Development of a decision support framework for optimal investment strategies in offshore wind energy projects

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Summary of the project

Offshore wind (OW) market comprises of a diverse pool of equity investors: Utilities, OEMs and EPCI contractors, Independent Power Producers, Pension Funds, Infrastructure Funds, Institutional investors, and Sovereign wealth funds. Different classes of investors commonly accept to uptake risks of higher or lower magnitude and of different nature, while their entry and exit timings to the investment differ, too.

A framework for deriving optimal investment decisions for different types of investors in the OW industry is presented. The framework aspires to:

- Map different strategies followed by stakeholders in the offshore wind industry;
- Develop an integrated cost-revenue model of high fidelity, which will allow for the evaluation of the investment at different stages of its life, taking into account uncertainties of key input parameters;
- Optimise investment decisions for the different clusters of investors in the context of a case study.

Flow chart

1. Cluster Analysis

- Statistical analysis based on real data from industry to identify different investor trends

2. Life cycle cost/revenue model

- A detailed cost model, taking into account key cost factors and also considering the time that expenses occur, in order to factor them in the total life cycle costs

3. Temporal cost profiles of the OW farm investors

- Application of the life cycle cost/revenue model for decision support of investment decisions of OW farms taking into account the different strategies followed

4. Design optimisation of an offshore wind based on lifecycle techno-economic assessment

- Structural optimisation which would consider techno economic criteria under different scenarios: reduction of inspections, incorporation of condition monitoring systems, life extension scenarios

5. Case study application

- Application of methodology to a case study

Overview of methodology

Life cycle cost/revenue model for strategic investment decision of offshore wind farms

- CAPEX → ❖Accurate installation costs (vessels, personnel) ❖Fabrication costs
- OPEX → Accurate O&M cost modelling ❖Weather distribution ❖Vessel costs ❖Failure rates ❖Calendar/condition based planning and costing
- Energy production → ❖Real power curves ❖Site specific wind data
- Financing → ❖Weighted Average Cost of Capital (WACC) ❖Cost of debt capital ❖Cost of equity capital

+ Revenue module
- Forward curves

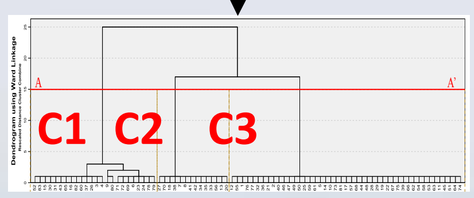
+ Stochastic module
- Stochastic cost modelling

Cluster analysis to identify profiles of investors

Collection of data of OW projects

Characteristics of key clusters
- Holding length (Entry year, Exit year, Divestment year
- Stake divested
- Risk appetite
- Cost of capital

Statistical Analysis of real data through cluster analysis



Optimisation problem

- Structural optimisation which considers techno economic criteria
- Revenue maximisation of offshore energy assets
- Minimisation of financing costs
- Optimal investment decisions for the different investor types

Preliminary results

Cluster analysis

Derivation of 3 distinct investor clusters:

C1) Late entry investors: Third party capital/enter after commission of the plant/retain a low risk profile /low WACCs

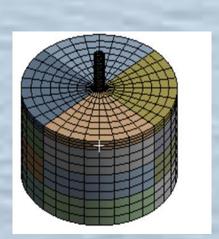
C2) Pre-commissioning investors: IPPs, EPCI and OEMs/enter at the beginning of the project's lifecycle/exit timing prior commissioning of the OW farm (late construction)/high WACCs

C3) Build-own-transfer investors: Major Utilities and IPPs/ enter from licensing period/develop and operate the asset/low WACCs

Structural optimization

FEA (finite element analysis) and GA (genetic algorithm) for optimized thickness distributions under different material safety factors, coupled with a cost model → Effect of structural design elements (based on design standards) on the capital and inspection and maintenance costs and, as a result, on the levelised cost of energy of the technology (Ioannou et al., 2017c).

Inspection scheme	Base case: Inspection every 7 years	Inspection every 13 years	No inspections
Mass increase (%)	0	6.5	12.2
CAPEX to OPEX ratio	**14.36**	**14.51**	**14.62**
LCOE (£/MWh)	120.44	120.95	121.42



Conclusions

- As the number of operating wind farms increases, commercial aspects begin to receive a lot of attention.
- Currently, investors from different backgrounds and with different strategies seek for opportunity instances throughout the lifecycle of the asset to invest by purchasing stake of the ownership and contribute equity capital.
- Cost models need to take into account the temporal costs of the investment and address the specificities of the different investors.

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Relevant references

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