Development of an Optimized Operation & Maintenance Strategy of Offshore Wind Farms

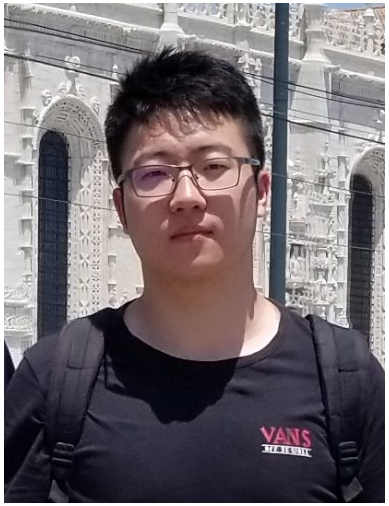
PhD Candidate: Mingxin Li
Promotor: Rudy R. Negenborn
Co-promotor: Xiaoli Jiang

TWIND Summer School 08/07/2021

Overview

- Self Introduction
- PhD Project
- Research Progress
- Published articles

Self Introduction



PhD candidate: Mingxin Li

Institution: Delft University of Technology

Period: September 2019 ~ present

Promotor: Prof. Rudy R. Negenborn

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PhD topic: Development of an Optimized Operation & Maintenance Strategy of Offshore Wind Farm

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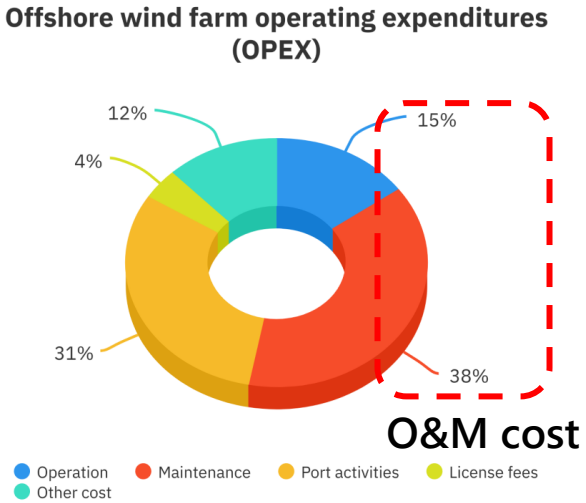
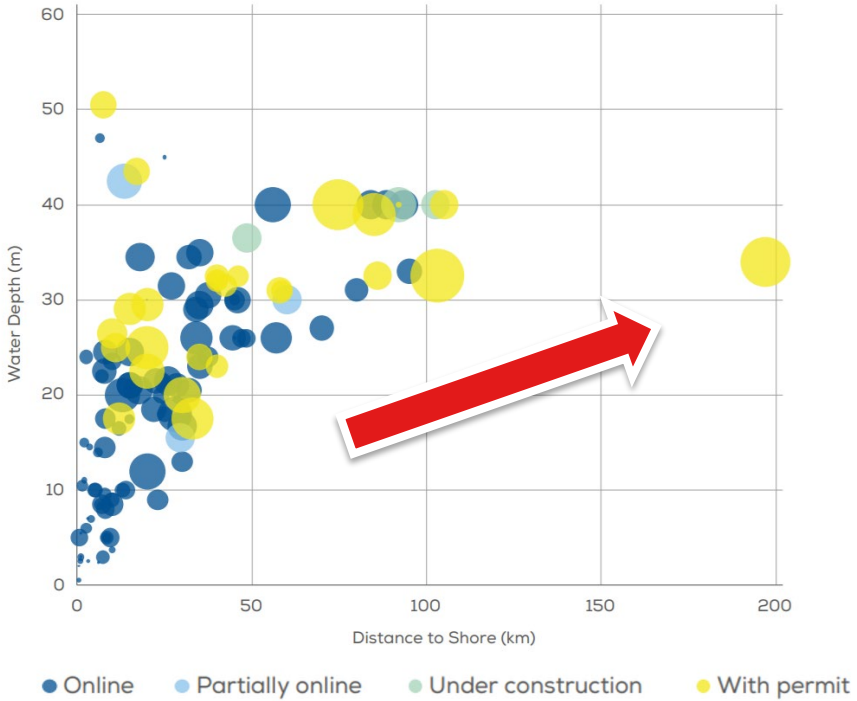
PhD Project





Breakdown of operational expenditures of an offshore wind farm [1]

Average water depth and distance to shore of offshore wind farms in Europe [2]

[1]Lagerveld, S. Röckmann, C. Scholl, M. 2014. A study on the combination of offshore wind energy with offshore aquaculture. IMARES Report C056/14.
[2]OFFSHORE WIND IN EUROPE. Key trends and statistics 2018

PhD Project

- **Project Objective:**

Develop a mathematical model for the offshore wind farm O&M strategy in order to reduce costs and increase power production during the full lifetime

- **Scope of Work:**

1. A basic maintenance model integrating multiple types of maintenance opportunities
2. Investigating influence of uncertainties on the performance of the maintenance model
3. Dynamic maintenance strategy considering updating data
4. Joint optimization of O&M strategies integrating logistics and spare parts management
5. Adaptability of the developed O&M model in different scenarios

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PhD Project

- Work package 1: Developing a maintenance model integrating multiple types of maintenance opportunities (completed)

• Degradation-based opportunity • Incident-based opportunity • Multiple age-based opportunity

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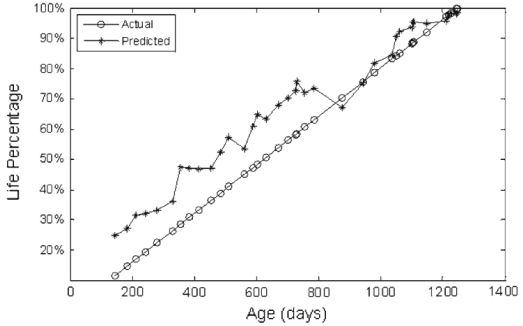
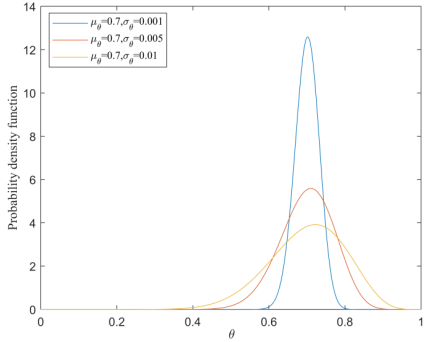
PhD Project

- Work package 2: Investigating influence of uncertainties on performance of maintenance model (in progress)

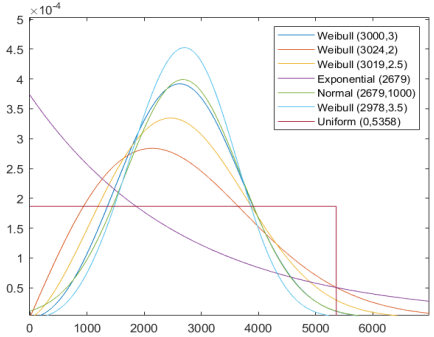
- Deviation of predicted and real failure times



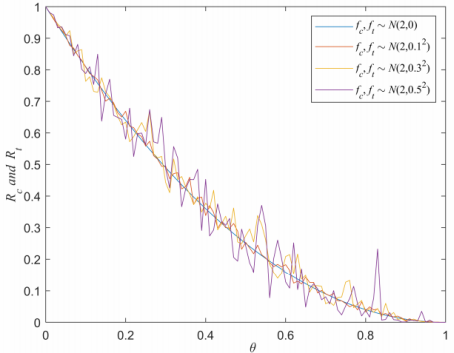
- Stochastic maintenance quality



- Stochastic attributes of time to failure



- Uncertain repair cost and time



PhD Project

Work package 3: Dynamic maintenance strategy considering updating data

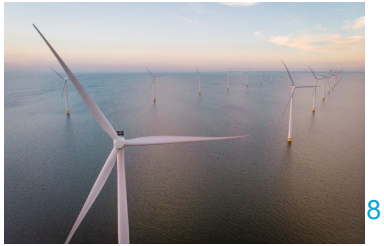
- New information and data on degradation and remaining useful life of components becomes available
- Updating maintenance decisions
- An adaptive and dynamic maintenance strategy

Work package 4: Joint optimization of O&M strategies integrating logistics and spare parts management

- Spare parts management policy
- Logistics options
- Meteorological conditions

➢ Work package 5: Adaptability of the developed O&M model in different scenarios

- Configuration and capacity
- Geographic location
- Decision maker and beneficiary



Research Progress (Work package 1)

- 250MW offshore wind farm located at North Sea
- The operation lifetime:20 years
- Five critical components (generator, bearing, gearbox, rotor-blades, pitch system)
- Input data is collected from literature and report [1-3]

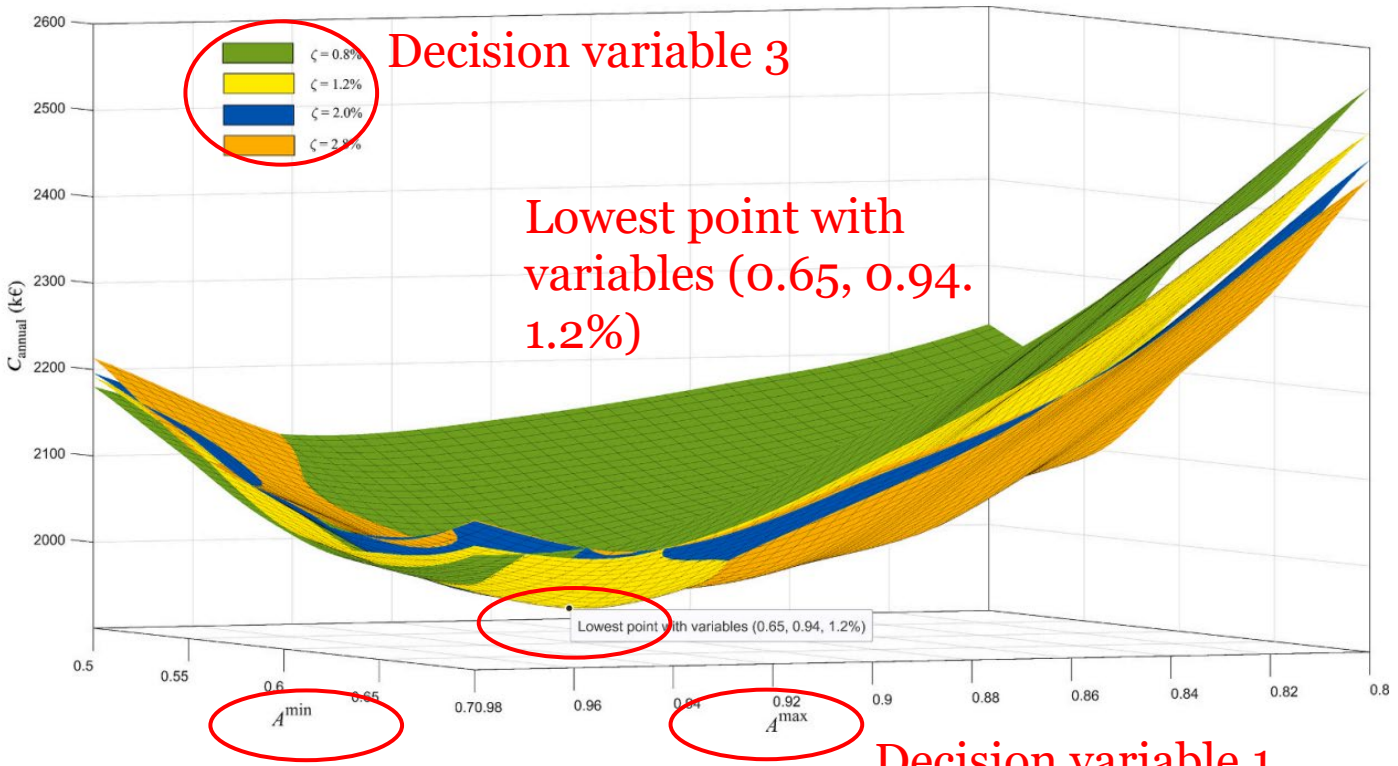
Component	Shape parameters	Scale parameters (days)	Failure replacement (k€)	Preventive replacement (k€)
Rotor&blade	3	1847	215	55
Bearing	2	1811	60	15
Gearbox	3	1477	260	65
Generator	2	1594	90	25
Pitch system	3	1144	46	10

[1]B. Le and J. Andrews, "Modelling wind turbine degradation and maintenance," Wind Energy, vol. 19, pp. 571-591, May 2015.

[2] J. Jonkman, S. Butterfield, W. Musial, and G. Scott, "Definition of a 5-MW Reference Wind Turbine for Offshore System Development," National Renewable Energy Lab. (NREL), United States, NREL/TP-500-38060, February 2009.

[3] B. R. Sarker and T. I. Faiz, "Minimizing maintenance cost for offshore wind turbines following multi-level opportunistic preventive strategy," Renewable Energy, vol. 85, pp. 104-113, January 2016.

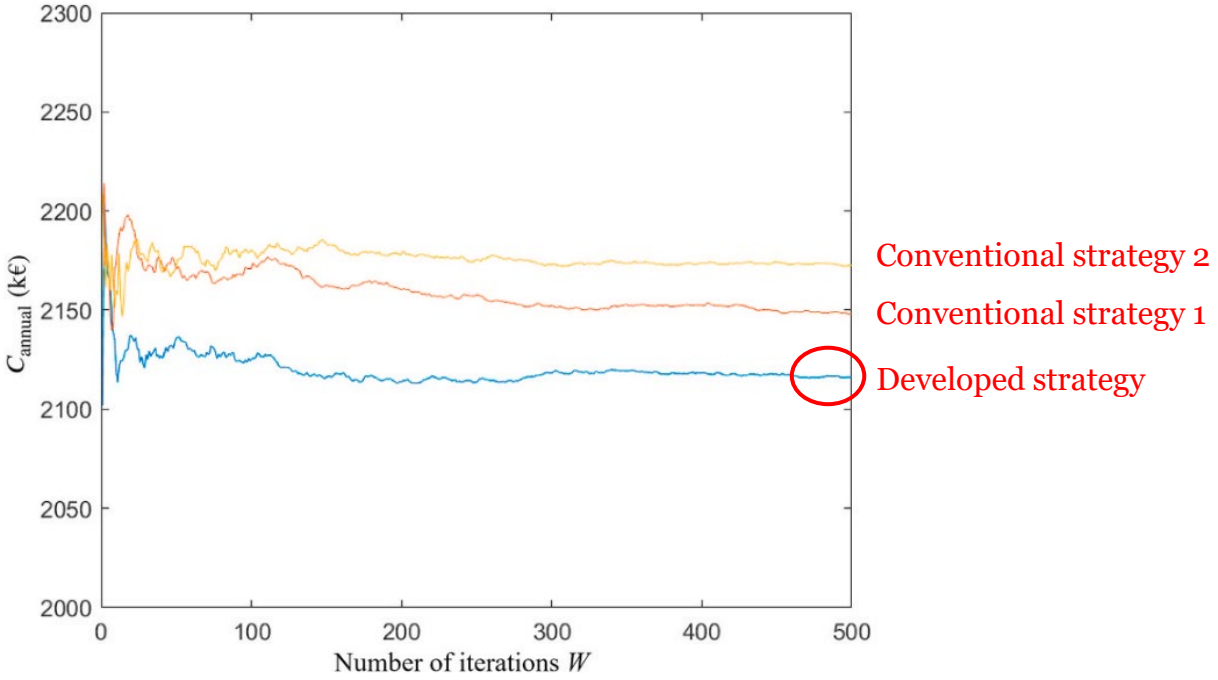
Research Progress



Annual costs versus combinations of decision variables Amin, Amax, ζ

Research Progress

- Developed strategy (degradation, incident, and multiple age-based opportunities)
- Conventional strategy 1 (degradation and incident-based opportunities)
- Conventional strategy 2 (degradation, incident, and single age-based opportunities)



Comparison of three opportunistic maintenance strategies.

Published articles

Journal articles:

[1] **Li, M.***, Jiang, X., Negenborn R, R., 2021. Opportunistic maintenance for offshore wind farms with multiple-component age-based preventive dispatch. *Ocean Engineering* 231, 109062.

[2] **Li, M.**, Jiang, X., Carroll J., Negenborn R, R., A robust multi-objective optimization of maintenance strategy for offshore wind farms. To be submitted.

Conference articles:

[1] **Li, M.*,** Jiang, X., Polinder, H., Negenborn R, R., 2020. A Review of Maintenance Strategy Optimization for Wind Energy. *In: Proceedings of the 4th International Conference on Renewable Energies Offshore*, Lisbon, Portugal, pp. 469-480.

[2] **Li, M.*,** Jiang, X., Carroll J., Negenborn R, R., 2021. Influence of uncertainty on performance of opportunistic maintenance strategy for offshore wind farms. Accepted. *Global OCEANS 2021*, San Diego, United States.

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Thank you for the attention!