Maintenance Decision-making Models for Cost Minimization of Offshore Wind Farms

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BACKGROUND

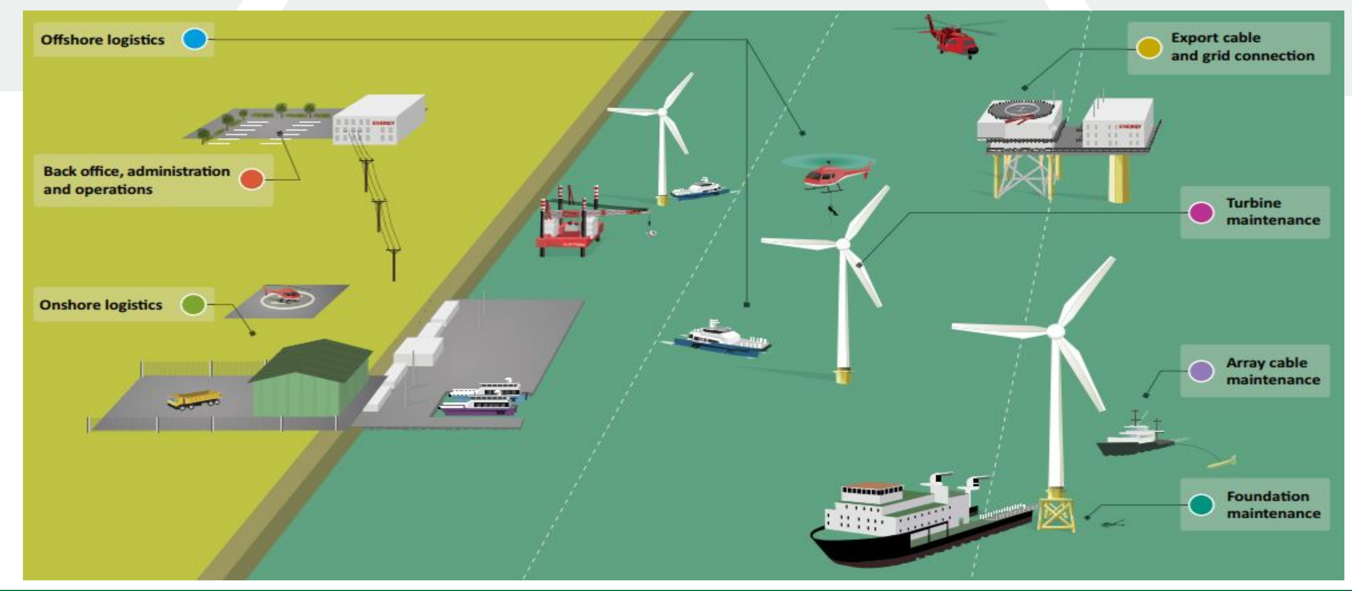
Offshore Wind farms (OWFs) are in its stage of continual development over the past two decades to meet the future energy demand of the human population. OWFs are very expensive assets, not only to build but also to maintain. Maintenance decisions at OWFs are very much affected by the uncertain weather and sea-state conditions at OWFs and greatly influence the overall Operation and Maintenance (O&M) cost and the cost of energy produced.

AIM AND OBJECTIVES

AIM Develop an effective decision-making model considering uncertainties for cost-effective maintenance of OWFs

OBJECTIVES

- Investigate the effect of uncertainties in OWF maintenance
- Develop a cost minimization model for better maintenance decision-making



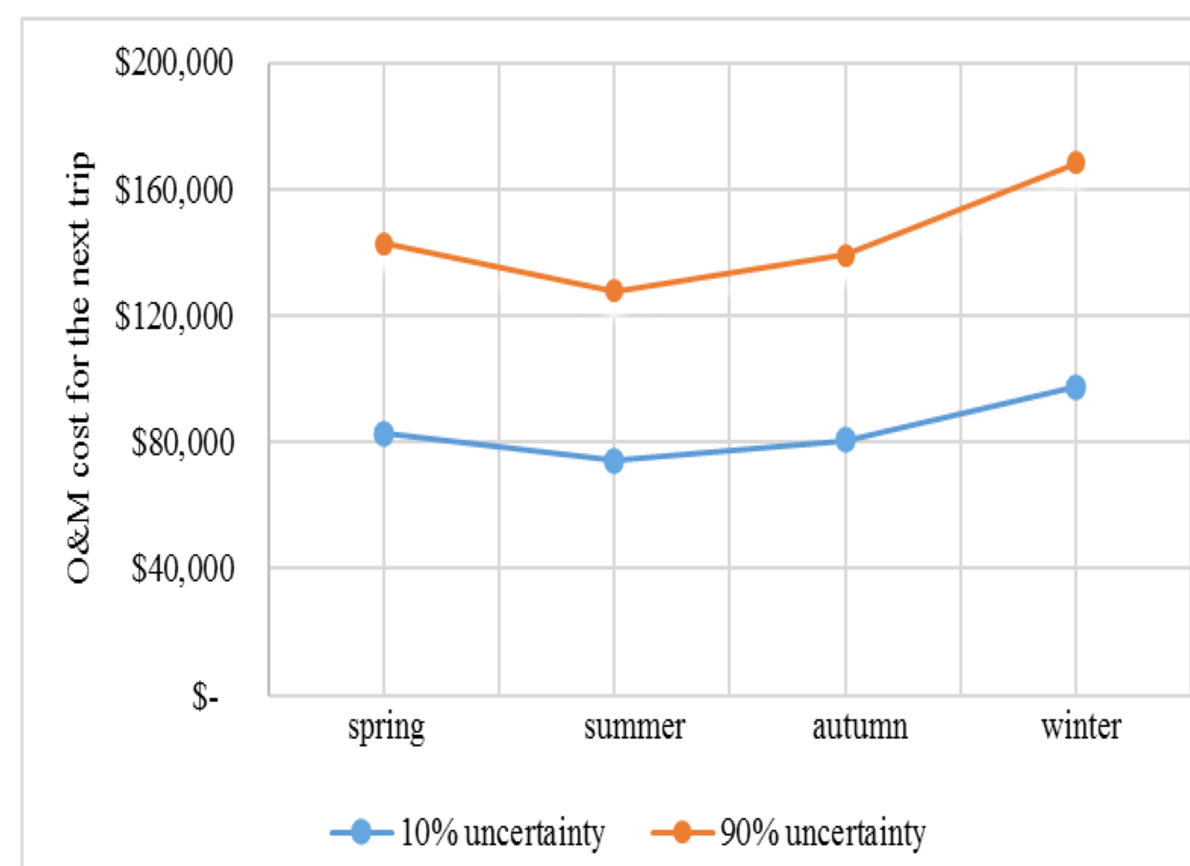
RESULTS

UNCERTAINTY IN WEATHER AND SEA-STATE CONDITIONS AT OFFSHORE

The harsh weather and sea-state conditions limit accessibility to OWF and also affect turbine component lifetimes. Accessibility limitations increase downtime and production losses. Component failures affect the number of corrective maintenance activities needed and thereby increase maintenance effort and costs. The weather and sea-state conditions at offshore vary with season and these seasonal changes have a significant effect on the O&M costs.

SEASONAL VARIATIONS OF O&M COSTS

Our analysis is focused on the next future maintenance trip considering uncertainties at OWFs. The time variables involved in a maintenance execution (waiting time, travel time and repair time) are used to capture the uncertainties in OWF maintenance, by treating them as independent random variables. Waiting time represents the total delay in maintenance execution and captures all the uncertainties due to weather and sea-state conditions. The repair time and travel time are assumed to be the same for all four seasons. Our proposed model which expresses the O&M cost as a function of three stochastic time variables involved in maintenance execution enables us to study the seasonal O&M cost variations. The effect of weather and sea-state uncertainties in OWF O&M cost have been studied for different seasons, and this completes our first objective.



$$\boldsymbol{O\&M\ cost\ for\ the\ next\ future\ maintenance\ trip = f\ (waiting\ time, travel\ time, repair\ time)}$$

FUTURE DIRECTIONS

DECISION-MAKING MODEL FOR COST-EFFECTIVE MAINTENANCE

The second objective is to develop a stochastic cost minimization model for effective maintenance decision-making. Maintenance decision making at OWFs should consider operational, tactical and strategic scenarios with risks/uncertainties to achieve cost-effective maintenance. A number of decision support models have been developed for OWF Maintenance and very few are optimization models while most are simulation models. Almost all the models were developed for long-term maintenance or a turbine lifetime of 25 years. This motivates us to focus on short-term optimization models for OWF maintenance. Our analysis on the next future maintenance trip considering uncertainties at OWFs will be continued to optimize maintenance decisions.

FUTURE FES MILESTONE

Development of methods for measuring performance and impacts of risk conditions and failures and optimizing operation and maintenance for other non-electrical infrastructure assets.

PARTNERS

CURRENT PARTNERS

- Dr. Yi Ding, Professor, College of Electrical Engineering, Zhejiang University, China.

FUTURE EXTERNAL PARTNERS

Our future external partners may include the following

- Colleagues at NAIT
- Colleagues at other Canadian Universities
- International Colleagues
- Industry partners currently collaborating with us on applied research
- New industry partners

FES PROJECT OVERVIEW

T11-P01 Decision support systems for improved construction and maintenance of non-electrical infrastructure for energy

The processes of constructing, operating and maintaining long-life energy infrastructure assets, involves many complex risks. The main risk involved in offshore energy projects is weather conditions. At offshore, decision-making will involve enormous uncertainty. Data required for decision-making may be limited or may not exist and so expert knowledge will be required for effective decision-making.

To address these issues, innovative modelling and decision-making approaches will be developed to address the unique characteristics of energy projects (e.g. OWFs), deal with different types of risks (e.g. weather, sea-state, etc.), and address data limitations in developing and validating models and decision-support tools.

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