Wind Resource Assessment

Wind Resource Assessment for offshore wind farms is not as complex as onshore wind zones due to unrestricted topographic effects, obstacles, roughness class, etc. but offshore wind assessment studies needs to account for factors like wind shear, atmospheric stability, local land breeze effects, wave dependent roughness etc.

Some of the important parameters that need to be discussed while assessing the offshore wind resource are:

Resource Area for setting up an offshore wind farm

As per the National Offshore Wind Energy Policy 2015, there are two main maritime areas in which structures can be built:

i. Indian territorial waters, which are generally extended up to 12 nautical miles (nm) ~ 22.2 kms from the baseline; and
ii. Exclusive Economic Zone (EEZ), beyond the 12 nm limit to 200nm (~370.4 kms), where the wind structures can be built as per international law.

Satellite Data Sources

In order to assess the preliminary wind potential across the coast, the satellite data is being used to capture the long term climatology and wind speed trends. There are various satellite sources like NCEP/NCAR, MERRA, ERA, GFS, CFSR etc. which are available at temporal resolution of 1h, 3h or 6h and at spatial resolution of between 50-250 kms. This can analyzed to understand the potential zones for setting up an on-site measurement campaign.

Land Use and Environmental Exclusions

Land-use and environmental exclusion areas such as marine paths, environmentally protected areas, national marine sanctuaries, wildlife refuges, shipping and towing lanes, and offshore platforms and pipelines, etc. are eliminated from the total potential resource area.

Wind Resource at the given Hub Height

The wind resource is typically analyzed in a variety of heights for a wind project, but the most important height is the hub height which is specific to the wind turbine configuration in each project.

Mesoscale Mapping

An initial meso-scale modelling and mapping of the wind resource is carried out for the purpose of planning the development of new and efficient wind energy projects. This assessment can be used to find out the most appropriate locations for wind resource measurement campaigns. This will create a hypothetical boundary layer field of wind speed across the region of interest (RoI) using processed satellite data as well as on-site measured data (if available) at certain specified heights (typically 100-120 m) at a spatial resolution of 0.3 to 1 sq. km.

On Site Met Data Measurements

On site measurements serves a critical aspect in reducing the uncertainty of any offshore wind farms project. Categorically, two types of remote sensing systems are available on the market: SoDAR (Sonic Detection and Ranging) and LiDAR (Light Detection and Ranging).

Typically, the instruments for offshore measurement are mounted over a support structure in form of lattice towers generally guyed to the sea bed. Costs for offshore metrological measurements are broadly driven by the cost of constructing of the support structure for the meteorological mast.

LiDARs have been replacing met masts to become the sole wind measurement tool for offshore resource assessment and power curve verification purpose.

A LiDAR can measure the wind conditions up to a height of typically 200 meters.. Thus the wind speed and wind direction for the whole rotor blade area can be obtained and hence used to develop an accurate wind energy yield forecast. Measurements are carried out using mounted LiDAR based met station or floating LiDARs.

The latest entrant to this market segment is Floating LiDAR technology. Floating LiDAR devices were designed as a faster and less expensive alternative to met-masts. A floating LiDAR device substitutes an anemometer on a fixed mast structure with a LiDAR sensor on a floating platform, typically a buoy. A LiDAR is a laser-based sensor that measures the wind speed and direction by tracking the motion of air particles and has been accepted as a reliable and accurate technology for onshore wind resource assessment.

Recently, “The Carbon Trust”, London, has announced their completion of world’s largest trial for floating LiDARs. Prior to such trials of floating LiDARs, the main roadblock for adoption of this technology was the unavailability of validated data from such systems showcasing the reliability of the measurements in an offshore environment. Some of the notable gains from a floating LiDAR involve minimized cost and time, ability to capture additional meteorological and oceanographic data from the surrounding environment across multiple locations.

MCP - Long Term Correction

The MCP (Measure-Correlate-Predict) is a combination of measured site data and mesoscale / reanalysis data to estimate long term wind conditions at the site.

Typical MCP methods include:

- Linear regression MCP
- Matrix MCP
- Weibull Scale MCP
- Wind Index MCP

Wind Turbine Generator and its Power Curve

With a typical wind turbine power curve of latest offshore wind turbine generators having a capacity range between 5-8 MWs and wind resource datasets collected through a met tower, estimates of the energy production can be calculated for each individual turbine by performing flow and wake modelling.

With advancements in blade’s swept area and generator’s technology, manufacturers are moving towards exploiting as much energy from the wind as possible.

Wind Farm Layout Design

The process for designing an offshore wind farm is similar to the process for an onshore wind farm. While designing a layout for a new wind farm, the following factors should be taken into consideration:

- Site Constraints (including bathymetry and seabed soil conditions)
- Wind resource
- Wake Losses
- Visual Impact
- Predominant Wind Direction

- Area occupied per turbine
- Footprint secondary use

Gross Energy Modelling

Based on the met data measurements and the flow modelling, the gross production estimates can be determined incorporating long term wind forecasts for the projected life cycle.

Net Energy Yield

As per the offshore industry practice, the energy degradation and losses pertaining to power transmission, machine availability, grid availability, blade soiling, array efficiency etc. are accounted to the gross energy estimates and shall further be used to determine the Net PLF estimates for the projected life cycle of the Offshore wind farm.

Uncertainties and Probability of Exceedance

Broadly, the uncertainties associated to Offshore wind power projects are accounted on following factors

- Wind speed uncertainty – 2% in European market
- Long Term Correction
- Extrapolation – horizontal and vertical
- Model uncertainty
- Historical wind speed variability - 6% in the European market
- Uncertainties related to losses

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

1. NREL guideline- 2016: Offshore Wind Energy Resource Assessment for the United States
2. Presentation by Poushali Maji/Andy Oldroyd from Oldbaum Services on Offshore WRA
3. MEASNET: Evaluation of site-specific wind conditions, Vers. 2, April 2016
4. Framework for the Categorization of Losses and Uncertainty for Wind Energy Assessments, DNV KEMA Energy & Sustainability, 5 February 2013
5. IEC 61400-15, Assessment of site specific wind conditions for wind power stations (expected in draft during 2017)
6. Planning and Development of Wind Farms: Wind Resource Assessment and Siting. Niels G. Mortensen. DTU Wind Energy Report-I-45, DTU Wind Energy, December 2013
7. Floating LiDAR Technology (http://www.pes.eu.com/assets/misc_dec/axys-edpdf-911649615105.pdf)

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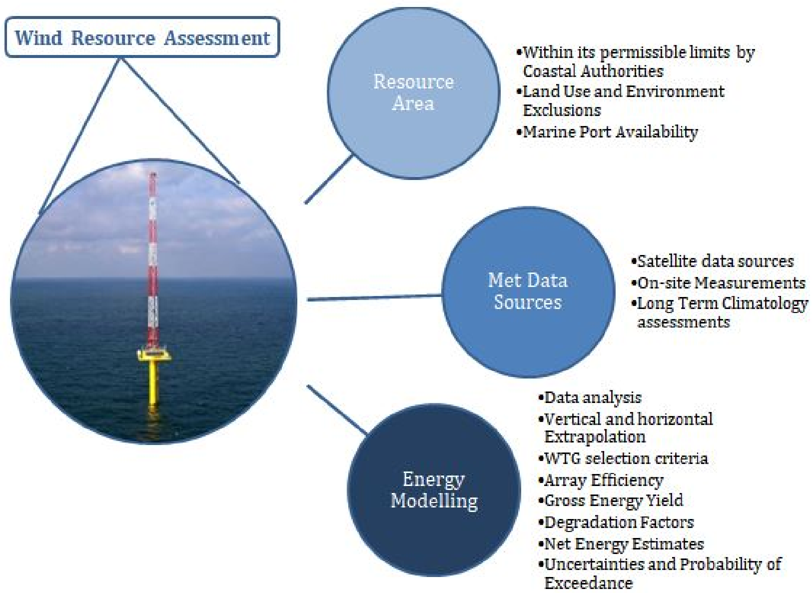

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