Technical aspects of Offshore Wind Farms

Consultations of the Guide to OWF

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15.09.2011

MANAGING RISK DNV

DNV - Independent foundation since 1864

300 offices

100 countries

9,000 employees, out of which 76% have academic degree

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Offshore Wind Energy - compilation of DNV competencies

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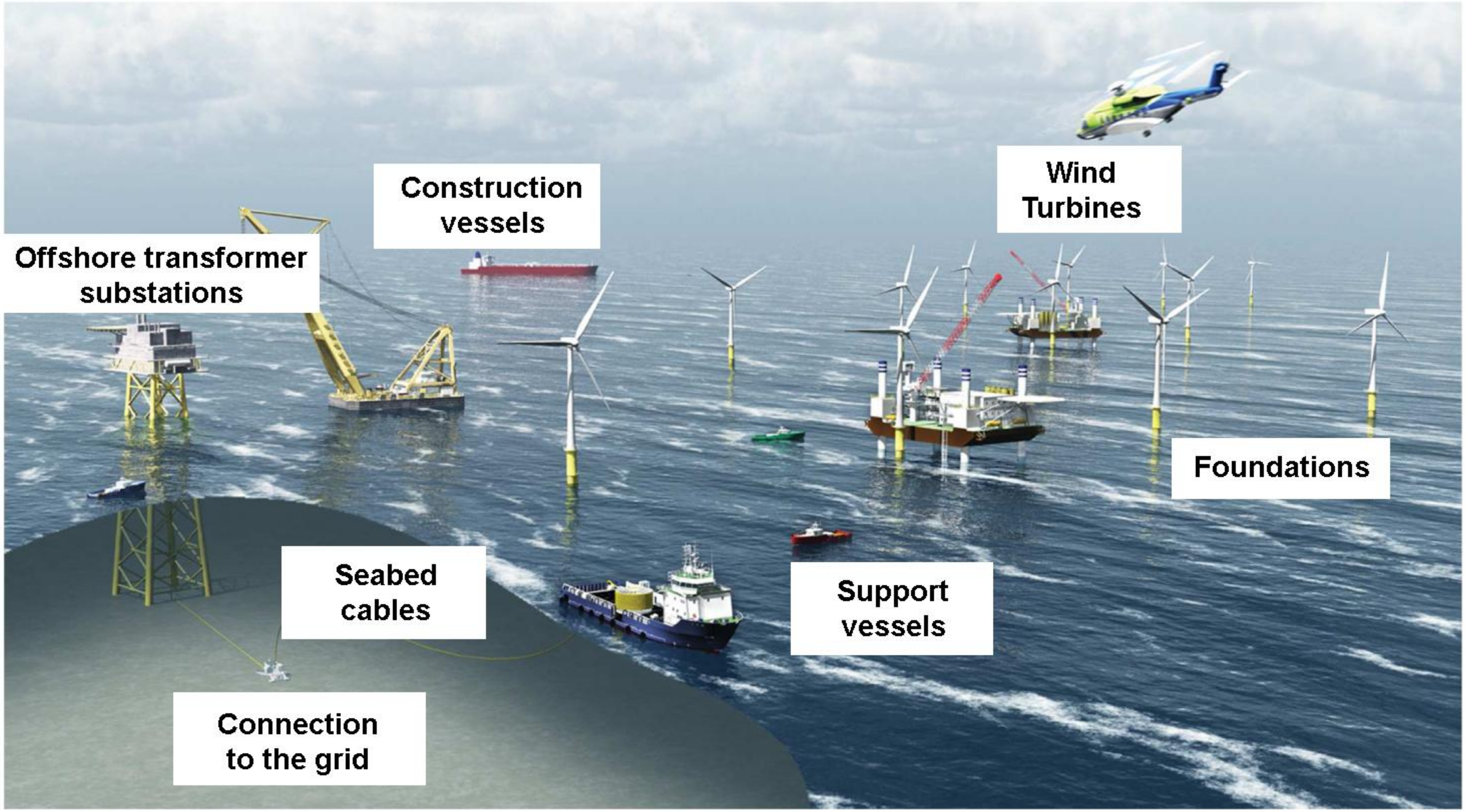
25 years of hands-on experience with wind turbines

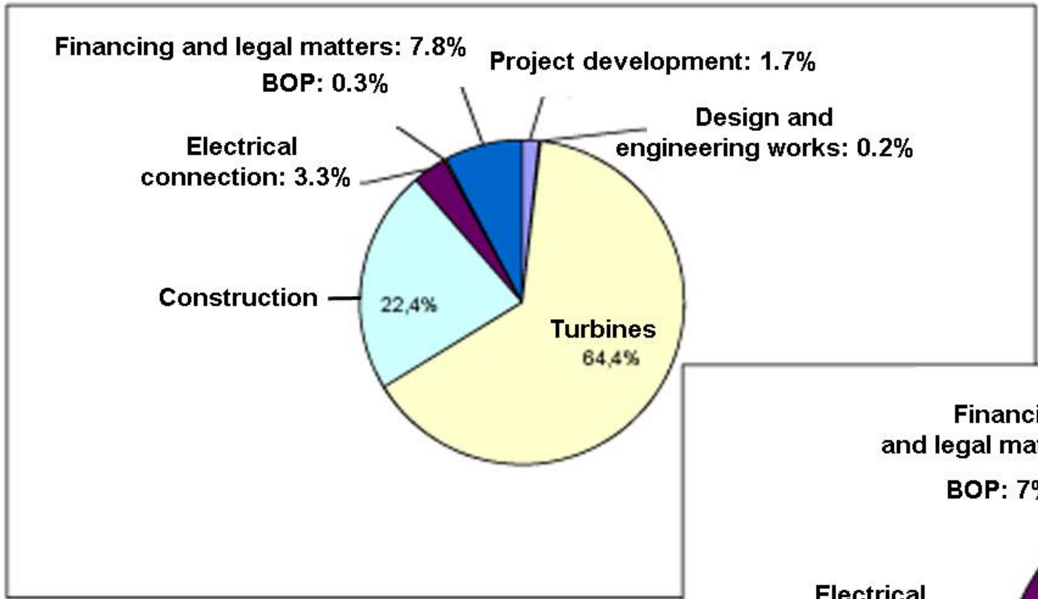
40+ years of offshore oil & gas experience

Global leader in the project risk management and in offshore wind farm certification

Main technical elements of offshore wind farms

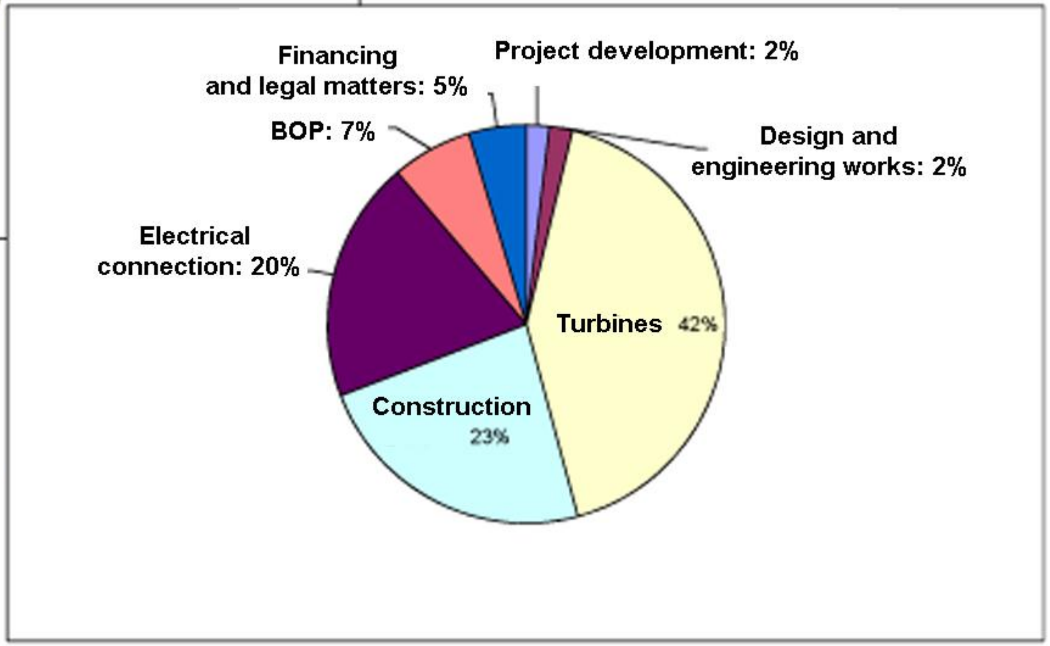


Distribution of costs of offshore and onshore wind farms



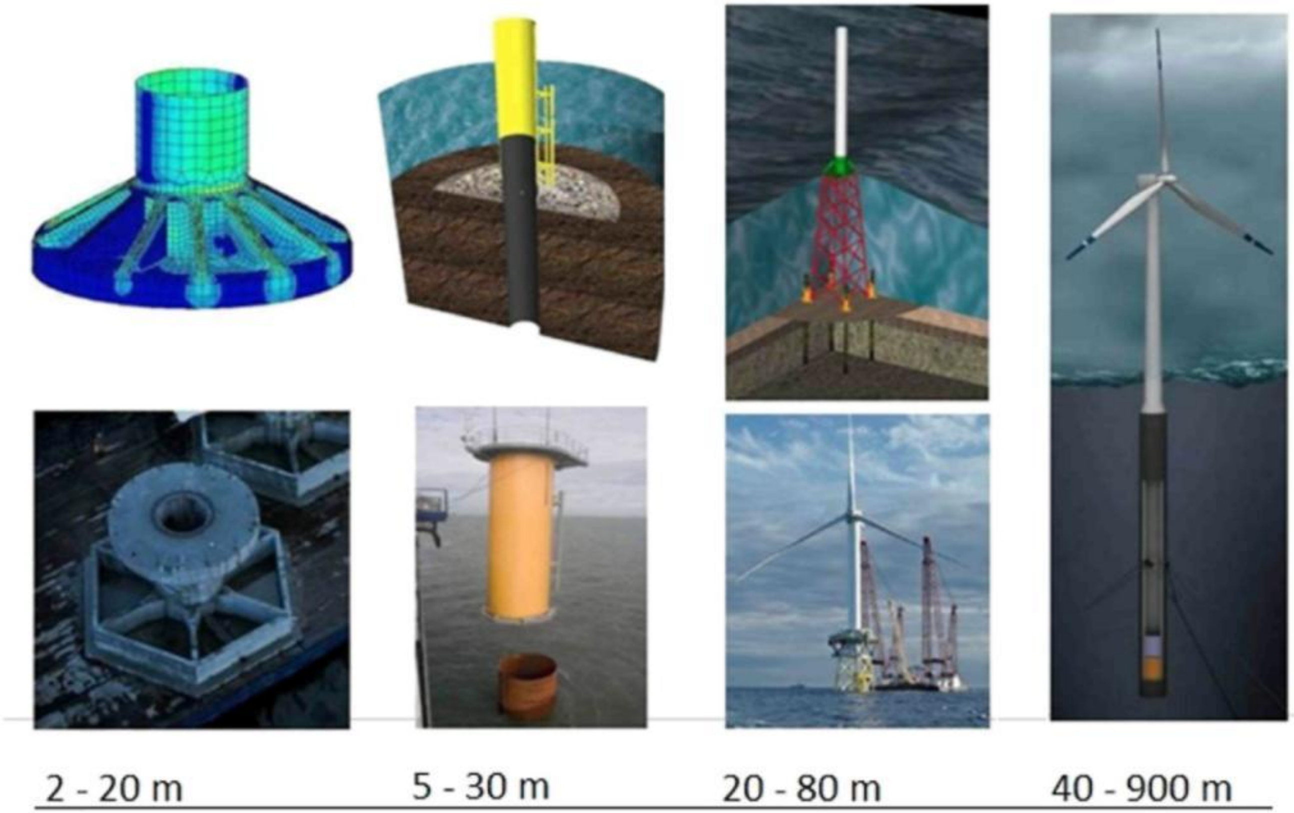
Onshore wind farms

Offshore wind farms



Basic types of foundations for offshore wind farms

- Gravity base
- Monopile
- Jacket
- Floating



Offshore wind turbines

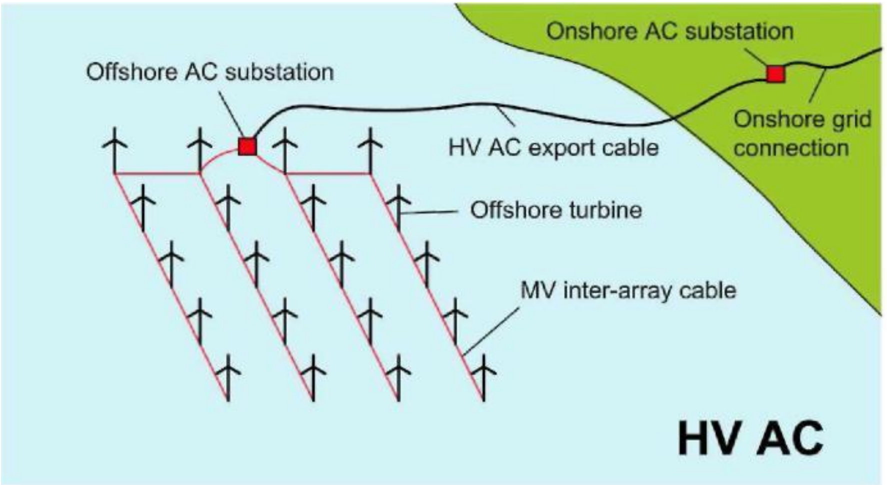
Range of nominal power

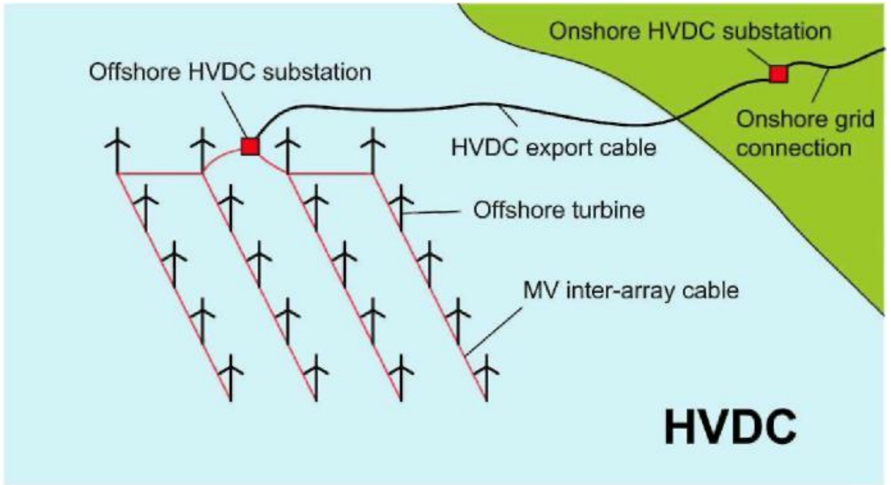
- 3.0 MW 3.0 – 6.0 MW
- 5.0 MW 5.0 – 20.0 MW (forecasted)

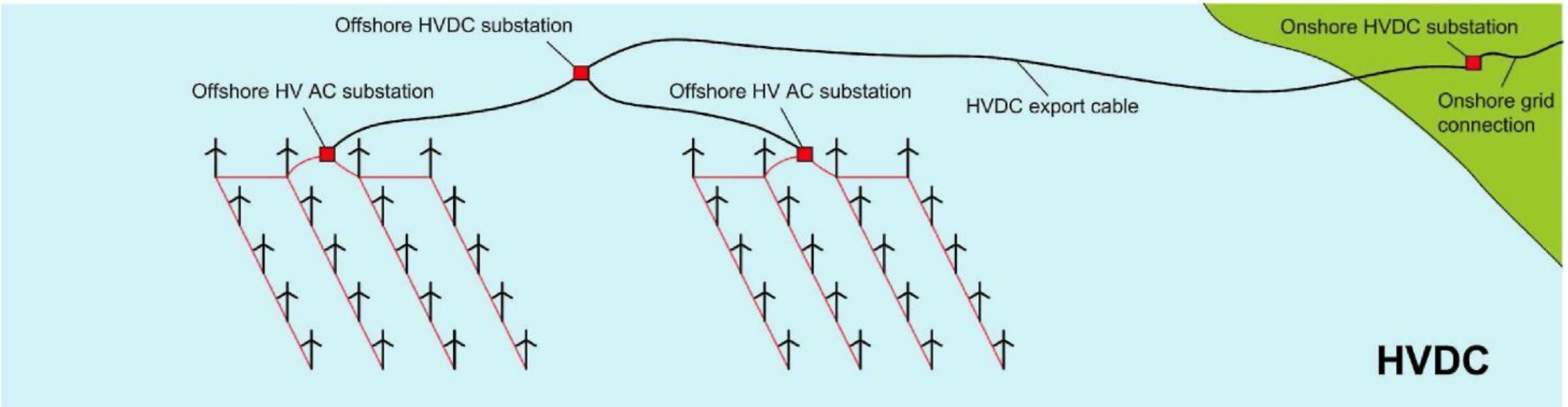
Examples of the largest available wind turbines:

6M REpower- 6,15 MW used in the projects: Thornton Bank phase II, Belgium 148 MW
5M REpower- 5,075 MW used in the project: Ormonde 150 MW
Vestas V90 - 3MW, in the project: Thanet, UK 300 MW
BARD 5.0 in the project: Hooksiel, Germany
Siemens SWT-3.6-107 in the project: Gunfleet Sands, UK 173 MW

Offshore wind farm grid connection







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Examples of transformer substations

Project	Horns Rev I (DK)	Nysted I (DK)	Barrow (UK)	Lillgrund (S)
				
Wind farm size	80 x 2 = 160 MW	72 x 2.3 = 165.6 MW	30 x 3 = 90 MW	48 x 2.3 = 110 MW
Commissioning	Dec 2002	Jul 2003	Jun 2006	Jun 2008
Water depth	6 ... 14 m	6 ... 10 m	15 ... 20 m	4 ... 8 m
Distance to shore	14 ... 20 km	10 km	7.5 km	7 km
Foundation	3 piles	gravity	monopile	gravity
Voltages	33 / 150 kV	33 / 132 kV	33 / 132 kV	33 / 138 kV

Examples of projects certified by DNV

Barrow (UK) – 90MW

Bligh Bank (Belgium) – 330MW

Borkum West II (Germany) – 400MW

Burbo Banks (UK) – 90MW

Egmond aan Zee (Netherlands) – 108MW

Greater Gabbard (UK) – 500MW

Gunfleet Sands (UK) – 172MW

Horns Rev I & II (Denmark) – 160MW and 209MW

Jeju (South Korea) – 21MW

Kentish Flats (UK) – 90M

Lillgrund (Sweden) – 110MW

Lynn and Inner Dowsing (UK) – 90MW

Typical OWF project Schedule

2011: Start of wind measurements
2012: Preliminary location specification
2013: Selection of turbines and their distribution design
2014: OWF Technical design certification
2015: Stage 1 construction preparation
2016: Stage 1 construction
2017: Stage 2 construction, Reassessment of Stages 3 and 4
2018: Stage 3 construction
2019: Stage 4 construction

London Array Phase I project Schedule

2001: Initial environmental analyses
2005: Start of wind measurements - mast installation
2005 – 2007: Planning
2008: Conclusion of contracts with suppliers
2009: Construction permit
2010: Onshore transformer substation construction
2011: Initiation of the construction phase of the offshore parts of the project
2011: December - planned power generation test
2012: Construction completion

Gunfleet Sands project Schedule

2002: Preliminary location assessment
2004: Permit to execute Stage 1
2006: Permit to execute Stage 2
2008: Onshore project infrastructure construction
2008: Initiation of the construction of both Stages
2008: Offshore transformer substation construction
2009: Measuring mast on the transformer
2010: Commissioning of the offshore wind farm

Examples of productivity data and power distribution per km^2

Gunfleet Sands 173 MW / 17.5 km^2 = 9.9 MW / km^2,

Turbines: SWT – 3-6 productivity 37.6%, 2009

Robin Rigg 180MW / 18 km^2 = 10 MW / km^2,

Turbines: Vestas V90 productivity 35%, 2009

Lynn, 97 MW / 10 km^2 = 9.7 MW / km^2,

Turbines: SWT – 3-6 productivity 39%, 2009

Thanet, 300 MW / 35 km^2 = 8.6 MW / km^2,

Turbines: Vestas V90 productivity 36.5%, 2010

Summary:

- Typical productivity: 37%
- Power distribution: 9.5MW/ km^2
- Turbine power: 3.0MW -6.0MW

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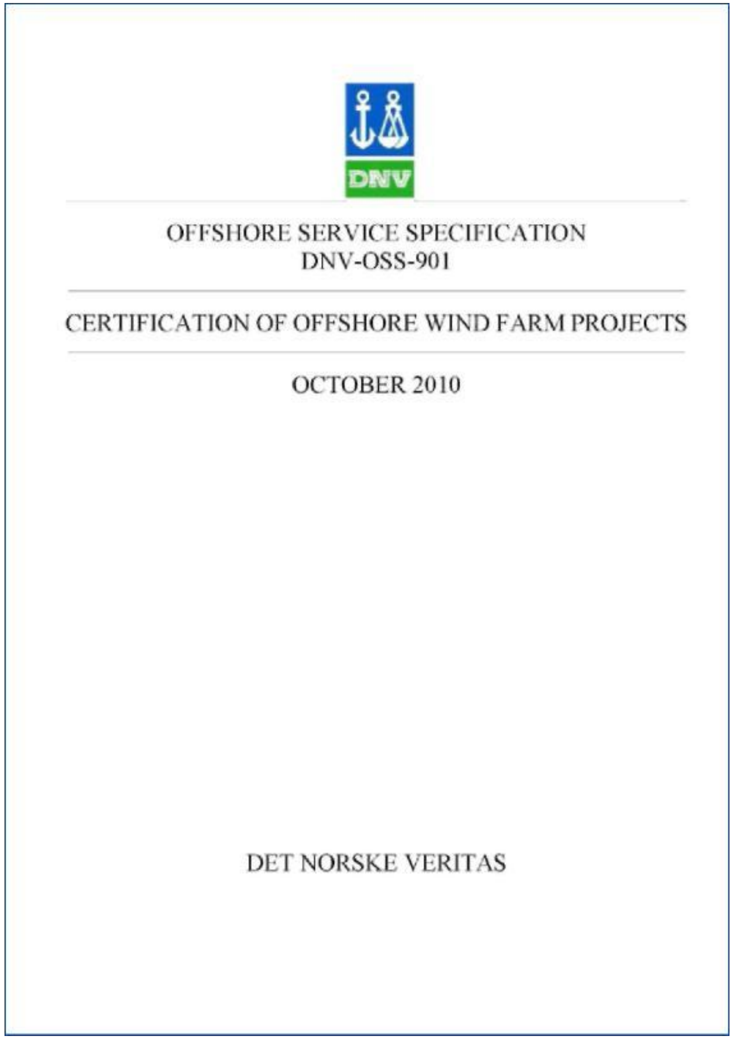
DNV „Offshore” - requirements and recommended practices

- **OFFSHORE SERVICE SPECIFICATIONS**
  Provide principles and procedures of DNV classifications, certification and consultancy services
- **OFFSHORE STANDARDS**
  Provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore service
- **RECOMMENDED PRACTICES**
  Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards

DNV-OSS-901

- Certification of Offshore Wind Farm Projects
- Presents the principles and procedures for DNV services with respect to certification of Offshore Wind Farm Projects.
- Introduces a levelled description of certification involvement during all phases of an offshore wind farm’s life; from assessment of site conditions to in-service.
- Assists in planning the certification by defining the tasks for a verification plan allowing a transparent and predictable certification scope of work as well as defining terminology for certification and verification involvement.

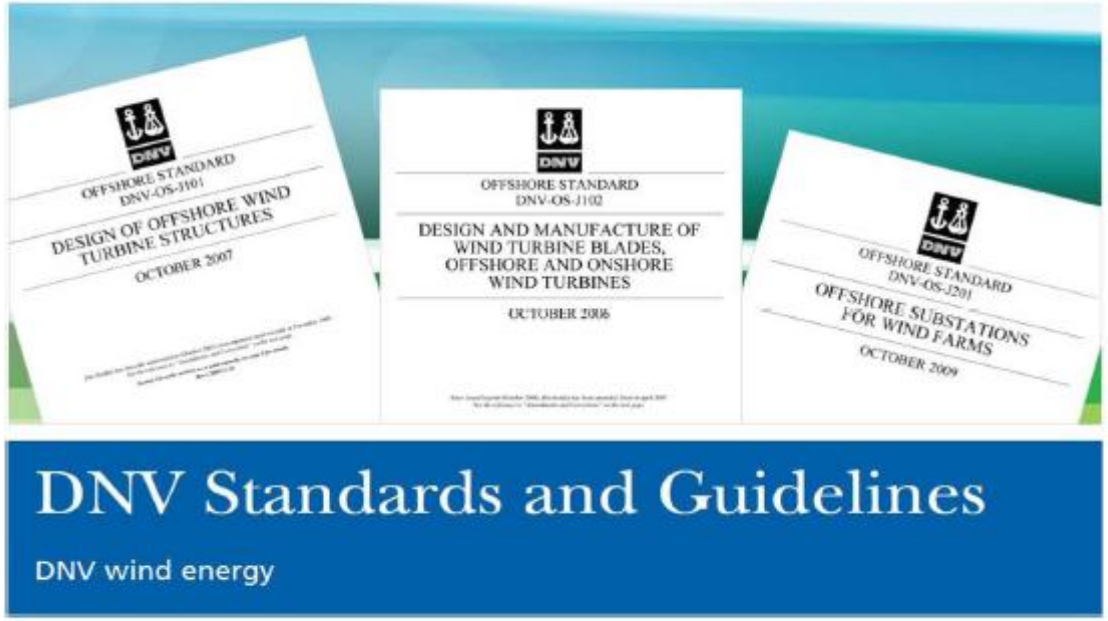

OFFSHORE SERVICE SPECIFICATION
DNV-OSS-901

CERTIFICATION OF OFFSHORE WIND FARM PROJECTS

OCTOBER 2010

DET NORSKE VERITAS

DNV standards



- DNV Standard DNV-OS-J101: Design of Offshore Wind Turbine Structures
- DNV Standard - DNV-OS-J102: Design and Manufacture of Wind Turbine Blades
- DNV Standard - DNV-OS-J201: Design of Offshore Substations

Safeguarding life, property and the environment

www.dnv.pl

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