Global Mapping of Maintenance Strategies with Quantification of Key Performance Indicators

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Offshore Wind Energy 2017
Leaders in O&M Modelling for offshore wind
Optimisation of O&M strategy in terms of cost efficiency for offshore wind farms
5 Wind Farms in Europe

**Dogger Bank**
800 MW (200 x 4 MW)
150 km / 30-35 m depth

**Hywind**
400 MW (50x 8 MW)
20 km / 200 m depth

**Horns Rev 3**
400 MW (100 x 4 MW)
30 km / 20-25 m depth

**Bard**
800 MW (100 x 8 MW)
150 km / 50 m depth

**Borssele**
400MW (50 x 8 to 10 MW)
30 km / 30 m depth

https://www.ecn.nl/publications/ECN-E-16-055
6 Wind Farms in United States

Channel Island North
600 MW (75 x 8MW)
127 km / 575 m depth

Lake Erie
345 MW (100 x 3.45 MW)
30 km / 30 m depth

New York
600 MW (100 x 6MW)
70km / 30 m depth

Kitty Hawk
600 MW (100 x 6MW)
143 km / 30 m depth

Oahu South
400 MW (50 x 8MW)
22 km / 700 m depth

Corpus Christi
600 MW (100 x 6MW)
102 km / 30 m depth

In collaboration with:

NREL
NATIONAL RENEWABLE ENERGY LABORATORY
3 Wind Farms in Asia

**Fuhai**
108 MW (30 x 3.6 MW)
20 km / 15 – 30 m depth

**Haiyang**
200 MW (40 x 5 MW)
8-10 km / 20 – 45 m depth

**Choshi**
120 MW (50 x 2.4 MW)
3.4 km / 12 m depth
What are the main drivers to optimize the O&M Strategy?

Distance to the shore:
- CTV: 12 m/s, 1.5 m
- CTV+: 15 m/s, 2.0 m
- SES: 17 m/s, 2.5 m
- SOV: 20 m/s, 3.0 m
- Daughter craft: 10 m/s, 1.0 m
- Helicopter: 20 m/s, 4.0 m
- Jack-up barge: 10 m/s, 2.0 m

O&M Strategies:
- Selection of the right mix of logistic solution.
- Primary Vessels
- Secondary Vessels
- Vessels for replacement

Vessels for replacement
Optimisation and Selection of the “most suitable O&M Strategy” with ECN O&M Calculator

- Criterion of min 95% availability (Time and Yield)
- Cost-effective solution
What are the main drivers to optimize the O&M Strategy?

Distance to the shore:
- Fuhai: 20 km, CTV
- Borssele: 30 km, CTV+
- Great Lakes: 30 km, CTV

< 50 KM
What are the main drivers to optimize the O&M Strategy?

- Distance to the shore:
  - Dogger Bank: 150 km
  - Kitty Hawk: 143 km
  - Gemini: 85 km

- SOV & Heli: 75 km

- United States of America
- Mexico
- Colombia
- Spain
- France
What are the main drivers to optimize the O&M Strategy?

- **Gulf of Mexico**
  - **Bottom Fixed Wind Turbine**
    - 25 m
    - Jack up Barge

- **Borssele**
  - 16 - 38 m
  - Jack up Barge

- **Choshi**
  - 12 m
  - Jack up Barge
What are the main drivers to optimize the O&M Strategy?

- Water Depth
  - Hawaii: 700 m
  - Hywind: 200 m

- Towing Vessel + 2 Tug boats
  - Hawaii: 700 m
  - Hywind: 200 m
Weather conditions

Gemini

Ws = 7.63 m/s, Hs = 1.55 m

Fuhai

Ws = 6.39 m/s, Hs = 1.55 m

Pacific

Ws = 8.24 m/s, Hs = 2.01 m
What are the main drivers to optimize the O&M Strategy?

**Assumption:** Hurricanes increase the failure rates of 20% of the most sensitive components

**Outcomes:** 4% increase of repair costs (M$/year)

Source: self-illustration based on Taiwan Typhoon Information Center & The Saffir-Simpson Hurricane Wind Scale
What are the main drivers to optimize the O&M Strategy?

Weather conditions - Special weather conditions

Great Lakes

Logistic solutions
- Ice Breaker
- Helicopter as secondary access vessel

Outcomes
- Ice Breaking Vessel Availability: ~ +0 %
- Helicopter Availability: ~ +3.2 %
- CTV & Heli is the most suitable strategy
What are the main drivers to optimize the O&M Strategy?

Vessels advancement
Market variety

New York
70 km
SES

SES
17 m/s, 2.5 m

Gemini
85 km
SOV & Heli

SOV
20 m/s, 3.0 m
What are the main drivers to optimize the O&M Strategy?
Regulations – Jones Act in United States

To comply with the Jones Act:

- Additional support vessels are required
  ~ Increase of the O&M costs of 18%
- Alternative option: In-house manufacturing of the vessels in US
What are the main drivers to optimize the O&M Strategy?

Future of O&M:
- Sharing of Resources
  - **Vessels**
  - **Harbours**
- Condition based maintenance: monitoring systems
  - *Decrease of failure rates by 25%*

- Between 2 wind farms: 14.5 M€/year* savings
- Saving of 12.5% in total O&M effort (M$/year) **

* Considering 2 wind farms of 400 MW
** Considering a monitoring system price of 2 M$/year
What are the main drivers to optimize the O&M strategy?

- Distance to the shore
  - Borssele: 30 km
  - Gemini: 85 km
  - Dogger Bank: 150 km
  - Great Lakes: 30 km (Ice)
  - New York: 70 km
  - Hawaii: 200 m
  - Dogger Bank: 200 m
  - Borssele: 30 km

- Ice
- Hurricanes
- Towing Vessel + 2 Tug boats
- CTV +
- SES
- SOV

Each site needs a dedicated O&M strategy.
Thank You!!!