Baltic InteGrid
Integrated Baltic Offshore Wind Electricity Grid Development

Today and future technology for offshore wind and grid development

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29 November 2017
BIG TWG Seminar 'Market & Technology'

DTU

EU STRATEGY FOR THE BALTIC SEA REGION FLAGSHIP

Interreg Baltic Sea Region

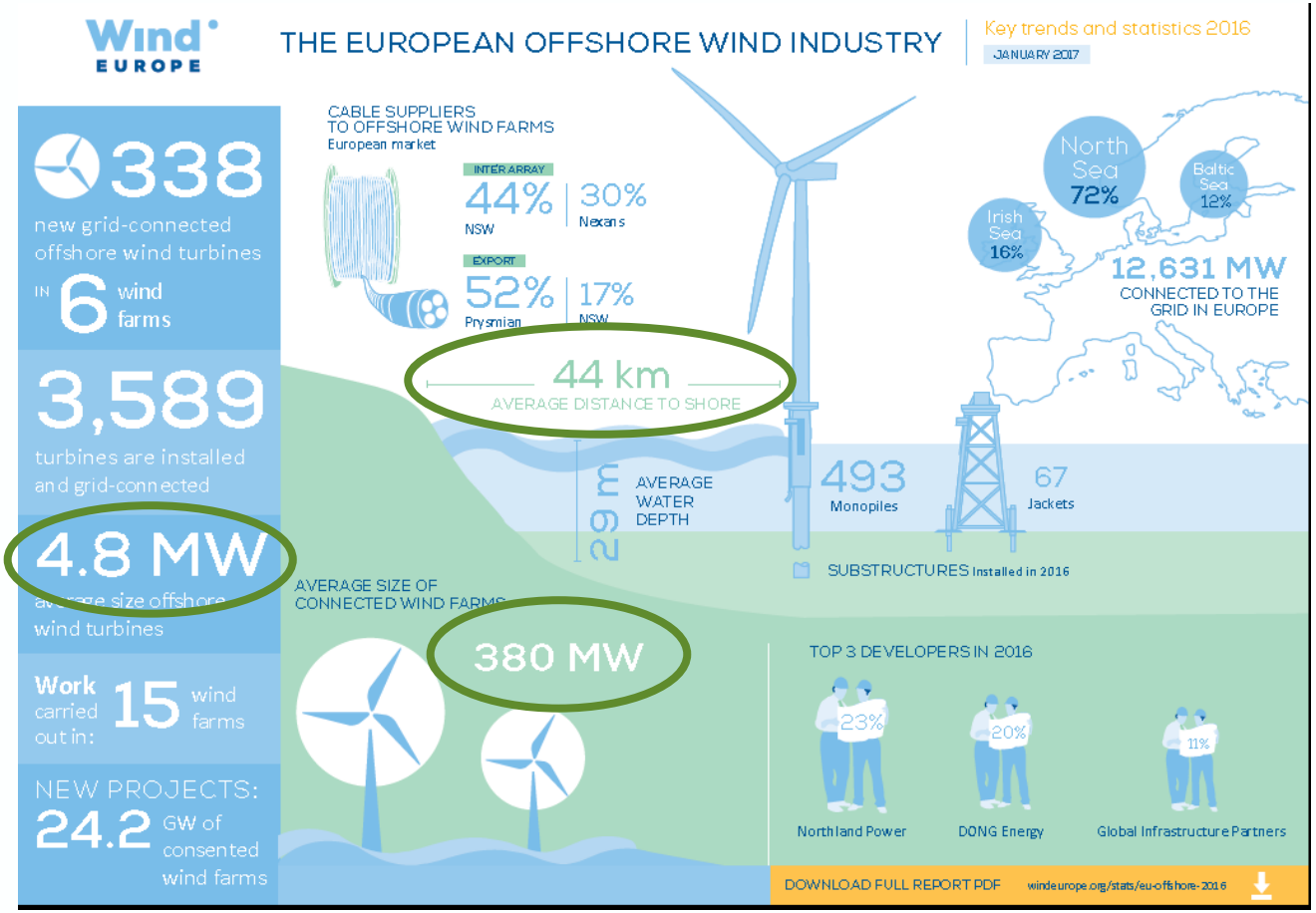
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Agenda

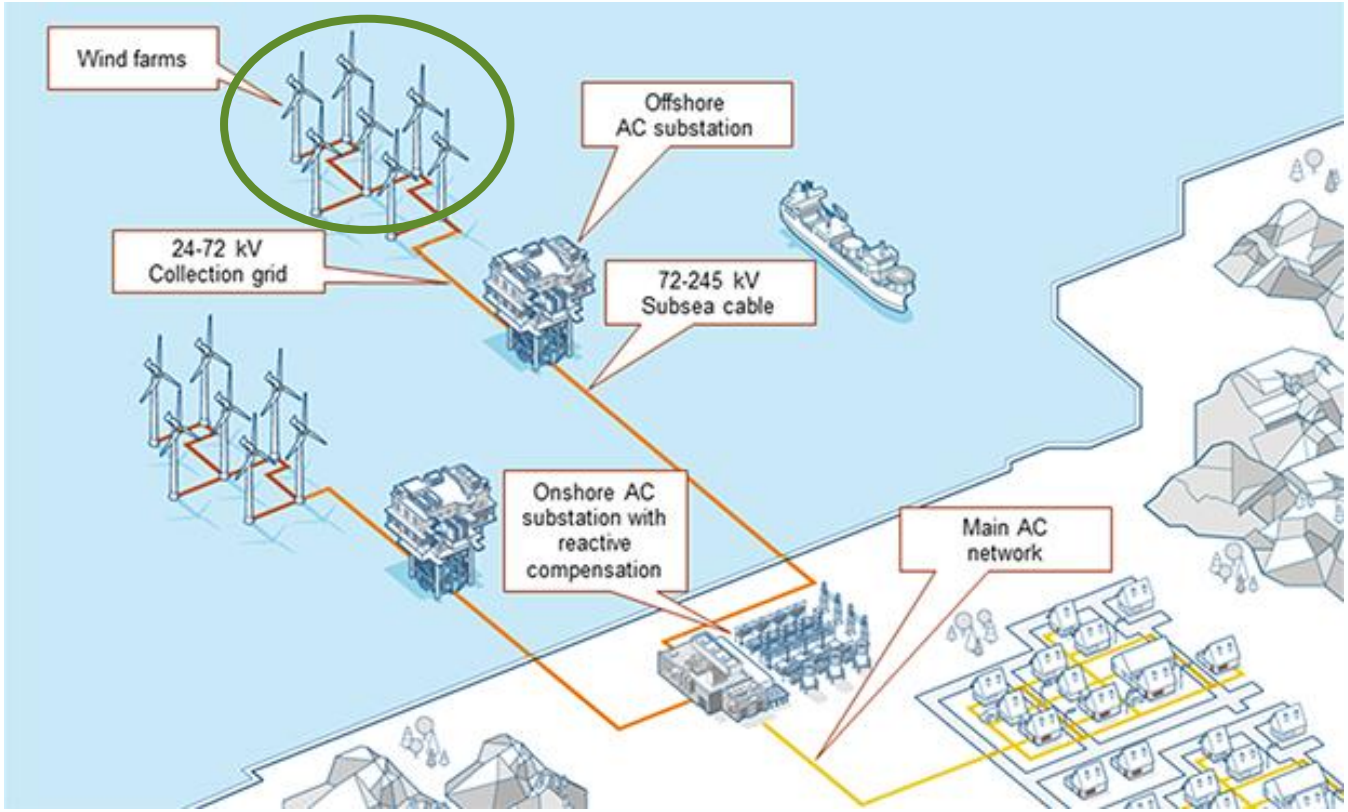
1 Background

2 Technology trends
   1 Offshore wind turbine size
   2 Inter-array voltage level
   3 Offshore substations
   4 HVDC technology
   5 Overplanting

3 Concluding remarks

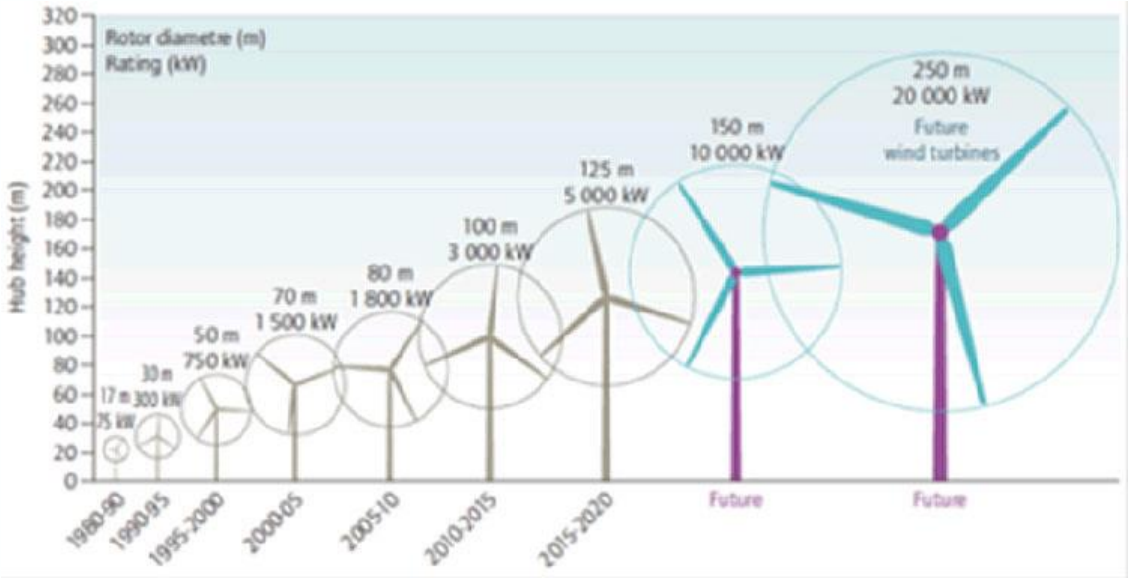

Wind EUROPE
THE EUROPEAN OFFSHORE WIND INDUSTRY
Key trends and statistics 2016
JANUARY 2017
338
new grid-connected offshore wind turbines
IN 6 wind farms
3,589
turbines are installed and grid-connected
4.8 MW
wind turbines
Work carried out in: 15 wind farms
NEW PROJECTS: 24.2 GW of consented wind farms
CABLE SUPPLIERS TO OFFSHORE WIND FARMS
European market
INTER ARRAY
44% NSW
30% Nexans
EXPORT
52% Prysmian
17% NSW
44 km
AVERAGE DISTANCE TO SHORE
29 m
AVERAGE WATER DEPTH
493 Monopiles
67 Jackets
SUBSTRUCTURES Installed in 2016
AVERAGE SIZE OF CONNECTED WIND FARMS
380 MW
North Sea 72%
Baltic Sea 12%
Irish Sea 16%
12,631 MW
CONNECTED TO THE GRID IN EUROPE
TOP 3 DEVELOPERS IN 2016
23%
Northland Power
20%
DONG Energy
11%
Global Infrastructure Partners
DOWNLOAD FULL REPORT PDF
windeurope.org/stats/eu-offshore-2016

AC connected offshore wind power plants



Source: **ABB**

Growth in size of wind turbines



Source: **EWEA**

WINDPOWER OFFSHORE

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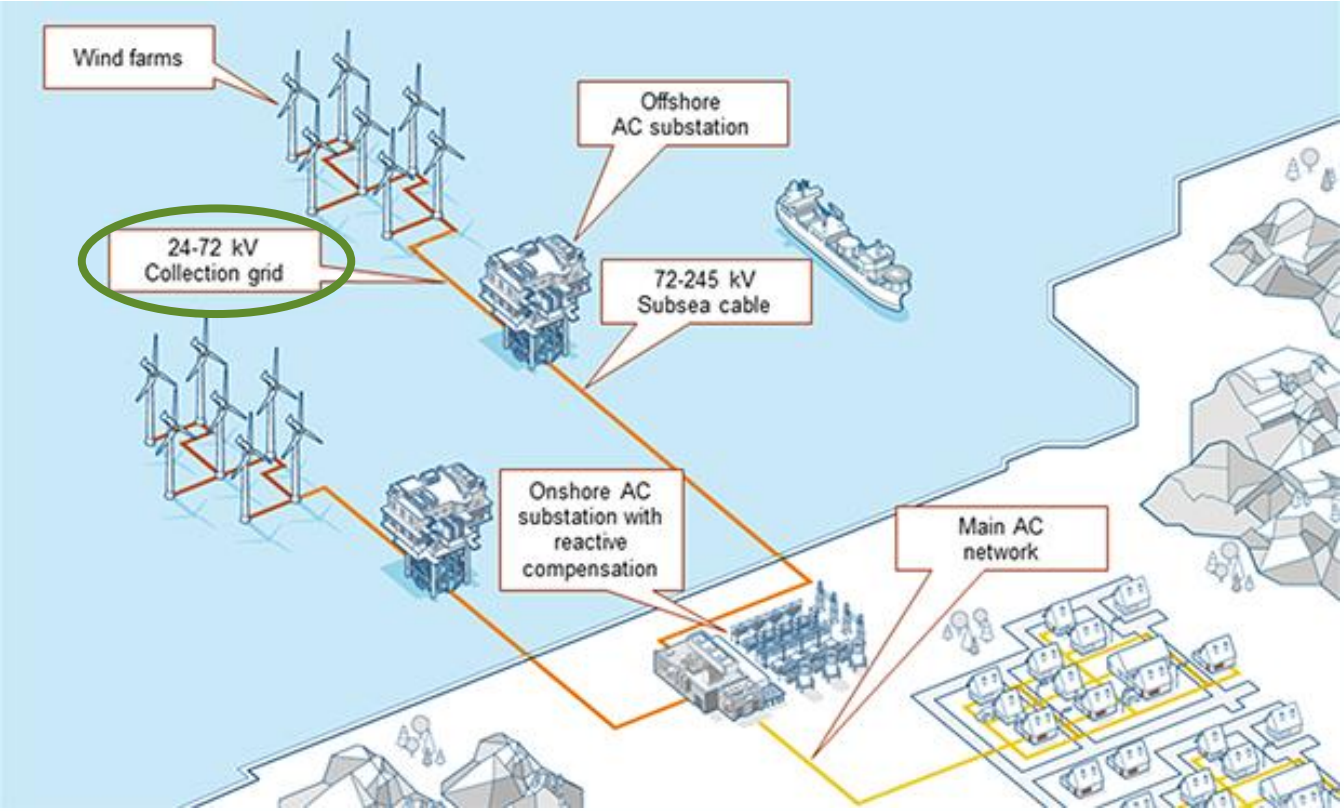
UNITED KINGDOM

Triton Knoll selects MHI Vestas 9.5MW

18 September 2017 by David Weston, Be the first to comment

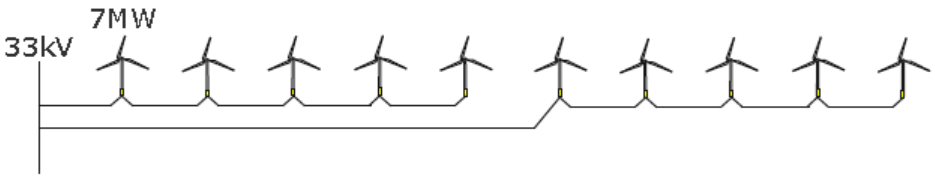
Source: MHI Vestas

AC connected offshore wind power plants

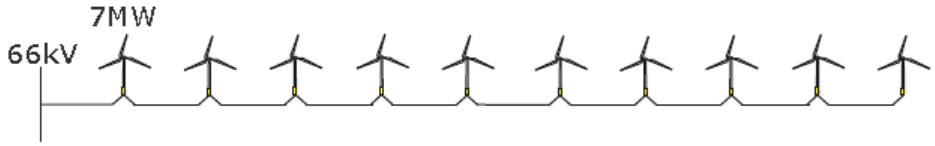


Source: **ABB**

66 kV systems for offshore wind farms



Case 1: 33kV, 3-Core, 630mm^2 copper conductor cable



Case 2: 66kV, 3-Core, 630mm^2 copper conductor cable

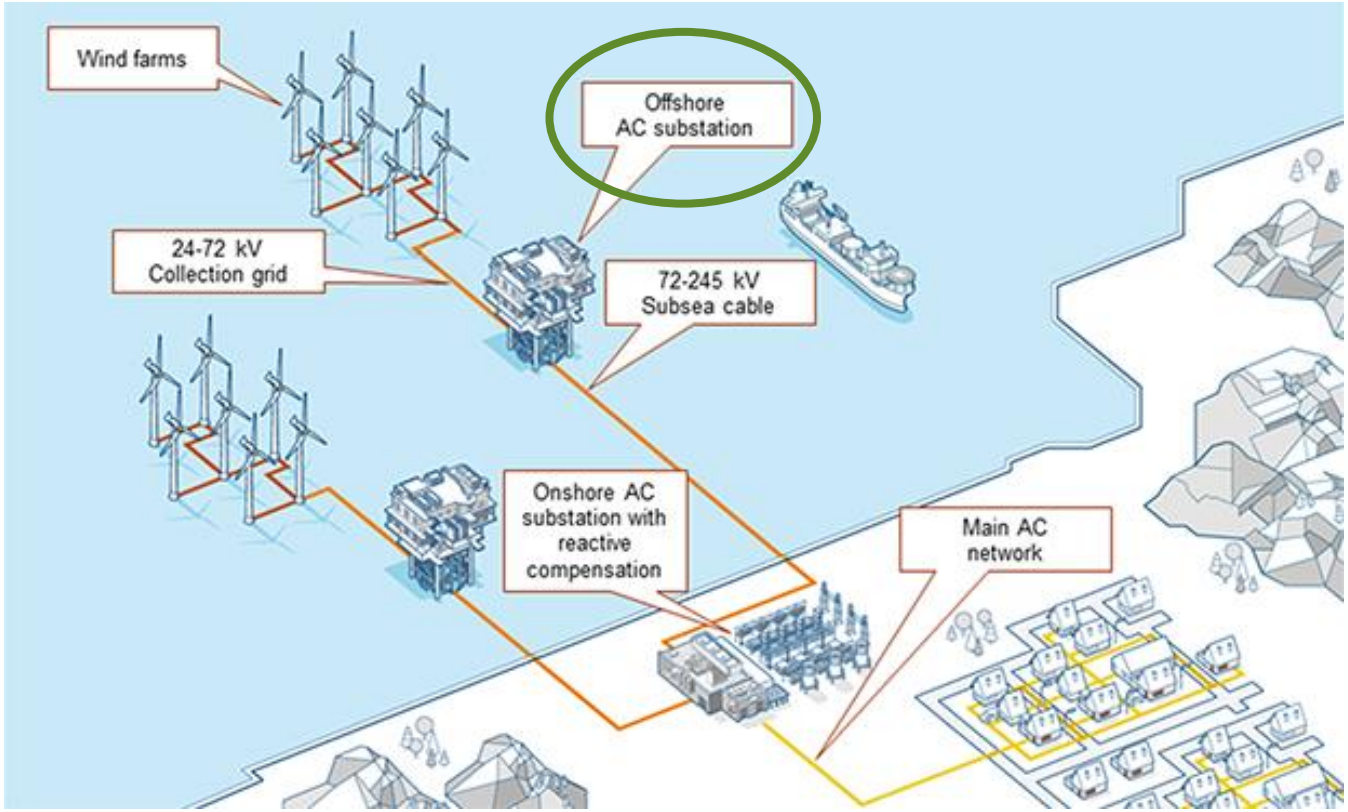
Source: **DNV GL**, **66 kV Systems for Offshore Wind Farms , Report 2015**

“Borssele offshore wind farm (1,400 MW) […]. A comparison between the two design options showed that approximately one third of cable length (135 km), worth 50 million euro can be saved when switching to 66 kV inner-array cables.”

”CAPEX reduction of up to 15% can be achieved when using a 66-kV-inter array solution compared to a 33-kV usual basic design a 350 MW wind farm using radial layout”

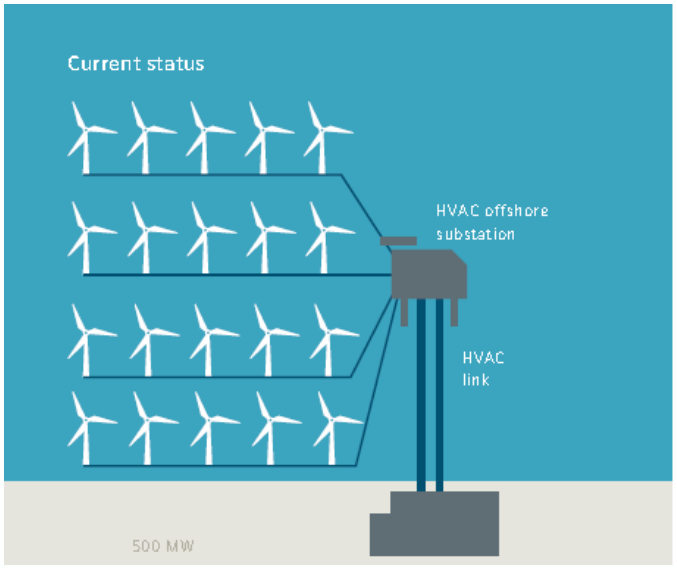
Source: **DNV GL**, **66 kV Systems for Offshore Wind Farms , Report 2015**

AC connected offshore wind power plants



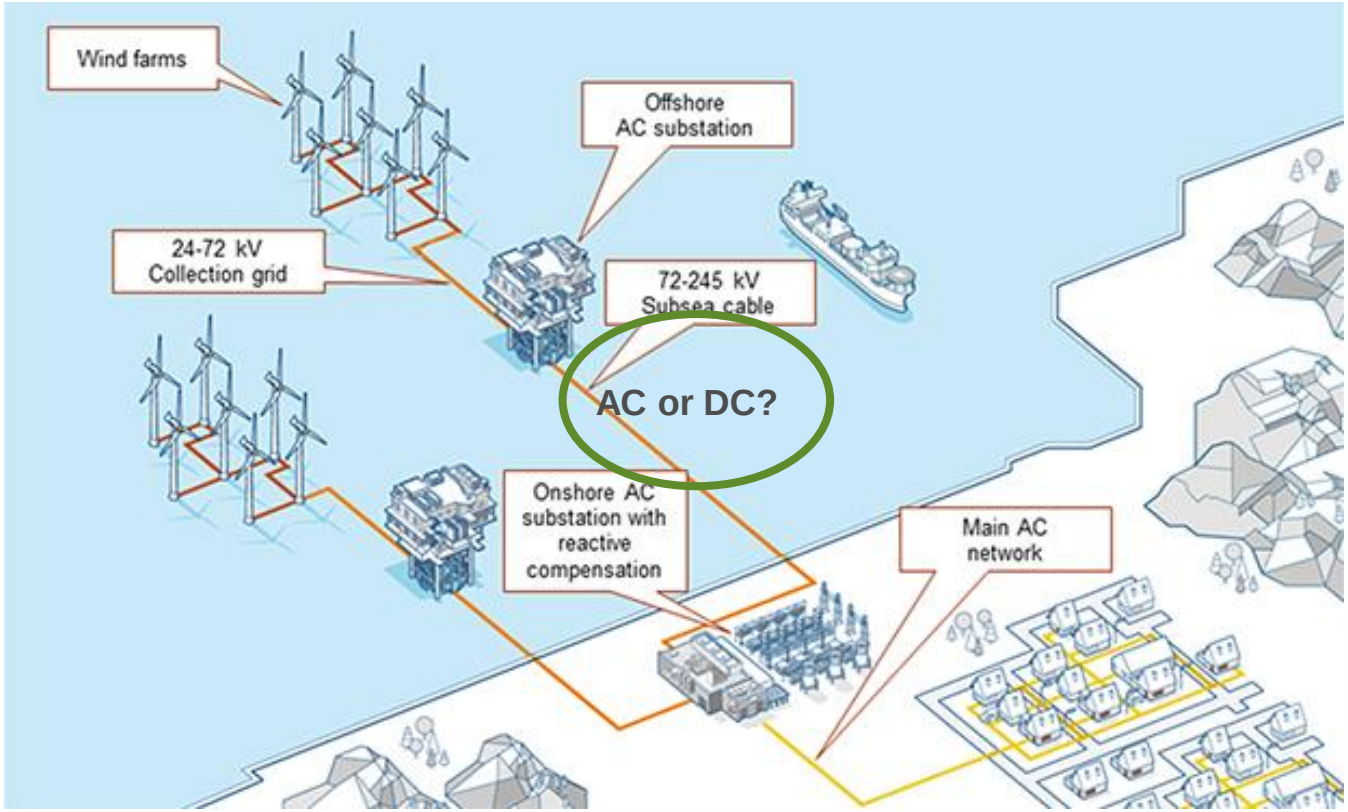
Source: **ABB**

Hornsea Project One
3 substations
36m x 23m x 20m
2.800 tonnes

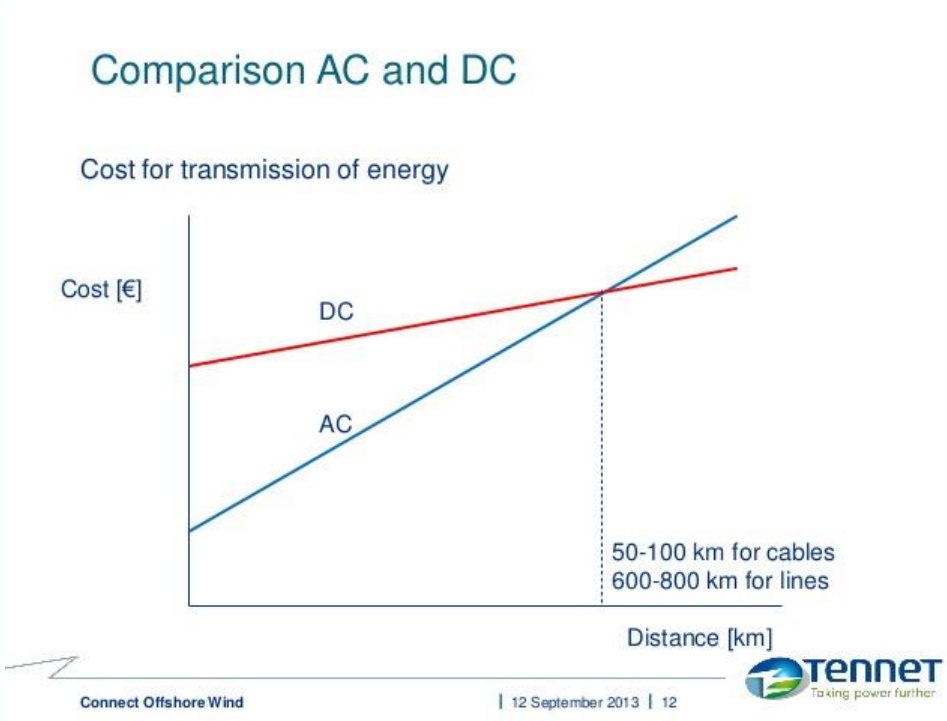


Source: **Siemens**

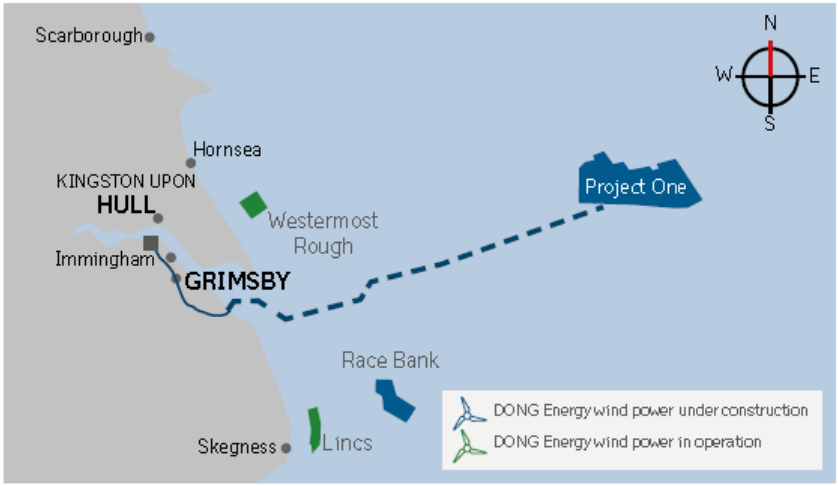
AC connected offshore wind power plants



Source: **ABB**


Comparison AC and DC
Cost for transmission of energy
Cost [€]
DC
AC
50-100 km for cables
600-800 km for lines
Distance [km]
Connect Offshore Wind
| 12 September 2013 | 12
TenneT
Taking power further

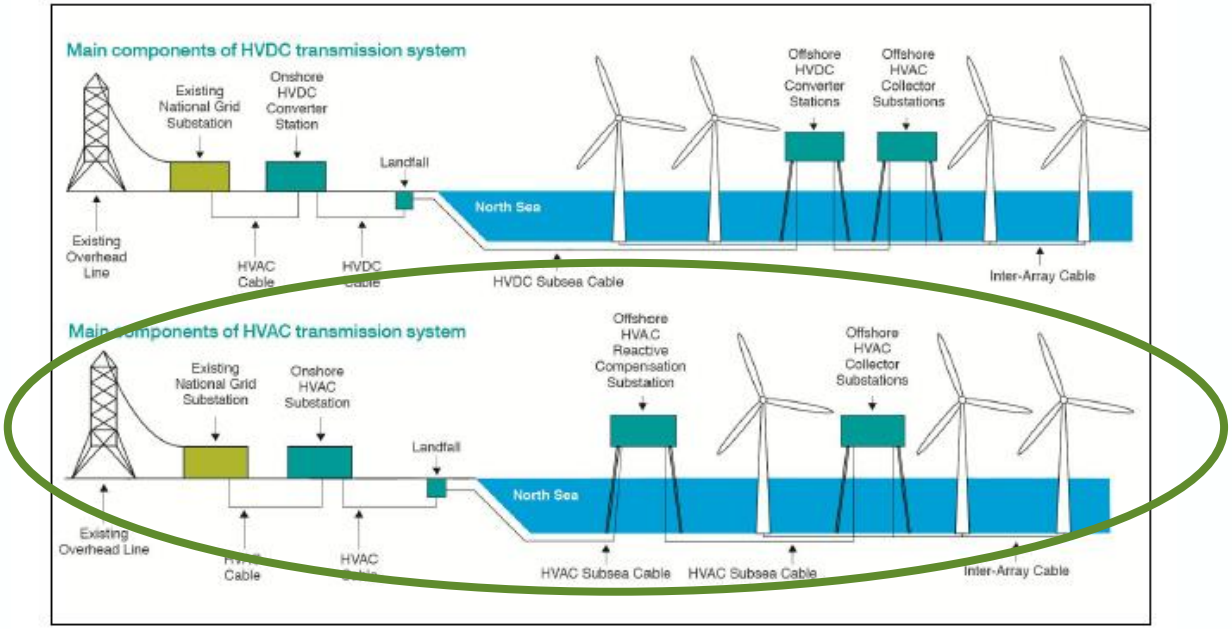
AC or DC transmission?



Hornsea Project One will be located 120km off the Yorkshire coast in an area covering approximately 407km².

Source: **Ørsted**

AC or DC transmission?



Source: **SMartWind, Hornsea Offshore Wind Farm Project One Environmental Statement, 2013**

HVDC Connected offshore wind in Germany

HVDC Light (ABB):

800 MW, ±320 kV

HVDC Plus (Siemens):

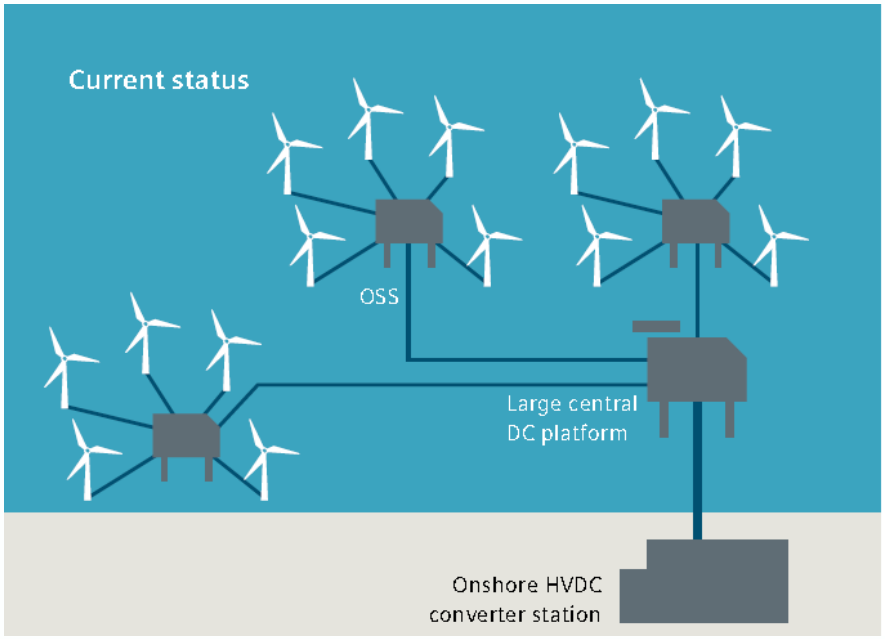
900 MW, ± 320 kV

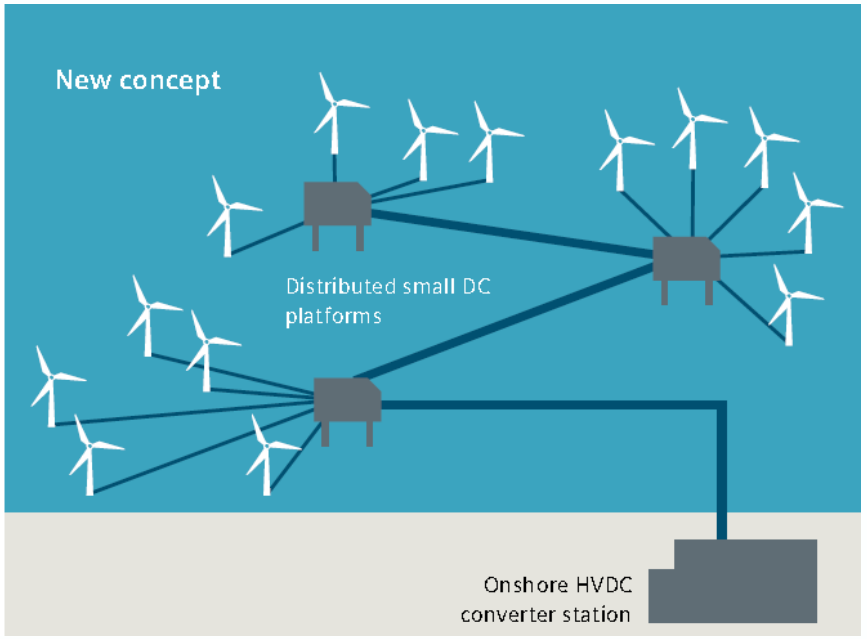
VSC HVDC (GE):

900 MW, ±320 kV

Source: **Siemens**

VSC vs Diode rectifier





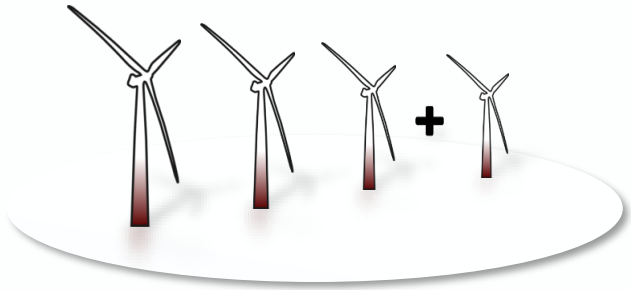
Source: **Siemens**

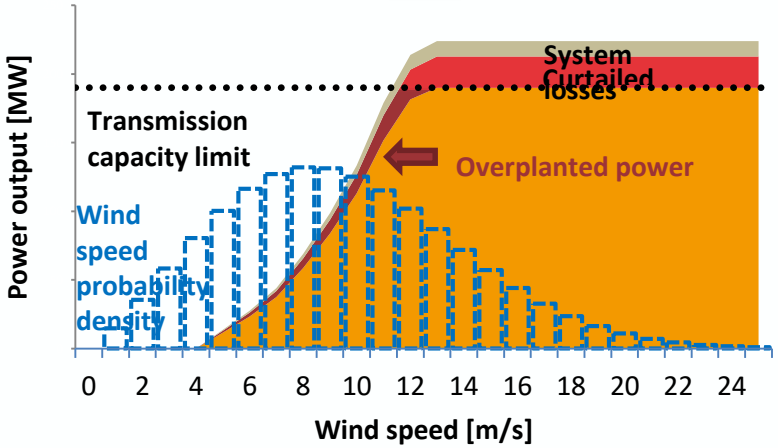
Concept:

Capacity optimization

Utilization of transmission capacity

Requires curtailment of power

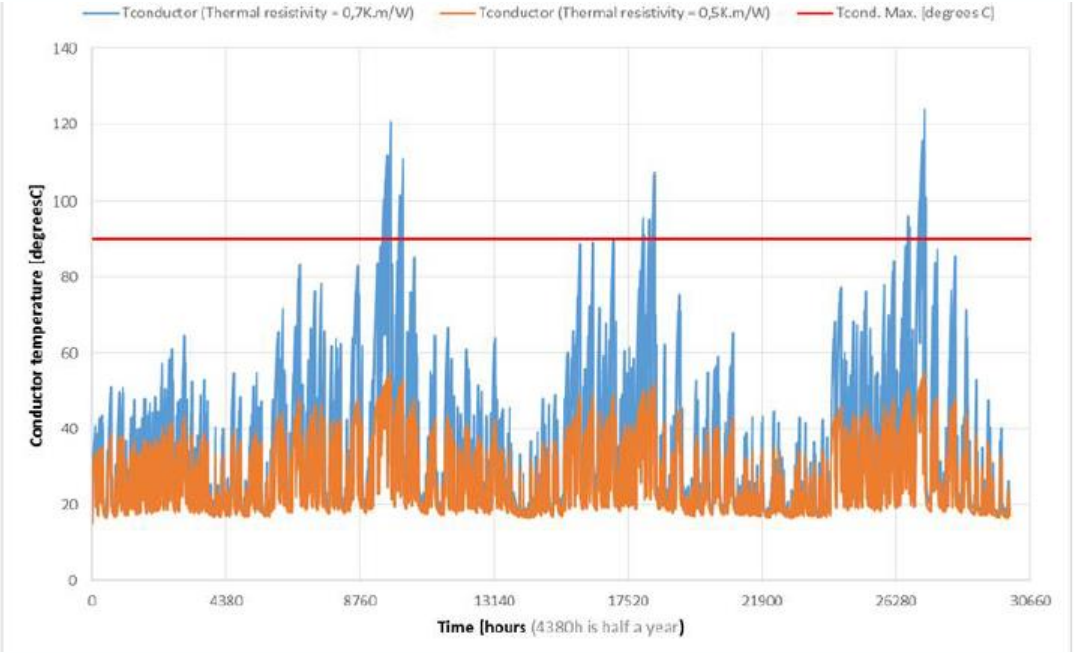




Source: **Christoph Wolter et al., Overplanting in offshore wind power plants in different regulatory regimes**

Dynamic line rating

“TenneT is inclined towards allowing the PPMs to transmit **8%** above their rated power (350MW), which is **30MW** extra, with the requirement for PPM's to **curtail** their produced power, in case the 220 kV export cables reach their maximum allowable temperature limits “



Source: **TenneT, Position paper, Overplanting, 2016**

Bigger

Higher

Smaller (or) **Larger**

(more) **Efficient**

Flexible operation

Questions & Discussions

Thank You