

Simulation and Optimisation of Offshore Renewable Energy Arrays for Minimal Life-Cycle Costs

R. Kuipers

November 12, 2019

The problem

- Focus on modern windfarms in the North Sea, relatively far from the coast, 100+ wind turbines, lifespan of about 20-30 years, costs of installation in range of £100 million or higher
- Optimize logistics of operations on offshore windfarms (OWFs) in each phase of the life-cycle:
 - Installation
 - Maintenance
 - Decommission
- Logistical decisions consists of layout, vessel scheduling, routing, number and types of vessels
- Small optimisations can have significant effects on costs, as vessels can cost upwards of £100,000 per day
- Methods used are optimisation and simulation

Key challenges

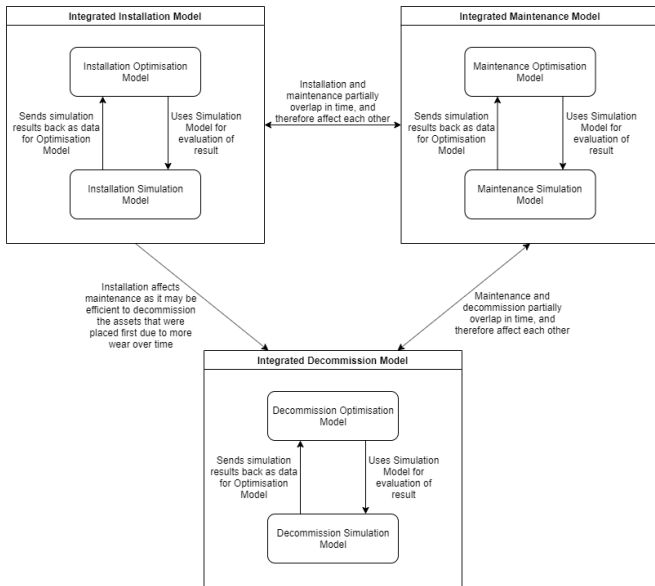
- Long lead-up times for many decisions means no last-minute scheduling
- Maritime weather conditions can be unpredictable
- Looking at the whole life-cycle includes a lot of different types of decisions
- Location-specific circumstances can have a big effect on weather conditions and duration of tasks
- Phases are not independent, maintenance starts at the same time installation starts

- Design an integrated optimisation and simulation model spanning the entire life-cycle of an Offshore Wind Farm, based on sub-models for each phase of the life-cycle.
- Sub-objectives:
 - Design an integrated optimisation and simulation model for the installation projects of an OWF.
 - Design an integrated optimisation and simulation model for the maintenance projects of an OWF.
 - Design an integrated optimisation and simulation model for the decommissioning projects of an OWF.

- Various attempts to improve the installation phase, through integer programming and local search, combined with simulation
- A lot of research has been done in various areas of maintenance, including supply chain management, mitigating failure rate, condition based maintenance
- Not a lot of research has been done on decommission projects, but they are similar in structure to installation projects
- No research at all has been found that looks at the entire life-cycle and how the different phases affect each other

- Reviewed a large part of the literature, primarily on installation projects and secondarily on maintenance projects and general non-deterministic scheduling and logistics
- Laid the foundations for a decision support tool suited to analyse and optimise schedules for any phase of the life-cycle, based on site-specific characteristics of the project
- Planned the interactions between my various models

Model interactions



- Develop full models for each stage of the life-cycle
- Determine specific interactions between the stages
- Implement models in the tool, develop it further for full commercial functionality
- Validate and test the tool (and underlying models) using real data