Decision Support for Offshore Wind Turbine Installation
Gintautas, Tomas; Sørensen, John Dalsgaard; Heggelund, Yngve

Publication date: 2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Abstract

Costs of operation & maintenance, assembly, transport and installation of offshore wind turbines contribute significantly to the total cost of offshore wind farm. These operations are mostly carried out by specific ships that must be hired for the operational phase and for duration of installation process, respectively. Duration, and therefore ship hiring costs is, among others, driven by waiting time for weather windows for weather-sensitive operations.

Today, state of the art decision making criteria for weather-sensitive operations are restrictions to the significant wave height and the average wind velocity at reference height. However, actual limitations are physical, related to response of equipment used e.g. crane wire tension, rotor assembly motions while lifting, etc. Transition from weather condition limits to limits on physical responses in decision making would improve weather window predictions, potentially reducing cost of offshore wind energy. This poster presents a novel approach to weather window estimation using ensemble weather forecasts and statistical analysis of simulated installation equipment response. An important aspect of any novel methodology is evaluating how well it performs compared to the standard methods given the same input. Both – proof of concept and evaluation are done and presented in a form of synthetic case study – an offshore wind turbine rotor lift operation at the FINO3 met-mast location. Performance of both methods is measured in terms of number and length of predicted weather windows.

Graphical representation of the model

- Forecasted met-ocean conditions
- Hydrodynamic multibody motion simulator
- Operation description (cranes, vessels, lifting equipment, etc.)
- Time series of relevant responses (equipment loads, motions)
- Operational Acceptance limits (maximum crane loads, allowable motions)
- Statistical model
- Estimates of statistical parameters of extreme responses
- Estimates of Probability of Operation Failure
- Decision making based on combination of Probabilities and/or Costs of failed operations

Methods

Weather Input to SIMO

Short term study – proof of concept. ECMWF weather forecasts, 3 days lead time:
- Multiple weather parameters (wind speed and direction, wind-sea and swell parameters and directions).
- 51 forecast ensembles to ensure low statistical uncertainty

Long term study – verification of proposed methodology. ECMWF forecasts updated daily
- Forecasts (scatter) and measurements at FINO3 location (green line) for summer of 2014

Proposed methodology. Proof of concept and verification

SIMO software is used to simulate the installation sequence using systems of barges, cranes, control wires/tugs and wind turbine components. The installation process is split into different phases. Each phase has multiple failure criteria, example:

- Phase 1: Pre-deployment
- Phase 2: Deployment
- Phase 3: Operation Limits
- Phase 4: Lift Operation
- Phase 5: Operation Limits
- Phase 6: Fallback

3. Steps 1-2 are repeated for 51 forecast ensembles individually (example lead time 36 hours).
4. The Probability of Failure for one acceptance limit is estimated using the 51 ensembles. Combining all the limits states in one Probability of failure for the whole operation.

Results of long term verification study

- The proposed methodology is performing better, with −10% improvement in terms of total length of predicted weather windows. With weather increasing forecast uncertainty the length and total number of weather windows decreases. Using less, but uncertain, weather forecasts, would be very beneficial for performance of proposed method.

Acknowledgments

The research is funded by The Research Council of Norway, project No. 225231/070 - Decision support for offshore wind turbine installation. The authors also acknowledge Christian Michelsen Research, Meteorologisk Institutt (Norway), MARINTEK, Uni Research, University of Bergen (UiB) and STATOIL for their valuable inputs and support.

Conclusions

It can be concluded that the procedure for estimation of Probability of Failed Operations produces consistent results and could be used to assist in decision making for Offshore Wind Turbine installation. The proposed methodology is performing better, with −10% improvement in terms of total length of predicted weather windows. With weather increasing forecast uncertainty the length and total number of weather windows decreases. Using less, but uncertain, weather forecasts, would be very beneficial for performance of proposed method.