Corrosion monitoring - Insights from the Offshore Renewable Energy sector

2nd International Symposium on Corrosion and Fouling

1 April 2019 | Antwerp Maritime Academy, Belgium

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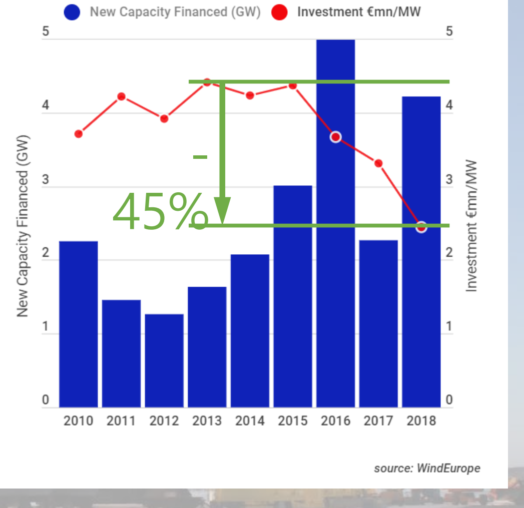
Foundation design
© Force Technology 2014
https://www.energy.gov/eere/articles/us-conditions-drive-innovation-offshore-wind-foundations


Installation MP based design
https://www.offshorewind.biz/2013/09/06/report-on-offshore-wind-monopile-foundation-available-at-fast-market-research/
PES Wind
J. Offshore Mech. Arct. Eng 139(6), 061901

Important differences

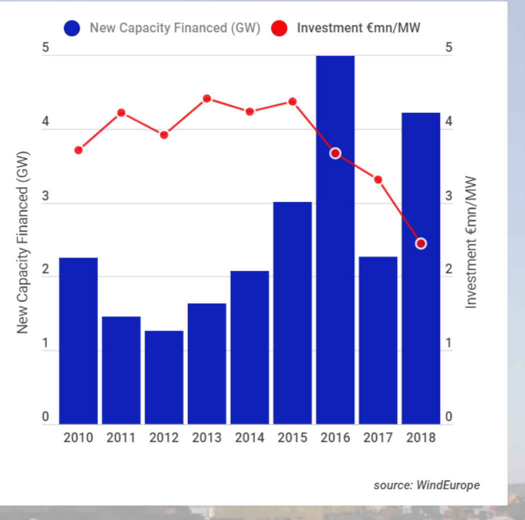
Differences in economics

COUNTRY	NO. OF WIND FARMS CONNECTED	CUMULATIVE CAPACITY (MW)	NO. OF TURBINES CONNECTED	NET CAPACITY CONNECTED IN 2018	NO. OF TURBINES CONNECTED IN 2018
TOTAL	105	18,499	4,543	2,649	409
United Kingdom	39	8,183	1,975	1,312	222
Germany	25	6,380	1,305	969	136
Denmark	14	1,329	514	61	42
Belgium	7	1,186	274	309	8
Netherlands	6	1,118	365	0	1



Differences in economics

- Mass production
- Economics of scale
- Cost reduction



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Differences in inspection

- Unmanned
- Approx. 2/day
- Not coming to port
- Window of opportunity
- Health & Safety

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Corrosion protection design

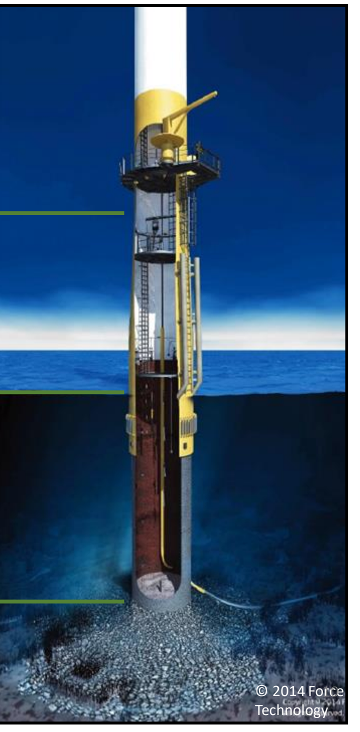
Peter H. Møller, Ramboll
Int. Conf. on Corrosion Protection for Offshore Wind 2019

Atmospheric zone

Splash zone

Submerged zone

Burried zone



Corrosion protection design

Peter H. Møller, Ramboll
Int. Conf. on Corrosion Protection for Offshore Wind 2019

With deeper water, focus shifting to ICCP as a means of Cathodic Protection.

Monitor functionality and protection of ICCP system??

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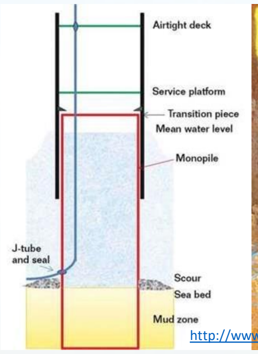
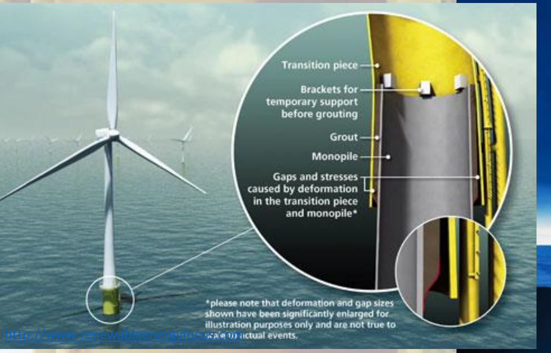
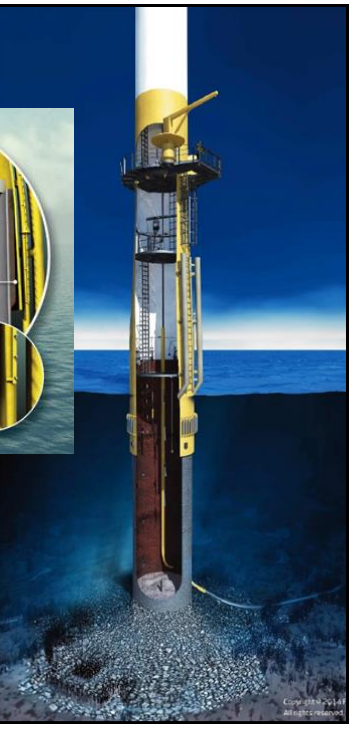
Corrosion protection design



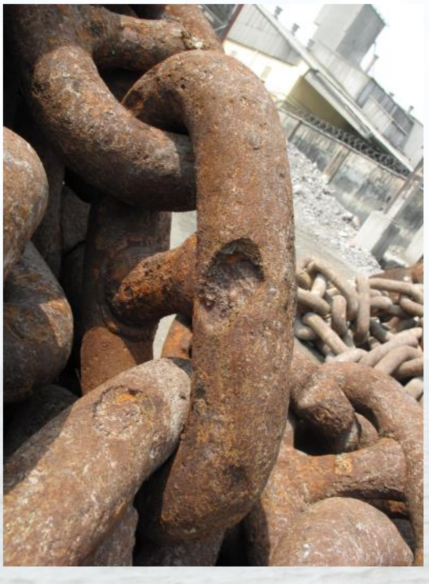


http://www.materialsperformance.com



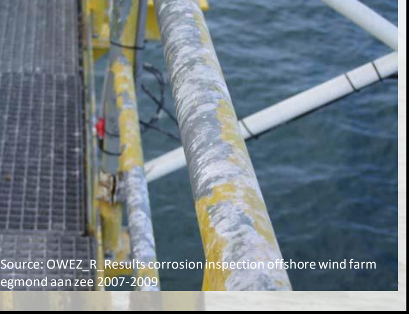
Internal protection
- Closed compartment? Airtight?
- Changing water conditions?
- Below mudline? MIC?
- Corrosion rates?

Corrosion protection design



Floating wind

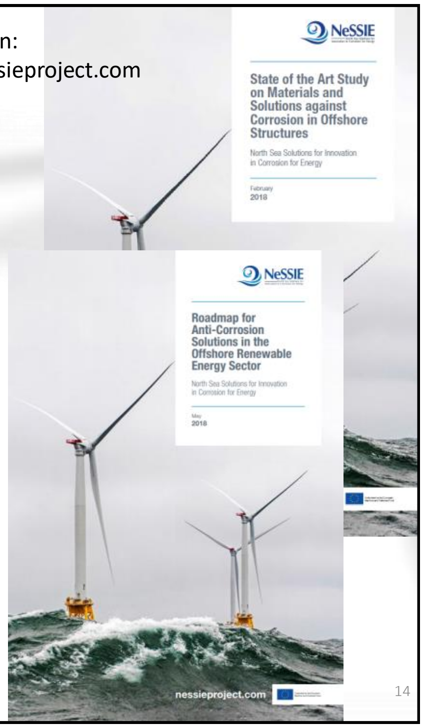
Secondary steel



Source: OWEZ_R_Results corrosion inspection offshore wind farm egmond aan zee 2007-2009

NeSSIE
North Sea Solutions for Innovation in Corrosion for Energy

Reports on:
www.nessieproject.com



North Sea Solutions in Corrosion for Energy

Development of three demonstration projects related to innovative anti-corrosion solutions for ORE in the North-Sea Basin, in order to reduce the LCoE by tackling the challenge of corrosion

Map corrosion challenges → Build supply chains → B2B contacts → Develop demonstrators and business plans

Co-funded by the European Maritime and Fisheries Fund

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Coatings

Cathodic Protection

Drone inspection

Monitoring

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Coatings

Cathodic Protection

NeSSIE

North Sea Solutions for Innovation in Corrosion for Energy

Final Conference

"Building Demonstration Cases for the Blue Economy: Lessons from NeSSIE and the Regions"

Brussels 24th of April

www.nessieproject.com

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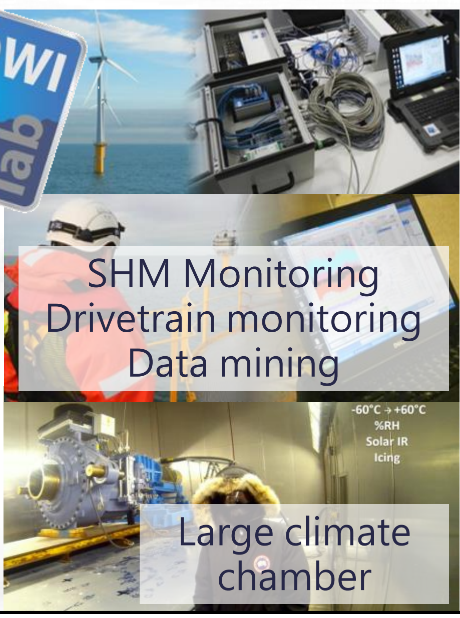
sirris driving industry by technology

VUB VRIJE UNIVERSITEIT BRUSSEL

UNIVERSITEIT GENT

www.owi-lab.be



Coatings

Cathodic Protection

Drone inspection

Monitoring

Why?

How?

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CORROSION
Protection
FOR OFFSHORE WIND

12 – 14 MARCH 2019 | SWISSÔTEL BREMEN, GERMANY

C
11:15
-
13:15

CORROSION MONITORING AND DATA INTERPRETATION FOR LIFE ASSESSMENT

Structural monitoring of offshore windfarms has become common practice. But how about corrosion monitoring? During the workshop, the key objectives of corrosion monitoring will be discussed. Participants will also explore the challenges related to corrosion monitoring and data interpretation; and possible approaches to tackle them.

- Potential gains of Corrosion monitoring
- Technical challenges and data interpretation
- Direct corrosion measurements vs. monitoring of environmental parameters
- Digital twin methodology for corrosion, fleet assessment

Christof Devriendt, RD&I Coordinator, **Offshore Wind Infrastructure Lab**

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Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- O&M optimisation

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Why?

Industrial challenges

- **Monitoring of CP efficacy**
- Checking of design assumptions
- RUL and life extension
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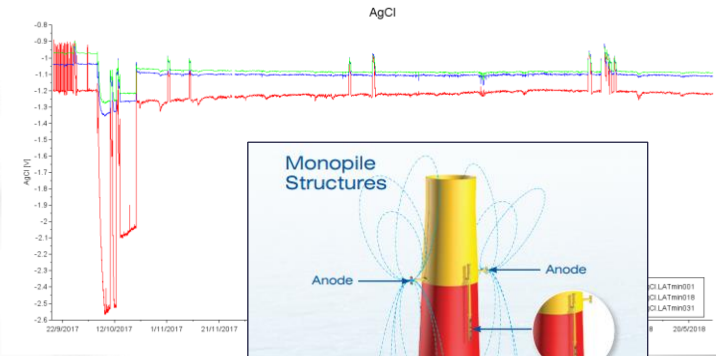

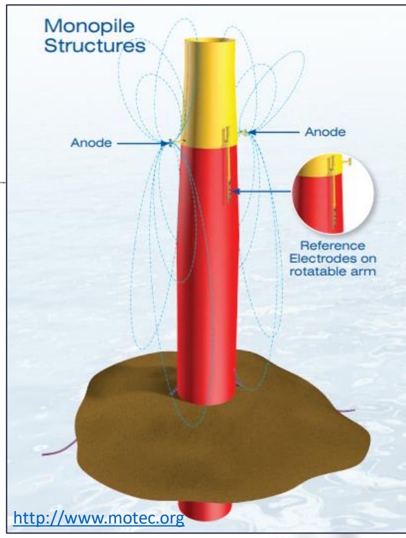

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Why?

Industrial challenges

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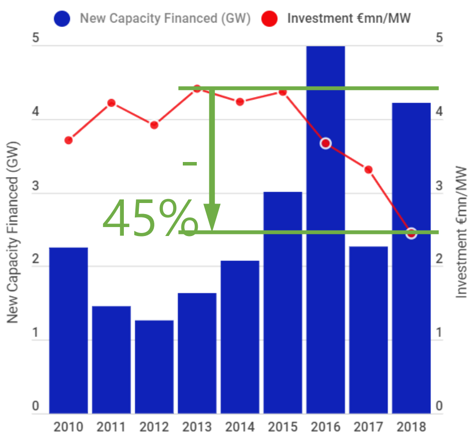
- O&M optimisation

Design improvement to reduce costs…



…but, also cut costs in corrosion protection?

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Why?

Industrial challenges

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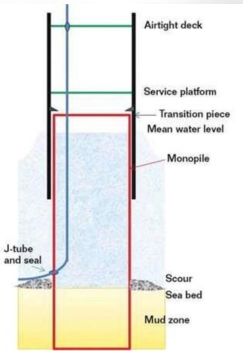
- **Checking of design assumptions**
- **RUL and life extension**
- O&M optimisation

Airtight designs…



…what now?

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Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- **RUL and life extension**
- O&M optimisation

Risk reduction/control

Philosophy of good documentation

Knowing the history of the structure

Confirm corrosion allowance not exceeded

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Why?

Industrial challenges

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- **O&M optimisation**

Very limited

Not a focus of corrosion monitoring (yet)

Health and Safety issues

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How?

	Periodic Inspection		Continuous Monitoring
CP Monitoring	*ROV mounted potential 'stabbers'* *Drop cell potential measurement* *Visual anode inspection*	Similar technologies	*Reference electrodes* *SCADA data* *Anode currents*
Direct corrosion monitoring	*Corrosion coupons* *Visual inspections* *Ultrasound wall thickness on Crawlers*	Similar technologies	*ER probes* *LPR probes* *Hyperspectral cameras* *Acoustic emission* *EIS sensors*
Environmental parameter monitoring	*Water sampling* *Bacteria counts* *CTD Rosette*	Similar technologies	*Dissolved oxygen* *Temperature* *pH* *Salinity*

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How?

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BASIC → ADVANCED

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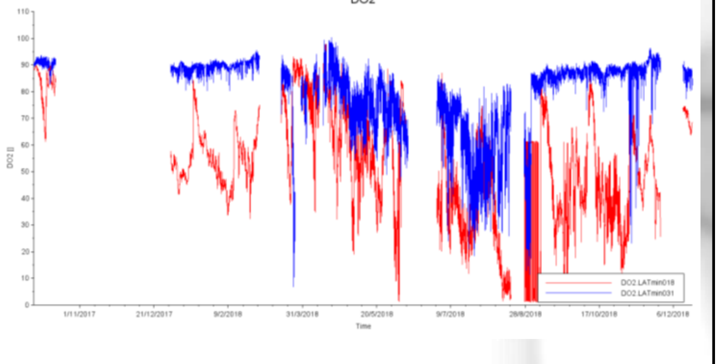
Lessons Learned

Environmental parameters (water quality)

Lifetime of sensors should be very long, because corrosion is a slow process.
Need for maintenance should be minimal (maintenance interval >> periodic inspection interval).

- Energetically active sensors imply the presence of cables in the structure under monitoring
- Impact of fouling
- Need for re-calibration
- Robustness of sensors and data acquisition
- Data quality

"The sensors need more maintenance than the structure."



Periodic inspection preferred

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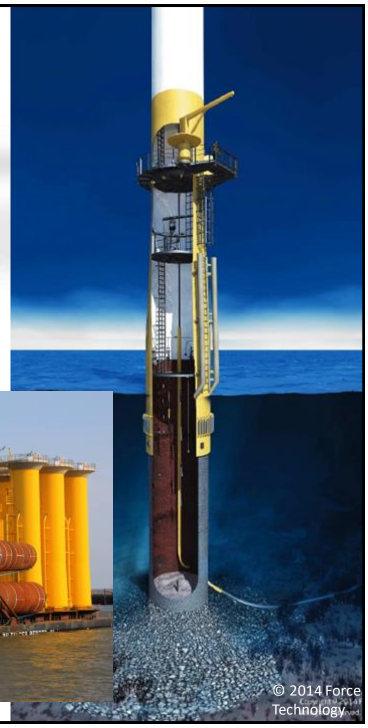
Lessons Learned

Corrosion rates

Corrosion coupons	ER sensors
▪ Location/Position ▪ Exposure time ▪ Starting conditions ▪ Electrical connection to structure	▪ Location/Position ▪ Element material ▪ Pitting/Fouling/MIC/Conductive scales ▪ Combination with CP ▪ Have a 'disconnected' sensor as a reference

"Corrosion coupons and ER sensors measure the corrosivity of the marine environment rather than actual changes in wall thickness."



Application in other sectors?

- Monitoring of CP efficacy
- Checking of design assumptions
- RUL and life extension
- O&M optimisation