Introducing MCDA for offshore wind farm repowering
A case study on Gotland
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Abstract

With an ever-increasing number of offshore wind farms reaching the end of their lifetimes, the decision to either repower or decommission them will be made. Repowering a wind farm may be a financially viable option, as some of the decommissioning and installation expenses can be shared, and the wind resource is well known, which lowers the risk of the project. Furthermore, wind turbine technology has substantially developed over the last decades, and repowering a site can considerably increase production. However, the decision to repower a site is influenced by several technical, economic, environmental or social factors.

Given the many stakeholders (developer, local community, government, etc.) and factors involved, the complexity of the repowering decision-making process is high. Therefore, the use of multi-criteria decision analysis methods provides a valuable tool for decision makers. Facilitating a structured framework to identify the best possible option for all stakeholders. In this study, the PROMETHEE II methodology is applied to the case of both Gotland, the first offshore wind farm in Sweden. Four scenarios were designed, varying the total number of capacity and the number of turbines. Criteria were defined, including the annual energy produced, capital cost, avian impact and local acceptance. Seven relevant stakeholders (including the developer, local population, and local government) have been identified, and their preferences for all of the criteria have been gathered.

The application of PROMETHEE II provided a ranking of repowering scenarios, and several key conclusions were obtained. The stakeholders that prefer economic criteria favor scenarios with a higher capacity, while the stakeholders that prefer environmental criteria favor scenarios with a lower capacity. Furthermore, the likelihood of consensus among all stakeholders was analyzed. The findings suggest one scenario with low possibility of consensus, two with medium, and one with high, which would be the most likely to succeed.

Objectives

- To optimize the decision-making processes.
- To find the best scenarios for negotiation.

Scenarios

- Background wind farm
  - Located at the southern tip of Gotland, Sweden
  - Started producing power in March 1998
  - Connection of five Wind World 5000/12 wind turbines

- Scenarios 2, 3, and 4: 4900 kW capacity, with a new offshore wind farm.

- Scenarios 2, 3, and 4 can be split into two groups:
  - Lower capacity - Scenarios 2, 3 & 4
  - Higher capacity - Scenarios 5 & 6

- Stakeholders

  - Local people
  - GEAS
  - Fishermen and sellers
  - Environmentalists
  - Municipality
  - Regions
  - Developer

- Criteria

  - Energy criteria
    - Annual energy production
    - Capital costs
    - Internal rate of return
    - Operation & maintenance costs
    - Sale price
  - Social criteria
    - Local acceptance
  - Environmental criteria
    - Avian impact
    - Emission of CO2
    - Impact on birds
  - Technological criteria
    - Decommissioning/cost of installation

- MCDA

- Results

- Conclusions

- References

- Acknowledgements

Overview of Potential Savings

When the decommissioning works and the construction of the new offshore farm are carried out simultaneously, the potential for cost savings is enormous. An overview of potential savings that the owner could enjoy through repowering can be found in Table 2.

Quantitative Visual Impact Assessment

1. Infringing turbine
2. Right-hand turbine
3. Left-hand turbine

VI sub-criterion: Turbine height
- The total height of a turbine

VI sub-criterion: Visual coverage
- Horizontal angle multiplied by vertical angle

VI sub-criterion: Turbine density
- The amount of turbines that are perceived from the examination point divided by the distance from the rightmost turbine to the leftmost turbine.