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The Potential Benefits of Direct-to-Shore MVDC Connections for Offshore Wind

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Abstract

Can Medium Voltage DC technology remove the need for a substation offshore? TNEI Services, in partnership with Scottish Power and Scottish Enterprise, have performed exploratory research into the prospective market for MVDC technology, via stakeholder engagement and technical case studies. This paper highlights the potential for cost reductions if a large offshore wind farm was to use direct to shore MVDC transmission at 60 kV. A cost benefit model has been prepared which considers capital and operational costs using the latest available information. The results of this modelling are supported by wider market analysis and engagement with industrial and academic stakeholders.

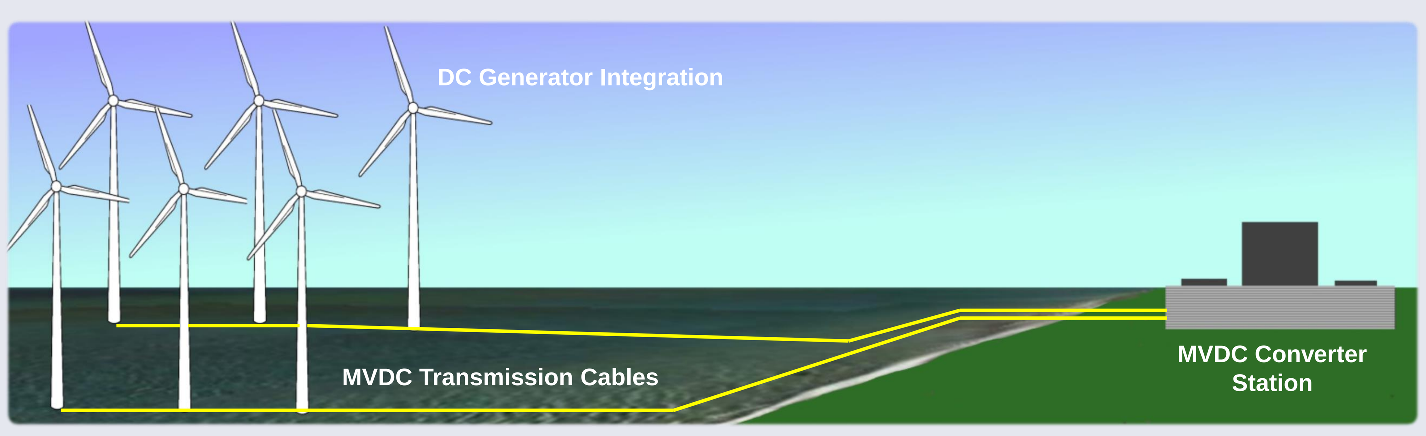
Objectives

The objectives of this work were as follows:

•To assess the lifecycle costs of a 1 GW offshore wind farm, using multiple connection topologies (including direct MVDC) and a variable transmission distance;

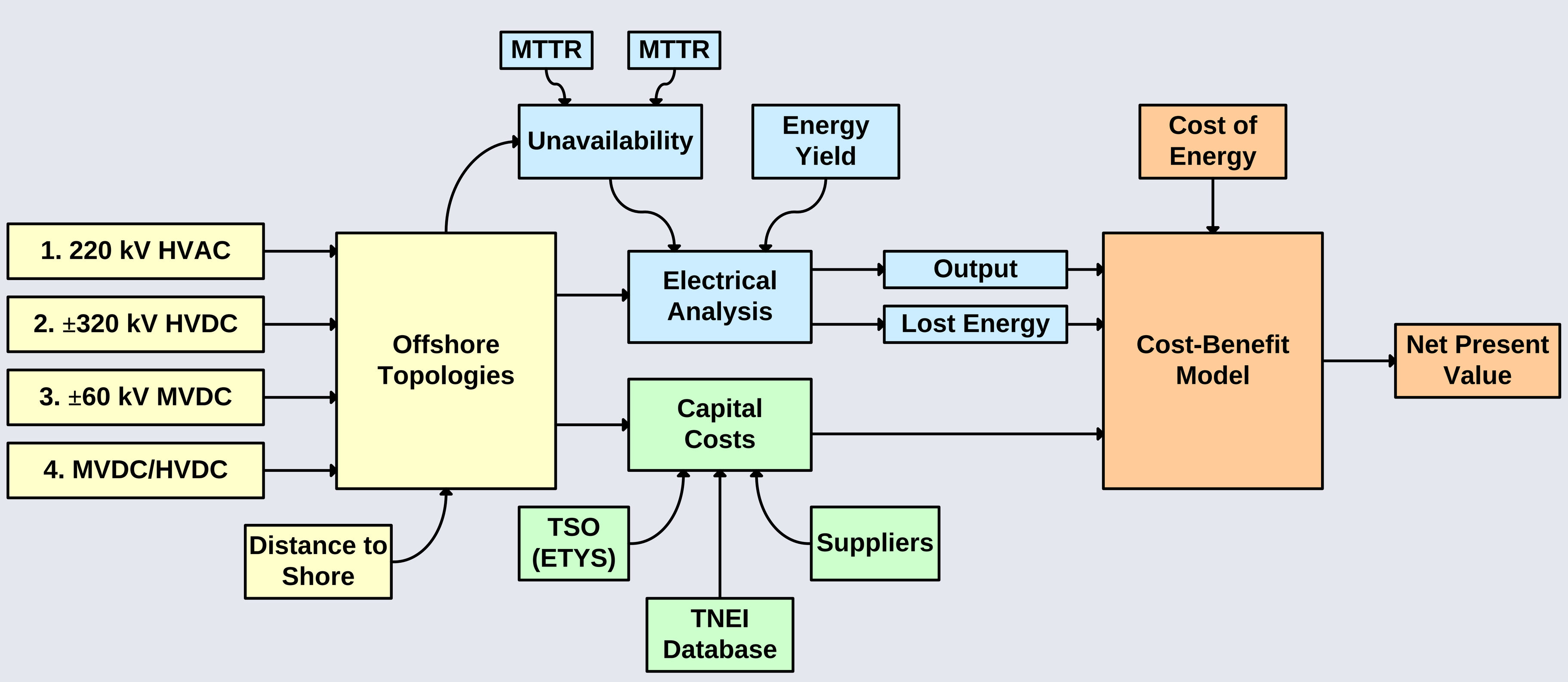
•To investigate current opinions of MVDC technology within industry and academia;

•To determine if direct MVDC transmission for offshore wind, with no offshore platform, is feasible and whether there is an industry appetite



Methods

The cost benefit modeling approach is outlined in the figure below:



1. HVAC:

Conventional 220 kV HVAC transmission with 33 kV AC arrays, two offshore platforms

2. HVDC:

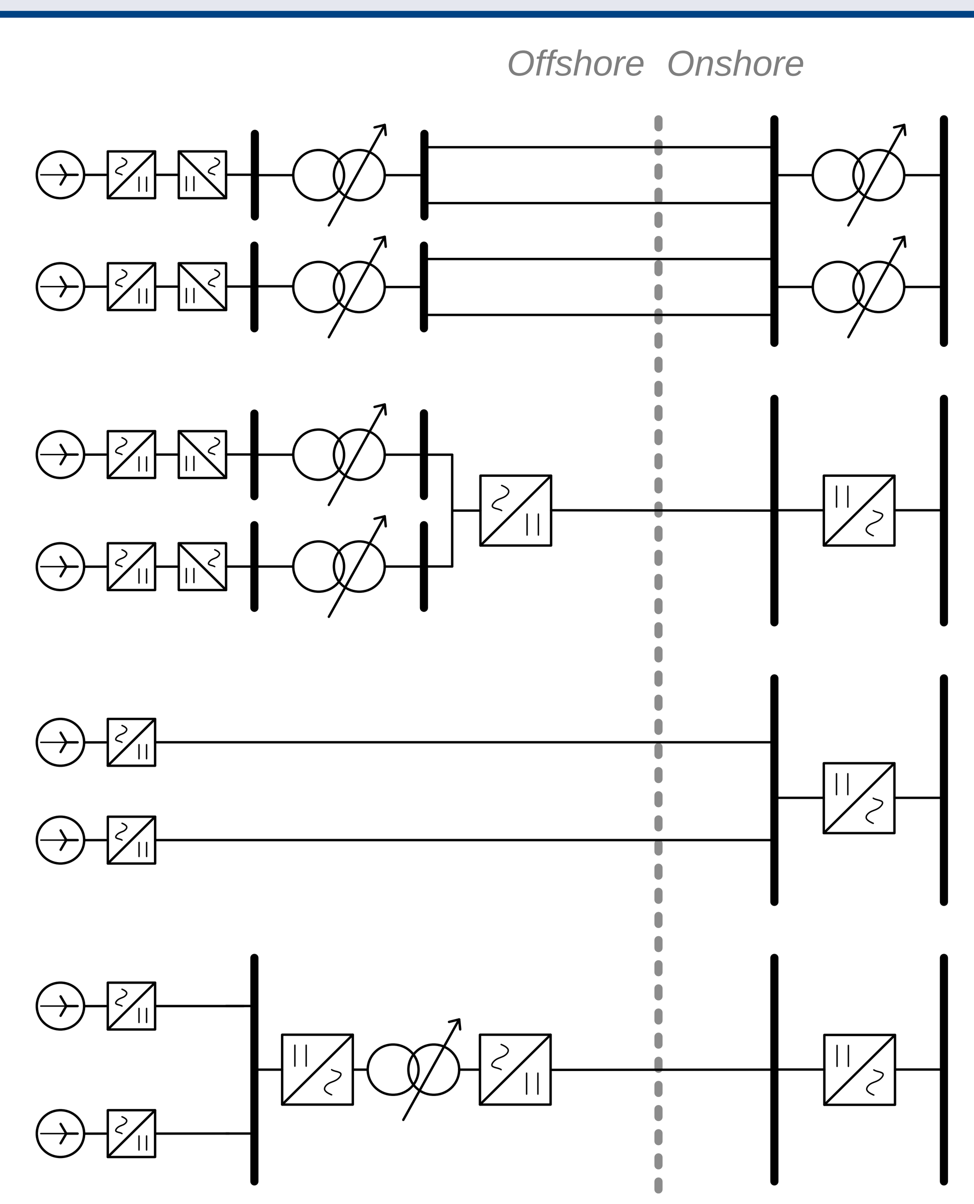
Conventional ±320 kV HVDC transmission with 33 kV AC arrays, three offshore platforms

3. Direct MVDC:

±60 kV MVDC transmission with ±60 kV MVDC arrays, no offshore platforms

4. MVDC/HVDC:

±320 kV HVDC transmission with ±60 kV MVDC arrays, three offshore platforms

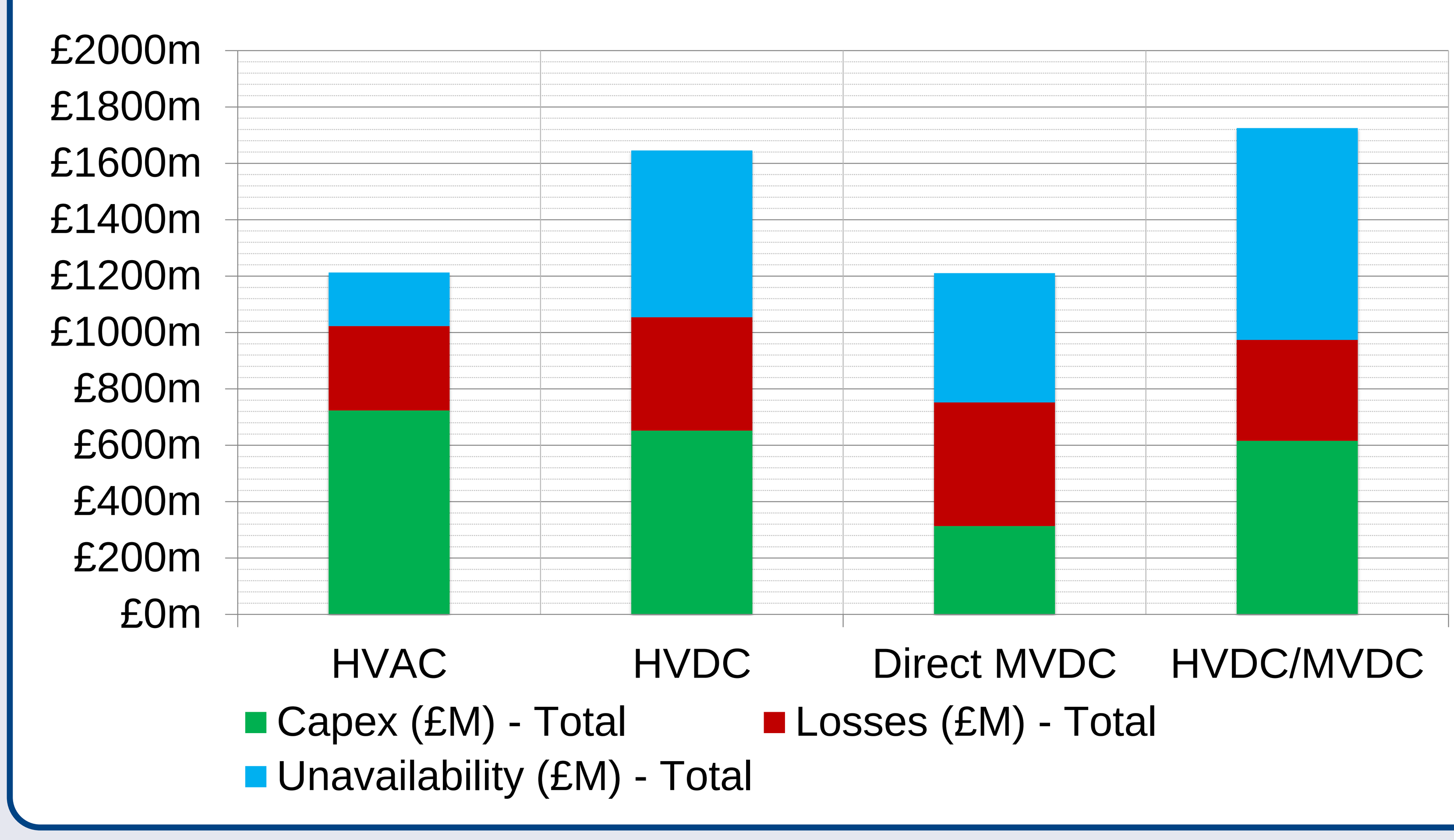


It has been assumed that:

- DC systems can be protected using a single breaker with AC disconnectors
- Generator DC integration technologies are readily available

Results

Comparing Electrical System Costs for 105 km, £120 /MWh



Breakeven Distances for Direct MVDC Transmission		Capital Cost & Availability		
		Best Case	Mid Case	Worst Case
Cost of Energy	£140/MWh	119 km	153 km	153 km
	£120/MWh	72 km	105 km	153 km
	£100/MWh	50 km	61 km	105 km

Conclusions

•**Capital Cost:** Direct MVDC has lowest capital cost in every case. This could reduce project risk

•**HVDC:** Converter unavailability is very costly, which makes MVDC looks like a better option than HVDC at longer distances

•**Lifecycle Costs:** No matter what sensitivities are explored, there is always a breakeven point where MVDC looks like the best option

•**Improvements:** Using redundant rings and improving DC protection would reduce availability costs. Larger circuits, or higher voltages, could reduce losses.

Stakeholders	Summary of Responses
Developers	Not much interest at the moment. Technology needs to be proven before it is considered, especially generator integration.
Converter Suppliers	Expertise is there, but won't provide off-the-shelf products without market need. Converters & DC Protection are both critical.
Turbine Suppliers	Minimal activity, some R&D projects. Unlikely to change Unless the market demand MVDC collector systems.
Academics	Opinions vary between DNOs, but some think the technology is ready. Demonstration projects could help de-risk converters.
Network Operators	Technical barriers are less severe than market barriers. Academia has focused on HV and LV but interest in MVDC is increasing.

References

1. Power Networks Demonstration Centre. (2013). "Investigation into the Development of a MVDC Demonstration Project".

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