



John P. Daniel, Pittsburg, PA, Nov 12, 2012

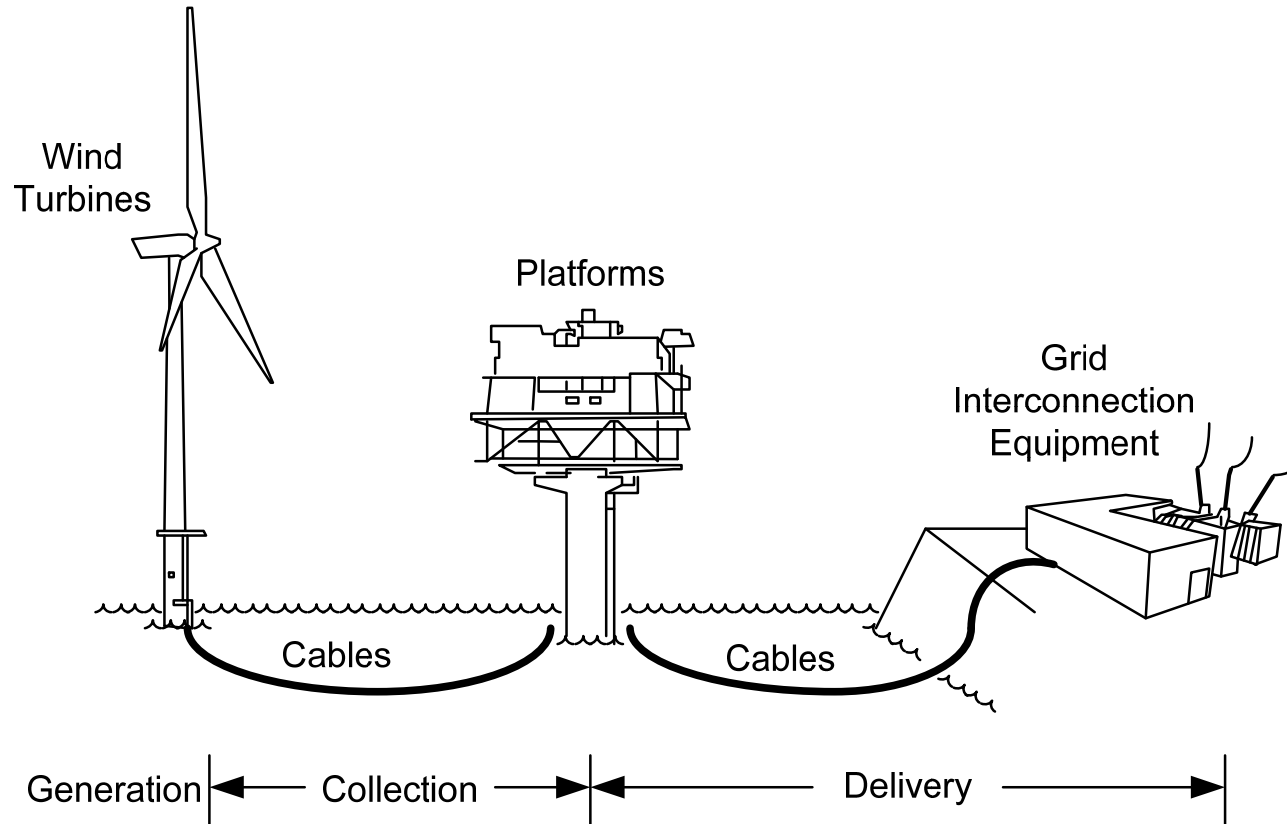
Offshore Wind Connection Systems

Offshore Wind Connections

Overview

- General Offshore Systems
- Collector System Options
- Delivery System Options
- Cables
- Platforms
- Regulatory Issues

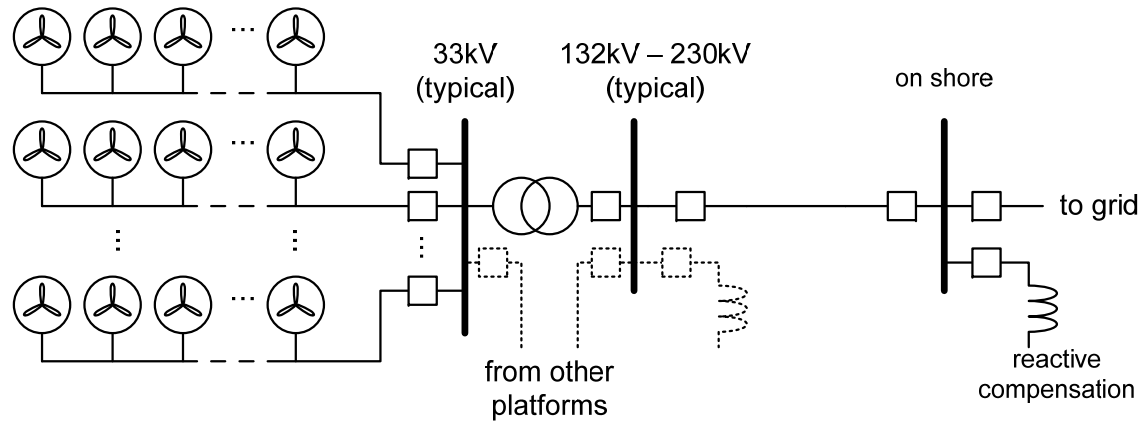
General Offshore Systems



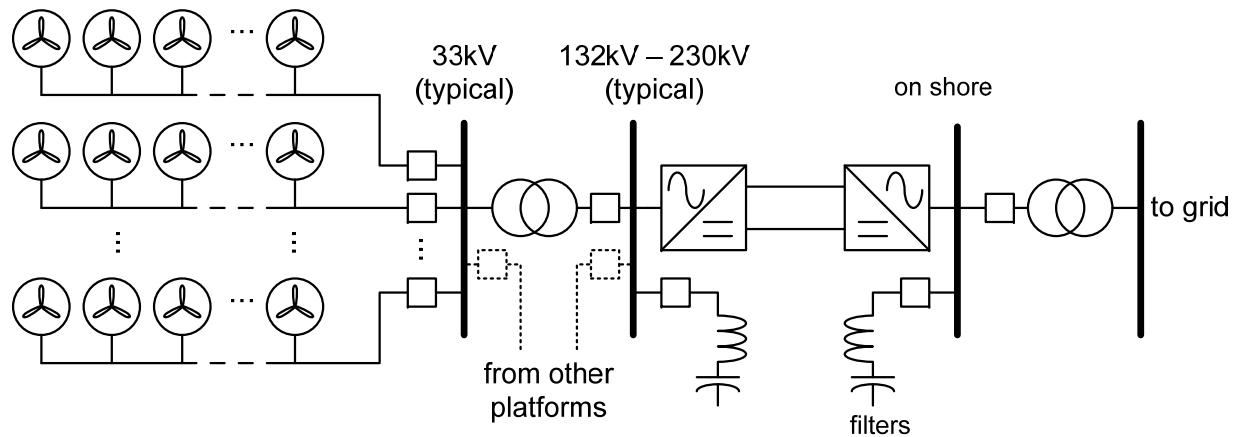
- Enclosed substations
- GIS for AC
- Possible connections between platforms
- AC collectors used to date
- AC and DC delivery used
- Radial connections only to date

General Offshore Systems

Typical System with AC Delivery

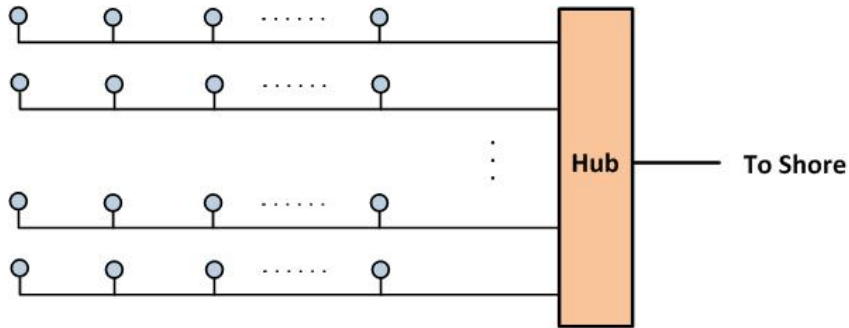


Typical System with DC Delivery

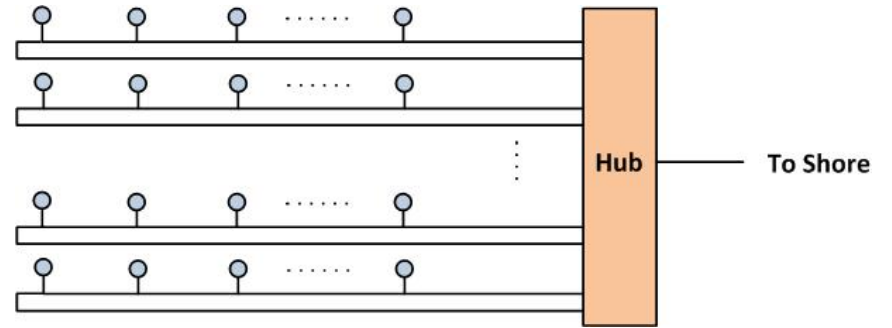


Collector Systems

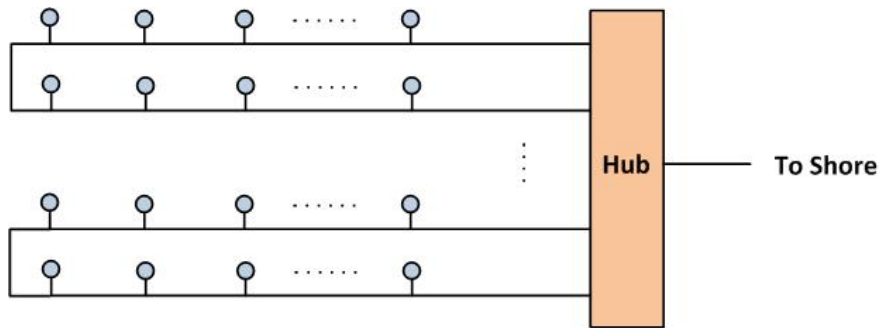
Radial



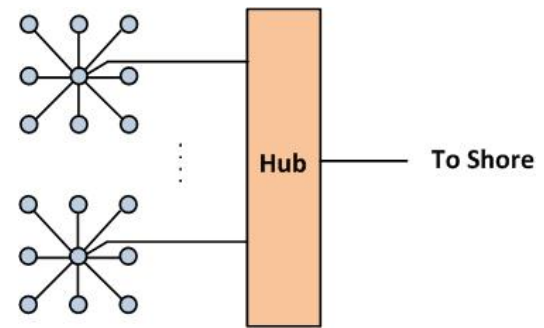
Single Sided Ring



Double Sided Ring

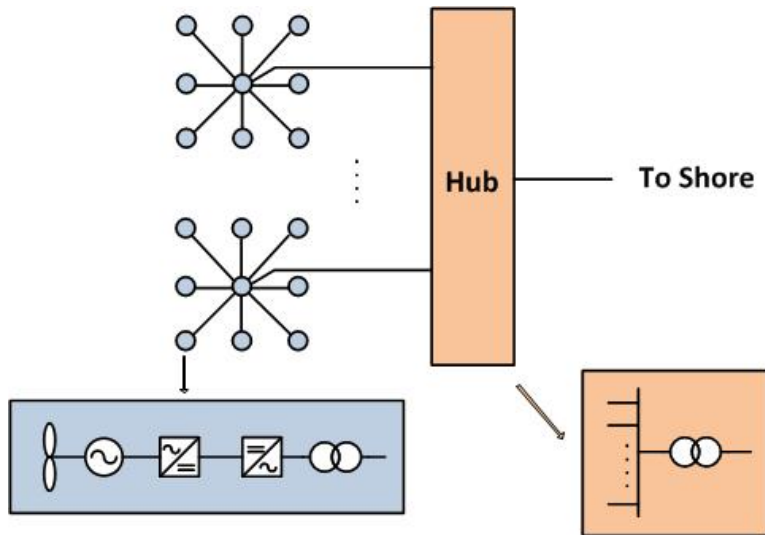


Star

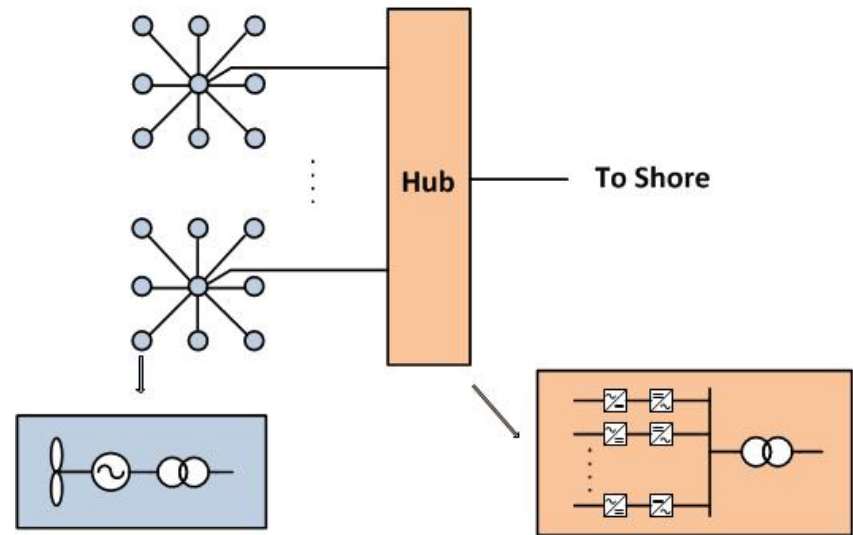


Collector Systems

Conventional

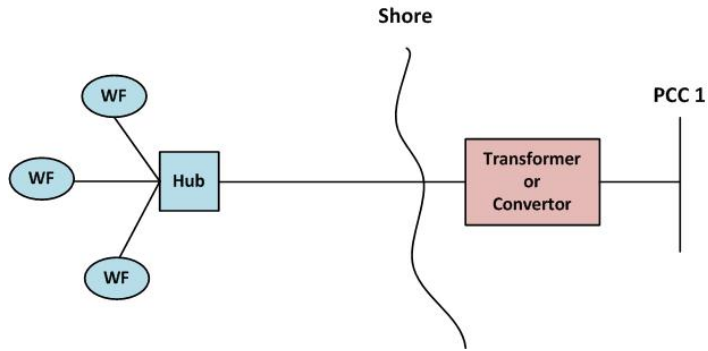


Cluster

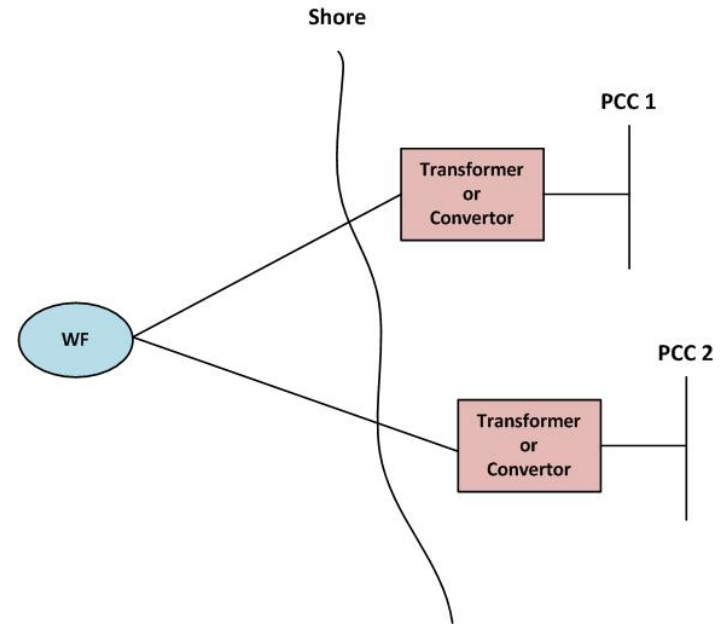


Delivery Systems

Radial

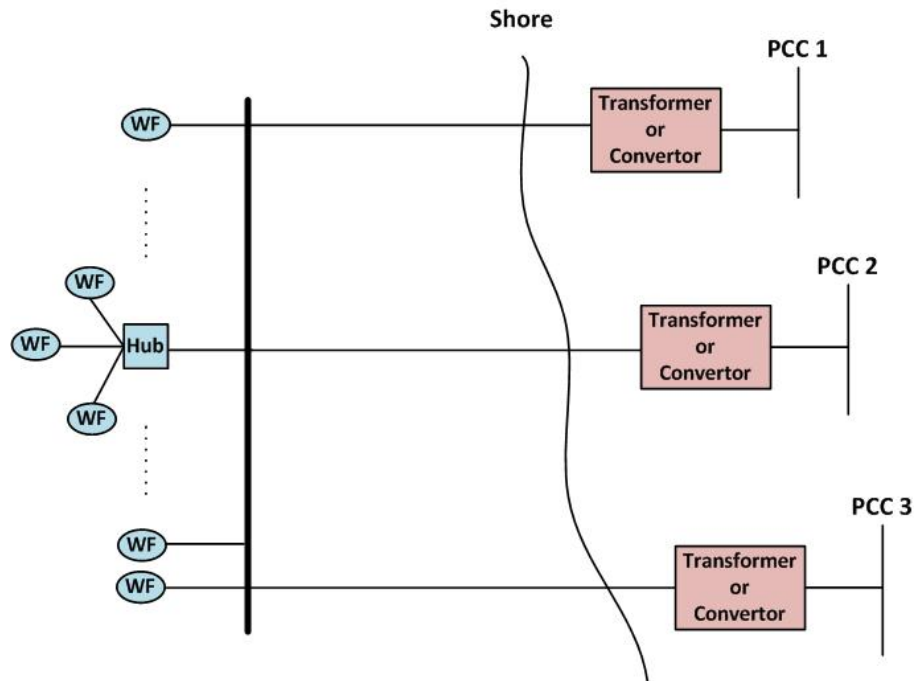


Split Connection

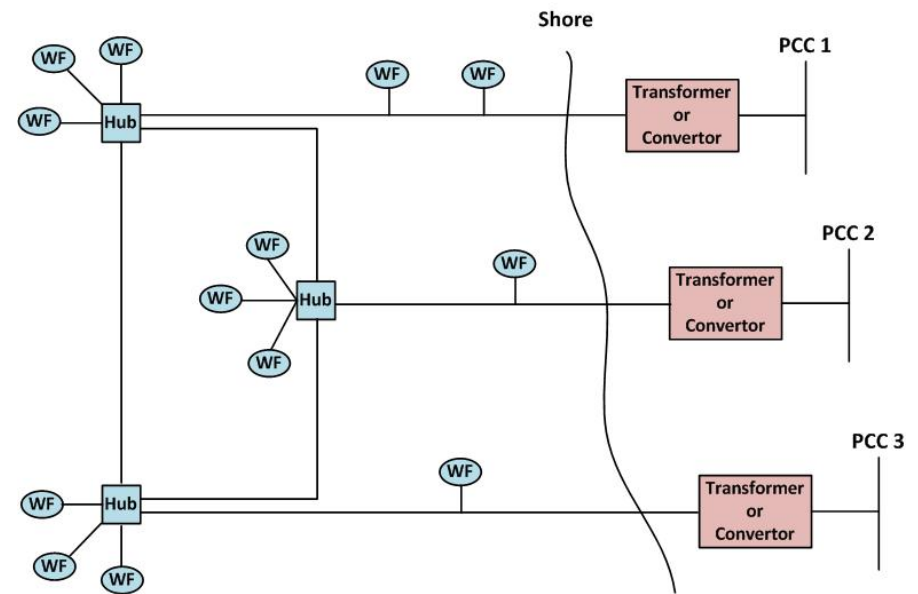


Delivery Systems

Backbone



Grid



- Build out over time?
- Offshore power flow control
- Onshore power flow considerations

Delivery Systems

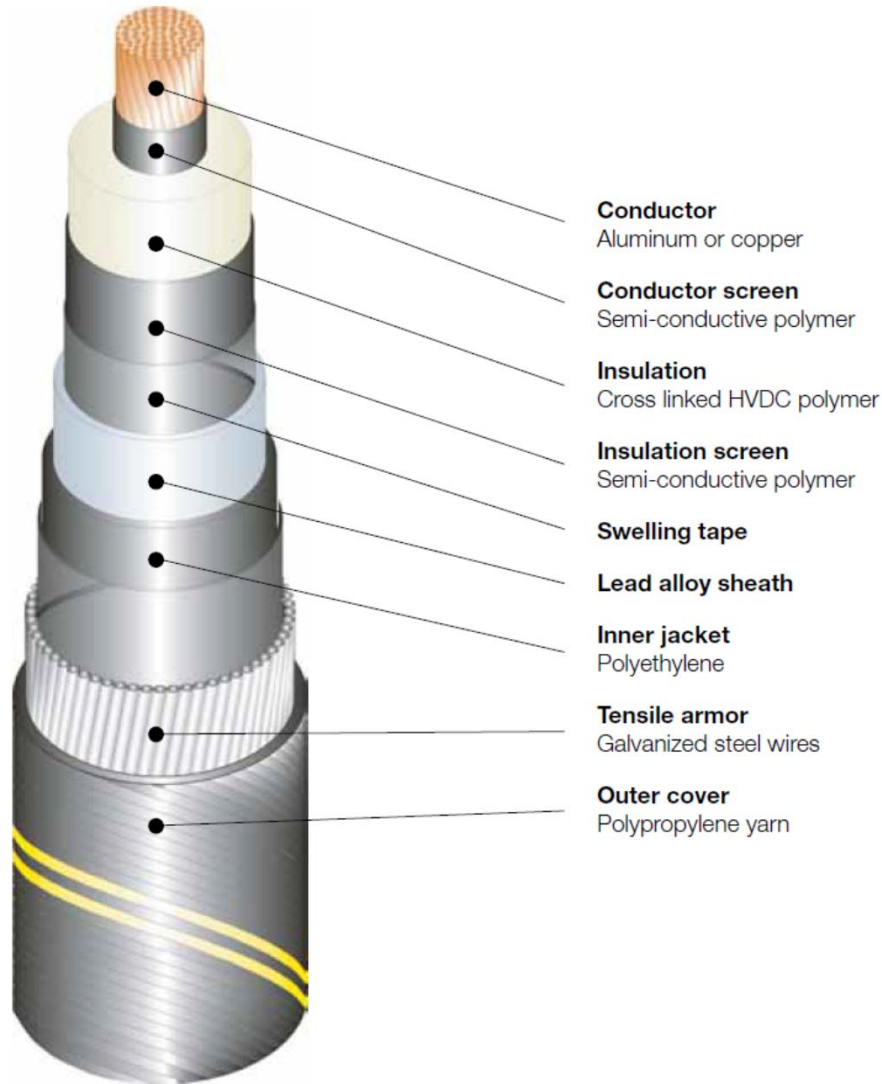
- AC

- Standard equipment
- GIS offshore to conserve space
- Cable compensation usually required – on shore but often offshore

- DC

- Voltage Source Converters
- Air insulated
- May need filters
- Multi-terminal backbone or grid
 - Regional possible today with no DC breakers
 - Interregional require DC breakers

Cables



- **AC cables**

- Single-core vs. tri-core
- Distance limits due to charging

- **DC cables**

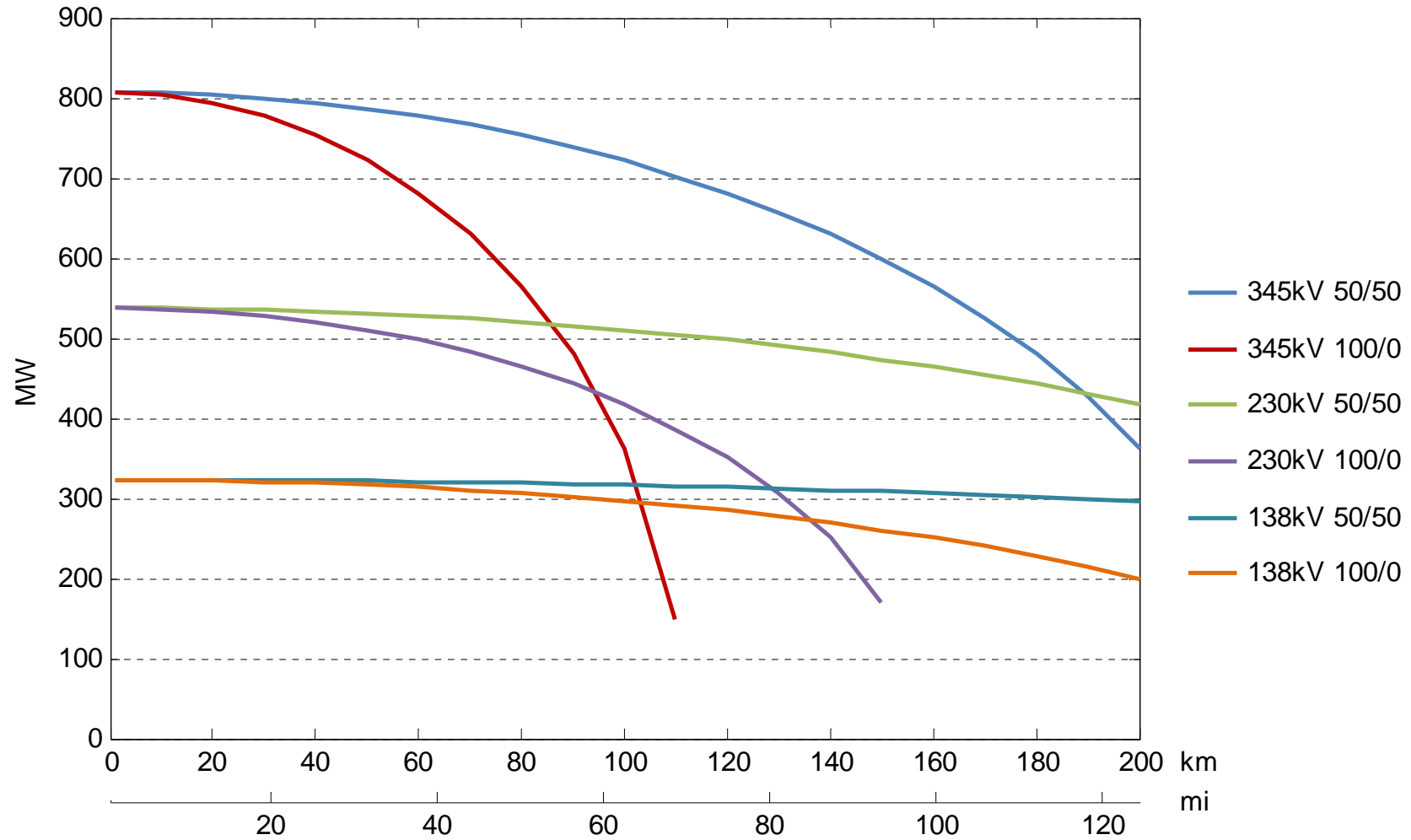
- No charging concerns
- Longer distances possible

- **Installation**

- Location concerns
- Environmental concerns

Cables

AC Power Transfer Limitations



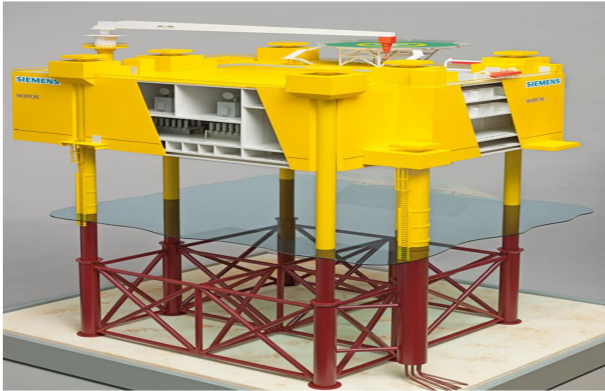
Platforms



Conventional fixed platform (jacket & topside)

Used by ABB for BorWin 1 (in operation 2010) and Dolwin 1 (planned completion March 2013)

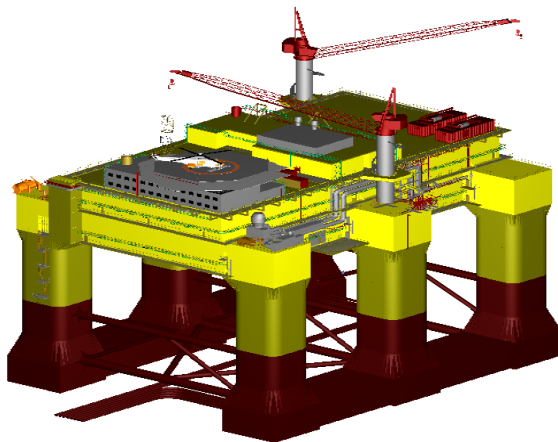
- + Well proven concept – reliability / certification
- + Number of yards with fabrication experience
- Installation/lifting only during May-Sep
- Requires worlds largest crane vessel (cost,availability) and multiple offshore lifts



Jack-up platform

Self-installing(floating)

- + No large crane vessel required
- + Many yards prepared to fabricate (without design risk)
- Limited experience for large platforms >10 000 tons
- Complex design of jack-up system and platform to handle offshore jack-up operation for this weight



Gravity Based platform

Used by ABB for Dolwin 2 (in operation 2014) and other tenders. Unique concept developed by ABB and Aibel

- + Well proven semi-submersible design but placed on seabed – low environmental impact
- + No large crane vessel required
- + Easy to de-commision
- Competitiveness for smaller applications <700 MW ?

Regulatory Issues

- Utility Grid Codes
- Permitting and Exclusion Zones
- Cost Recovery Regulations
- Inter-regional operation and tariffs
- Renewable Portfolio Standards
- Governmental Tax Credits
- Governmental Support and Policy Decisions

Building the future on real experience



Princess Amalia
120 MW
AC connection
2008

Thornton Bank
325 MW
AC connection
2012



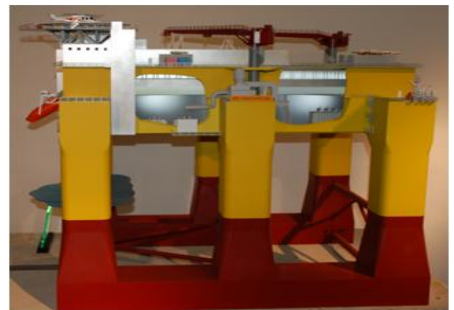
BorWin1
400 MW
HVDC connection
2009

DolWin1
800 MW
HVDC connection
2013



Troll 1 & 3
80+80 MW HVDC
Power from shore
2005 / 2015

DolWin2
900 MW
HVDC connection
2014



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