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SETTING SAIL: EU PRIORITIES TO DELIVER NORTH SEAS OFFSHORE WIND

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The European Commission has recognised the critical role that offshore renewable resources, especially offshore wind, will play in enabling the Union to become climate neutral by 2050. It has set ambitious deployment targets as part of the EU Strategy on Offshore Renewable Energy.

Modelling undertaken by E3G and researchers from Imperial College London suggests an estimated €30-60bn in savings are available in the period out to 2050 from establishing an offshore grid that connects offshore wind capacity and links the power systems of coastal countries, including non-EU countries[1]. In addition to cost savings, this approach would reduce the number of onshore connections and their associated environmental impacts.

This briefing summarises the modelling and sets out four ‘critical path’ recommendations if the EU is to realise these benefits:

1. **The TEN-E Regulation and the Renewable Energy Directive should be used to establish the process for delivering an integrated offshore network.** This should include new mechanisms for grid planning and for allocating the costs and benefits of offshore assets. There should be a specific requirement on member states to co-operate to define the

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[1] Compared to the situation where countries establish independent offshore networks.

integrated offshore grid that will allow them to deliver their offshore wind ambitions at least cost. Initial network plans should support delivery of the EU's 2030 ambitions.

2. **The European Scientific Advisory Board on Climate Change, which will be established under the recently approved EU Climate Law, should be requested to provide independent science-based advice on the key assumptions that should be used to develop the network plan**. It should also maintain oversight on the entire process to ensure outcomes are aligned with the climate neutrality pathway. This is because the optimal deployment of offshore resources depends critically on a wide range of assumptions about the future use of gas and the nature of energy consumption.
3. **The EU and UK should commit to proceed with a shared offshore network project that connects offshore wind farms (so-called 'hybrid interconnector') by the end of 2021 such that it becomes operational before the end of 2029**. There are significant benefits for both the EU and UK from ensuring the offshore power networks connects offshore renewable resources and onshore power networks of both parties. With little time available, a political commitment is required to inject urgency and establish a process to realise the benefits. This commitment should be underpinned by a new memorandum of understanding to develop the regulatory framework and delivery processes by the end of 2023.
4. **The EU should establish new mechanisms to enable and promote Europe-wide buy in to the North Seas project.** Participation of all stakeholders including those outside the energy industry and not in countries with a North Seas coast is appropriate given the overall strategic importance of the project to EU climate targets and economic growth.

Current policy agenda

The European Commission (EC) launched an EU Strategy on Offshore Renewable Energy in November 2020[2]. This initiative recognised the critical role that offshore renewable resources, especially offshore wind, will play in enabling the Union to become climate neutral by 2050. Offshore wind presents the opportunity to produce large volumes of renewable electricity at low cost and with limited environmental impact. To this end, the strategy proposed an increase in the EU's offshore wind capacity from its current level of 12GW to at least 60GW by 2030 and to 300GW by 2050[3]. Whilst there is vast potential across all of Europe's sea basins, the shallow and windy North Seas[4] represents the key opportunity.

The strategy proposed a variety of measures to promote the scale-up of offshore wind capacity including providing a clear and supportive legal framework, mobilising relevant funds to support the sector's development, and ensuring a strengthened supply chain. However, it recognised that cross-border co-operation between member states on long-term planning and deployment would be critical. To support this objective, the EC has proposed a framework under the revised TEN-E Regulation for long-term offshore grid planning, involving regulators and the member states in each sea basin[5]. It would require member states to ‘jointly define and agree to co-operate on the amount of offshore renewable generation to be deployed within each sea basin by 2050, with intermediate steps in 2030 and 2040’. It also requires the European Network of Electricity Transmission System Operators (ENTSO-e) to ‘develop and publish integrated offshore network development plans starting from the 2050 objectives, with intermediate steps for 2030 and 2040’. The recently published proposal for revision to the Renewable Energy Directive (RED) similarly calls for member states to co-operate on the amount of offshore renewable generation to be deployed within each sea basin and to ‘increasingly consider the possibility of combining offshore renewable energy generation with transmission lines interconnecting several Member States, in the form of hybrid projects or, at a later stage, a more meshed grid’[6]

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[2] An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future; COM (2020) 741, 19th November 2020

[3] The EC aims to complement this with 40GW of ocean energy and other emerging technologies such as floating wind and solar by 2050.

[4] Includes the North Sea, Irish Sea, West Atlantic and Baltic Sea

[5] Proposal for a Regulation of the European Parliament and of the Council on guidelines for trans-European energy infrastructure and repealing Regulation (EU) No 347/2013; COM (2020) 824, 15th December 2020

[6] Proposal for a Directive of the European Parliament and of the Council, COM (2021) 557 final

Attempts to promote co-operation between member states in deploying offshore wind capacity have been underway for some time. The North Seas Countries' Offshore Grid Initiative was a regional cooperation of 10 countries formalised by a memorandum of understanding in 2010. The objective was to facilitate the coordinated development of a possible offshore electricity grid in the greater North Seas area. Following the Paris Climate Agreement, this initiative was re-booted in 2016 with the establishment of the North Seas Energy Co-operation, which aimed to facilitate the cost-effective deployment of offshore renewable energy, in particular wind, and promote interconnection between the countries in the region.

The country with access to the largest potential offshore wind resource in the North Seas is the UK. However, the UK left the North Seas Energy Co-operation initiative when it departed the EU in January 2020. The Offshore Renewable Energy Strategy and the proposed revision to the TEN-e Regulation make no reference to the role of non-EU countries in developing offshore wind resources. However, the post-Brexit trade agreement does require the EU and UK to '*co-operate in the development of offshore renewable energy by sharing best practices and, where appropriate, by facilitating the development of specific projects*'. It also envisages the creation of a successor technical forum to the North Seas Energy Co-operation for discussion between 'the European Commission, ministries and public authorities of the Member States, United Kingdom ministries and public authorities, transmission system operators and the offshore energy industry and stakeholders more widely, in relation to offshore grid development and the large renewable energy potential of the North Seas region'.

All analyses show that the path to climate neutrality must be based on an energy system that involves significant growth in electricity demand from electrification. Also, this electricity must be produced largely from renewable energy sources. Fully exploiting offshore wind resources will be key to the successful realisation of this vision and in delivering the associated economic benefits of the European Green Deal. The challenge for the EU is now to ensure that the policy framework turns this vision into reality.

Benefits of grid integration

Earlier this year, E3G and researchers from Imperial College London published modelling that suggests significant savings - €30-60bn in the period out to 2050 - can be achieved by co-ordinating the connection of offshore wind projects through offshore hubs[7]. Therefore, major deployments of offshore wind should not proceed on an incremental 'project-by-project' basis.

Further significant cost savings arise through strategic planning of an offshore grid both within and between the territorial waters of each country (comparison of studies 2, 3, and 4 in the modelling – see Annex 1). This involves moving from a hub-based approach to a meshed grid that connects the territorial waters of several countries. Figure 1 shows the optimal grid configurations produced by the model for each scenario and the impact on total system costs for each country is shown in Annex 2.

Whilst there is a modest overall cost saving available from creating separate offshore grids in individual country territorial waters (€2bn for the medium ambition scenario and €6bn for the high ambition scenario in the period out to 2050), **the major cost savings arise through the creation of a fully interconnected offshore grid**. This leads to an additional saving of €32bn in the medium ambition scenario and €29bn in the high ambition scenario compared to country-based grids in the period out to 2050. Germany alone benefits by ~€7bn in the high ambition scenario.

Importantly, the last chart in Figure 1 illustrates that **many of the cross-border connections are between EU states and the UK and these will be important in delivering the savings**.

Benefits of sectoral integration

The introduction of additional **system flexibility through enhanced demand side response or hydrogen production through electrolysis can provide additional cost savings** (studies 5 to 8). Figure 2 shows the net cost benefit[8] of each study[9] compared to the base case[10].

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[7] The modelling scope is summarised in the Annex, and the full study available here: **https://www.e3g.org/publications/offshore-wind-in-the-north-seas/**

[8] Net cost benefit shows that savings in network and generation costs due to hydrogen production are offset by the costs of electrolysis facilities.

[9] S2 refers to study 2 etc.

[10] The base case is the current 'radial' approach where each project has a separate onshore grid connection

Figure 1: Optimal network for different levels of strategic grid integration

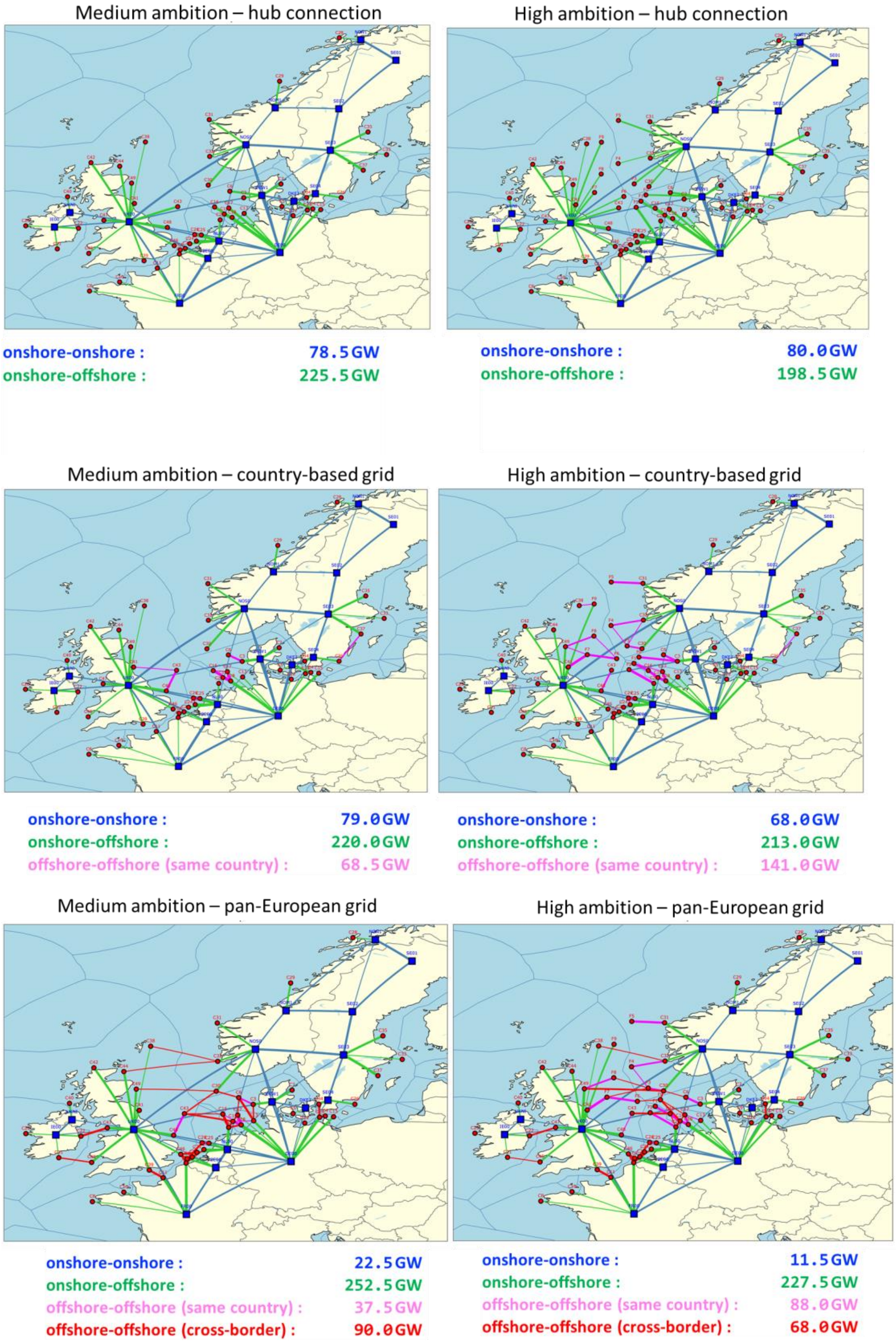
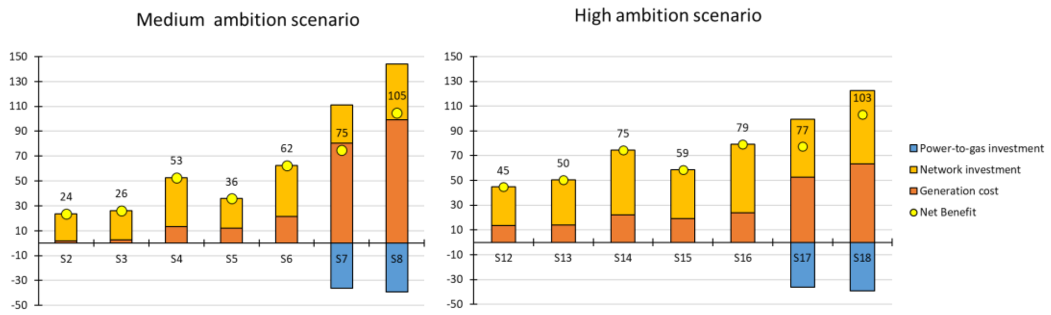


Figure 2: Net cost benefit of each study (in £bn) compared to radial connection



The ENTSO-e ten-year network development plan (TYNDP) 'Global Ambition' scenario was used to define the network (topology, generation mix, demand) for the nine countries. This provides an internally consistent set of data for the energy system which represents one pathway that aligns with the 2050 climate neutrality goal. However, this does not mean it represents the best pathway. It has several limitations including a high on-going dependence on gas, of which full costs and emissions are not fully understood, and on carbon capture and storage, where the speed and costs of deployment are uncertain.

The relatively low electricity demand used in this scenario is particularly important and arises from the ENTSO-e assumptions relating to the use of gas and levels of distributed power generation. This meant that the model did not choose to build all the available offshore wind capacity in any of the studies. Indeed, much of the cost savings achieved in the higher flexibility studies arose from the reduced generation capacity required to meet demand since less renewable generation capacity is required to produce the same level of output.

These studies highlight that **the optimal buildout of offshore wind in the North Seas will depend on several key assumptions**. These include:

- demand for green hydrogen,
- the deployment of smart and controllable demand side response, improvements in energy efficiency,
- the volumes of decentralised energy resources,
- the electrification of other sectors, and
- the extent of power trading between EU member states.

An offshore grid cannot therefore be planned in isolation and **requires assumptions based on deep expertise in technology developments and deployment potentials in all these areas to create a coherent integrated whole system plan**.

Optimising green hydrogen production

A further two scenarios were run where demand was increased to produce hydrogen (study 9 with electrolysers offshore and study 10 with electrolysers onshore) such that all the potential offshore wind capacity was utilised. The additional electricity generated that could be converted into hydrogen is summarised in the following table:

Table 1: Electricity available for hydrogen production

Year	Medium Scenario (TWh/year)	High Scenario (TWh/year)
2030	0	0
2040	0	165
2050	258	941

This highlights that **production of significant quantities of green hydrogen from offshore wind in the North Seas will not happen quickly and will require very ambitious goals for offshore wind deployment**. These studies compared the costs of building additional power networks and producing hydrogen onshore with the co-location of hydrogen production at offshore wind hubs. In the latter case, it is assumed that existing gas network infrastructure would be re-purposed to pipe hydrogen ashore. The additional costs of the power network are significant (€44bn in the medium ambition scenario and €166bn in the high ambition scenario). Assuming the costs of re-purposing gas pipes to transport hydrogen onshore is significantly lower than these amounts[11], this suggests that the **preferred approach for green hydrogen production will involve co-location of electrolysis and offshore wind generation where access to a repurposed gas network is possible**. The system costs for these studies, including investment in electrolyser capacity, is shown in Annex 3.

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[11] Note that: the costs of re-purposing onshore gas infrastructure and appliance for hydrogen use are high and uncertain, the geography of pipelines versus offshore wind resources still needs to be mapped and this analysis draws no conclusions about onward transmission within the onshore gas network or the extent of the overall hydrogen demand.

It is important to note that high utilisation of offshore wind capacity could also be achieved if surplus generation could be traded throughout the EU, which in this model was restricted to meeting demand in the 9 modelled countries.

Policy implications for the EU

Strategic grid planning to realise cost benefits

The evidence from this modelling suggests that the cost savings of a long-term strategically planned network that will connect the various sea basins and their renewable resources to an integrated European power market are overwhelming. In addition to costs, this will also avoid unnecessary onshore grid connections which increase environmental impacts and slow project delivery. **The European Commission is, therefore, right to call for urgent action to deliver an integrated strategic grid plan as part of the revised Trans-European Energy Networks Regulation (TEN-E Regulation).**

However, as the energy system becomes increasingly interdependent, the optimal deployment of offshore renewables and the associated network infrastructure will depend on a range of factors. **Assumptions about the future role of gases, including hydrogen, will be critical in deriving an optimal strategic plan.** Other assumptions relating to electricity consumption (distributed generation, efficiency, flexibility) will also be extremely important. The benefits of geographical coherence will not be realised unless plans are aligned with those relating to gas system development and the refurbishment of the built infrastructure.

Whilst it is important that individual member states control deployments in their territorial water, **these should be informed by a common understanding of technology developments and deployment potentials across the energy system**. ENTSO-e can advise on power network issues but does not have the deep expertise required in other areas, particularly those relating to changes in energy consumption. There is the need for an independent science-based body to advise on the key assumptions that should be used to develop a long-term plan. This is important, for example, to ensure plans for offshore wind deployment are not limited, perhaps to levels far lower than those set out in the Offshore Renewables Strategy, based on over-ambitious expectations of the future role of hydrogen produced from fossil gas. The European Scientific Advisory Board on Climate Change, which will be established under the recently approved EU Climate Law, could play a key role in ensuring coherent long-term infrastructure plans are produced.

The EC should, therefore, request this independent advisory body at the earliest opportunity to consider the assumptions that should be used to underpin plans for the strategic development of offshore renewable resources. It would draw on relevant independent expert bodies operating at member state level and, where appropriate, in third countries. It should also maintain oversight of the entire process to ensure outcomes are aligned with the climate neutrality pathway. This work would also prove extremely valuable for parallel activities relating to the development of EU gas infrastructure and upgrading the built environment.

Trading across borders for a cheaper and more secure energy system

The pursuit of a single market in energy has always been a key objective for the EU. This is now even more important with the requirement to access vast amounts of renewable electricity as cheaply as possible. The best resources lie at the periphery of the continent, including offshore wind in the North Seas and elsewhere, as well as the vast solar potentials in Southern Europe. The EU electricity market must ensure this is freely traded and available to all member states. Treating renewable electricity as a purely national resource will limit the scope to exploit offshore wind resources and may undermine the ability to achieve the deployment targets set out in the EU Strategy on Offshore Renewable Energy. Whilst the modelling discussed in this paper was limited to North Seas countries, the pan-European benefits of strategic projects such as the North Seas grid need to be more clearly quantified and articulated when discussing associated market and governance developments.

Creating an integrated offshore grid to connect offshore wind capacity and link the power systems of coastal countries will be critical in ensuring the cost-effective sharing of renewable resources. This will require new approaches to system planning and new rules for allocating the costs and benefits associated with system assets. The revision to the TEN-E regulation proposed by the EC sets out an approach to tackle these issues and the reaction to these proposals by other EU institutions represents an important test of the willingness of EU member states to work collaboratively to achieve the goals of the European Green Deal. This initiative should be reinforced with a **specific requirement within the RED that member states co-operate to define the integrated offshore grid that will allow them to deliver their offshore wind ambitions at least cost.**[12]

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[12] The text proposed by the EC has the right ingredients but stops short of that by only encouraging Member States to “consider” the associated grid planning needs. **COM (2021), 557 final**

An even bigger prize is available if the integrated offshore grid connects with the offshore wind resources and power systems in key neighbouring countries. Working together with the UK will be critical if the EU is to fully realise the potential benefits of renewable resources in the North Seas. The post-Brexit trade agreement recognises the importance of collaborating on this issue but is vague and lacks a specific objective. Most critically, there is no clarity over how much resource sharing will be desirable between the two blocks. This is inconsistent with the urgency reflected in ambitious offshore wind deployment targets.

The goal to achieve climate neutrality is shared by the EU and UK and the importance and urgency of making the most of the renewable resources in the North Seas demands that this should become a political priority for both parties. By 2025, both will need to submit enhanced climate targets as part of their Paris Agreement obligations. The extent to which ambition can be increased will depend on the ability to develop North Seas resources fast and cost-effectively – and this in turn depends on the level of UK-EU co-operation.

This year, the EU and UK should make a political commitment to proceed with a network project that connects the UK and EU with several offshore windfarms (often call a 'hybrid interconnector'). The target should be set for this project to become fully operational before the end of 2029, thereby helping to contribute to the delivery of UK and EU 2030 targets for offshore wind.

This commitment should include the requirements that the hybrid interconnector be scalable as part of a fully meshed offshore grid and connects windfarms in both UK and EU waters. **This commitment should be underpinned by a new memorandum of understanding to develop the regulatory mechanisms and delivery processes. These processes should be finalised and agreed by the end of 2023 and include:**

- The mechanism for planning the interconnector and the parties who need to be involved.
- The process for allocating contracts to construct and operate the interconnector, including identifying cost recovery mechanisms.
- The trading arrangements for power flows across the interconnector, including any financial support for the connected windfarms.
- The terms by which windfarms can connect to the interconnector.

- A clear mechanism by which these approaches can be applied to subsequent offshore network projects as part of an integrated offshore grid.
- A co-operation platform involving non-energy stakeholders such as other marine users, onshore environmental and social interests, and non-North Seas member states to ensure a fair allocation of costs and benefits of the project.

Summary of policy recommendations

- **Enable strategic planning of an integrated offshore power network that anticipates future deployment of offshore assets**: The revision of the TEN-E Regulation and RED should be used to establish the process for delivering such a network. Critically, it must require that the offshore network is consistent with broader energy system infrastructure plans (including onshore electricity, gas, hydrogen, and programmes to upgrade buildings) and that grid planning needs are assessed alongside renewable plans. Also, tight deadlines must be imposed for producing the plan to ensure it reflects the urgency of delivering targets for offshore wind capacity.
- **Ensure network and generation planning is science-based and uses a transparently and independently derived set of assumptions** – particularly those relating to future energy consumption of gas, hydrogen, and electricity. The EC should request the European Scientific Advisory Board on Climate Change at the earliest opportunity to consider the assumptions that should be used to underpin plans for the strategic development of offshore renewable resources. This independent advisory body should work with relevant independent expert bodies at member state level and in third countries and should maintain oversight of the entire process to ensure outcomes are aligned with the climate neutrality pathway.
- **Inject urgency into developing the process for resource sharing between the EU and the UK through a political declaration setting clear targets for co-operation.**
  - The EU and UK should commit to proceed with a hybrid interconnector between the UK and EU by the end of 2021 with the target that it becomes operational before the end of 2029.
  - This hybrid interconnector must be scalable as part of a fully meshed offshore grid and connect windfarms in both UK and EU waters.
  - This commitment should be underpinned by a new memorandum of understanding to develop the regulatory mechanisms and delivery processes which must conclude by the end of 2023.

- **The EU should establish new mechanisms to promote participation of all stakeholders** including those outside the energy industry. This should include specialist interests such as other marine users, onshore environmental and social interests, and non-North Seas countries. There is a significant role for parliamentarians in facilitating a collaborative approach to exploiting offshore renewable resources and in communicating the benefits of strategic and integrated network planning. This is appropriate given the overall strategic importance of the project to EU climate targets and economic growth.

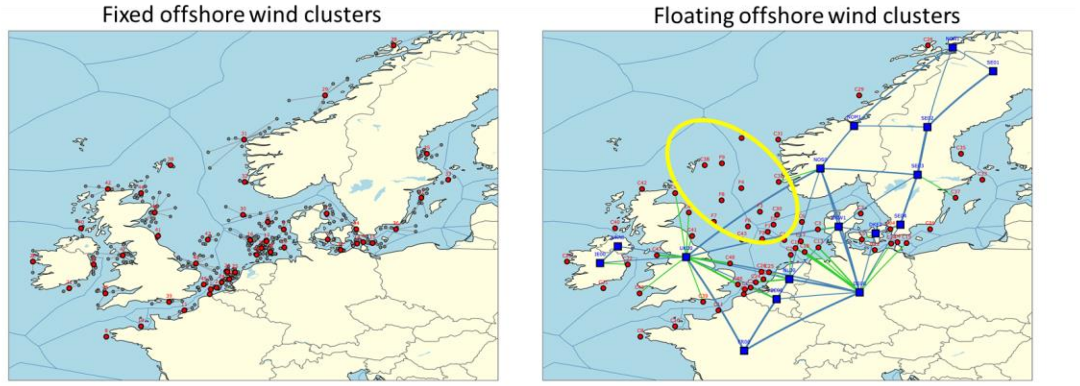
Annex 1 – Modelling scope

Scope of modelling

E3G has recently published results of a modelling exercise undertaken with researchers from Imperial College London[13]. Whilst this report is focused on the policy actions that must be taken in the UK, the modelling results relate to the territorial waters of seven EU member states (Ireland, Sweden, Denmark, Germany, Netherlands, Belgium, and France) plus UK and Norway. It is, therefore, relevant to the development of offshore wind resources in the EU.

The modelling considered two scenarios. The first, or medium ambition scenario, is focused purely on fixed offshore wind installations and considered 340GW of potential capacity grouped into 49 clusters. The second, or high ambition scenario, also included the potential for floating installations further offshore, raising the capacity to 490GW by adding a further 10 clusters of 15GW (Figure A1).

Figure A1: Offshore wind clusters



The 2025 to 2050 period was split into 3 stages: stage 1 from 2025 to 2030, stage 2 from 2030 to 2040, and stage 3 from 2040 to 2050. The growth in potential offshore wind capacity for each country and for each scenario is shown in Figure A2.

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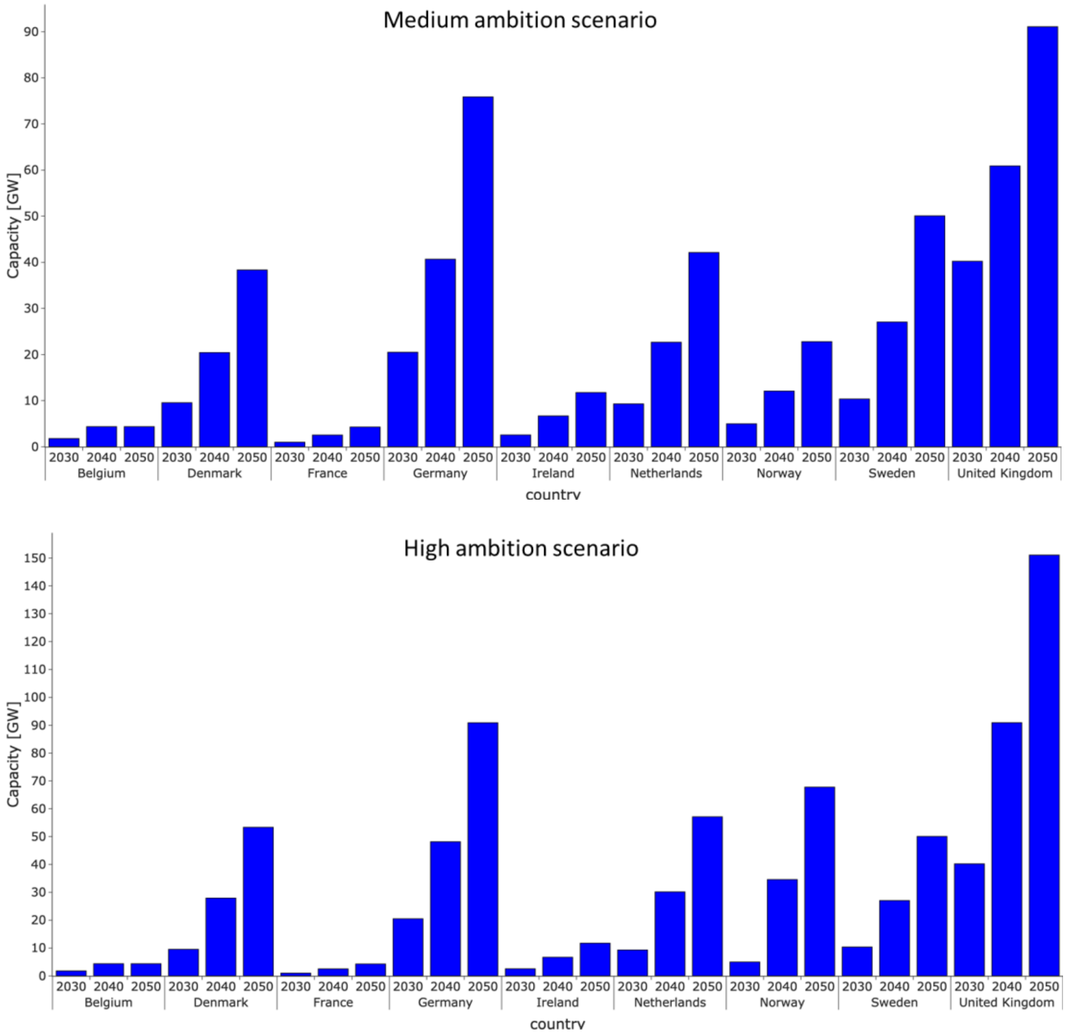
[13] Offshore wind in the North Seas – from ambition to delivery, Skillings and Strbac, March 2021

Figure A2: Offshore wind capacity by country



Eight cases were studied for each scenario. These were designed to compare how system costs change between using the current radial connection approach, more strategic grid co-ordination within country regions (hub approach), and a fully interconnected grid both within and between countries around the North Seas[14]. They also explored how improved system flexibility through enhanced use of demand side response (DSR) and co-location of offshore wind and hydrogen producing electrolysis plant can reduce system costs. These cases are summarised in the following table:

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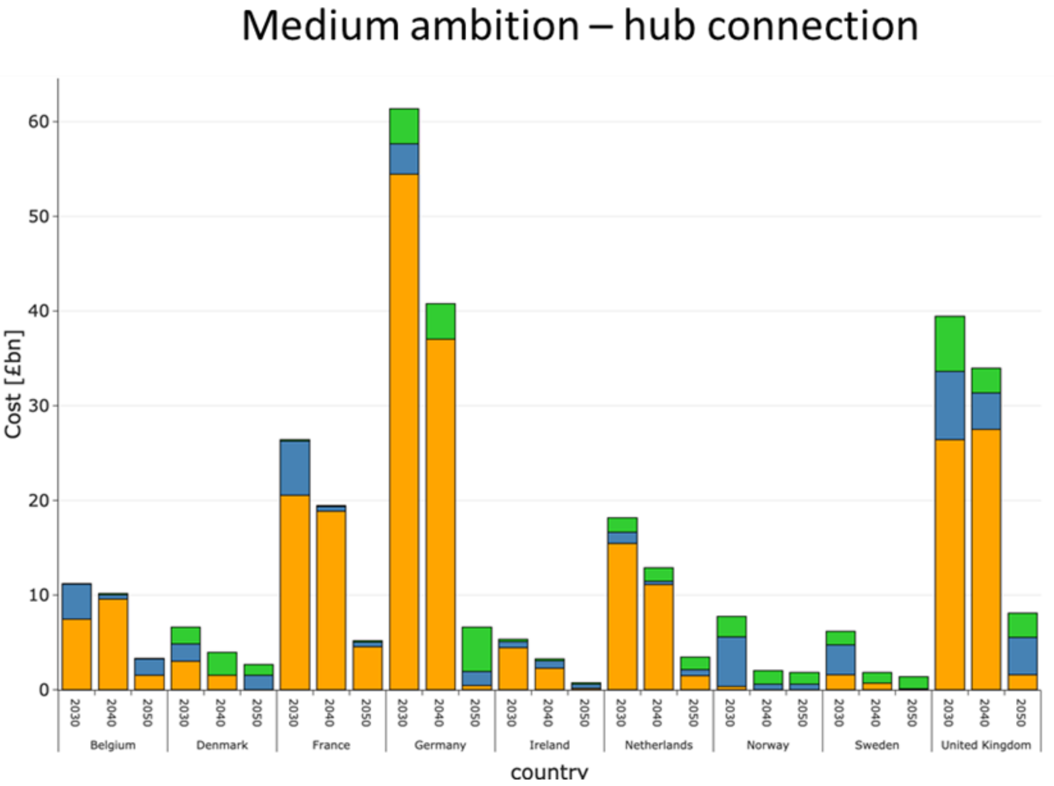
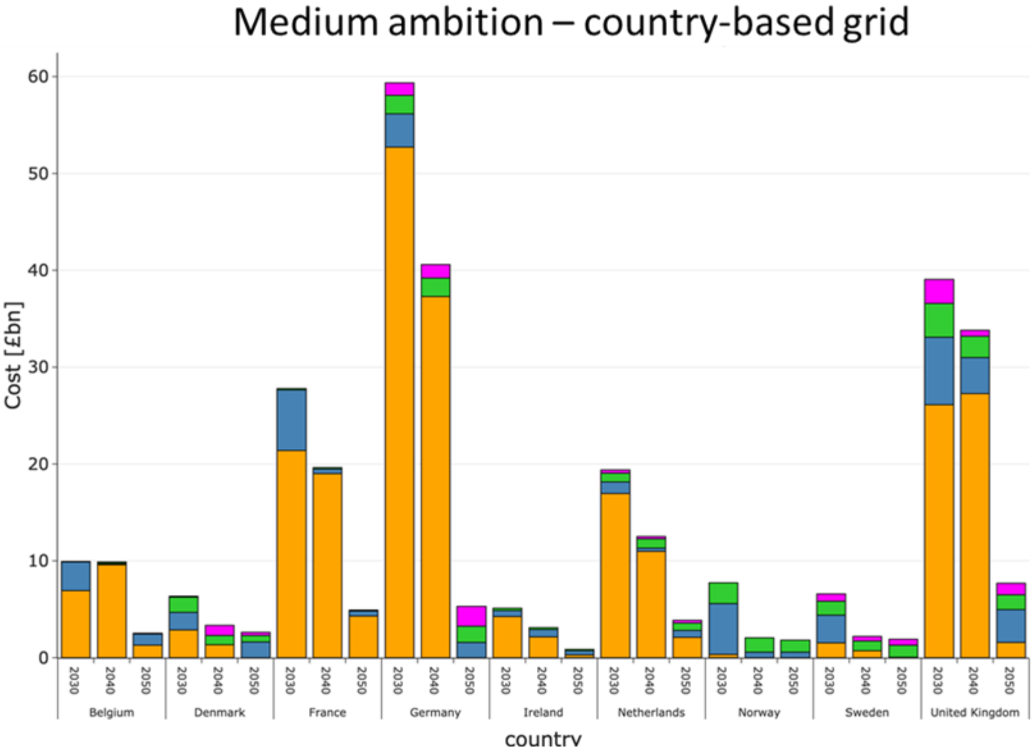
[14] The issues relating to grid connection and design options are explained in the original report.

Table A1: Studies modelled for each scenario

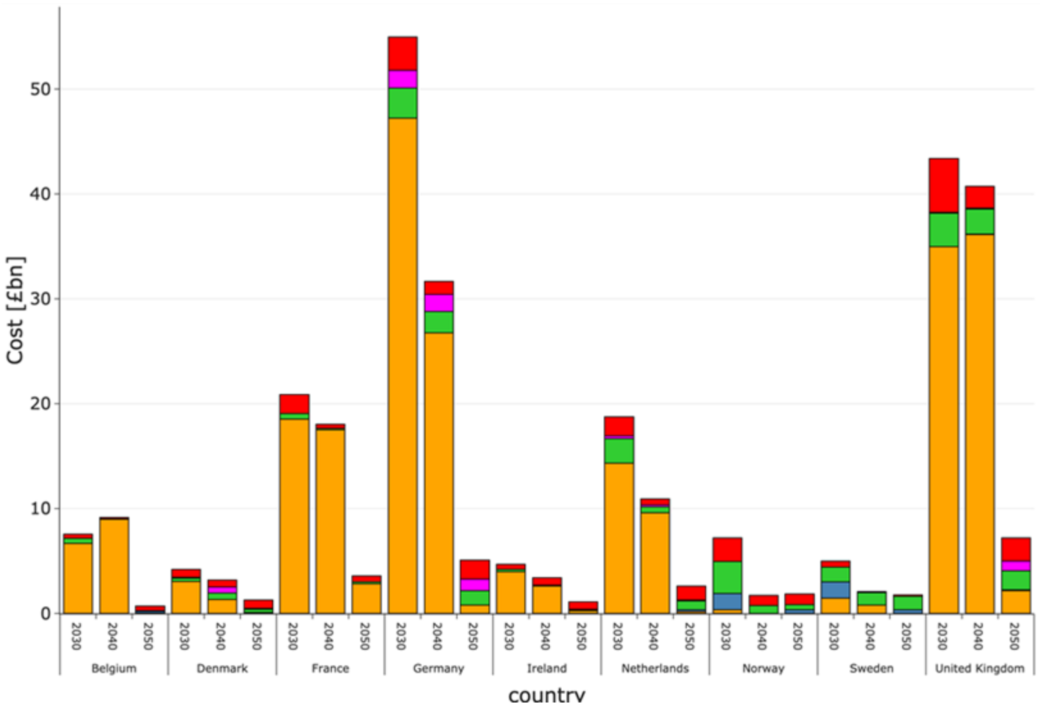
Study index	Integration level	Connections	DSR	Hydrogen
1	None	Radial	N	N
2	None	Hub	N	N
3	Member-centric	Hub	N	N
4	Pro-European	Hub	N	N
5	Member-centric	Hub	Y	N
6	Pro-European	Hub	Y	N
7	Member-centric	Hub	N	Y
8	Pro-European	Hub	N	Y

Annex 2 - System cost breakdown for different levels of grid integration

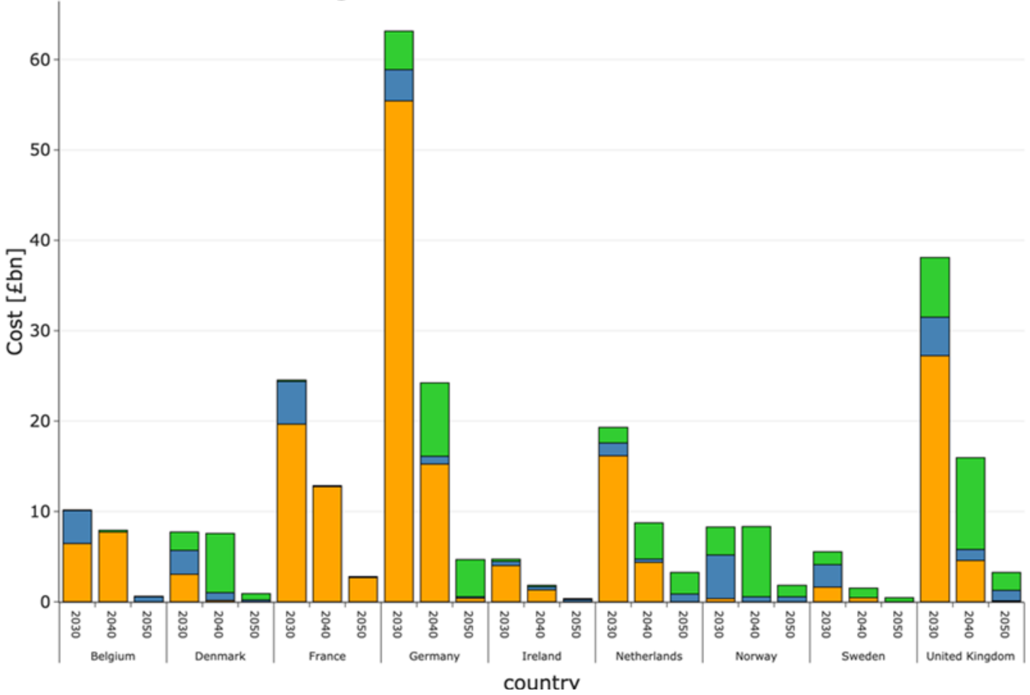


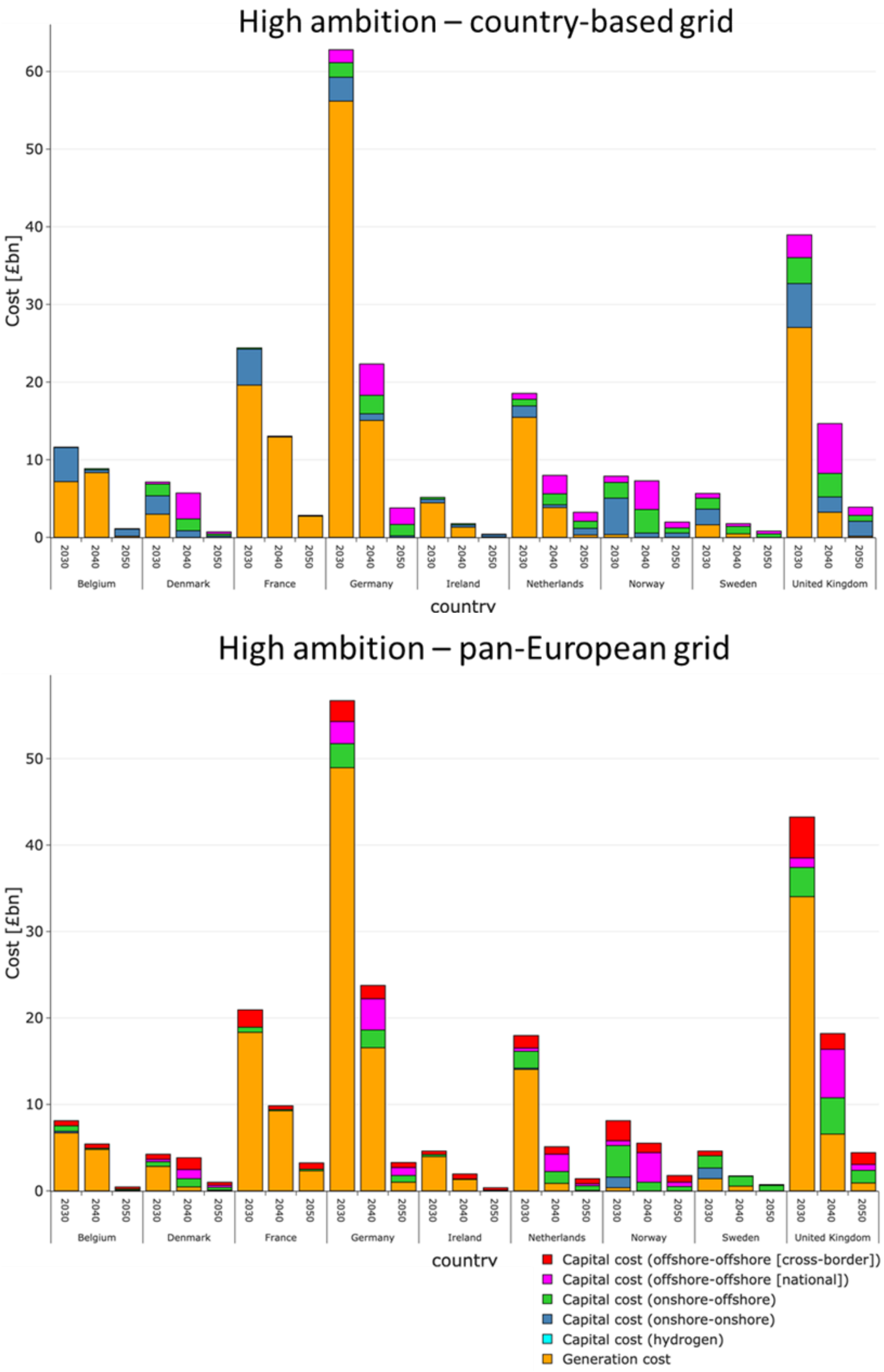


Medium ambition – pan-European grid



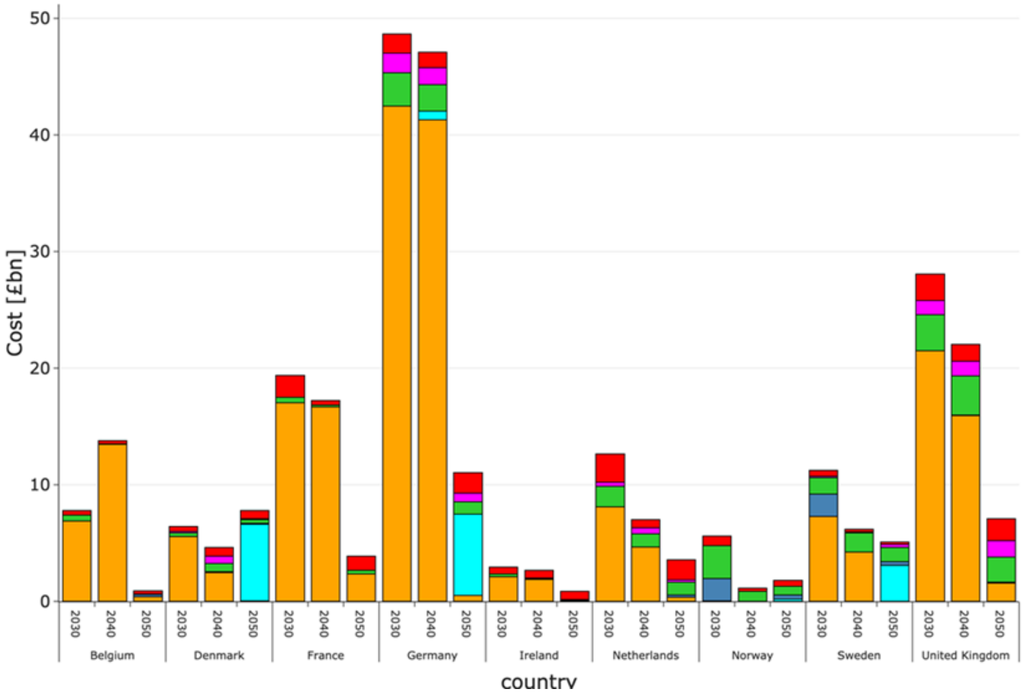
High ambition – hub connection



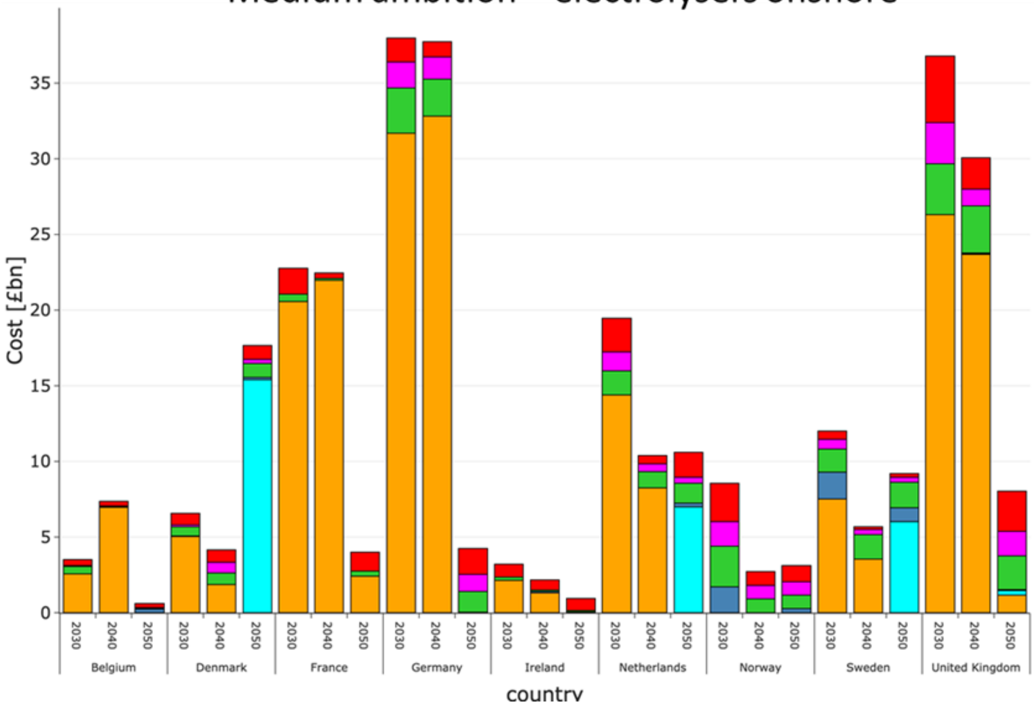

High ambition – country-based grid
Cost [£bn]
0
10
20
30
40
50
60
2030
2040
2050
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
United Kingdom
country
High ambition – pan-European grid
Cost [£bn]
0
10
20
30
40
50
2030
2040
2050
Belgium
Denmark
France
Germany
Ireland
Netherlands
Norway
Sweden
United Kingdom
country
🟥 Capital cost (offshore-offshore [cross-border])
🟪 Capital cost (offshore-offshore [national])
🟩 Capital cost (onshore-offshore)
🟦 Capital cost (onshore-onshore)
🟦 Capital cost (hydrogen)
🟧 Generation cost

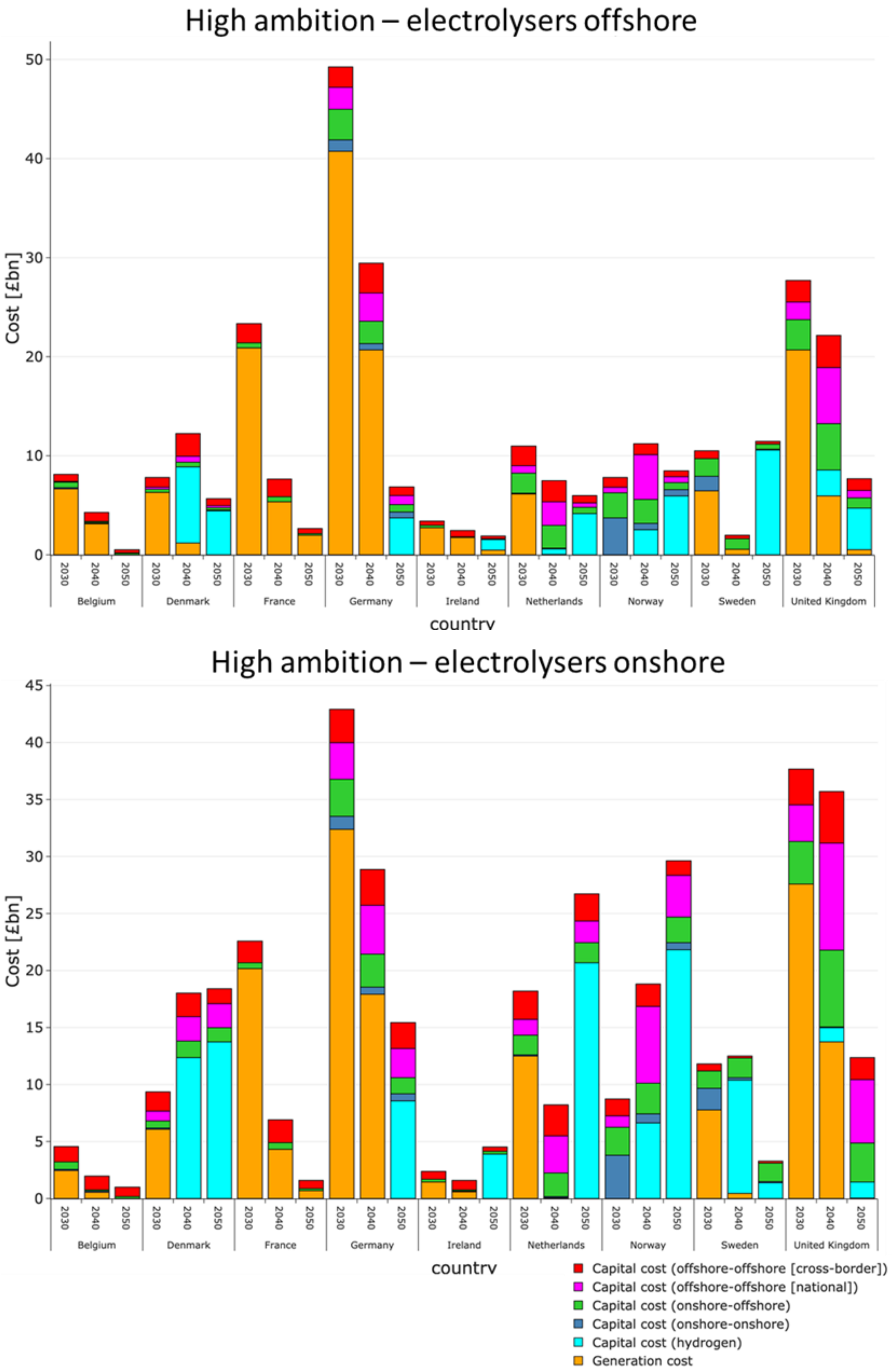
Annex 3 - System cost breakdown with hydrogen production allowing full utilisation of potential offshore wind capacity

Medium ambition – electrolysers offshore



Medium ambition – electrolysers onshore





High ambition – electrolysers offshore

High ambition – electrolysers onshore