NOWIcob – A tool for reducing the maintenance costs of offshore wind farms

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Outline

1. Describe prototype of life-cycle profit model (NOWIcob)
2. Illustrate use by test cases
3. Possible applications
Motivation

- Estimating life-cycle O&M costs and profit
- Optimizing the maintenance strategy
Model overview: Input and output

Controllable options
• Choice of vessel mix
  • number, type, buy/rent
• Shifts
• Number maintenance personnel
• Location maintenance base
• Time-/condition-based maintenance
• ...

Uncontrollable external factors
• Weather
• Failure rates
• Electricity price
• Price for vessel
• ...

NOWIcob: Event-based Monte Carlo simulation

Operation and maintenance strategy

Uncertain future

Results
Availability, O&M costs, life-cycle profit, ...

NOWITECH Norwegian Research Centre for Offshore Wind Technology
NOWIcob: Norwegian offshore wind power life cycle cost and benefit model

- Life-cycle profit model
- Event-based simulation of operational phase of an offshore wind farm
- Focus on maintenance activities
  - Weather limits
  - Weather model
  - New maintenance concepts
- Monte Carlo to take into account uncertainties
- Long-term, system-wide perspective
Model overview: Flow scheme

Input data

Weather simulation

Maintenance & logistics

Results
Input data

- Locations
  - Weather data

- Turbines
  - Power curves
  - Subcomponents

- Maintenance tasks
  - Failure/inspection rates
  - Maintenance type
  - Operation steps
  - Working duration
  - Cost of spare parts etc.
Input data

► Vessels
  ▪ Weather limits for access etc.
  ▪ Other abilities
  ▪ Costs
  ▪ Maintenance base
  ▪ Mother ship?
  ▪ Several shifts?
  ▪ Order time?

► Shifts
  ▪ Working hours
  ▪ Shifts per day

Weather simulation

Maintenance & logistics

Results
Weather simulation

- Markov chain weather model
  - Transition matrix from historic weather data
  - Generates simulated time series
Weather simulation: Markov chain model

From state

To state

1 2

1 1

1 1

1

1 2

1

1

1

33% 67%

33% 33% 33%

100%
Weather simulation

► Markov chain weather model
  ▪ Transition matrix from historic weather data
  ▪ Generates simulated time series

► Simulated time series
  ▪ Same statistical properties
  ▪ Wind speed and wave height
  ▪ Hourly resolution
  ▪ Captures seasonal variations
Maintenance & logistics

► Entire life time of the wind farm
► Scheduling for each shift
► Restrictions:
  ▪ Weather
  ▪ Personnel
  ▪ Vessels
► Taking into account:
  ▪ Waiting time
  ▪ Travel time
  ▪ Access time
  ▪ Working time
Results

- Electricity produced
- Electricity-based availability \( (E/E_{\text{ideal}}) \)
- Net present value of
  - Income
  - O&M costs
  - Profit
Multiple simulation runs

- New weather and new failures
- Histogram of results
  - Estimating probability distribution
  - Uncertainties / risks

[Bar chart showing electricity-based availability with frequency on the y-axis and percentages on the x-axis]

Input data
Weather simulation
Maintenance & logistics
Results
Examples of results

► Test case: Far-offshore wind farm (150 km)
  ▪ Conventional logistics solution
  ▪ New concepts:
    • Mother ship
    • Offshore platform
Examples of results: conventional

- Frequency

- Electricity-based availability

- %: 43,0 %, 48,0 %, 53,0 %, 58,0 %, 63,0 %, 68,0 %
Examples of results: concepts

- Mother ship
- Platform
- Conventional

Frequency

Electricity-based availability

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Examples of results: concepts

![Bar chart showing electricity-based availability of mother ship and platform. The y-axis represents frequency and the x-axis represents electricity-based availability in percentages.]
Examples of results: availability vs personnel

![Graph showing the relationship between electricity-based availability and the number of maintenance personnel. The graph indicates an increase in availability as the number of personnel increases, plateauing at around 94% with 10 personnel.]
Examples of results: profit vs personnel
Possible applications

► Optimizing the maintenance strategy (design phase)
► Sensitivities – important parameters for offshore wind
► Estimating life-cycle O&M costs and profit
► Evaluating introduction of new technical concepts
Summary

- NOWIcob: Norwegian offshore wind power life cycle cost and benefit model
- Simulating O&M of offshore wind farm
- Focus on weather, access criteria, and novel concepts
- Output: Availability, O&M costs, profit, ...