Multi-Objective Optimisation methods for Offshore Wind Farm Location Selection

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Summary

This research aims to devise and apply a methodology to make more informed decisions and increase the confidence in strategic investments in the offshore wind energy sector, so as to ultimately reduce the offshore wind costs in the UK by modelling the processes of selecting the wind farm location and support structure. The best location should be discovered by considering the conflicting nature of the cost elements, so as to reduce overall cost at the early stages of a wind energy investment. The suggested methodology combines multi-objective optimisation and Multi-Criteria Decision Making methods along with industrial experts' insight, in order to make more informed decisions. This is applied to the selection of the optimum offshore wind farm location and support structure type and has the potential to expand further and be transferred to many scientific areas.

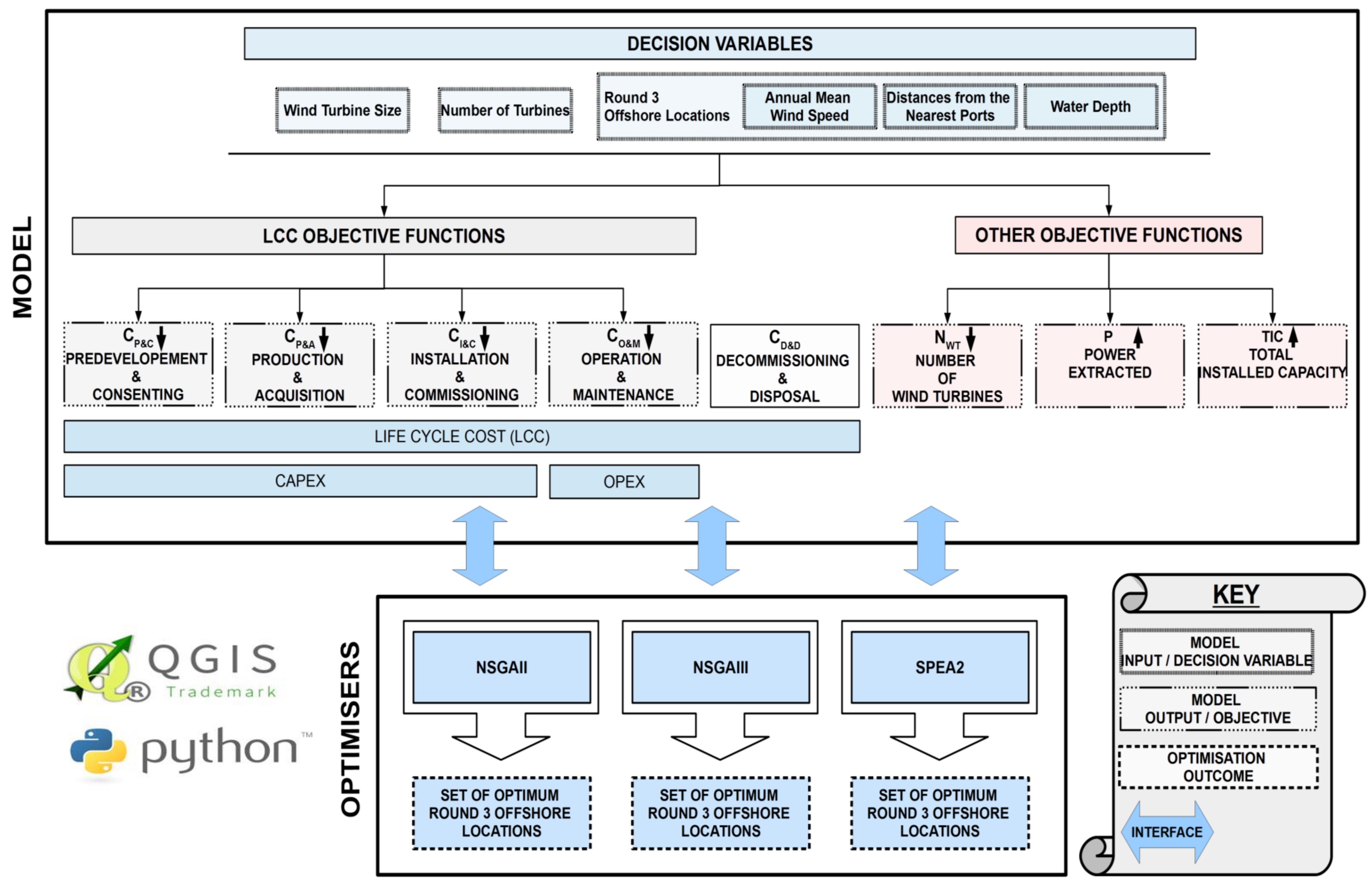
Introduction

The UK technology roadmap highlights that the offshore wind costs need to be reduced to £100 per MWh by 2020 and a greater confidence over financial motivations is required. The location of a wind farm and the type of support structure have great impacts on the total cost [1]. A Political Economic Social Technological Legal Environmental (PESTLE) analysis in three European countries was conducted in order to categorise the vital factors affecting the wind energy sector and to reveal opportunities and challenges in the development of wind farms [2].

The proposed steps follow:

- ❑ Implementation of a Life Cycle Cost (LCC) model in order to estimate the wind energy costs by capturing the related resources and operations at the early stages of the development of an offshore wind farm
- ❑ Performance of a Multi-Objective Optimisation (MOO) in Round 3 offshore locations by linking the previous model to 3 state-of-the-art optimisers in order to compare the effectiveness of the optimisers, discover non-dominated solutions and reveal the interplay among conflicting objectives

Methodology



$$LCC = C_{P\&C} + C_{P\&A} + C_{I\&C} + C_{O\&M} + C_{D\&D}$$
$$CAPEX = C_{P\&C} + C_{P\&A} + C_{I\&C}$$
$$OPEX = C_{O\&M}$$

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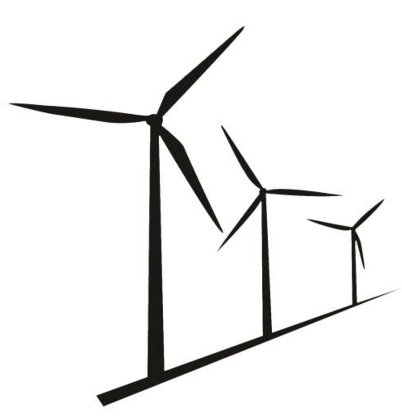

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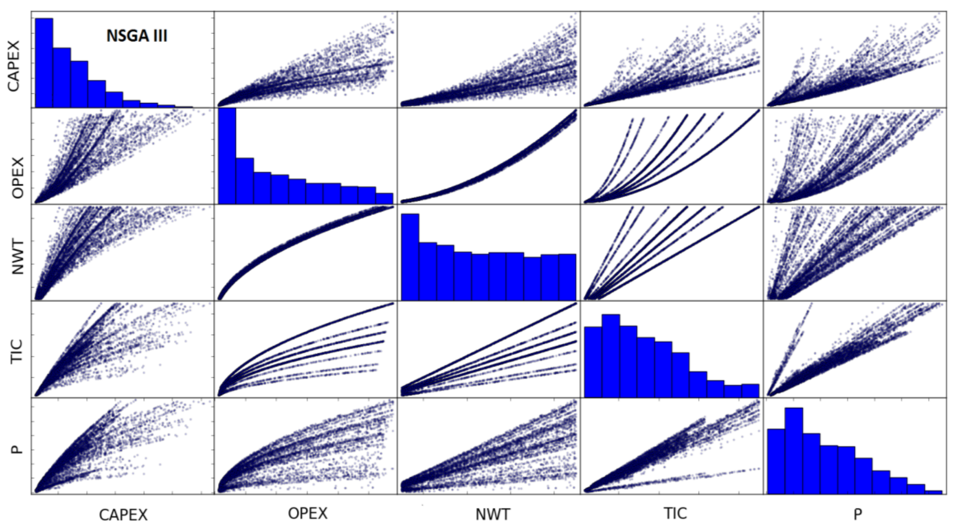
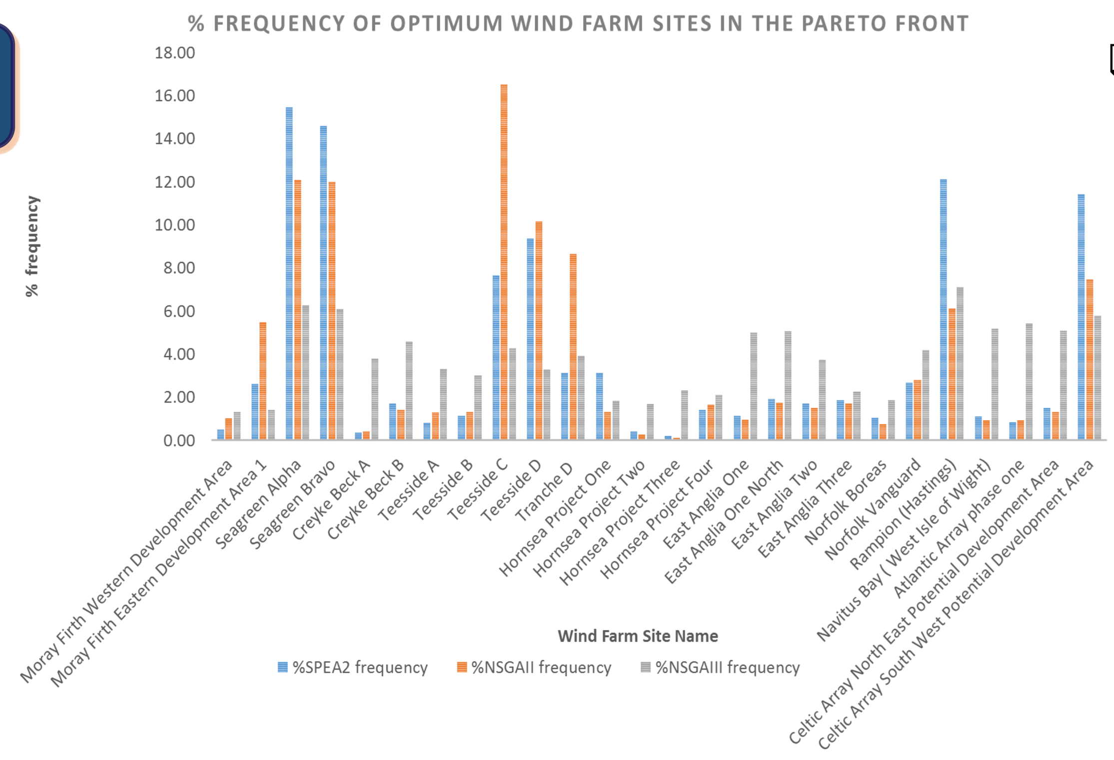
Results

❑ The performance of the algorithms has shown that NSGAIII demonstrated better results and showed its suitability in MOO.



Scatter plot matrix among CAPEX, OPEX, NWT, P and TIC by using NSGAIII



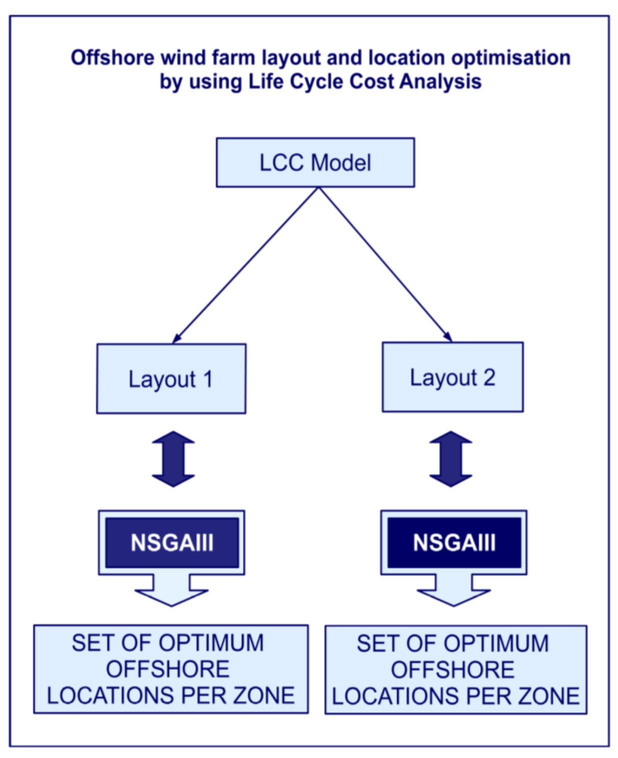
❑ The results provide developers with the flexibility to assign costs in different development phases as convenient; Interplay between investing more money on installation or maintenance.

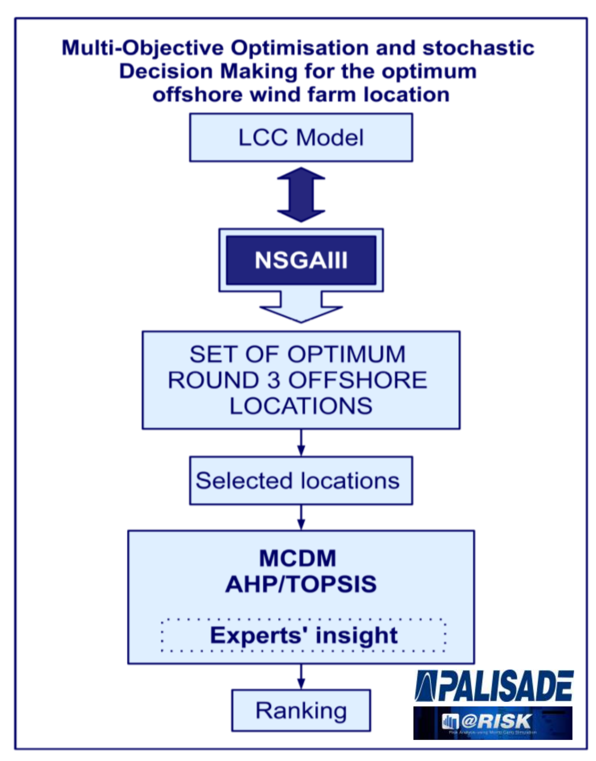
Conclusions

A methodology for selecting the optimum wind farm location was created so as to increase stakeholders' confidence over financial incentives and reduce the energy production cost by using techno-economic LCC and physical factors of each location. The outcomes could impact a possible extension of the Round 3 zones in the future of the UK and will help decision makers to make more cost efficient investment.

Future work

- ❑ Reform the optimisation problem and investigate two different offshore wind farm layouts in order to assess the cost-effectiveness and discover the non-dominated optimum solutions.
- ❑ Following the assessment of the effectiveness of six MCDM methods applied to a reference case in order to identify the best offshore support structure under uncertainty in [3], TOPSIS and AHP will be linked to the optimisation process. in order to rank the previously discovered solutions of wind farm locations.





References

[1] Department of Energy and Climate Change, "UK renewable energy roadmap," 2011.
[2] V. Mytilinou, A. J. Kolios, and G. Di Lorenzo, "A Comparative Multi-Disciplinary Policy Review in Wind Energy Developments in Europe," *International Journal of Sustainable Energy*, pp. 1-21, 2015.
[3] Kolios, A.; Mytilinou, V.; Lozano-Minguez, E.; Salonitis, K. A Comparative Study of Multiple-Criteria Decision-Making Methods under Stochastic Inputs. *Energies* 2016, *9*, 566.

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