What are the game changing components that will optimize the maintenance process?

Saskia Greiner, Susanne Appel, Henning Albers
Hochschule Bremen, Institute of Environmental and Biotechnology

Torsten Renz
IZP Dresden
CONTENT

1. Starting situation
2. Process risks in Offshore Wind Farms
3. Offshore Wind Farm systems` performance
4. Analysis of process risks
5. Optimization potentials
6. SystOp Offshore Wind
1. STARTING SITUATION

Offshore wind energy today

- Companies focuses on financing, grid connection, assembly and set up of offshore wind turbines (OWT)

- First operation experiences shows:
  - Portion of operating costs base is represented by ~ 75% in terms of 20 years runtime
  - Electricity production costs ~ 10 €ct/kWh

[Windenergierereport,2011]
1. STARTING SITUATION

Improvement of economy is needed, by reduction of:

- **Investment costs**
  - Optimized set up concepts & logistics
  - Light OWT and support structures
  - ...

- **Operation costs**
  - Optimal choice of maintenance strategy
  - Optimized organizational and procedure structure
  - Functional technology
1. STARTING SITUATION

Reduction of operation costs

• Good strategic maintenance planning
  – Can be reached with clear process descriptions and definitions with evaluated risks
  – Difficult because of high number of interfaces, players and interactions

⇒ Method of resolution:

  Analysis and Evaluation of Process Risks
2. PROCESS RISKS IN OFFSHORE WIND FARMS

Process risks in OWF

- Human, e.g. failures because of their activities / actions
- Hardware, e.g. IT is under construction or crane is damaged
- Material, e.g. damaged transport boxes or no information
- Method, e.g. way of doing work
- Environment, e.g. stormy weather or non-compliance with a rule

⇒ Delays and aborts of process steps
⇒ Significant financial implications, e.g. loss of income or logistic costs
3. OFFSHORE WIND FARM SYSTEMS` PERFORMANCE
3. OFFSHORE WIND FARM SYSTEMS` PERFORMANCE

- Process Landscape of OWF Maintenance -

**OWF-modules:**
- substation/living platform, turbine, substructure, cabling within the OWF

**recording & evaluation**
- inspection on-site
  - monitoring & data analysis
  - other inspection requirements
  - repair requirements
  - improvement requirements
  - maintenance requirements

**mission planning**
- inspection on-site
- repair on-/ off-site
- replacement of large components
- improvement on-/ off-site

**preparation**
- living vessel
- PTV
- helicopter
- Jack up
- special vessel e.g. diving vessel

**execution**
- outward journey residence
  - living vessel
- PTV
- helicopter
- Jack up
- special vessel

- on-site
  - repair
  - maintenance
  - PTV
- inspection
  - replacement of large components
- Jack up
  - special work
  - special vessel

**post processing**
- return journey
  - living vessel
  - helicopter
  - Jack up
  - special vessel
3. OFFSHORE WIND FARM SYSTEMS` PERFORMANCE

Process model: Return trip by PTV

- **Process monitoring**
  - documentation for OWT

- **Boat landing & return journey**
  - access is established
  - every person on board
  - radio message for returning

- **Crew**
  - OWT arrived
  - execute boat-landing
  - access is established
  - transfer occurs
  - preparedness of return trip turned out

- **Operator**
  - people tracking
  - process monitoring on-site completed

- **External maintenance company**
  - all technicians, material, waste on board
  - safety transfer of service technicians, material,...
  - load and ensure material and waste on board

---

VDI Wissensforum

Hochschule Bremen
University of Applied Sciences
Institut für Umwelt- und Biotechnik

IZP
3. OFFSHORE WIND FARM SYSTEMS` PERFORMANCE

• Process models are the basis for risk analysis and process optimization

• But: Only some sub-processes have a high risk or have to be optimized.

⇒ Find the risk- & optimization-relevant sub-processes!
4. ANALYSIS OF PROCESS RISKS

Risk-relevant processes: Extract of selection criteria

Key process
prime importance for process leading & availability of OWT

Financial impact
significant impact on assets or income and expenses

Complexity
complicated net of players, their activities and interactions

Dependency of resources
process depends on less number of staff, …
4. ANALYSIS OF PROCESS RISKS

Extract of risk-relevant processes

- **Recording & Evaluation:**
  - decisions about maintenance activities at OWT with a great impact on expenses and incomes

- **Mission Planning**
  - best combining of planned work assignments under current requirements, e.g. weather conditions, logistics, …

- **Preparation**
  - don’t forget materials, tools, spare parts, …
  - redundant material
4. ANALYSIS OF PROCESS RISKS

The method: FMEA

1. step: system elements & system structure
2. step: function & function structures
3. step: failure analysis
4. step: risk evaluation
5. step: optimization

Tool for obtaining knowledge in the company

inter-divisional initiated improvement of product or process

[IZP, 2012]
4. ANALYSIS OF PROCESS RISKS

FMEA-Example: Return trip by PTV

- Process monitoring
  - Operating company
  - Documentation for OWT
  - Process monitoring on-site completed
  - Every person on board

- Boat landing & return journey
  - Captain
  - Handler sea
  - Crew
  - OWT arrived
  - Execute boat-landing
  - Connect access system with OWT
  - Open access system
  - Return trip to sea port
  - Return journey started

- Transfer of technicians / material / waste
  - External maintenance company
  - Access confirmed
  - Safety transfer of service technicians, material, waste on board
  - Load and ensure material and waste on board
  - All technicians, material, waste on board

- Access is established
- Transfer occurs
- Preparedness of return trip turned out
4. ANALYSIS OF PROCESS RISKS

FMEA-Example: Return trip by PTV

- **process monitoring**
- **documentation for OWT**
- **people tracking**
- **process monitoring on-site completed**
- **radio message for returning**
- **return trip to sea port**
- **return journey started**

**connect access system with OWT**

- **access is established**
- **transfer occurs**
- **preparedness of return trip turned out**

- **access confirmed**
- **transfer of technicians / material / waste**
- **safety transfer of service technicians, material, etc.**
- **load and ensure material and waste on board**
- **all technicians, material, waste on board**
4. IDENTIFICATION & EVALUATION OF PROCESS RISKS

Process structure: Return trip by PTV

- Execute boat-landing
  - Connect access system with OWT
  - Send message to operation company "Access is established"
  - Send message to technician "Access is established"
  - Receive message from technician "transfer occurs"
  - Send message to operating company "Every person on board"
  - Receive message from technician "All technicians, material, waste on board"
  - Open access system
  - Return trip to sea port
  - Send message to operating company "Radio message for returning"
  - Receive message from captain haulier sea "Access is established"
    - Safety transfer of service technicians, material, ...
    - Load and ensure material and waste on board
    - Send message to captain haulier sea "Preparedness of return trip turned out"

- Transfer of technicians/material/waste
  - Transmit messages

- Process monitoring
4. IDENTIFICATION & EVALUATION OF PROCESS RISKS

Process structure: Return trip by PTV

Return Trip by PTV

Boatlanding & return journey

Connect access system with OWT
4. ANALYSIS OF PROCESS RISKS

Failure analysis

- Connect access system with OWT
- Keeping contact of gangway and OWEA not possible
- Cause element: Detective top of gangway
- Cause element: Detective supporting point of OWEA

- Connect access system with OWT
- Defective gangway
- Cause element: Detective gangway

- Connect access system with OWT
- Sea with waves > 1.5 m
- Cause element: Sea with waves > 1.5 m
- Cause element: Detective supporting point of OWEA

- Connect access system with OWT
- Defective compensation of seawater
- Cause element: Detective hydraulic system

Safety transfer of service technicians, material, and waste:
- Delay < 1h

Transfer of technicians/materials/waste:
- Safe transfer of technicians with 1d < delay < 1w
- Safe loading of transport good with 1d < delay < 1w

Load and ensure material and waste on board:
- Delay < 1w

Operation OWP
- Potential loss of generation 10.50 MWh
- Operation OWP
- Potential loss of generation 80-100 MWh
- Operation OWP
- Potential loss of generation 100-200 MWh
- Operation OWP
- Potential loss of generation 200-500 MWh

Recouping OWEA achieves full performance with 1d < delay < 1w
4. ANALYSIS OF PROCESS RISKS

Failure analysis

Safety transfer of service technicians,…
Safe transfer of technicians with $3h < \text{delay} < 6h$

Return trip PTV
Return trip by PTV with $1d < \text{delay} < 1w$

Connect access system with OWT
Deficient compensation of sea waves

Operation OWP
Potential loss of generation $10…50 \text{ MWh}$

- Reconditioning
- Return trip by PTV
- Return trip by PTV with $1d < \text{delay} < 1w$

Potential loss of generation $100…200 \text{ MWh}$
Potential loss of generation $200…500 \text{ MWh}$

Causes:
- Defective top of gangway
- Defective supporting part of OWEA
- Defective gangway

Effects:
- $10…50 \text{ MWh}$ potential loss of generation
- Safe transfer of technicians with $3h < \text{delay} < 6h$
- $1d < \text{delay} < 1w$ return trip
- Deficient compensation of sea waves

Operation OWP
Potential loss of generation $10…50 \text{ MWh}$

Effect $\leftrightarrow$ Failure $\leftrightarrow$ Cause
# 4. ANALYSIS OF PROCESS RISKS

## Risk evaluation

<table>
<thead>
<tr>
<th>Effects</th>
<th>S</th>
<th>C</th>
<th>Failure Mode</th>
<th>Causes</th>
<th>Preventive Action</th>
<th>O</th>
<th>Detection Action</th>
<th>D</th>
<th>RPN</th>
<th>R/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function: 1.5.3.2.4.3.2.2.2.a</td>
<td>Compensation of see-saw (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.4.2 Potential loss of generation 10,50 MWh (1)</td>
<td>2</td>
<td>1</td>
<td>FMEA Prozess</td>
<td>Item Code:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.3.2.4.3.2.2.2.a.1</td>
<td>Deficient compensation of see-saw (1)</td>
<td></td>
<td>Item Code:</td>
<td>Revision State:</td>
<td>Responsible:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.3.2.4.3.2.2.2.a.2</td>
<td>See with works &gt; 1.5 m (1)</td>
<td></td>
<td>Item Code:</td>
<td>Revision State:</td>
<td>Responsible:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.3.2.4.3.2.2.2.a.3</td>
<td>Missing are planned for wave</td>
<td></td>
<td>Item Code:</td>
<td>Revision State:</td>
<td>Responsible:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.4.2 Potential loss of generation 100..200 MWh (1)</td>
<td>3</td>
<td>1</td>
<td>FMEA Prozess</td>
<td>Item Code:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.4.2 Potential loss of generation 100..200 MWh (1)</td>
<td>4</td>
<td>1</td>
<td>FMEA Prozess</td>
<td>Item Code:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;&gt; 1.4.2 Potential loss of generation 200..500 MWh (1)</td>
<td>5</td>
<td>1</td>
<td>FMEA Prozess</td>
<td>Item Code:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function: 1.5.3.2.4.3.2.2.2.b</td>
<td>Save transfer of persons + material + waste (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**General Information:**

- Number: 1.5.3.2.4.3.2.2.2
- Page: 1

**Specific Information:**

- Type/Material/Fabrication/Load: Instantzstellung
- Item Code:
- Revision State:
- Responsible:
- Company:
- Created: 25.03.2013
- Modified: 27.05.2013

---

**EINE VERANSTALTUNG DES VDI WISSENSFORUMS | 18.-19.06.2013**
4. ANALYSIS OF PROCESS RISKS

Risk evaluation

<table>
<thead>
<tr>
<th>Effects</th>
<th>S</th>
<th>C</th>
<th>Failure Mode</th>
<th>Causes</th>
<th>Preventive Action</th>
<th>O</th>
<th>Detection Action</th>
<th>D</th>
<th>RPN</th>
<th>R/D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>FMEA</td>
<td>Process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type/Mode/Fabrication/Load:**

- Instandsetzung

**Item Code:**

- FMEA

**Responsible:**

- Projekteam

**Company:**

- API GmbH

**Created:** 25.03.2013

**Process Element:** 1.5.3.2.4.3.2.2.2 ✡ Connect access system with OWT

**Function:** 1.5.3.2.4.3.2.2.2.a ✡ Compensation of see-saw (1)

- Initial State: 13.05.2013
- Missions are planned for wave-height forecasts below 1.5 m only (1)
- Monthly service, preventive exchange after two years (1)

**Function:** 1.5.3.2.4.3.2.2.2.b ✡ Save transfer of persons + material + waste (1)

- Initial State: 13.05.2013
- Check before mission (1)
5. OPTIMIZATION POTENTIALS

- Combining of different work assignments and parties concerned for more effectiveness and efficiency
e.g. yearly maintenance with period tests

- Redundant hardware offshore
  e.g. accumulators or tools

- Adequate assistance for technicians
  e.g. operating procedures, checklists, …
  e.g. training courses
5. OPTIMIZATION POTENTIALS

- Support in operational management
  
  e.g. shared software application for all parties concerned
  
  e.g. adapted people- and vessel-tracking systems

- Knowledge transfer from power plants and oil & gas
  
  e.g. combination of preventive maintenance and periodic inspection
6. SystOp Offshore Wind

- **Cooperation:**
  Hochschule Bremen, IZP Dresden, Universität Hamburg, BTC AG

- **Run time:**
  01.05.2011 – 30.04.2014

- **Goal:**
  Recording, Analysis and Optimization of Offshore Wind Farm Systems’ Performance in Maintenance

- **Funded by:**
  [Image of the German Federal Ministry of Education and Research]
6. SystOp Offshore Wind

Bugsier Reederei- und Bergungsgesellschaft mbH & Co. KG
DEWI-OCC Offshore and Certification Centre GmbH
DOTI GmbH & Co KG
EWE Energie AG
EWE Offshore Service & Solution GmbH
Frisia-Offshore GmbH
Hochtief Solutions AG
htm Helicopter Travel Munich GmbH
Nehlsen GmbH
Nordwest Assekuranzmakler GmbH & Co. KG
PHH Personaldienstleistung GmbH
REETEC GmbH Regenerative Energie- und Elektrotechnik
RKM Personaldienstleistungen GmbH
Signalis Germany
Windparkservice GmbH
WindMW
WKU AG
wpd windmanager GmbH & Co. KG
Thank you very much.

Hochschule Bremen
Institute for Environmental and Biotechnology
Neustadtswall 30
28199 Bremen
Saskia Greiner
saskia.greiner@hs-bremen.de
Prof. Dr.-Ing. Henning Albers
henning.albers@hs-bremen.de
Susanne Appel
susanne.appel@hs-bremen.de

IZP Dresden
Stauffenbergallee 4
01099 Dresden
Torsten Renz
t.renz@izp.de

www.systop-wind.de
[Windenergiereport, 2011]

[IZP, 2012]
Ingenieurgesellschaft für Zuverlässigkeit und Prozessmodellierung, Dresden