

## SUBSTATION DESIGN FOR ANHOLT OFFSHORE WIND FARM

**Complete substation design for one of the world's largest offshore wind farms which will produce electricity to 400,000 households**

A substation is one of the core elements in the electrical grid of the wind farm. It collects the power production from the wind turbines and transmits the energy to the land-based power transmission grid through submarine cables.

There are many shared technical details in the design of an offshore substation and traditional offshore facility platforms. At Ramboll we have transferred our experience in offshore structures from the past 30 years to become among the market leaders in the design of substations for offshore wind farms.

### **One substation - electricity to 400,000 households**

One of Ramboll's most recent major substation projects is the Anholt Offshore Wind Farm, located 22 km off the coast of the island Anholt in Denmark. The wind farm will become one of the world's largest

offshore wind farms when it is in operation in 2013.

The 400 MW wind farm will produce energy equivalent to the annual energy consumption of 400,000 households, or 4% of Denmark's total power consumption. 111 wind turbines will produce the energy.

The substation and shore cable are operated by the Danish energy provider Energinet.dk which is owned by the Ministry of Energy and Climate. The state-owned energy company DONG Energy owns and operates the wind farm.

### **Evaluation of scenarios**

Ramboll headed the detailed design of the substation platform, including substructure and complete topside design. In the design process many different scenarios have been evaluated.

The planned location of the wind farm in an area with very difficult seabed conditions, risk of ice loads during winter and heavy ship traffic have been important factors in the design process.

### **Two design proposals**

The substructure design included both detailed design of a steel jacket solution as well as tender design of a combined concrete GBS/Steel structure (GBS = Gravity Based Structure).

The steel jacket solution was initially selected by the client as being the

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**DESIGN IN ACCORDANCE WITH NEW STANDARDS**

The Anholt Offshore Wind Farm substation is one of the first offshore substations to be designed according to the DNV-OS-J201 standard for Offshore Substations for Wind Farms.

The standard describes the basis for safe design, layout and operation of offshore wind farms. It is developed to provide a common set of safety requirements for all platforms associated with offshore wind farms and other

renewable energy projects.

The new standard will become one of the future standards used for European offshore wind farms.

preferred solution. However, prior to tendering the fabrication contract of the platform, the client chose to include a tender design by Ramboll of a GBS solution combining the installation benefits of a floating concrete structure with that of a steel structure on top.

**Fit-for-purpose substation**

The fit-for-purpose substation is designed with due consideration to the wishes and requirements laid out by Energinet.dk as to serviceability, accessibility and the operation of the platform over the expected lifetime of 25 years. The substation is fully optimised in space and weight dimensions.

**Essence of the transformer platform**

The Anholt topside consists of a central area where the three main transformers and 220 kV GIS switchgear are located, and

enclosed modules where the auxiliary equipment is placed.

The topside structure is divided into several platform deck levels, including a helideck. The structure carries equipment for high-voltage transmission and distribution and other facilities such as emergency generator, batteries and panels for wind turbine control etc.

The substation will transfer energy from the 33kV radial cables of the wind turbines, transform the energy and export it onshore via a 220 kV cable where it will be connected to the national grid.

**Site development and Environmental Impact Assessment**

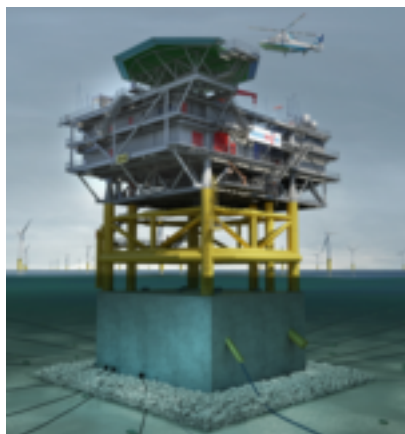
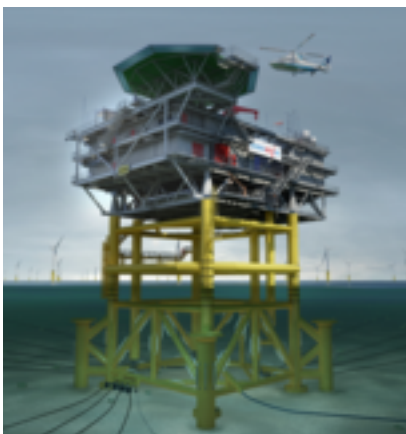
Ramboll has also performed site development and full-scale Environmental Impact Assessment (EIA) on the Anholt Offshore Wind Farm project.

The analysis included siting of the farm and proposals for possible alternative sites, outline foundation design, decommissioning of structures and constructional and operational risk analysis with respect to shipping traffic.

In addition, Ramboll also performed environmental assessment of the establishment of a sea cable to the island of Anholt from the wind farm.

**Ship collision analysis**

In order to state the optimal location for the wind farm, the risk of ship collision was essential to evaluate. Ramboll assisted with analysing the risk to the general ship traffic from the ship traffic related to the construction of the Anholt Offshore Wind Farm.



**LEFT**

The substructure design initially included a detail design of a steel jacket with traditional driven piles as foundation.

**RIGHT**

The concrete GBS/ steel structure combines the installation benefits of a floating concrete structure with that of a steel structure on top.