoring system links to the wind farm.

The centre of operations in Norden

The town and port of Norden in the district of Aurich is the onshore headquarter of the alpha ventus facility. While the offices are in the town itself, the offshore service vessel “Windforce I” is moored in the port of Norddeich. The control centre operates in shifts, normally with two supervisors per shift. All information and data are gathered there. The wind farm operating status is displayed real-time on numerous monitors showing images, maps, and data. The operating data collected includes wind speeds, output levels, oil temperatures and nacelle alignments among others. The data is monitored and evaluated in a CMS (condition monitoring system) to allow early identification of unusual values and in turn ensure that appropriate measures are taken. The shift supervisors coordinate and monitor the work of the service teams at the wind farm and are also available at all times as point of contact on the mainland. A number of adjustable and fixed webcams are installed at the wind farm to allow shift supervisors to also monitor helicopter flights and shipping movements around the wind farm.

Because of its distance from the coast as well as the curvature of the earth, the offshore wind farm cannot be seen from either the mainland or from the North Frisian islands even under conditions of excellent visibility.

Offshore: Servicing

The annual plant servicing takes place in spring and summer, when the weather conditions allow the maintenance ship “Windforce I” to access the farm.

The average working day of an offshore service technician starts early in the morning, usually at about 06.00 in the port of Norddeich. “Windforce I” is first loaded with all necessary tools and materials for the planned servicing procedures. After the service team has checked in the ship starts its approx. two-hour trip to alpha ventus. During summer months the working day can be 12 hours long. Several service teams, up to a maximum of 25 persons, have room on board. All necessary spare parts and tools are transported in containers or big bags; these are then lifted from the service vessel’s quarterdeck directly onto the wind turbine using the crane fitted to the service platform of each wind turbine. Direct transfer of personnel from the boat to the wind turbine is only permitted without baggage. For safety reasons, at least three technicians always work together on any one wind turbine. The servicing work required per wind turbine currently adds up to approx. 450 service hours per annum. This is a massive cost factor which’s significant

reduction is mandatory. This work includes anti-corrosion measures, checking of safety systems, replacing defective components and topping up operating fluids such as lubricants or cooling. The scope and frequency of the servicing work of each of the wind turbines in operation is specified and co-ordinated with the manufacturers Senvion and Adwen. The servicing concept is in turn certified and provides the basis for the recurring tests as specified by the regulator.

Perhaps the most unusual workplaces on a wind turbine are the rotors and the foundations. The tips of the blades cut through the air at a speed of up to 320 kilometres per hour when at full load. They are among the wind turbines' components subject to the highest loads and therefore require regular monitoring. This is the job of industrial climbers who, like mountaineers, abseil from the wind turbine nacelle to inspect and service the blades. The foundations are inspected regularly by divers. The professional divers carry out their work from special diver support vessels.

Safety at sea

The wind farm, which lies outside the Wadden Sea World Natural Heritage and the 12-mile zone, is in the Exclusive Economic Zone (EEZ), in which the provisions of the UN Law of the Sea permit economic utilisation by the Federal Republic of Germany, and which is thus subject to a special legal regime.

The Federal Institute for Navigation and Hydrography investigated the site and gave permission for construction of the project. One of the decisive factors for such a permit is that the project "shall not impair the safety and ease of traffic and shall not endanger the marine environment".

Associated research projects

alpha ventus is studied by a large number of research projects from which it is hoped to gain important knowledge for what is still the young German offshore industry. The research is taking place under the umbrella of the RAVE initiative (Research at alpha ventus) and comprises 34 individual research projects funded by the German Ministry for Economic Affairs and Energy (BMWi) with about Euro 50 million. Many different aspects of the wind farm are covered and analysed, e.g. the development of new wind farm control systems and technical optimisation of plant components through to the impact of the offshore wind farm on the immediate marine environment. The marine ecosystem - marine mammals, fishes, sea bed organisms, sea birds, migrating and resting birds - was surveyed for the first time two years prior to start of construction and monitored precisely during construction work and operations.

Retrospective: Building period

alpha ventus started life under the name "Offshore test field Borkum West". Borkum West, subsequently renamed alpha ventus, was actually the first offshore wind farm for which the Federal Maritime and Hydrographic Agency (BSH) granted

an official building permit. A large number of additional permits for offshore projects in the North Sea and the Baltic have been granted since then by the BSH (as sole regulator). In the meantime standards for permitting procedures have been introduced and are subject to further evaluation and development. Here again, alpha ventus was the pioneer.

As the joint platform for many players from the fields of politics, business and research, the German Offshore Wind Energy Foundation has been involved in the alpha ventus project from the word go. The foundation acquired the permitting rights at the site in 2005, with support from the German ministry of the environment, and subsequently leased these rights to the alpha ventus DOTI consortium and has accompanied the project as the licence holder up to the present day.

Autumn 2008 saw the start of initial preparatory work. The first structure to be constructed was the offshore substation at the south-eastern corner of the future wind farm. This was followed by the laying of the 60 km sea cable connecting the wind farm to the German national grid. The cable laying was completed in spring 2009.

In mid-April 2009 work started on constructing the wind turbines. The first milestone was finally reached on 1 June with the anchoring of the six Tripod foundations for the Adwen (formerly AREVA Wind resp. Multibrid) wind turbines. This was followed by the step-by-step assembly of the first tower segments. From mid-July onwards, the turbines were completed in sequence with the top tower segment, the nacelle and the rotor star, followed by commissioning.

Work on the foundations for the six Senvion (formerly: REpower) units was then commenced in June 2009. In September 2009 the jackets, which are the basic foundation structures for the Senvion turbines, were transported to the building site and anchored into place on the seafloor in a short six-day period with the help of the crane ship “Thialf”. The first 5M was completed by 30 September 2009. On 16 November 2009 alpha ventus was completed in its entirety, the 12th and last turbine being finally assembled on that day in the early hours of the morning. This was followed by commissioning of the wind turbines, completed in April 2010. The actual offshore building period for all twelve wind

Summary of construction activities:

August 2007:
- Start of building work on the cable route

Summer/autumn 2008:
- Laying of sea cable
- Preparations for grid connection

September 2008:
- Construction of offshore substation platform

Spring/summer/autumn 2009:
- Connection of sea cable
- Commissioning of substation
- Construction of six Adwen AD-116 turbines (AREVA Wind resp. Multibrid M5000)
- Start of calibration and test operations, first grid feed-in on 04.08.2009
- Construction of six Senvion 5M (REpower) wind turbines
- Laying of internal farm cabling

November 2009:
- Completion of wind farm
- Continuation of calibration and test operations

April 2010
- Official commissioning

February 2014
- First terawatt hour generated

March 2016
- 1.5 terawatt hours generated

turbines therefore amounted to seven months, from April to November 2009.

Outlook: alpha ventus as reference project

alpha ventus can be considered to be both stress test and pioneering project for a new generation of wind turbines in the open sea. The objective is to demonstrate the technical and technological viability as well as the economic feasibility of offshore technologies - also in far-coastal locations. The knowledge and experience gained in the process refers not only to the technology but also to the process as a whole: from the permitting procedures and environmental audits over the safety concept, the tendering process, the logistics and the various construction stages through to individual maintenance jobs and details of operational procedures. The experience gained in the operation of the wind farm represents crucial basic knowledge for Germany's nascent offshore wind industry.

The DOTI operating companies EWE, E.ON and Vattenfall have already put to good use the experience gained in the construction and operation of alpha ventus. By the end of 2015, three new offshore wind farms have been completed in the German Bight: Riffgat (EWE), Amrumbank (E.ON) and Dan Tysk (Vattenfall).

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Federal Ministry for Economic Affairs and Energy: www.bmwi.bund.de/en and www.erneuerbare-energien.de
German Offshore Wind Energy Foundation: www.offshore-stiftung.de/about-us
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