Workshop
Offshore-Windenergienutzung
Technik, Naturschutz, Planung

STATE OF THE ART OFFSHORE WIND TECHNOLOGY

Per Grud, Vestas Wind Systems A/S, Denmark

Deutsches Windenergie-Institut GmbH
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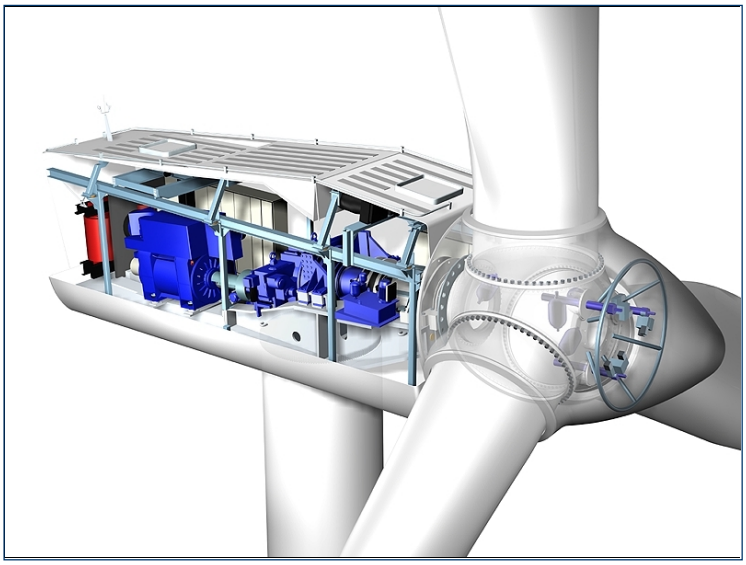
Presentation

- Vestas Offshore Wind Turbine Generator
  - V80 -2.0 MW Optispeed™
- Moving Wind Turbine Generators Off-shore
  - **E**nvironmental **I**mpact **A**ssessment Framework
  - Foundation
  - Installation
  - O&M
- Conclusion

Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (i)



Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (ii)

- The turbine is the latest and largest serial produced turbine from Vestas Wind Systems A/S in Denmark, and is based on the experience gained from the well known V66–1.65 MW wind turbine
- The turbine is specially adapted for offshore sites, and varies from a standard V80 turbine mainly by a higher degree of corrosion protection, heating/dehumidification of the nacelle and a higher rpm

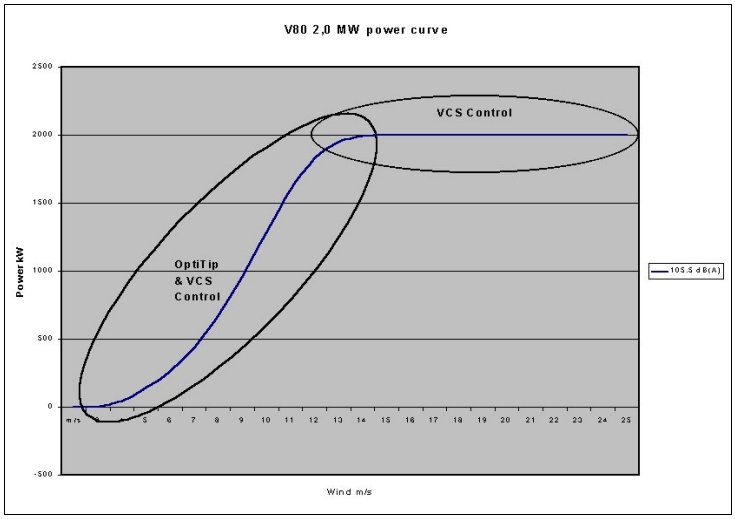
Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (iii)

- OptiSpeed™ versus OptiSlip®
  - Natural evolution/upgrade of OptiSlip® with controllable slip
  - The turbine is also equipped with the well known Vestas OptiTip« system which makes the turbine choose the optimum blade angle at any given wind speed

Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (iv)



Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (iv)

- Rotor
  - 3 bladed - upwind
  - RPM: static 18.1 rpm/min. variable from 9 – 20.7 rpm
  - Blade length: 39 m
  - The blades are made out of fiber glass reinforced epoxy, and consists of two blade shells, bonded to a supporting beam, all made by means of methods and tools developed by Vestas, using the pre-preg fiber glass material
  - The blades are bolted to the hub via a steel insert in the root end of the beam and a 4-point ball bearing

Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (v)

- Blade Control
  - A separate hydraulic pitch cylinder for each blade
  - Emergency and controlled braking is done by feathering the blades, giving a very smooth, safe and controlled stop of the turbine
  - For parking the turbine a mechanical hydraulic brake, located on the high speed shaft of the gearbox, is applied
- Main Bearings
  - 2 spherical roller bearings in separate housings

Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (vi)

- Gearbox
  - The gearbox is freely floating on the end of the main shaft. It has one planetary and two helical stages. It is equipped with oil filter, oil heater and oil cooler
- Generator
  - 4-poled, asynchronous 2000 kW, 690 V, 50 or 60 Hz, wound rotor. Power Factor: 0.98 cap. to 0,96 ind.
- Controller
  - 3x690V, modular built, microprocessor based with possibility for remote monitoring. Located in the nacelle

Vestas Offshore Wind Turbine Generator

V80 -2.0 MW Optispeed™ (vii)

- Transformer
  - Dry-type, cast resin. High voltage: 6 – 36 kV. Located in the nacelle
- Tower
  - Conical tubular. Material: rolled steel plate. Bottom diameter: 4 meter. Hub heights: 60, 67 and 78 meters

Upcoming Danish Offshore Projects

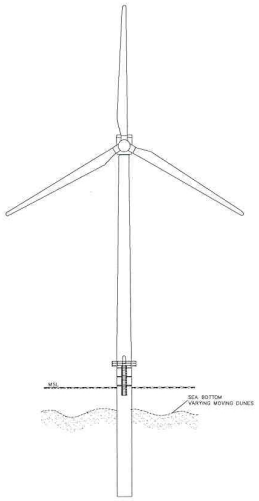
Locations

- Energy Plan 21
  - Passed by Danish Parliament in 1996
  - 4000 MW wind power installed offshore before 2030
- Action Plan
  - Mapping/siting offshore windfarms
  - 5 offshore wind farms @ 150 MW to be installed before 2008

Environmental Impact Assessment
Projected Measures to Limit Environmental Impact (...Abstracts...)

- Turbine
  - Navigation / aviation lights
  - Retaining systems for copper dust, used oil, etc.
  - Decommissioning and removal of the plant
- During Construction and Operation
  - Protection of wreckage and national heritage
  - Collecting of waste
  - Appropriate means of transport to/from the wind farm

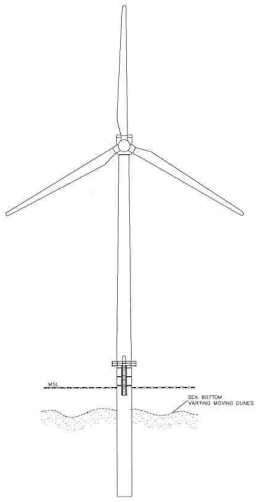
Foundation
Monopile



LIC Engineering A/S

- Advantages
  - No seabed preparation
  - Relatively simple to manufacture
  - Insensitive to scour
- Disadvantages
  - Requires specialised installation equipment
  - Sensitive to large boulders when driven w./ pile hammer
  - Flexible at greater water depths

Foundation
Monopile



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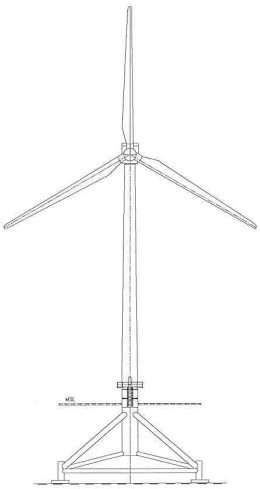
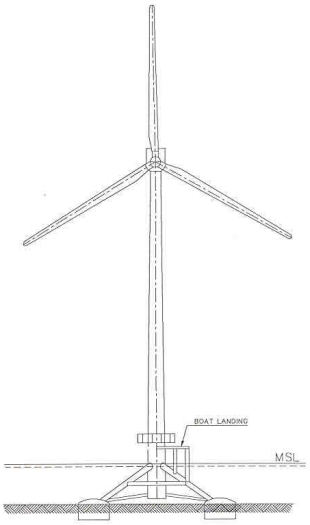
Foundation
Tripod / Jacket Structure



LIC Engineering A/S

- Advantages
  - Applicable to greater water depths
  - No or limited seabed preparations
- Disadvantages
  - Not applicable in shallow waters
  - Braces
    - Increases ice load
    - Makes boat access difficult

Foundation
Suction Pile Jacket



LIC Engineering A/S

- Advantages
  - Float out complete turbine(?)
  - Modify to use only one suction pile below main column (?)
  - Reduce need for heavy installation equipment
- Disadvantages
  - Limited experience
    - Design
    - Installation
  - Cost

Installation
Considerations

- Installation Season
  - North Sea
    - April through August/September
  - Protected Danish Waters
    - April through September/October

Installation

Methods (i)

Loose Item, Tunø Knob 1995

Installation

Methods (ii)

Single Lift, SMIT Proposal

SMIT MARITIME CONTRACTORS

Operation & Maintenance

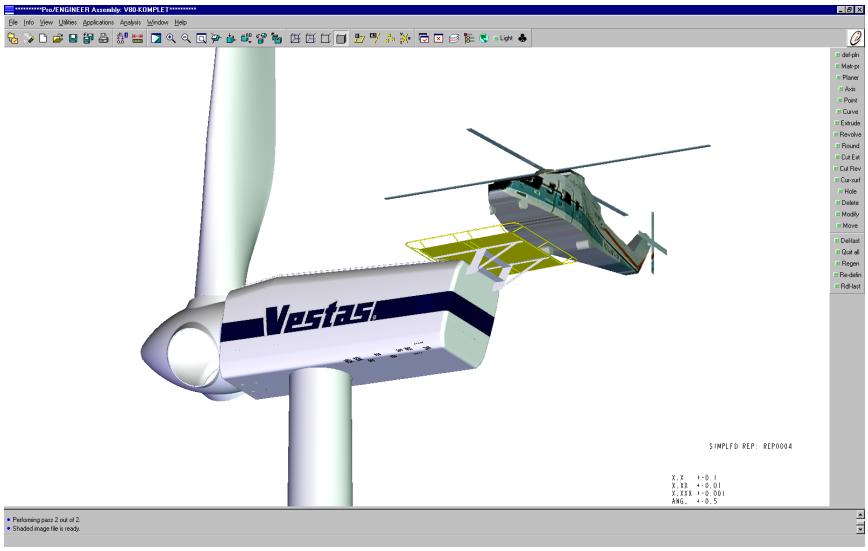
- Goal
  - One annual scheduled service per installed offshore wind turbine
- Means of Transport
  - Boat(s)
    - Zodiac (MOB boat) - mobilisation of service crew from “mother ship or central platform
    - Heavier vessel for transit transport of heavy service gear
  - Helicopter
    - Hoist of personnel and light service gear

Operation & Maintenance
Boat Access

ESVAGT

Operation & **Maintenance**

Helicopter Access



Conclusion

- Some Main Issues to Address by Moving Wind Turbine Generators Off-shore
  - Corrosion Protection, e.g. ISO 12944-1/8
  - Remote Monitoring and Control
    - Preventive Maintenance
  - Safe Access to Structures