Task 5.5
Operation and maintenance strategies design and optimization

27-03-2017
Michele Martini
Bilbao, ES
IHCantabria (Spain)
Outline

Content of this presentation

• Motivation

• Problem statement

• Studied topics

• Secondment

• Conclusions
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Motivation

The offshore wind market

- Turbine size: 3.0 MW in 2010 → 4.2 MW in 2015
- Farm size: 156 MW in 2010 → 338 MW in 2015

12,000 MW at the end of 2015

Increased distance from the coast

Alignment with onshore wind
Motivation

Limitations of bottom-fixed turbines

- Fixed offshore wind feasible up to 50m depth
- Limited geographical potential

Floating systems
Motivation

Floating systems for offshore wind energy

Hywind (Statoil) - 2 MW, Norway, 2009

WindFloat (Principle Power) - 2 MW, Portugal 2011

Fukushima FORWARD - 2-5-7 MW, Japan 2011

Hywind (Statoil) - 30 MW, Scotland, 2018
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Problem statement

The availability challenge

«The percentage of time a wind turbine is capable of producing electricity»


Failure
Preventive maintenance
Harsh weather conditions

Average availability onshore

Average offshore

Beginning of operation

Baseline OpEx
30% OpEx cost reduction

LCOE [€/MWh]

Availability [%]
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    o Operational stops and long-term energy yield
    o Variability of offshore accessibility parameters
    o Walk-to-work transfer for floating platforms
    o Impact of downtime on electricity generation

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Introduction

Four specific problems...
• Detected as of primary importance
• Weakly (or not at all) treated in the literature

1. Relationship between operational stops and long-term energy yield;

2. Temporal and spatial variability of offshore accessibility parameters;

3. The evaluation of walk-to-work transfer for floating platforms;

4. Impact of downtime on electricity generation of a floating farm.
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(1) Operational stops and long-term energy production

Questions:
(a) Which parameters define the operating envelope of a floating wind turbine?

(b) Is it possible to have operational stops below conventional cut-out (25 m/s)?

(c) What is the influence of operating thresholds on the long-term energy production?
Studied topics

(1) Operational stops and long-term energy yield
Studied topics

(1) Operational stops and long-term energy yield

Published paper in Wind Energy (2015)
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(2) Variability of offshore accessibility parameters

Questions:
(a) How do we define and calculate accessibility?
(b) How does it vary in time and space?
(c) Can it be a design parameter as wind resource is?

Definition of accessibility parameters → Hindcast data extraction → Time variation of accessibility → Spatial variation of accessibility → Influence of thresholds

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μ 57.2  σ 52.5  σ/μ 0.92

(Hindcast data extraction)

Mean waiting time under daylight regime
Case I: T(s1, s2) day
Case II: T(s1) day
DBK TB3 DBK TB3
1990 292.6 36.8 600.3 60.0
1991 42.0 24.6 76.3 32.5
1992 44.4 27.8 80.4 41.1
1993 34.6 25.4 55.4 33.6
1994 48.8 25.7 95.5 39.0
1995 67.9 31.0 134.4 56.9
1996 48.4 26.7 116.1 38.0
1997 35.3 22.6 57.5 32.4
1998 54.7 27.9 119.9 41.9
1999 43.8 28.0 94.3 44.3
2000 61.7 31.5 134.4 58.7
2001 44.7 23.9 77.2 36.9
2002 66.7 32.7 143.7 48.1
2003 36.1 24.2 69.3 32.8
2004 42.2 27.9 98.6 45.3
2005 56.9 27.9 125.0 43.8
2006 39.5 26.7 66.6 39.8
2007 43.9 27.6 76.7 41.7
2008 66.8 30.4 101.6 46.0
2009 33.1 24.4 55.9 35.1
2010 38.9 23.3 65.4 32.7
2011 37.1 23.2 64.7 31.5
2012 36.1 25.1 61.2 36.7

μ 57.2  σ 52.5  σ/μ 0.92
Studied topics

(2) Variability of offshore accessibility parameters

Accessibility (8 hours windows)

Mean waiting time
Studied topics

(2) Variability of offshore accessibility parameters

Published paper in Wind Energy (2016)
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(3) Walk-to-work transfer for floating platforms

Questions:
(a) How to evaluate risk of access to floating wind platforms?
(b) What is the impact of floating platform motions on access risk?
(c) What is the long-term accessibility for a chosen spot?
Studied topics

(3) Walk-to-work transfer for floating platforms

Floating wind turbine
Studied topics

(3) Walk-to-work transfer for floating platforms

Published paper in Ocean Engineering (2016)
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(4) Impact of downtime on electricity generation

Questions:
(a) How to model the **stochastic nature** of failure-reparation events?
(b) How to include **operational stops** for floating systems?
(c) How to estimate **uncertainty** in energy production **evaluation**?
Studied topics

(4) Impact of downtime on electricity generation

Studied topics

Academic outcome

University of Cantabria – Doctoral Thesis

Modelization and Analysis of Operation and Maintenance of Floating Offshore Wind Farms

Environmental Hydraulics Institute of Cantabria «IHCantabria»
April 7, 2017
Santander, Spain
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Secondment

An industrial «hands-on» experience

- **Umbra Cuscinetti S.p.A. (Italy)**

- **Manufacturing company** of mechanical and electro-mechanical components

- R&D and **commercial** projects in marine energy

- Eleven months in an **industrial** environment during OceaNET-ITN

- Will continue with Umbra **after** OceaNET-ITN
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Conclusions

Summary of OceaNET-ITN experience

• Investigated specific problems of O&M for marine energy

• Methodologies applied to wind energy but equally applicable to wave/tidal

• Intense dissemination activities

• 11 months secondment at Umbra Cuscinetti S.p.a.

• 8 OceaNET-ITN training courses, 3 IHCantabria training courses

• Ph.D. thesis defense next week (April 7) at IHCantabria (Spain)

• Start contract with Umbra Cuscinetti on April 11
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GRANT AGREEMENT №: 607656
PROJECT: OceaNET
Back-up slides

Accuracy of RBF

Santander 1994-2013; M = 1000

Hub acceleration, 75.0% qtl. [ms$^{-2}$]
RMSE=0.040

Hub acceleration, 90.0% qtl. [ms$^{-2}$]
RMSE=0.042

Hub acceleration, 95.0% qtl. [ms$^{-2}$]
RMSE=0.044

Hub acceleration, 99.7% qtl. [ms$^{-2}$]
RMSE=0.051
Back-up slides

Definition of accessibility parameters

Approachability: 12/20 = 60%
Accessibility: 9/20 = 45%
Mean waiting time: (3+8)/2 = 5.5 Δt
Back-up slides

Maximum regular wave height – CTV access – Floating VS Fixed

Floating VS fixed wind turbine

Floating is better

Bottom-fixed is better
Back-up slides

Dissemination activities/1

Papers published in peer reviewed journals (3)
  2 over 14 journals for 5-year IF in Marine Engineering (2014)
  4 over 130 journals for 5-year IF in Mechanical Engineering (2014)
  4 over 130 journals for 5-year IF in Mechanical Engineering (2014)

Papers under revision in peer reviewed journals(1)

Papers on other journals (2)
Back-up slides

Dissemination activities/2

Conference papers (4)

• Martini, Michele; Jurado, Alfonso; Guanche, Raúl; Losada, I., 2016. Evaluation of walk-to-work accessibility for a floating wind turbine, in: ASME 35th International Conference on Ocean, Offshore and Arctic Engineering. Busan, South Korea.


Conference posters (3)


Back-up slides

Training courses

OceaNET attended courses (8)
- Offshore Renewable Energy Farms (EXE, Falmouth, UK)
- Socio Economic Aspects of Offshore Renewable Energy (UCC, Cork, IE)
- Wave Energy Modelling (ECN, Nantes, 08.2015)
- Abaqus Training Course (SIMULIA, Santander, 05.2015)
- Modelling of Offshore Wind Turbines (MARIN, Wageningen, 04.2015)
- Offshore Wind Technology (Fraunhofer-IWES, Bremerhaven, 02.2015)
- Entrepreneurship and Innovation Management (Católica Lisboa, Lisbon, 12.2014)
- Wave Energy Technology (Instituto Superior Técnico, Lisbon, 07.2014)
- Advanced Climate Modelling (IH Cantabria, Santander, 05.2014)

IH Cantabria attended courses (3)
- Abaqus training course (SIMULIA, Santander, 2015)
- Basic training course for Ph.D. students (UC, Santander, 2015)
- Advanced training course for Ph.D. students (UC, Santander, 2016)
Back-up slides

INORE – The International Network on Offshore Renewable Energy

Role and experience
• Communications Manager (2015-2016)
• Vice Chair (2016-2017)

Activities
• Organization of 2015 European Symposium in Italy
• Organization of 2016 PTO workshop at AWTEC in Singapore
Timeline of OceaNET-ITN

2014
- H1: Joined OceaNET @IH Cantabria; learnt Spanish; course IH
- H2: Sent 1st paper; enrolled in Ph.D.; courses IST, UCL

2015
- H1: Sent 2nd paper; course FR-IWES
- H2: Sent 3rd paper; course MARIN, ECN

2016
- H1: Sent 4th paper; course EXE, UCC
- H2: Secondment; Ph.D. thesis

2017
- H1: Secondment; end of OceaNET
- H2: Start contract with Umbra Cuscinetti S.p.A.