Market modelling and socio-economic analysis of a potential multi-purpose interconnector between GB and the Danish energy island

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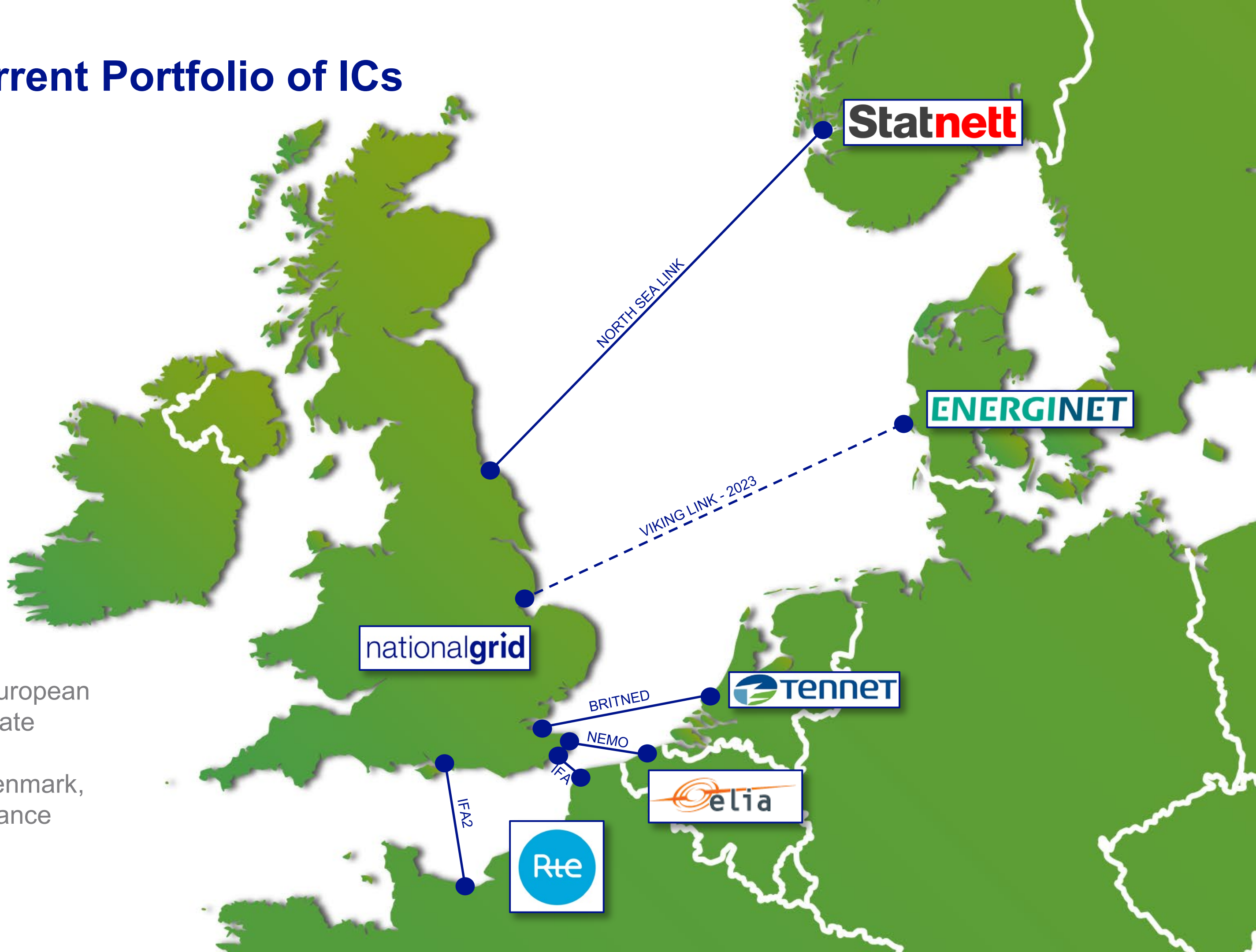
nationalgrid

National Grid's Current Portfolio of ICs

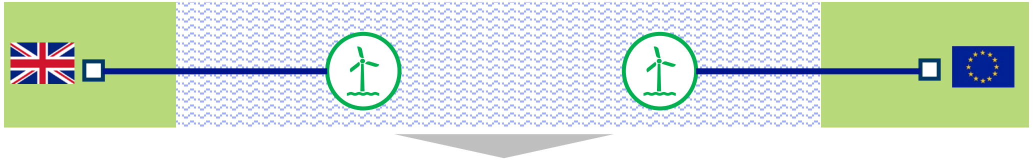


8GW

By 2024 National Grid and our European partners will jointly own and operate ~8GW of interconnector capacity connecting the UK to Norway, Denmark, the Netherlands, Belgium and France

Multi-Purpose Interconnectors ("MPIs") combine offshore windfarms ("OSW") and interconnectors

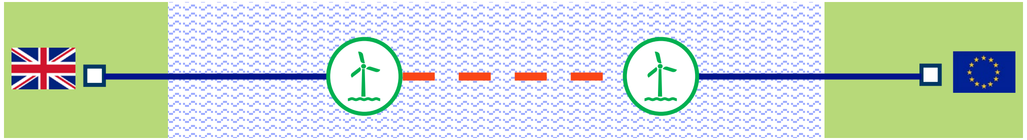
Currently, the UK and other countries are in the process of building a large number of single-purpose OSW radial connections…



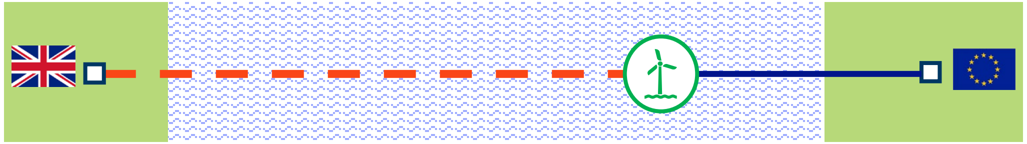
… but MPIs that connect OSW to multiple countries potentially facilitate cross-border flows as well as flows from OSW

Many types of MPI configurations are possible – for example:

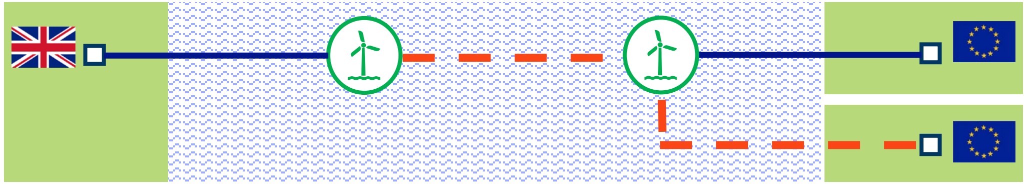
a) **connecting two offshore wind farms to each other…**



b) **... or connecting an individual wind farm directly to two markets…**



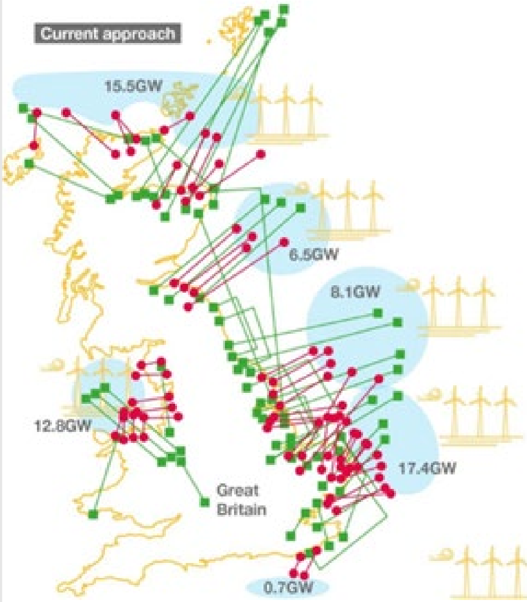
c) **…or other permutations such as multiple markets *and* multiple windfarms**



Multi-purpose interconnectors (MPIs) are dual functionality cross-border transmission assets that combine interconnectors with offshore wind connections

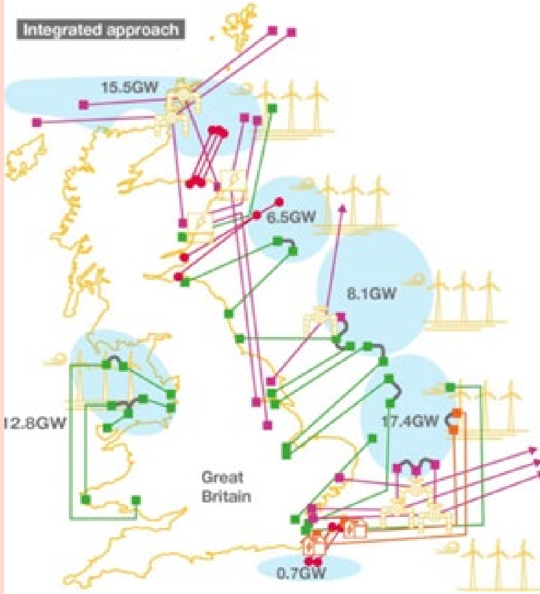
Current approach

- Offshore wind, interconnectors & bootstraps developed separately
- UK-centric approach to offshore grid
- Competition for space between offshore projects
- Adverse impacts on coastal communities
- Increased risk of Planning delays
- Challenge to deliver 2030 & 2050 ambition



Integrated approach

- Coordination of projects, corridors, technologies, sites
- Offshore grid shaped with EU/EEA partners
- Continued benefits of offshore wind & interconnectors
- What stakeholders may accept
- Reduces impacts and mitigates Planning delays
- Helps deliver 2030 & 2050 ambition



Source: National Grid ESO Offshore Coordination Proposals

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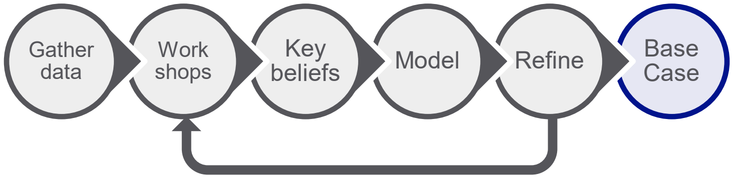
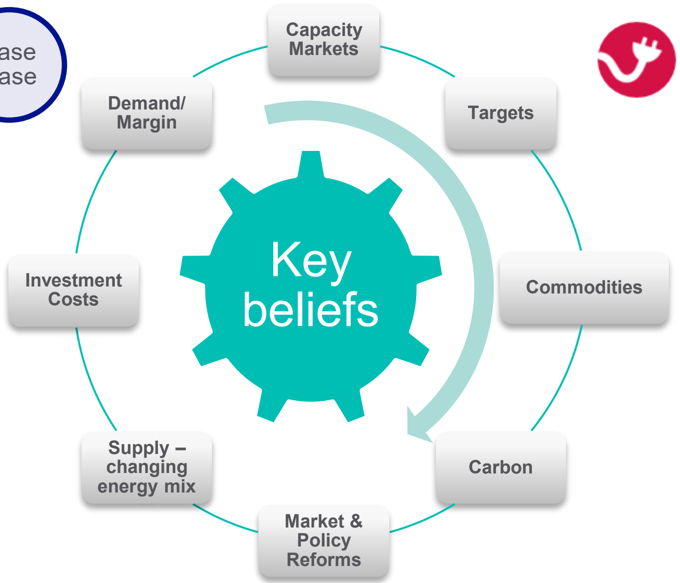
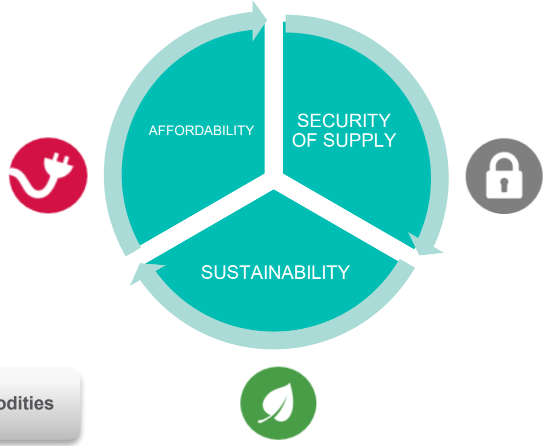
We have developed internal capability to perform market modelling analysis and created a set of scenarios. We use external sources to benchmark our assumptions

We constantly Feedback & Challenge







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PLEXOS BY ENERGY EXEMPLAR
Wind EUROPE
entsoe
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Future Energy Scenarios
Renewables.ninja

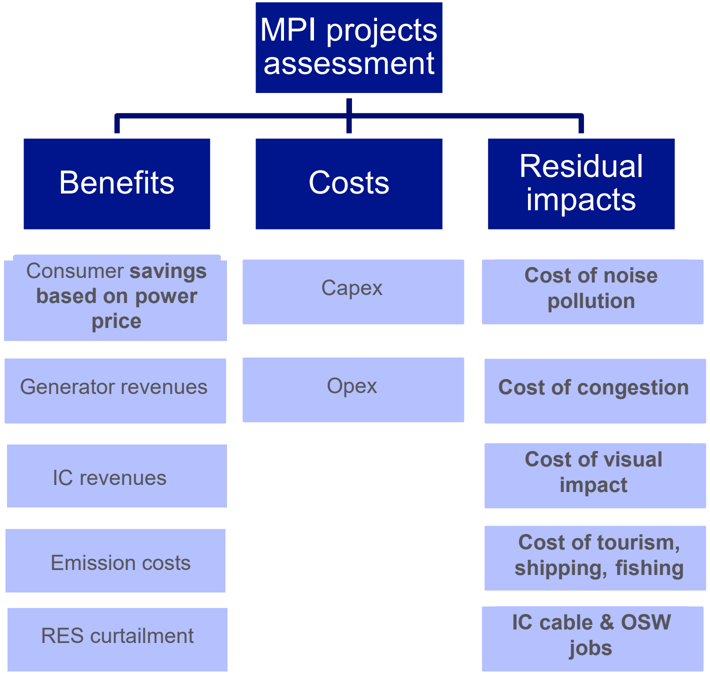
Across all scenarios and different configurations we analyse the results from a project revenue and a societal impact perspective

For GB, Belgium, Norway, Netherlands & rest of modelled EU countries, under each scenario, among other metrics we calculate :

- the generation mix including imports/ exports
- P2P & MPI **congestion revenues**
- P2P & MPI Capex requirements
- Other technologies Capex requirements

In order to perform the **Socio-economic welfare (SEW) analysis** and Cost-benefit analysis (CBA), for each scenario we create a counter-factual case. In there we assume MPIs are replaced by other low carbon technologies, whereas associated offshore wind's capacity deployment is delayed by 2years.

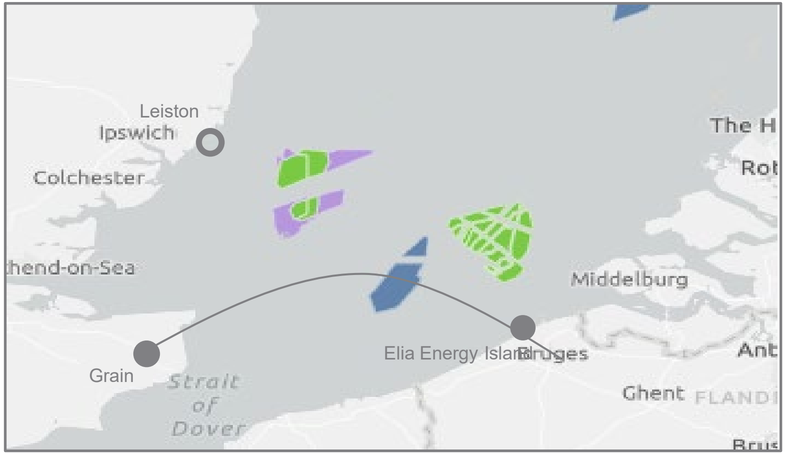
The metrics selected for the SEW analysis follow Ofgem & ENTSOe standards.



(*) Results & analysis to be provided at a later stage

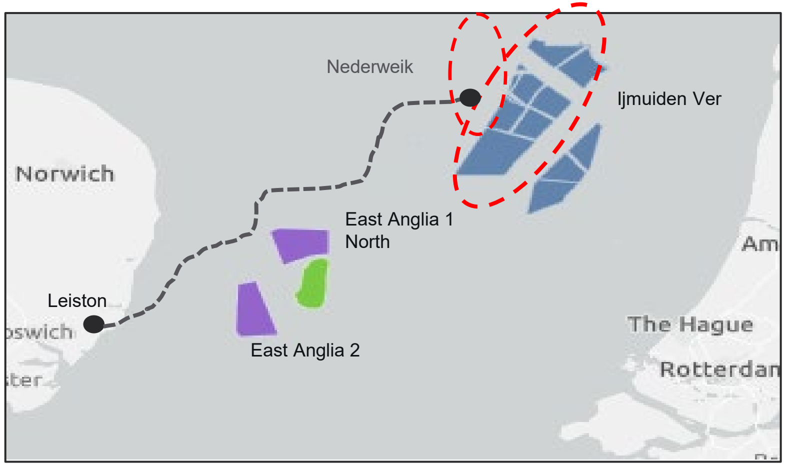
MPI projects that have received regulatory support in the recent MPI C&F window

Nautilus



- Has the potential to connect up to 1.8GW of GB offshore wind.
- It connects to Princess Elisabeth offshore wind zone in Belgium where an artificial island will be created
- The total cable's route is estimated to be 190km and aim to go-live in 2030

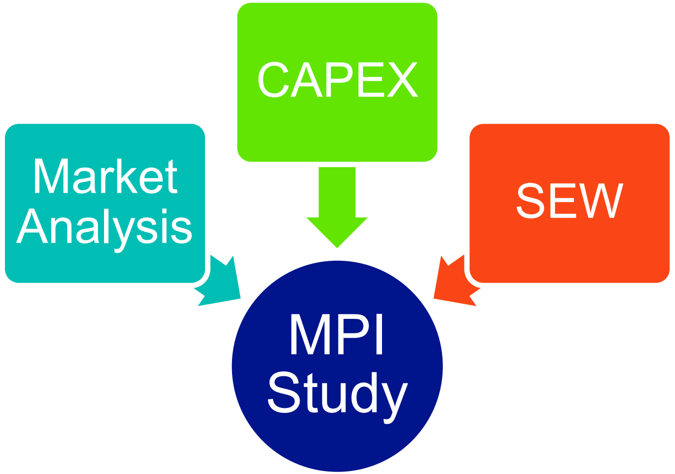
Lion Link



- There will be a direct connection from the I-Ver (Dutch offshore wind development zone) to GB connecting 2GW of Dutch wind
- Possibility to include GB offshore wind farm projects in the East Anglia area
- Expect the project to commence commercial operations in 2030

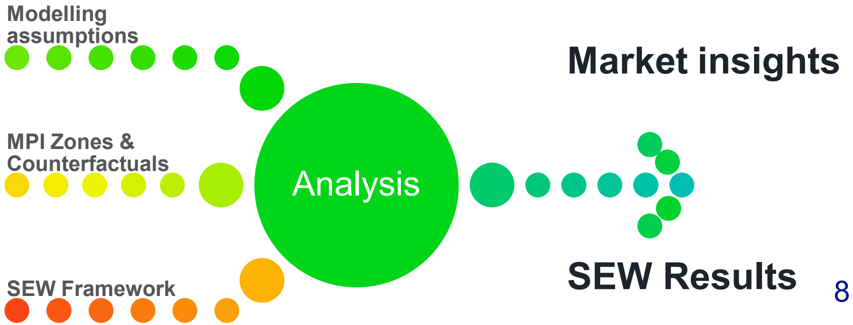
How we structured the analysis

Evaluate commercial opportunities in MPIs by looking at three main pillars

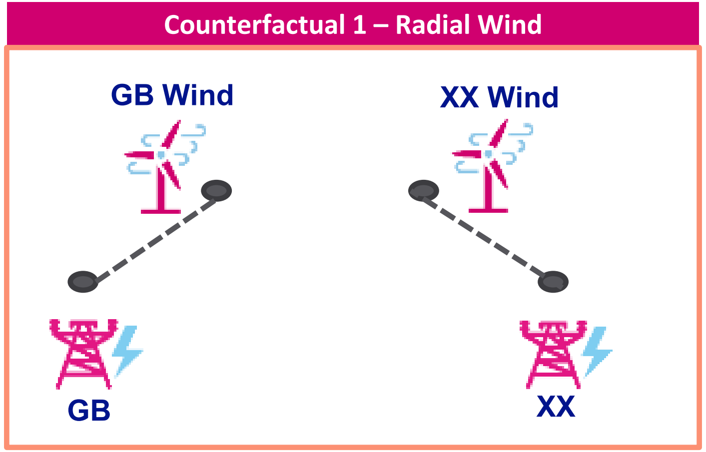


- **We did not cover:**
  - Cost of grid reinforcement
  - CAPEX optimisation

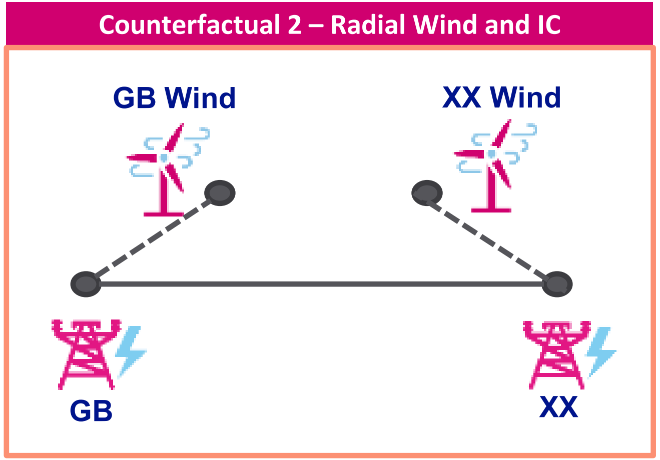
- **Set modelling assumptions and key market determinants and drivers**
- **Developed a number of internal scenarios to evaluate different capacities and markets and run sensitivities**
- **Formulated a framework to perform consistent SEW comparison**
- **Set up the appropriate counterfactuals to compare them with MPIs**



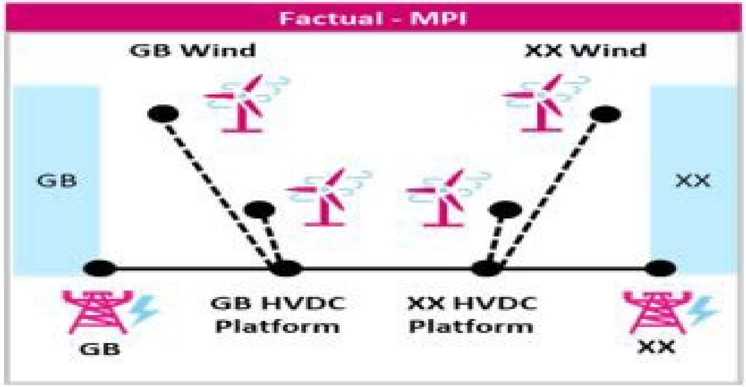
Factual and counterfactuals that are used in the comparison analysis



Represents multiple single purpose OFTO connections



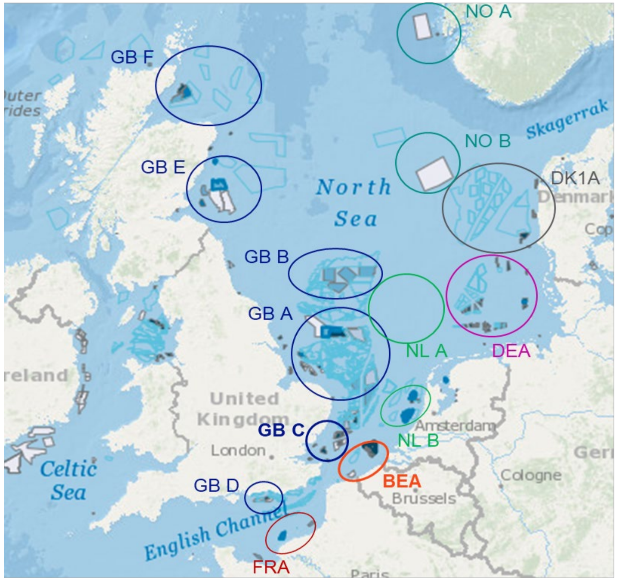
Combination of multiple single purpose OFTO along with P2P IC



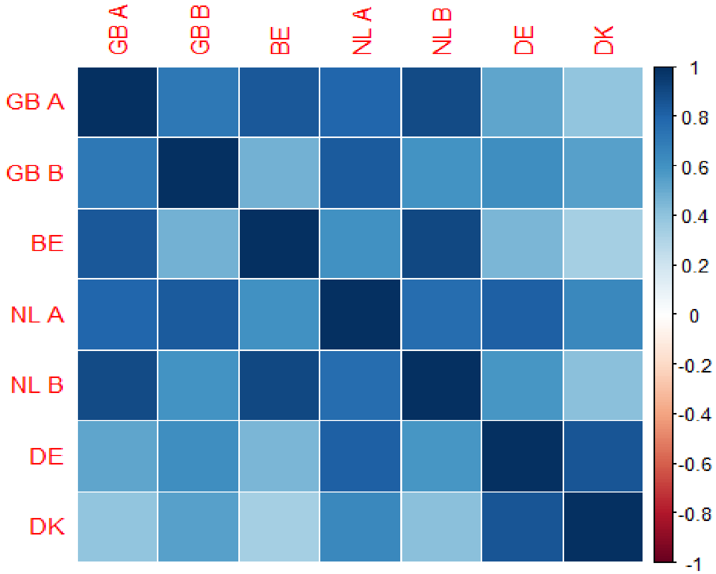
An MPI solution which integrates multiple offshore wind farms coupled with cross-border functionality

Offshore wind zones, correlation factors and potential revenue streams for MPIs

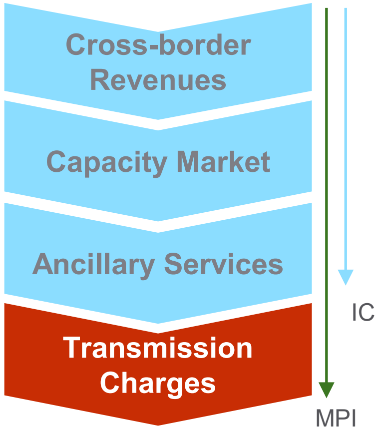
North Sea Offshore Wind Zones



Wind Correlation Factors



MPI/IC Revenue Streams

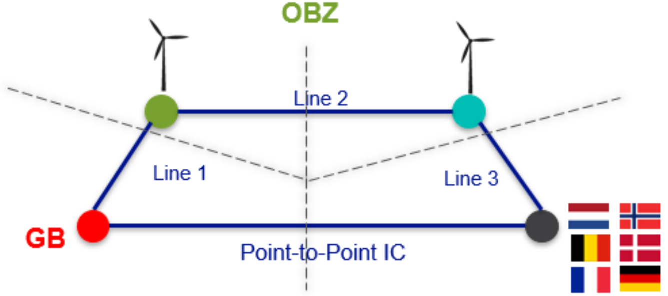


We are able to extract detailed hourly data relevant for interconnector and wind farm operators. We are also able to model different regulatory arrangements for offshore wind and MPIs, as well as revenue sharing schemes.

Data that can be extracted from Plexos

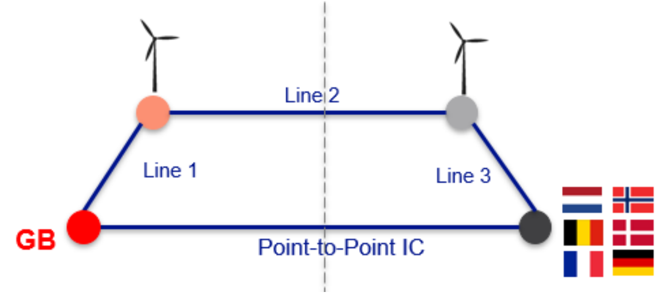
Broad category	Sub-categories
Generation (annual & hourly)	Power Prices for all zones
	Wind generation
	Captured Wind Revenues in and outside offshore bidding zones
	H2 Electrolyser consumption profiles and captured prices
Transmission (annual & hourly)	P2P/MPI flows
	P2P/MPI utilization rates
	Breakdown of wind and cross-border flows for MPIs
	Breakdown of MPI revenues

Offshore Bidding Zone Approach (OBZ model)



- Provides higher socio-economic welfare benefits due to lower impact on interconnector revenues.
- In line with EU regulation.
- Lowest revenues for OWFs, which capture the lowest price of the two markets.

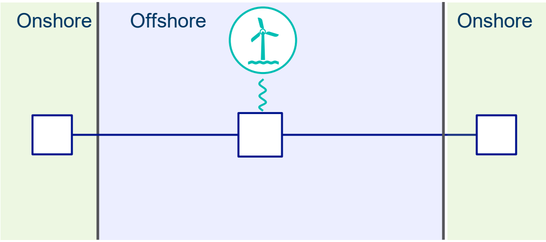
Home Market Approach (HM model)



- Provides higher revenues for wind farms as they are paid the power price from their domestic market.
- Does not comply with 70% rule from CEP

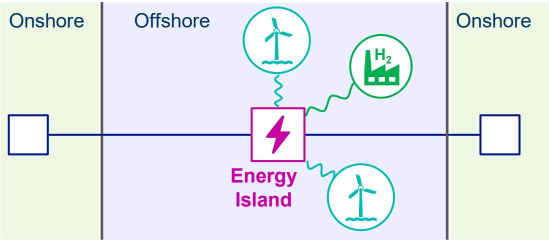
Evolution of offshore wind connections from MPIs to energy islands and ultimately the development of a meshed grid in the North Sea

Hybrid Projects



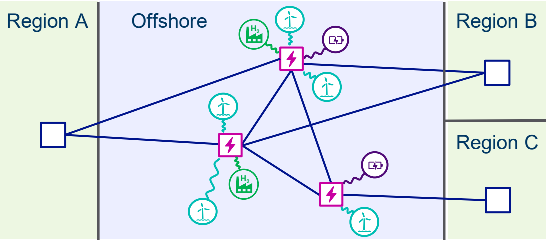
- Hybrid projects are the **first step** in creating **coordinated offshore transmission** infrastructure.
- These can then act as a **gateway investment** to future developments.

Energy Islands



- Beyond a single converter station for hybrid projects, artificial platforms can be developed in the North Sea…
- … connecting **OSW** and other technologies, such as **Hydrogen** electrolysers.

Meshed Offshore Grid

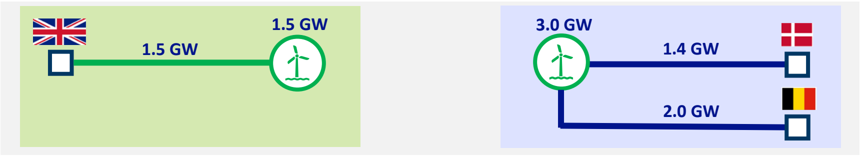


- As energy islands are further built out, there will the opportunity to **link** these together….
- … forming a **mesh of offshore generation and storage**, and **multiple OBZs**.

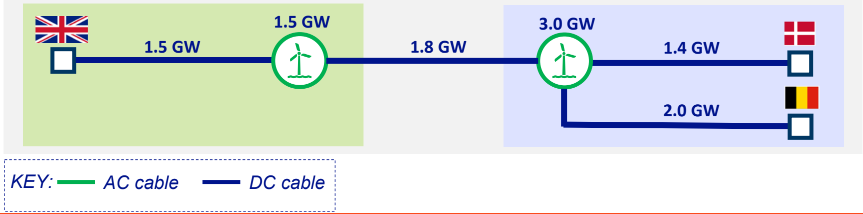
- **The transition from standalone offshore wind connections to MPIs and energy island will require significant amount of cooperation and coordination among European TSOs and regulators**
- **It will require regulatory changes and market reforms to accommodate to support new ways of connecting offshore wind farms in Europe**

Total SEW benefits outweigh costs in our assessment for the Danish Energy Island project. Significant CO2 reduction benefits alongside congestion rent

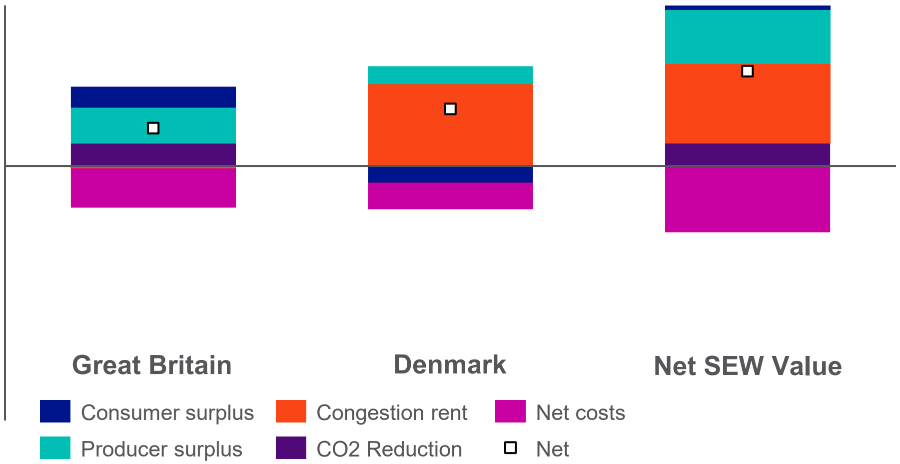
Baseline – Standalone radial links



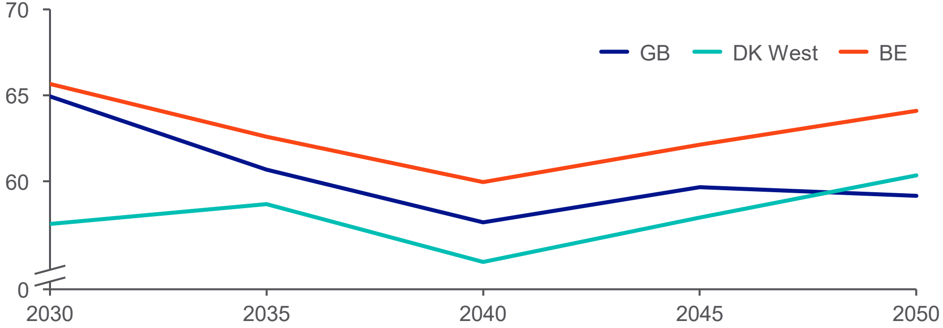
Proposed MPI configuration



SEW benefits of the project, 2030 – 2050 (€m)



Power Prices 2030 – 2050 (€/MWh)



Key takeaways:

- GB becomes a net exporter to Denmark after 2045 driven by the significant low carbon generation deployment.
- The project delivers net benefits to GB and Denmark individually and collectively. Benefits are driven by CO2 reduction in GB and strong congestion revenues in DK.
- GB benefits from increased consumer surplus and CO2 reduction, while Denmark benefits from increased producer surplus and congestion rent surplus.
- BE continues to be the most expensive of the three markets which means GB consumers would benefit during peak hours at which Belgium prices are going to be lower.
- Since BE prices are on average higher than both GB and DK, more exports from those two countries drive higher generator surplus.