OFFSHORE WIND FARM GRID INTEGRATION CHALLENGES

Wind Power R&D seminar - Deep sea offshore wind power; 20-21 January 2011, Royal Garden, Trondheim
Kamran Sharifabadi, Statkraft Energy AS
FOREWIND OFFSHORE WIND PROJECTS

Round 3
THE DOGGERBANK ZONE

Dogger Bank Zone

- 135-300 kilometres east of the Yorkshire coast
- Zone: 8660 km$^2$
- Ocean depth: 18-63 meter
- Potential of installed capacity: 9-13 GW
ONE ZONE – SEVERAL PROJECTS

Tranche A
- Identified by July 2010
- 2 years of comprehensive stakeholder engagement, surveys and studies in progress
- Apply for consent end of 2012
- Consent decision end of 2013
- Commence pre construction work thereafter

Tranche B
- Identified by July 2011

Tranche C
- Identified by July 2012

Tranche D
- Identified by July 2013
GENERAL CHALLENGES

→ Accurate modelling of energy capture for large arrays and multiple arrays

→ Increased reliability for turbines to reduce access requirements in more challenging locations

→ Collector grid, offshore & onshore grid,

→ Offshore installation technologies

→ Costs of technology development
CHALLENGES WITH OFFSHORE GRID

→ AC or DC transmission lines and grid
→ Grid development & interface on shore
→ Off shore installations, platforms
→ Operation & Maintenance, Marine operations
→ Infeed loss risk due to DC link failure,
→ Real time balancing, need for rotating reserves
ELECTRICAL SYSTEM DESIGN

Alternative configurations and technologies

- Meshed or radial network?
- How many substations? Subsea reactive compensations?
- How many collector platforms?
- Distance between turbines? How many turbines per string?
  - Wake effects vs. available area, CAPEX (cables) and OPEX (O&M, reliability)
- Wind farm grid voltage?
- AC or DC collector grid?
- Point to point or multi-terminal grid interface?
OWNERSHIP AND RESPONSIBILITIES

UK Transmission Network

National Grid

V= 400kV AC

Offshore Collection Developer then OFTO

V ≥ 132kV AC

Turbine Arrays Developer

DC grid & grid design

Transmission Owner (OFTO)

V ≥ +/-320kV DC

Onshore Converter Station

V= 400kV AC

Cable Landfall

Offshore Converter Station

Offshore Collector Station

V≥33kV AC

Onshore Cable Route

Offshore Cable Route

Offshore Collector Station

Statkraft
COLLECTING THE POWER

Radial configuration is the traditional solution
✓ 33 kV AC
✓ Adopted from onshore wind farms
✓ Approximately 8 turbines on each array string (max. 40MW)
✓ Two or three variations on cross section
OFFSHORE CABLE TECHNOLOGY

- **275kV 3 core AC cable**
  - 630mm² copper conductors
  - 500MVA capacity
  - 5-7 year development timescales
  - Not used in studies

- **500kV HVDC XLPE Bipole Pair**
  - 2500mm² copper conductors
  - 2000MW capacity
  - 4 year development timescales
  - Not used in studies

- **650kV MI (PPL) Bipole – laid separately**
  - 2500mm² copper conductors
  - 3000MW Capacity
  - 2-3 year development timescales
  - Not used in studies before 2020
GRID INTERFACE CHALLENGE

Figure 5.12a – East Coast: Radial Strategy Offshore Design

Figure 5.12c – East Coast: Integrated Strategy Offshore Design

Source: ODIS 2010
INTERCONNECTION INITIATIVES (UK)

North Seas’ Countries Grid Initiative
- Political declaration of 10 N Sea countries
- Signed up to by UK Government

Existing interconnectors
- IFA (GB – France): 2GW
- Moyle (NI – Scotland): 450MW

Under construction
- BritNed (GB – Netherlands): 1GW
- East-West (GB – Ireland): 500MW

Other potential links
- Belgium: 1GW from 2016/17
- France: 1GW from 2018
- Norway: 1GW – 2GW from 2018
- Ireland #2: 1GW max from 2018

Map source: ENTSO-E draft TYNP
THE “SUPERGRID” ?

Renewable electricity around the North Sea

Current and potential future undersea cables connecting renewable international energy projects, as proposed in the European Wind Energy Association's 20-year master plan.

- In operation
- Planned/under construction
- EWEA recommended by 2020-2030
- Offshore node
- Application area/lease/licence for wind farm
- Application for approved wind farm area
- Proposed wind farm area
- Offshore wind farms in operation/under construction
- Offshore wind farms planned/proposed

Map showing various locations such as Norway, Sweden, Estonia, Latvia, Lithuania, Poland, Germany, France, and the UK.
INTEGRATED SOLUTIONS WITH MULTITERMINAL

Grid interface
Point 1

- Power flow control?
- Fault handling?
  - Faults in DC system
  - Faults in AC system
- Stability?

Grid Interface
Point 2

Consumption, oil platform

Connected on
i. AC side? or
ii. DC side?

2 x 500 MW
2 x 500 MW
2 x 500 MW
SOME TECHNOLOGY GAP EXAMPLES

- Platform design needs to be defined for each application
- Development of high capacity AC Cables, subsea reactive compensation technologies
- Development of 1GW or higher VSC HVDC links and multiterminal solutions

Suppliers indicate that these technologies can be developed but require a large market to justify the development costs
TECHNOLOGY GAPS SUMMARY

In general:

- Scaling up VSC HVDC technology for GW transmission
- Reliability for offshore application must be demonstrated
- XLPE submarine cable systems must be proven for operation at 300kV DC or higher, Cable joint technologies for deep see
- Multi-terminal HVDC technology & control strategies, power flow
- Development of DC Circuit Breakers
- Automatic network restoration
- DC Protection relay technologies for DC grid
OFFSHORE SUBSTATIONS

R1 – “Onshore” design

R2 - Integrated designs

R3 – Standardisation?

Sheringham Shoal
(Areva + Wood Group Engineering)

Global Tech 1 (400MW)
WAY FORWARD AND SUMMARY

→ How can we future proof the new technologies & solutions with focus on costs?

→ How can we assure and identify the show stoppers?

→ Technology development with vendors R&D programs, national and EU R&D programs.

It is required to develop new technologies and approaches, with focus on reliability, flexibility and lower costs