Effects of the Support Structure Design on the Economic Viability of Offshore Wind Projects: an Interdisciplinary Analysis

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Summary

In this work, a probabilistic, interdisciplinary analysis of an offshore wind (OW) project is conducted by combining an aero-elastic offshore wind turbine (OWT) model with an economic viability model. The impact of different monopile designs (more durable designs – i.e. increased lifetimes – and those with lower CAPEX) on the stochastic cost efficiency of a simulated OW project is investigated. The results indicate that the effect of stochastic lifetime differences exceeds the effect of CAPEX on the considered project competitiveness. This means that more durable and thus more costly designs are preferable.

1. Introduction

To further improve the competitiveness of OW projects, optimizations of OWT substructures with regard to costs and reliability are needed. For optimized substructure designs, interdisciplinary analyses considering complex engineering and economic aspects are most suitable. Such combined approaches are not wide spread and, if any, deterministic. We address this research gap by combining an OWT model estimating costs and lifetimes, with an economic viability model for probabilistic investment analyses. With our approach, we investigate the impact of different monopile designs on the stochastic cost efficiency of an OW project. By varying diameters and wall thicknesses of the monopile, we create designs with increased average lifetimes but higher CAPEX (durable designs, "Dur") and those with shorter average lifetimes but decreased CAPEX (cheaper designs, "Chp"). Subsequently, the stochastic cost efficiency of the different designs within an entire OW project is analyzed.

2. Models

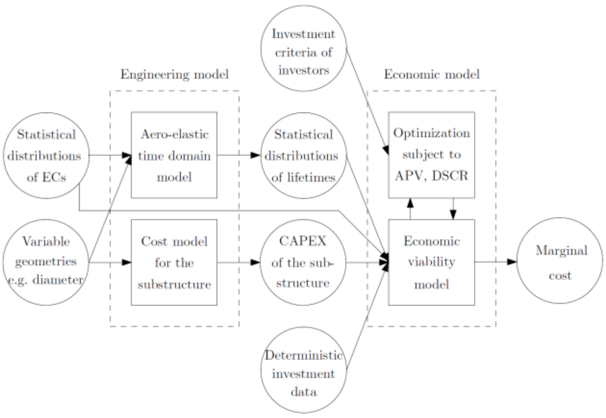

Fig. 1: Combined engineering and economic model

An overview of the interdisciplinary approach is given in Fig. 1. As OWT model, we utilize the FASTv8 software and a probabilistic modelling approach according to [1]. Engineering wind farm aspects are not considered. The economic viability model is an extension of [2]. We formulate an optimization problem to determine the marginal cost (minimum sales price per unit of electricity setting the mean adjusted present value (APV) equal to zero) of the analyzed OW project given each monopile design separately.

3. Results

Exemplarily results, showing the APV and marginal cost in ct/kWh, are given in Fig. 2. Designs with increased lifetimes have in most cases higher APV and lower marginal costs, and therefore, are more cost-efficient solutions.

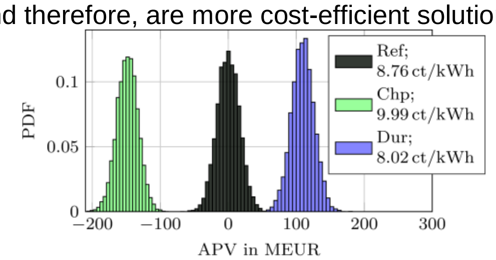

Fig. 2: APV PDF compared to the reference design ("Ref") and marginal costs for all designs.

4. References

[1] Hübler C, Gebhardt CG, Rolfes R, Methodologies for fatigue assessment of offshore wind turbines considering scattering environmental conditions and the uncertainty due to finite sampling, Wind Energy 2018.

[2] Piel J-H, Hamann JF, Koukal A, Breitner MH, Promoting the system integration of renewable energies: Toward a decision support system for incentivizing spatially diversified deployment, JMIS 2017; 34 (4): 994-1022.