



# Proposals for the future use of the alpha ventus test field

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# 1. Introduction

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The first German offshore wind farm, alpha ventus, was built in 2009 as a test field for the development of offshore wind energy. The accompanying research initiative 'research at alpha ventus' (RAVE) comprises research, development and demonstration activities in a coordinated approach. In parallel with the development of the test site and the use of offshore wind energy, the content of the research has changed over the last 12 years: While the initial focus was on the feasibility of offshore wind farms, today the research focuses on operational and reliability issues. To date, more than 35 projects have been carried out with around 120 million Euros in funding from the German government.

At the beginning of 2024, the alpha ventus test field is no longer supported with the higher guaranteed electricity price of the German Renewable Energies Act. Due to the small number of turbines and the high repair and maintenance costs for turbines that are not anymore in regular production, it is economically difficult to operate alpha ventus outside the additional EEG funds. This raises the question of whether the alpha ventus test field should continue to be operated and, if so, with what objectives. If the test field is to be dismantled, the question also arises whether the test field's subsequent use for research purposes is possible and valid.

The planned increased expansion of offshore wind energy in Germany raises several questions that need to be answered through research, development and demonstration. This requires test facilities in an operational wind farm. The alpha ventus test field offers ideal opportunities to provide the necessary data and tests in such an environment. It is an established, valuable research infrastructure in which the legal and organizational issues of cooperation between research and operation have been clarified. Comprehensive long-term measurement data from 12 years of operation is available in a research archive. The research platform FINO1, located in the test field, provides relevant reference values for wind and oceanography. The existing alpha ventus electric power transformation substation can also be used for research purposes.



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## 2. Collection of ideas for research at alpha ventus

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The research institutions involved in the RAVE initiative have compiled a list of research needs for offshore wind energy that they believe should be carried out at the alpha ventus test site. The aim is not to collect the research needs in offshore wind energy, but to focus on the topics and project ideas that are difficult or impossible to implement without alpha ventus.

The aim of this collection is to gather a wide range of potential research questions. These will be discussed with all stakeholders to identify the most important ones that can be carried out at the test site.

alpha ventus is the oldest German offshore wind farm and the only one that has been continuously carrying out research. The first part of the topics and project collection illustrates the research questions that should be carried out at the wind park during operation, irrespective of a decision to dismantle the wind turbines.

If the decision is to dismantle the wind turbines there are opportunities for high-risk research projects while the turbines remain in operation. The potential damage during these projects can be borne due to the special circumstances. Initial ideas on this are summarized in section 2.2.

Once dismantled, the installations offer a unique opportunity to analyze components that have been in service for a long time. In addition, the loads to which they have been subjected are well known due to RAVE measurements. The resulting research opportunities are presented in section 2.3.

Section 2.4 deals with the issues that arise during dismantling and recycling. Issues relating to the subsequent use of the site, the foundations and the electric power transformation substation are discussed in the final section. Here alpha ventus offers a unique opportunity to analyze the issues that will arise with larger commercial offshore wind farms in a few years' time.



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## 2.1 Research questions in the ongoing operation of alpha ventus

alpha ventus was built as a test site to investigate the research issues relevant to the use of offshore wind energy in Germany. The further development of offshore wind energy raises new questions that can be investigated there. The turbines have been under operational load for the longest time. At the same time, long-term measurement results from extensive research are available. In addition, the test site is now situated in the center of a large cluster of wind farms, so the effects of the wind farms that have been built over the years in the surrounding area can be studied. This provides ideal conditions for the test site to be used for various research purposes, irrespective of an eventual dismantling. The provision of services for research could make it possible to operate alpha ventus economically.

### **Test field for the demonstration of offshore hydrogen production**

Demonstration of offshore hydrogen production (using a jack-up platform next to the transformer substation or building a hydrogen research platform on the foundation of a wind turbine).

### **Test field for the co-utilization of wind farm areas**

Due to the limited area in the German EEZ (exclusive economic zone) compared to the final expansion targets, the possibility of co-utilizing offshore areas should be investigated:

- Use of alpha ventus as a test field for the investigation of offshore wind farms for fishing
- Use for the demonstration of aquaculture and vertical aqua farming, for which there is no test field anywhere in such an exposed location
- Co-use of the wind farm area for military and/or shipping (e.g. for strategic topics such as radar systems, threat scenarios (air/water)) (see also R&D Centre Kiel / FINO 3)

### **Modelling of yield losses due to wind farm expansion in the surrounding area**

alpha ventus was the first German wind farm and therefore was not influenced by other wind farms at the beginning of its operating phase. The shadowing effects due to wakes gradually increased as neighboring wind farms were built.

- Effects of expansion of neighboring wind farms on yield - investigation of yield losses compared to models, including global blockage

### **O&M at a wind farm with long operating experience**

Research questions on O&M can best be investigated at a wind farm with long operating experience.

- Integration of the already approved 'FlexiWind' project regarding life cycle research (beyond 2023)
- Testing of an acoustic condition monitoring system for electrical components - failures of electrical components are particularly relevant - leading to the idea of an acoustic monitoring system to be tested offshore
- Innovation test field of autonomous inspection and service technologies (ROVs, drones, etc.) – can be realistically tested at an operational aging wind farm
- Inspection and detection of maintenance hotspots on welds and grouted joints, alphaventus is 'finally' old enough.

## 2.2 Research questions before dismantling

Once the decision to dismantle alpha ventus has been made, the time until the dismantling is actually carried out offers unique research opportunities to intervene in operations that would otherwise not be possible due to the associated risk.

### Testing control algorithms

New wind farm and turbine control systems can be tested and validated in an operational wind farm, e.g. for lifetime optimization, wake control, etc.

### Testing boosters

The possibility and effects of targeted overloading of the turbines (boosters) can be tested (also in connection with wind farm control)

### Testing new components

The wind turbines can be used as test units for testing new components, which can be analyzed in the laboratory after dismantling. Differences between standard components and new components can directly be compared.



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## 2.3 Investigations on the dismantled systems

For the first time, alpha ventus will offer the opportunity to examine turbines that have been subjected to many years of real offshore operation in a laboratory after dismantling and to record the condition of all components. This is very useful since the extensive measurements from the test site provide a very accurate picture of the loads and operating conditions over the entire service life.

- Laboratory testing of the components can be used to validate and optimize the life span of offshore wind turbine design. This would be of interest for the plain bearings used in the AD5 turbine type
- Statements can be made about the distribution of damage along the turbines in relation to their operating conditions

## 2.4 Dismantling, recycling, repowering

alpha ventus could be the first offshore wind farm in Germany to be dismantled. Therefore it makes perfect sense to test innovative dismantling methods that can later be used for other wind farms on a larger scale. The operation on the test field should encompass the entire life cycle of marine infrastructures.

### Soil properties after dismantling

- Investigation of the geomechanical condition and load-bearing capacity of the sea floor after the dismantling of the foundations
- Geotechnical investigations regarding anchoring, pile driving, etc.

### Dismantling methods of turbines and foundations

- Demonstration of dismantling methods for turbines and foundations with additional scientific monitoring of the dismantling. Recycling processes can be included. Different dismantling concepts could be tested on one turbine first
- Investigation of the damage and benefits of various methods for partial or complete removal of the foundation (see also ongoing research project "DeCoMP" (Large-scale investigations of technical solutions for the removal of foundation piles of offshore wind turbines; FKZ 0324316))

### Logistics

- Development and validation of logistical concepts for dismantling and recycling

## 2.5 Subsequent utilization of the area / foundations / transformer substation

- In view of the continuing rapid development of technologies for offshore wind energy utilization (turbine size, foundations, floating facilities, etc.), it seems sensible to continue to use the alpha ventus site as a test field for research and demonstration after the current turbines have been dismantled. Test field for new wind turbines, e.g. new turbine types or shallow water floaters; compared to a new test field, this would have the advantage that the transformer substation and the grid connection can continue to be used. Additionally, the measuring mast FINO 1 is located in the immediate vicinity
- Use of the foundations for testing e.g. airborne wind turbines
- Using the area as a test area for sound: hammering experiments with double bubble curtains
- Expanding the test field for other marine renewable energy sources (wave energy, tidal energy, hydrogen production), also beyond the purely technical aspect with a view to sustainable use of the marine environment

### 3. Options for the continued use of alpha ventus as a research infrastructure

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alpha ventus was not built as a purely commercial wind farm. Such a small offshore wind farm, with two different types of wind turbines and two types of foundations, could only be built as a test field with investment funding from the BMWK. During the high remuneration phase of the Renewable Energies Act for the wind farm, it could economically be operated as a purely commercial wind farm. After the end of the high remuneration period, the question of economic operation becomes relevant. If alpha ventus is seen and utilized as a research infrastructure, it should be investigated as to whether the operation of alpha ventus can be funded within the framework of research projects. However, this can only be done if the expected added value for research is proportional to the necessary support for operation.

If continued operation of alpha ventus does not (any longer) make sense, a short but very important phase for research before the actual dismantling can be used for the experimental investigation of new operating concepts. Research could be carried out that would not be possible otherwise.

Dismantling of alpha ventus could take place a few years before the first large commercial German offshore wind farms are dismantled. It therefore makes sense to test the methods and logistical concepts required for dismantling and repowering at alpha ventus.

From a research perspective, it is extremely important to analyze the units in the laboratory after they have been dismantled and to compare the actual damage with simulated turbines. This could provide new insights into the design of offshore wind turbines, as well as improving the accuracy of remaining service life and the possibility of extending it.

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