Reference Cases for Benchmarking Operations and Maintenance Models for Offshore Wind Farms

Rebecca Martin, EDF Energy R&D UK Centre/ IDCORE, UK
Iver Bakken Sperstad, SINTEF Energy Research, Norway
Iain Dinwoodie, University of Strathclyde, Wind Energy Centre for Doctoral Training, UK
Ole-Erik V. Endrerud, University of Stavanger, Norway

Motivation

As offshore wind energy is a new area for operations research , O&M cost modelling software tools are developed to support activities in this field. Lack of real data means there are limited options for verification of these models A step towards verification and increased model credibility is code-to-code comparison where model results are compared with those from other models [1-3].

Objectives

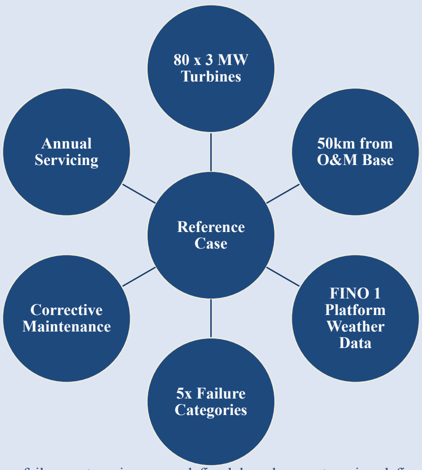
- Develop and provide reference cases for model developers
- Run reference cases with four models and present results
- Identify and understand important modelling assumptions for estimating performance of the four O&M models and logistics strategies.

Methodology

- Define base case of inputs to compare models with
- Run models
- Define additional 15 cases (Table 1) to compare model sensitivities
- Compare average annual O&M costs and availability from models

Reference Cases

Full details of the reference cases can be found in [4]



Five failure categories were defined based on categories defined in the RELIAWIND [5] project:
I. manual reset,
II. minor repair,
III. medium repair,
IV. major repair,
V. major replacement,
Each category (i) had a corrective maintenance strategy with annual failure rate per turbine (λ), an average repair time and different resources (technicians and vessels) assigned to complete the repair operation.

Table 1: Reference Cases labels and descriptions

Case	Case description
More CTVs	2 more CTVs & 30 more technicians
Fewer CTVs	2 fewer CTVs
More technicians	10 more technicians
Fewer technicians	10 fewer technicians
Failure rates down	λ_i x 0.5
Failure rates up	λ_i x 2
No HLVs	$\lambda_{major, minor} = 0$
No weather limits	Weather limits for CTVs & HLVs = inf.
Historical weather data	No generation of synthetic weather time series. Deterministic time series used instead.
Manual resets only, Minor repairs only, Medium repairs only, Major repairs only, Major replacements only	$\lambda_{\neq i} = 0$
Annual services only	$\lambda_i = 0$

Models

- ● **NOWIcob** model developed by SINTEF Energy Research
- ▲ **UiS** model developed by University of Stavanger
- ■ **ECUME** model developed by EDF R&D
- ◆ **Strathclyde CDT Offshore Wind OPEX** model developed by Strathclyde University


Crew Transfer Vessel (CTV)

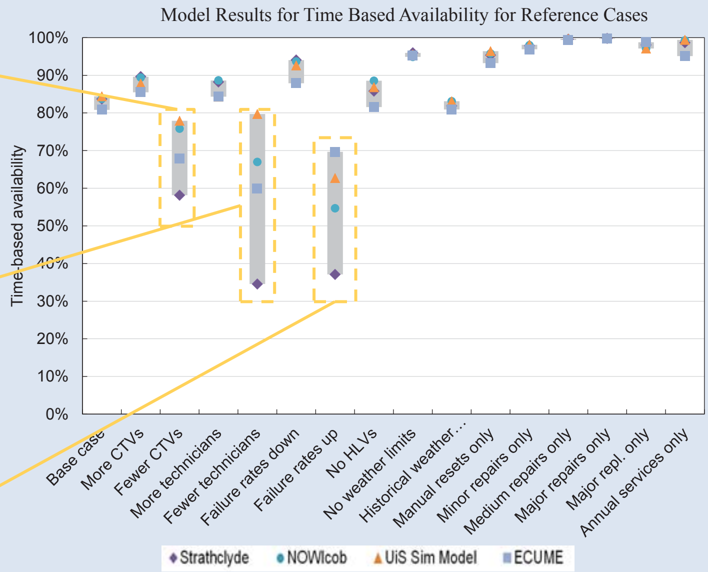

Heavy Lift Vessel (HLV)

Results

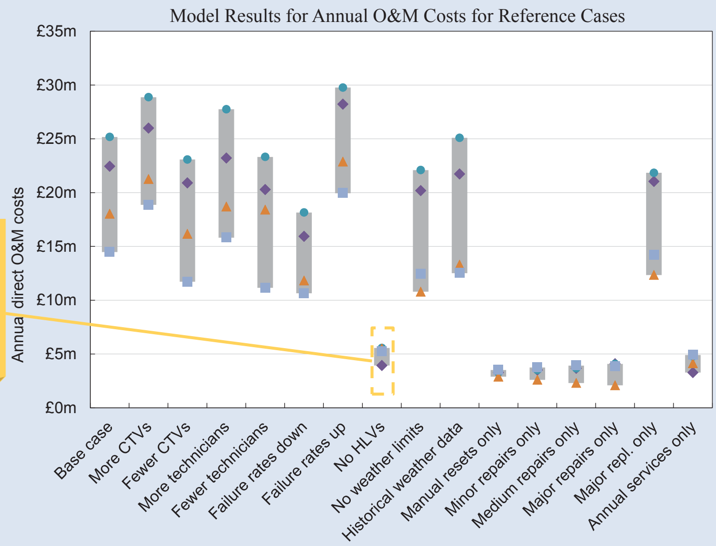
Parallel maintenance tasks:
Models with fixed limit of parallel repairs lower results. Those limited by resources had higher results

Assignment of Maintenance Tasks
Models that can assign small maintenance tasks to vessels & technicians offshore are less sensitive to reduction of technicians

Failure Event Generation
Models generating turbine failures based on total period (total period = turbine uptime + downtime) were not equally sensitive to change in failure rate as models that generate failures based on turbine uptime only



HLC Charter Length
Without HLVs, costs results converge. Models with fixed minimum charter length produced higher costs and models which allows chartering of HLV as needed produced lower costs.



Conclusions

Different modelling assumptions led to major differences in cases where maintenance resources are highly restricted. It can be concluded that the following model assumptions may have a large effect on the simulation results, and the modeller should therefore pay high attention to these when deciding on a modelling approach:

- Approach on modelling of charter options for heavy-lift vessels
- Possibility to perform parallel maintenance tasks in a shift
- Approach of modelling failures
- Possibility to assign maintenance tasks to vessels when offshore

References

[1] Sargent, R.G., Verification and Validation of Simulation Models, Journal of Simulation, 2013, 7, 12–24.
[2] Karimirad, M. Meissonnier, Q. Gao, Z. Moan, T. Hydroelastic code-to-code comparison for a tension leg spar-type floating wind turbine. Marine Structures. 2011. 24, 412-435.
[3] Jonkman, J. Musial, W. Offshore Code Comparison Collaboration (OC3) for IEA Task 23 Offshore Wind Technology and Development. Technical Report. 2010. NREL/TP-5000-48191
[4] Dinwoodie, I. V. Endrerud, O. Hofmann, M. Martin, R. Sperstad, I.B.. Reference Cases for Verification of Operations and Maintenance Simulation Models for Offshore Wind Farms. Wind Engineering. 39 (1-14).
[5] Wilkinson, M., Hendriks, B., Spinato, F., Gomez, E., Bulacio, H., Roca, J., Tavner, P., Feng, Y. and Long, H., Methodology and Results of the Reliawind Reliability Field Study, European Wind Energy Conference, Warsaw, 2010

EERA DeepWind' 2015 Conference
Trondheim
4th – 6th February 2015