Beyond borders

Unlocking the power of UK-EU offshore wind coordination

December 2024

Prepared on behalf of:

Breakthrough Energy

Introduction to the Baringa report from Breakthrough Energy

The North Sea is one of the world's most promising regions for offshore wind, which provides the opportunity for the European Union and the United Kingdom to meet shared energy and climate challenges through collaboration. However, realising the full potential of this opportunity requires addressing significant barriers that currently hinder effective cooperation.

The rapprochement between the UK and the EU provides a window of opportunity to harness the benefits of a realignment between the UK and the EU to meet ambitious decarbonisation targets – working collaboratively to accelerate deployment efforts in the North Sea.

This report focuses on identifying and addressing inefficiencies and barriers to deployment that have emerged in the post-Brexit landscape. These include suboptimal trading arrangements, stalled progress under the Trade and Cooperation Agreement (TCA), the erosion of coordination between network operators, and divergent processes in planning and supply chain procurement.

The consequences of these barriers are leading to missed opportunities for material project cost savings, delays in project delivery, and fragmented efforts to capitalise on the region's vast offshore wind potential. All of these issues lead to higher costs for consumers and impact economic growth and productivity. By addressing these issues, policymakers can unlock substantial benefits for UK and EU citizens and business.

This report provides a comprehensive analysis of these barriers and offers recommendations to address them. It emphasises the need for renewed dialogue and the alignment of regulatory and policy frameworks to support cooperation. Only through such efforts can the EU and the UK fully leverage the strategic advantages that the North Sea offers, achieving the shared goals of energy security, decarbonisation and affordability.

We hope this report serves as a foundation for decisive action, inspiring the collaborative spirit needed to enable the North Sea to be a global energy powerhouse.

Philipp Offenberg
Director, Breakthrough Energy Europe

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Director UK, Breakthrough Energy Europe

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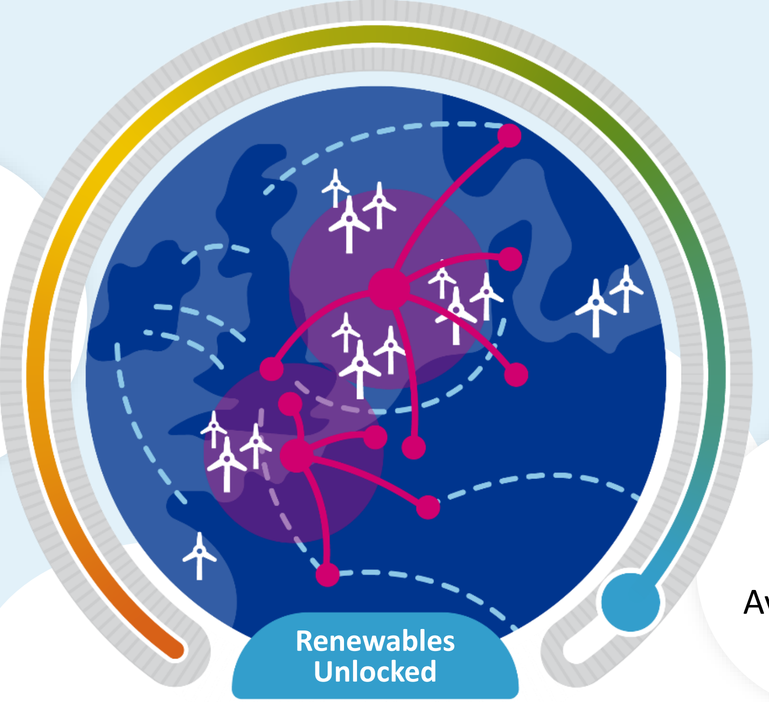
Coordination between the UK and the EU presents our best chance of delivering our national and collective offshore wind ambitions at pace

Going further for less

Coordination smooths the path to EU & UK net zero delivery with up to 16% lower investment costs

€44bn

Annual consumer savings from lower electricity costs (by 2040)



>250m tons CO_2

Avoided between 2030-50

Energy security and independence

Reducing natural gas imports by the equivalent of 6.5 million homes each year

What policy steps do we need to take to unlock the benefits of coordination

SHORT TERM → LONG TERM

Address trade barriers	Join cooperation networks	Link the ETS	Industry vision
Action plan for after TCA GB re-enters EU market coupling	UK Membership NSEC, IC developers participate in ENTSO-E	Recognition of UK carbon price for CBAM	Targeted procurement and supply chain

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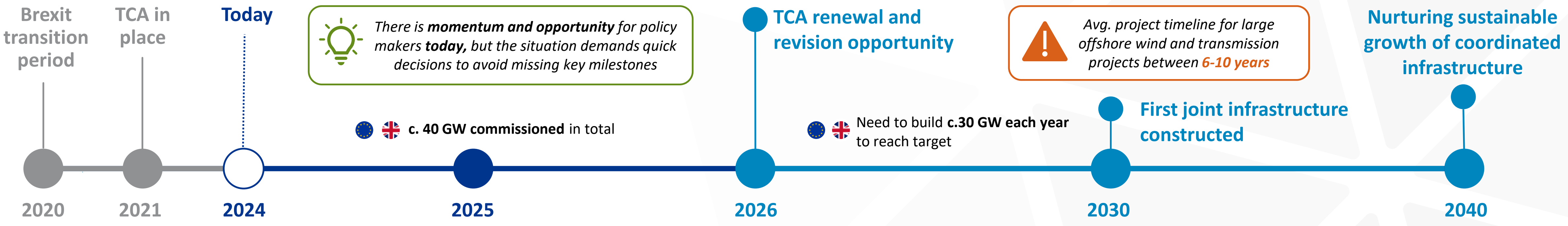
Action is needed now to address existing barriers between the EU-UK and create an environment that enables achieving net zero ambitions in the long-term



Governance	*Utilise learnings from the Specialised Committee on Energy (TCA) for an enduring policy and regulatory platform for UK-EU cooperation*	*Create a cooperation platform between UK and the EU-TSOs, revisiting UK System Operator's ENTSO-E membership*	*Re-instate UK's membership in the North Sea Energy Cooperation, to supersede/strengthen beyond the current MoU*	*Revise regulation to facilitate risk transfer and financing, supporting offshore infrastructure growth*
Coordination	*Develop a vision for an agreement to supersede the TCA's initial term to provide long-term legal certainty*	*Promote an action plan, with timelines and responsibilities for the introduction of technical procedures under the TCA*	*Prioritise targeted coordination on planning and consenting to accelerate development timelines*	*Design coordinated supply chain procurement and create a supply chain vision for the North Sea*
Market and trading	*Develop a methodology to link UK ETS to EU ETS to avoid trade distortions*	*Recognition of the UK carbon price as an equivalent to the CBAM rebates further removing trade friction*	*Implement price coupling with EU joining Single Day-Ahead Coupling through receiving a 3rd country inclusion service*	

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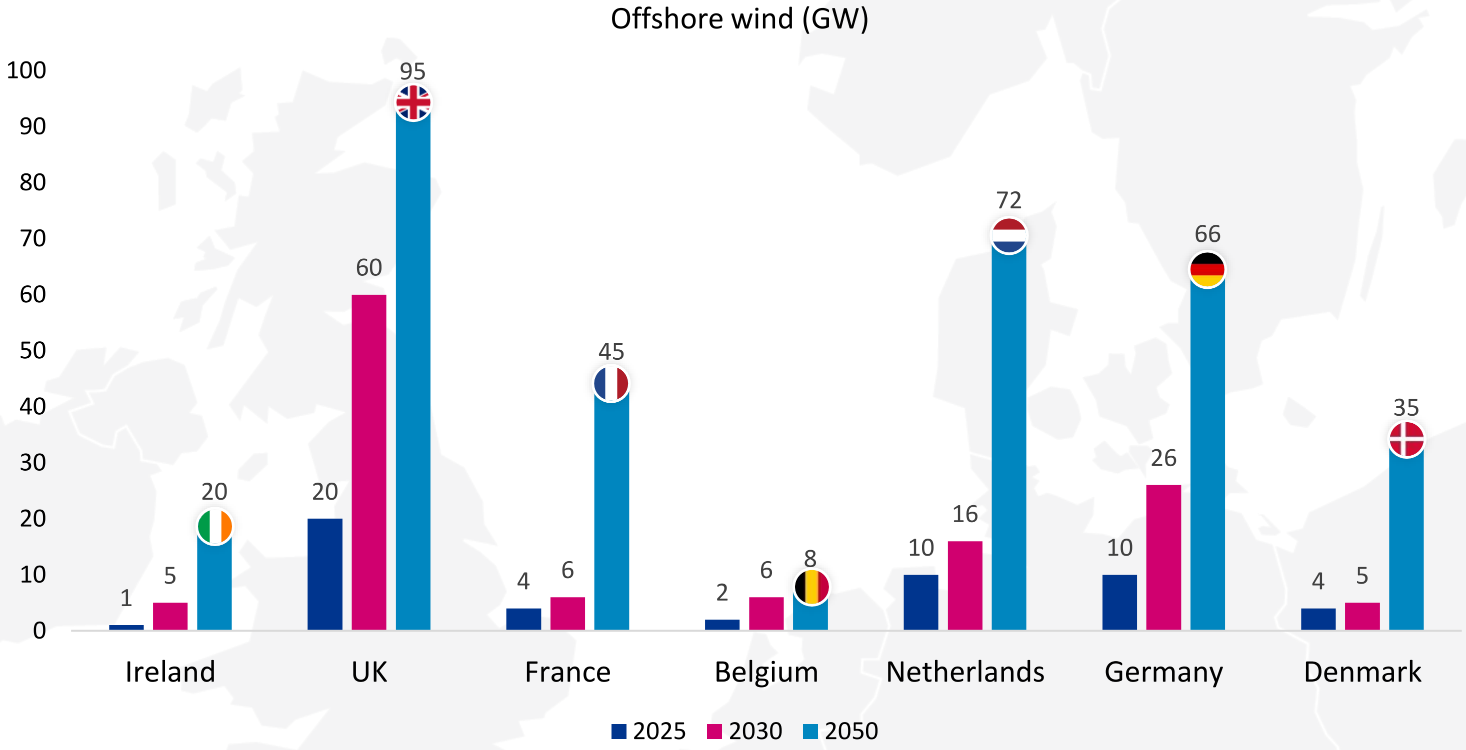
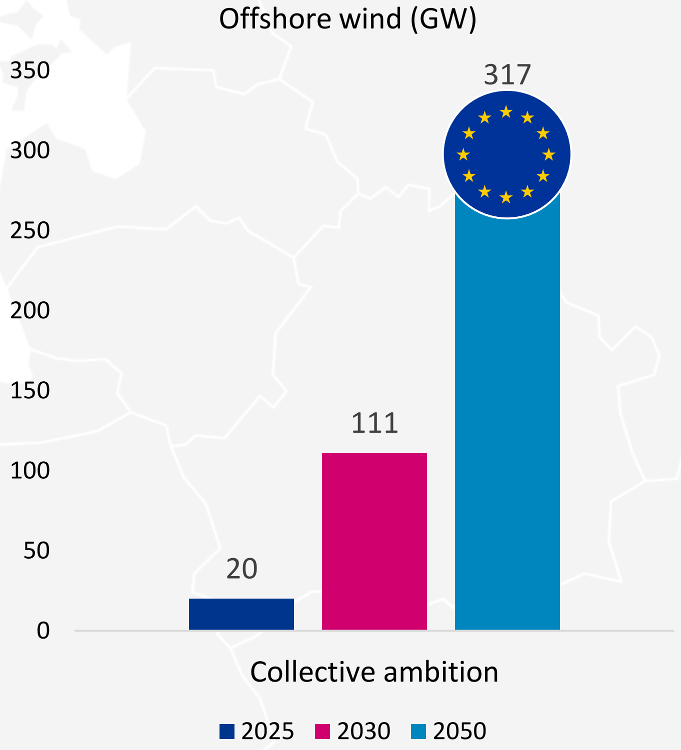
The EU and UK set ambitious targets for offshore wind to facilitate the energy transition and meet net zero targets – there is a significant investment challenge



Comparison of the expected capacity of offshore wind in 2025 to Government ambition in 2030 and 2050 reveals the significance of the investment gap we face in offshore wind infrastructure across Europe



Aggregated across the EU, this presents a stark investment need over the next 5 years and then sustained out to 2050

Sources: UK Government, Ostend Declaration, Recharge news, ENTSO-E, European Commission

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Collective and coordinated action could help bridge the investment gap, however, this is limited by the current lack of coordination between the UK and EU

There is an opportunity to maximise value in the North Sea through coordination but barriers remain…

Barrier 1

Current **inefficient trading arrangements** between the UK-EU.

Significant issues implementing a post-Brexit efficient coupling arrangement.

Barrier 2

Limited progress under the Trade Cooperation Agreement.

Timelines are significantly overdue. TCA's initial term ceases in 2026.

Barrier 3

Loss of coordination at a working level between the TSOs and DSOs as well as at a policy making / institutional level (such as between regulators). The MoUs are not translating to actionable commitments.

Barrier 4

Divergent processes in planning, consenting and supply chain procurement.

Low **political appetite** for large scale coordination without understanding the collective, and individual, benefits to the UK and the EU.

Implication 1

Increased system costs, higher costs for consumers and a reduction in social welfare. Estimates are €500-560m per annum in generation costs.[1]

Implication 2

Investment and regulatory uncertainty, particularly for infrastructure investments that have long asset lives, leading to a higher cost of transition.[2]

Implication 3

Renewable and climate targets at risk, missing national government and collective EU targets.

Implication 4

Reduced interoperability, limited investment in manufacturing capacity and higher likelihood of operational curtailment and slower investment.

The barriers have significant implications for both the EU and the UK

1. Elecxit: the Cost of Bilaterally Uncoupling British-EU Electricity Trade, EPRG Working group. Available here: eprg-wp1916.pdf (cam.ac.uk) and National Grid, submission to UK parliament. Available here: EUE0079 - Evidence on Leaving the EU: implications for UK energy policy (parliament.uk)
2. A broad coalition of energy associations and TSOs also supports this premise that limited price coupling and regulatory uncertainty is likely to make investment less attractive (Joint Letter)

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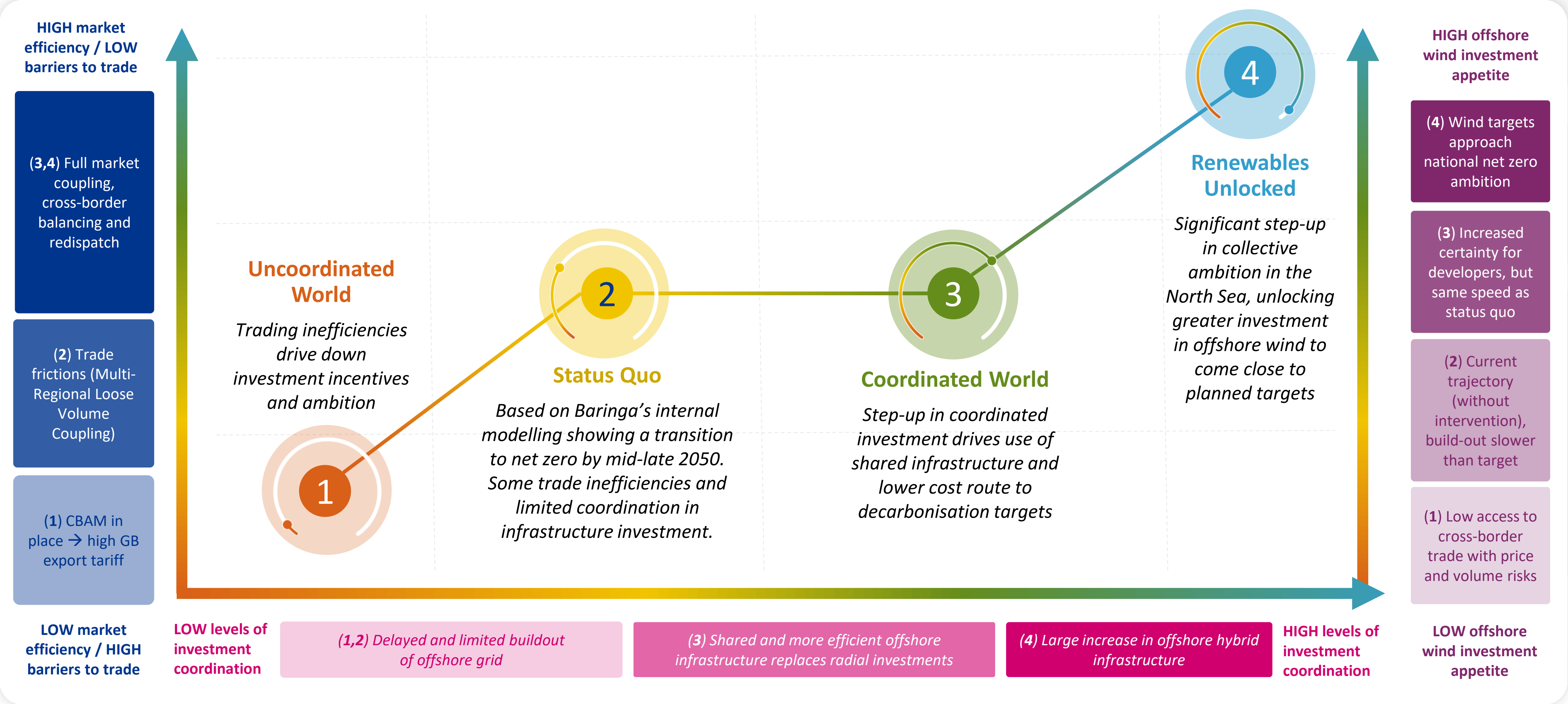
We have used these dimensions to develop four states of the world that form the basis of the economic assessment of opportunity in the North Sea



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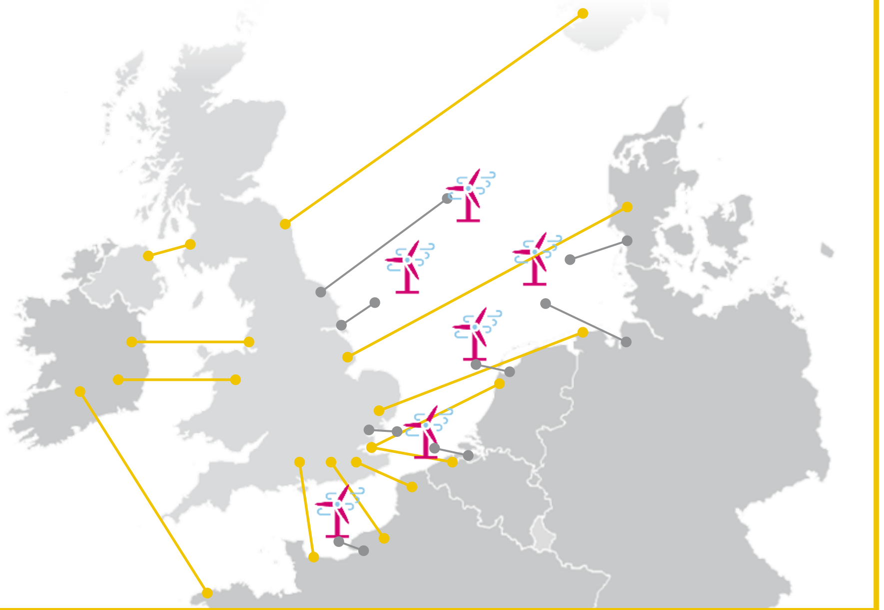
Exploring the impact and potential value of offshore grid and offshore wind coordination potential in the North Sea

Status Quo

*Based on Baringa's internal modelling (Reference Case) showing a transition to net zero power by mid-late 2050 with investment focus on **domestic/radial** offshore wind deployment and **point-to-point interconnection.***

P2P Interconnector — Radial offshore wind cable



Total offshore wind capacity	2030	2040
	82 GW	*171 GW*

We adapt our modelling approach to show greater levels of coordination between the UK and EU Member States in the Coordinated world.

Market efficiency

Removal in any residual trading inefficiency

Investment coordination

Development of 2 large Offshore Hybrid Assets connecting GB, NO, DK, DE, NL and GB, NL, BE, FR

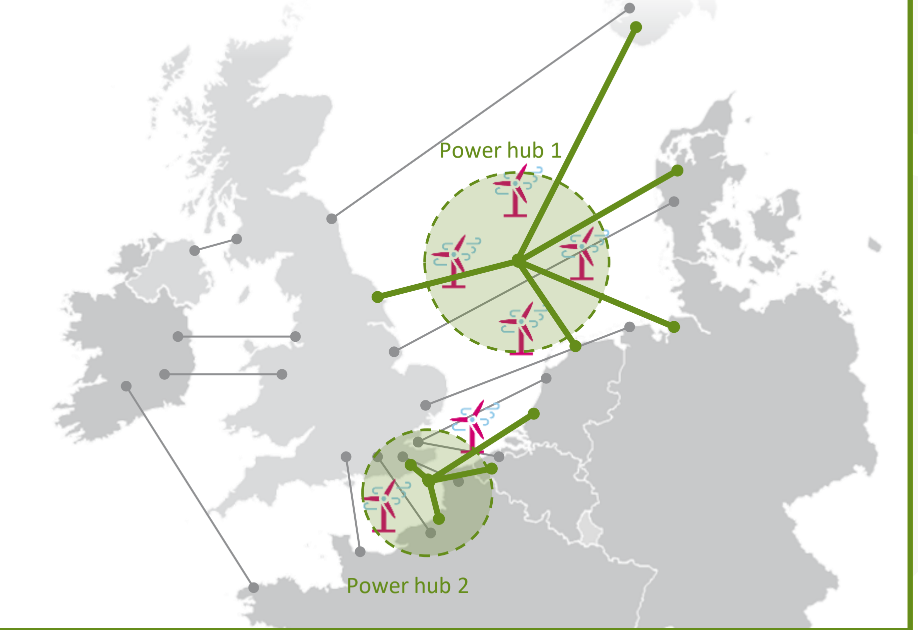
Offshore wind

Same total level of offshore wind development but transfer of 8GW from domestic investment to coordinated investment

Coordinated World

*Based on the same underlying scenario as the Status Quo but with a move from domestic, to **coordinated offshore wind and grid infrastructure.** See more methodology and assumption details in the appendix.*

Hybrid interconnector — P2P Interconnector



Total offshore wind capacity (Developed coordinated via hybrid interconnectors)	2030	2040
	82 GW *(8 GW)*	*171 GW* *(34 GW)*

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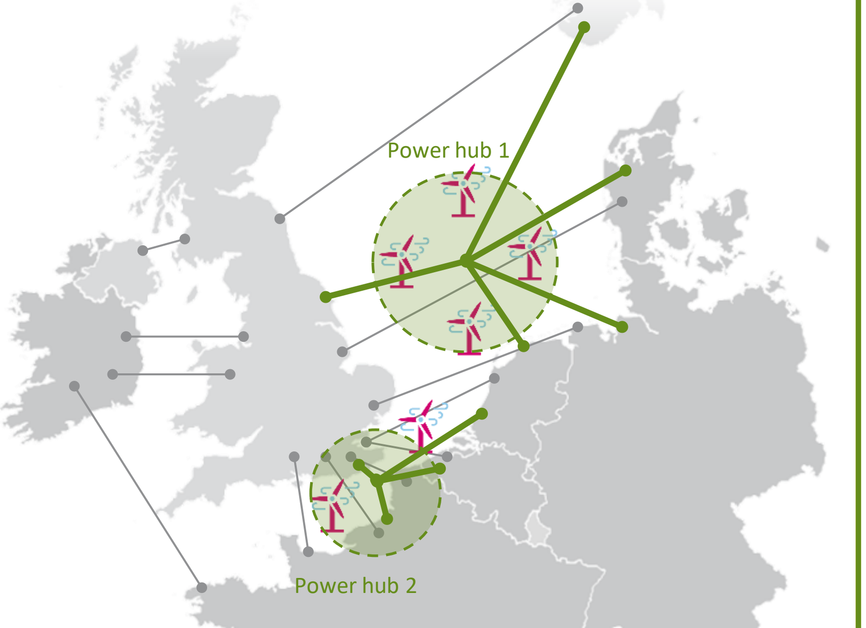
We stretch this approach to show the potential value that could be achieved if coordination unlocks investment far beyond current investment trajectories

Coordinated World

*Based on the same underlying scenario as the Status Quo but with a move from domestic, to **coordinated offshore wind and grid infrastructure.** See more methodology and assumption details in the appendix.*

Hybrid interconnector — P2P Interconnector



Total offshore wind capacity
(Developed coordinated via hybrid interconnectors)

	2030	2040
Total offshore wind capacity	*82 GW (8 GW)*	*171 GW (34 GW)*

We showcase a state of the world where greater coordination unlocks higher renewable potential across the North Sea.

Market efficiency

No market frictions

Investment coordination

We develop the same number of coordinated network assets but with greater transmission and offshore wind capacity

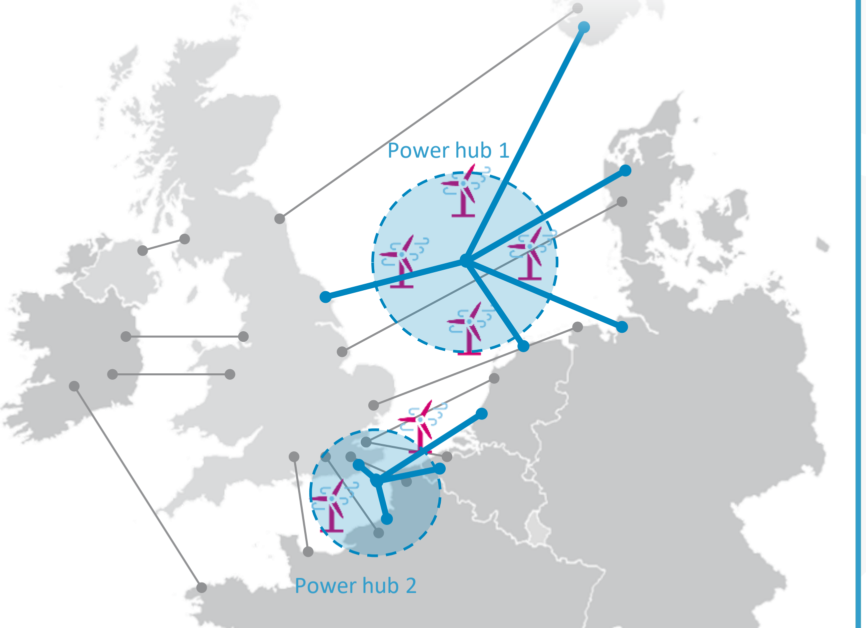
Offshore wind

We assume an additional 65GW of offshore wind unlocked by 2040 as a result of coordinated offshore wind ambition and sharing of resources, within bounds of theoretical potential and targets

Renewables Unlocked

***Significant offshore wind build out** compared to the Coordinated World to reflect the potential value of coordination and cooperation across the North Sea.*

Hybrid interconnector — P2P Interconnector



Total offshore wind capacity
(Developed coordinated via hybrid interconnectors)

	2030	2040
Total offshore wind capacity	*105 GW (23 GW)*	*236 GW (65 GW)*

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We can see how increasing coordination and cooperation could drive cost savings, market economic benefits and decarbonisation benefits across the EU

	1 Uncoordinated World	2 Status Quo	3 Coordinated World	4 Renewables Unlocked
2040	*Low levels of coordination and trading inefficiencies drive down investment incentives and ambition*	*Piecemeal coordination and domestic-focused investment limits opportunity for coordination action*	*Step-up in coordinated investment drives use of shared infrastructure and lower cost route to decarbonisation targets*	*Significant step-up in collective investment in the North Sea, unlocking greater realisation of offshore wind, nearing planned targets*
Grid investment costs	***N/A***		**Coordination drives costs savings** from sharing infrastructure offshore[1] *8% CAPEX saving* — For 8 GW 2030 example — *16% OPEX saving*	*65 GW more capacity* By 2040, **65 GW more wind and cables are developed,** requiring an annual investment cost of c.€16-20bn
Economic impacts and pricing	€2.8bn annual extra costs[2] **Prices for the consumer rise** in the EU due to less efficient trade with GB and limited access to GB RES	***Counterfactual***	≈ **Similar price levels as Status Quo,** the coordinated grid configuration does not significantly benefit or disadvantage one country	*€44bn annual saving[2]* Average **20% wholesale price reduction** in directly connected zones in 2040, and a total of **€44bn across EU saved each year**
Renewables and decarbonisation	Up to >20% increase in GB curtailment **Less efficient use of renewables** and **increases in curtailment levels**		*Avoid 0.5m ton CO_2* Between 2030–2050, we see **gradual reductions in CO_2** emissions due to more efficient use of RES	*Avoid >10m ton CO_2* Faster decarbonisation with emissions **24% lower in 2040** compared to the status quo

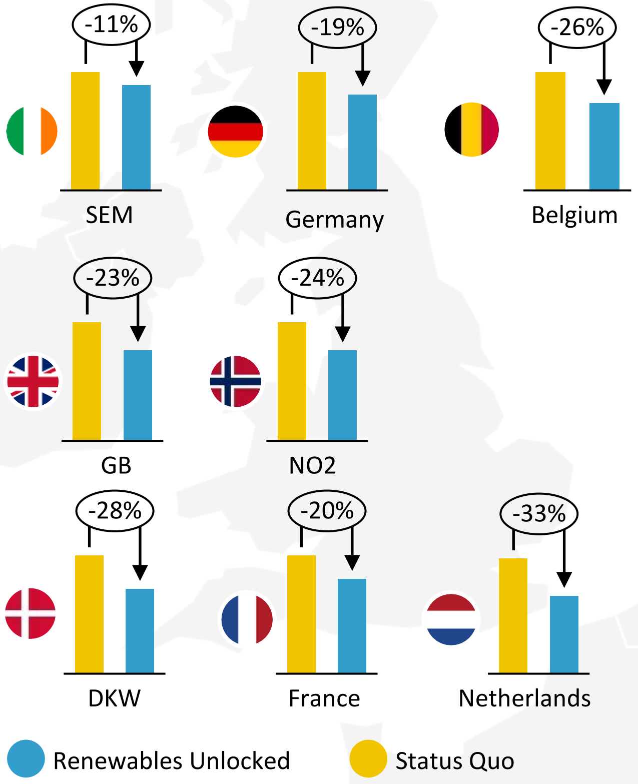
[1] Based on example delivery of 8 GW of offshore wind through coordinated hybrid infrastructure by 2030

[2] Annual savings/costs, Reference year 2040 used. Savings calculated based on wholesale price reduction x Demand. Societal costs from CfDs, PPAs or other contracts not taken into account

By 2040, cooperation could lead to 20% lower wholesale electricity prices on average across countries, reductions in infrastructure costs and in emissions costs

Consumer price savings

Annual GB connected zones impact (2040):
- **€44bn** of consumer cost savings
- **11.6 million tonnes CO_2** avoided



Infrastructure cost savings

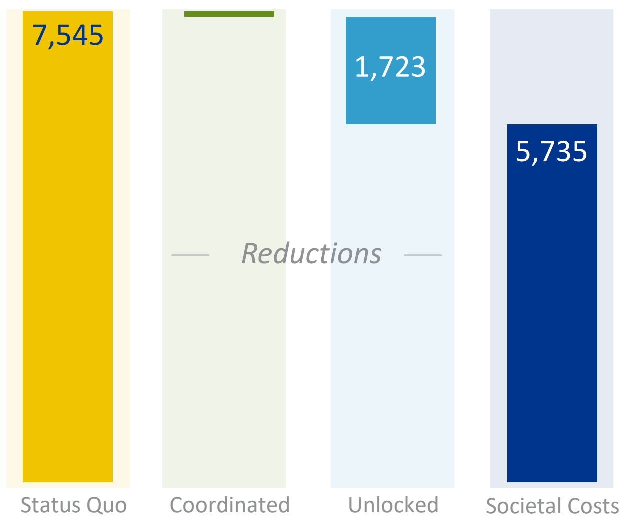
2040 Infrastructure cost savings (real 2024)
(Coordinated World vs. Status Quo)

€7bn
investment costs savings

€9bn
operational costs savings

Carbon emissions reductions

2040 Annual Societal Costs from emissions
(m€, real 2024)



The economic cost of emissions calculated by the difference in total emissions multiplied by the projected ETS carbon price in 2040.

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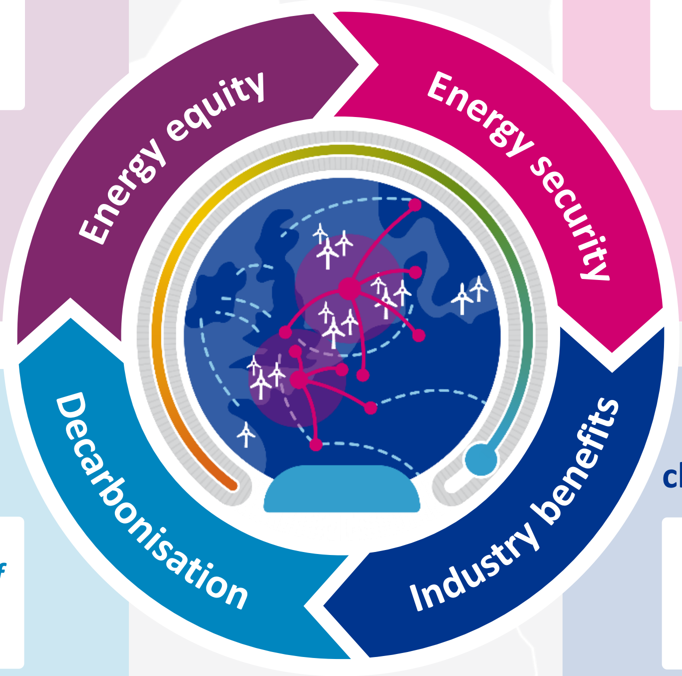
The value of coordination and cooperation goes beyond the economic benefits and includes value from flexibility, security of supply and the supply chain

Coordination results in higher economic and social welfare

- *Wholesale market price impacts*
- *Asset costs reduction*
- *Increased market access reducing the cost of managing the system*

Coordination enhances the resilience and the reliability of our interconnected systems

- *Increased security of supply*
- *Grid stability and reliability*
- *Accelerated grid connections processes*



Coordination is an enabler to achieve our net zero targets

- *Emissions reduction*
- *Greater integration of renewables*
- *Increased system flexibility*

EU and UK's energy industry have higher chances of delivery success through coordination

- *Supply chain efficiencies*
- *Innovation, job and capability build-out*
- *Financing efficiency*

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Action is needed now to address existing barriers between the EU-UK and create an environment that enables achieving net zero ambitions in the long-term

*There is **momentum and opportunity** for policy makers **today,** but the situation demands quick decisions to avoid missing key milestones*

Avg. project timeline for large offshore wind and transmission projects between 6-10 years

Timeline

- **2020** – Brexit transition period
- **2021** – TCA in place
- **2024** – Today
- **2025** – **c. 40 GW commissioned** in total
- **2026** – TCA renewal and revision opportunity; Need to build **c.30 GW each year** to reach target
- **2030** – First joint infrastructure constructed
- **2040** – Nurturing sustainable growth of coordinated infrastructure

Governance

- *Utilise learnings from the Specialised Committee on Energy (TCA) for an enduring policy and regulatory platform for UK-EU cooperation*
- *Create a cooperation platform between UK and the EU-TSOs, revisiting UK System Operator's ENTSO-E membership*
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- *Develop a vision for an agreement to supersede the TCA's initial term to provide long-term legal certainty*
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Market and trading

- *Develop a methodology to link UK ETS to EU ETS to avoid trade distortions*
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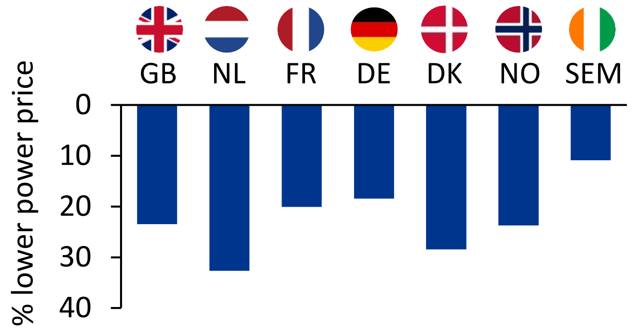
Details on benefits

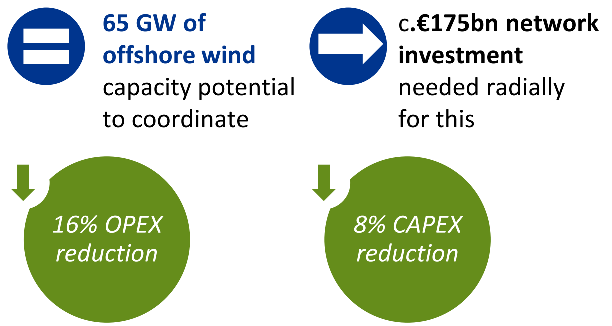
Coordination results in higher economic and social welfare

Price impact



- **Greater coordination** could unlock renewables between European and UK offshore grids driving down wholesale electricity prices as connecting markets benefit from being part of a larger power market with **greater diversity** in generation and demand.
- The **reduction in wholesale prices** is driven by the **accelerated buildout** of offshore wind, **increased interconnection** and a more **more efficient** coupling between EU and UK.
- Lower power prices enables other sectors to decarbonize and electrify (i.e. heat and transport)

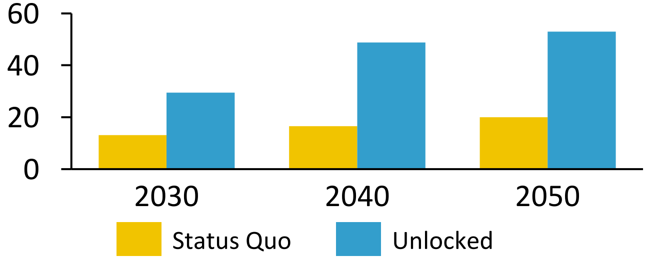
Infrastructure costs



- Coordinating infrastructure investment and operation results in **cost savings,** both capex and opex**,** driven by greater opportunities for the development of offshore hybrid assets, reduction in duplicated assets (such as converter stations) and operating more efficiently than radial offshore connections in the Status Quo scenario.
- Comparing the coordinated scenario to the status quo, we demonstrate a reduction in capex and opex, of 8% and 15% respectively, due to a more **coordinated approach to hybrid assets,** reducing cables, interconnectors and converters needed to achieve the same offshore wind and IC capacity.

System cost

Total cross-border capacity[2] (GW)



- Cross border capacity between UK-EU would increase under the renewables unlocked scenario, reducing the likelihood of curtailment.
- **Higher interconnection** counts as **reserve capacity** which may improve procurement costs for TSOs.
- System operators will have more options for **counter-trading or cross-border redispatch**, all expected to bring operational costs down.
- Through **efficient coupling**, generators and traders have efficient access to other markets, saving overall trading costs.

1. Article 15 of the TEN-E regulation sets out the intent to create guidance for cost and benefit sharing for the integrated offshore network development plans (which will include the north-sea given its potential as a priority corridor)
2. Cross-border capacity includes offshore grid hybrid lines used for offshore wind, this capacity is derated by 50%.

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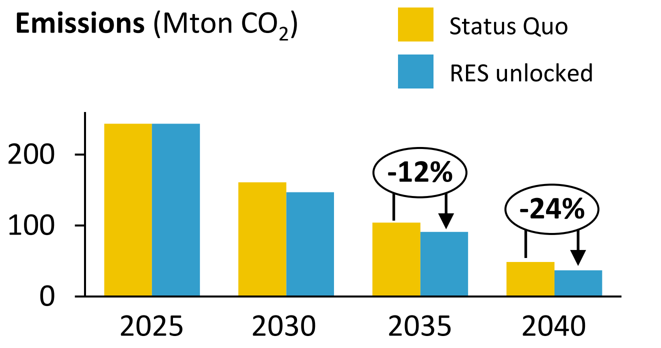
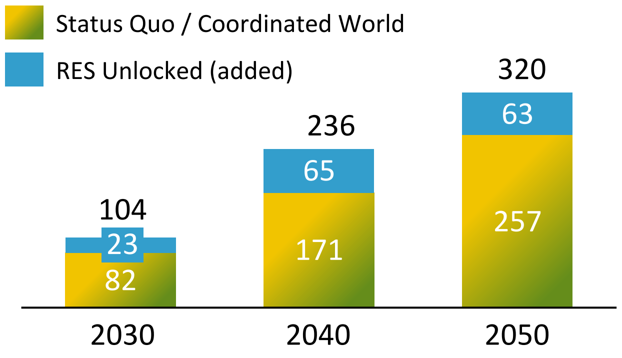
Coordination facilitates emissions reduction, higher RES and reduced renewable curtailment

Emissions reduction



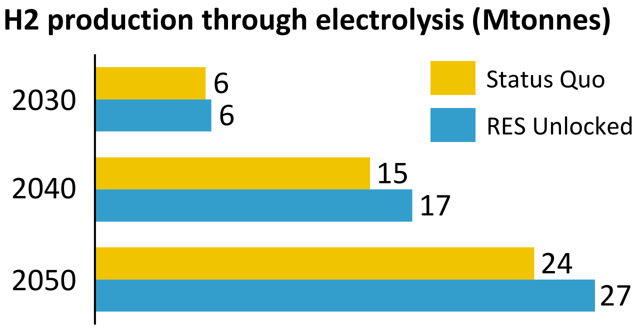
- More **efficient dispatch** of renewables across a larger, better connected power system, including the North Sea, will **reduce emissions.**
- The observed reduction in emissions is particularly pertinent for the 'Renewables unlocked scenario' which demonstrates the **environmental benefits** of coordination, where renewable sources **reduce our reliance on gas** and other fossil fuel sources.
- Increased RES integration **achieves decarbonisation** in the energy sector, which enables decarbonisation in other sectors (heat and transport).

RES integration



- Higher renewable capacity in the 'Renewables unlocked' scenario, aligns most closely to **Governments' ambition** and **net zero** targets.
- For the coordinated world and the RES unlocked scenario, we expect that greater reliance on multi-purpose interconnection, due to **coordinated regulatory frameworks/oversight,** would result in electricity flows that would better integrate RES and exploit different RES generation profiles in the North Sea.

Increased flexible demand and H2



- More hydrogen production due to consistently **lower priced hours** where they are enabled to switch on **as flexible demand sources.**
- **Higher green H2 production allows for quicker decarbonisation of hard-to-abate industrial sectors,** which use H2 as feedstock or can replace gas usage.
- The impact may be even greater if we consider the full potential of offshore electrolysis opportunities as a result of better coordination

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Coordination enhances the resilience and reliability of our interconnected systems

Security of supply

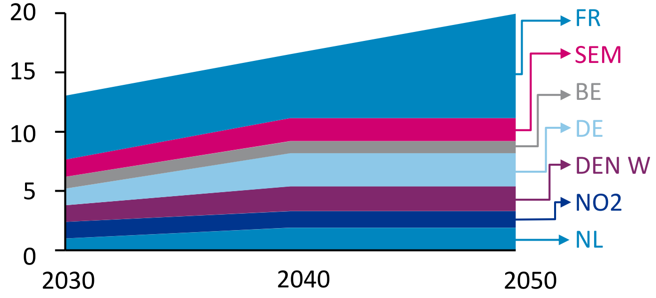
8th January 2021 case study:

- System stability issues in Continental Europe, which meant that many generating units changed control mode. Some 1.7 GW of automatic interruptible load was disconnected in France and Italy.
- Nordic synchronous area provided 535 MW and UK contributed a further 60 MW to provide system stability.

- ▶ Greater levels of interconnection and coordination between GB and EU Member States **improves security of supply,** improving our ability to manage supply/demand shocks and the risk these pose to our energy systems.[2] High levels of coordination establishes a path for secure energy supply, which can **withstand external shocks.**
- ▶ The EU has ambitious goals. Higher levels of interconnection, through greater reliance on MPIs, and improved coordination allows EU member states and the UK to leverage flexibility and enhance security of supply through leveraging generation in the UK as well.

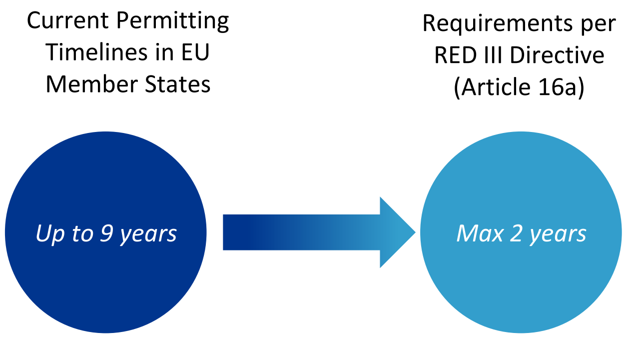
Grid stability and reliability

Cross-border Capacity potential GB-EU for grid services (GW)



- ▶ Meshed, integrated power systems with **high levels of interconnection** and coordinated rules and operating procedures provide greater grid stability and reliability for system operators to manage changing grid requirements / outages.
- ▶ TSOs would be able to **tap into various cross-border resources,** such as PICASSO, MARI, FCR to balance the grid and maintain grid frequency.
- ▶ The UK would benefit from gaining access back into the European market, and the other countries would have a wider set of resources available to them in periods of scarcity or in disturbances' events.

Accelerated grid connection processes



- ▶ Better regulatory and oversight coordination between the UK and the EU will enable Member States to coordinate planning and consenting, which ultimately leads to fulfilling the **RED III directive.** RED III restricts the timeline for planning and consenting to two-years, particularly for UK-EU offshore projects in the North Sea.
- ▶ Better coordination between UK and the EU will **facilitate the designation of specific zones in the North Sea** which will facilitate **faster permitting processes,** biodiversity consideration(s) and better allocation between competing requirements (shipping, defence, energy).

1. National Grid, A connected Future, Why Electricity interconnection between Europe and the UK matters, August 2021.
2. According to the ACER monitoring report, price volatility due to the invasion of Ukraine would have been around seven times higher if national markets had been isolated in 2022, which demonstrates the benefits of coordination and integration between UK-EU. The future of European Competitiveness, Part B – In-depth analysis and recommendations, September 2024.

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Europe's and UK's industry and energy sectors have higher chances of success and more cost-effective delivery of decarbonisation trajectories

Supply chain

- ↑ Interoperability
- ↑ Standardisation
- ↑ Manufacturers' investment

- A strong vision, plan and delivery model for the European offshore grid provides the foundation for **more efficient pan-EU supply chain strategies,** supporting the speed and cost of delivery of Europe's net zero ambition
- A coordinated approach across the EU-UK for offshore assets in the North Sea would signal to manufacturers and supply chain providers to **anticipate the requirements and invest,** which builds up regional supply chain pipelines.
- A clear plan and coordinated approach could unlock even greater value if accompanied by **asset standardisation** to produce interoperable equipment at a large scale

Financial efficiency

- ↑ Investment certainty
- ↑ Regulatory risk
- ↓ Cost of equity

- A **clear and coordinated** regulatory and risk transfer mechanism for offshore grid development would **de-risk investment** and support lower cost financing.
- The scale of investment required necessitates pooling investment from a whole range of sources (public and private) to achieve the UK's and the EU's ambitious goals.
- The establishment of a **clear regulatory coordination framework** and a vision for cooperation is a clear regulatory certainty signal to **reduce regulatory risk** and motivate private investors. This is particularly important for infrastructure assets with asset long lives.

Innovation, job and capability build-out

- ↑ Secure specialist skills
- ↑ Innovation
- ↑ Knowledge transfer

- Delivering the network required to reach our 2050 goals will require a step change in capabilities, innovation and capacity presenting a high opportunity for growth in a **highly skilled sector,** driving strong job creation and GVA opportunities for European Member States and the UK.
- Benefits in a coordinated approach, particularly for hybrid projects (instead of many small radial project) are likely to include a **stronger bargaining position** for Transmission Owners. Economies of scale and scope will assist TSOs in **securing specialist engineering design** and operation skills (such as in HVDC and offshore) for the scale of infrastructure required in the North Sea.

1. The future of European Competitiveness, Part B – In-depth analysis and recommendations, September 2024.

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Appendix

Our four scenarios aim to capture the impact of potential major paradigm changes while keeping other assumptions the same

	Status Quo / Counterfactual	Uncoordinated World	Coordinated World	Renewables Unlocked
Overview	Our central view on decarbonisation, electricity demand, policy and prices. Piecemeal coordination and domestic-focused investment limits opportunity for coordination.	Trading inefficiencies drive down investment incentives and ambition	Step-up in coordinated investment drives use of shared infrastructure and lower cost route to decarbonisation targets	Significant step-up in collective ambition in the North Sea, unlocking greater investment in offshore wind to come close to planned targets
Net zero, economy	Net zero targets are achieved but with some delay. Most markets reach net zero for the full economy in the mid-late 2050s.	- No change compared to counterfactual	- No change compared to counterfactual	↑ Net zero targets are largely achieved – most markets reach a net zero economy by 2050.
Offshore wind buildout	Offshore wind capacity expands slower than targets in most countries, with some delays. Targets set not fully reached and long-term deployment is dependent on economic incentive in model, leading to lower capacities.	- No change compared to counterfactual.	- Equivalent total amount of capacity, but a proportion of new capacity is built through hybrid interconnection.	↑ Accelerated buildout of wind capacities compared to Status Quo. Capacities get close to reaching national targets.
Transmission & Interconnectors	Interconnection buildout is expanded but in a more conservative pace and with some delays compared to TYNDP. Lion Link is built with 3-year delay, Nautilus is not built.	- No change compared to counterfactual.	- Equivalent amount of effective interconnection capacity through both P2P IC and hybrid interconnectors.	↑ Increase in Interconnection capacity on top of Status Quo case, as part of hybrid infrastructure built for the additional offshore wind
Trading arrangements and policy	Multi-Region Loose Volume Coupling is assumed leading to a small trade penalty (0.50 €/MWh) for EU exchanges with GB in the model.	↓ CBAM is implemented, imposing a high import tariff based on fossil fuel generation emissions average (e.g. 40 €/MWh in 2030)	↑ Return to market coupling and UK entering EU single energy market again. Implicit and efficient trading.	↑ Return to market coupling and UK entering EU single energy market again. Implicit and efficient trading.

Note: 1) Arrows provide the qualitative outlook in comparison to the counterfactual/Status Quo; Conventional power demand is assumed to stay constant across scenarios, storage and H2 electrolysis capacities are also unchanged. It is assumed all extra offshore wind energy will be brought onshore via cables, offshore electrolysis was not considered in this study.

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Two energy hubs were assumed in two offshore bidding zones shared by countries, either additional or transferred from domestic capacities dependent on scenario

Approach and methodology

- ENTSO-E estimates about 10% of new offshore wind capacity could potentially be connected via hybrid infrastructure by 2030. By 2040 and 2050 this increases up to 36% and 46% respectively. We use this ratio to create two energy islands in the North Sea and transfer new built wind capacity there to be under hybrid and coordinated infrastructure instead of radially connected. In the RES unlocked case, all this capacity is additional.
- The energy hubs function as Offshore Bidding Zones (OBZ), operating as dedicated zones in our pan-EU market simulation model, exporting through the interconnector lines.

Offshore wind capacities (GW)

	2030				2040				2050			
	Uncoordinated	Status Quo	Coordinated World	RES Unlocked	Uncoordinated	Status Quo	Coordinated World	RES Unlocked	Uncoordinated	Status Quo	Coordinated World	RES Unlocked
BE	5.1	5.1	4.1	5.1	6.5	6.5	3.5	6.5	7.6	7.6	3.6	7.6
DE	22.8	22.8	21.8	22.8	52.6	52.6	48.1	52.6	78.8	78.8	65.8	78.8
FR	3.8	3.8	3.3	3.8	23.3	23.3	21.3	23.3	44.7	44.7	35.7	44.7
GB	35.3	35.3	32.5	35.3	51.4	51.4	39.4	51.4	64.2	64.2	48.2	64.2
NL	10.2	10.2	8.2	10.2	26.8	26.8	18.8	26.8	40.3	40.3	24.3	40.3
DK	3.2	3.2	2.2	3.2	6.8	6.8	2.3	6.8	7.8	7.8	2.8	7.8
SEM	0.9	0.9	0.9	0.9	6.5	6.5	6.5	6.5	8.7	8.7	8.7	8.7
OBZ 1			6	15			25	45			50	50
OBZ 2			2	8			9	20			18	18

Source used: ENTSO-E ONDP Northern Seas, Baringa Reference case research

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Total effective interconnector capacity is assumed to stay the same across Uncoordinated, Status Quo and Coordinated, with added capacity for Unlocked

Interconnector capacity (GW)

2030

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
GB - FR	5400	5400	5400	5400
GB - SEM	1450	1450	1450	1450
GB - BE	1000	1000	1000	1000
GB - DE	1400	1400	1400	1400
GB - DEN W	1400	1400	1400	1400
GB - NO2	1400	1400	1400	1400
GB – NL	1000	1000	1000	1000
OBZ 1 – NL	-	-	2000	4000
OBZ 1 – DE	-	-	1000	2000
OBZ 1 – DK	-	-	1000	2000
OBZ 1 – GB	-	-	2000	4000
OBZ 1 – NO2	-	-	0	1000
OBZ 2 - GB	-	-	600	2000
OBZ 2 - FR	-	-	500	1500
OBZ 2 - BE	-	-	500	1500
OBZ 2 - NL	-	-	500	1500

2040

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
GB - FR	5400	5400	4400	5400
GB - SEM	1450	1950	1950	1450
GB - BE	1000	1000	0	1000
GB - DE	1400	2800	800	1400
GB - DEN W	1400	2100	100	1400
GB - NO2	1400	1400	900	1400
GB – NL	1000	1900	200	1000
OBZ 1 – NL	-	-	8000	14000
OBZ 1 – DE	-	-	4000	7500
OBZ 1 – DK	-	-	4000	7500
OBZ 1 – GB	-	-	8000	14000
OBZ 1 – NO2	-	-	1000	2000
OBZ 2 - GB	-	-	3500	7000
OBZ 2 - FR	-	-	1750	8000
OBZ 2 - BE	-	-	2750	2500
OBZ 2 - NL	-	-	1000	2000

2050

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
GB - FR	8800	8800	5400	5400
GB - SEM	1950	1950	1950	1450
GB - BE	1000	1000	0	1000
GB - DE	2800	2800	0	1400
GB - DEN W	2100	2100	0	1400
GB - NO2	1400	1400	0	1400
GB – NL	1900	1900	0	1000
OBZ 1 – NL	-	-	14000	14000
OBZ 1 – DE	-	-	13000	13000
OBZ 1 – DK	-	-	5000	5000
OBZ 1 – GB	-	-	14000	14000
OBZ 1 – NO2	-	-	3000	2000
OBZ 2 - GB	-	-	4000	4000
OBZ 2 - FR	-	-	8000	8000
OBZ 2 - BE	-	-	3000	4000
OBZ 2 - NL	-	-	2000	1000

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Wholesale prices impact per scenario

Approach and methodology

- Wholesale prices are annual, time-weighted averages from hourly power market simulation outputs in PLEXOS. All bidding zones in Europe are modelled simultaneously in the Baringa pan-EU model.
- Consumer price impacts are calculated through the following formula: $(CountryPrice_{Scenario} - CountryPrice_{StatusQuo}) * CountryDemand_{Conventional}$ (where for conventional demand the flexible demand such as Heat Pumps, EVs and H2 Electrolysis is removed)

Wholesale price (€/MWh (real 2024))

2030

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
BE	87.0	85.3	85.3	76.7
DE	84.1	82.9	83.0	77.0
FR	80.5	79.0	79.3	73.8
GB	78.1	85.4	86.2	75.8
NL	84.4	83.0	82.8	75.1
NO2	82.1	79.8	80.5	71.0
DK W	82.8	81.2	81.1	72.9
SEM	99.0	100.4	100.6	96.7
Connected Zones to GB	**82.7**	**82.8**	**83.1**	**76.1**
Wider EU	**85.7**	**85.5**	**81.1**	**85.7**

2040

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
BE	83.5	80.6	79.9	59.4
DE	81.4	79.0	79.3	64.4
FR	73.7	71.4	73.0	57.1
GB	58.8	67.9	71.4	51.9
NL	81.0	78.3	77.1	52.7
NO2	63.9	61.9	63.5	47.2
DK W	76.9	73.5	76.0	52.6
SEM	74.4	76.6	78.2	68.3
Connected Zones to GB	**74.8**	**74.6**	**75.5**	**58.5**
Wider EU	**75.5**	**74.8**	**75.5**	**63.3**

2050

	Uncoordinated	Status Quo	Coordinated world	RES Unlocked
BE	75.2	73.0	69.3	53.9
DE	69.6	68.5	66.6	55.5
FR	64.3	62.9	62.8	50.5
GB	61.6	68.9	69.6	51.1
NL	69.1	67.7	63.9	49.5
NO2	50.8	50.0	51.2	42.4
DK W	63.9	62.5	63.8	49.8
SEM	82.2	84.6	84.9	76.6
Connected Zones to GB	**66.9**	**67.2**	**66.1**	**53.0**
Wider EU	**67.9**	**67.9**	**67.0**	**57.9**

Building 8 GW in Coordinated World vs. Status Quo around 2030

Capex costs

Status Quo

Component	Amount (GW or %)	Costs (€m, real 2024)
Radial HVDC for wind farms		
Offshore converter stations	8.2	4,387
Onshore converter stations and substations	8.2	2,313
Offshore substations	8.2	2,879
Offshore export cables	8.2 (270 km x 8)	3,745
Onshore export cables	8.2 (20 km x 8)	241
Devex	10%	1,356
Contingency	7.5%	1,119
System Costs	-	16,043
Interconnector builds (HVDC)		
Onshore converter stations (Country A)	4	1,119
Onshore converter stations (Country B)	4	1,119
Offshore export cable	4 (350km x 4)	2,349
Onshore export cable	4 (20km x 4)	117
Devex	10%	471
Contingency	7.5%	388
System cost		5,564
Total Costs		**21,608**

Coordinated World

Component	Amount (GW or %)	Costs (€m, real 2024)
MPI HVDC		
Offshore converter stations	8.2	4,387
Onshore converter stations and substations	8.2	2,313
Offshore substations	8.2	2,879
Offshore export cables	8.2 (510 km x 8)	7,074
Onshore export cables	8.2 (20 km x 8)	241
Devex	10%	1,356
Contingency	7.5%	1,119
System Costs	-	19,980
Interconnector builds (HVDC)		
N/A		
Total Costs		**19,980**

Note: Cost estimations are based on high-level average costs of infrastructure by 2030. Costs are extrapolated from a per unit basis cost assumption. With learning rates and economies of scale, costs could further develop and decrease in later years.

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Building 8 GW in Coordinated World vs. Status Quo around 2030

Opex costs

Status Quo

Component	Amount (GW or %)	Costs (€m, real 2024)
Radial HVDC for wind farms	8 (270km)	5,644
Interconnector builds (HVDC)	4 (350km)	7,113
Total Costs		**12,756**

Coordinated World

Component	Amount (GW or %)	Costs (€m, real 2024)
MPI HVDC	8 (510km)	10,660
Total Costs		**10,660**

Note: Cost estimations are based on high-level average costs of infrastructure by 2030. Costs are extrapolated from a per unit basis cost assumption. With learning rates and economies of scale, costs could further develop and decrease in later years.

Emissions impact per scenario

Approach and methodology

- Emissions are CO_2-equivalent emissions from the power sector.
- Emissions savings are calculated from the difference in total emissions between the status quo case and the scenario in question.

Emissions impact (m tons CO_2)

2030

	Uncoordinated	Status Quo	Coordinated World	RES Unlocked
BE	10.8	10.5	10.3	9.1
DE	88.7	86.9	86.8	81.5
FR	10.2	9.8	9.8	9.3
GB	23.5	27.6	28.2	23.4
NL	20.2	19.5	19.4	17.4
NO2	0.0	0.0	0.0	0.0
DK W	0.9	0.9	0.9	0.9
SEM	5.6	5.5	5.6	5.3
Connected Zones to GB	**160.0**	**160.7**	**161.1**	**147.0**
Wider EU	**314.2**	**308.9**	**309.0**	**294.3**

2040

	Uncoordinated	Status Quo	Coordinated World	RES Unlocked
BE	4.0	3.7	3.4	2.2
DE	25.8	24.8	24.4	19.8
FR	5.8	5.7	5.7	4.9
GB	1.2	2.4	2.8	0.4
NL	9.3	8.9	8.6	7.0
NO2	0.0	0.0	0.0	0.0
DK W	0.8	0.7	0.7	0.6
SEM	2.3	2.4	2.4	2.1
Connected Zones to GB	**49.0**	**48.6**	**48.0**	**36.9**
Wider EU	**113.0**	**109.9**	**109.0**	**92.7**

2050

	Uncoordinated	Status Quo	Coordinated World	RES Unlocked
BE	1.5	1.5	1.4	1.0
DE	4.8	4.6	3.7	1.4
FR	-0.2	-0.3	-0.3	-0.3
GB	-4.8	-4.7	-4.7	-5.5
NL	7.4	7.4	7.3	7.0
NO2	0.0	0.0	0.0	0.0
DK W	0.9	0.9	0.9	0.8
SEM	0.5	0.5	0.5	0.4
Connected Zones to GB	**10.1**	**10.1**	**8.9**	**4.8**
Wider EU	**40.7**	**40.5**	**38.7**	**33.0**

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