Regulatory Challenges in the Development of Offshore Electrical Networks

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Supported by: Prof Keith Bell & Dr Ander Madariaga (ORE Catapult)

Project Background

- Short review project funded by “offshore electrical infrastructure research hub[1]”
  - Collaboration between Strathclyde, Manchester & ORE Catapult
  - 5-year programme with co-funding to address to all aspects of offshore electrical infrastructure
  - “Hub & spoke” model - open to collaboration with industry and academic partners

<u>Project Aim:</u>

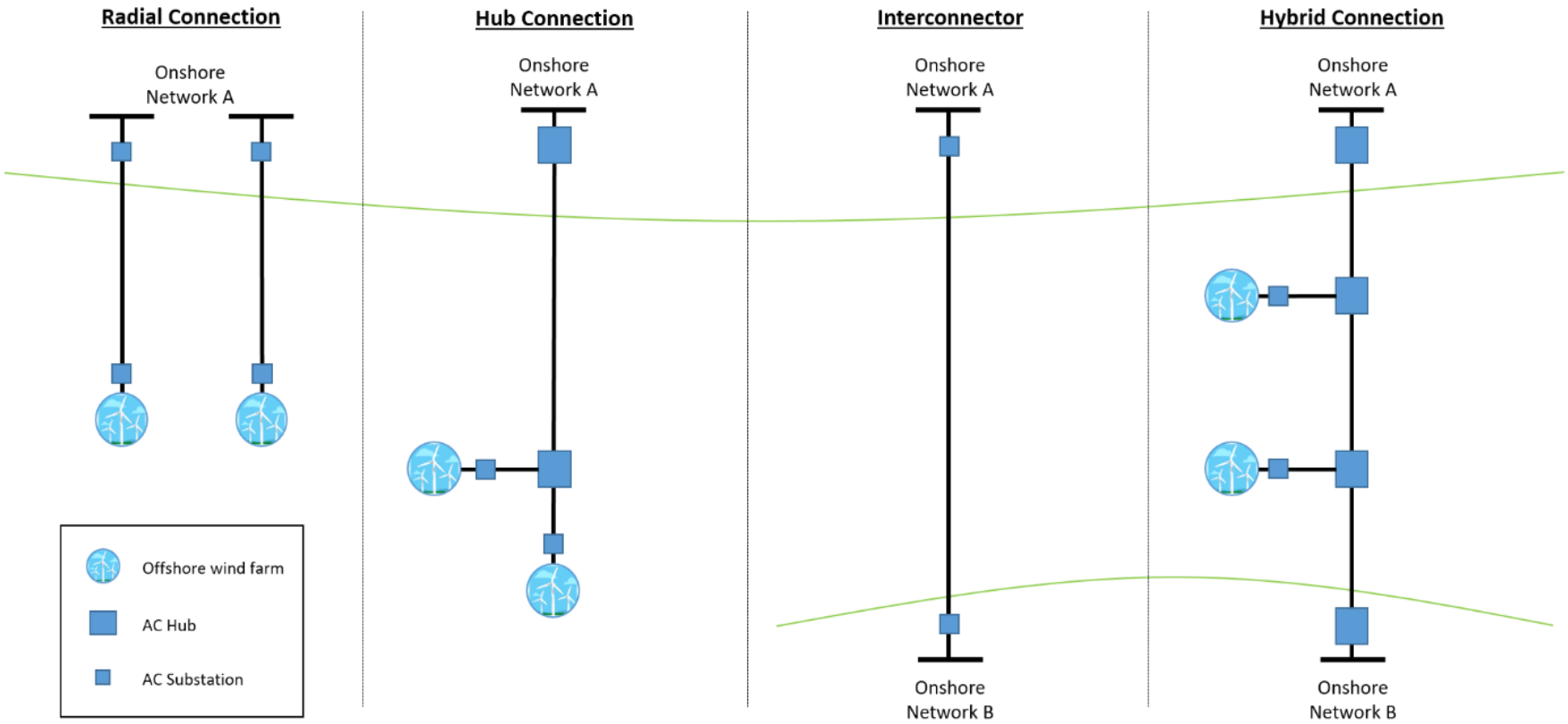
“Identify regulatory issues affecting design, deployment & utilisation of offshore networks in the UK”

- Via overview of high level regulatory models
- Comparison with practices in other countries across Europe

1. https://ore.catapult.org.uk/work-with-us/our-collaborations/electrical-infrastructures-research-hub/

Types of Offshore Network

4 main configurations options available for offshore networks



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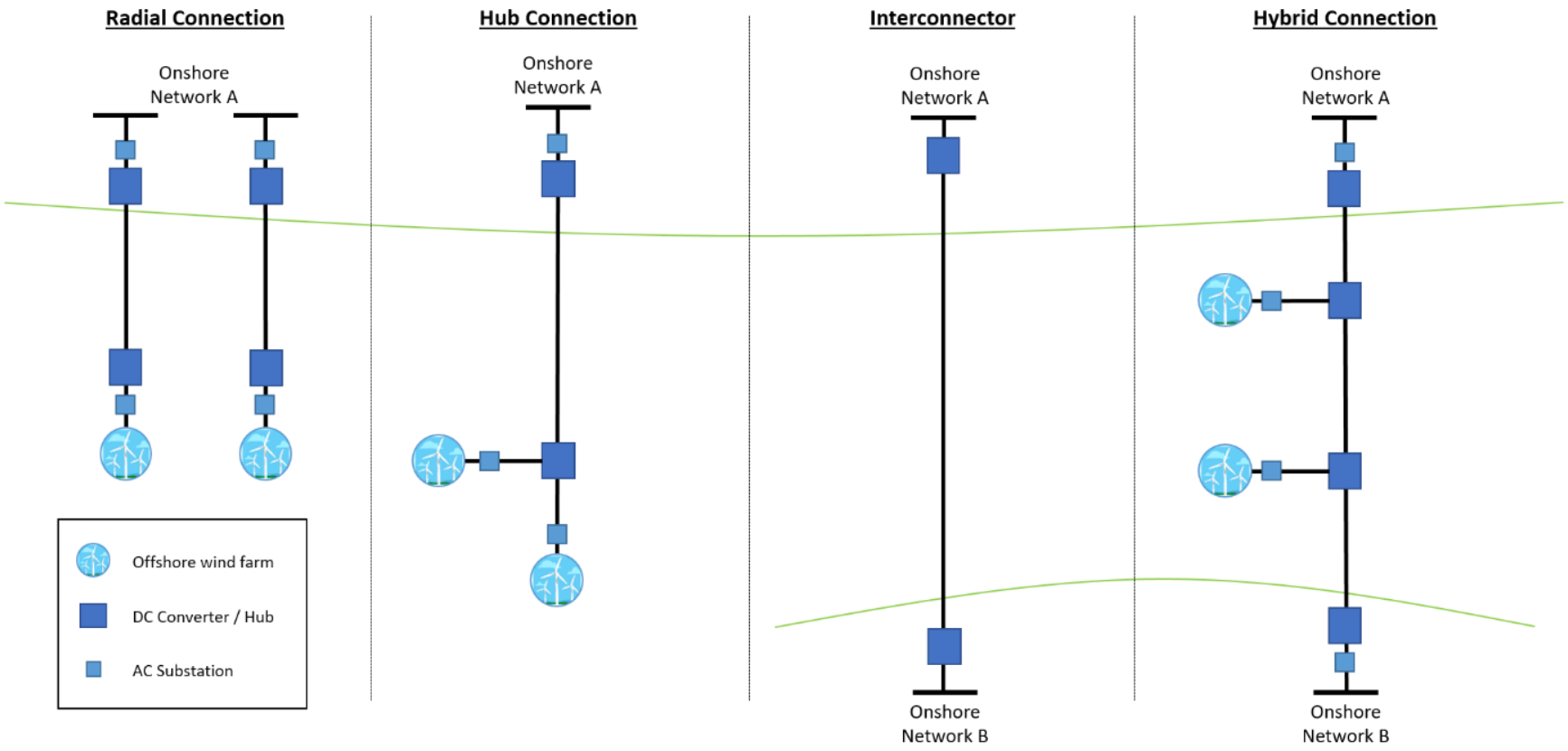

Types of Offshore Network

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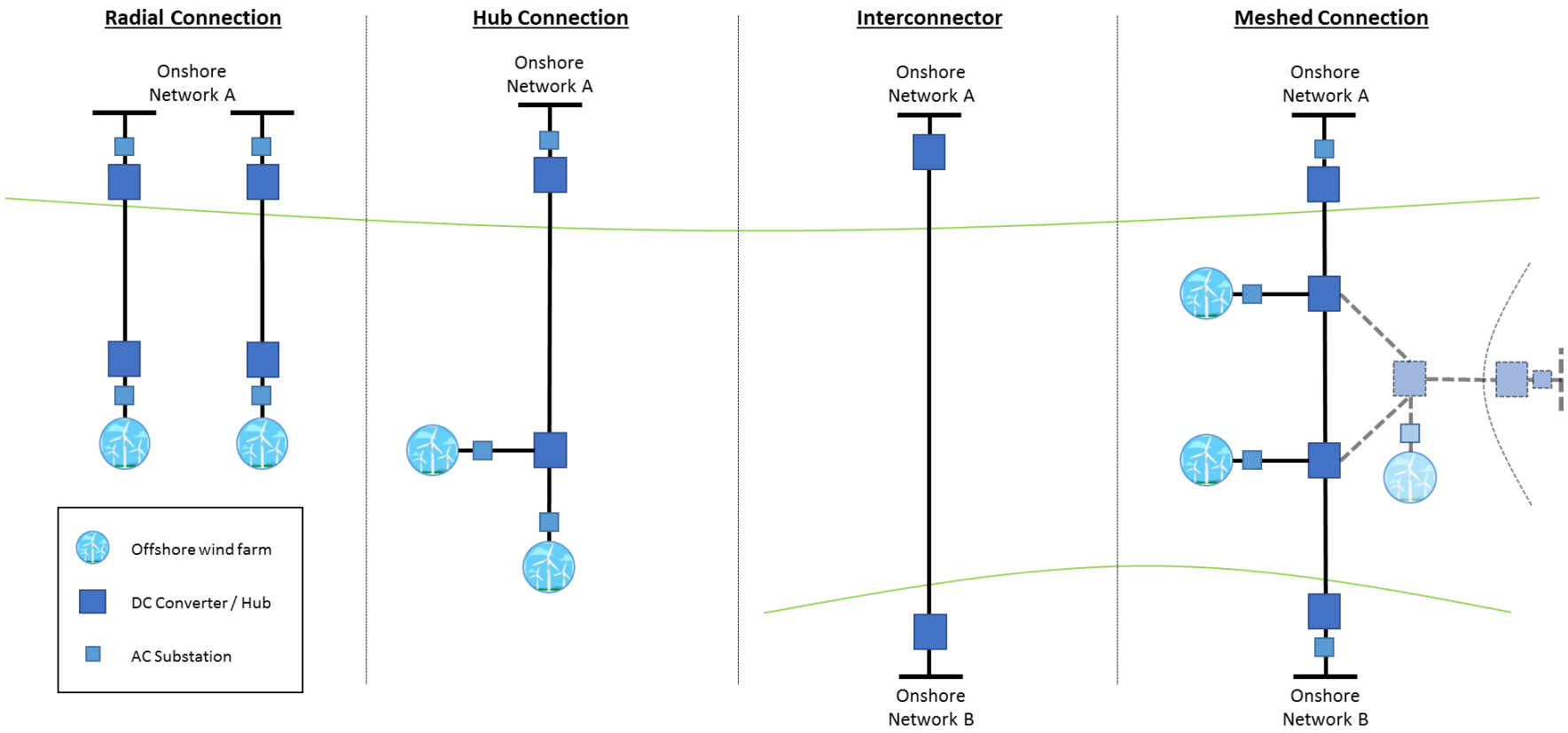


Regulatory Regimes - Overview

Three main possibilities for offshore transmission asset (OTA) development

Developer led approach

- Offshore wind farm (OWF) developer takes responsibility for development and operation of OTA's
- Remuneration for OTA factored into the OWF tender process

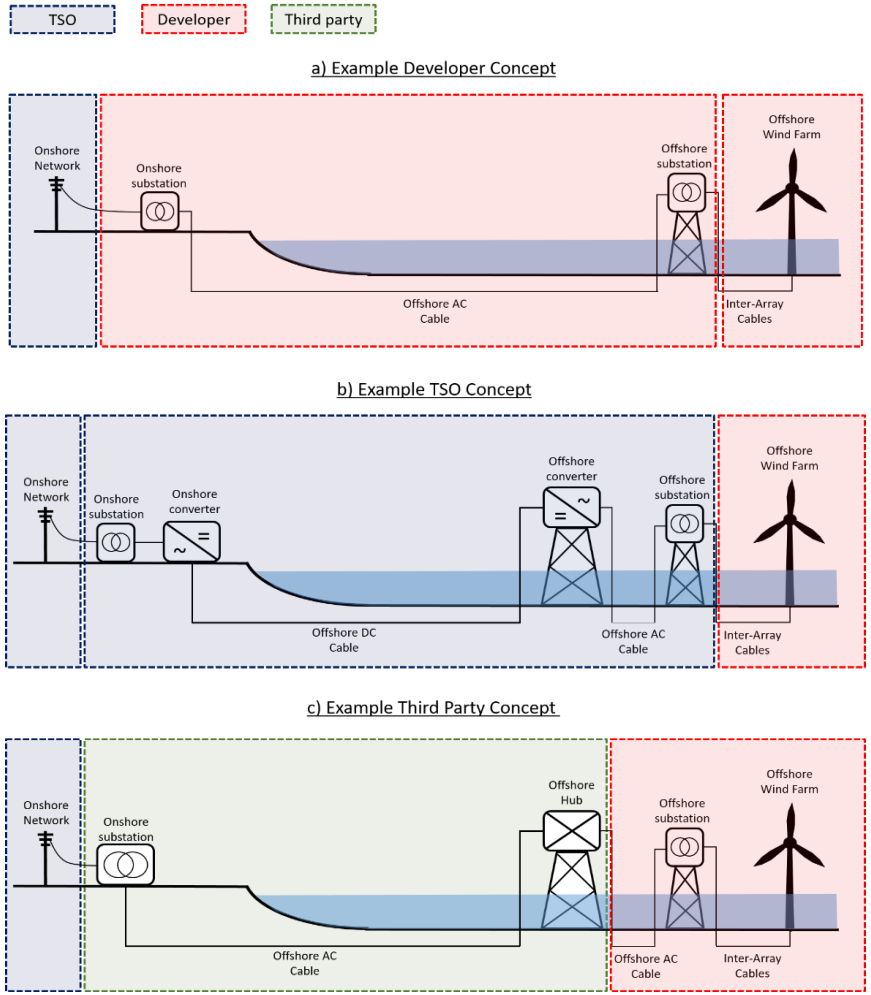
TSO led approach

- Transmission system operator takes responsibility for development and operation of OTA's
- OTA part of TSO's regulated asset base

Third Party approach

- A third party takes responsibility for development and operation of OTA's
- Separate tender for OTA development

Should be noted that build and operation phase can be separated with possibility for hybrid approaches e.g. UK OFTO regime



Qualitative comparison of different regimes

Criteria	Developer led approach	
	Pros	Cons
Planning & Design	✓ Co-ordinated development of OWF & OTA's ✓ allows bespoke solutions ✓ Harmonised interface design ✓ Well suited to radial approach	× Little incentive to consider future system requirements / long-term planning × Less suited to hub or hybrid approaches × Still reliant on TSO for onshore reinforcements
Project Finance	✓ Flexible finance structures available - commercial entity ✓ Tender process gives high incentive to minimise CAPEX & drive down costs	× Higher cost of capital than state backed TSO's
Project Construction	✓ Single entity development of OWF & OTA's ✓ Lower interface risk ✓ Lower delay risk	× Transmission infrastructure non-core business function × Higher cost, lower efficiency build than TSO
Project Operation	✓ OWF Developer incentivised to deliver high availability of OTA ✓ O&M can be co-ordinated across OWF & OTA asset fleet	× Increased response time to grid outages possible due to OTA / onshore TSO interface

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Qualitative comparison of different regimes

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Criteria	TSO led approach	
	Pros	Cons
Planning & Design	✓ **Enables holistic approach to offshore network planning** ✓ **Better suited to hub or hybrid approaches** ✓ Co-ordinated design can minimise overall OTA investment vs multiple individual projects ✓ **Potential for standardised designs & economies of scale** ✓ Integration with onshore grid reinforcements	× **New, more complex designs have higher delivery risk** × Interface between OWF & OTA × **Standardisation can stifle innovation**
Project Finance	✓ Government supported TSO has lower cost of capital ✓ Single entity with secure project pipeline can minimise procurement costs	× **Monopoly approach - low cost pressure, lack of incentive to minimise costs**
Project Construction	✓ **Can co-ordinate onshore reinforcement work with OTA development**	× **Interface risks between OTA & OWF** × **Risk of delays, stranded assets, financial penalties**
Project Operation	✓ TSO has large asset base and standardised equipment so can lower OPEX costs ✓ Reliability incentivised via reward/penalty system but dependent on regulatory model and criteria set	× Argument that costs can be partially socialised so lower incentive to maximise availability

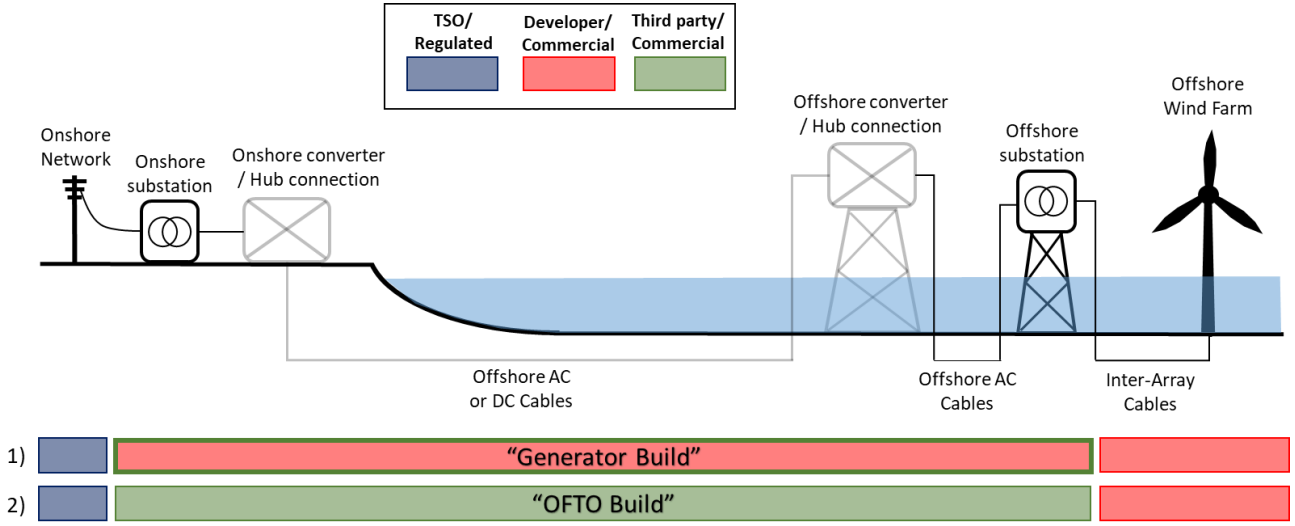
Qualitative comparison of different regimes

Criteria	Third Party approach	
	Pros	Cons
Planning & Design	✓ **Depends on the specifications of the tender – potentially suitable for radial, hub or hybrid approaches**	× **Additional interface - OWF : OTA : TSO**
Project Finance	✓ Flexible finance structures available - commercial entity ✓ **Tender process gives high incentive to minimise CAPEX & drive down costs**	× Higher cost of capital than state backed TSO's
Project Construction		× **Interface risks between OTA & both OWF & TSO** × **Risk of delays, stranded assets, financial penalties**
Project Operation	✓ Reliability incentivised via reward/penalty system but dependent on regulatory model and criteria set	

Country Comparison - UK

Competitively tendered OFTO regime

- Owner and operator of offshore transmission assets in GB is a separate entity (OFTO)
- “Generator build” option
  - OWF developer has option to build OTA but must sell to OFTO after completion
  - Only option used to date
- “OFTO build” option
  - If OWF developer declines to build the OTA a new tender process would be initiated

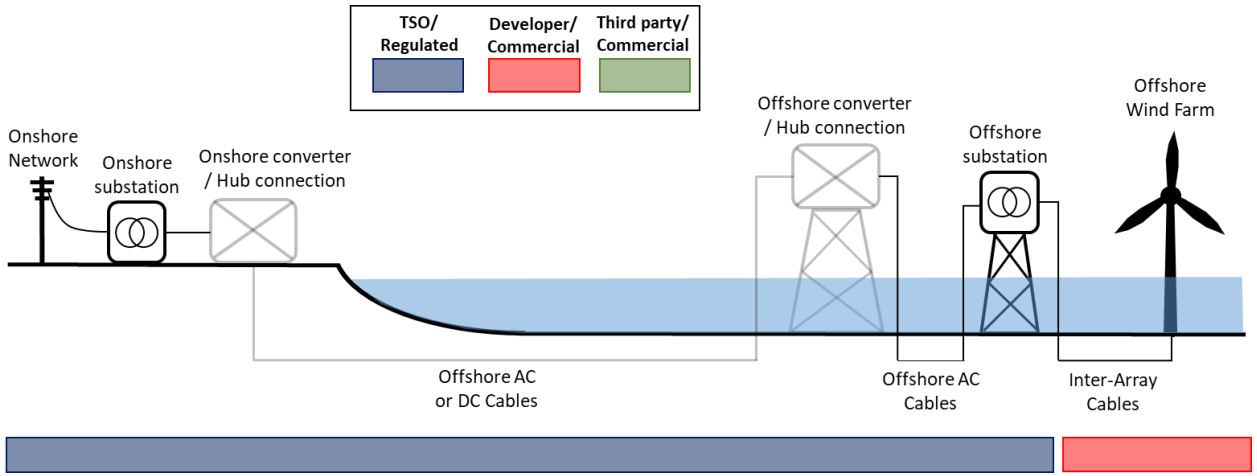


- Only radial developments deployed to date
- Clustering/hub connection possible but subject to single entity success in tender process
- Hybrid connection difficult under OFTO model – legal & regulatory barriers
  - OFTOs & interconnectors treated as separate legal entities
  - Different subsidy regimes

Country Comparison - Netherlands

TSO Monopoly on OTA development

- Since 2015 TenneT have operated as “TSO at Sea”
- Grid connection takes place at OWF
  - TenneT fully responsible for building “Grid at Sea”
- Motivated by co-ordinated OWF development
  - Centrally planned roll-out
  - Standardised 700MW design
  - Opportunity to cluster / share assets

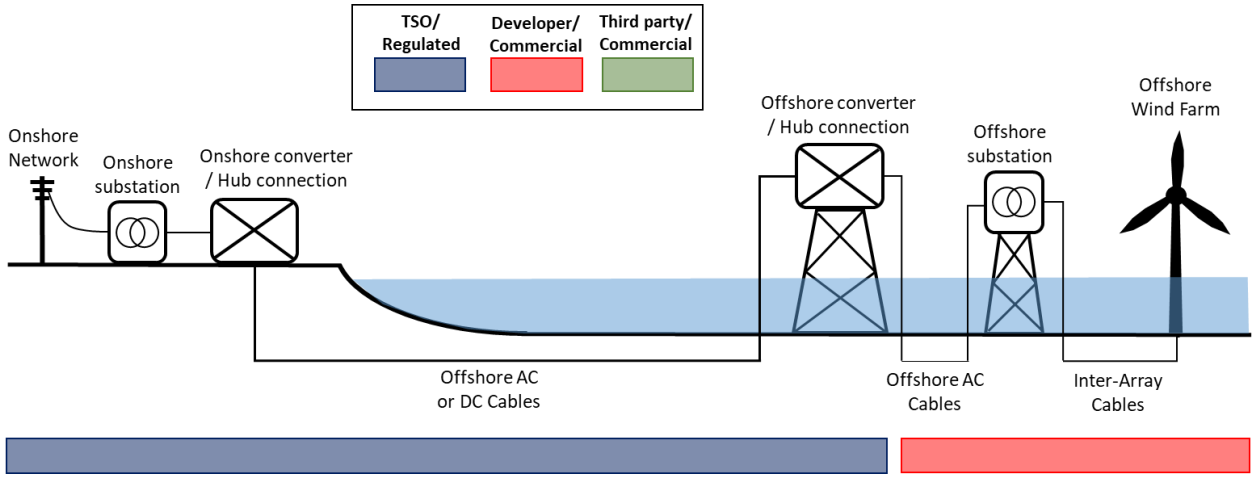


- Largely radial developments with some co-ordination
- Hub connections possible but not implemented
- Hybrid connection should be possible under existing regime with few legal / regulatory barriers
  - TenneT own both interconnectors and “Grid at Sea” so fewer legal barriers to merger

Country Comparison - Belgium

TSO Monopoly on OTA development

- Elia responsible for all OTA development
- Modular offshore Grid (MoG) concept
  - Elia build “plug at sea” offshore hub and transmission link to shore
  - OWF developers responsible for connection to offshore hub
- Motivated by co-ordinated OWF development
  - Centrally planned roll-out to minimise total infrastructure

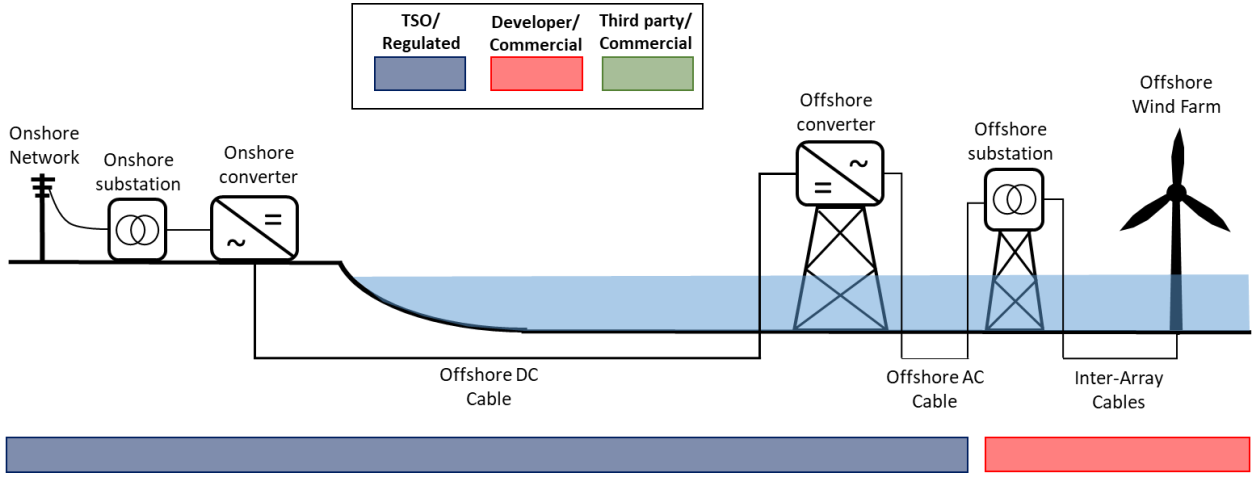


- Hub connections currently being implemented
- Hybrid connections potentially possible under current regime
  - Although 50% TSO ownership rule for interconnectors at present that may be tested in multi-terminal offshore grid scenario

Country Comparison - Germany

TSO Monopoly on OTA development

- TenneT (North Sea) and 50Herz (Baltic Sea) responsible for OTA development out to OWF substations
- TenneT 1st to make use of large scale HVDC deployment in hub design approach
  - 9 operational HVDC platforms and more under development
- Motivated by co-ordinated OWF development and long distances from shore
- Experienced a number difficulties with project delays / stranded assets / interface issues



- HVDC hub connections already implemented
- 1st Hybrid connection under construction with Denmark
- Kriegers Flak Combined Grid Solution
  - 400MW link between existing German and Danish OWFs
  - Facilitated by TSO – TSO co-operation, no third party ownership barriers

Country Comparison - Denmark

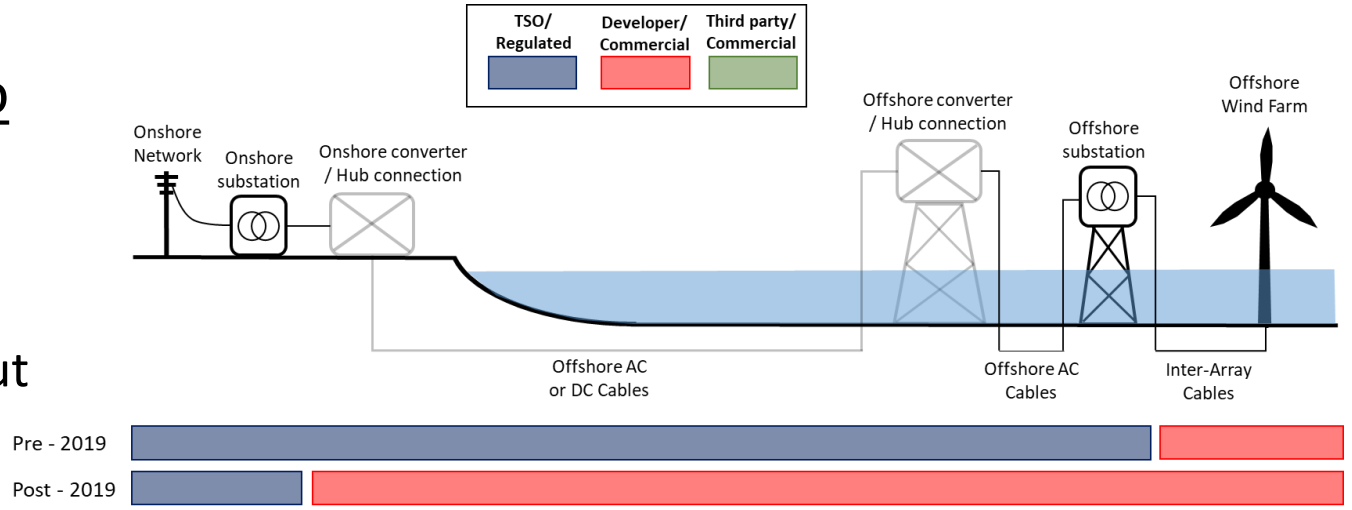
TSO build model to date but switching to Developer build model

Pre - 2019

- Energinet responsible for OTA development out to and including OWF substations

Post - 2019

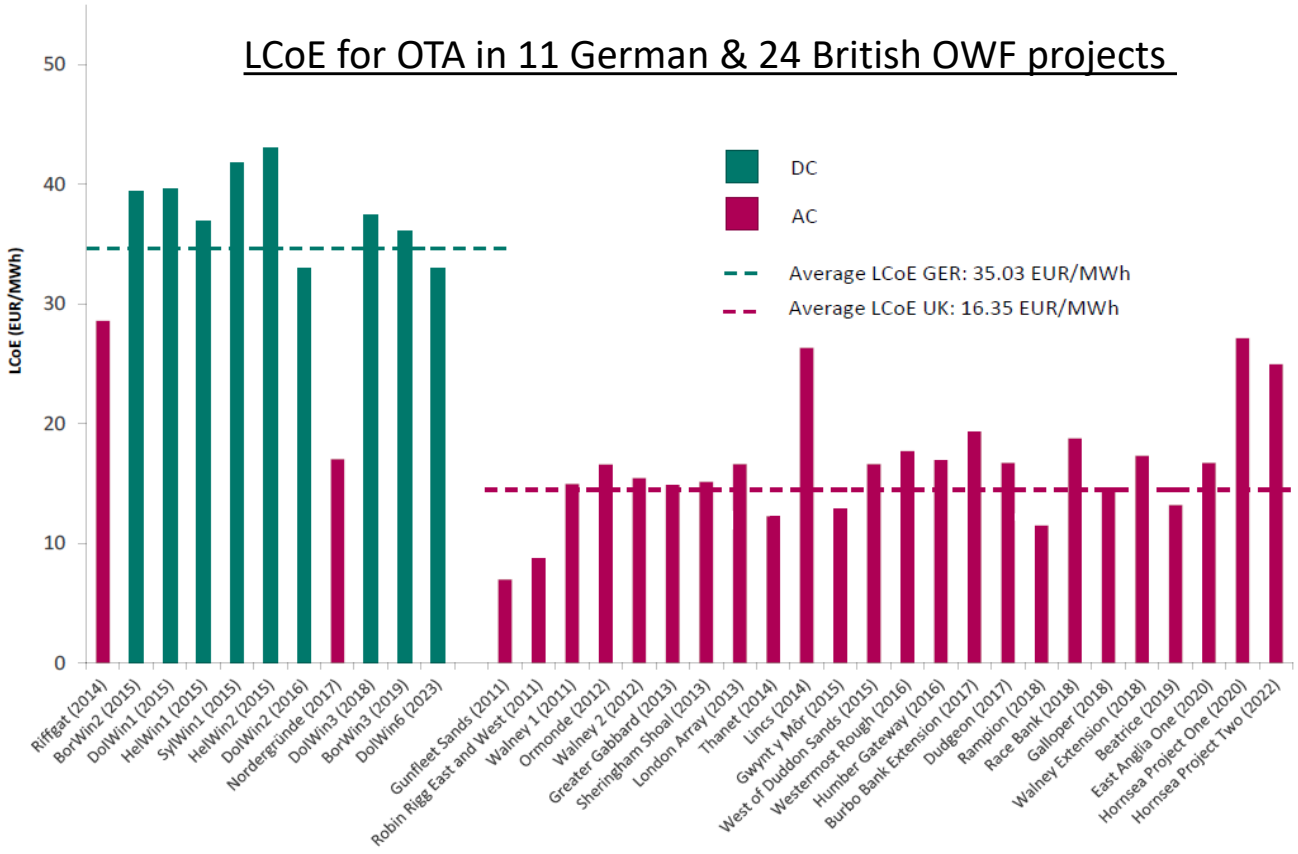
- Tender for new OWF development mandates change to developer build model for OTA's
- Motivated by perception that increased competition will drive faster and more cost effective solutions
  - "Listened to industry"



- Only radial developments deployed to date
- Clustering/hub connection possible within pre-2019 framework but little opportunity to date
- Hybrid grid being implemented under TSO build model
  - Kriegers Flak Combined Grid Solution
- Greater barriers to future replication under Developer build model

Cost Comparison of Regulatory Regimes

- German report by DIW ECON commissioned by Ørsted Offshore wind:



Source: DIW ECON – Market design for an efficient transmission of offshore wind energy, 2019

- Compares GB vs German offshore transmission asset (OTA) developments
- Levelised cost of energy calculation – much higher costs found for German developments
- Even after correcting for distance, technology & other factors still a large gap (€6.7bn to 2030)
- Attribute this to a lack of:
  - i) competition in the regulatory arrangement
  - ii) integration in OWF & OTA development
- Is a comparison between long established near shore HVAC project designs and new far shore HVDC projects really fair?
  - Could natural learning curve drive costs of HVDC options lower in future?

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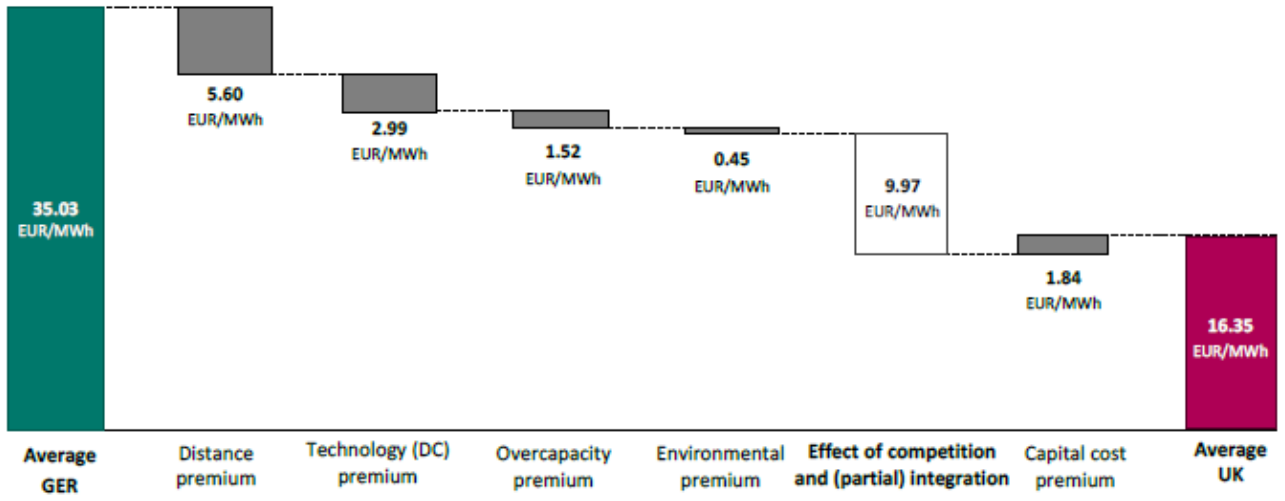
Breakdown of average LCoE difference between Germany and the UK



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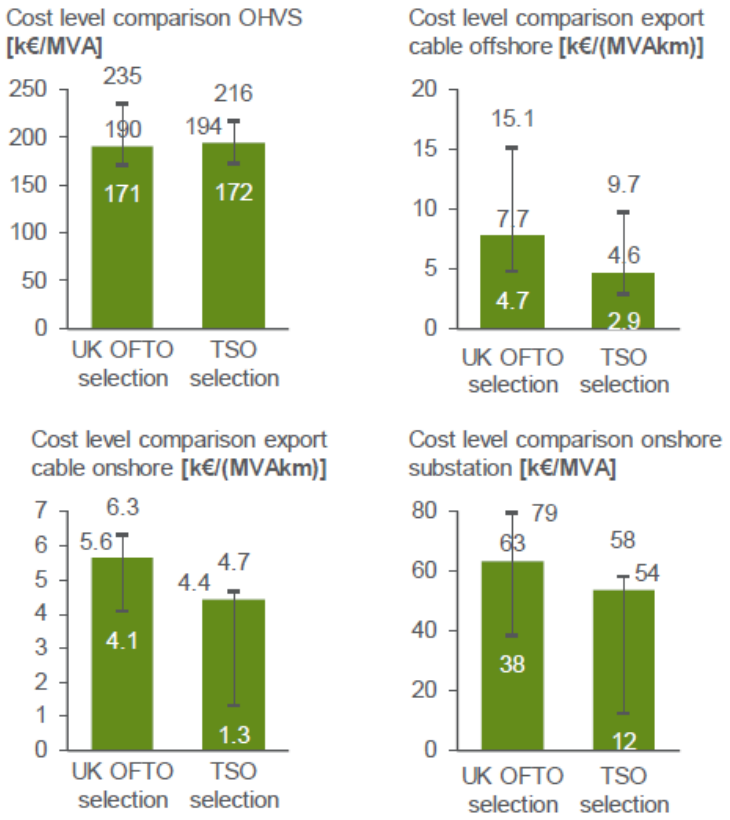
Cost Comparison of Regulatory Regimes

- Dutch report by Navigant commissioned by TenneT & RTÉ:

Figure 10. Cost Level Comparison Results (CAPEX only)



Source: Navigant analysis

- Compares six GB OFTO projects vs FR, DK, NL, BE offshore transmission asset developments
- Sub-system level CAPEX comparison made between a range of comparable projects
  - Offshore substation, onshore substation, offshore cable, onshore cable
- UK OFTO projects deemed to be more expensive with higher costs for export cables and onshore substations in particular
- Conclude that TSO development model can be delivered at lower cost than OFTO model even before considering wider system benefits of holistic approach
- Some limitations to approach
  - Relatively small sample of projects
  - Excludes German examples
  - Max GB offshore substation capacity 400MVA vs 800MVA for Dutch comparison. Economies of scale could factor

Source: Navigant – Connecting Offshore Wind Farms: a comparison of offshore electricity grid development models in Northwest Europe, 2019

Conclusions

- GB OFTO model successful to date
  - Competitive tenders seen to drive down costs but tailored to radial approach
- TSO model allows more co-ordinated approaches
  - Surely required to best facilitate 2030 or 2050 UK OWF capacity targets
    - 30GW by 2030 (Sector deal) - 75GW (CCC) or 80GW (Wind Europe) by 2050
- Is a regulatory model that combines benefits of coordinated planning and high competition possible for future OTA expansion?
  - Needs to ensure certainty & visibility of future OWF pipeline
  - Centrally planned and guaranteed development zones
  - Could “OFTO Build” model be applied to full development zones?
- Co-ordination at national level only 1st Step
  - PROMOTioN project has looked at regulatory options for meshed offshore grid
  - Choice between centrally planned (single regulator/single TSO) and nationally driven approaches with co-operation