Quantifying O&M savings and availability improvements from wind turbine design for maintenance techniques

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Abstract and Introduction

Abstract

- Wind turbine manufacturers, owners and operators all aim to reduce the cost of energy (CoE) from wind turbines.
- Operations and Maintenance (O&M) costs can make up to 30% of the CoE for offshore wind turbines.
- With these high costs O&M has been identified as an area of possible cost reductions to improve the CoE
- This analysis focuses on cost savings on two turbine types from inbuilt lifting mechanisms, reduced repair times from design for maintenance techniques and redundancy.

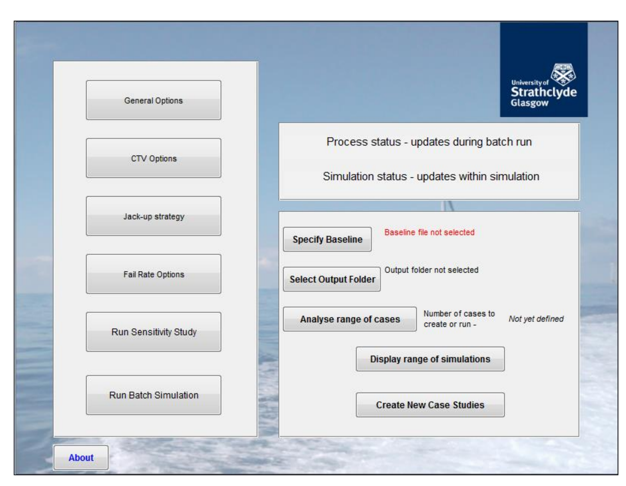
Introduction

- This paper shows the results of an analysis carried out to determine the value added to two wind turbine types when design for maintenance techniques, redundancy and in built lifting mechanisms are utilised for drivetrain variations.
- The two turbine types are DFIG turbines and PMG turbines
- Whether value is added is based on O&M cost saving and availability improvements.
- This analysis was carried out for a site hypothetical offshore site located 50km offshore using wind and sea data from the FINO offshore site.

Offshore O&M Model and Analysed Population Overview

Offshore O&M Model

O&M Model



- Strath OW-OM model developed by the University of Strathclyde [1].
- In this analysis the model is used to determine O&M costs and availability.
- The model provides these outputs based on the inputs detailed below and through calculating accessibility and power production of the wind farm by using a Markov chain Monte Carlo failure model and multivariate auto-regressive climate model.
- The inputs required to obtain these outputs are detailed below
- A baseline availability and O&M cost per MWh is obtained for both turbine types.
- Inputs are then adjusted to simulate in-built lifting, redundancy and reduced repair times

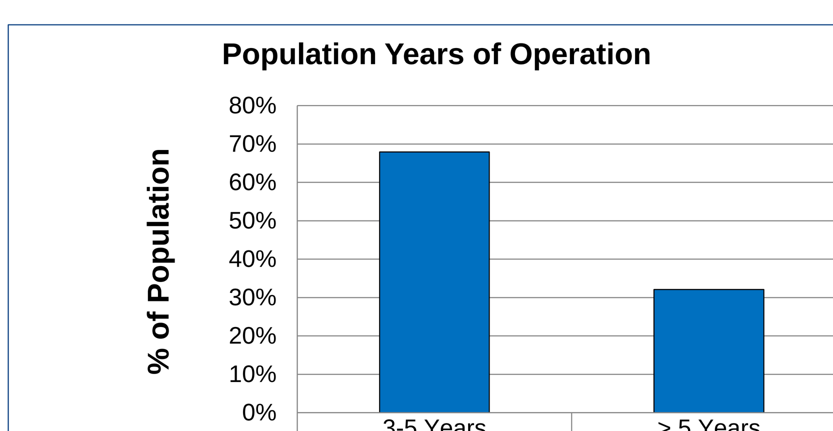
Model Inputs

- Failure rates, repair times, repair costs, required technicians, and empirical power curves are obtained from the analysis of the population detailed in the next section.
- The operational parameters for the vessels were obtained from [2]

Analysed Population Overview

The following population was analysed to obtain the inputs required for the model detailed in the previous section:

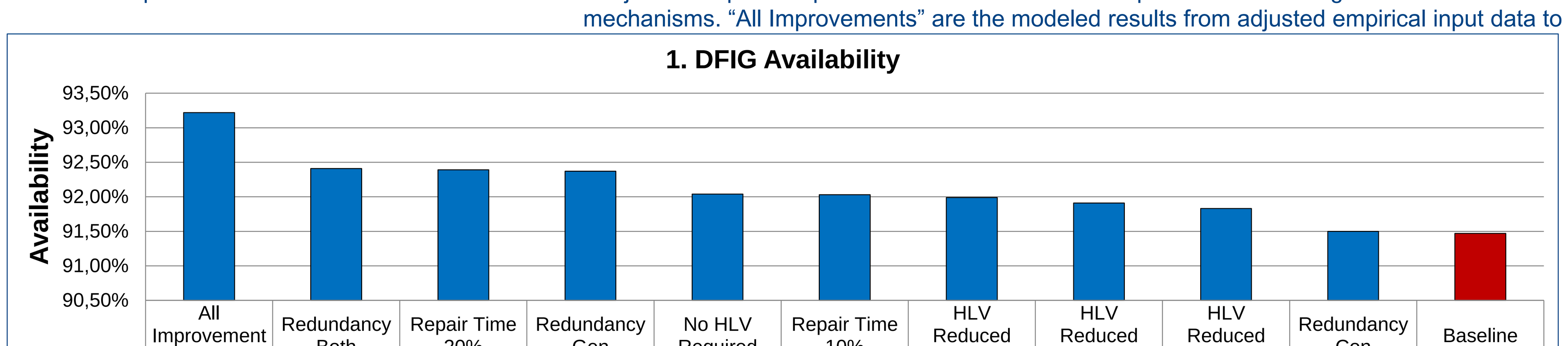
- Population of ~350 offshore wind turbines
- From between 5-10 offshore wind farms
- Modern multi MW turbines between 2 and 4 MW
- Gear driven turbines
- 68% of population has been operating for between 3-5 years
- 32% for over 5 years
- For the 2nd turbine type the population was adjusted based on [3]



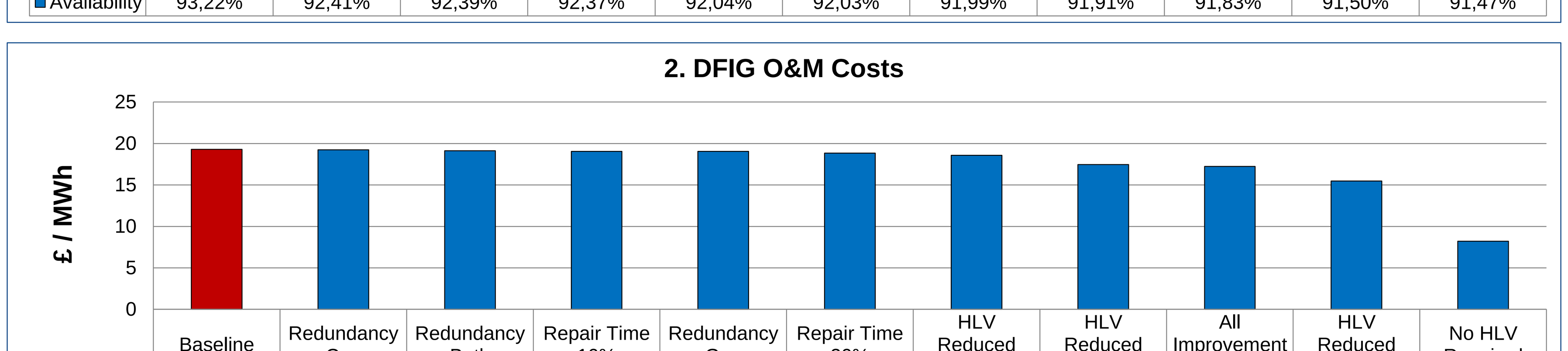
	3-5 Years	> 5 Years
Years of Operation	68%	32%

Results

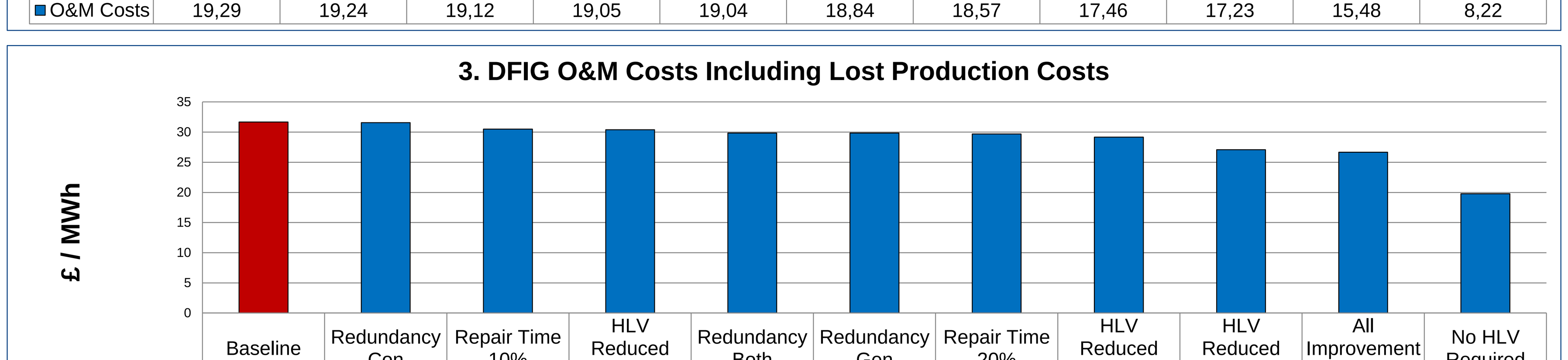
In the following graphs the "Baseline" are the modeled results obtained from the empirical data. "Redundnacy Con" "Redundancy Gen" and "Redundancy Both" are the modeled results from adjusted empirical input data to simulate redundancy in the converter, generator and both combined. "Repair time 10%" and repair time 20% are the modeled results from adjusted empirical input data to simulate reduced repair time from design for maintenance techniques. "HLV reduced" is the modeled results from adjusted empirical input data to simulate reduced requirement for HLV due to the use of in-built lifting mechanisms. "All Improvements" are the modeled results from adjusted empirical input data to simulate all of the above improvements with repair times reduced by 10% and HLV usage by 50%.



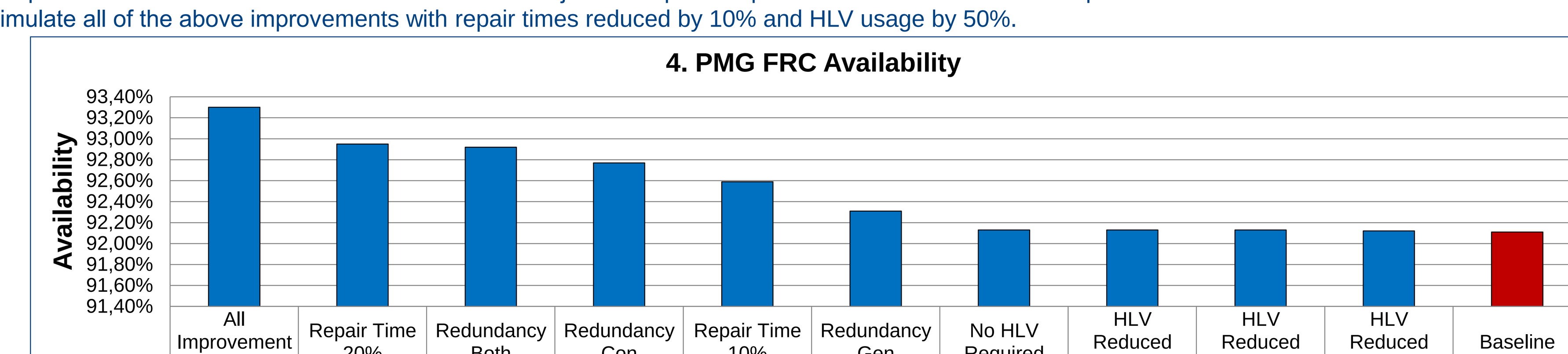
	All Improvements	Redundancy Both	Repair Time 20%	Redundancy Gen	No HLV Required	Repair Time 10%	HLV Reduced 75%	HLV Reduced 50%	HLV Reduced 25%	Redundancy Con	Baseline
Availability	93,22%	92,41%	92,39%	92,37%	92,04%	92,03%	91,99%	91,91%	91,83%	91,50%	91,47%



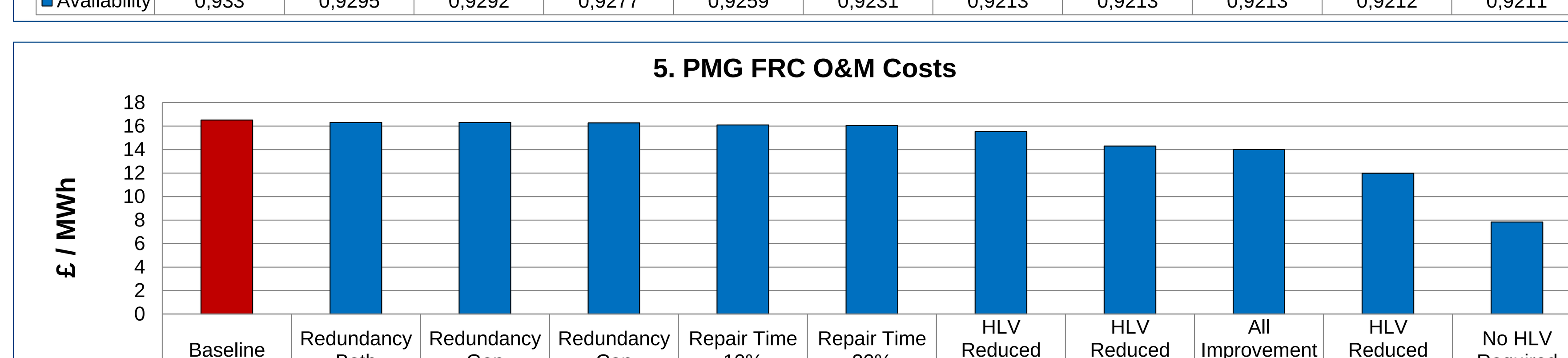
	Baseline	Redundancy Con	Redundancy Both	Repair Time 10%	Redundancy Gen	Repair Time 20%	HLV Reduced 25%	HLV Reduced 50%	All Improvements	HLV Reduced 75%	No HLV Required
O&M Costs	19,29	19,24	19,12	19,05	19,04	18,84	18,57	17,46	17,23	15,48	8,22



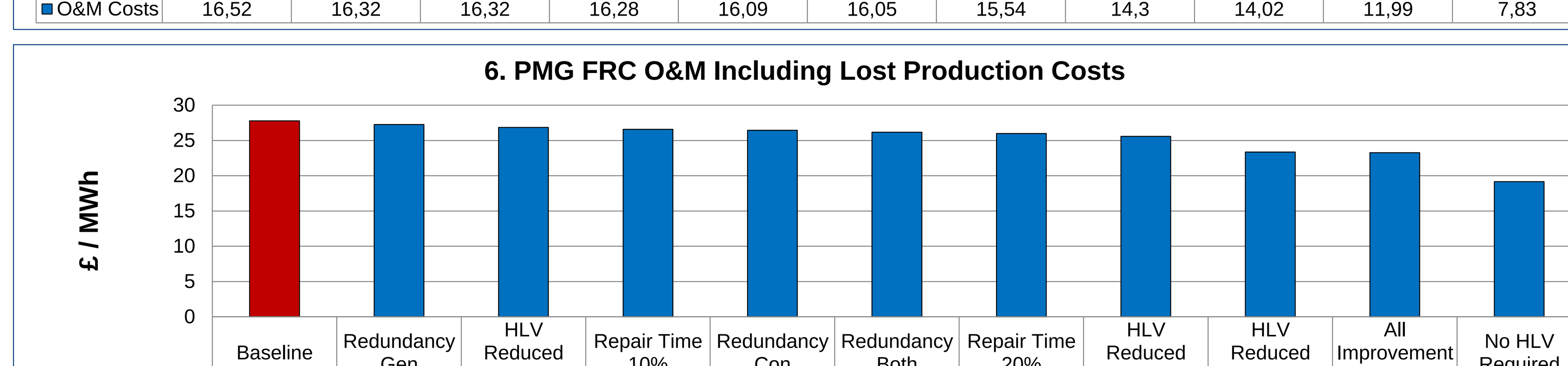
	Baseline	Redundancy Con	Repair Time 10%	HLV Reduced 25%	Redundancy Both	Redundancy Gen	Repair Time 20%	HLV Reduced 50%	HLV Reduced 75%	All Improvements	No HLV Required
O&M Costs Total	31,67	31,56	30,49	30,39	29,85	29,84	29,68	29,17	27,09	26,66	19,78



	All Improvements	Repair Time 20%	Redundancy Both	Redundancy Con	Repair Time 10%	Redundancy Gen	No HLV Required	HLV Reduced 75%	HLV Reduced 50%	HLV Reduced 25%	Baseline
Availability	0,933	0,9295	0,9292	0,9277	0,9259	0,9231	0,9213	0,9213	0,9213	0,9212	0,9211



	Baseline	Redundancy Both	Redundancy Gen	Redundancy Con	Repair Time 10%	Repair Time 20%	HLV Reduced 25%	HLV Reduced 50%	All Improvements	HLV Reduced 75%	No HLV Required
O&M Costs	16,52	16,32	16,32	16,28	16,09	16,05	15,54	14,3	14,02	11,99	7,83



	Baseline	Redundancy Gen	HLV Reduced 25%	Repair Time 10%	Redundancy Con	Redundancy Both	Repair Time 20%	HLV Reduced 50%	HLV Reduced 75%	All Improvements	No HLV Required
O&M Costs Total	27,79	27,26	26,86	26,59	26,45	26,18	25,98	25,59	23,35	23,28	19,17

Discussion and Conclusions

1. For the DFIG turbine redundancy in the power train improves availability by ~1%, reducing repair times by 10% through DFM techniques improves availability by 0.57% and reducing the need for HLVs by 50% improves availability by 0.5%.
2. For the DFIG turbine reducing the need for HLVs by 50% reduces O&M costs by £1.83 / MWh, reducing repair times through DFM techniques reduces O&M costs by £0.24 / MWh and redundancy in the power train reduces O&M costs by £0.17 / MWh
3. For the DFIG turbine reducing the need for HLVs by 50% reduces O&M costs (including lost production costs) by £2.50 / MWh, redundancy in the power train leads to a reduction of £1.82 / MWh and reducing repair times through DFM techniques leads to a reduction of £1.18 / MWh
4. For the PMG FRC turbine redundancy in the power train improves availability by 0.81%, reducing repair times by 10% through DFM techniques improves availability by 0.48% and reducing the need for HLVs does not reduce availability due to CTV restraints.
5. For the PMG FRC turbine reducing the need for HLVs by 50% reduces O&M costs by £2.22 / MWh, reducing repair times through DFM techniques reduces O&M costs by £0.43 / MWh and redundancy in the power train reduces O&M costs by £0.20 / MWh
6. For the PMG FRC turbine reducing the need for HLVs by 50% reduces O&M costs (including lost production costs) by £2.20 / MWh, redundancy in the power train leads to a reduction of £1.61 / MWh and reducing repair times through DFM techniques leads to a reduction of £1.20 / MWh
7. Eliminating the need for a HLV reduces the DFIG turbine overall O&M costs to roughly the same amount as the PMG FRC turbine. The total O&M costs for the DFIG turbine drop below the Total O&M cost for the PMG turbine basecase if HLV usage is reduced by up to 50% or repair times reduced by at least 20%.

References and Acknowledgement

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