Risk management and Energi E2´s responsibility during installation, commissioning and operation and maintenance of Nysted Offshore Wind Farm

Poul Erik Ter-Borch, Production Manager, E2 Wind Energy, Denmark

Nysted Offshore Wind Farm

ABSTRACT

Nysted Offshore Wind Farm was installed in the course of 2003 and commissioned in December 2003. It comprises 72 2.3 MW wind turbines, corresponding to a total installed capacity of 165.6 MW.

The project was completed below budget and it was commissioned one month earlier than planned. The wind farm is owned jointly by DONG, Sydkraft and Energi E2. Energi E2 was in charge of project implementation and has been the operator for nearly two years.

The project was implemented on a multi-contracting basis; throughout all the stages, Energi E2 has been deeply involved in all project details, and the two other owners have also followed the project carefully. Hence, the owners have all assumed a substantial part of the responsibility for the project.

The operation data for the first two years are highly satisfactory: with 97%, availability has been high, the well functioning boat landing has provided high accessibility, and only few repairs and corrections have been made - factors that together form the basis for optimal production.

This report describes how the multi-contracting concept combined with Energi E2´s risk management and deeply involvement in the details worked through the different project phases and reviews the choice of concept for new plants.

INTRODUCTION

Nysted Offshore Wind Farm has a total installed capacity of 165.6 MW and an annual production of 600,000 MWh. It was commissioned on 1 December 2003 and has been in operation for nearly two years.

Since Nysted Offshore Wind Farm was among the first major offshore wind projects, there was no previous experience in the industry to build on. Energi E2 chose to divide the works into sublots and invite tenders from companies with the specific task as their core competence. Energi E2 is used to this concept for construction of power plants, which is our background and primary area of competence. We have gained much valuable experience from the construction of Nysted Offshore Wind Farm, which will benefit the next projects on which we have embarked.

Energi E2 is also directly involved in the operation and maintenance of the plant and thus gathers useful experience in this field as well, which will be passed on in this report.

PROJECT HISTORY

The project has been underway for almost 10 years, and it is one of two Danish demonstration offshore wind farms – the other one is the Horns Reef project. A number of environmental research projects follow the project and deliver a lot of precious information.

The wind farm is situated in the western part of the Baltic Sea, south of the Danish island Lolland, see Figure 1, Nysted Offshore Wind Farm situated south of Lolland – close to Germany.

A 2.3 MW stall controlled Bonus turbine is used. It is a turbine much like the 2 MW Bonus turbine of the E2 Offshore Wind Farm at Middelgrunden. The stall control is the Bonus Combistall, which pitches the full length of all blades for control of power output. The concrete gravity foundations from the Danish contractor Aarsleff are also a well-known technology. 33 kV PEX cables excavated 1 m into the sea bed are used internally in the wind farm, and to shore the transmission company decided to use a 132 kV PEX cable.

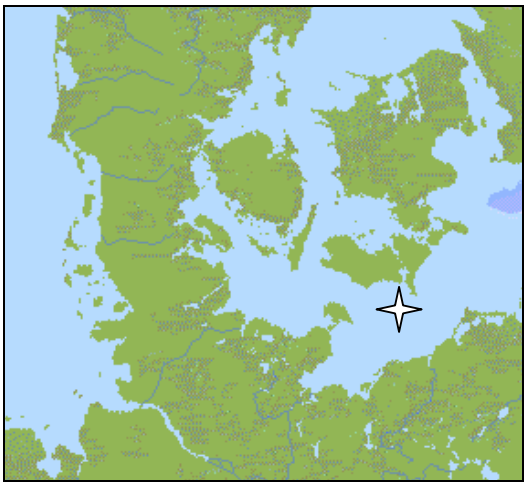

Figure 1, Nysted Offshore Wind Farm situated south of Lolland – close to Germany.

Nysted Offshore Wind Farm is owned by a consortium of three energy companies: Danish-based Energi E2 and DONG and the Swedish company Sydkraft. At the end of this year, DONG and Energi E2 will merge into one company, which will be a major player in the market, and Sydkraft is expanding its offshore activities rapidly.

Planning and Installation:
The project is based on the full range of E2 competences gained in the course of sixty years of power plant implementation and 15 years of offshore wind implementation in Denmark. Vindeby in 1991, Middelgrunden in 2000 and Samsoe in 2002 are some important offshore wind references. E2 took the contract coordination risk and know-how injection possibility by holding separate contracts on turbines, foundations, internal cabling and SCADA – using the E2 multi-contracting concept. The result is a project on the frontline of the technological development with few problems and full exploitation of the lower cost of the newest technology.

Offshore works on foundations and main cabling were initiated in the year before turbine installation to reduce the risk of delayed turbine works. In June 2002 Aarsleff initiated excavation works for the foundations. The main cable to shore was installed in October 2002. The offshore transformer platform was the bottleneck of the project programme, but it was ready just in time by mid-May 2003.

Figure 2 , Installation of Aarsleff's ballasted concrete gravity foundation with Eide Barge 5 from June 2002 to July 2003.

The working method of E2 includes intensive design review participation and intensive installation supervision. At project peak, 50 E2 representatives were busy in the project following foundations, turbines and cables. Close cooperation between E2 and the contractors prevented many problems, and this is a key element behind the eventual success.

Half the foundations were commissioned by Aarsleff when A2SEA started installing turbines for Bonus by 9 May. Within 79 very busy days – including weather delays – the 72 turbines were installed without any major problems. Aarsleff finished the foundation works, and ABB connected

cables simultaneously to enable smooth grid connection of the turbines in packages of 4 to 9 turbines. The first turbine started running by mid-July and all of them were operational by mid-September. Bonus worked hard and final commissioning of turbines by 1 December was one month early compared to the original schedule.

Figure 3, Turbine erection at Nysted Offshore Wind Farm May-July 2003.

OPERATION EXPERIENCE

The following issues describe how problems have been solved through risk management and deeply involvement provided from Energi E2 and competent performance from our contractors.

O&M organisation:
From the start, the plan was for the wind farm to be operated jointly by Bonus and Energi E2. Energi E2 provide the site manager which is in charge of the daily work and risk management of the whole wind farm including health and safety, and Bonus provide the service manager which is in charge of maintaining the turbines. Bonus was to provide all skilled workers at the start, and Energi E2 should gradually deploy its own personnel over a five-year period. This principle has worked well, and Energi E2 is still expected to be able to handle all O&M activities at the end of the period. In addition to this, Energi E2 is in charge of O&M of roughly 300 wind turbines in Denmark.

Demonstration turbine:
To test all details during erection and operation before installation of the wind turbines offshore, a demonstration turbine (turbine 73) was erected at Rødbyhavn. The installation concept was tested on this turbine, and the wind technicians who would be in charge of operation and maintenance of Nysted Offshore Wind Farm had the opportunity to test the operability and serviceability of the wind turbine. No radical changes were needed, but several details were changed to facilitate the future operation and maintenance work.
Since the licence to operate the demonstration turbine at Rødbyhavn has expired, the turbine has been dismantled, and we are working on getting approval for erecting it at Masnedø near the town of Vordingborg.

Nacelle:
The only component that has caused problems is the gearbox; one high-speed bearing and one medium-speed bearing have been replaced by redesigned bearings. The gearbox is designed for rapid and on-site replacement, and the replacement was planned to take place at an early time to prevent the damage to the bearings from causing a breakdown of operations and thus loss of production. The replacement would last 48 hours per wind turbine and the work was primarily carried out in periods with low wind.
More severe damage has occurred on the medium-speed and planet gear wheels. Due to insufficient hardening penetration depth, the teeth lack the necessary strength, and with time cracks develop and the teeth break off. Five IMS (Inter Mediate shafts) have been replaced on site, and eight gearboxes have been replaced in their entirety.
Wind turbines are fitted with an advanced vibration monitoring system, so sensitive that it was possible to detect the damage to the teeth before they could cause total damage to the gearboxes; only two gearboxes have been destroyed and this occurred at the beginning of the operating phase before the monitoring system had been run in.
An improved hardening process for the gear wheels has been developed, and this appears to have solved the problem.
Siemens Windpower, leading experts and Energi E2 have cooperated closely to solve the problem at a minimum of interruption and loss of production.

Blades:
The lightning protection system has worked satisfactorily with no damage or defects.

Tower:
The towers have not posed any major problems, only the lifts had some running-in problems. In future projects, we will make sure that the lift design is as robust and reliable as possible and also include the option to commission the whole system on shore before the offshore installation.

SCADA
Nysted Offshore Wind Farm is equipped with a conventional overall SCADA system operating above the control system installed at the wind turbines. To a certain extent, the two systems contain the same functionalities, and based on this experience, in our future planning we will aim to use the control system of the wind turbines and add on a few special features.
Only general data to be used for management reporting will be exported to a common overall SCADA system, which can cover several wind farms.

Machine transformer:
Excessive winding temperatures have been observed on five transformers, blowers have been fitted under all transformers and this has solved the problem.
Vibrations from the foundations propagate through the transformer supports to the transformers. This has led to a broken cable shoe, but no fire as the arc monitoring system disconnected the system.
Vibration dampers and more flexible cables will be installed.

Foundations:
The concrete foundations have worked satisfactorily, and a recent dive survey showed that all foundations are in good condition.

Marine cables:
Surveys of all marine cables have been conducted, and there are no signs of damage to cables or scour protection, only few holes near the foundation have been filled with stones.
The cable network was designed with as few switchgears as possible to minimise offshore maintenance work. Thus, cables can only be disconnected one row at a time, and this has proved quite sufficient for normal operation.

Main transformer:
Excessive winding temperatures have been ascertained, but increased blower capacity has solved the problem.

Export cables:
A cable survey has been conducted to check cable position and depth, few holes have been filled with stones.

Boat landing and vessel transport:
Energi E2 is responsible for supplying the vessel transport, which is currently being handled by a subcontractor.
Due to the boat landing concept, the wind turbines can be accessed from 360 degrees so that it is always possible to go up against current and wind. Due to the small tide differences, it is possible to access the platform directly from the vessel. For daily transport of wind technicians, a conventional single-hull vessel is used. It has room for 12 passengers and 1,000 bhp engine power. All in all, this solution provides access to the wind turbines at a significant wave height of 1.2 m corresponding to 80% of the year.
Energi E2 is making an effort to improve transport capacity and wind turbine accessibility, e.g. by acquiring a larger vessel of a length of 22 m and 1,800 bhp engine power. The target is to have access to the turbines for more than 90% of the days in a year.

Ports and onshore facilities:
Energi E2 has established new port facilities and buildings for personnel, workshop and stores. The facilities are used by all personnel involved in the operation and maintenance of the wind farm. The facilities are spacious, and fortunately the workshop has not been used very frequently since the extent of repairs has been fairly limited.

Service:
The annual service inspection is carried out as planned; the work is done by teams comprising both Siemens and Energi E2 personnel.

Maintenance management:
For recording of maintenance activities, component data, spare parts, costs, etc., the maintenance management system, SAP PM, has been set up. Moreover, all large components are numbered according to a so-called VKS identification system, which is based on the KKS identification system for power plants.
The identification and maintenance systems were not set up from the beginning and have not been working until now. It is advisable to have the systems ready for commissioning to facilitate the recording process.

Environmental protection and health and safety:
Energi E2 has environmental and health and safety responsibility in relation to Nysted Offshore Wind Farm.

Energi E2 finds that working on offshore wind farms is dangerous for the following reasons:

- Work at sea is generally dangerous and requires compliance with a number of safety rules.
- Working at heights requires careful protection of both personnel and materials.
- Working with high voltage requires careful compliance with safety rules and regulations.
- Heavy work requires physical strength and wide use of aids to prevent worn-out employees.
- The distance to shore makes a rescue operation difficult.
- In terms of the environment, hazardous substances are difficult to retrieve from the sea, otherwise a wind farm must be considered an environment-friendly plant.

Nysted Offshore Wind Farm is certified both regarding the environment and the health and safety and regular audits take place.
The certification system may seem elaborate and bureaucratic, which is why the day-to-day work with health, safety and environment should be as simple as possible. Ultimately, the objective is to create the best possible conditions for the workers and minimum environmental impact.
The operating period of nearly two years has seen two major accidents, a broken foot and a broken wrist, and two minor spill of diesel oil in the harbour.
We have recorded six near-miss incidents.
In our experience, it is important that all personnel have the right attitude and training with respect to H&S work to avoid accidents.

OPERATING RESULTS
The first two years of operation have seen average wind turbine availability of 97%, which is highly satisfactory; moreover, the cable system and main transformer have been in stable operation, so the total availability of the wind farm has been at an average of 96%.
Wind resources have been below average for the past two years; if production is adjusted for this factor, the wind farm fulfils the production forecast of 600,000 MWh per year.

FINANCIAL ASPECTS:
The wind farm was established at a cost below budget, and operating costs for the first two years are within the budget.

CONCLUSION:
We believe that the favourable operating results have been achieved through a combination of the multi-contracting concept, where Energi E2 has managed the risks through deeply involvement in all details, and competent companies that have contributed actively to solving the problems which inevitably arise during a project of this type.
The detailed insight gained by Energi E2 during the construction and operation phases constitutes the platform on which we will build the next projects.

ACKNOWLEDGEMENT:
I would like to thank the many dedicated employees of Energi E2 as well as our partners, DONG and Sydkraft, for their great attention and support during the peoject, which has enabled me to give this report on a successful project.