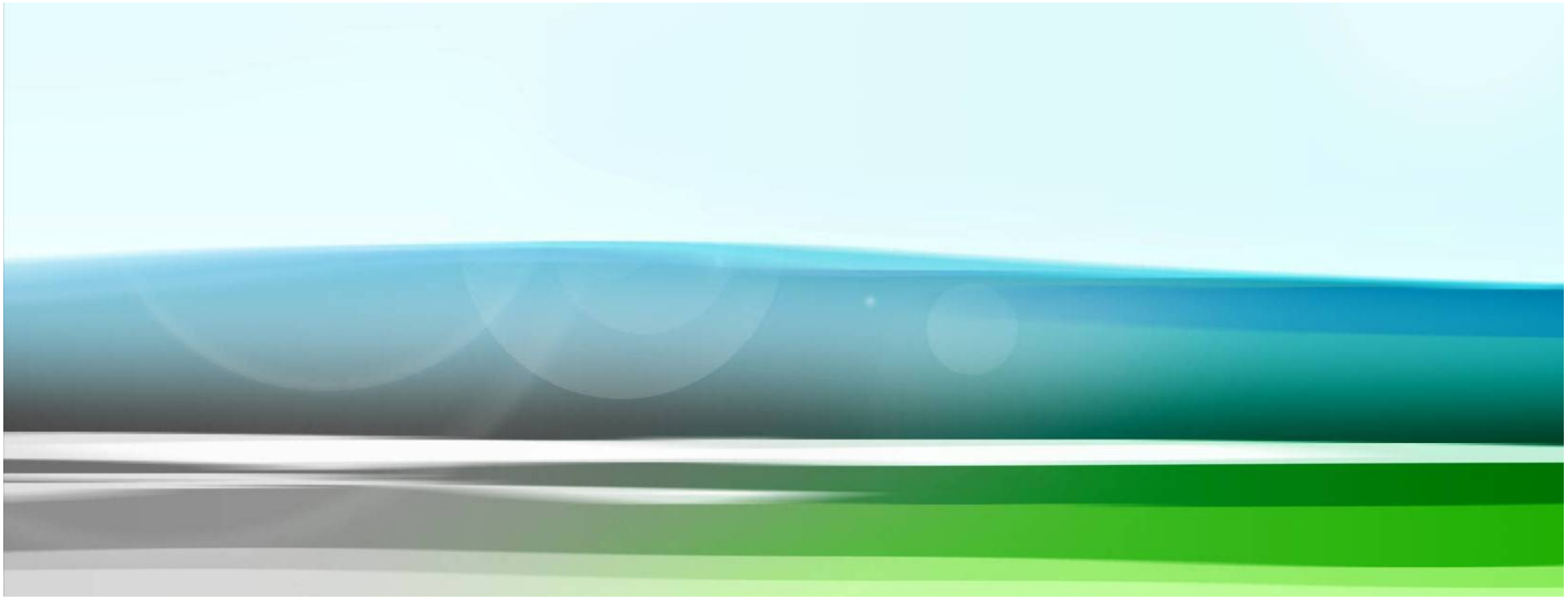


Offshore Wind Risks - Issues and Mitigations

DNV Offshore Wind

Soren Karkov
October 2010

MANAGING RISK

DNV – an independent foundation

Our Purpose

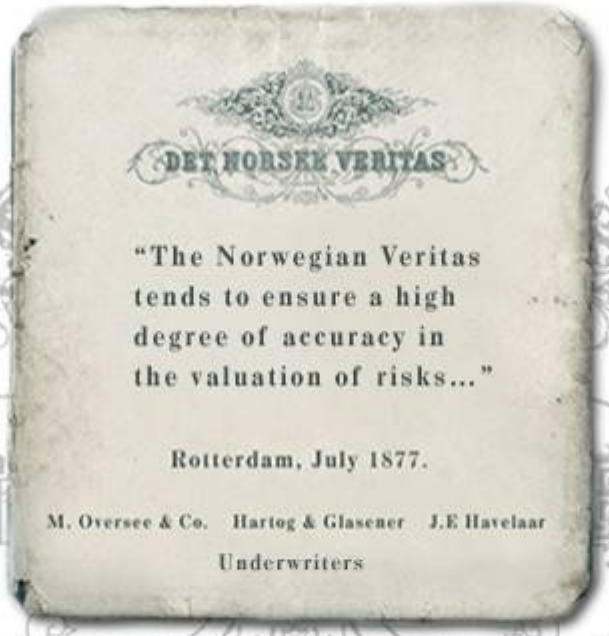
To safeguard life, property and the environment

Our Vision

Global impact for a safe and sustainable future

More than 145 Years of Managing Risk

- DNV (Det Norske Veritas) was established in 1864 in Norway
- DNV is a leading international provider of services for managing risk
- DNV is a foundation and reinvests all profits in services, research and development



DNV – An Independent Foundation

300
offices

100
countries

9,000
employees, of which 76% have a university degree

A trusted player in shipping

80

Authorised by more than 80 flag administrations

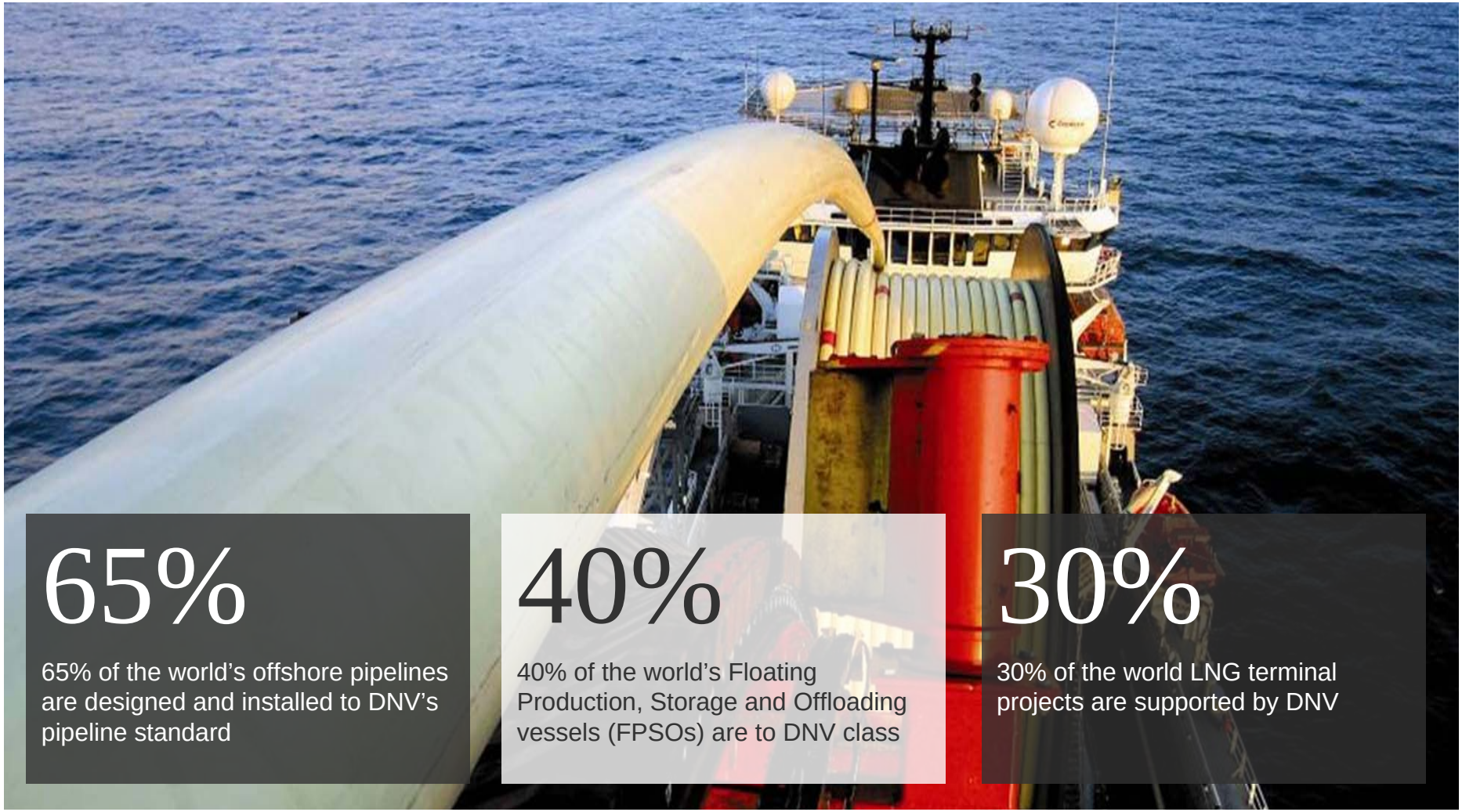
21.9%

DNV classed 21.9% of all new-building of ships in 2008 (in Gross Tonnes)

15.5%

15.5% of the world fleet is to DNV Class (in Gross Tonnes per 08/2009)

Expert role in the oil and gas industry



Impacting climate change issues

1st

Released the world's first standard for qualification of carbon capture technology

48%

48% of all Clean Development Mechanism (CDM) projects are validated by DNV

75%

75% of the world's offshore wind projects are certified and verified by DNV

Global

Developed a global rating scheme for monitoring ships' environmental performance

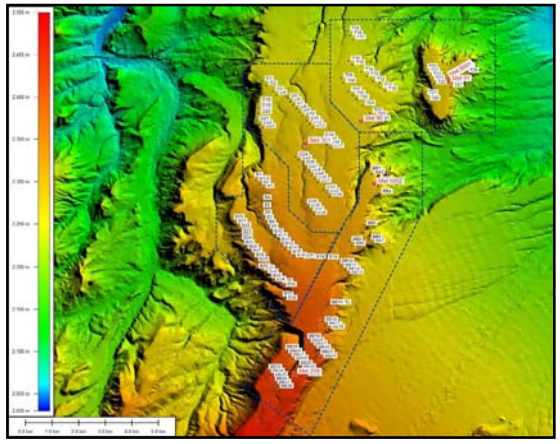
Services to the Wind Industry

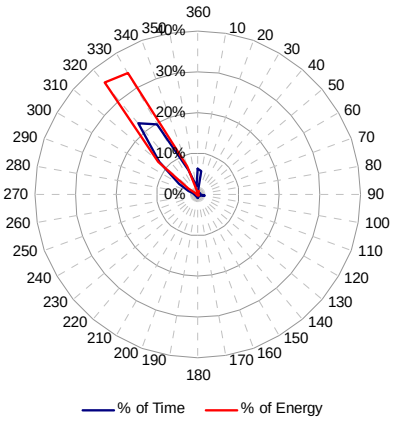
Advisory Services

- Wind Resource Assessment
- Project Development Support
- Due Diligence
- Marine Advisory Services
- Asset Risk Management
- Wind Turbine Technology
- Health, Safety and Environmental Risk Management
- Training and Educational Programs

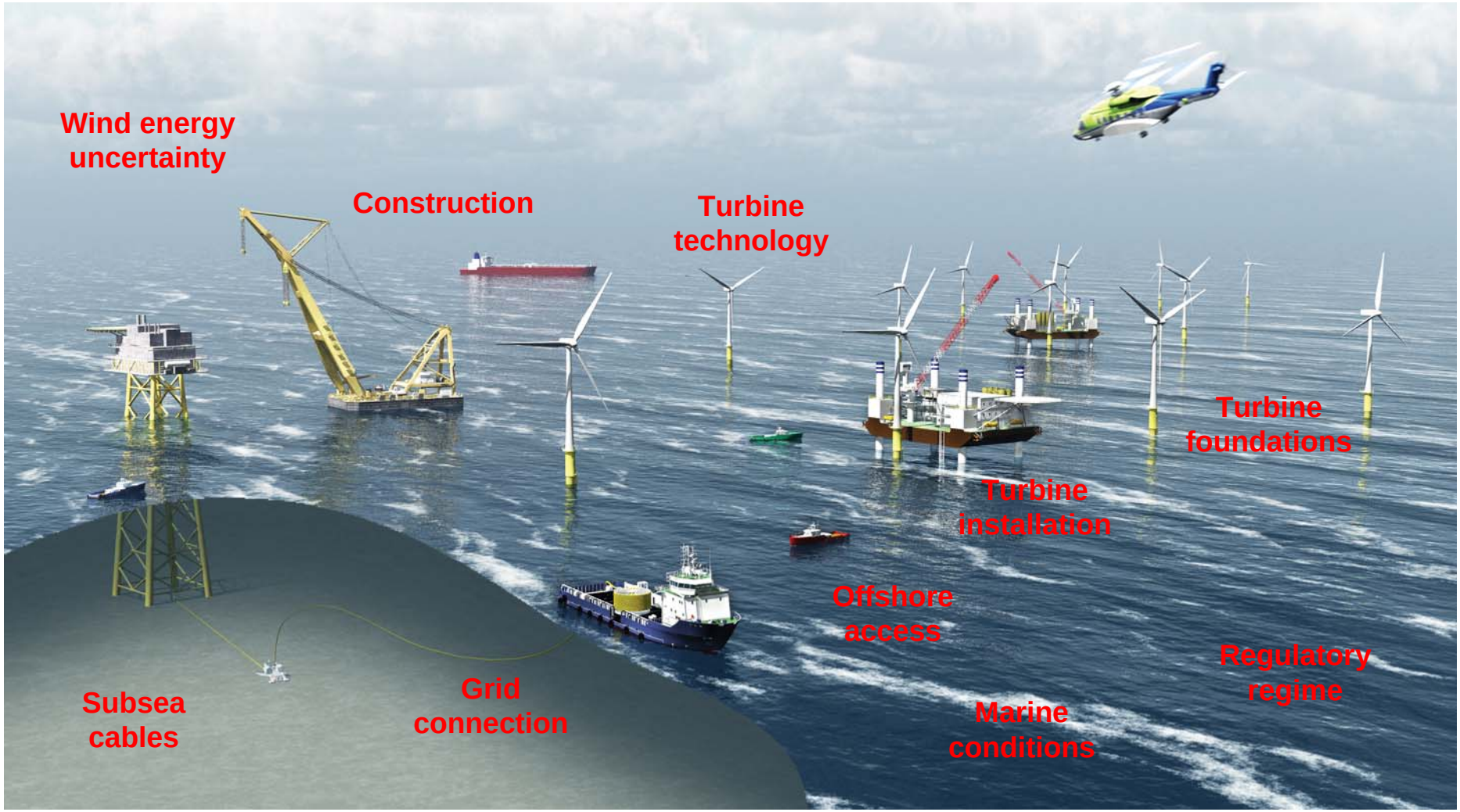
Accredited Services

- Project Certification
- Type Certification
- Testing Services
  - Power Performance Testing
  - Loads Testing

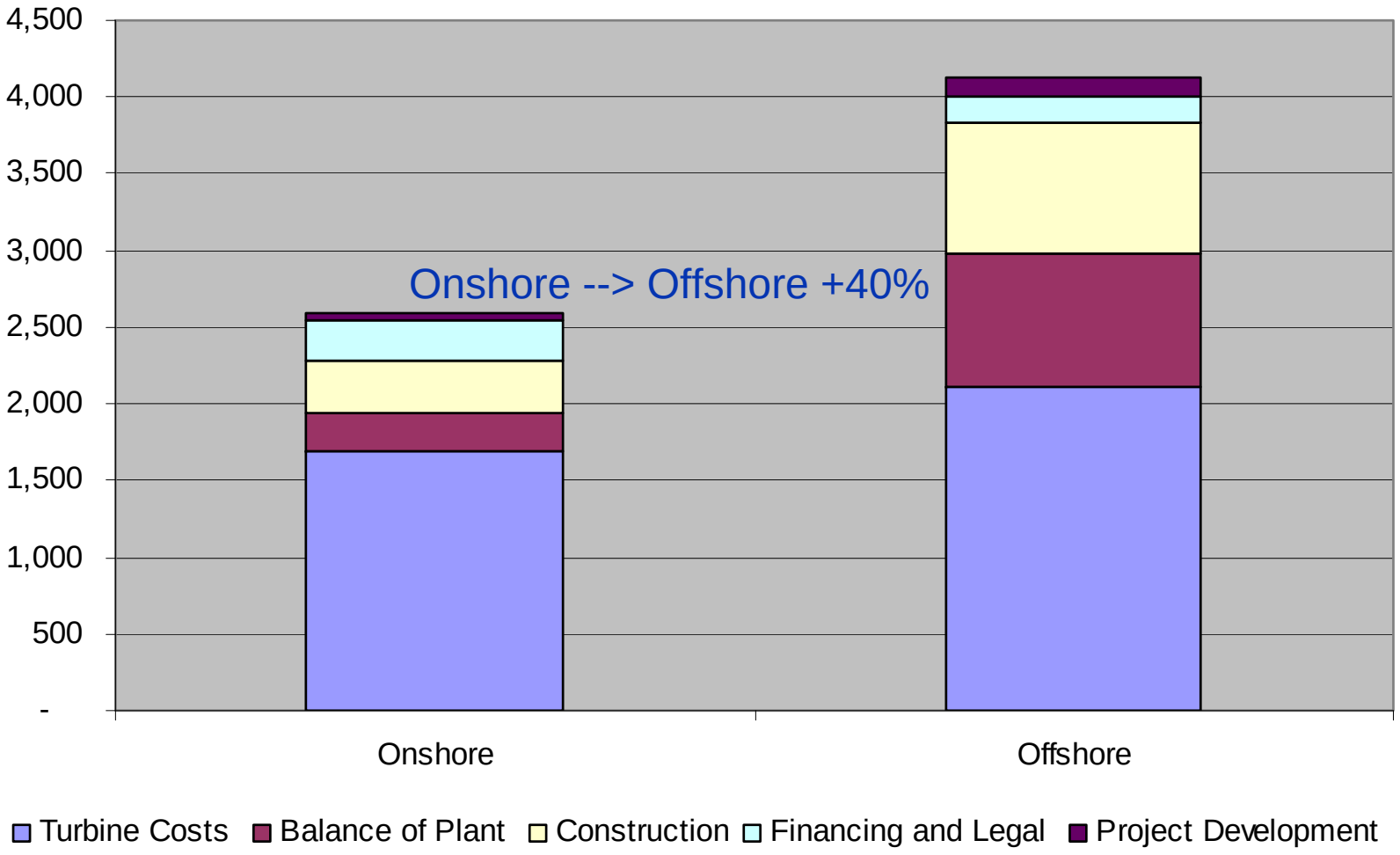




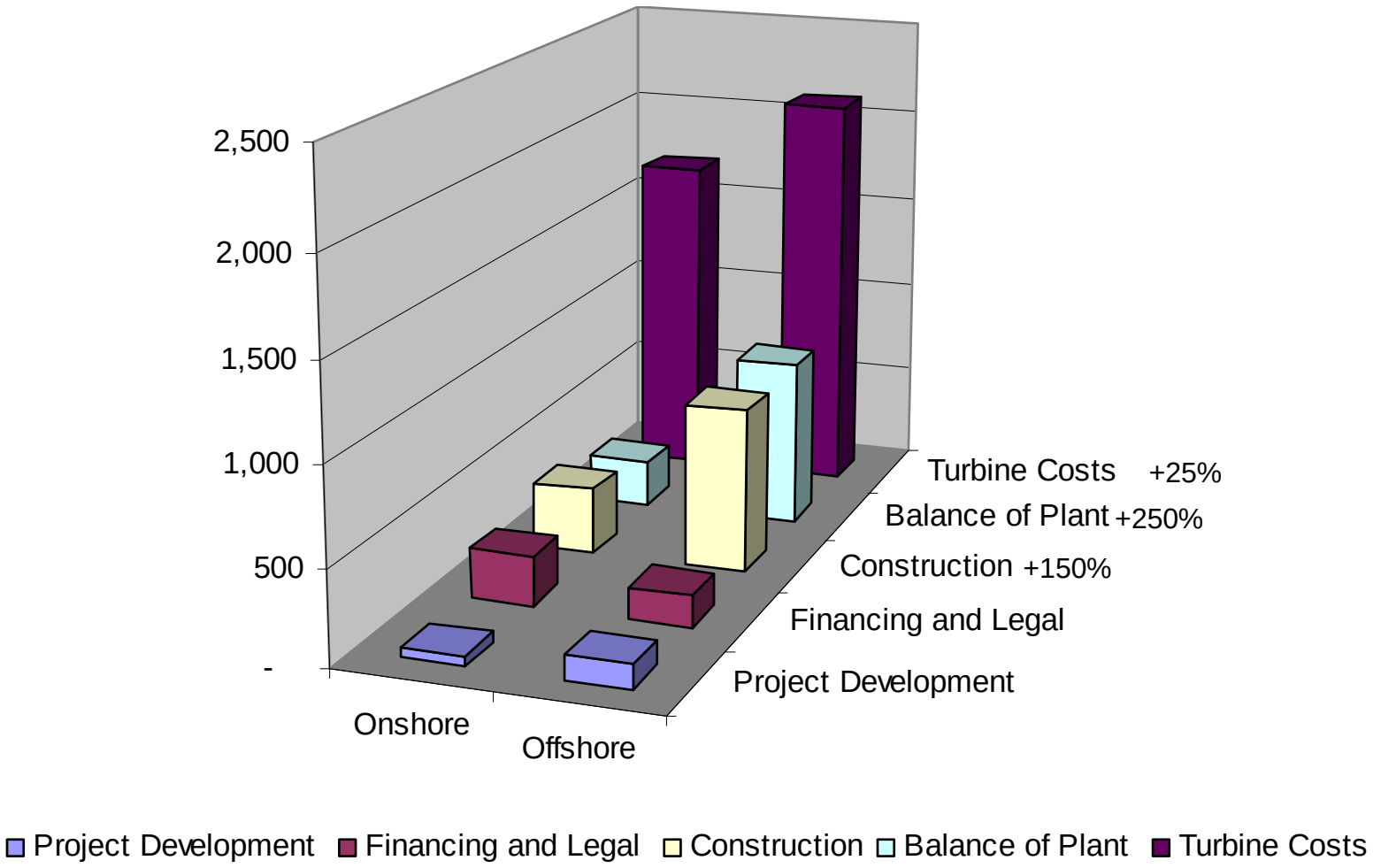
Major Risks in Offshore Wind Farms



Onshore – Offshore Wind Farms Project Costs



Onshore – Offshore Wind Farms Project Costs



Wind Energy Uncertainty

- **Issue**
  - Reliability of kWh generated estimates
  - Real on-site data are scarce
  - Wind resource estimates have large uncertainty
  - Loss factors are not well understood (e.g. wakes and turbulence)
  - Potential large variation in wind resource across the site

- **Mitigation**
  - Offshore measurement (fixed tower, novel solutions) over sufficient period of time (> 2 years)
  - Layout optimisation and understanding the trade-offs
  - Transparency of energy estimates

Site Conditions – Marine Environment

- **Issue**
  - **The weather and sea conditions**
  - **Varying water depths and sea bed conditions across a site**
  - **Weather window for offshore work is small**

- **Mitigation**
  - **Solid, site-specific information**
    - Measurement campaigns
    - Data mining
    - Geotechnical investigation
    - Safety factors in design
  - **Relevant learning from oil and gas**
  - **Development / use of equipment / methods suitable in adverse conditions**

Wind Turbine Technology

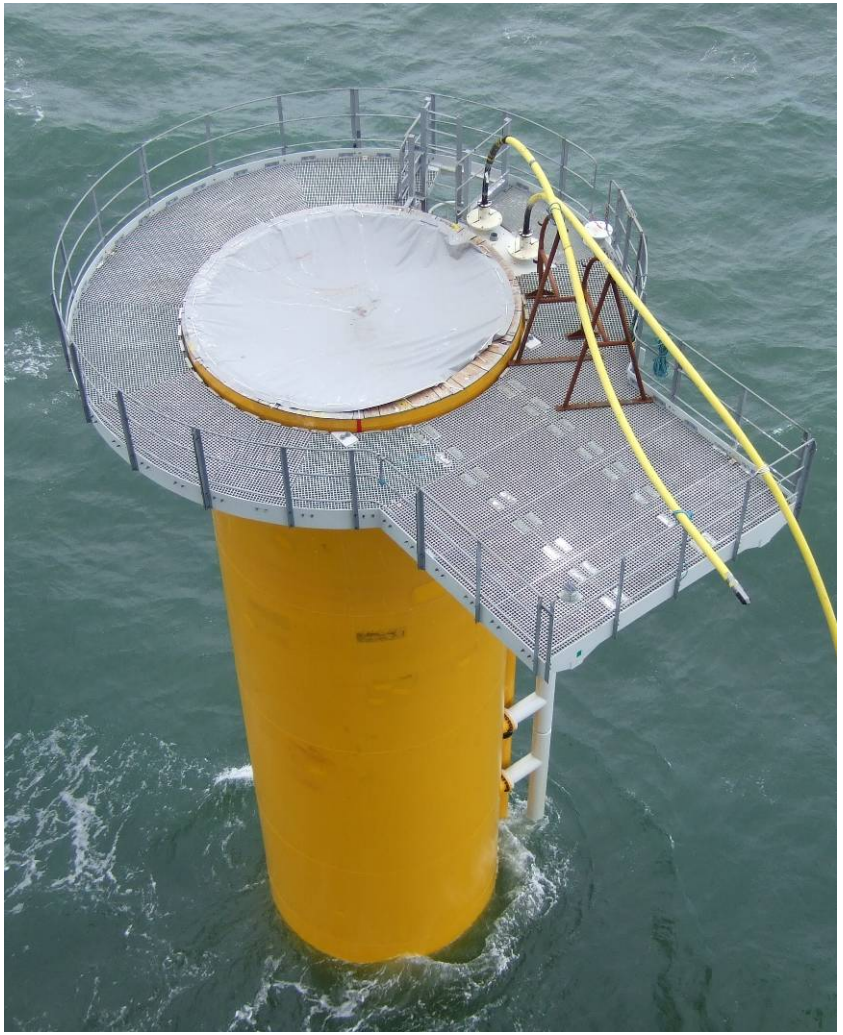
- **Issue**
  - **Large MW turbines required 10 MW?**
  - **Component failures difficult to rectify offshore**

- **Mitigation**
  - **Turbine selection**
  - **Strong warranty agreements**
  - **Condition monitoring**
  - **Data monitoring, analysis and response**
  - **Proactive maintenance**
  - **Further research into design loadings**
  - **Turbine type certification**

Wind Turbine Foundations

- **Issue**
  - **Costly foundation designs due to:**
    - Harsher marine conditions
    - Deeper water
    - Larger turbines
  - **Shallow-water solutions may not work**

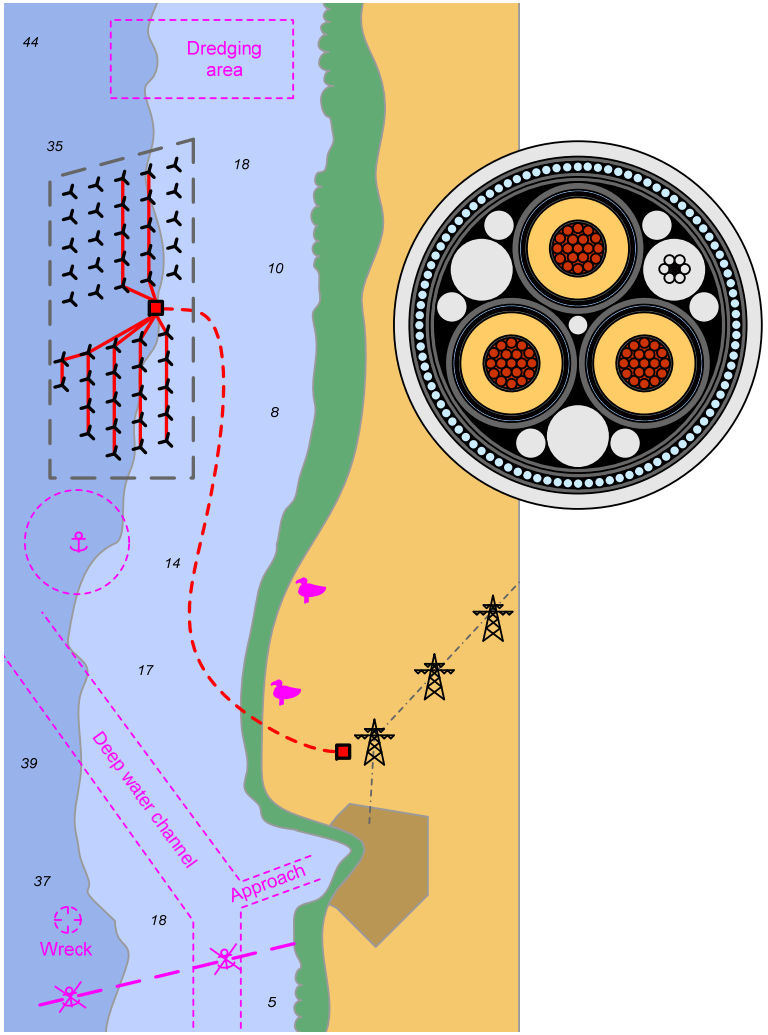
- **Mitigation**
  - **Standardisation**
  - **Quality control during manufacture**
  - **Information sharing between WTG manufacturer and foundation designers for benefit**



Subsea Cables and Power Transmission

- **Issue**
  - **Many problems during cable installation, e.g. improper cable handling**
  - **Human introduced hazards (e.g. anchoring)**
  - **Natural hazards (seabed mobility)**
  - **Unplanned downtime not considered in energy estimates**

- **Mitigation**
  - **Cabling**
    - Understand site-specific conditions
    - Chose appropriate cabling design (e.g. armour, burial depth, scour protection)
    - Work with experienced partners
    - Plan with contingencies
  - **Substation**
    - Realistic expectations for annual maintenance time
    - Include unplanned outages
    - Diligent inspections and maintenance



Construction

- **Issue**
  - Major project
  - Contract strategy selection
  - Managing the interfaces
  - Supply chain and facilities
  - Unexpected technical issues

- **Mitigation**
  - Previous project experience
  - Project lifecycle engineering supervision
  - Installation concept studies
  - Develop your own team
  - Plan A, B and C
  - Project Certification

Offshore Access

- **Issue**
  - Current access solution (boat fendering) limited by sea state (e.g. < 1.5 m significant wave height)
  - Access to turbines more frequent than expected
  - Health and safety issues – reputational risk

- **Mitigation**
  - Improvement of current solutions (e.g. to 3 m significant wave height)
  - New access solutions (e.g. heave-compensated gangway)
  - Additional access by helicopter-hoisting

Grid Connection

- **Issue**
  - Load centers far away from offshore wind farm
  - Congestion in certain areas of the grid
  - Long distance / high power will require (less proven) offshore HVDC solutions
  - Uncertainty about ownership / operation of assets

- **Mitigation**
  - Early dialogue between developer and grid operator
  - Careful evaluation of various options

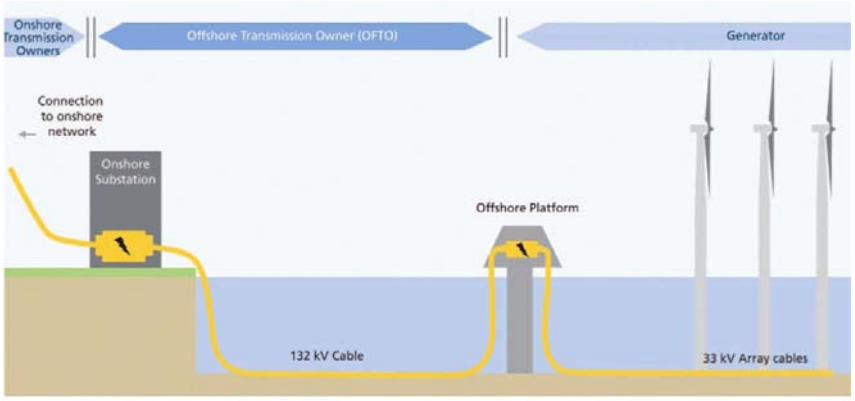
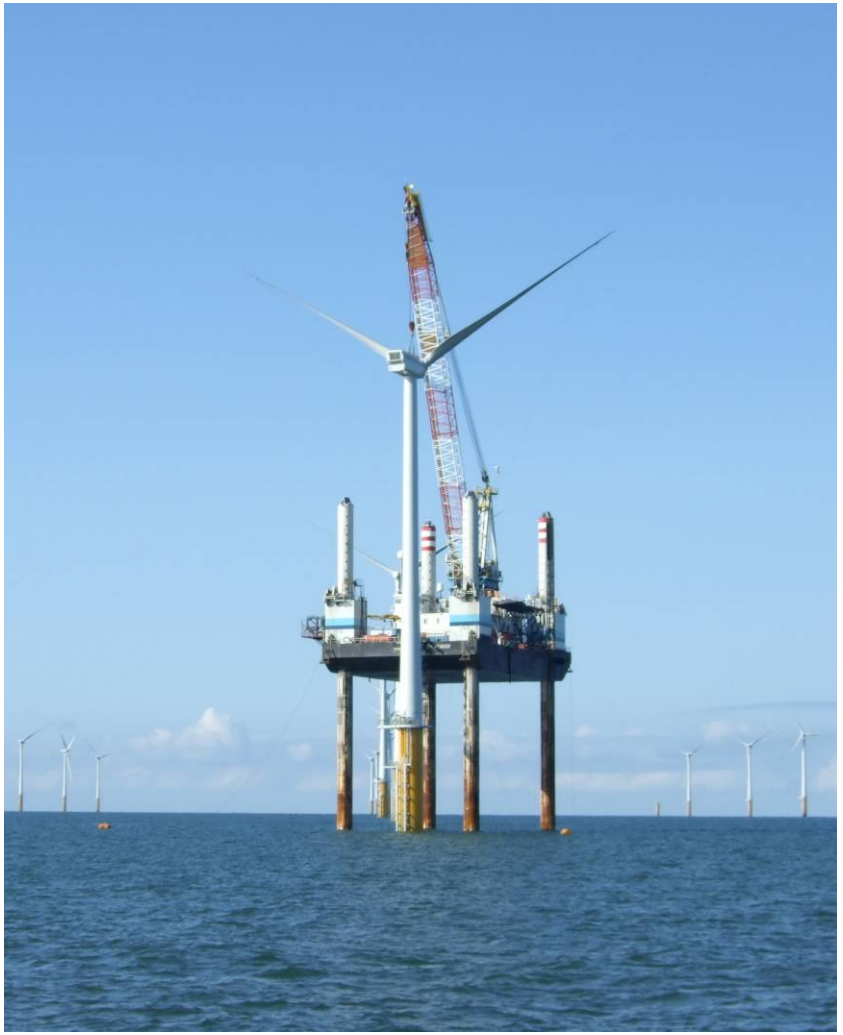


Diagram to demonstrate the proposed regime for offshore transmission

Construction Vessels

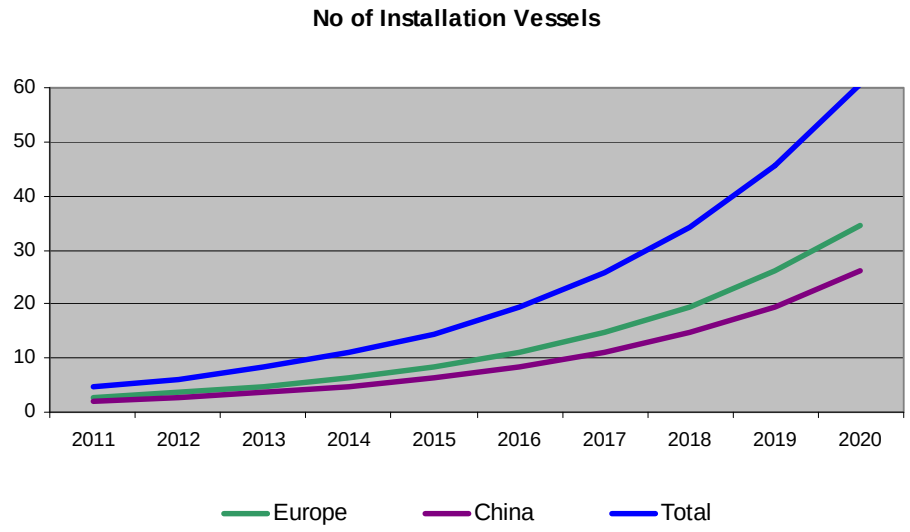
- **Issue**
  - **Vessels are scarce and expensive (e.g. +200 k$/day + mob/demob)**
  - **Capabilities (crane, deck space, propulsion) limited**
  - **Vessel reliability**

- **Mitigation**
  - **Developers building own vessels**
  - **Long-term contracts (but uncertainties about project schedules)**



Offshore Wind: Need for new installations vessels

- China have a target for 2020 of 30 GW offshore wind power capacity
- 40 GW of offshore wind capacity in the EU by 2020
- Assumption: Turbine size = 3 MW and 1 vessel installs 100 turbines per year



Conclusion:

20-25 vessels needed in Asia

30-35 vessels needed in Europe

+ vessels for foundation and maintenance & repair

- Lead time: 3 – 5 years

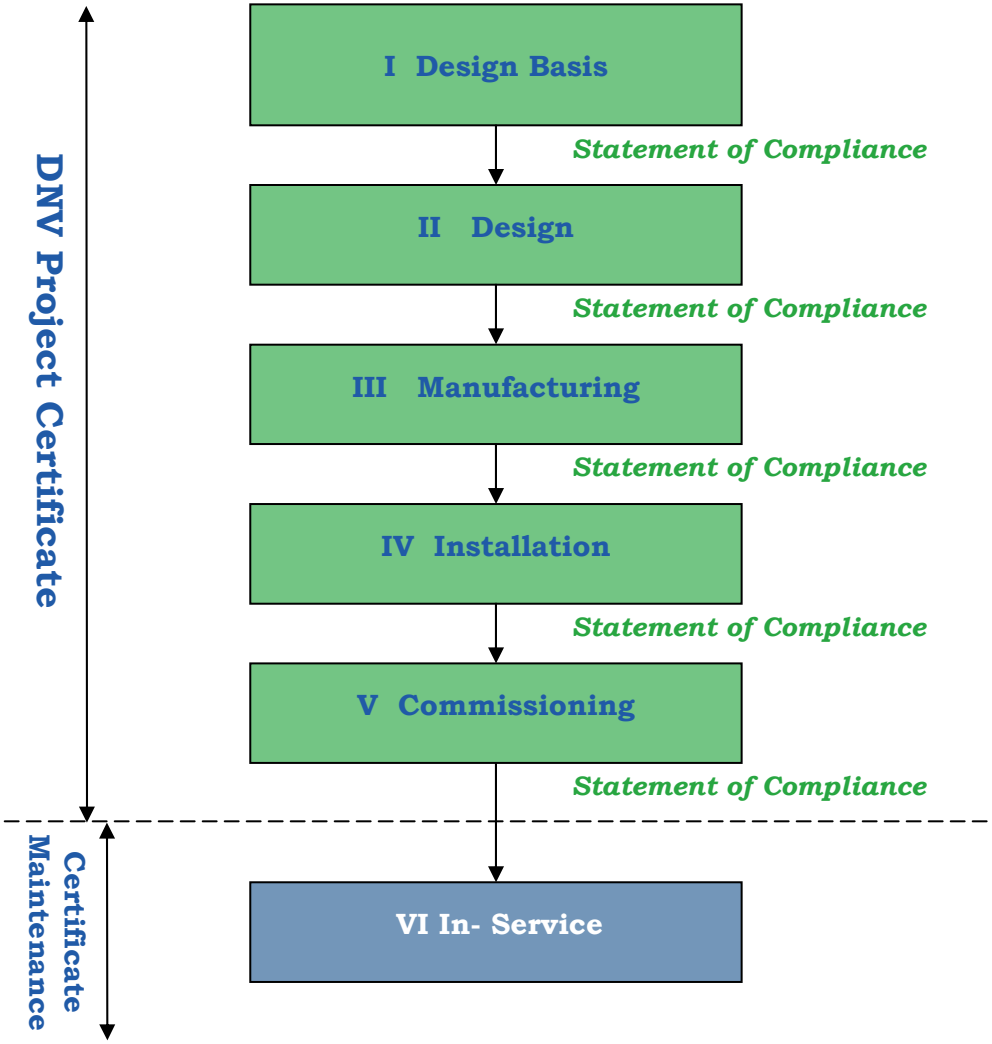
Project Certification

Project Certification

- **Third party conformity evaluation of**
  - **One or more wind turbines at a** specific location
  - **From design evaluation to monitoring of commissioning and operation**

- **Project Certificate covers**
  - **One or more** wind turbines**, including the** foundation's
  - **Evaluated for the specific external conditions** at an installation site
  - **No period of validity**

Project Certification – DNV-OS-J101



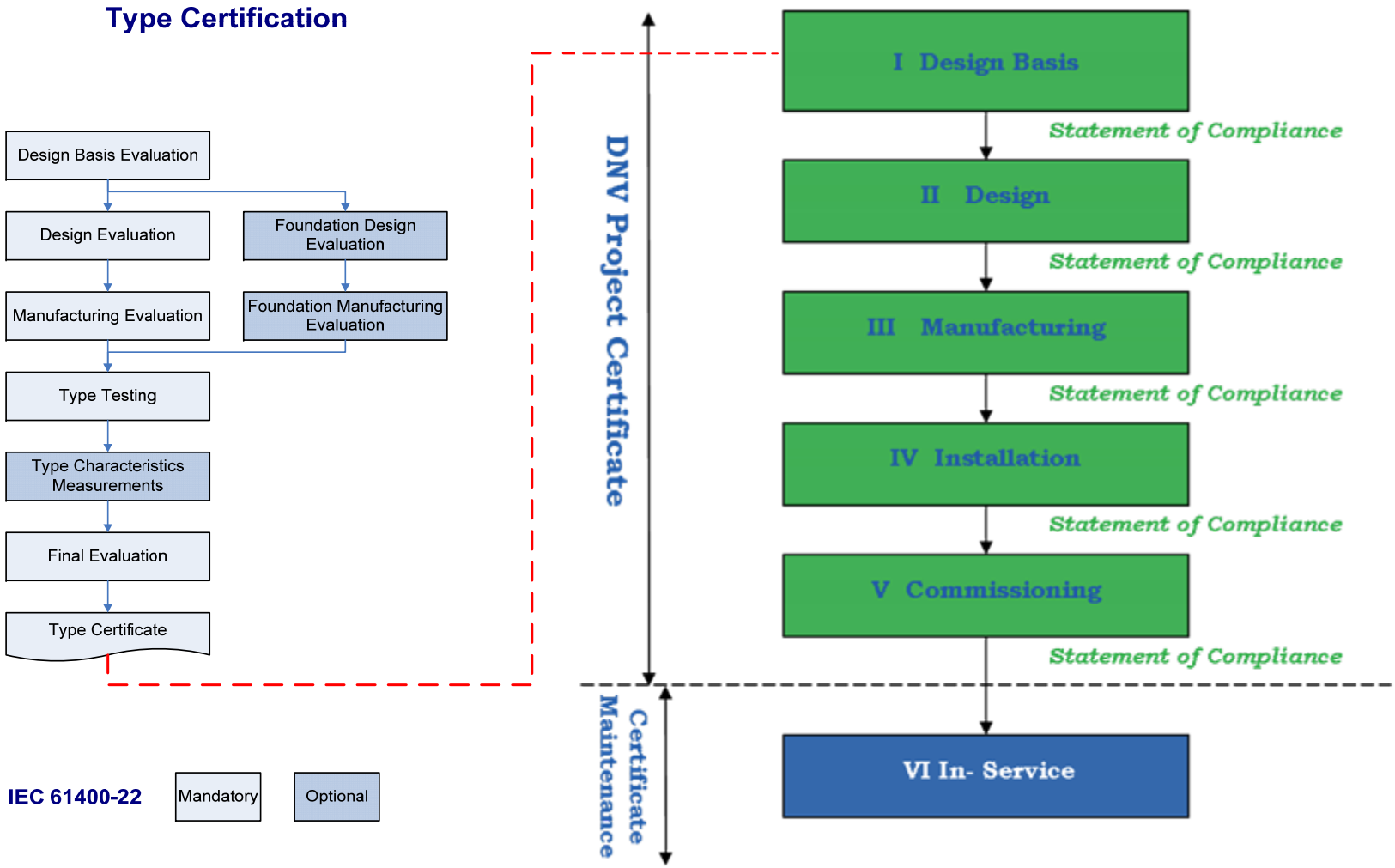
Project Certification phases:

- Phase I : **Verification of Design Basis**
- Phase II : **Verification of Design**
- Phase III : **Manufacturing Survey**
- Phase IV : **Installation Survey**
- Phase V : **Commissioning Survey**
- Phase VI : **In-Service**

Each phase will be completed with a Statement of Compliance

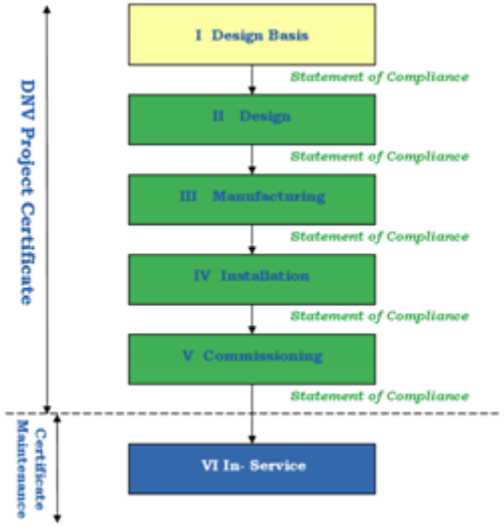
- **Phase I-V => *Project Certificate***
- **Phase VI => *Certificate Validation***

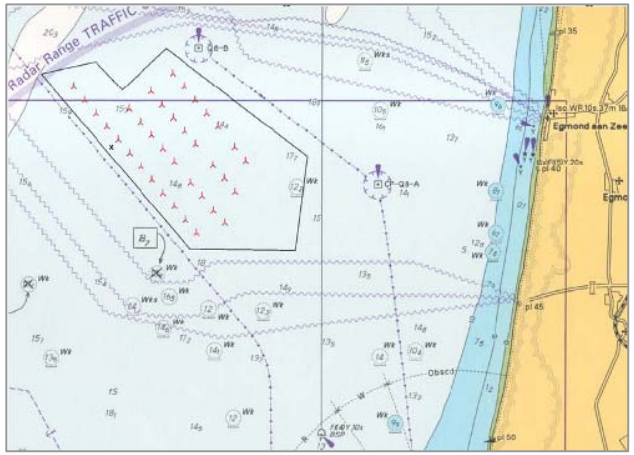
Type Certification & Project Certification



Verification of Design Basis

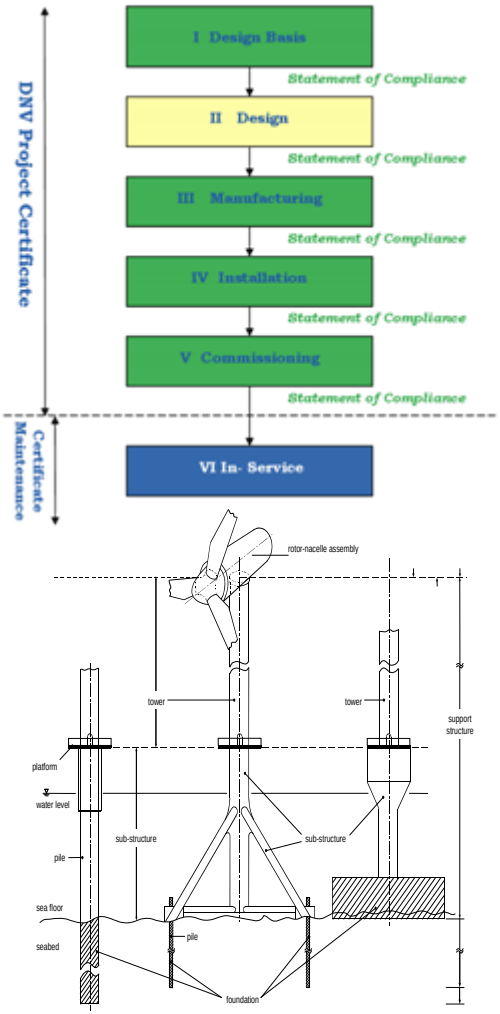
- **Site Conditions**
  - meteorological conditions
  - oceanographic conditions
  - geotechnical conditions
- **Codes, Standards and Requirements**
- **Design Methodology**
- **Wind Turbine Type Certificate**
- **Grid Connection**
- **Installation and Commissioning**
- **Operation and Maintenance**





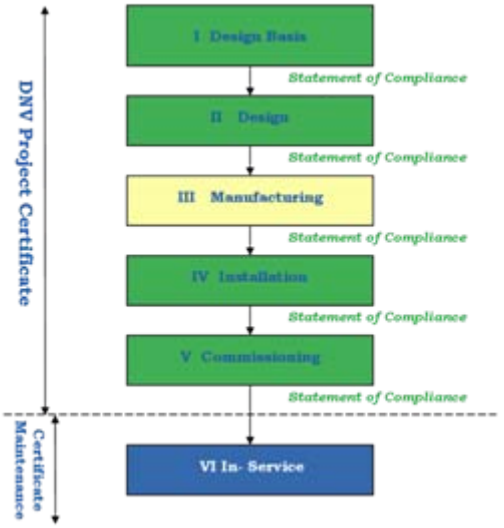
Verification of Design

- **Verification of Load and Response for the integrated structure**
  - **Rotor-nacelle**
  - **Sub-structure**
  - **foundation**
- **Verification of Wind Turbine**
- **Verification of Support Structure**
- **Verification of Substation, Cables and J-tubes**
- **Verification of Installation and Commissioning Procedures**
- **Verification of Operation and Maintenance**



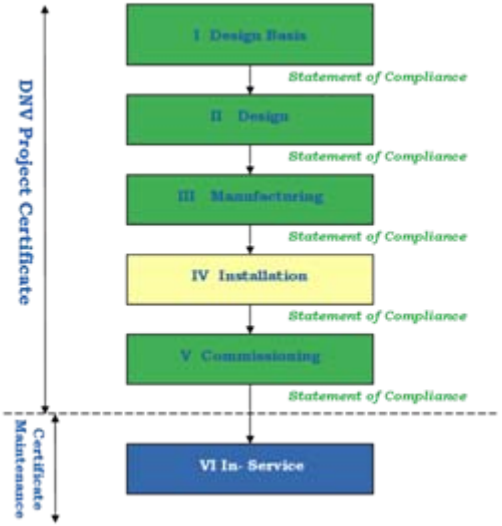
Manufacturing Survey

- **Manufacturing Survey of Wind Turbine**
- **Manufacturing Survey of Support Structure and Substation structure**
- **Manufacturing Survey of Electrical Components and Systems**



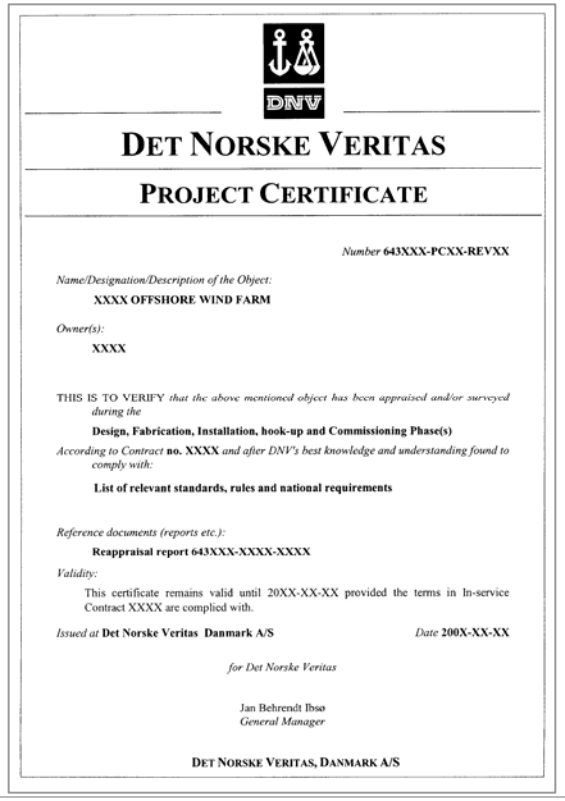
Installation Survey

- **Marine Verification**
  - Installation procedure
  - Installation survey
- **Warranty Survey**



Commissioning Survey

- **Review/approval of procedures**
- **System check**
- **Equipment Checks**



DET NORSKE VERITAS

PROJECT CERTIFICATE

Number **643XXX-PCXX-REVXX**

Name/Designation/Description of the Object:
XXXX OFFSHORE WIND FARM

Owner(s):
XXXX

THIS IS TO VERIFY *that the above mentioned object has been appraised and/or surveyed during the*
Design, Fabrication, Installation, hook-up and Commissioning Phase(s)
According to Contract **no. XXXX** *and after DNV's best knowledge and understanding found to comply with:*
List of relevant standards, rules and national requirements

Reference documents (reports etc.):
Reappraisal report 643XXX-XXXX-XXXX

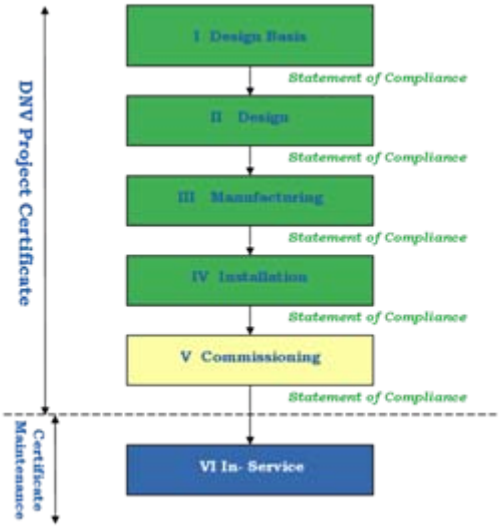
Validity:
This certificate remains valid until 20XX-XX-XX provided the terms in In-service Contract XXXX are complied with.

Issued at **Det Norske Veritas Danmark A/S** *Date* **200X-XX-XX**

for Det Norske Veritas

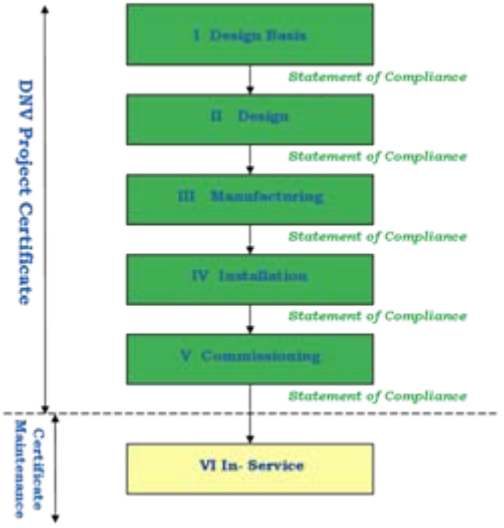
Jan Behrendt Ibsø
General Manager

DET NORSKE VERITAS, DANMARK A/S



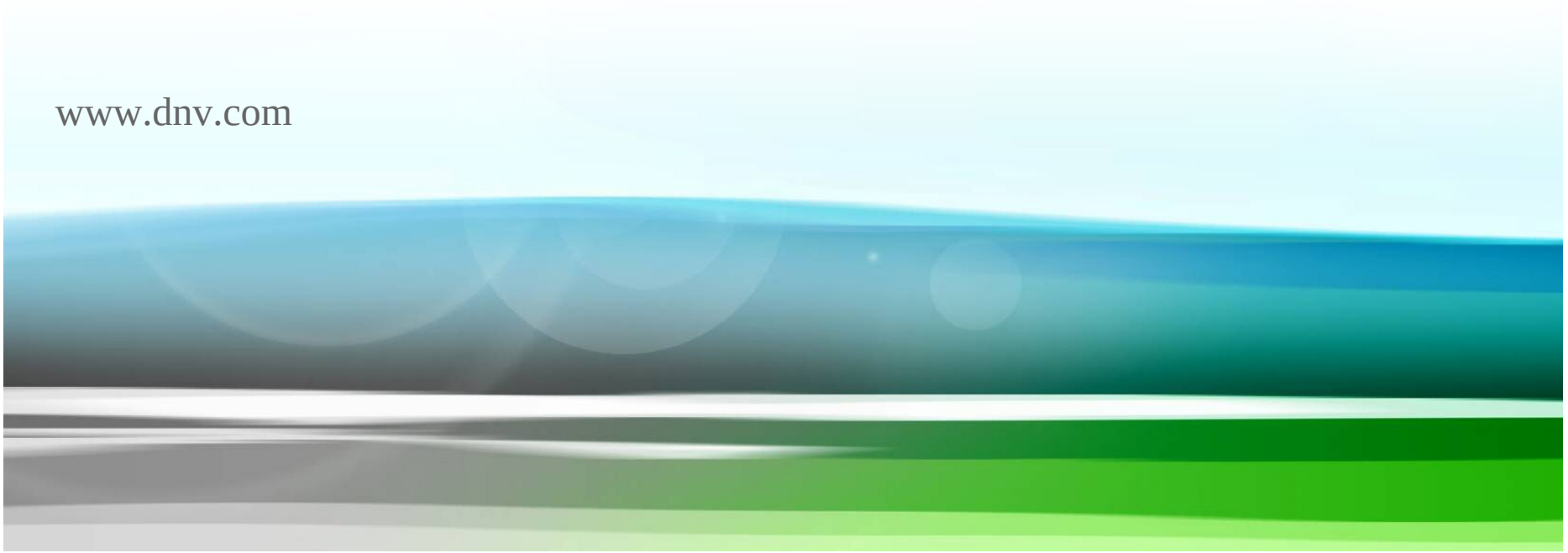
In-service

- **Annual Survey Onshore Part**
  - **Review of Maintenance, Repair Program**
  - **Inspection Program**
- **Annual Survey Offshore Part**
  - **All main components in Wind Turbines**
  - **Structures and Cables below water**
  - **Substation Topside all main components/systems**



Safeguarding life, property and the environment

www.dnv.com



MANAGING RISK