Offshore Wind Infrastructure Application Lab (OWI-Lab)

The use of a large climate chamber for extreme temperature testing & turbine component validation

Winterwind 2013

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General introduction

What is OWI-Lab?

Reliability & Robustness

Reducing O&M cost

Laboratory testing in wind energy applications

(Extreme) temperature tests

Cases: gearbox, transformer, switch gear (BOP)

Cold climate wind turbines

Large climate chamber testing

Conclusions

Remote located wind turbines

Introduction

sirris

driving industry by technology

Collective centre of the Belgian technology industry

- Non-profit organisation
- Industry owned

Mission: To help companies implement technological innovations

- Collective centre
- Industry driven
- Technological Innovation
- Shared R&D
- Knowledge transfer
- Innovation projects
- Shared capacity
- High tech infrastructure
- Multi-disciplinary approach
- Large partner network
- 130 Experts

Introduction

Antwerp
Offshore Wind Infrastructure Application Lab

Ghent
Materials Engineering
Materials Research Cluster Gent

Leuven
Mechatronics
Technology Coaching
Sirris Leuven Composites Application Lab

Hasselt
Materials Engineering
Production Technology
Smart Coating Application Lab

Liège
Additive Manufacturing
Materials Engineering
Sirris Microfabrication Application Lab

Brussels
Software Engineering & ICT
Technology Coaching

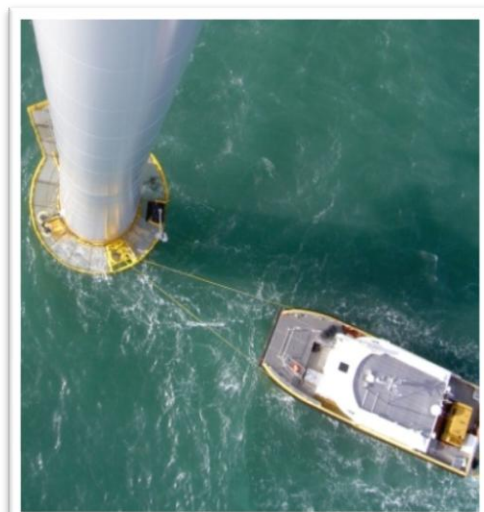
Charleroi
Additive Manufacturing
Bio-manufacturing platform

OWI-Lab = 5.5 mio € investments in state-of-the-art test & monitoring infrastructure

Stationary and Floating LIDAR (FLIDAR™)

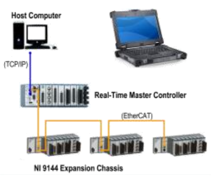
Wind turbine component Test Lab with large climate chamber (Temperature testing)

Remote measurement & monitoring systems (SHM & CMS)



Development of tools for smart O&M

Offering OWI-Lab



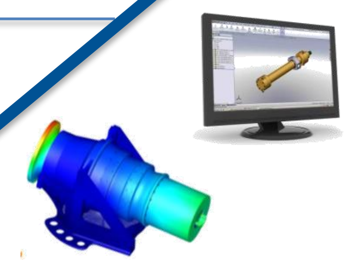
(Raw)
DATA

Test & Measurement services

Test & Monitoring Infrastructure

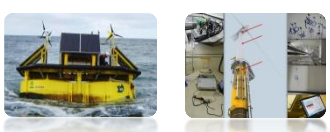
DATA
(Processed)

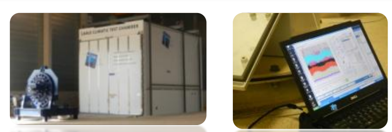
Information & insights



Knowledge

- Design purpose (CAPEX)
- O&M purpose (OPEX)
- Higher energy yield





Shared Capacity
Access to high-tech infrastructure

Shared R&D
Technological developments with industrial partners

Innovation Projects
Realisations from idea to product


Remote located wind turbines







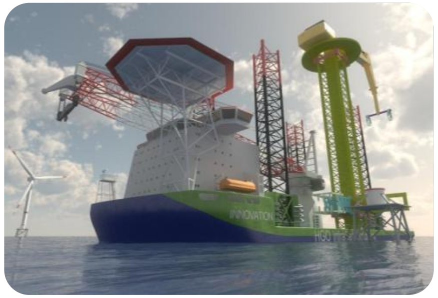

- Specialized tools and equipment needed
- Harsh and difficult conditions
- Trained professionals needed

→ <u>Expensive maintenance tasks</u>

How to reduce theses O&M costs

In general 2 strategies:

1. **Reducing costs to perform maintenance**
   - New efficient maintenance tools & equipment
   - Design for maintainability
   - Condition monitoring & SHM
   - Predictive maintenance strategies & tools
   - Reliable weather forecasting tools
   - …



Source HighWind

Source Gamesa

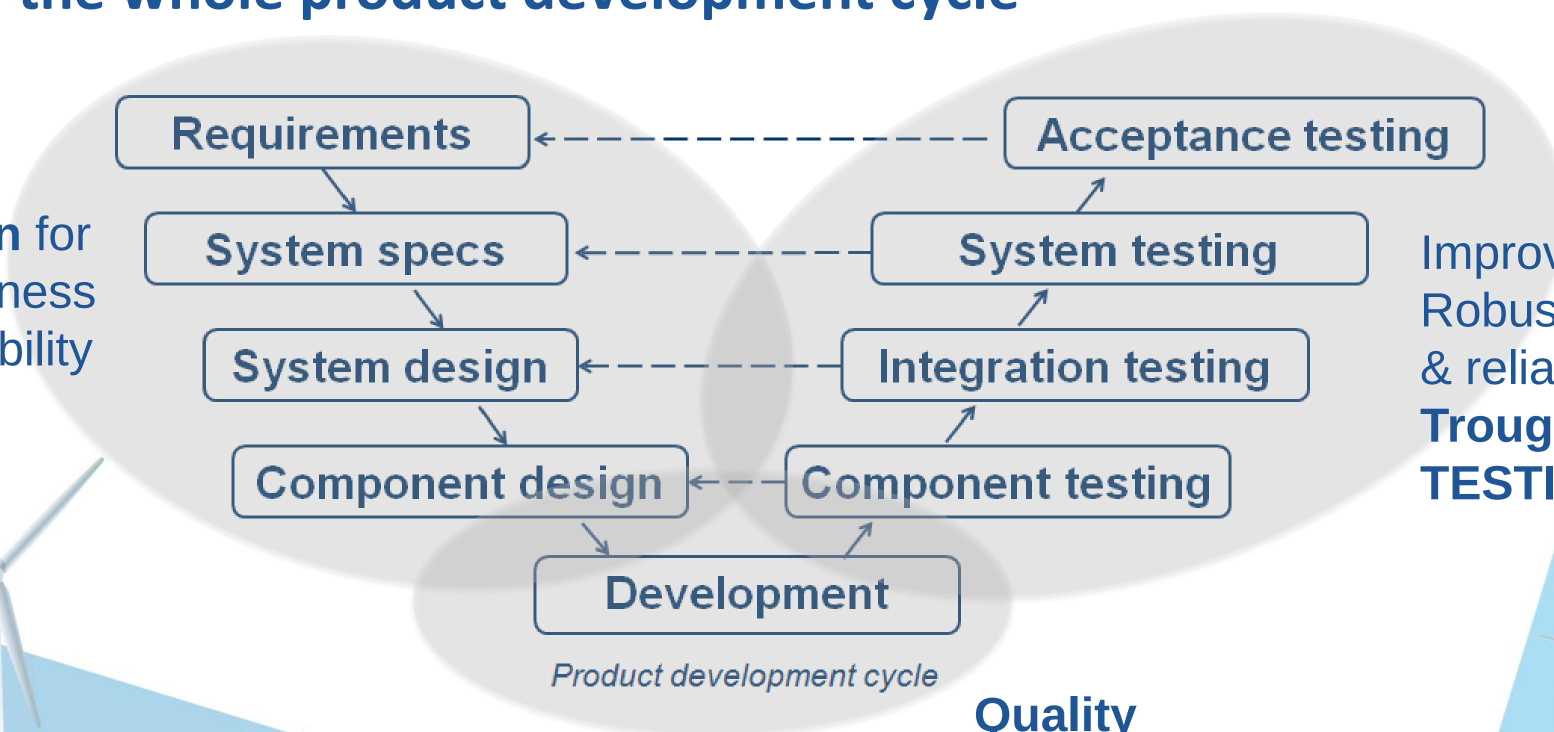
Source OWI-lab

How to reduce theses O&M costs

In general 2 strategies:

2. **Improving component <u>robustness & reliability</u> throughout the whole product development cycle**

Design for robustness & reliability



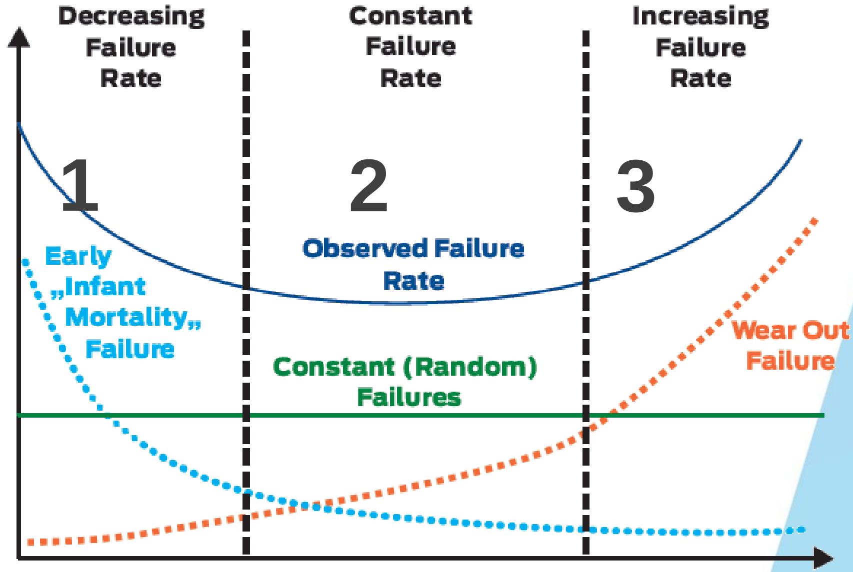
Improving Robustness & reliability **Trough TESTING**

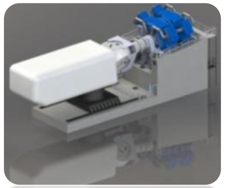
Quality

Improving Robustness & reliability Trough TESTING

- In general three kinds of testing:

1. End-of-line testing
2. Development testing
3. Endurance testing





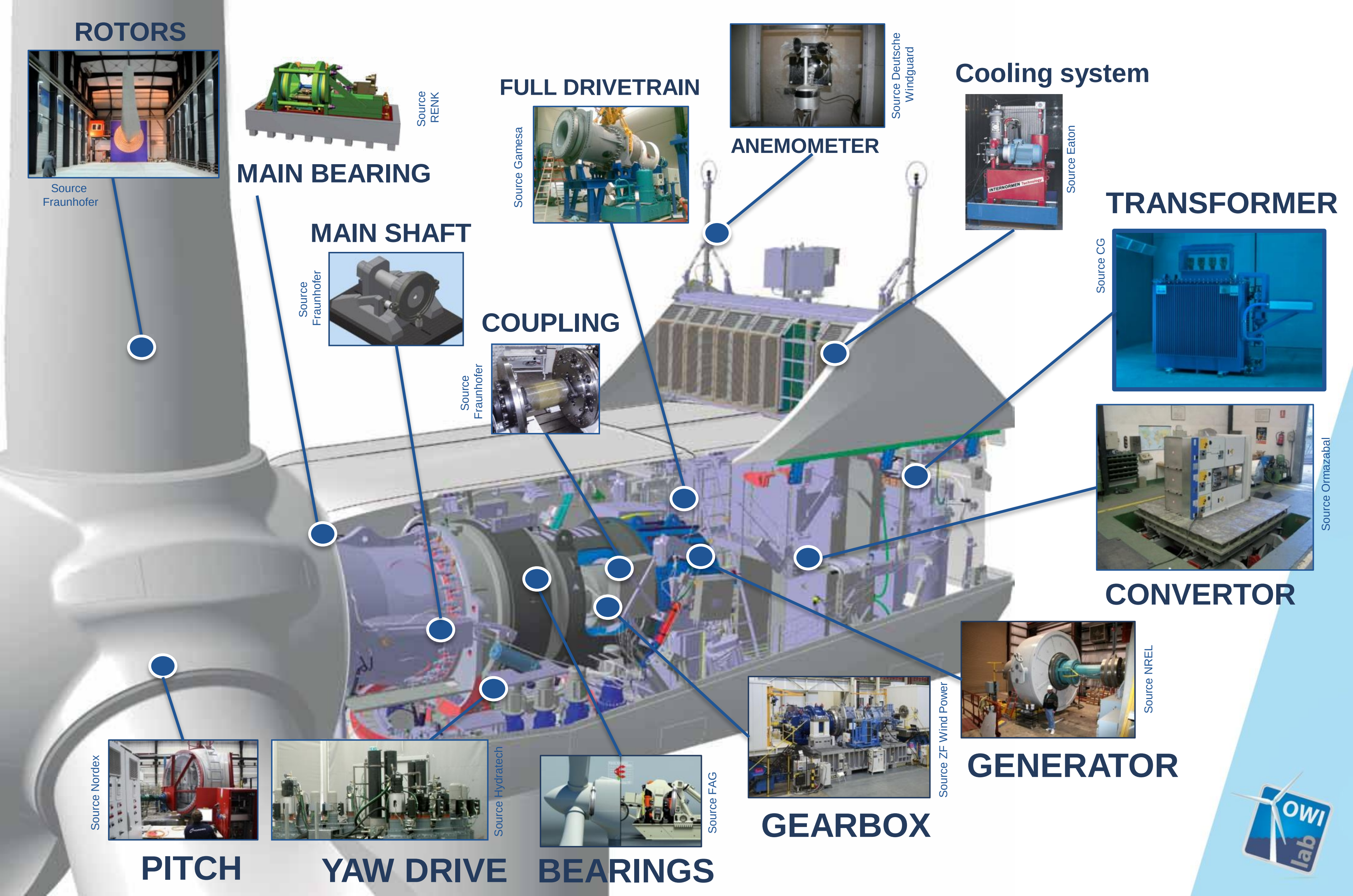
Source Lorc

Source OWI-Lab

Source Vestas

→ **Sub-component, component, and full system level**

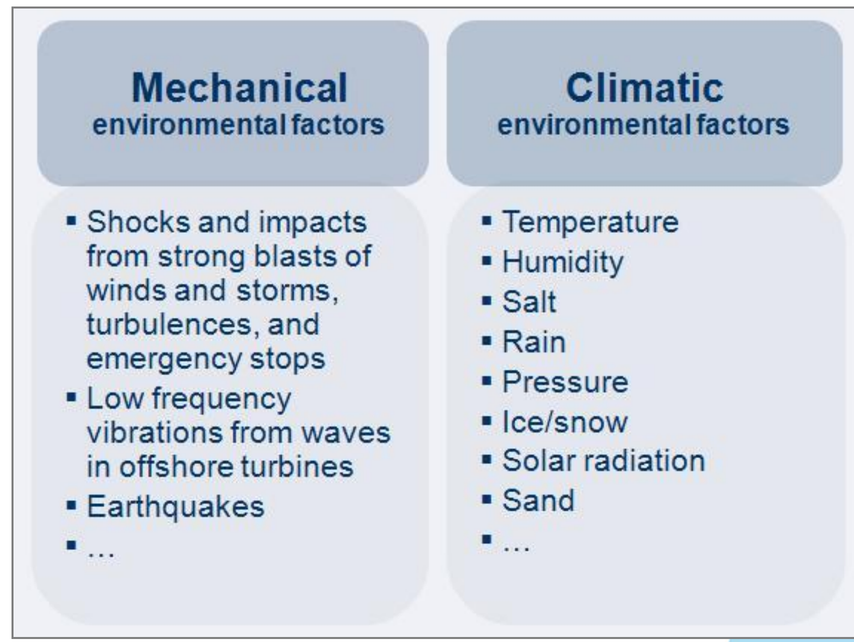
Examples component testing



Which factors to test?

- Depends on the location of the wind turbine:
  - Location: onshore, offshore, cold climate, desert,…
  - Wind speeds classification
  - Environmental factors

- The IEC 61400-1 suggests considering environmental factors in design & testing of wind turbines.



Why extreme temperature testing?

- On & offshore wind turbines standard designed to operate in temp. range of -10°C → +40°C.
- In some cold climate regions turbine need to operate at -40°C or even -50°C ; in hot regions +50°C can occur.
- A proper cold start procedure has big influence on the reliability and productivity (idling & heating strategy).
- Storage specifications of turbine components can even be lower than the operating condition.
- Example from components in an offshore turbine (client specification):
  - Storage: -40°C to +50°C
  - Operation: -20°C to +30°C

Why extreme temperature testing?

- Possible impacts of (extreme) temperatures:
  - Differential thermal expansion of (sub)-components and materials.
  - Lubrication can become more or less viscous which effects the oil/grease flow in bearing, raceways, gears.
  - Materials can become brittle at low temperatures (metals, rubbers, plastics)
  - Cooling systems can experience overheating problems, during extreme heat
  - Performance and efficiency change due to temperature variations
  - …

Source: Areva

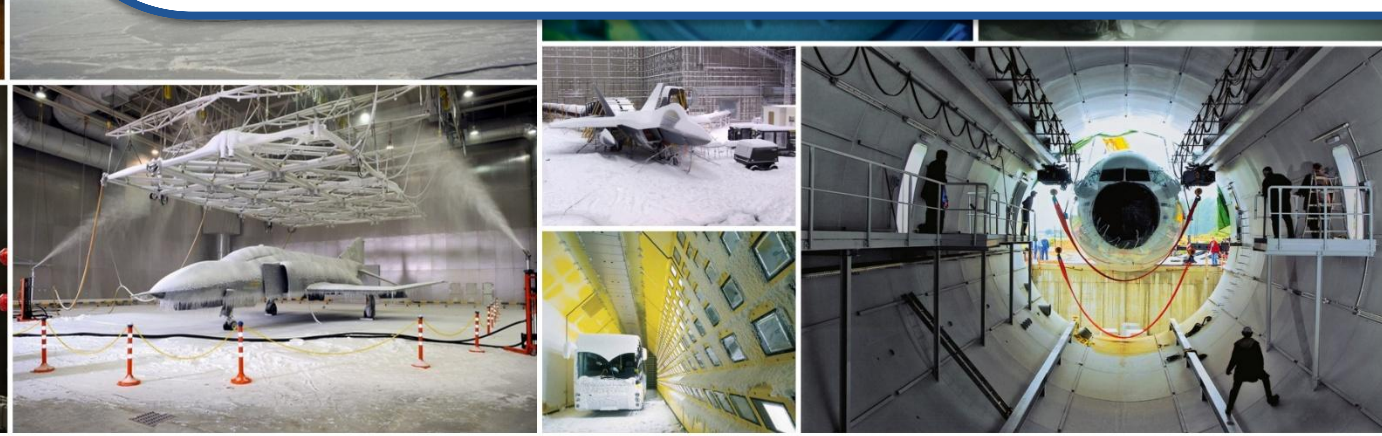
gearbox oil @-30°C
Source: Voith

Source: JaKe

- Large climate chambers exist for development testing
- Commonly used in the automotive, aerospace, defense industry for robustness & reliability tests
- No PUBLIC climate chambers yet specialized for wind energy application and heavy machinery

  → capable of handling heavy weights (multi-MW components)

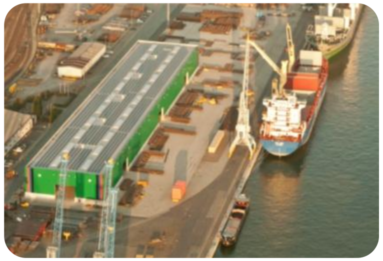
  → dedicated auxiliaries for system testing




LARGE CLIMATIC TEST CHAMBER

Large climate chamber for heavy machinery

- Located at breakbulk terminal in the Port of Antwerp
- Maximum test dimensions: 10m x 7m x 8m (LxWxH)
- Test volume: 560m³
- Temperature test range: -60°C → +60°C
- 45ton/m² capacity ; components up to 150 ton
- 150 kW cooling capacity @ +60°C
- 250kW cooling capacity @-20°C
- 40 kW cooling capacity @-60°C
- Cooling down rate:
  - Empty chamber +20°C → -60°C: 1 hour
  - 100 ton steel: 60 hours
- Heating up rate:
  - 100 ton steel -60°C → +20°C: 48 hours



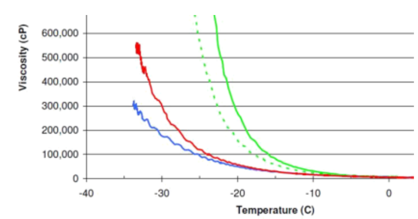
Why Climate chamber tests on wind turbine components?

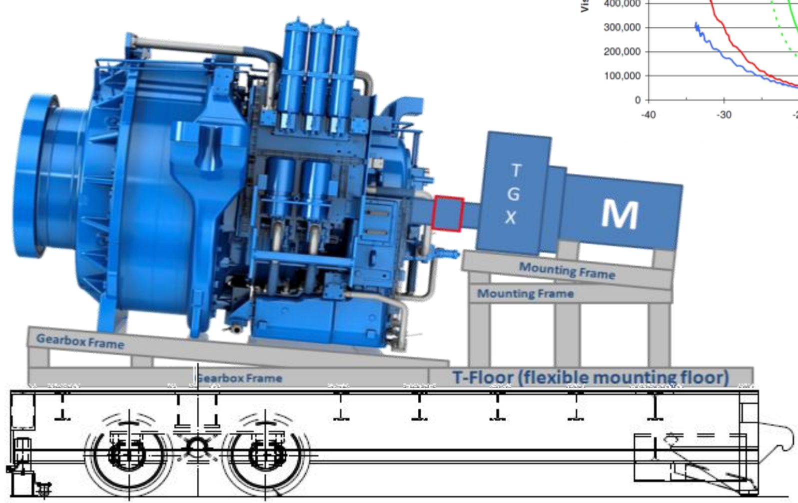
- Prototype development & optimization tests
- Model validation
- Performance tests
- Design verification
- Certification tests

Examples: Gearboxes, Transformers, Power convertors, Pitch & yaw systems, Switch gears, Hydraulics, Cooling & heating systems, Maintenance lifts,...

Case: gearbox cold start test

- Check behavior grease and oils at -30°C/ -40°C
  (influence of viscosity on start-up)
- Check influence on sealing (prevent leakage)
  (temperature effect on materials: rubbers, metals, plastics)
- Proper heating strategy by external oil heater
- Check cold start-up time





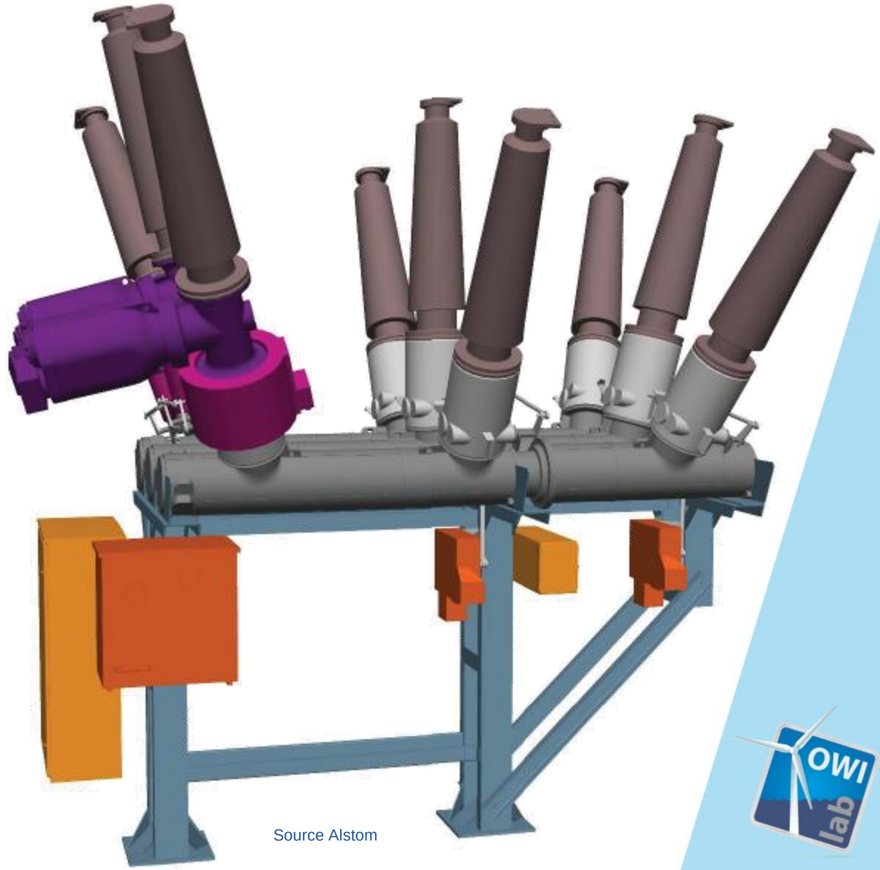
Case: Cold test CG SLIM transformer for offshore turbine

- Short circuit test
- Storage test

Case: switch gear cold test

Also Balance Of Plant (BOP) systems need to be robust (Case Alstom Hypact @ -60°C)

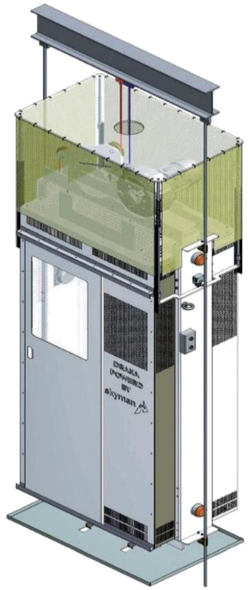
Source Siemens, Alstom, ABB



Source Alstom

What else to test?

- Not only large components like gearboxes and transformers.
- Different turbine components need to be tested for environmental impacts (cold, corrosion, humidity,…) if there is a risk for failure by these factors.
- Field testing provides experience and knowledge, but testing in a controlled environment lowers cost and increases time-to-market.



Source Sky Man

Source Siemens

Conclusions

- Reliability & robustness is key for wind turbines at remote locations.
- Extreme environmental scenario's have to be tested.
- Advanced testing becomes more and more important to reduce the time-to-market of turbine components, ensure reliability to clients and to obtain certification.
- (Extreme) temperature testing is needed for the validation of certain components.
- OWI-lab invested in a large climate chamber in order to support manufacturers in the testing process .