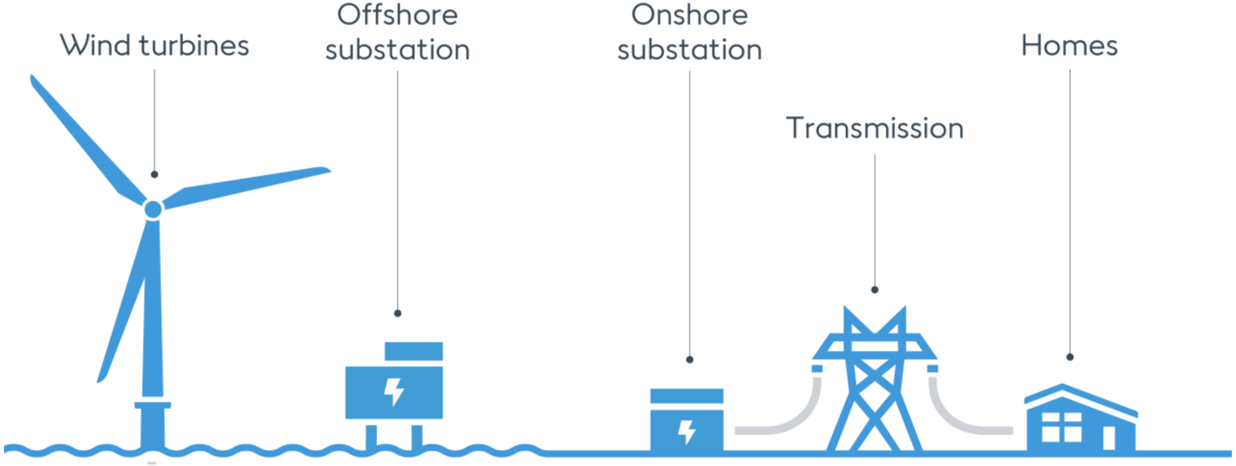
Ørsted

Offshore wind Transmission systems

Energy integration to the grid: models and examples from different markets



Clara Ferran Roig
Senior business developer offshore (new markets)

Ørsted

World leader in offshore wind with ~9GW installed and 27 wind farms in operation

Strong commitment to the development of renewable hydrogen and e-fuels with project pipeline of +3GW

Recognised on the CDP Climate Change A List as a global leader on climate action with a target of becoming carbon neutral by 2025

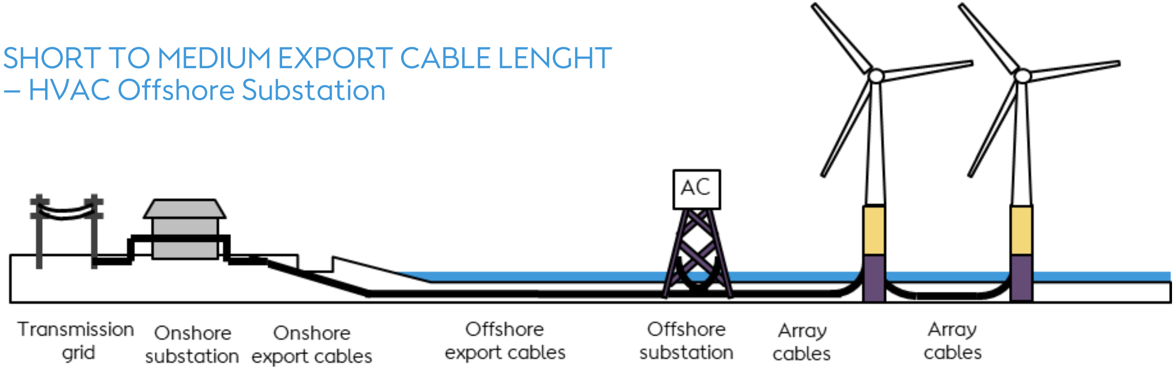
Growing presence in Spain through onshore renewables business and offshore partnership with Repsol

Headquartered in Copenhagen, Denmark
2021 group revenue of EUR 10.4 billion
~7,700 employees globally

Image: O&M technicians servicing Ørsted's Anholt wind farm

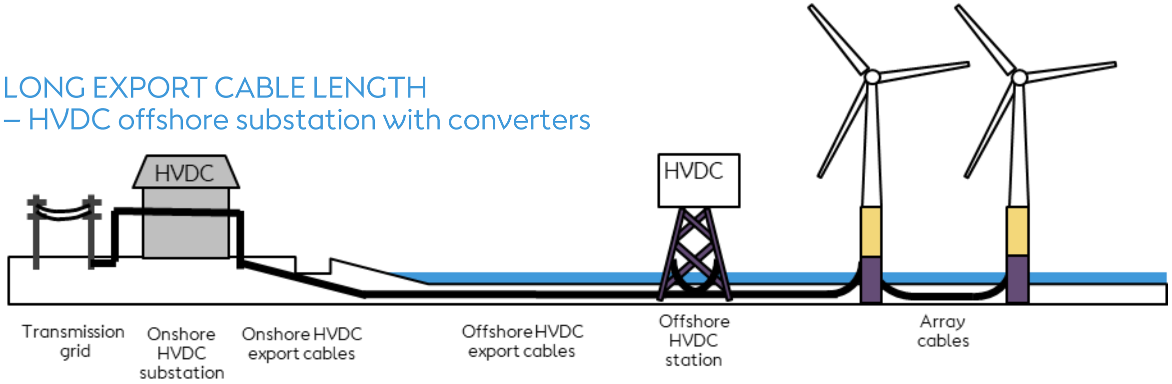
Distance to shore generally indicates the type of high voltage cable chosen (alternating/direct current) which determines de type of Transmission system assets

SHORT TO MEDIUM EXPORT CABLE LENGHT – HVAC Offshore Substation



Hight Voltage Alternating Current
Typical wind farm size 150 to 400 MW per circuit
Examples: Walney 1 & 2 , Burbo Banks 2, Borssele

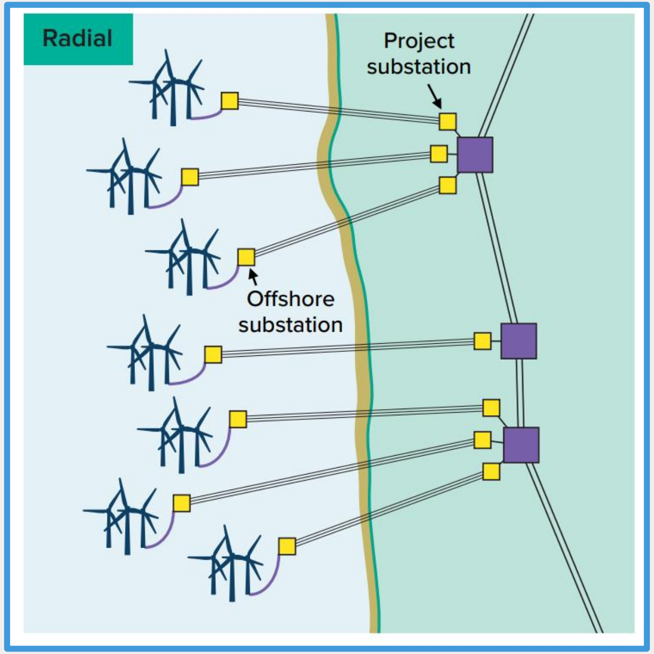
LONG EXPORT CABLE LENGTH – HVDC offshore substation with converters



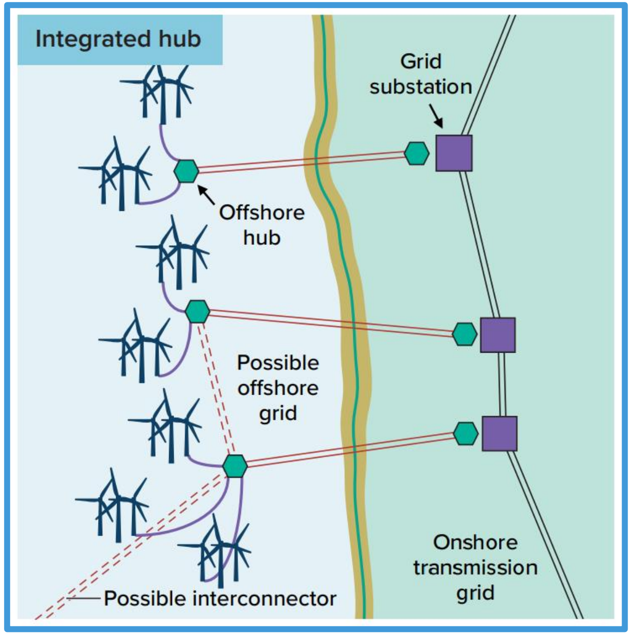
Hight Voltage Direct Current
Typical wind farm size > 900 MW
Example: New German and UK projects, Borkum Riffgrund 3
HVDC systems , can transmit power over longer distances therefore voltage losses are lower.
It is a more complex system, requires offshore and onshore converter stations (from AC to DC at the point of generation and from DC to AC at the point of consumption)
They are generally more costly

Ørsted

The two main design options for transmission systems are Radial or Integrated Hub and are determined by governments



- Straightforward option to deliver power from a single OWF to a single POI
- Project specific and often developer led

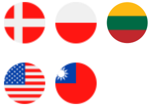
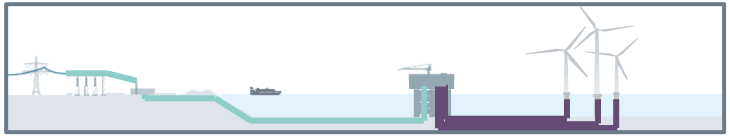
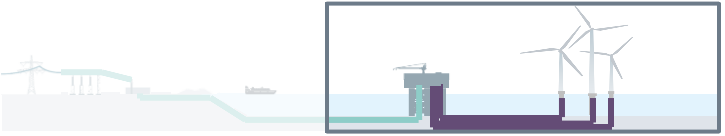


- Ocean grid that connects multiple OWFs to multiple POIs
- Strategic development and needs to be TSO led as part of a larger plan
- Can be monopolistic (DE) assignment or competitive (US)

 World Bank Group. 2021. Key Factors for Successful Development of Offshore Wind in Emerging Markets. ESMAP, World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

Ørsted

Governments decide what assets will be included in the auction – models differ by country

	Model	Examples	Offshore wind developer construction scope	Description
RADIAL	Full scope			• Developer constructs, owns and operates offshore wind farm (OWF), offshore substation (OFS) and grid connection[2]
RADIAL	Turnkey/ OFTO[1] scope			• Developer constructs, owns and operates the OWF and constructs OFS and grid connection • After COD, ownership and O&M responsibility of OFS and grid connection transferred to TSO (turnkey model) or third-party (OFTO model)
RADIAL	Limited scope			• Developer constructs, owns and operates OWF • TSO constructs, owns and operates OFS and grid connection
HUB	Split scope			• Developer constructs, owns and operates OWF and OFS • TSO constructs, owns and operates grid connection (and offshore hub)

1 Offshore transmission asset owner.

Ørsted

Studies[1] that compare different offshore transmission models conclude that integration and competition determine rate-payer risk, cost and impact on environment & community

	Competitive (developer or 3rd party builds OTA)	Monopoly (TSO builds OTA)
RADIAL	**rate payer risk** ● **cost** ● **environment&community impact** ●/●	**rate payer risk** ● **cost** ● **environment&community impact** ●/●
RADIAL	simpler to plan, design and execute	
RADIAL	Flexibility towards technology development and innovation	
RADIAL	Increased short term environmental and community disturbances	
RADIAL	No coordination costs	Coordination costs
RADIAL	One entity manages full risk and timing, the chances of delays are lower and little or no impact on ratepayer.	Increased risk of delays with impact to the ratepayer due to responsibility dispersion among entities.
HUB	**rate-payer risk** ● **cost** ● **environment&community impact** ●	**rate-payer risk** ● **cost** ● **environment&community impact** ●
HUB	Requires long term strategy and commitment from governments (at least 10 years look ahead) and large amounts of pre-investment.	
HUB	coordination costs among entities	
HUB	Standardized design doesn't allow for flexibility towards technology development and innovation. Risk of becoming obsolete.	
HUB	higher operational impact in case of failure of export system or damaging event	
HUB	Environmental disturbances can be decreased due to smaller amount of cable and landfall works	
HUB	Risk of timing discoordination between windfarm and hub still present and taken by the rate-payer however it might be lower do to competition setup.	Increased risk of delays due to responsibility dispersion among entities with impact on rate-payer.

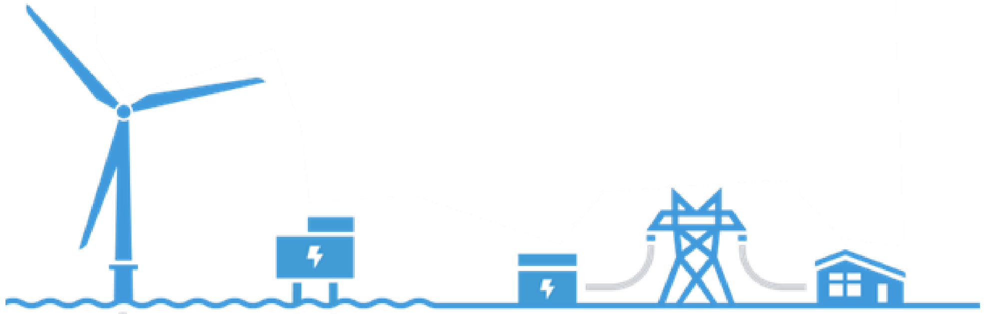
1 Levitan & Associates, Inc. (2020). Offshore Wind Transmission Study Comparison of Options prepared for New Jersey Board of Public Utilities. Boston.
DIW Econ. (2019). Market Design for an Efficient Transmission of Offshore Wind Energy: A Study Comissioned by Ørsted Offshore Wind. Berlin
World Bank Group. 2021. Key Factors for Successful Development of Offshore Wind in Emerging Markets. ESMAP, World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

Ørsted

Reflections on transmission systems for floating offshore wind in Spain: The party best able to manage risk and benefit from ownership should assume responsibility for the offshore transmission assets

Key elements to consider regarding transmission model and risk responsibility distribution:

- ❖ Offshore construction experience
- ❖ Timing
- ❖ Development and evolution of floating technology



Ørsted

Gracias!

Clara Ferran Roig , Eólica y Mercado
Febrero 2023