

An offshore wind farm is shown against a cloudy sky. A central wind turbine is the focal point, with several bright yellow, glowing lines radiating from its nacelle towards other turbines in the distance, symbolizing a network or energy flow. The sea is visible in the foreground.

Balancing and optimizing the electricity grid

*Holistic approach to offshore network planning*

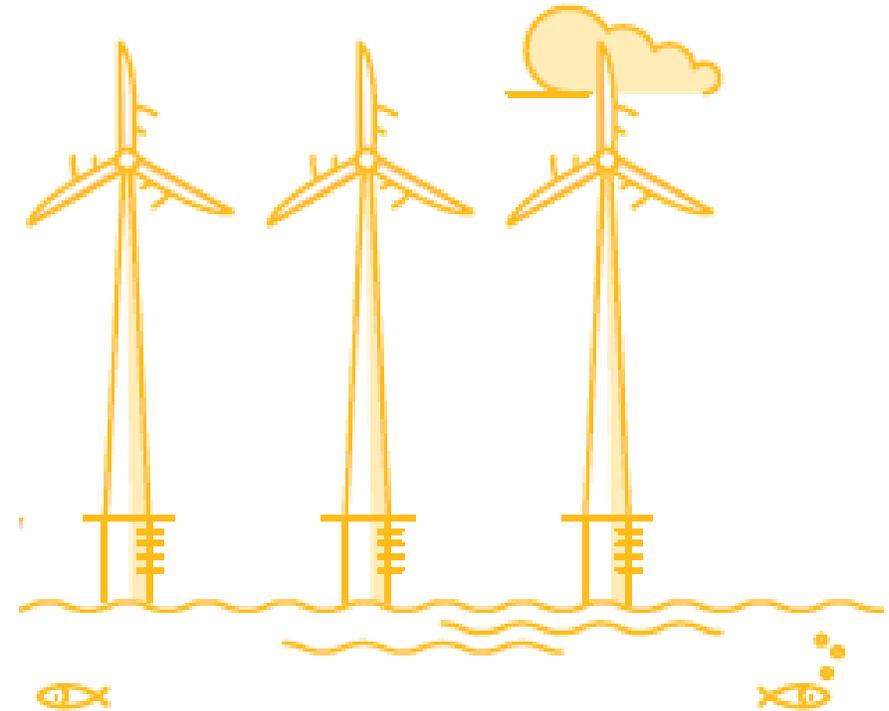
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HUB2021

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# Great Britain Net Zero Targets

- The UK government has a target of **net zero** greenhouse gas emissions target by **2050**
- **40GW** of offshore wind is needed in Great Britain by **2030**
- Between **83** and **88 GW** of network connected offshore wind is needed by **2050**
- Only **10 GW** of offshore wind has been installed in Great Britain – requiring the pace at which that was delivered to be more than quadrupled to meet net zero targets



# What is Offshore Coordination?



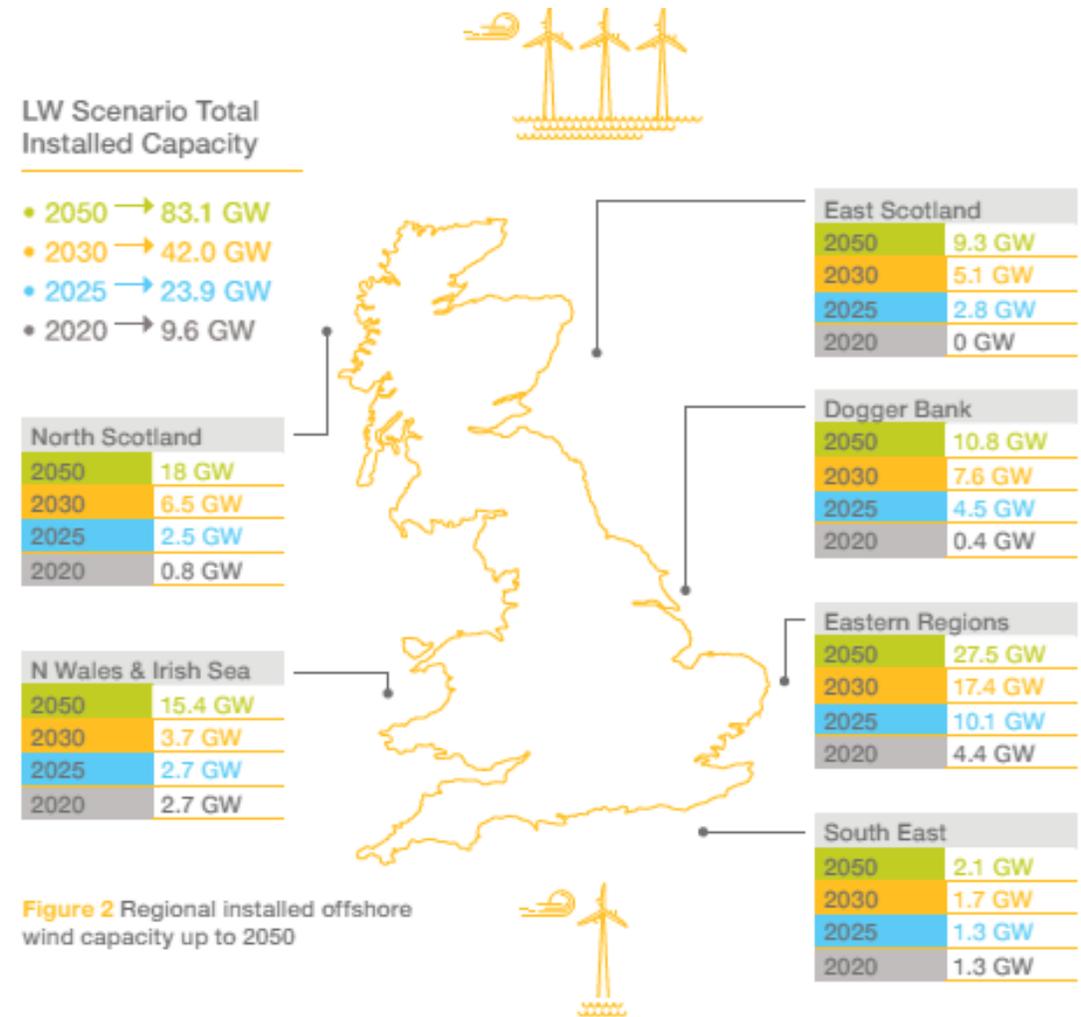
# Overview Integrated vs Status Quo

| Status quo - Project by project transmission build up  | Integrated - Transmission asset sharing enabled   |
|--|---|
| <ul style="list-style-type: none"><li>• Requirements for each project considered separately</li></ul>                      | <ul style="list-style-type: none"><li>• Takes account of possible future requirements</li></ul>   |
| <ul style="list-style-type: none"><li>• Only considers point-to-point offshore network connections</li></ul>               | <ul style="list-style-type: none"><li>• Considers a range of connection options including multi-terminal/meshed HVDC and HVAC options</li></ul> |
| <ul style="list-style-type: none"><li>• Individual project optimisation and transmission (HVAC or HVDC) decision</li></ul> | <ul style="list-style-type: none"><li>• Considers whole system optimisation and transmission technology decisions</li></ul>                     |
| <ul style="list-style-type: none"><li>• Onshore and offshore network designs are considered separately</li></ul>           | <ul style="list-style-type: none"><li>• Considers effect on onshore system as part of offshore design development</li></ul>                     |
| <ul style="list-style-type: none"><li>• Interconnectors are designed and connected separately</li></ul>                    | <ul style="list-style-type: none"><li>• Possibility that interconnector/bootstrap capacity can be shared by an offshore wind farm</li></ul>     |
| <ul style="list-style-type: none"><li>• Local community impacts are managed on a project-by-project basis</li></ul>        | <ul style="list-style-type: none"><li>• Local community impacts considered on an overall impact basis</li></ul>                                 |

The increased levels of offshore wind mean there will be an increase in onshore infrastructure in all options.

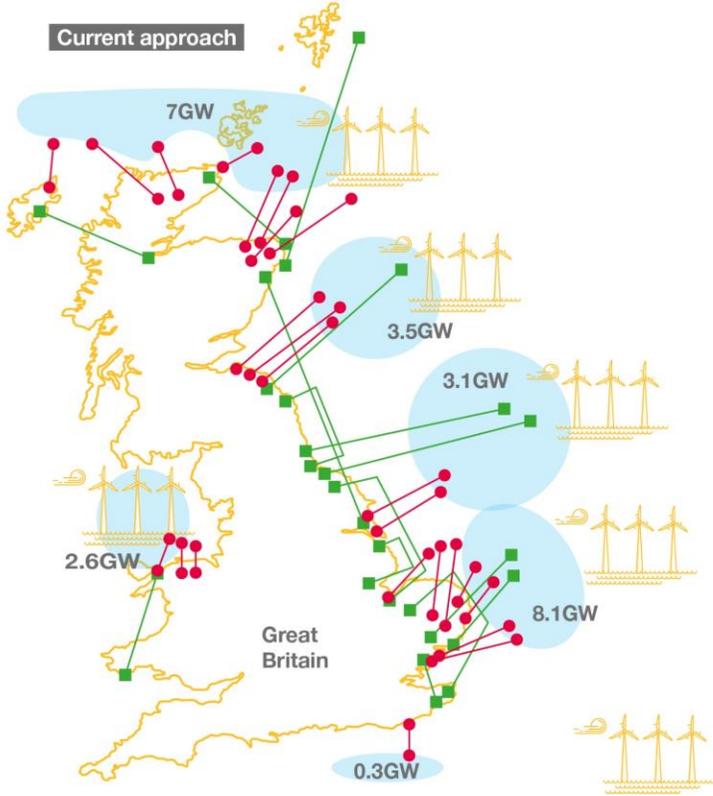
# Overview Integrated vs Status Quo

- **Leading the Way Future Energy Scenario**
  - 40 GW of offshore wind by 2030
  - 83 GW of offshore wind by 2050
  - 22 GW interconnectors in 2030 and 27 GW in 2050
- To perform our analysis, we split the waters around Great Britain into **six regional offshore wind development zones**.

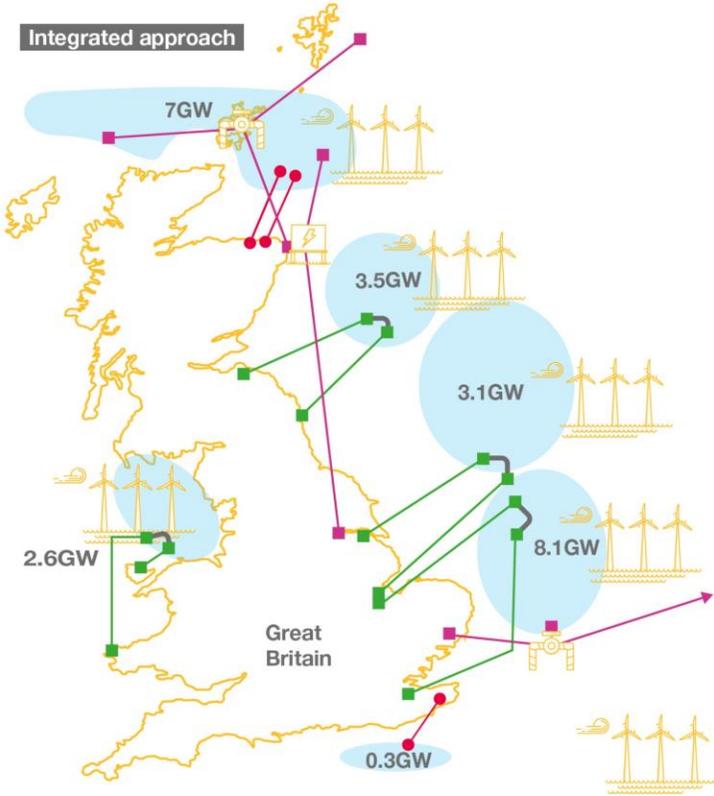


# How it could look in 2030

GB implementation by 2030



Cost: £15 billion  
Total Assets: 149



Cost: £12 billion (-17%)  
Total Assets: 60% reduction

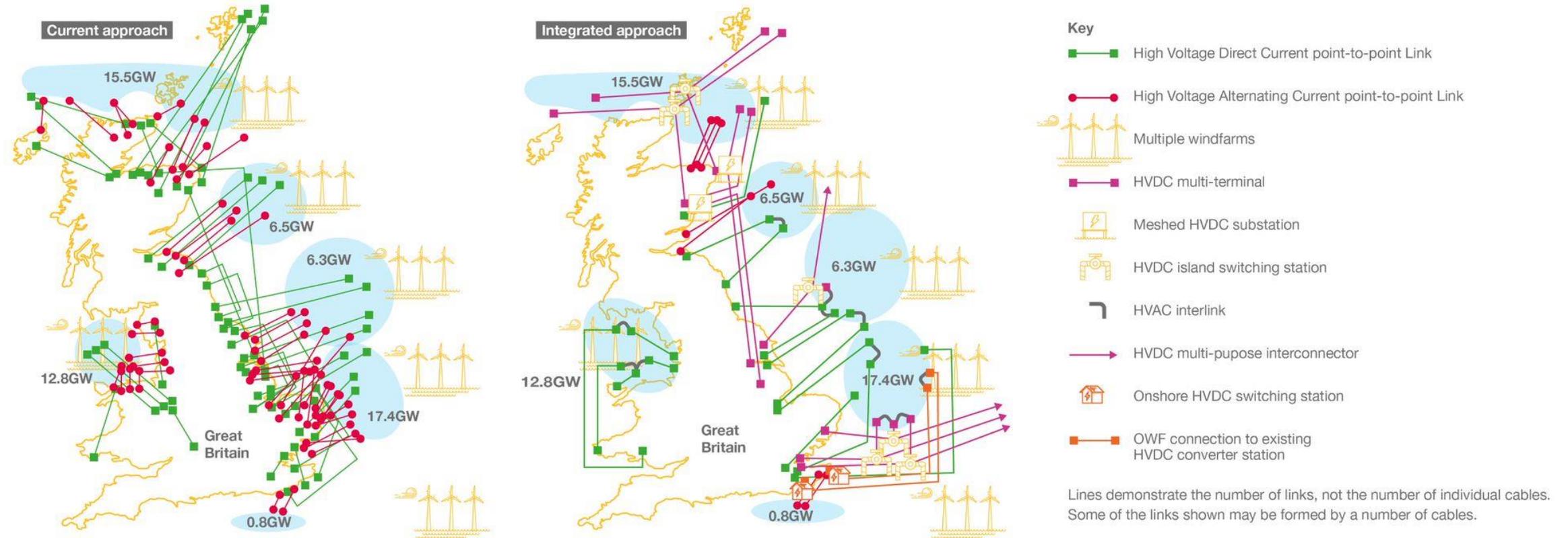
**Key**

- High Voltage Direct Current point-to-point Link
- High Voltage Alternating Current point-to-point Link
- Multiple windfarms
- HVDC multi-terminal
- Meshed HVDC substation
- HVDC island switching station
- HVAC interlink
- HVDC multi-purpose interconnector
- Onshore HVDC switching station
- OWF connection to existing HVDC converter station

Lines demonstrate the number of links, not the number of individual cables. Some of the links shown may be formed by a number of cables.

# How it could look in 2050

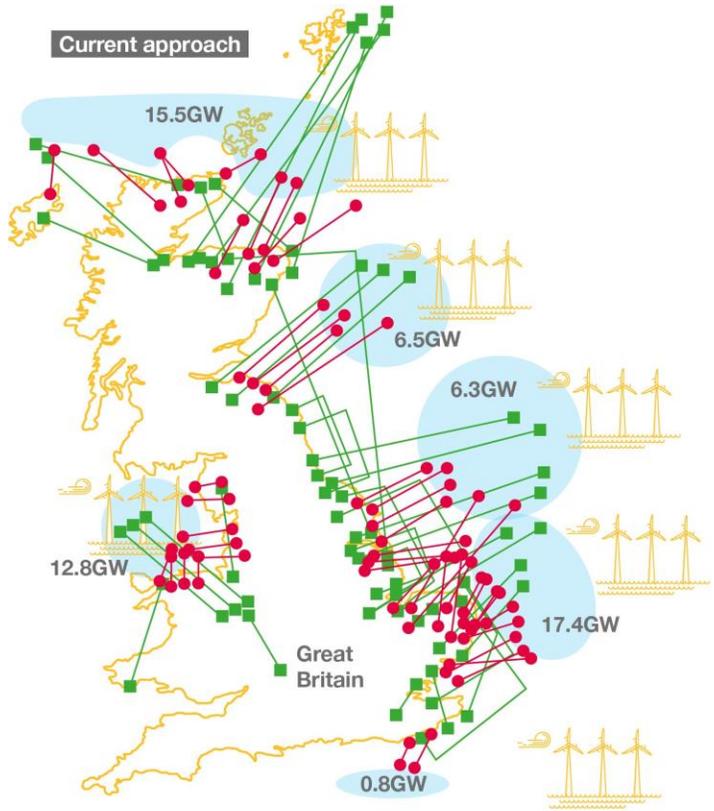
## GB implementation by 2050



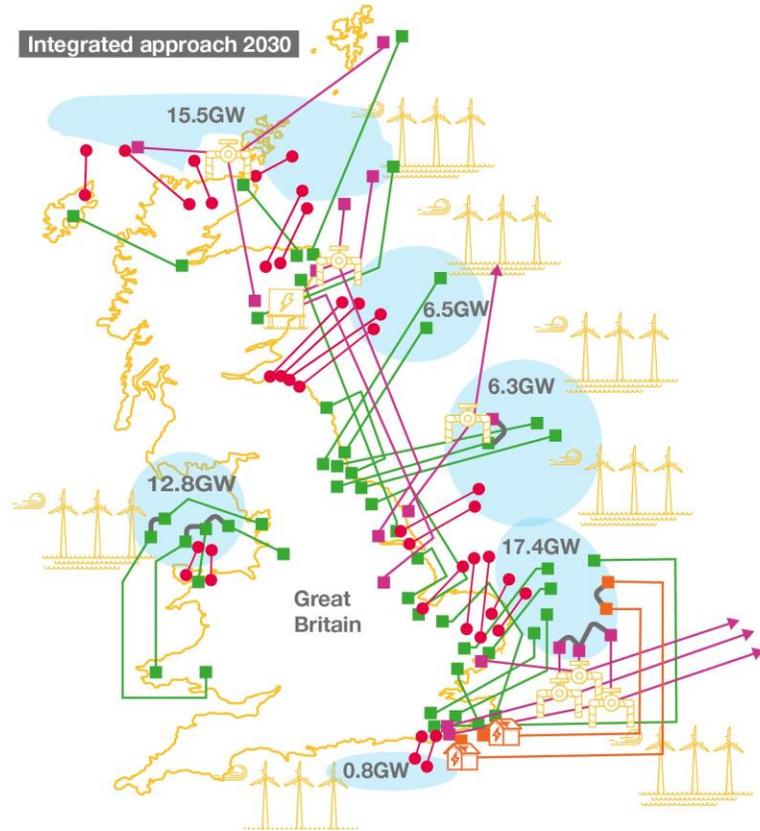
Capex Cost: £29 billion  
 Total Assets: 330  
 Total Landing points: 105

Capex Cost: £23 billion (-18%)  
 Total Assets: 70% reduction  
 Total Landing points: 30

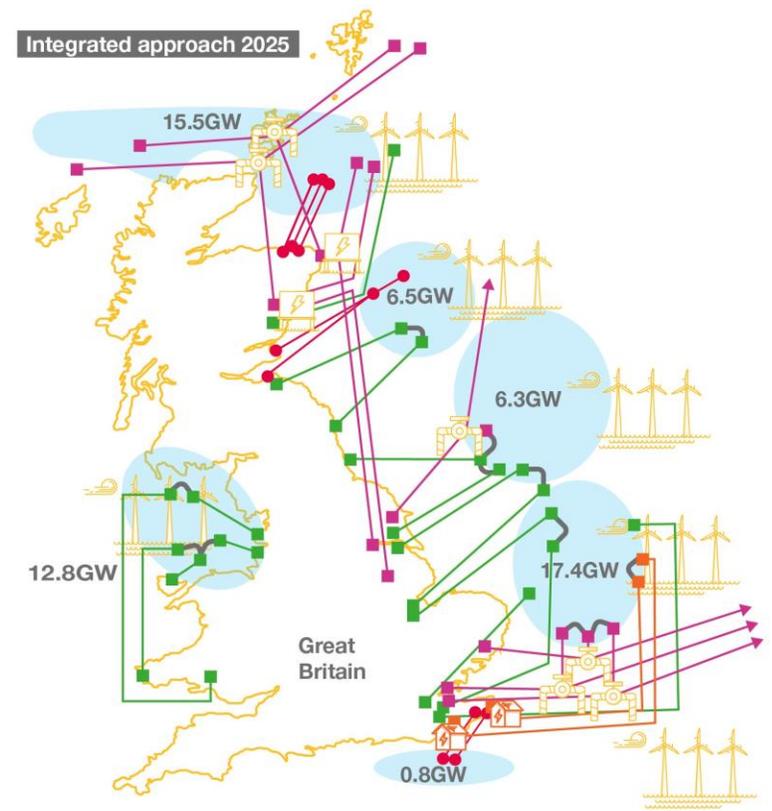
# How it could look in 2050 – Sensitivity Analysis



Capex Cost: £29 billion  
Total Assets: 330  
Total Landing points: 105



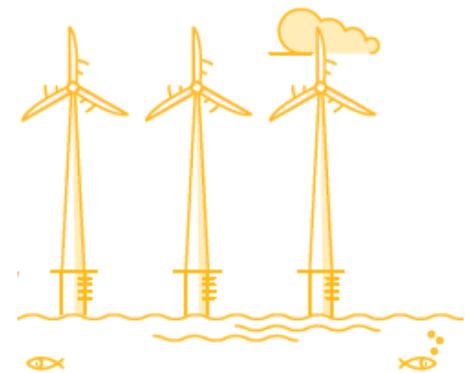
Capex Cost: £27 billion (-8%)  
Total Assets: 40% reduction  
Total Landing points: 60



Capex Cost: £23 billion (-18%)  
Total Assets: 70% reduction  
Total Landing points: 30

# Technology barriers and system risks to achieving the integrated option

- Our work has highlighted key barriers and risks. These can be divided into technology availability and system risks.
- Apart from the highlighted change to the Grid Code, an integrated approach could be implemented without progress on any of these recommendations.

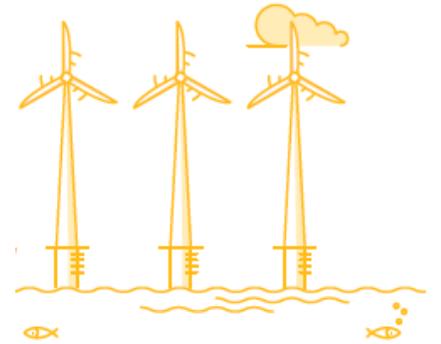


# Technology availability

- There is a need for **HVDC circuit breakers (DCCBs)** to be progress to commercial use in Europe
- DCCBs have been used in three projects in China but not at transmission levels in Europe
- Almost all the HVDC systems in operation today have been developed as point-to-point systems without the use of circuit breakers

## Where?

The Integrated option utilises DCCBs in two locations in Scotland, which we consider the optimal approach for transporting electricity further south.

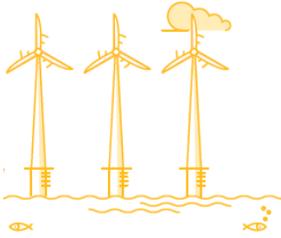


## What happens if they don't progress to commercial use?

However, an integrated design can be developed in alternative ways if DCCBs are not available. If this was the case there would be additional network infrastructure required, coming at an additional cost. This would also have the potential to increase the likelihood of network faults and therefore impact on system reliability and operability.

# Technology continued

- Higher capacity **HVDC submarine and underground cables** need to be brought to commercial use in Europe to enable the power transmission from offshore to onshore at the capacities envisaged in the Integrated option if the change to the SQSS standard is made.
- The proposed Integrated option assumes that individual cables with capacities of **1.8 GW are available by 2040**. Two such cables together in a bi-pole arrangement will allow connections of 3.6 GW. Currently, the highest individual HVDC cable capacity that is widely available is 1.4 GW, with higher capacities limited in supply options.

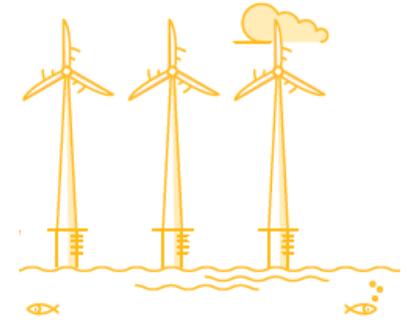


**A targeted innovation strategy and support for early commercial use is required**

**No other material HVAC or HVDC critical technology or asset dependencies that would impact development of an offshore integrated network**

# Impact of System risk on Offshore Integration

In order to deliver the **benefit of the Integrated option** we have identified that some changes are required to technical network codes and standards.



## SQSS

Cost-benefit analysis  
aligning on and offshore  
infeed loss limits

**Grid Code** clarify rules in  
relation to integrated  
HVDC-connected offshore  
windfarms

**Work to understand these changes and their impact should commence immediately to reduce the likelihood of missed opportunities**

# Offshore Network Coordination – Key Messages



**£6 billion** (18%) potential savings by **2050** if integration starts from 2025



Flexibility is needed to deliver projects in train without putting their delivery and the 2030 offshore wind target at risk



The number of assets could be reduced by **50%** creating significant environmental & social benefits



Support for commercial deployment is needed to deliver all of the required technology



Benefits are reduced the later integration begins – by half if integration starts in 2030.



Additional onshore infrastructure is required to connect wind, however integration can minimise the overall increase in infrastructure

# What's next for Offshore Coordination?



Thank you for listening,  
any questions?

