



Overview of challenges associated with offshore wind farms in cold climates



pieterjan.jordaens@owi-lab.be

www.owi-lab.be

 **Winterwind** FEB 6-8
INTERNATIONAL WIND ENERGY CONFERENCE 2017

Quick Introduction



▪ Sirris - collective technology centre in Belgium

- Supporting companies with implementing technology innovations
- Multidisciplinary R&D and innovation projects in technology industry
- Different technology sectors: Automotive, Energy, Aerospace, ICT, ...
- Different key expertise: ICT, Manufacturing, Mechatronics, Materials
- High-tech test and R&D infrastructure

▪ OWI-Lab - RD&I center for wind energy in Belgium

- Set-up in 2010 as a new application lab at Sirris to support wind energy R&D
- Scope: wind energy in general - focus on **'offshore wind'** and **'cold climate'**
- Range of new and unique test & monitoring infrastructures
- Partnership with 3 Belgian universities for wind energy research (VUB, KU Leuven, UGent)
- Member of EERA JP Cold climate
- Member of IEA Wind Task19 Wind Energy in Cold Climates





6.X MW offshore
Gearbox

Climatic & Icing testing in the large climate chamber

**Icing test
Shipping Industry**

Climatic & Icing testing in the large climate chamber

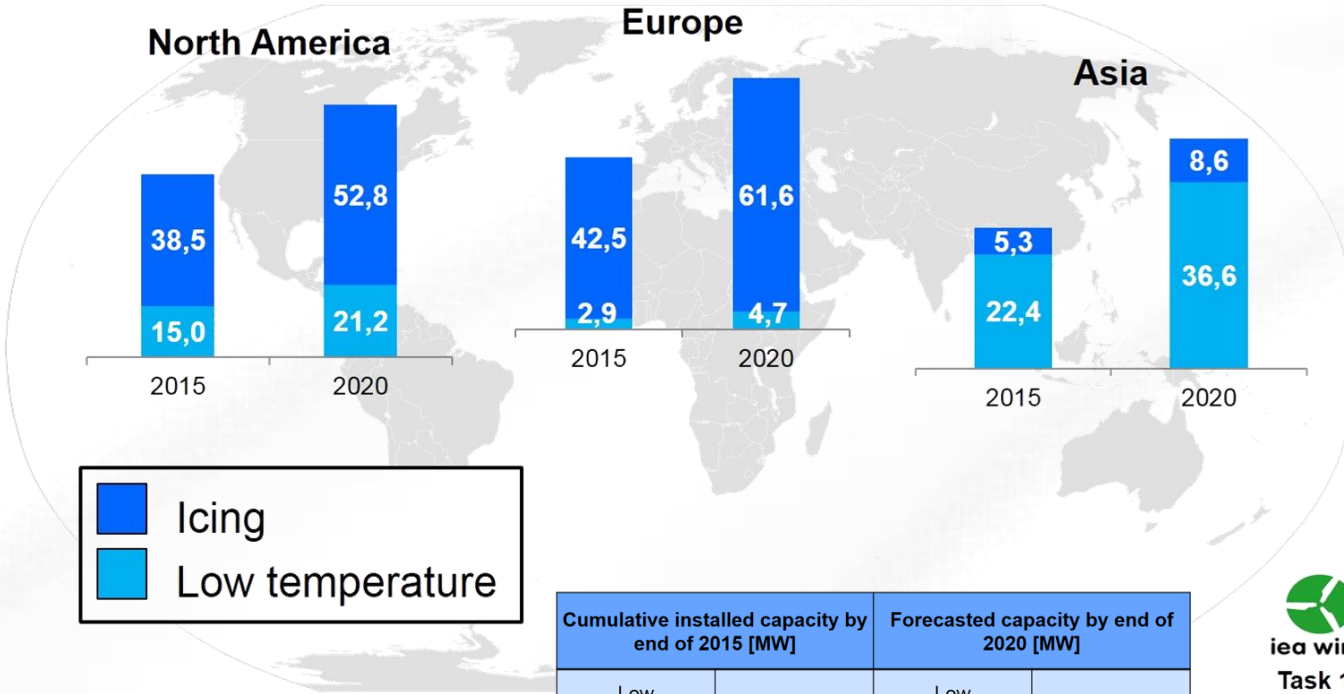




MARKET OPPORTUNITY

Cold climate market

Cold climate markets 2015-2020



Cumulative installed capacity by end of 2015 [MW]		Forecasted capacity by end of 2020 [MW]	
Low temperature	Icing*	Low temperature	Icing*
40 500	86 500	62 500	123 000
Total 127 000		Total 185 500	

*: IEA Ice Classification ≥ 2 meaning > 44h/a of meteorological (in-cloud) icing



IN DEPTH: Offshore wind warms to the cold Baltic Sea

05-03-2015



RUSSIA: Russia's first offshore site planned for White Sea

19 January 2017 by Eugene Gerden. Be the first to comment

RUSSIA: The country's first offshore wind power plant is set to be built in the White Sea, near the town of Kem, northwest Russia, according to a recent agreement.

Source: Windpower Monthly – 19/01/2017

Icebreaker Windpower Applies for Construction Permit



Illustration. Source: MHI Vestas

Icebreaker Windpower Inc. has filed an application for a certificate to construct the 20.7MW Icebreaker offshore wind farm in Lake Erie with the Ohio Power Siting Board (OPSB).
The application for a certificate of environmental compatibility and public need was officially submitted on 1 February 2017, and it is anticipated that the certificate will be issued in 2017, OPSB said.

The developer is proposing to construct a wind farm in Lake Erie, which would consist of six MHI Vestas V126-3.45 MW wind turbine generators installed on mono bucket foundations, some 8-10 miles off the Cleveland coastline, along with submerged electric collection cables, and a facility substation. The energy generated at the wind farm will deliver power to a single point of interconnection on the existing Cleveland Public Power (CPP) electric grid – 138 kilovolt (kV) Lake Road Substation.

Construction is anticipated to begin in May 2018 and be completed by October 2018. The wind farm is expected to be commissioned by November 2018.

Source: Offshore Wind Biz – 01/02/2017

DNV GL Joins Canadian Offshore Wind Project



Source: Beothuk Energy

DNV GL has won a contract to provide the Canadian offshore wind developer Beothuk Energy with the constraints analysis, wind resource and energy assessment, Levelized Cost of Energy (LCOE) modeling and a preliminary wind farm layout for the 180MW St. George's Bay project off western Newfoundland and Labrador.

Beothuk awarded the contract to DNV GL through its engineering firm, Madera Engineering.

"This work program will provide key information for moving forward with the project's design, providing a foundation for engineering, planning, and development of Canada's first offshore wind farm," Kirby Mercer, Chairman and CEO of Beothuk, said.

Beothuk selected St. George's Bay as a preferred location for the 180MW demonstration wind farm in February 2014.

The wind farm comprises 30 6MW turbines installed across an area of 40 square kilometres in the Gulf of St. Lawrence, an area identified as having Class A offshore wind conditions.

Apart from the project in St. George's Bay, Beothuk is planning to build a 1GW offshore wind farm off Nova Scotia.

Source: Offshore Wind Biz – 01/06/2016

Azerbaijan plans first Caspian offshore wind farm at 198MW



By Bernd Radowitz in Berlin Tuesday, February 09 2016
Updated: Tuesday, February 09 2016

Azerbaijan's state oil company SOCAR is planning to build the first offshore wind farm in the Caspian Sea, consisting of 60 turbines with a combined capacity of 198MW, Recharge has learned.

Source: Windpower Monthly – 09/02/2016

FINLAND: Offshore project designed to withstand Arctic conditions

29 February 2016 by Gerard O'Dwyer. Be the first to comment

FINLAND: Much is at stake for Finland's first commercial offshore wind farm, the €120-million 40MW Tahkoluoto project in the Gulf of Bothnia, in the north of the Baltic Sea, west of Finland. Scheduled for commissioning in the third quarter of 2017, the project will be custom-designed and built to withstand the local icy conditions.



Frozen... The 2.3MW pilot turbine (right) is sited off Finland, testing the arctic weather conditions on the turbine and steel caisson foundations (left) ahead of installing the country's first commercial offshore project (top).

Analysis: Siemens adds checks after nacelle drop

Source: Windpower Monthly – 29/02/2016

DONG, Eversource to Develop Bay State Wind Together



DONG Energy is teaming up with Eversource Energy, a transmission builder from New England who has acquired a 50% ownership interest in Bay State Wind, to jointly develop the project planned of Massachusetts, the United States.

The proposed offshore wind farm would be located approximately 15-25 miles south of Martha's Vineyard in an area that has the potential to develop at least 2,000 megawatts of electricity – enough to power one million Massachusetts homes, DONG Energy said.

Source: Windpower Monthly – 14/12/2016

Not taking into account the offshore projects in 'cold climate' – low temp / icing

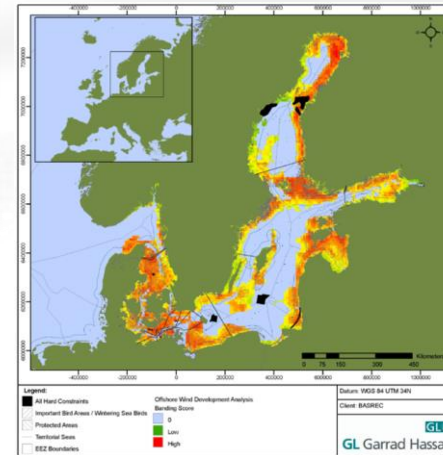
Offshore Cold climate market – niche market?

- **Baltic Sea - huge potential (130GW)** – ongoing large scale projects
- Bothnian Sea – demo projects
- USA: Great lakes & East coast – demo projects
- White Sea Russia – demo projects
- Caspian Sea Azerbaijan – demo projects
- Canada: lakes & East coast – planned demo projects
- ...

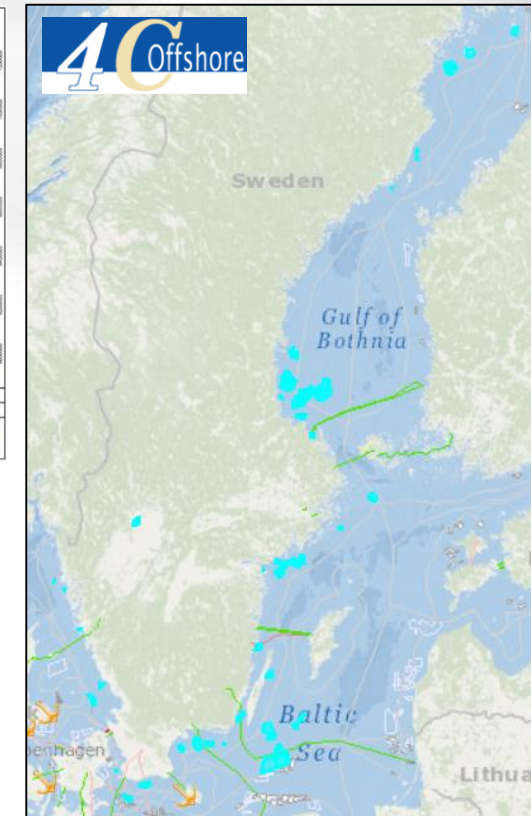
Advantage Baltic Sea VS North Sea offshore wind farms

- Near-shore solutions (depth) : 30% cost reduction to far-shore North Sea
- Low significant wave height
- Lower salt levels
- Good wind speeds – wintertime: air density advantage
- Grid connection advantages
- O&M: short distance to shore

- **But also some challenges to tackle due to site specific environmental conditions**



Shell boss sees offshore wind value amid 'unstoppable' shift



Source: BASREC – Study 'Conditions for deployment of wind power in the Baltic Sea Region' + 4C Offshore



CHALLENGES
&
SOLUTIONS

Only applying heated anemometers will not do the job



Insights in some specific challenges

The Great Lakes Could Be Getting Its First Offshore Wind Farm

 ELIZABETH MILLER × JANUARY 20, 2017 × ENERGY × TECHNOLOGY

Source Joshua Nowicki



Source: US Coast Guard



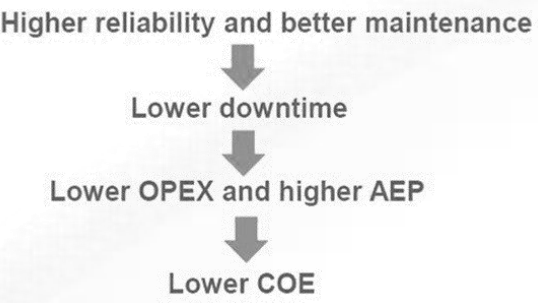
Stunning pictures of Michigan's St Joseph Lighthouse transformed into giant icicles as arctic blast continues to sweep across the US



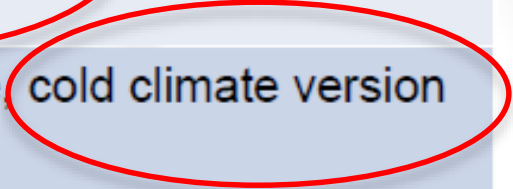
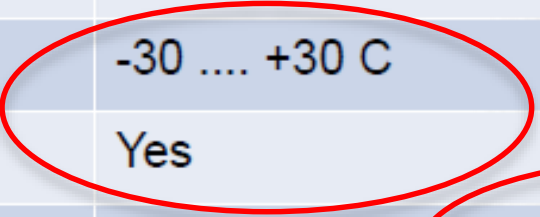
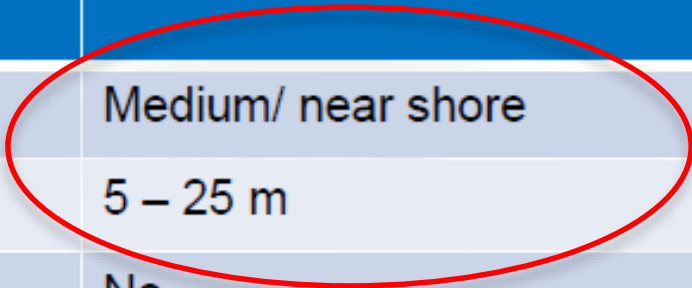
Source: NTNU

Standard North Sea offshore VS cold climate offshore (Baltic sea / Bothnian sea)

$$COE = \frac{CAPEX + OPEX}{AEP}$$

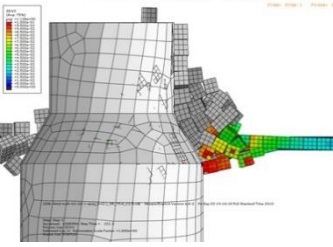


Factors that affect the offshore wind power price	North sea	Baltic sea
Distance from the shore	Long	Medium/ near shore
Depth	20 – 40 m	5 – 25 m
Tidal	Yes	No
Waves	High, up to 6,5m	Low, average near Vilsandi 0,6 m, 6 m wave possible once in 40 years
Wind class	IECI	IEC I/II
Saltiness	High	Low
Temperature	-10 ... +30 C	-30 +30 C
Ice (Drift Ice / Pack Ice)	No	Yes
Wind turbine design	Offshore turbine	Semi-offshore cold climate version

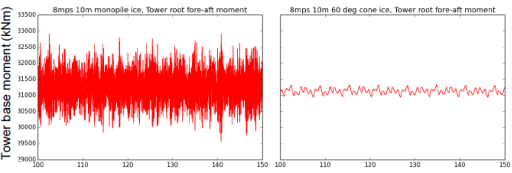


Potential challenges in the value chain of 'offshore cold climate'

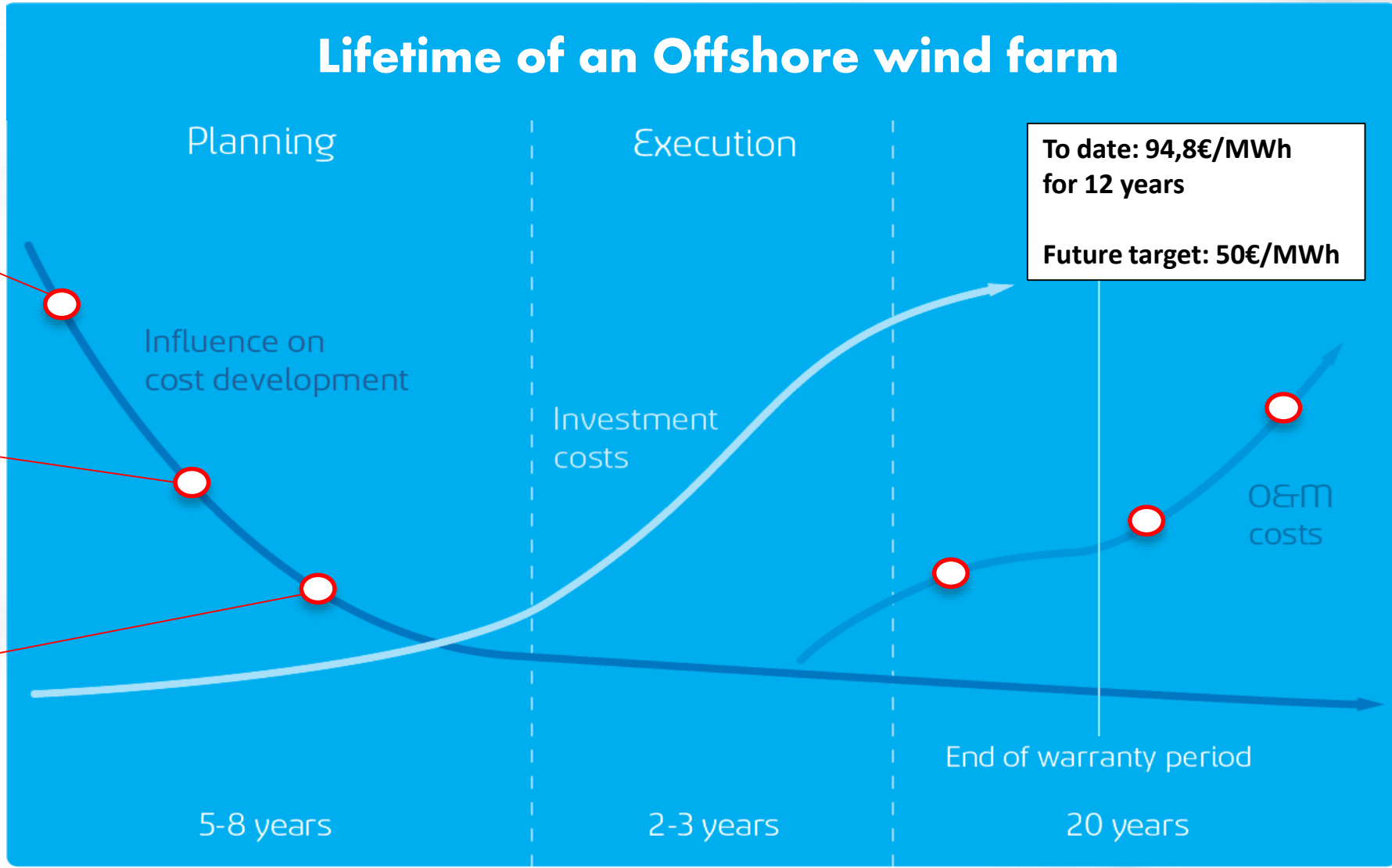
Source: STRABAG OW EVS



Source: VTT & Suomen Hyötytuuli Oy



Source: Demag

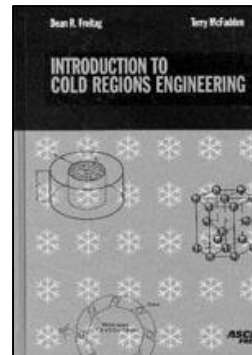
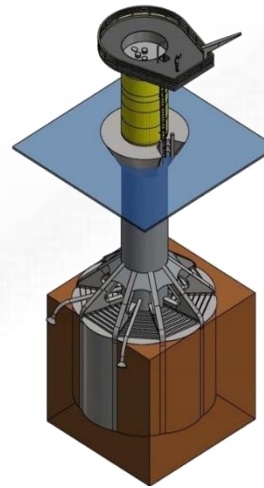


Overview of challenges to overcome in the lifetime of an 'offshore cold climate' WF



Example: ice removal on floating lidar buoy

Source: Offshore wind biz

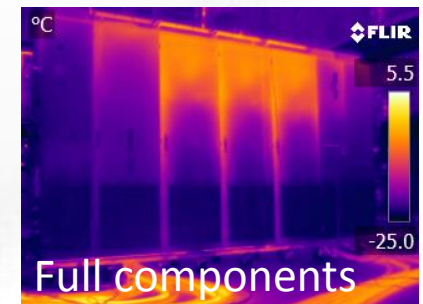
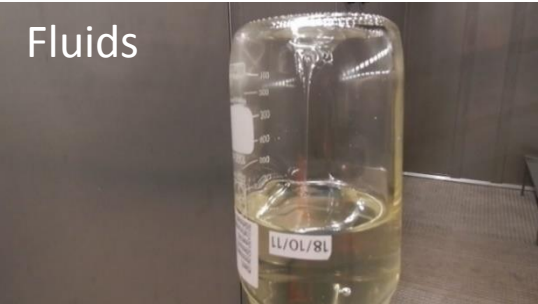


- Good understanding of site specific conditions
 - Temperature specification / cold climate package needs
 - Sea ice loads / ice induced vibrations
 - Wave / soils conditions (sand, rock, chalk)
 - Icing scour (foundation & cabling)
 - Weather window (installation phase)
- Uncertainties & risk assessment
- Design for O&M (procurement VS O&M team)
 - Condition monitoring
 - Structural Health Monitoring
- Health & Safety topics
- Reliable resource assessment tools
 - Data quality
 - Battery life / Electronics
 - Power production
 - H&S topics
- Certain choices have impact on the full chain !

Overview of challenges to overcome in the lifetime of an 'offshore cold climate' WF



↓



DNV-GL

RECOMMENDED PRACTICE

DNVGL-RP-0363 Edition April 2016

Extreme temperature conditions for wind turbines

DNV-GL

OFFSHORE STANDARD

DNVGL-OS-A201 Edition July 2015

Winterization for cold climate operations



8 MW offshore



3 B2 J3

WWW.APELMANN.NL

B2 J3

B2 J3

A 28

C1

C2

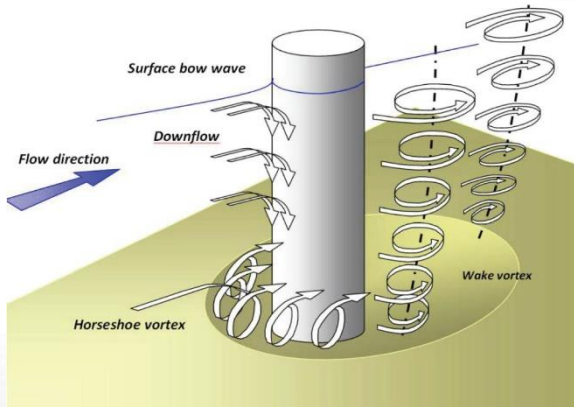
RED ROCK

1000000

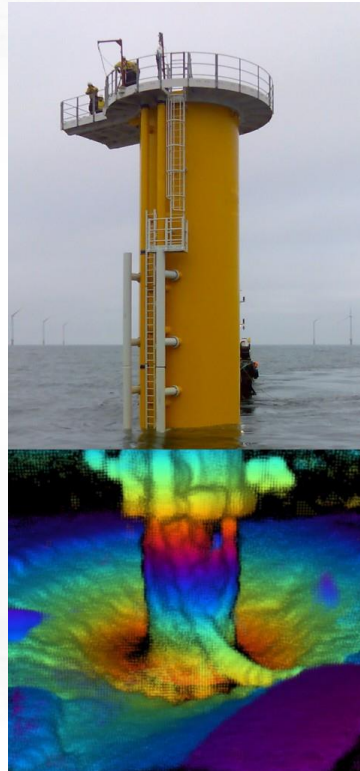
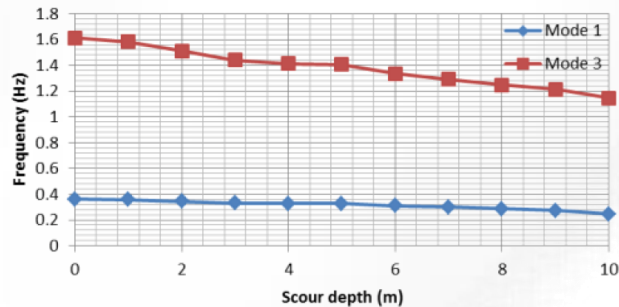


**Ampelmann develops
industry's first motion
compensated gangway
system operable at
minus 28 degrees
Celsius**

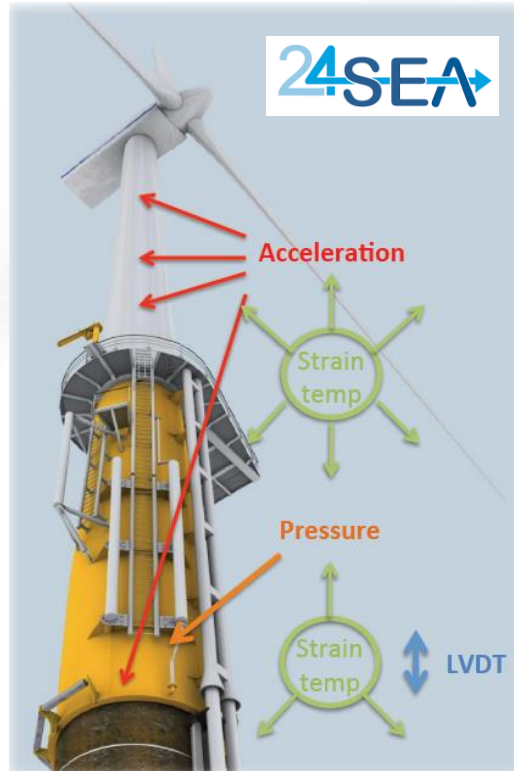
Overview of challenges to overcome in the lifetime of an 'offshore cold climate' WF



Influence of scour on Eigen modes



North Sea



- Ice induced vibrations a problem?
- Load data for design optimization
- Ice scouring a problem?



Offshore cold climate ?



Liberty ship - cargo ship US Army World War II – [link](#)

“well-known and dramatic example of the brittle fracture of steel that was thought to be ductile”



Contact person & more information

pieterjan.jordaens@owi-lab.be

be.linkedin.com/in/pieterjanjordaens/en



@OWI_lab



**Knowledge sharing – LinkedIn Group:
Offshore Wind Infrastructure
Application Lab (OWI-Lab)**



www.owi-lab.be