FOWPI (https://www.fowpi.in/)
FIRST OFFSHORE WIND PROJECT OF INDIA

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O&M Aspects of Offshore

Introduction

With continuous developments in offshore wind technology, one of the fastest growing renewable energy source markets in the world is reaching a mature stage. An increasing number of large offshore projects are planned and developed worldwide, and in some areas, deeper waters are explored in search of optimal locations for extraction of renewable energy.

Simultaneously, stakeholders aim to drive projects costs down by optimising processes where possible. One of the main stages of an offshore wind farm project is the operation and maintenance phase, which accounts for approximately 30 % of the lifetime costs of a modern offshore wind farm project. The main goal of the operation and maintenance phase is to reduce the lifetime cost of the project and maximizing the total energy production, thus optimising the cost of energy. At the same time risks, health, safety and environmental concerns must be handled satisfactorily. The key equipment to be maintained in a modern offshore wind farm is the wind turbine that accounts for about 50% of the O&M budget. The other important equipment to maintain are:

- export cable, onshore grid connection and offshore substation (if any)

- array cable

- wind turbine foundation

- IT infrastructure

The following sections will introduce a general understanding of the key concepts for operation and maintenance (O&M) of offshore wind farms.

Key Stakeholders Role

The Original Equipment Manufacturer (OEM)

OEMs contribution to drive project costs down is reflected in the effort spent for developing new turbine designs that require fewer regular service visits and less turbine downtime.

Normally the OEM is responsible for the wind turbine O&M for the first years, corresponding to the warranty period. After this, the OEM will maintain a certain degree of involvement (full in case of agreement extension) in the wind turbine O&M due to the extensive knowledge of their own technology.

The Project Owners

The project owners are overall responsible for procurement of all operational services related to an offshore wind project up the interface with the offshore transmission system owner. The project owner can choose the degree of involvement in the O&M phase, conducting it either in-house ("hands-on" approach) or contracting out to a third party ("hands-off approach"). The project owner has the option of extending the O&M agreement for a specific number of years when end-of-warranty is reached but often he takes full or in-part responsibility.

The Offshore Transmission System Owner

The offshore transmission system owner owns and operates the offshore transmission infrastructure, which is linked to one or more maintenance contracts.

Aspects of O&M

Wind Turbine Availability Warranty

O&M agreements typically includes an availability warranty, where availability is a measure of the proportion of time where a wind turbine, or a wind farm, is capable of producing electricity. In order to handle claims related to availability it is required to have strict definition of downtime caused by turbine failures or malfunctions.

Energy Yield based Warranty

The wind turbine availability warranty can be replaced or coupled in O&M agreements with energy yield based warranty, where a minimum yearly production target is set for the offshore wind farm.

Cost of Energy

Cost of Energy is a measure of profitability of a project. It is defined as the lifetime total cost divided by the total energy production.

Personnel

Operating and maintaining wind turbines requires workers to have extensive technical knowledge and safety training, sophisticated capabilities to diagnose component performance, knowledge and skills to schedule replacement components, and ability to accommodate changing weather conditions [3].

Operation

The operation phase covers aspects such as environmental monitoring, administration, electricity sales, remote monitoring of the wind farm assets, planning, spare part management, onshore and offshore logistics.

Onshore and Offshore Logistics

Onshore and offshore logistics refers to all those facilities and means of transportation that allows for a smooth and efficient operation and maintenance of an offshore wind farm. The onshore logistics will include the leasing of a quayside, part stores/warehousing, an office space at the port base, and eventually an helicopter landing platform. The offshore logistics will include workboat or helicopters for crew transportation, service vessels, larger vessels and jack-up barges for heavier components transportation, and in case of offshore-based operations, motherships, fixed platforms or offshore support vessels.

Maintenance

Maintenance should be carried out preferably in times of low wind to minimise loss of production (service wind speed range is specified in OEM manuals.) Maintenance is typically divided into three categories:

- Scheduled maintenance

Which defines planned replacement or repairs, typically on wear and tear components, based on experience, best practice, and on input from surveys and inspections. Routine servicing of a typical offshore wind farm should take place once or twice a year. Oil and filters need to be replaced, operating components and bolt-pretension levels need to be inspected.

- Unscheduled maintenance

Which covers ad-hoc replacement or repairs of damaged or failed components. Typically, the unscheduled maintenance costs are higher than the scheduled maintenance due to severity of damage, uncontrollable weather conditions and accessibility issues.

- Preventive maintenance

Which defines proactive replacement or repairs based on input from monitoring systems, surveys and inspections. "Big Data" and "Failure Mode Effects and Criticality analysis" (FMECA) are expected to play a major role in the scheduling of preventive maintenance.

Health and Safety

The offshore environment poses high risks from a health and safety point of view. So a proper health and safety management plan is vital for the operation of an offshore wind farm. The plan should include risk assessment, method statements and procedures. Regular safety auditing of contractors should be carried out along with inspection of safety equipment.

Regular Site Inspection

Regular inspections of the wind farm infrastructure are necessary and the minimum inspection scope must comply with OEM specifications.

Alarm Management

Rapid response times to alarms and warnings need to be guaranteed by O&M providers. Remote control rooms may be developed for the management of O&M activities across a portfolio of offshore wind farms.

Spare Parts

Spare parts planning is extremely important in the O&M process of remote offshore wind farm. The objective is to minimize potential extended downtimes due to lead time in obtaining spare parts. This can be obtained by building an inventory of spare parts on site or across a portfolio of projects and by having spare parts agreement in place with suppliers.

Reporting

Modern offshore wind farms generate an enormous amount of data that is collected in advanced monitoring systems. The reporting capabilities of these systems should be exploited to ensure that valuable and relevant information is available to the decision makers in an informative and effective manner [3].

Finding the balance

The project owner aims to minimize the cost of energy, thus ensuring maximum profit from the electricity produced. Maximizing the availability (i.e. reducing lost revenue) of the wind farm does not necessarily lead to the minimum cost of energy. Thus, an important aspect is to find a balance between the investment in O&M and the wind farm availability.

General O&M Strategies

In order to reduce lifetime costs of the project, an O&M strategy should be deployed to find the perfect balance between lost revenue and O&M costs. This means that an effective maintenance strategy will focus on maximizing project returns via increased operating efficiency and plant availability.

Selecting the best O&M strategy for an offshore wind farm depends on many site-specific conditions, such as distance to shore, available port facilities, vicinity to other projects, accessibility (i.e. weather windows), offshore substation design, project size.

The most influential factor on the definition of an O&M strategy is the distance of the wind turbines from onshore facilities. The successful operation of the wind farm will at a certain distance be limited by transit time, predictability of accessibility etc. Generally, the strategies can be categorised into three pillars depending on the distance between the project and shore [1].

	Onshore base	Onshore base with helicopter	Offshore base
Distance to shore	Up to 12 NM	12-40 NM	> 40 NM

Means of transportation for staff	Workboat based	Workboats and helicopter support	Fixed or floating offshore base with accommodation for staff.

Table 1 | Operating strategies for offshore wind power

It is noted that site-specific factors could result in the adoption of an operational strategy that deviates from the categories introduced above. For medium distance projects, workboats would be more suited for scheduled activities while helicopters to provide a faster response time in case of unscheduled activities to minimise the downtime of turbines.

Independent of the O&M strategy, general good practice includes clear and effective communication between the project owner, O&M contractor and all other parties and authorities involved in the wind farm project. Furthermore, there should be a strategy, outlined in procedures and guidelines, for scheduled, preventive and unscheduled maintenance.

Vital Input from Monitoring, Data Analysis and Forecasting Systems

Modern data monitoring and analysis systems can provide vital input to the operation and maintenance of wind farms.

Condition Monitoring System

Condition monitoring systems (CMS) is a key technology and can cover vibration, temperature, pressure, oil analysis-, optical fibre- and acoustic based monitoring systems for wind turbine components such as gearbox, generator, bearing, drive train, blades, pitch, brake and yaw systems.

The main purpose of the CMS is to deliver information on the state of components, and hence it can be used to detect failures before they occur.

CMS systems can deliver real-time information, which can be utilized in a turbine curtailment strategy and incorporated in the SCADA systems.

Big Data

The term, which is trending in various industries, defines systems that can handle data of high complexity and size. It normally refers to predictive analytics based on data streams from a variety of sources. For an offshore wind farm, this could for example be analysis of fuel data from vessels, personal data from staff and BoP component specific data from CMS and SCADA systems.

All data generated from a wind farm project is assimilated in a complex database system coupled with machine learning and Artificial Intelligence (AI), enabling decision support tools for project owners based on predictive analytics and diagnostics. This could for example shift the approach to maintenance, where the scheduling of optimum maintenance periods could become a data-driven process, taking account many more variables than what is feasible today, potentially driving the costs associated with operation and maintenance of offshore wind farms down. For example, combining meteorological historical conditions, load measurements, wind turbine performance information, the system could point out a blade related issue and suggest to repair the blade's leading edge before performance could drop below an unacceptable threshold.

Forecasting

Forecasting services are important for successful operation and maintenance of offshore wind farms, in relation to planning maintenance activities, risk management and for administrative purpose in terms of estimating the expected electricity output from the wind farm.

Several companies deliver specialised software related to highly accurate weather forecasting as well as power production forecasts for onshore and offshore wind farms.

Forecasting services can, for example, provide input to planning of maintenance activities avoiding weather downtimes when resources are deployed at the wrong time and instead targeting low wind speed periods to reduce health and safety risks, improves accessibility and minimizes lost production in case wind turbines must be stopped.

Contracts and Agreements

Typically, a multi contract approach with overall responsibility on the project owner is applied, where OEM, third party companies with specialty services, forecasting services etc. have different responsibility areas [1].

The O&M set of agreements can include, but is not limited to:

- **Turbine operation and maintenance**
  Agreement governing the operation and maintenance of the wind turbines. and laying out the

KPIs for such service.

- **Spare parts**

Agreement governing the supply of spare parts for the wind turbines lifetime. Special attention shall be placed on the main components quality delivered in case of refurbished parts.

- **Array cable maintenance**

Agreement concerning the maintenance of the array cable within the wind turbines and the offshore substation, if any. Special attention shall be placed on protecting the cables from damages due to movement.

- **Foundation maintenance**

Agreement related to the maintenance of the wind turbine foundations. Special attention shall be placed to corrosion of structures, access platform and scour protection.

- **Export cable and grid connection maintenance**
  Agreement related to the operation and maintenance of the onshore substation, offshore substation, if any, and export cable to the shore.
- **Offshore logistics**
  Agreement related to service vessels, larger vessels and jack-up barges, helicopters, and motherships or fixed platforms linked to offshore-based operations.
- **Onshore logistics**
  Agreement concerning the establishment of a service base including facilities as quayside, warehouse and part stores, and office space.

The project owner may try to reduce the number of interfaces related to wind farm O&M after the warranty period. This could be achieved taking over the O&M responsibility but at the cost of extensive training of staff or bundling several agreements together reducing the number of service suppliers.

For more information, refer the following informative links/material:

1. GL Garrad Hassan, 2013, “A Guide to UK Offshore Wind Operations and Maintenance”, Scottish Enterprise and The Crown Estate (http://www.hi-energy.org.uk/Downloads/General%20Documents/guide-to-uk-offshore-wind-operations-and-maintenance.pdf)

2. Clifford Chance, “Offshore Wind: Operation and Maintenance (O&M) Agreements” (https://www.cliffordchance.com/briefings/2017/03/client_briefing_-offshorewindoperationan.html)

3. Wind- Getting O&M Under Control (http://www.renewableenergyfocus.com/view/26582/wind-getting-o-m-under-control/)

4. Offshore Wind Metocean Web Portal (http://www.stormgeo.com/solutions/renewables/offshore-wind-energy/offshore-wind-metocean-web-portal/)

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For more details on FOWPI project, please email:
info@fowpi.in (mailto:info@fowpi.in) or fowpi.india@gmail.com (mailto:fowpi.india@gmail.com)
Phone +91.124.4319500,
Telefax +91.124.4319501,
Direct +91.9687800983/8849012213

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