

Offshore wind farm electrical engineering

(when considering the operation of array cabling at voltages of 66kV)

29th January 2015

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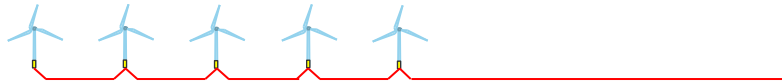
DNV GL Renewables Advisory (RA)

- DNV GL (RA) has worked with almost every major manufacturer. It has led the market for manufacturer services for many years and is continuously developing its industry standard turbine design software.
- DNV GL has been supporting investors in wind farms for over two decades. The detailed technical understanding of its experts provides a solid basis for informing intelligent decisions, regardless of the scale of the project or investment, or the lifecycle stage.
 - Offshore team
 - Front End Engineering Design Studies (for numerous offshore wind farms)
 - Procurement assistance

Drivers behind the consideration of higher array system voltages

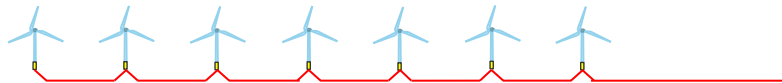
- Wind energy installations are becoming much larger, in terms of:
 - Site installed capacity
 - Wind turbine rating/capacity
- Increase in voltage allows an increase in current carrying capacity

2MW



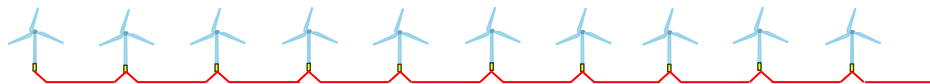
11kV → ~ 10MVA

5MW



33kV → ~ 35 MVA

7MW

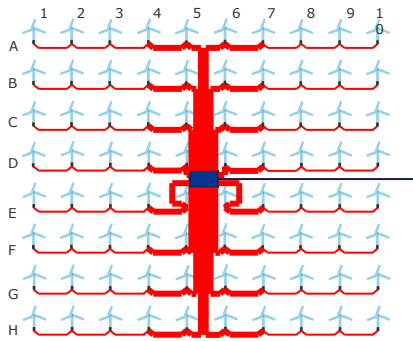


66kV → ~ 70 MVA

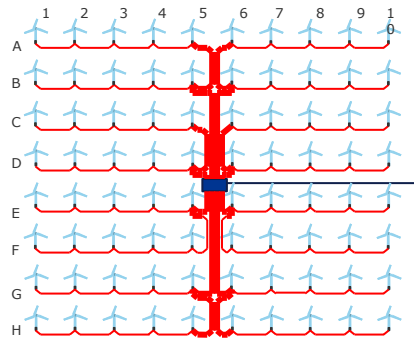
Drivers behind the consideration of higher array system voltages

- Array cable quantity
 - Savings can be achieved if the cable quantity can be reduced.
- Offshore substations
 - Significant savings can be achieved if there are fewer substations.
- Losses
 - Annual (and hence lifetime) production losses can be minimised if the collection and transport of power can be undertaken more efficiently.

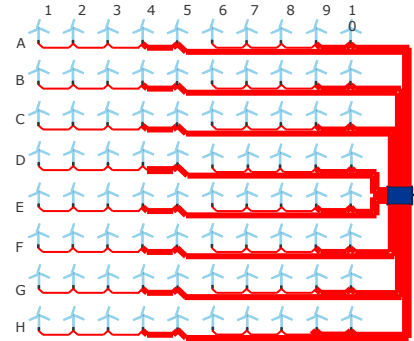
Array cable layouts



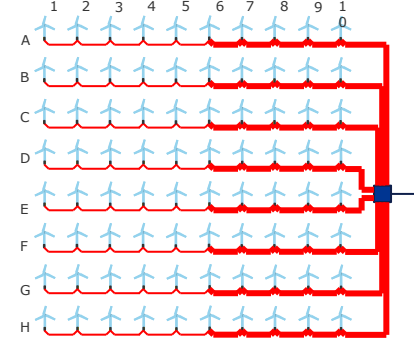
Option 01 (33kV)



Option 02 (66kV)



Option 03 (33kV)



Option 04 (66kV)

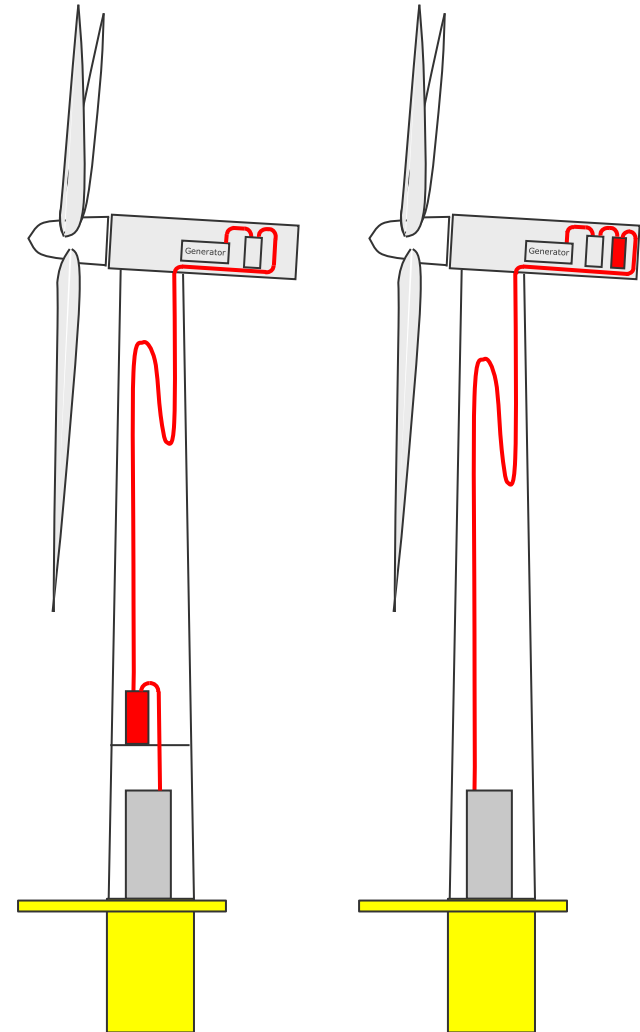
Layout:	01	02	03	04
Voltage (kV)	33	66	33	66
Substation location	Inner	Inner	Outer	Outer
Losses (MWh) / yr	15,541	7,907	25,225	10,938
Cable: 630+240mm ²	59 + 59 = 118	20 + 89 = 109	109 + 59 = 168	59 + 49 = 108
Losses (%)	0.54	0.27	0.88	0.38
Losses (£) Assuming £130/MWh	2,020,330	1,027,910	3,279,250	1,421,940

Assumptions

- 66 kV array system operating voltage
- 7 MW wind turbine capacity
- 154m rotor diameter
- 1,078 m wind turbine spacing
- 10 rows x 8 columns x 7MW = 560 MW
- Restrict cables to two sizes (630 & 240 mm²)
- Annual wind data from UK round 3 project in North sea
- Annual capacity factor: 0.52
- £130 per MWh

Wind turbine electrical systems

- Topside mass (Rotor and Nacelle)
 - 7MW medium speed turbine: Considerable
- 3.3/33kV > 3.3/66kV transformer
 - Oil
 - Cast resin (Preferable)
- Tower cables
 - Flexible cables: LV / MV / HV
- Tower frequency response
- Wind turbine switchgear
 - ~~IEC 62271-200~~ → IEC 62271-203
- Support structure
 - Monopile / Jacket etc.: Added mass

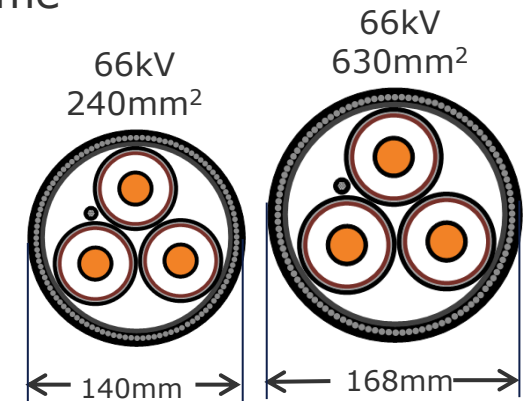
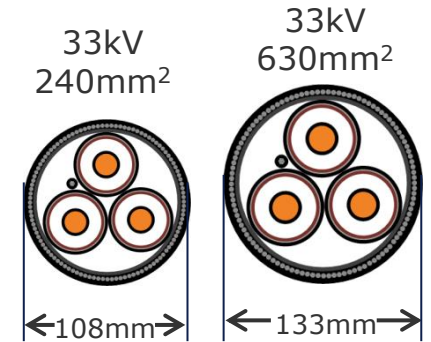


66 kV Subsea cable supply

- Construction and supply
 - 33kV subsea cables – wet design
 - Relatively low bending radius
 - Can be supplied on drums/coiled
 - Relatively straightforward to install

- 66kV subsea cables (at the moment) – not quite the same
- Lead sheath
- Would need to be installed from carousel
- Higher bending radius when compared with 33kV

- Testing / Certification of 66kV subsea cables



66 kV Subsea cable installation

- Installation / Trenching
 - No major issues
 - May require enhanced tooling



Photo courtesy of London Array Limited / Carel Kramer



Photo courtesy of Stemat BV / Walney 2



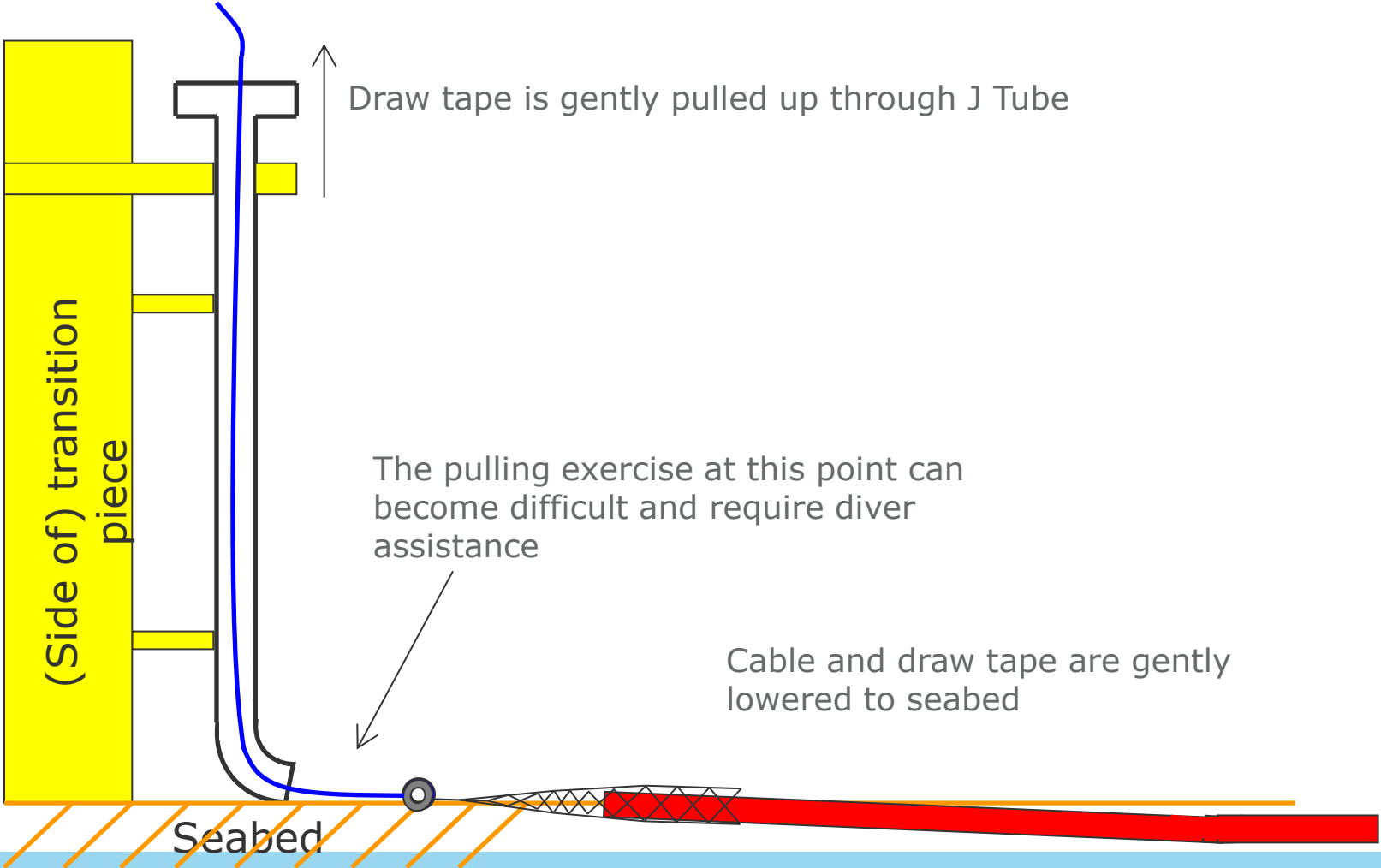
66 kV Subsea cable installation

- J Tubes
 - Would need to accommodate larger diameter cables
 - Could be more complicated (than it already is!)



66 kV Subsea cable installation

- J / I Tube - Cable installation



66kV Cable – Benefits / Drawbacks

Area	Issue	Benefits	Drawbacks
Cable supply	Reduction in quantity	Up to a third the quantity of cable when compared with the 33kV option.	Increase in unit cost (€/m) of cable
Cable Installation	Reduction lay operations	Reduced installation time	Enhanced, more costly cable installation tooling requirements
	Cable congestion	Lower risk of damage to other cables around substation during cable laying	
	Cable congestion	Reduced thermal interaction of cabling around substation foundation and within substation J-Tubes	

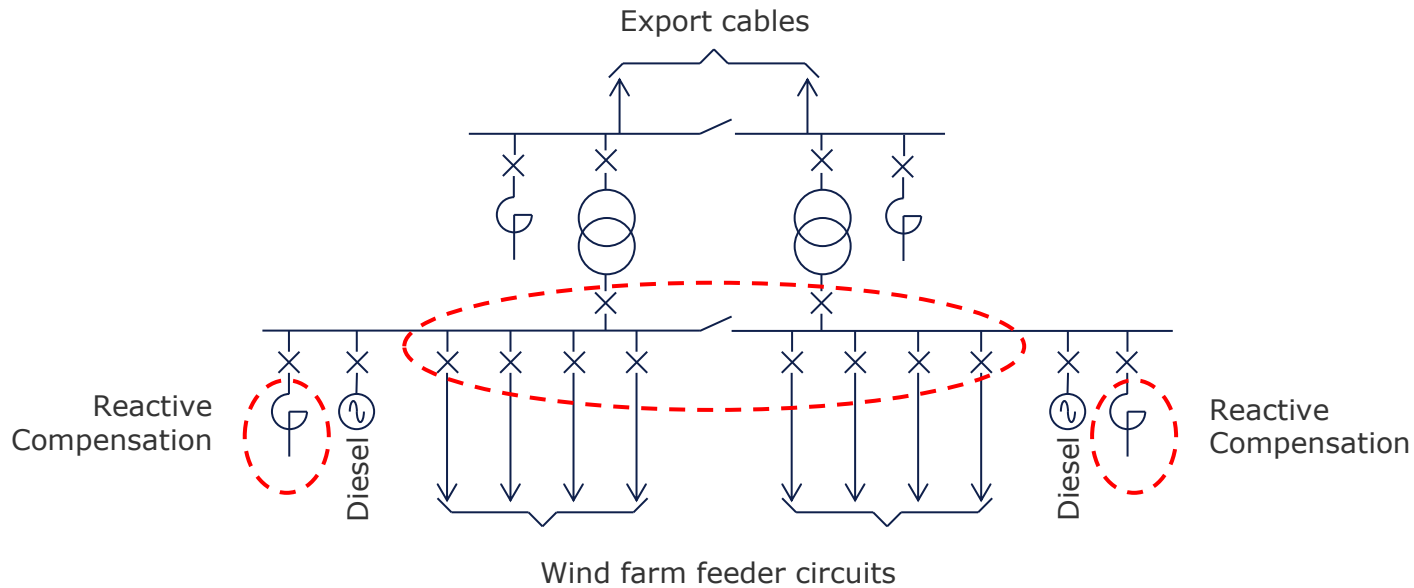
- Costs
 - Elevation in unit cost of cable (Although a reduction in quantity)
- Risk areas
 - Certification of cable
- Timelines
 - Variable: 12 to 18 months

Offshore substation – electrical systems

- Cable management
- 66 kV switchgear
- Reactive power compensation



Photos courtesy of London Array Limited



End – thank you for listening

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