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Cap and floor regime: Initial Project Assessment of the FAB Link, IFA2, Viking Link and Greenlink interconnectors

Consultation

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Overview:

This consultation provides our minded-to position on the Initial Project Assessment of four interconnector projects - FAB Link (to France), IFA2 (France), Viking Link (Denmark) and Greenlink (Ireland).

This Initial Project Assessment considers the need for the four projects and interactions between them, as well as interactions with the proposed NSN interconnector to Norway which we consulted on in December 2014. We seek views on our assessment of these four projects and aim to take a decision in summer 2015.

Context

Electricity interconnectors are the physical links which allow the transfer of electricity across borders. They have potentially significant benefits for consumers: lowering electricity bills by allowing access to cheaper generation, providing more efficient ways to deliver security of supply and supporting the decarbonisation of energy supplies.

In May 2014 we consulted on our proposals to extend the cap and floor regulatory regime to near-term interconnector projects. Our August 2014 decision confirmed this approach and established our cap and floor assessment process. The cap and floor regime is the regulated route for interconnector investment in GB, which sits alongside the existing exemption route. Five projects applied for cap and floor regulation in our first application window and we decided in October 2014 that all five projects were eligible for our Initial Project Assessment (IPA) stage. We consulted on our IPA for the NSN interconnector to Norway in December 2014.

This consultation provides our minded-to position on our IPA of four interconnector projects - FAB Link (to France), IFA2 (France), Viking Link (Denmark) and Greenlink (Ireland). We seek views on our assessment of these four projects and aim to take a decision in summer 2015.

Associated documents

Cap and floor regime: Initial Project Assessment for the NSN interconnector to Norway
Published: December 2014

Decision on project eligibility as part of our cap and floor regime for near-term electricity interconnectors
Published: October 2014

Decision to roll out a cap and floor regime to near-term electricity interconnectors
Published: August 2014

The regulation of future electricity interconnection: Proposal to roll out a cap and floor regime to near-term projects
Published: May 2014

Decision on the cap and floor regime for the GB-Belgium interconnector project Nemo
Published: December 2014

Integrated Transmission Planning and Regulation (ITPR) project: draft conclusions
Published: September 2014

Contents

Executive Summary

Electricity interconnectors can offer significant benefits to existing and future consumers, but interconnection between Great Britain (GB) and other markets remains limited. This is why we have put in place our cap and floor regime for new electricity interconnectors. We want to facilitate the delivery of more interconnection in a way that's economic, efficient and timely.

We published our assessment of the NSN interconnector to Norway in December 2014. We have now assessed four further projects – FAB Link, IFA2, Viking Link and Greenlink – at the Initial Project Assessment (IPA) stage of our cap and floor framework. **We are minded to grant FAB Link, IFA2 and Viking Link a cap and floor regime in principle, subject to no material escalation in costs.** This is because we expect these projects to be in the interests of GB consumers and GB as a whole. **We are minded not to grant Greenlink a cap and floor regime.** This is because the project does not seem to be in the interests of GB consumers or GB as a whole based on the information available. We are now seeking views on these minded-to positions.

About the projects

Our first cap and floor application window closed in September 2014. We received five eligible project applications. We consulted on the IPA of the NSN project to Norway in December 2014. This consultation covers the remaining four projects.

The FAB Link project is a proposed 1.4GW interconnector between France and GB via the island of Alderney. The project has been designed to allow the potential connection of future tidal generation at Alderney. It is being jointly developed by Transmission Investment and RTE, the French transmission system operator.

The IFA2 project is also planning to further connect the French and GB transmission systems. The project would have a capacity of 1GW and is being developed by National Grid Interconnector Holdings (NGIH) and RTE.

The Viking Link project is a proposed 1GW interconnector between GB and Denmark, developed by NGIH and Energinet.dk, the Danish transmission system operator.

The Greenlink project is a proposed 500MW interconnector between GB and Ireland, being developed by Element Power.

The four proposed projects could provide a cumulative capacity of 3.9GW.

What our assessment shows

We have assessed the four projects in line with our principal objective, which is to protect the interests of current and future GB consumers. We have also taken into account the expected overall impact of the project on GB and, where relevant, the EU as a whole, in line with the objectives of the Electricity Directive.

We have considered a range of impacts to assess whether a project is likely to be in the interests of GB consumers. We have considered the strategic benefits of interconnectors, have used quantitative analysis where possible to understand the

magnitude of different impacts, and have considered relevant factors not taken into account by our quantitative analysis.

Our analysis shows a wide range of potential benefits as well as highlighting costs, but overall gives us confidence that for three of the four projects (FAB Link, IFA2 and Viking Link) there are likely to be significant net benefits for GB consumers. The business case for both FAB Link and IFA2 is primarily driven by the high proportion of nuclear in the French energy mix. This drives lower wholesale prices in France and complements the thermal and wind-based GB market. The economic case for the Viking Link project is driven by maximising the value of GB and Danish renewables. The existence of complementary wind resource in Denmark and GB could lead to more efficient dispatch of renewable generation in both markets. Further, the generally lower wholesale price in Denmark would also be expected to enable the flow of power into GB. These projects can provide security of supply and sustainability benefits. Our modelling suggests these projects could cumulatively increase GB consumer welfare by between £3bn and £8bn in the Base case.[1] We do not have material concerns with the technical attributes of these proposals. The project plans for delivery seem reasonable, though timescales are tight and subject to potential supply chain constraints.

Our assessment shows that Greenlink, the proposed project to Ireland, is unlikely to deliver benefits for GB consumers. The economic case for Greenlink is primarily driven by the development of complementary wind resource in Ireland and GB, which could lead to more efficient dispatch of generation and a sharing of renewables between the two markets. GB and Ireland have reasonably similar generation mixes. Our market modelling indicates limited benefit from projected flows across the interconnector. The project is also expected to increase the cost of operating the transmission system in GB, and offers limited strategic benefits as it connects to a smaller market with a more similar generation mix and more correlated wind output (when compared with for instance Denmark).

About this consultation

The IPA stage assesses the projects' impacts on GB consumers and GB welfare, including how the projects interact. We have assessed these projects based on the information submitted to us by developers in September 2014.

This consultation is mainly aimed at interconnector developers and a technical audience. Stakeholders wanting a high-level overview of our assessment may wish to read Chapters 1 to 3. More detail is provided in the subsequent chapters.

This consultation document forms our impact assessment for the four projects. Stakeholders should submit responses to Cap.Floor@ofgem.gov.uk by 2 May 2015. Subject to consultation responses, we expect to publish our decision on the IPA of these projects in summer 2015.

[1] The range reflects the fact that the modelling does not capture dynamic effects, such as generators' responses to changes in profit levels. The lower end of the range represents the modelled impact on GB total welfare which informs whether there are likely to be efficiency improvements in GB from building the interconnector. We think this measure indicates how these dynamic effects might ultimately affect consumers.

1. Background and overview of projects

Chapter Summary

This chapter includes background on the cap and floor regime, an overview of the four projects assessed in this document and the scope of this consultation.

Background

1.1. Electricity interconnectors are the physical links which allow the transfer of electricity across borders.[2] They allow electricity to be generated in one market and used in another.

1.2. Interconnectors can offer significant benefits to existing and future consumers, but the amount of interconnection between GB and other markets remains limited. This is why we consulted on proposals to extend our cap and floor regime to new near-term electricity interconnectors in May 2014.[3] We want to facilitate the delivery of more interconnection in a way that's economic, efficient and timely.

1.3. In our May 2014 consultation we highlighted a number of potential benefits that interconnectors can provide to consumers:

- lowering electricity bills through allowing access to cheaper sources of electricity generation
- lowering electricity bills through providing alternative, cheaper ways to achieve secure electricity supplies, for example by connecting new providers of short-term balancing services to the System Operator (SO)
- supporting the decarbonisation of energy supplies by making it easier to manage intermittent renewable generation sources and locate low carbon generation where it is most efficient.

1.4. In August 2014 we published our decision to extend the cap and floor regime to near-term electricity interconnectors, and opened an eight-week application window.[4] The cap and floor regime is now the regulated route for interconnector investment in GB, which sits alongside the existing exemption route (whereby project developers can apply for exemptions from certain aspects of European legislation).

[2] For ease, we will refer to electricity interconnectors as 'interconnectors' in the remainder of this document.
[3] Read our May 2014 consultation on our proposals for our cap and floor regime at: https://www.ofgem.gov.uk/publications-and-updates/regulation-future-electricity-interconnection-proposal-roll-out-cap-and-floor-regime-near-term-projects
[4] Read our August 2014 decision letter at: https://www.ofgem.gov.uk/publications-and-updates/decision-roll-out-cap-and-floor-regime-near-term-electricity-interconnectors

1.5. This application window closed on 30 September 2014. Five projects applied to be assessed and regulated under our cap and floor regime. We published our decision in October 2014 noting that all five projects met our minimum eligibility criteria, and so were eligible for the Initial Project Assessment (IPA) stage of our cap and floor assessment process.

Overview of projects

1.6. We have assessed four projects in this consultation – FAB Link, IFA2, Viking Link and Greenlink. We have assessed these projects based on the information submitted to us in September 2014. We acknowledge that aspects of these projects may change, and that connection dates may be affected as a result. Where projects are successful at our IPA stage but aspects of these projects change materially, we will reassess parts of our IPA as necessary. If projects are delayed beyond the end of 2020 the length of the cap and floor regime would be reduced by the length of the delay.[5]

1.7. Table 1 below gives an overview of the main characteristics of each of these projects.

Table 1: Main characteristics of IPA projects

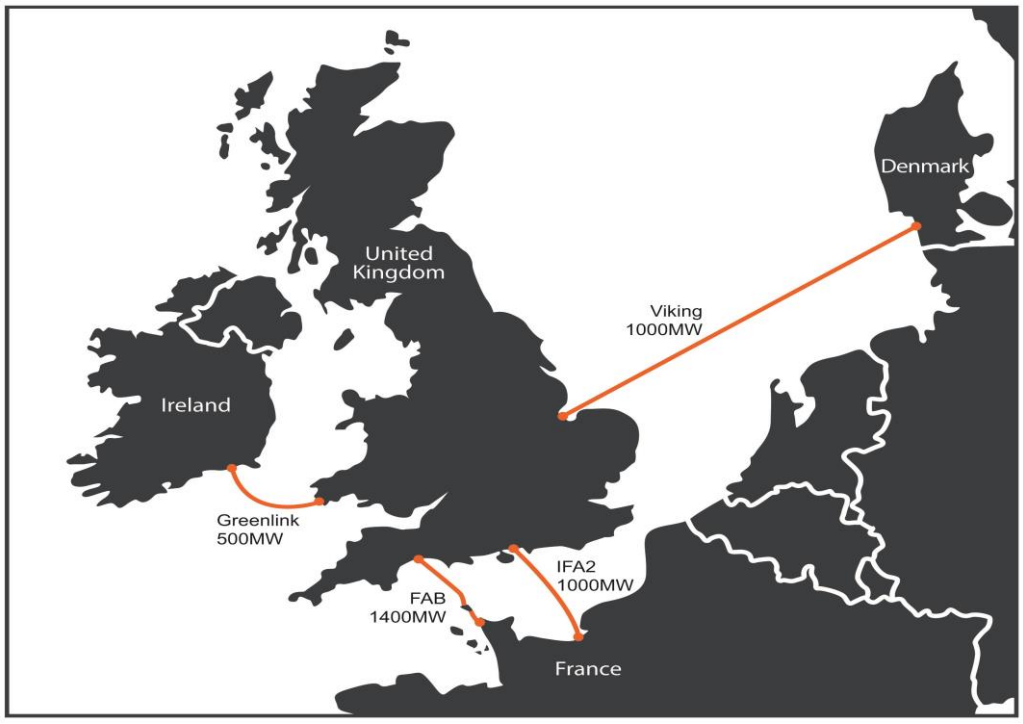
Project name	Developers	Connection locations	Capacity	Proposed cost and revenue sharing
FAB Link	Transmission Investment and RTE[6]	Menuel in France and Exeter in Devon, England[7]	1.4GW	65% (GB) and 35% (France)
IFA2	National Grid Interconnector Holdings (NGIH) and RTE	Tourbe in France and Chilling in Hampshire, England	1GW	50% (GB) and 50% (France)

[5] We will start the 25-year cap and floor period from the earlier of the actual connection date or 1 January 2021.
[6] RTE is the French transmission system operator (TSO).
[7] FAB Link connects GB and France via the island of Alderney, and is expected to enable the future connection of up to 300MW of tidal generation in the waters off Alderney.

Viking Link	NGIH and Energinet.dk[8]	Revsing in Denmark and Bicker Fen in Lincolnshire, England	1GW[9]	50% (GB) and 50% (Denmark)
Greenlink	Element Power	Great Island in Ireland and Pembroke in Wales	0.5GW[10]	50% (GB) and 50% (Ireland)

1.8. Indicative connection locations for the four projects assessed in this consultation are shown in Figure 1, below.

Figure 1: Map showing indicative connection points for the four projects



[8] Energinet.dk is the Danish TSO.
[9] NGIH has indicated that it is considering a capacity of 1.4GW but that this is dependent on changes to Danish system requirements. In this consultation we have assessed the project on the basis of a capacity of 1GW, in line with the developer's cap and floor submission.
[10] Element Power has indicated that it is considering a capacity of 0.7GW but that this is dependent on changes to Irish system requirements. In this consultation we have assessed the project on the basis of a capacity of 0.5GW, in line with the developer's cap and floor submission.

1.9. If all the projects in this cap and floor window went ahead it would represent a substantial increase in GB electricity interconnector capacity, which is currently just under 4GW.[11] The total is expected to increase to just under 6GW with the Nemo and ElecLink projects, which are 1GW each in capacity.[12] The NSN project, which we consulted on in December 2014, has a capacity of 1.4GW. The four projects in the scope of this consultation represent a combined capacity of 3.9GW. Overall, the projects in the pipeline could increase GB's interconnector capacity to over 11GW.

Scope of this consultation

1.10. This consultation contains our minded-to position on our IPA of the four interconnector projects outlined in the previous section. This follows our IPA of the NSN project to Norway which we published in December 2014.[13]

1.11. This document is also our Impact Assessment (IA) for the four projects.[14] We have put the impacts of these throughout the analysis in this document. Areas relating to our IA guidance which are not in the main body of the document are included in Appendix 2.

1.12. We intend to open a second cap and floor application window in September 2015 if there is enough interest from developers.[15]

[11] GB is currently connected to other electricity grids by the BritNed, East-West, IFA and Moyle interconnectors.
[12] We published our final decision on ElecLink's exemption request in September 2014 and our final decision on Nemo's cap and floor regime in December 2014. For more information see: https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors
[13] Our consultation on the IPA of the NSN project closed in February 2015. We expect to publish a decision on the IPA of NSN in March 2015.
[14] We assess these impacts in line with our IA guidance, available here: https://www.ofgem.gov.uk/publications-and-updates/impact-assessment-guidance
[15] Developers should let us know by 1 May 2015 if they could be interested in applying for the second window.

2. Structure of our Initial Project Assessment

2.1. The IPA is an assessment of the needs case and impacts of projects, interactions between projects, and whether projects are likely to be in the interests of GB consumers.

2.2. We have considered the impact on GB primarily by looking at the social welfare impacts of projects. When discussing total GB social welfare we consider a number of different factors:

- impacts of projected flows between the connecting markets (Chapter 4)
- impacts on the operation of GB's transmission system (Chapter 5)
- the costs of onshore transmission reinforcements needed to accommodate the four projects (Chapter 5)
- qualitative assessment of hard-to-monetise impacts, such as strategic or sustainability benefits that the projects could provide (Chapter 6).

2.3. In addition, we have assessed a number of areas to ensure that the four projects are sensible, efficient and well-justified:

- assessment of project connection locations and routes (Chapter 7)
- assessment of project plans (Chapter 8).

2.4. When reaching our minded-to positions on each project we have also considered distributional impacts and wider dynamic and efficiency effects, such as investment driven by longer-term impacts of changes to generator profit levels which are not fully taken account of elsewhere in our analysis.[16]

2.5. We think that the modelled impact on GB total welfare indicates how these dynamic effects might ultimately affect consumers. We think that this measure indicates whether there are likely to be efficiency improvements in GB from building the interconnector, and have taken it into account when reaching our minded-to positions.

2.6. Our IPA has been informed by a number of sources of information:

- Submissions received from the project developers – Transmission Investment for FAB Link, NGIH for IFA2 and Viking Link, and Element

[16] For example, Pöyry's modelling assumes that any changes to generator profit levels resulting from interconnector build will persist over time without response from generators in terms of market entry, exit or bidding behaviour.

Power for Greenlink. These submissions include background on the projects, economic modelling, details on the technical design of projects and project plans.

- A report from Pöyry consultants on the potential impacts of projected flows between connecting markets. This forms the basis of our assessment of flows between markets in Chapter 4.

- Reports from National Grid Electricity Transmission (NGET) in its role as the GB system operator (SO). These reports cover the potential impact of proposed interconnectors on the operation of GB's transmission system and inform our analysis in Chapter 5.

- Input from NGET on the connection process for each project and estimated costs of connection to GB's transmission system. This informs our analysis in Chapter 5.

- Our assessment of connection location, capacity, cable route and technology choices is informed by support from our technical consultants, Fichtner. This analysis is set out in Chapter 7.

2.7. Supporting reports (published alongside this consultation) have been provided independently and were not drafted in consultation with the developers of the five projects that are being assessed under the first cap and floor window.[17]

2.8. We have assessed the four projects in line with our principal objective, which is to protect the interests of current and future GB consumers. We have also taken into account the expected overall impact of the project on GB and, where relevant, the EU as a whole, in line with the objectives of the Electricity Directive.[18]

2.9. Chapter 3 provides an overview of our Initial Project Assessment for the four projects. This highlights the key points of our analysis and our minded-to position for each project. Chapters 4 to 8 then provide further information on the analysis that has informed these minded-to positions.

[17] These reports were first published alongside our IPA consultation on the NSN project in December 2014.
[18] The Electricity Directive refers to Directive 2009/72/EC, available at: http://ec.europa.eu/energy/gas_electricity/legislation/legislation_en.htm

3. Summary of our Initial Project Assessment

Chapter Summary

This chapter contains our minded-to position for each of the projects. This summarises the analysis that is detailed in Chapters 4 to 8.

Question box

Question 1: Do you agree with our minded-to positions on the four projects considered in this consultation?

Question 2: Is there any additional information that you think we should take into account when reaching our decision on the IPA of the projects?

How we've reached our conclusions

3.1. In the sections below we've set out our minded-to position on the needs case for each of the four projects.

3.2. In reaching these we've considered the factors set out in Chapter 2, above. For each project in turn, we look at the underlying rationale for the project. We also combine a number of factors to give a quantified estimation of GB consumer welfare and GB total welfare in Tables 2 to 5.[19] These tables show:

- The estimated impact on wholesale prices as a result of flows across the interconnector (shown in the first row of the tables). These figures were modelled by Pöyry and are explained in Chapter 4.
- The estimated impact of any cap or floor payments that are triggered by interconnector revenues (shown in the second row of the tables). These figures were also modelled by Pöyry and are explained in Chapter 4.
- The indicative cost of onshore reinforcements needed to connect the projects to the GB transmission system (shown in the third row of the tables). These figures have been provided by NGET and are explained in Chapter 5.
- The estimated impact of the project on operation of the GB transmission system (shown in the fourth row of the tables). These figures were modelled by NGET and are explained in Chapter 5.

[19] It is important to note that these are indicative figures and have been calculated by different parties using different assumptions in some cases.

3.3. We have combined these figures to give the estimated totals shown in rows 5 and 6 of the tables.[20] We have then adjusted these to account for potential impacts of the GB capacity market (CM), with the adjusted figures shown in rows 7 and 8 of the tables. More information on how we've accounted for the CM is in Chapter 4.

3.4. Each table gives a base, low and high estimate of the impact of projects. These refer to a combination of the scenarios used in Pöyry's modelling and in NGET's analysis. Further details are in Chapters 4 and 5 and the supporting reports (published alongside this consultation).

Our view on the IPA of FAB Link

3.5. The business case for FAB Link is primarily driven by the high proportion of nuclear in the French energy mix, which drives lower wholesale prices in France and complements the thermal and wind-based GB market. The lower wholesale prices are generally expected to drive imports to GB which would lower our wholesale prices. The project can provide security of supply benefits by diversifying energy resources in GB. It also provides option value of being able to connect future tidal resources around Alderney.

3.6. We summarise the quantifiable overall impact of FAB Link in Table 2 below. Our analysis shows that the total consumer benefits from trade with France through the FAB Link interconnector far outweigh the costs to consumers from the connection of the project. The project also offers potential benefits for system operation. The quantitative analysis for FAB Link shows benefits to consumers of approximately £3.5bn in the Base case. The total GB impact is also positive in all scenarios.

Table 2: Summary analysis for FAB Link[21] (£m, 2013)

	Base	Low	High
GB wholesale price savings £m NPV	2,121	366	2,492
Impact of cap and floor payments £m NPV	519	0	1,117
Onshore reinforcements costs £m (these are a one-off cost, not discounted over 25yrs)	-42	-59	-25
System operation impacts £m NPV	827	429	1,226
Total quantified GB consumer impact £m NPV	**3,425**	**735**	**4,810**
Total quantified GB impact £m NPV	**1,535**	**386**	**2,546**

[20] All contributing figures in Tables 2 to 5 are given in net present value (NPV) terms, discounted over a period of 25 years, with the exception of the onshore reinforcement costs (which are presented as a single investment figure). All costs and benefits are given in a 2013 price base.
[21] Based on the 65:35 cost and revenue sharing factor proposed by the developers.

Total quantified GB consumer impact £m NPV (with CM)	**3,512**	**744**	**4,896**
Total quantified GB impact £m NPV (with CM)	**1,489**	**340**	**2,500**

3.7. The quantitative results for FAB Link are very strong. The impacts are also positive under the Low and High scenarios. Even if the other four IPA projects[22] are built, FAB Link's economic case remains strongly positive. The high benefit of FAB Link compared to the other project to France (IFA2) is primarily due to FAB Link's relatively low estimated cost and higher capacity.[23] The results of our technical analysis of the FAB Link project are detailed in Chapter 7. We do not currently have any concerns about the proposed technology choices submitted by FAB Link.

3.8. In addition to the positive impacts mentioned above, the project is mature and appears able to meet a 2020 timeline. We conducted a qualitative assessment on the benefits of the FAB Link project and we believe that FAB Link would result in additional benefits to GB consumers to those captured in Table 2. The additional connection with France would further enhance security of supply by diversifying generation sources. FAB Link includes an aspect of anticipatory investment in order to allow the development of integrated systems in the future.

3.9. Having considered the information above, **we are minded to grant FAB Link a cap and floor regime in principle**, **subject to no material escalation in costs.**[24]

Our view on the IPA of IFA2

3.10. As with the FAB Link project, above, the difference in generation mix between the GB and French markets is the main driver in the business case for IFA2. The project can also deliver additional security of supply and strategic benefits.

3.11. We summarise the quantifiable overall impact of IFA2 in Table 3 below. The total consumer benefit from trade with France through the IFA2 interconnector far outweighs the costs of connection. The project also offers potential benefits for system operation. The quantitative analysis for IFA2 shows benefits to consumers of approximately £2bn in the Base case. The quantified total GB impact is also positive in the Base case and High scenario.

[22] The term 'the other four IPA projects' refers to the projects assessed in the first cap and floor window (ie including the NSN project).
[23] To test this conclusion we have modelled the impacts of FAB Link if its projected operating costs were the same level as those of comparable projects. Even in this situation the results for FAB Link remain strongly positive.
[24] The granting of a cap and floor regime in principle is subject to no material escalation in costs relative to the estimates submitted to us by project developers, or in line with those for comparable projects. This applies to FAB Link, IFA2 and Viking Link.

3.12. In the Low scenario the quantified total GB impact is negative and of the order of -£205 million. The negative figure in the Low scenario is due to the quantified costs on producers and interconnectors outweighing the benefits to consumers. This is driven by a relatively extreme scenario with negative interconnector value and underlying market assumptions, and we don't think this carries enough weight to counter the positive impact suggested by the Base case.

Table 3: Summary analysis for IFA2[25] (£m, 2013)

	Base	**Low**	**High**
GB wholesale price savings £m NPV	1,457	321	1,692
Impact of cap and floor payments £m NPV	1	-215	197
Onshore reinforcements costs £m (these are a one-off cost, not discounted over 25yrs)	-97	-136	-58
System operation impacts £m NPV	602	296	909
Total quantified GB consumer impact £m NPV	**1,963**	**265**	**2,740**
Total quantified GB impact £m NPV	**578**	**-157**	**1,255**

Total quantified GB consumer impact £m NPV (with CM)	**1,974**	**312**	**2,784**
Total quantified GB impact £m NPV (with CM)	**531**	**-205**	**1,207**

3.13. We asked Pöyry to look at the interaction between IFA2 and other interconnectors. The analysis found that even if the other four projects are built, the economic case remains positive.[26] As with the FAB Link project, our qualitative assessment shows that IFA2 would result in additional benefits to GB consumers to those captured in Table 3, such as enhancing security of supply by diversifying generation sources. The results of our technical analysis of the IFA2 project are detailed in Chapter 7. We do not currently have any concerns about the proposed technology choices submitted by IFA2. In addition to the positive impacts mentioned above, the project is mature and appears able to meet a 2020 timeline.

3.14. Having considered the information above, **we are minded to grant IFA2 a cap and floor regime in principle**, **subject to no material escalation in costs.**

[25] Based on an assumed cost and revenue sharing ratio of 50:50 between the developers.
[26] Pöyry's assessment of sensitivity to other interconnectors assumes that the Nemo and ElecLink projects are operational by 2020.

Our view on the IPA of Viking Link

3.15. The economic case for the Viking Link project is driven by maximising the value of GB and Danish renewables. The existence of complementary wind resource in Denmark and GB could lead to more efficient dispatch of renewable generation in both markets. Further, the generally lower wholesale price in Denmark would also be expected to enable the flow of cheaper power into GB.

3.16. We summarise the quantifiable overall impact of Viking Link in Table 4 below. The total consumer benefit from trade with Denmark through the Viking Link interconnector far outweighs the costs to consumers from the connection costs. The quantitative analysis for Viking Link shows benefits to consumers of approximately £2.6bn in the Base case. The quantified total GB impact is also positive in the Base case and High scenario.

3.17. In the Low scenario the quantified total GB impact is negative and of the order of -£484 million. The negative figure in the Low scenario is due to the quantified costs on producers and interconnectors outweighing the benefits to consumers. The figure here is of a greater magnitude compared to IFA2 because of the relatively higher cost of building the Viking Link. This is also for a relatively extreme scenario with strongly negative underlying market assumptions, and we don't think this carries enough weight to counter the positive impact suggested by the Base case.

Table 4: Summary analysis for Viking Link[27] (£m, 2013)

	Base	Low	High
GB wholesale price savings £m NPV	2,169	724	2,465
Impact of cap and floor payments £m NPV	-21	-638	57
Onshore reinforcements costs £m (these are a one-off cost, not discounted over 25yrs)	-29	-41	-17
System operation impacts £m NPV	516	218	813
Total quantified GB consumer impact £m NPV	**2,635**	**264**	**3,318**
Total quantified GB impact £m NPV	**638**	**-437**	**1,435**
Total quantified GB consumer impact £m NPV (with CM)	**2,635**	**311**	**3,346**
Total quantified GB impact £m NPV (with CM)	**590**	**-484**	**1,388**

3.18. Pöyry's analysis did not find that the construction of Viking Link was sensitive to other projects. In addition, our qualitative assessment indicates that

[27] Based on an assumed cost and revenue sharing ratio of 50:50 between the developers.

Viking Link would offer additional security of supply benefit by connecting to a new market, further increasing the diversity and resilience of GB's energy supply. The results of our technical analysis of the Viking Link project are detailed in Chapter 7. We do not currently have any concerns about the proposed technology choices submitted by Viking Link. While the project is mature, we understand that the developers are considering alternative capacity options and that this could delay planned delivery of the project.

3.19. Having considered the information above, **we are minded to grant Viking Link a cap and floor regime in principle**, **subject to no material escalation in costs.**

Our view on the IPA of Greenlink

3.20. The economic case for Greenlink is primarily driven by the development of wind resource in Ireland and GB, which could lead to more efficient dispatch of generation and a sharing of renewables between the two markets. We note that GB and Ireland have reasonably similar generation mixes. We also already have two interconnectors with the Irish market, which is smaller and technically weaker than the continental system, and so our view is that there are limited additional strategic benefits as a result of the project.

3.21. We summarise the quantifiable overall impact of Greenlink in Table 5 below. The total consumer benefit from trade with Ireland is outweighed by the costs to GB consumers resulting from impacts on system operation. The quantitative analysis for Greenlink shows costs to GB consumers of approximately £240m in the Base case. The impact on GB consumers is also negative in the Low scenario. In the High scenario the impact on GB consumers is slightly positive at £103m.

3.22. Similarly, the quantified total GB impact (ie including the impacts on producers and interconnectors) is negative in the Base case and Low scenario, and slightly positive in the High scenario.

Table 5: Summary analysis for Greenlink[28] (£m, 2013)

	Base	Low	High
GB wholesale price savings £m NPV	51	-178	147
Impact of cap and floor payments £m NPV	-18	-107	74
Onshore reinforcements costs £m (these are a one-off cost, not discounted over 25yrs)[29]	0	0	0
System operation impacts £m NPV	-292	-438	-146
Total quantified GB consumer impact £m NPV	**-259**	**-724**	**74**
Total quantified GB impact £m NPV	**-337**	**-581**	**1**
Total quantified GB consumer impact £m NPV (with CM)	**-240**	**-690**	**103**
Total quantified GB impact £m NPV (with CM)	**-318**	**-547**	**30**

3.23. Our independent modelling report, undertaken by Pöyry, informs the first two rows of the tables above. Pöyry's analysis shows different results to those submitted to us by Element Power. The difference is primarily driven by assumed renewables growth. The conclusion on the needs case for the project remains similarly negative when the results from the developer's modelling report are used to inform the tables above. This is discussed in more detail in Chapter 4 and Appendix 3.

3.24. The impact on GB system operation is more negative for Greenlink than the other projects. This is because the other projects provide some system operation benefits which offset increases in constraint management costs. NGET does not attribute any system operation benefits to Greenlink due to its connection to a smaller, technically weaker system (the Irish onshore grid). In addition, our qualitative assessment indicates that the additional benefits offered by Greenlink are limited. We also note that delivery by 2020 may be affected by uncertainty over the regulatory approach in Ireland.

3.25. Having considered the information above, **we are minded not to grant Greenlink a cap and floor regime.** This is because the project does not seem to be in the interests of GB consumers or GB as a whole based on the information available.

[28] Based on an assumed cost and revenue sharing ratio of 50:50 between the developers. Social welfare impacts on Moyle and East-West interconnectors are fully attributed to Ireland as these existing projects are 100% underwritten by Irish consumers.
[29] NGET has not provided local onshore reinforcement costs for Greenlink as the project does not yet have a formal connection agreement. NGET has highlighted that any costs are likely to be minor but these would have a negative impact on GB consumer and GB total welfare.

4. Economic market modelling of the impact of interconnector flows

Chapter Summary

This chapter summarises the economic market modelling analysis carried out by Pöyry consultants. We also provide a high level comparison of Pöyry and project developers' modelling results.

Question box

Question 3: What are your views on the approach Pöyry has taken to modelling the impact of cross-border interconnector flows?

Question 4: Do you have any additional evidence in this area that we should take into account?

Introduction

4.1. In this chapter we summarise the key findings from the independent economic modelling analysis of the FAB Link, IFA2, Viking Link and Greenlink projects, which we commissioned from Pöyry. We have used this analysis alongside other information (discussed in Chapter 2) to inform our decision-making. The detailed analysis is in the report prepared by Pöyry which we published alongside the consultation on the NSN project in December 2014.[30]

4.2. In particular, we present the following information for each project:

- the social welfare impacts as a result of electricity flows across the interconnector and associated changes in wholesale market prices
- summary of our sensitivity analyses for each project
- expected revenues for the four projects and the potential impact of cap and floor payments on consumer bills
- potential impacts of capacity mechanisms (CMs) on the four interconnectors
- a high-level comparison of Pöyry and developer modelling assumptions and results

[30] Read the Pöyry report at: https://www.ofgem.gov.uk/ofgem-publications/92097/791iccbaindependentreportfinal.pdf

4.3. This chapter does not include the GB social welfare impacts of onshore reinforcements or of system operation costs. These are discussed in Chapter 5.

Summary of modelling methodology

Estimating social welfare impact

4.4. A key element of Pöyry's economic modelling is the calculation of 'social welfare'. This is a common approach taken to evaluate the possible benefits of a new infrastructure investment.

4.5. Pöyry's social welfare modelling captures:

- impacts on consumers through electricity flows across an interconnector and resulting changes in wholesale market prices ('consumer surplus')
- the additional profit or loss for generators resulting from changes to wholesale prices and dispatch ('producer surplus')
- the revenue generated for interconnector owners through sale of capacity on their links ('interconnector surplus')[31], and
- the total welfare value as a result of each project which is calculated as a sum of consumer, producer and interconnector surpluses.[32]

4.6. The welfare modelling results for each group (consumers, producers and interconnector owners) represent the sum of the change in welfare due to each project.[33] Unless otherwise stated, impacts are measured in net present value (NPV) terms over the duration of the cap and floor regime (25 years).

4.7. The detailed methodology for calculating social welfare impacts is presented in Chapter 2 of Pöyry's report.

Scenarios

4.8. Pöyry has designed three scenarios for assessing the cap and floor projects. The scenarios aim to reflect a wide range of potential outcomes for interconnectors, broadly consistent with Pöyry's view of future interconnector value drivers:

[31] Please note that interconnector surplus includes impacts on all the interconnectors assumed in the analysis.
[32] The investment cost required to build the projects is net off as part of this analysis.
[33] In this chapter, the terms 'surplus' and 'welfare' are used interchangeably when discussing consumers, producers and interconnectors.

- The **Base case** is designed by Pöyry to represent a reasonable baseline against which interconnector projects can be assessed.

- The **Low scenario** is based on assumptions designed to result in unfavourable circumstances for interconnectors, to test a potential downside of each project.

- The **High scenario** is based on largely favourable assumptions to new interconnection, to test the potential upside of each project.

4.9. Pöyry developed these scenarios using recognised and publicly available sources of information such as National Grid's UK Future Energy Scenarios (FES)[34] and DECC's energy and emissions projections.[35]

4.10. For a detailed description of each scenario, and sensitivities that have been modelled on the Base case, please refer to the Chapter 3 of Pöyry's report.

Assessment of project interactions

4.11. To assist us in considering impacts where a number of interconnectors might come online at around the same time, we asked Pöyry to conduct its social welfare analysis using two modelling approaches:

- First additional (FA) approach – where a project is the only project connecting in 2020 out of the five cap and floor projects. This, in theory, represents the best case for an interconnector project as there is no additional interconnection connecting in 2020 which would reduce the project's congestion revenue. Under the FA analysis Pöyry still assumes additional interconnection in the future in line with the FES.

- Marginal additional (MA) approach – where a project is commissioning at the same time as the remaining four cap and floor projects. This in theory represents the worst case for an interconnector project as there are additional projects connecting in 2020 which would reduce the project's congestion revenue.

4.12. This allows us to understand the social welfare impact each individual project would have on its own (FA approach), and also to see how sensitive each project is to the remaining four interconnector projects assumed to be commissioned at the same time (MA approach). This way we can also understand the interactions between projects and take them into account when we make decisions.

[34] More information on National Grid's UK Future Energy Scenarios is available at: http://www2.nationalgrid.com/uk/industry-information/future-of-energy/future-energy-scenarios/

[35] More information on DECC's energy and emissions projections is available at: https://www.gov.uk/government/collections/energy-and-emissions-projections

4.13. In both the FA and MA approaches, the Nemo and ElecLink projects are assumed to come online before 2020.

4.14. In this consultation we only provide results for the MA modelling as this, in theory, represents a more conservative outlook for the value of interconnectors. However, we summarise differences between the FA and MA results to indicate to what extent each project is sensitive to other projects being built at the same time. Full FA results are available in Chapter 4 of Pöyry's report.

Modelling results

4.15. This section sets out results of the analysis for each project. This analysis is supported by the conclusions in Pöyry's December 2014 report.[36] However, there are some differences between the numbers presented in the Pöyry report and this chapter, which we set out below:

- **For Greenlink**, we adjusted the interconnector welfare calculations. For this analysis we have not attributed Greenlink's impacts on East West and Moyle interconnectors to GB, which has resulted in an increase to total GB welfare. This is because these two interconnectors are either fully underwritten or wholly owned by Irish and Northern Irish consumers respectively and so, it is more accurate not to include any impacts on these two interconnectors to GB. In Pöyry's report, these impacts were allocated to both GB and Ireland.

- **For FAB Link**, in this consultation document we present the results based on an assumed 65:35 cost and revenue split between GB and France as proposed by the developer. In Pöyry's report, a 50:50 split of cost and revenue was assumed for FAB Link so that the project could be compared on the same basis with others.

- We made a small revision to the indicative **cap levels** assumed for each project (except for NSN) to address a minor correction in cap and floor financial model calculations. This only had a minor effect on the modelling results, mainly in the High scenario. The impact of this correction was a slight increase in GB consumer welfare due to a slightly lower cap for all the projects.

FAB Link

Social welfare impacts

4.16. The modelling results suggest that flows across FAB Link would lead to a decrease in GB wholesale prices and would increase social welfare for GB consumers across all three scenarios modelled (see Table 6). This is largely

[36] Please note that the results presented in the Pöyry report are in Euros. In this document, we converted these results to GB pounds using an exchange rate of 1.186.

driven by lower modelled wholesale prices in France compared with GB and relatively low investment and operating costs of the interconnector.

4.17. The modelling suggests that flows across FAB Link would also result in an increase in total GB welfare under all three scenarios, as the increases in GB consumer and interconnector welfares offset any loss in GB producer welfare.

Table 6: FAB Link's social welfare impacts on GB (£m, 2013 prices)

		Base	Low	High
FAB Link[37]	GB consumers	2640	366	3609
	GB producers	-1762	-306	-2226
	GB interconnectors	145	-43	-38
	GB total	750	17	1345

Sensitivities

4.18. We also asked Pöyry to test how sensitive each project is to certain changes in assumptions in the Base case. In particular, Pöyry ran sensitivities to changes in renewable generation share (RES), removal of carbon price support (CPS) in GB and decrease in gas prices. For a detailed description of each sensitivity, please refer to Chapter 3 of Pöyry's report.

4.19. The analysis for FAB Link suggests that the project would still maintain positive GB consumer and overall GB benefits under each sensitivity (see Table 7).

Table 7: Results of sensitivity analysis for FAB Link (£m, 2013 prices)

	GB consumers	**GB producers**	**GB interconnectors**	**GB total welfare**
Base case	2640	-1762	145	750
High GB RES	1940	-1041	-32	867
No CPS	1823	-1242	0	581
Low gas price	2086	-1442	-9	635

Interactions with other projects

4.20. The comparative analysis between the FA and MA modelling results suggests that FAB Link's social welfare benefits are sensitive (ie under the Base case MA modelling the GB welfare is £91m lower than in FA analysis) to the other four interconnectors being built. However, this does not offset the economic

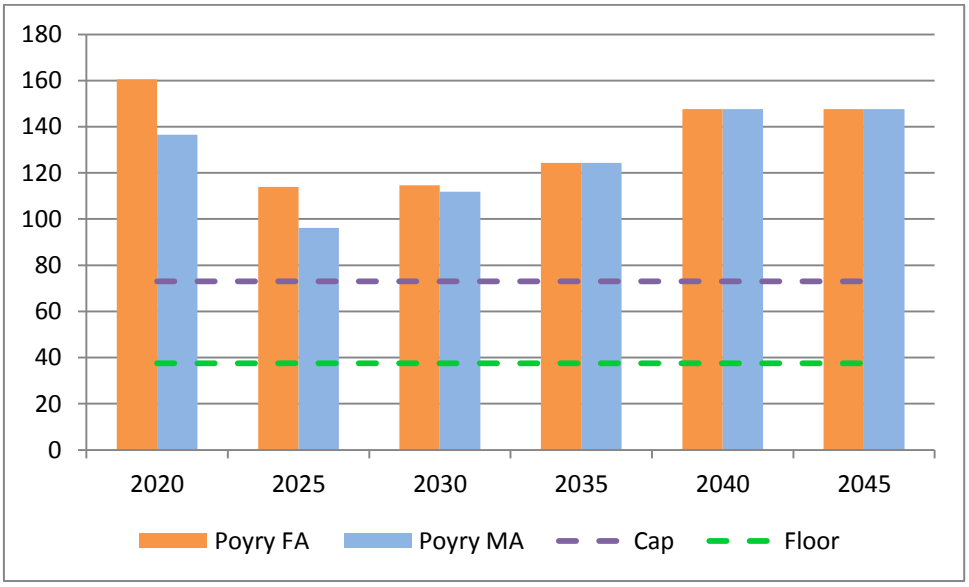
[37]This table shows MA modelling results based on a 65:35 split of costs and revenues between GB and France as proposed by the developer.

needs case as the project still remains largely positive under MA modelling (and the results presented throughout the consultation document are the MA results).

FAB Link congestion revenues and impact of cap and floor payments on consumer bills

4.21. Under the Base case scenario, FAB Link's projected revenues are above the cap (see Chart 1) and so the developer would make payments back to consumers. The total value of estimated cap payments from FAB Link to GB consumers is around £520 million over the course of the cap and floor regime (25 years). [38] This is equivalent to an estimated decrease of £0.33 on an average annual domestic GB consumer bill.[39]

Chart 1: FAB Link's projected congestion revenues,[40] Base case (£m, 2013 prices)



4.22. Under the Low scenario FAB Link's modelled revenues are between the cap and floor. As a result, there are no cap and floor payments to or from GB consumers.

4.23. Under the High scenario, FAB Link's projected revenues are well above the cap. In total, this would trigger cap payments to GB consumers of around £1.1

[38] The value of cap and floor payments has been accounted for in our social welfare analysis.
[39] This and the subsequent bill impact calculations are already captured in the measured social welfare impacts (eg in Table 6 for FAB Link). These calculations are based on average annual demand in 2012.
[40] For presentation purposes, the charts for each project show total projected congestion revenues and indicative levels of cap and floor based on estimated total project costs. Where the C+F regime would only apply to half the link, the costs and revenues shown on the charts would halve.

billion over the course of the cap and floor regime. This is equivalent to a reduction in an average annual domestic GB consumer bill of around £0.73.

IFA2

Social welfare impacts

4.24. The modelling results suggest that IFA2 would increase social welfare for GB consumers across all three scenarios modelled (see Table 8). This is largely driven by the modelled wholesale price differences between GB and France.

4.25. In terms of total GB welfare, modelling suggests that IFA2 would result in an increase in total GB welfare under Base case and High scenarios, as the increases in GB consumer and interconnector welfares offset any loss in GB producer welfare. Under the Low scenario, modelling suggests total GB welfare impact would be negative.

Table 8: IFA2's social welfare impacts on GB (£m, 2013 prices)

		Base	Low	High
IFA2	GB consumers	1457	106	1889
	GB producers	-1270	-248	-1533
	GB interconnectors	-114	-174	48
	GB total	73	-316	404

Sensitivities

4.26. The analysis for IFA2 suggests that the project would still maintain positive GB consumer benefits under each sensitivity. In terms of total GB welfare, only under the 'no CPS' sensitivity (ie where carbon price support in GB is removed) would IFA2 result in a slightly negative GB impact (see Table 9).

Table 9: Results of sensitivity analysis for IFA2 (£m, 2013 prices)

	GB consumers	**GB producers**	**GB interconnectors**	**GB total welfare**
Base case	1457	-1270	-114	73
High GB RES	936	-774	-26	135
No CPS	1035	-922	-16	-16
Low gas price	1135	-1018	-103	13

Interactions with other projects

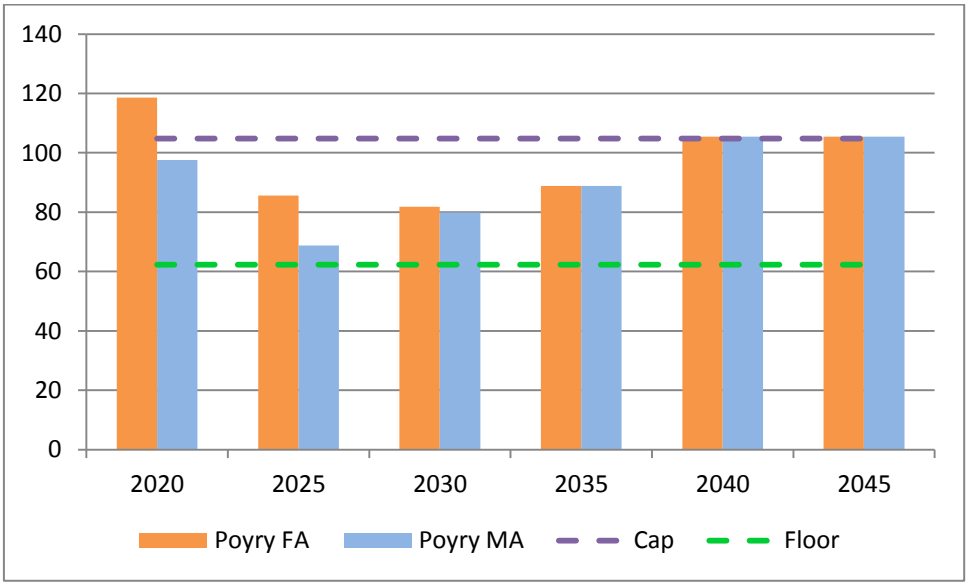
4.27. The comparative analysis between the FA and MA modelling results suggests that IFA2's social welfare benefits are sensitive (ie differences between GB welfare in Base case FA and MA analyses is around £66m) to the other four interconnectors being built. However, this does not offset the economic needs

case as the project still remains positive under MA modelling (results presented throughout the consultation document).

IFA2 congestion revenues and impact of cap and floor payments on consumer bills

4.28. Under the Base case MA scenario, IFA2's projected revenues are between the cap and floor (see Chart 2) and so there would be no cap and floor payments either to or from GB consumers.

Chart 2: IFA2's projected congestion revenues, Base case (£m, 2013 prices)



4.29. Under the Low scenario, IFA2's projected revenues are below the floor, triggering an estimated £215 million in floor payments from GB consumers over the course of the cap and floor regime. This would result in a £0.13 increase to an average annual domestic bill. However, this would be outweighed by the wholesale price savings to domestic GB consumers that IFA2 is estimated to result in. Our analysis suggests that these savings would reduce an average annual domestic GB consumer bill by around £0.25.

4.30. Under the High scenario, IFA2's projected revenues are mostly above the cap. In total, this would trigger cap payments to GB consumers of around £200 million over the course of the cap and floor regime. This is equivalent to a reduction in an average annual domestic GB consumer bill of around £0.14.[41]

[41] The total value of cap payments under the High scenario is lower than the value of floor payments under the Low scenario due to discounting. The average annual consumer bill impact is undiscounted and therefore, under the High scenario it is greater than under the Low scenario.

Viking Link

Social welfare impacts

4.31. The modelling results suggest that Viking Link would increase social welfare for GB consumers across all three scenarios modelled (see Table 10). This is largely driven by the modelled wholesale price differences between GB and Denmark.

4.32. In terms of total GB welfare, the modelling suggests that Viking Link would result in an increase in total GB welfare under the Base case and High scenarios, as the increases in GB consumer and interconnector welfares offset any loss in GB producer welfare. Under the Low scenario, modelling suggests total GB welfare impact would be negative.

Table 10: Viking Link's social welfare impacts on GB (£m, 2013 prices)

		Base	Low	High
Viking Link	GB consumers	2148	87	2522
	GB producers	-1905	-656	-2247
	GB interconnectors	-91	-45	364
	GB total	151	-614	639

Sensitivities

4.33. The analysis for Viking Link suggests that the project would still maintain positive GB consumer benefits under each sensitivity (see Table 11). In terms of total GB welfare, only under the low gas price sensitivity would Viking Link result in a negative GB impact. Gas prices have fallen significantly recently, but the average gas price used in the sensitivity is still considerably below the current gas price in GB.[42]

Table 11: Results of sensitivity analysis for Viking Link (£m, 2013 prices)

	GB consumers	**GB producers**	**GB interconnectors**	**GB total welfare**
Base case	2148	-1905	-91	151
High GB RES	1592	-1436	-64	92
No CPS	1795	-1706	-88	1
Low gas price	1143	-1237	-105	-200

[42] The statement is accurate as of 05 March 2015. The National Balancing Point (NBP) 7-day system average gas price was around 52 p/therm, as opposed to the average price of around 40 p/therm we used for the sensitivity analysis.

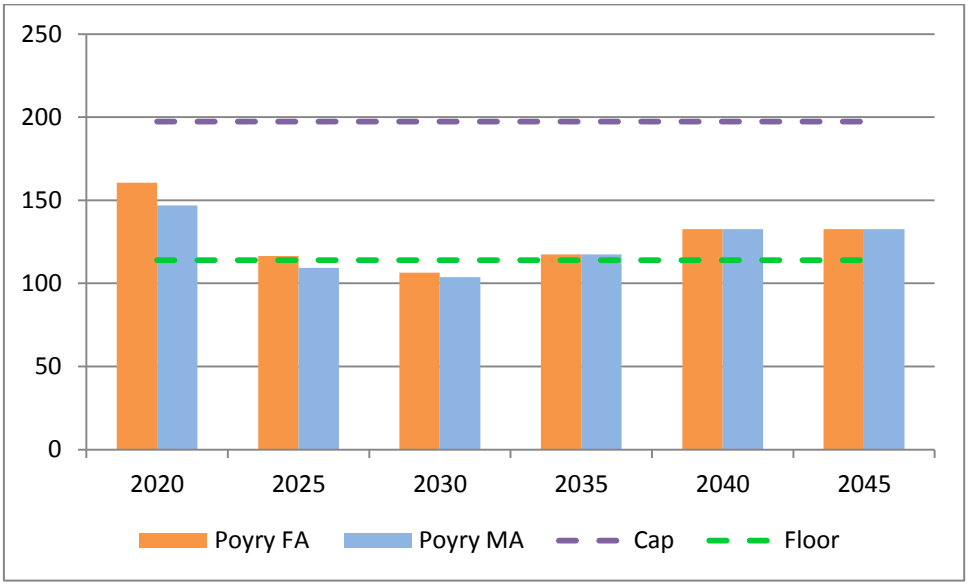
Interactions with other projects

4.34. The comparative analysis between the FA and MA modelling results for GB welfare suggests that Viking Link's social welfare benefits are not sensitive to the other four interconnectors being built (as the difference in GB welfare between Base case FA and MA results is £1m).

Viking Link's congestion revenues and impact of cap and floor payments on consumer bills

4.35. Under the Base case, Viking Link's projected revenues are mostly between the cap and floor (see Chart 3). The revenues fall slightly below the floor in some years. The total value of estimated floor payments from GB consumers is around £21 million over the course of the cap and floor regime (25 years). This is equivalent to an estimated increase of less than £0.01 on an average annual domestic GB consumer bill. The analysis suggests this would be significantly outweighed by the wholesale price savings to GB consumers that Viking Link is estimated to bring. Our analysis suggests these savings would reduce an average annual domestic GB consumer bill by £1.20.

Chart 3: Viking Link's projected congestion revenues, **Base case** (£m, 2013 prices)



4.36. Under the Low scenario, Viking Link's projected revenues are constantly below the floor. This would trigger floor payments from GB consumers of an estimated total value of around £640m over the course of the cap and floor regime. This is equivalent to an estimated increase of £0.38 to an average annual domestic GB consumer bill. However, it is still outweighed by the wholesale price savings to GB consumers that Viking Link is estimated to result in. Our projections suggest that these savings would reduce an annual average GB consumer bill by £0.43.

4.37. Under the High scenario, Viking Link's projected revenues are between the cap and floor or above the cap. Modelling suggests this would trigger cap

payments to GB consumers of around £60m over the course of the cap and floor regime. This is equivalent to a reduction in an average annual domestic GB consumer bill of around £0.38.

Greenlink

Social welfare impacts

4.38. The modelling results suggest that Greenlink would increase social welfare for GB consumers across two scenarios modelled, namely Base case and High scenario (see Table 12). This is driven by the modelled wholesale price differences between GB and Ireland.

4.39. In terms of total GB welfare, the modelling suggests that Greenlink would result in a welfare loss as GB consumer or producer gains (depending on the scenario used) would not fully offset GB welfare losses.

Table 12: Greenlink's social welfare impacts on GB (£m, 2013 prices)

		Base	Low	High
Greenlink	GB consumers	33	-285	220
	GB producers	-60	160	-142
	GB interconnectors	-18	-17	69
	GB total	-45	-143	148

Sensitivities

4.40. The analysis for Greenlink suggests that GB consumer welfare would turn negative under all sensitivities, except for high EU RES where it increases compared to the Base case.

4.41. In terms of GB welfare, Greenlink would still result in a negative impact under all sensitivities studied, except for high GB RES, where it turns positive (see Table 13).

Table 13: Results of sensitivity analysis for Greenlink (£m, 2013 prices)

	GB consumers	**GB producers**	**GB producers**	**GB total welfare**
Base case	33	-60	-18	-45
High GB RES	-24	75	16	67
High EU RES	96	-109	-38	-52
No CPS	-107	61	-13	-59
Low gas price	-6	-21	10	-16

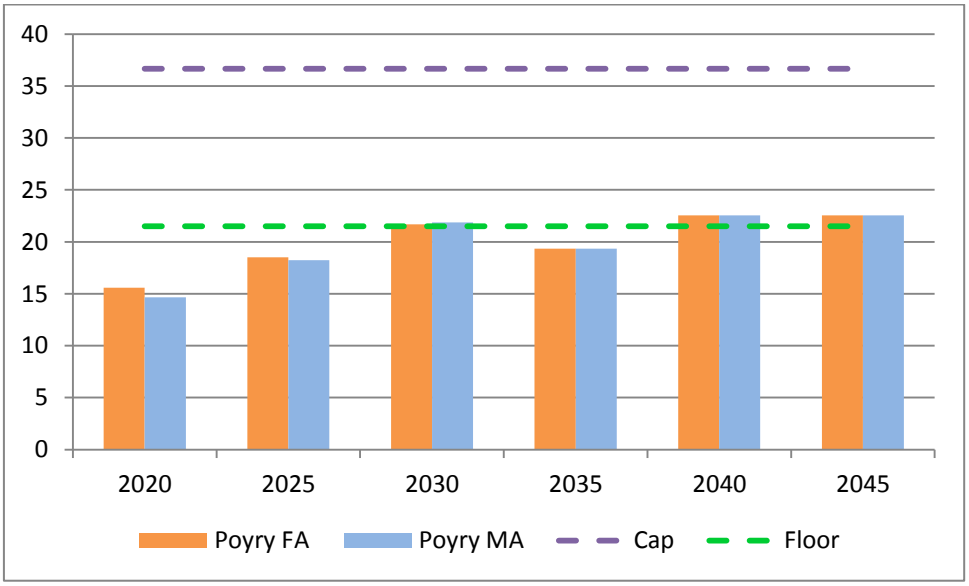
Interactions with other projects

4.42. The comparative analysis between the FA and MA modelling results for GB welfare suggests that Greenlink's social welfare benefits are not sensitive to the other four interconnectors being built as total GB welfare under Base case MA modelling increases by £8m compared to FA modelling.

Greenlink congestion revenues and impact of cap and floor payments on consumer bills

4.43. Under the Base case, Greenlink's projected revenues are below or at the floor (see Chart 4), which would trigger floor payments from consumers to the developer. The total value of estimated floor payments is around £20 million over the course of the cap and floor regime (25 years). This is equivalent to an estimated increase of £0.01 on an average annual domestic GB consumer bill. Our market modelling analysis suggests that these impacts would be offset by wholesale price saving to GB consumers. These savings are estimated to reduce an annual average domestic GB consumer bill by around £0.01.[43]

Chart 4: Greenlink's projected congestion revenues, Base case (£m, 2013 prices)



4.44. Under the Low scenario, Greenlink's projected revenues are constantly below the floor. This would trigger floor payments from consumers of around £110 million over the course of the cap and floor regime. This would translate into an increase of £0.06 to an average annual domestic GB consumer bill. This is in addition to an increase to GB wholesale price as a result of Greenlink. We estimate that this impact would further increase an average annual domestic GB consumer bill by £0.11.

[43] Please note that this estimate does not account for SO operation and network reinforcement costs as a result of Greenlink. These costs would also result in an impact on domestic GB consumer bills.

4.45. Under the High scenario, Greenlink's projected revenues are above the floor and sometimes above the cap. This would trigger cap payments to GB consumers of a total value of around £74 million over the course of the cap and floor regime. This is equivalent to a reduction in an average annual domestic GB consumer bill of around £0.06.

Impacts of capacity mechanisms on interconnectors

4.46. A number of EU Member States have been considering introducing capacity mechanisms (CMs). For this reason, we have assessed the potential impacts of allowing interconnectors to participate in CMs which:

- Create social welfare transfer via an interconnector from a country with a CM in place (as an interconnector could displace domestic generation taking part in the CM)

- Increase interconnector revenues (as an interconnector would receive an additional source of revenues).

4.47. While DECC has confirmed interconnectors will be able to participate in the GB CM, it remains unclear whether they will be able to participate in connecting countries' CMs. Given this uncertainty, we made assumptions based on the existing knowledge and advice received from Pöyry on whether there is likely to be a CM in each connecting country and whether interconnectors could expect to participate.

4.48. We made conservative assumptions for FAB Link, IFA2 and Viking Link to stress test these projects from the GB social welfare perspective. In particular, we assumed that these projects will only be able to participate in the GB CM and that the clearing price would be significantly higher than in the last year's auction. This results in greater social welfare transfer from GB to a connecting country via these interconnectors.

4.49. For Greenlink we made some optimistic assumptions from a total GB welfare perspective to test the potential upside for GB. In particular, we made a simplistic assumption that Greenlink will only be able to participate in the Irish CM. This would result in an increase to GB social welfare as half of Greenlink's Irish CM revenues would be attributed to GB. This is because half of these revenues would be subject to GB regulation (ie cap and floor) as per the developer's proposal for cost and revenue sharing.

Table 14: CM modelling assumptions used

Factor	Assumptions
Participation – eligibility to participate in GB and connecting country's capacity mechanisms.	**FAB Link, IFA2 and Viking Link**- eligible to participate in GB CM only. **Greenlink –** eligible to participate in Irish CM only.[44]
De-rating – percentage of the total interconnector capacity up to which it is allowed to bid into the CM auction.	**FAB Link, IFA2 and Viking Link**- de-rated to 70% of total capacity in the GB CM, based on Pöyry's analysis. **Greenlink:** de-rated to 80% of total capacity in the Irish CM, based on Pöyry's analysis.
Clearing price	**GB** - £30/kW as a reasonable mid-point between the 2014 auction price (£19.4/kW) and future auction price, as assumed in the Pöyry report (£38/kW). **Ireland** - £59/kW, based on Pöyry's assumptions.
Duration of CM policy	5 years (based on DECC's statement that the current CM for IC's will be a temporary measure until a pan-European CM is introduced[45])

4.50. Using the assumptions set out in Table 14, we have estimated the potential impacts that CM participation might have on each of the four projects:

- The CMs make interconnector projects more commercially viable as they provide an additional revenue stream making them less likely to fall below the floor and more likely to exceed the cap. The revenues from the CM in GB could be around £21 million annually for IFA2 and Viking Link and £29.4 million for FAB Link (assuming 70% de-rating and £30/kW clearing price in the GB CM). For Greenlink annual Irish CM revenues could be in the region of £ 23.6 million annually (assuming 80% de-rating and £59/kW clearing price).

[44] Technically, Greenlink would be allowed to participate in GB CM, but we think it is likely that it would receive a very low de-rating factor. For simplicity, we assume that Greenlink would be de-rated down to zero in the GB CM, meaning that it could not capture any revenue in GB CM.

[45] See DECC's consultation on CM supplementary design: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/358461/CM_October_Condoc_FINAL.pdf

- Viking Link, IFA2 and FAB Link could displace expensive GB generation from the CM and reduce GB producer surplus (ie generator profits). This would cause a welfare reduction in GB as half of the CM revenues (or 35% for FAB Link) accrue to a connecting country. This could be around £10.5 million annually for IFA2 and Viking Link, and £10.3 million annually for FAB Link. This translates into around £47.7 million and £46.5 million respectively in NPV terms across the five-year period for which we assumed the GB CM for interconnectors to stay in place.

- Allowing Greenlink to participate in the Irish CM could result in a social welfare transfer from Ireland to GB in the region of £11.8m annually or £53.3m in NPV terms (for the five-year period assumed).

Comparison of Ofgem and developers' economic modelling

4.51. As part of the cap and floor application, we asked developers to submit their economic modelling analysis. When assessing the projects, we compared each developer's and Pöyry's results and considered the key differences. We took both Pöyry and developers' economic modelling studies into account when considering each project.

4.52. For FAB Link, IFA2 and Viking Link we found that results were broadly similar and would not result in significantly different conclusions of our assessment. This is despite some differences in assumptions and modelling methodology that we have observed.

4.53. For Greenlink, we found that there were substantial differences both between the assumptions and modelling methodology which caused larger differences in results between the studies.

4.54. In particular, Element Power, the Greenlink developer, has assumed much greater renewables growth in the Republic of Ireland and Northern Ireland compared to the Pöyry Base case over a part of the 25 year period analysed. In addition, there are significant differences in the way the developer and Pöyry have modelled Single Energy Market (SEM) price formation, resulting in wind setting the market price more often in the developer's study than in ours. Consequently, the developer has presented significantly greater price differentials in its study compared to ours and therefore, a better economic case for Greenlink. We explore these differences in greater detail in Appendix 3.

5. Impacts on the GB transmission system

Chapter Summary

This chapter is an overview of the impacts of FAB Link, IFA2, Viking Link and Greenlink, on the operation of the national electricity transmission system. It also outlines the cost of onshore works to connect each project to the national electricity transmission system.

Question box

Question 5: Do you have any views on the information presented in this chapter?
Question 6: Are there any additional factors that you think we should have considered?

5.1. This chapter summarises two main areas:

- the impact FAB Link, IFA2, Viking Link and Greenlink projects could have on the operation of the national electricity transmission system (NETS), and
- the cost of onshore works required to connect each project.

5.2. The system operation impacts section is informed by studies provided by NGET. The detailed analysis is in a report prepared by NGET which we published alongside the consultation on the NSN project in December 2014.[46] The onshore reinforcement costs were also provided to us by NGET.

Impacts on GB system operation

5.3. The impacts on GB system operation fall under two broad categories:

- the impact each project may have on the value of ancillary services and boundary capability, and
- the operational cost (constraint cost) implication of each interconnector connecting to the transmission system.

5.4. NGET's analysis of the impact of each project on system operation uses 2020 as a single spot year in NGET's Gone Green scenario projection. The

[46]Cap and floor regime: IPA for the NSN interconnector to Norway, December 2014 consultation: https://www.ofgem.gov.uk/publications-and-updates/cap-and-floor-regime-initial-project-assessment-nsn-interconnector-norway-0

analysis was performed for a range of price forecasts for European markets and considers a price range for constraining interconnector flows. The upper and lower limits include sensitivities of these prices. NGET's analysis focuses on potential consumer benefits and doesn't consider how developers could extract value in delivering these benefits. This analysis also doesn't account for changes which may be imposed by the European Network Codes.

Value of ancillary services and boundary capability

5.5. NGET's 'Benefits of Interconnectors to GB Transmission System' paper says that existing and future interconnectors could help provide new ancillary services needed for future system operability. Such services include:

- **Frequency response** – The difference between system demand and generation results in changes to system frequency. NGET uses frequency response to ensure frequency can be maintained within required levels.
- **Black start** – This is the process of restoring power stations to operation following a total or partial shutdown of the transmission system. It requires isolated power stations to be started individually and used to gradually re-energise the system. According to NGET, interconnectors that use Voltage-Source Converter (VSC) technology can provide black start.[47]
- **Reactive response** - Reactive power availability on the transmission system affects voltage level. NGET manages voltage levels so that voltage is maintained. Interconnectors are able to provide reactive voltage support and displace the capital cost of reactive equipment required on the network. This benefit depends on the GB connection location however.
- **Boundary capability -** Interconnectors can be used to alleviate transmission network flows, resulting in displaced investment on the transmission network. This benefit depends on the GB connection location.

5.6. NGET's analysis illustrates that three of the interconnectors can positively contribute to the provision of frequency response,[48] reactive response and black start capability. Table 15 shows that FAB Link can contribute savings of between £32m and £63m, IFA2 between £22m and £48m, and Viking Link between £23m and £46m.

5.7. The system operation benefits of Greenlink connecting are minimal.[49] The connection location on the GB network limits the potential for boundary capability increase, or reactive response benefits from the link. Limited frequency response capability is also assumed due to the lower inertia of the Irish network. These conclusions are based on NGET's assumptions about the Irish transmission

[47] Current-Source converter (CSC) technology can only operate in an energised AC network; so interconnectors that use CSC technology would not have black start capability.
[48] NGET's analysis assumes 5 – 10% of the capability of each link is made available to provide frequency response.
[49] The impacts for Greenlink are presented as £0 in Table 15 above as they are not greater than £1m.

system. We note from NGET's analysis that this is not conclusive and further discussion with the Irish TSO is required to realise potential future benefits from black start and frequency response.

Table 15: System operation impacts of each interconnector

	FAB Link			IFA2			Viking Link			Greenlink		
	Low	Mid	Upper	L	M	U	L	M	U	L	M	U
Annual value of services & boundary capability (£m)	32	47	63	22	35	48	23	34	46	0	0	0
Annual operational costs (£m)[50]	-6	3	12	-4	2	8	-10	-3	4	-27	-18	-9
Total (£m)	26	50	75	18	37	56	13	31	50	-27	-18	-9

5.8. For boundary capability, NGET's analysis suggests that FAB Link would increase the B13 boundary capability by 80MW;[51] IFA2 could increase B13 boundary capability by 534MW and SC1 boundary by 40MW. There is no change in boundary capability attributed to either Viking Link or Greenlink; this is largely due to the connection location of both interconnectors. NGET's 'Benefits of Interconnectors to GB Transmission System' paper has further detail on this.

Operational costs

5.9. The operational cost implication of each interconnector connecting to the NETS reflects either an increase or decrease in constraint management costs which NGET incurs when balancing the electricity transmission system.

5.10. NGET's analysis demonstrates that at the mid-point, operational costs for FAB Link, IFA2 and Viking Link are marginal. However operational costs for these three interconnectors could increase or decrease depending on assumptions, as shown in Table 15.

5.11. Under all assumptions, Greenlink increases operational costs of the GB network. NGET indicate, however, that opportunities may arise for constraint management with other interconnectors to Ireland. This may be possible providing relevant reinforcements are made to the Irish network and necessary agreements are in place. NGET also note that Greenlink has not yet been subject

[50] A negative figure implies an increase in constraint costs while a positive figure denotes a reduction.
[51] This would increase to 200MW if both FAB Link and IFA2 were connected.

to the Connection and Infrastructure Options Note (CION) process.[52] If the CION process identifies a more suitable connection point then this could help to mitigate the increase in annual operational costs for Greenlink.

Our view of system operation impacts of each project

5.12. NGET's analysis highlights that system operation will become more challenging as significant volumes of low carbon generation are introduced. NGET suggests that additional reserve and frequency response will be required to cater for variable and intermittent low carbon generation. As a result, future interconnector projects are expected to provide increasing benefit.

5.13. Analysis indicates that FAB Link, IFA2 and Viking Link could help NGET manage system operation and alleviate some of the challenges it faces. Costs of operating the system are typically passed on to consumers, so if these projects can contribute to more efficient services then there is the potential to displace existing costly resources. If FAB Link, IFA2 and Viking Link were all in service and able to provide the ancillary services listed above, we consider that there could be significant savings for GB consumers.

5.14. We acknowledge limitations exist on the Irish network and therefore understand the reasons why the value attributed to Greenlink for ancillary services and boundary capability is minimal. However we note that future discussion and investigation with the Irish TSO may identify that Greenlink can provide black start and frequency response, so conclusions could change.

5.15. NGET's analysis suggests there is a risk that annual operational costs could increase for all four projects. However a change in assumptions used in NGET's modelling could reduce operational costs for FAB Link (by £12m), IFA2 (by £8m) and Viking Link (by £4m), as illustrated in the Upper range in Table 15. We therefore consider that there is potential for constraint management costs to reduce as a result of interconnection with markets outside GB. We also consider that even when operational costs are high for FAB Link, IFA2 and Viking Link, any increase in operational costs, particularly in the Low range, is offset by the value provided from ancillary services and boundary capability.

5.16. For Greenlink, under all assumptions modelled by NGET, constraint costs increase. The annual increase in system operation costs for Greenlink ranges between £9m and £27m. We note, however, potential constraint management with other interconnectors to Ireland and a change in connection location could change these conclusions.

[52] As part of the development of an offshore connection, NGET as System Operator coordinates with Transmission Owners (onshore and offshore) and Developers in an optioneering process to identify the most economic and efficient connection and infrastructure option; this is known as the CION process. Chapter 7 and Appendix 5 provide further detail on the status of the connection agreement for Greenlink.

Cost of onshore reinforcements

5.17. Onshore reinforcement costs reflect the investment that is required by NGET to connect each interconnector to its transmission system. The costs are recovered through Transmission Use of System (TNUoS) charges, which are paid by users of the transmission network. As well as assessing the system operation impacts of each interconnector connecting and associated benefits to GB consumers, it is important to consider the costs of connecting each interconnector to the NETS. This is because ultimately, costs will be passed on to GB consumers.

5.18. Combined costs of local and wider works required to connect each interconnector are as follows:[53]

- FAB Link - £42m of local works are required to upgrade the Exeter 400kV substation and refurbish overhead lines from Exeter to Hinkley.
- IFA2 - £97m of which £57m is allocated to wider works for installation of static VAR compensators (for fast frequency response) and mechanical switch capacitors (for voltage support) on the south coast. The £40m of local works is to install a new Gas Insulated 400kV substation at Chilling and to upgrade overhead lines.
- Viking Link - £29m of local works to convert and extend the Bicker Fen 400kV substation.

5.19. NGET was unable to confirm local or wider work costs for connecting Greenlink as the project has still to go through the CION process. As a result we have assumed local and wider costs of zero for Greenlink when reaching our minded-to positions, but note that this is likely to increase.

5.20. These costs are incorporated into our summary of the potential GB consumer benefit of each interconnector, which is discussed in Chapter 3.

[53] These costs are in 2013 prices and were obtained from NGET. Wider and local work costs quoted are indicative only. They are based on assumptions about the capability of the network in 2020, and therefore could change.

6. Hard-to-monetise assessment of interconnectors

Chapter Summary
This chapter summarises our assessment of the qualitative impacts of the four interconnectors eligible for assessment. The focus of this chapter is on our hard-to-monetise assessment in line with our Impact Assessment guidance.

We have concluded that there are net positive impacts for FAB Link, IFA2 and Viking Link, and that there are less positive impacts for Greenlink interconnector.

Question box

Question 7: Have we appropriately assessed the hard-to-monetise impacts of the interconnectors?
Question 8: Are there any additional impacts of the interconnectors that we should consider qualitatively?

6.1. Our qualitative assessment of the four eligible interconnectors has considered information received from developers as well as our own analysis, including hard-to-monetise factors. A number of the qualitative benefits identified in our assessment have been covered quantitatively in Chapters 4 and 5.

6.2. As part of the qualitative assessment, we have also considered hard-to-monetise impacts of interconnectors, in line with our Impact Assessment guidance.[54]

6.3. This hard-to-monetise assessment is concerned with more long-term sustainability and strategic issues, such as: optionality; diversity and resilience; pathways and lock-in; and natural asset and sustainability implications. These terms are explained in full in Appendix 4. There is a summary of this hard-to-monetise assessment in Figure 2.

6.4. The overall conclusion of the assessment is that there are positive impacts in many of the assessed areas as a result of FAB Link, IFA2 and Viking Link. These positive impacts are driven by a number of factors including increased "system meshing"; connection to alternative renewable sources; and the potential development into multi-purpose projects. The benefits offered by Greenlink beyond those associated with generic interconnection are more limited.

[54] See our Impact Assessment Guidance: https://www.ofgem.gov.uk/publications-and-updates/impact-assessment-guidance

Figure 2: Hard-to-monetise assessment of FAB Link, Greenlink, IFA2 & Viking Link

<table>
<tr><th colspan="3">Optionality</th></tr>
<tr><td colspan="3">Increasing interconnection generally has a dampening effect on wholesale prices, therefore reduces price signals for investment in other technologies such as generation and demand side response. The government's Capacity Market should ensure sufficient capacity on the system.

Greater interconnection allows for the possible development of projects into Multi-Purpose Projects (MPPs) in the future (eg potential connection of tidal power at Alderney in the case of the FAB Link project).</td></tr>
<tr><th colspan="3">Diversity and resilience</th></tr>
<tr><td colspan="3">Diversity of supply will be increased as interconnection increases, particularly with connection to a new country (Denmark).

Generation mix in France and Denmark is significantly different to GB. France has a high level of nuclear generation, with roughly 75% of generation being from nuclear in 2014.[55] Denmark's generation was 35% from renewable generation in the same year. [56] Ireland's mix is not significantly different to GB's, with a reliance on conventional thermal generation.[57] As discussed in the supplementary Pöyry report these differences in generation mixes are expected to continue over the cap and floor period. This is in line with current energy policies of the countries. For example, Denmark has a national energy agreement to meet 50% of electricity consumption from renewable sources by 2020.[58]

Interconnectors should increase system resilience against high-impact, low-probability events. The increased diversity and supply should guard against technical equipment failure, weather-related risks, volatility in global energy prices and attacks on energy infrastructure.

FAB Link and Greenlink would increase the diversity of interconnector owners in GB (Transmission Investment & Element Power respectively). Whereas Viking Link and IFA2 would be owned/operated by an incumbent interconnector developer in GB (National Grid Interconnector Holdings).</td></tr>
<tr><th colspan="3">Stress and security implications</th></tr>
<tr><td>Security of supply:
Interconnection has a positive impact on security of supply through system meshing and increased supply sources.[59] Even more so when connecting to systems that have significantly different energy mixes.</td><td>Potential for extreme price and/or volatility:
Interconnection lowers the potential for extreme prices and/or volatility.[60] Interconnectors have a dampening effect upon peak prices due to the volatility in one market being offset by stability in another.</td><td>UK's legally binding energy targets:
Imported electricity is assumed to have zero carbon impacts in GB, as the accounting is based on production. Therefore the expected high level of imports from France and Denmark would have a positive effect on the UK meeting its targets. Greenlink is unlikely to be a</td></tr>
</table>

[55] See World Energy Council - France: http://www.worldenergy.org/data/trilemma-index/country/france/2014/
[56] See World Energy Council - Denmark: http://www.worldenergy.org/data/trilemma-index/country/denmark/
[57] See World Energy Council - Ireland: http://www.worldenergy.org/data/trilemma-index/country/ireland/
[58] See Danish Energy Agency website: http://www.ens.dk/en/policy/danish-climate-energy-policy
[59] 'System meshing' refers to increasing the strength of transmission systems by further interconnecting them.
[60] When stress periods in connected systems are not directly correlated.

Cross-border balancing arrangements (eg. SO-SO trades) are in place with France and Ireland over the existing interconnectors. These arrangements increase the security of supply impact of FAB Link, Greenlink and IFA2. There is also the potential to have similar arrangements in place with the Danish TSO, however further discussions are required.		significant net importer or exporter; so its effects are low/unknown at this point. Even when not based on accounting terms, the net combined carbon output would be lowered through importing less carbon-intensive electricity from Denmark and France.
Learning by doing and supply chain development		
Potential for supply chain congestion as the cap and floor process could result in up to five additional interconnectors attempting to construct at similar times. The timing of this process also coincides with other DC cable/converter projects such as the building of marine cables to connect offshore renewables. We would expect the supply chain to respond to the upcoming demand for assets by adding output capacity where possible.		
Pathways and lock-in		
Building interconnectors allows additional flexibility in our system and market arrangements. An increasingly meshed transmission network has greater ability to cope with a range of future pathways and energy system developments.		
Natural asset and sustainability implications		
Consistency with UK 2050 targets: A high level of interconnection facilitates the achievement of long-term carbon targets by providing additional system flexibility.[61] Interconnection also adds market value to renewables, making wind more competitive through more efficient dispatch across two markets. Imported electricity is assumed to have zero carbon impacts as the accounting is based on production. Therefore the expected high level of imports from France and Denmark would have a positive effect on the UK meeting its targets.	**Cumulative carbon impacts:** Cumulative carbon refers to the impact in delaying of carbon reduction policies. This proposal will have minimal impacts on cumulative GB carbon emissions.	**Natural asset impacts:** Development of interconnectors might be less disruptive than alternative options for electricity supply (such as additional power stations), and should have a small offshore impact (post-construction) as the cable will be buried. Proportions of onshore lines and cables for all projects will also be buried, in order to reduce the visual impacts of the project. These proportions vary between projects.

[61] For example, see DECC's report on the benefits of more interconnection: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/266460/More_interconnection_-_improving_energy_security_and_lowering_bills.pdf

Summary of hard-to-monetise assessment

6.5. FAB Link is expected to provide net positive impacts. This impact is brought about by increasing the level of connection to a market with good existing SO-SO trading arrangements.[62] Many of the benefits are building upon those already realised through existing connection to France. FAB Link has the additional benefit of increasing the diversity of interconnector owners in GB.

6.6. IFA2 is likely to provide the same benefits as FAB Link, but on a slightly smaller scale because the capacity of the link is smaller.

6.7. For Viking Link, overall the impacts are likely to be net positive. The main drivers for this impact are the connection to a new market with a relatively different generation mix and demand profile. It is also expected that Viking Link will tend to import electricity from Denmark, which would contribute to the UK meeting its legally binding energy targets.

6.8. Greenlink is likely to provide significantly less benefit of the types discussed above. This is because the relatively small and similar market in Ireland, in combination with existing links, limits the size of the impact. We note that there is the possibility for cross-border trading between system operators, as is done over the East West and Moyle interconnectors.

[62] There is a current framework for cross-border trades (eg. SO-SO trades) between system operators over IFA interconnector. We have assumed that these arrangements can be extended to FAB Link and IFA2.

7. Assessment of connection location, capacity, cable routes and technical design

Chapter Summary

This chapter is a summary of our assessment of the justification for chosen connection location, capacity, cable route and technical choices for FAB Link, IFA2, Viking Link and Greenlink.

Question box

Question 9: Do you have any views on the information presented in this chapter?

7.1. This chapter is a summary of our assessment of each project's justification for choice of connection location, interconnector capacity, cable route and technical design (eg converter technology and cable type). There is more detail in Appendix 5.

7.2. As set out in our May 2014 consultation we will only re-examine connection location, capacity, cable route and technical design at the Final Project Assessment (FPA) stage if there have been significant changes to the information provided at the IPA stage. If there has not been enough information for us to reach a conclusion at the IPA stage we will examine these aspects at the FPA stage.

7.3. We focus on the GB site for connection location as we expect that the regulatory bodies in the respective connecting countries will do their own assessment of connection locations within their regulated areas.

7.4. Our assessment is informed by support from our technical consultants, Fichtner and NGET as system operator.[63]

FAB Link

Connection location

7.5. Exeter was chosen as the most suitable connection point as it could accommodate the required capacity with little need for significant onshore grid reinforcement. NGET has confirmed that Exeter was its preferred connection point for FAB Link. Based on information provided to us by NGET and by FAB Link, the

[63] In our August 2014 decision to roll out a cap and floor regime to near-term electricity interconnectors, we said we would ask NGET to provide information relating to the efficiency of the connection choices made by projects to inform our IPA.

developer, we consider that this connection location reflects a reasonable solution to accommodate a capacity of 1400MW and to minimise overall cable length, when compared to other reasonable options.

Capacity

7.6. Capacities of between 1000MW and 2000MW were considered. The developer chose a capacity of 1400MW. A capacity greater than 1400MW was not possible due to limitations in the amount of bidirectional interconnector flow that the onshore grid in France can accommodate. Less than 1400MW was not considered to be economically viable. Based on our assessment of the information provided to us by the developer, we believe that the choice of transmission capacity (1400MW) is justified.

Cable routes

7.7. There are environmental constraints at both ends of the interconnector. The final onshore and offshore route and landing points will be determined by the outcome of technical analysis (including engineering surveys), land availability (particularly for the convertor station), an environmental consenting process and stakeholder consultation. We agree with our technical consultants that connecting via Alderney facilitates further development of local renewable energy sources and does not impose a significant increase in cable length. We have no concerns relating to cable route at this stage.

Technology choices

7.8. The developer proposes to use VSC converter technology in a symmetrical monopole configuration. Based on information provided to us, and taking into account the network limitations at the French connection point, we consider the proposed use of VSC technology and cable configuration to be sensible. Cable technology is yet to be decided as the developer considers that tendering for this will allow an innovative and potentially more cost-effective solution. We note the benefits that may be realised by leaving open the type of cable technology and we will consider this further at the FPA stage.

IFA2

Connection location

7.9. Chilling substation was selected as the preferred location due to the risks (and associated deliverability and costs) associated with other connection sites. NGET agreed that Chilling was the most economic and efficient connection point, taking into account the significant onshore reinforcement and additional cable lengths that would be required at alternative connection sites. We consider that this connection location reflects a sensible solution to accommodate capacity of 1000MW and to minimise cable length from the connection site to shore, when compared to other reasonable options.

Capacity

7.10. A capacity of up to 2000MW was considered but due to the increased cost of achieving capacity above 1000MW and compliance with System Security and Quality of Supply Standard (SQSS) levels, National Grid Interconnector Holdings (NGIH) chose a capacity of 1000MW.[64] Based on our assessment of the information provided to us by NGIH, we believe that at this stage, reasons for a capacity of 1000MW are justified.

Cable routes

7.11. We acknowledge the reasons why the offshore cable length deviates 6% from the shortest possible route. We note that a shorter route could only have been achieved if IFA2 connected to the Haute-Normandie area in France. We understand that this is not possible because of significant power generation in Haute-Normandie which would restrict power flow from GB to France. Based on the information available to us at this time, we consider reasons for the offshore cable route are well justified. We note that further optioneering is required to identify the final landing point for the offshore cable. Once decided, if the landing point imposes a significant change to the overall cable length then this would be considered further at the FPA stage.

Technology choices

7.12. We agree with our technical consultants who consider that reasons for technology choices, particularly the proposed use of VSC, are reasonably justified based on the information provided to us, particularly for network stability in France. We note that although cross-linked polyethylene (XLPE) cable technology has been discounted at this time, alternative cable technologies will still be considered. Once confirmed, we will consider this further at the FPA stage.

Viking Link

Connection location

7.13. Bicker Fen was chosen as the preferred connection location as it was closest to the landfall site. We note that other connection sites were not considered viable as these would require additional onshore cabling which may have increased environmental impacts and led to additional consenting risks. We consider that Bicker Fen reflects the most suitable solution to accommodate capacity of 1000MW and to minimise cable length from the connection site to shore when compared to other reasonable options.

[64] The SQSS establishes the criteria and methodology that transmission licensees use in the planning and operation of the NETS: http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/SQSS/The-SQSS/

Capacity

7.14. Based on our assessment of the information provided to us by NGIH, we believe that the choice of transmission capacity (1000MW) is justified, particularly due to restrictions on the Danish transmission system which currently prevent capacity being greater than 1000MW.[65] We note though that there is ongoing consideration of an increase in capacity. If the capacity increases we will consider this further at the FPA stage and will consider whether this has any implications for our IPA assessment.

Cable routes

7.15. We note that further optioneering is required to identify the most suitable location for the GB landing point and onshore cable route. We also note that for the offshore cable route, a number of options have been assessed and the shortest route would require Viking Link to negotiate a new corridor through German waters, which presents a significant amount of risk for the developer. NGIH has committed to further engagement with the German authorities. Although the final cable route has not been decided for Viking Link, we note that efficiencies are sought for the offshore route but this is subject to further engagement with the German authorities. We will revisit justification for cable routes at the FPA stage once the final route is known.

Technology choices

7.16. Ongoing consideration is being given to converter technology and cable configuration and reasons for this appear justified. We note that, with regard to choice of converter technology NGIH is open to using either VSC or CSC at this stage. We agree with our technical consultants that consideration of Current-Source Converter (CSC) technology adds flexibility because of the potential supply chain limitations with VSC technology. Unlike other projects, CSC technology is a possible option because of where Viking Link connects. The strong network and resulting fault levels around Bicker Fen ensure that a CSC connection is possible. We also agree with our technical consultants that Mass impregnated non-draining (MIND) cable technology is a reasonable choice considering the chosen operating voltage level.

Greenlink

Connection location

7.17. As the connection agreement is still to be modified for Greenlink we were unable to get enough information from NGET about the connection location of this

[65] Danish infeed loss is 1000MW

interconnector.[66] We are therefore currently unable to assess the justification for the chosen connection location, even though Element Power considers that this is likely to remain at Pembroke. We note Element Power is currently in discussions with NGET to convert the existing generation connection agreement to an interconnector connection and when this happens NGET will undertake the CION process to identify the most suitable location.

Capacity

7.18. Based on our assessment of the information provided to us by Element Power, we believe that the reasons for choice of transmission capacity (500MW) seem reasonable due to infeed loss restrictions on the Irish transmission system.[67] We note that there is ongoing consideration for an increase in capacity to 700MW.

Cable routes

7.19. We understand that further optioneering is required to determine the final cable route. We consider that reasons for the GB shore landing point and cable route are reasonably justified, though may change if a more suitable connection location is identified through the CION process.

Technology choices

7.20. Element Power propose using VSC technology as it requires less reinforcement to the AC grid at the connection points and will allow a very rapid change of flow direction. Based on the information submitted to us, our technical consultants consider that use of VSC technology is sensible and we agree with this conclusion. We also agree with our technical consultant's view that the technical content of Element Power's submission was limited, which may be a reflection that the project is at early stages of development.

[66] Element Power currently has a generation connection agreement with National Grid to connect Irish Wind generation via HVDC transmission links to Pentir (1000MW) and Pembroke (2000MW). This is for the Greenwire project. It is expected that Element Power will apply to NGET to modify this agreement, to to change 500MW of capacity at Pembroke to an Interconnector agreement.
[67] The current Irish infeed loss is 500MW.

8. Assessment of project plans

Chapter Summary

This chapter contains our assessment of project plans submitted to us by the interconnector developers.

Question box

Question 10: Do you have any comments on our assessment of the project plans?

8.1. We outlined in our May 2014 consultation that we would require clear evidence that any project would be able to meet its planned connection date. Part of this was a project plan including milestones for consenting, procurement, financing, investment decisions and construction.

8.2. Table 16 outlines our high level assessment against criteria for an appropriate project plan. We have assessed each project in the same way as we did for NSN. A green marking indicates that we don't have any concerns on the criterion, based on the information received. A yellow marking indicates we have some minor concerns around how the project meets the criterion, but these risks could be managed by the developers and have a less material impact on the UK. A red marking indicates a criterion that we have serious concerns about the project meeting this criterion. We explain our reasons behind any yellow or red markings below, in the paragraph number indicated in the relevant table cell.

Table 16: Assessment of project plans to 2020

Required information	Identified criteria	Our assessment			
		FAB Link	IFA2	Viking Link	Greenlink
Key milestones from early stage of development to operation	All the key milestones are included.	8.3.			
	Plan is robust and achievable.		8.4.	8.6.	
	Contingencies are identified and addressed.			8.7.	
Detail on discussions held with NRAs and governments (including in connecting country)	Discussions with relevant stakeholders included.				
	Summary demonstrates clear understanding of connecting market process.				

Description of how C&F is expected to interact with the regulatory regime in connecting country	Description is clear, logical and reasonable.				8.8.
	Potential problems identified with solutions offered.				8.8.
Overview of developers' procurement plans	Robust and achievable.				
	Contingencies identified and addressed.				
Assessment of supply chain availability and engagement so far	Engagement so far is sufficient level.				
	Contingencies identified and addressed.	8.10.	8.10.	8.10.	8.10.
FID date	Realistic given any dependencies.		8.5.		8.9.

FAB Link

8.3. The project plan for FAB Link does not contain any milestones between FID and commissioning. We would have expected to see further milestones such as the design, manufacture and installation of the cable and converter, as were included in the other projects' plans.

IFA2

8.4. RTE is planning to submit its application for French planning permission (the Déclaration d'Utilité Publique or 'DUP') for IFA2 in Q3 2015. A substantial amount of work is required before this can be done, such as an environmental impact assessment. The FAB Link project plan includes two years for this to be done before the FAB Link developers submit a DUP application. It is not clear from IFA2's submission how much of this work (if any) has been completed. We would therefore have some concerns over how achievable the planning and consenting timelines are if the pre-submission works are not completed by Q3 2015.

8.5. FID is expected between April and December in 2016. We have some concerns that planning permission may take longer to secure than expected which could delay FID being taken. However this could be mitigated to some extent by the contingency NGIH has allowed in having a nine month window for FID.

Viking Link

8.6. NGIH has allowed 2.5 years to manufacture and install the 740km cable. This is similar to the time allowed by the other three projects, whose cables are all significantly shorter than Viking Link's. NGIH allowed an extra year for NSN, which is a similar length. We are therefore concerned that the timescales for Viking Link are ambitious and there could be delays to this part of the project. We

also understand that the developers are considering alternative capacity options and that this has the potential to delay planned delivery of the project.

8.7. No assessment of the main risks facing the project has been included in the Viking Link submission, so we cannot determine whether these appear to be under the developer's control. We do note NGIH's explanation that this is due to the early stage of the project, and so any risks would be generic to interconnectors and not Viking Link-specific.

Greenlink

8.8. At this stage it is not clear what the Irish regulatory regime for Greenlink would be. The developer's submission does include some views on how a cap and floor regime could be applied on the Irish side as well as the British side, and how these could interact. We have marked these criteria as red, as with uncertainty over the Irish regime we have concerns over whether the project can be delivered to the planned timescales.

8.9. Element Power says it plans to make its FID in May 2017. We question whether uncertainty regarding the regulation of Greenlink on the Irish side could delay the developers in taking FID.

General comments

8.10. The timescales for all four projects to connect in 2020 are tight. This could be exacerbated by constraints in the number of vessels available that can lay subsea cables. Currently only a few exist, and with these four projects and NSN and Nemo potentially being constructed at similar times, we have concerns that not all the projects would be able to access vessels at the times they need them. This has the potential to cause delays to project plans.

9. Next steps on our IPA

Chapter Summary

This chapter contains our minded-to position on the IPA of FAB Link, Greenlink, IFA2 and Viking Link. It also describes our next steps.

Conclusions

9.1. As stated in Chapter 3, we are **minded to grant FAB Link, IFA2 and Viking Link a cap and floor regime in principle and subject to no material escalation in costs.** This is because we expect these projects to offer benefits to GB consumers and to GB as a whole. **We are minded not to grant Greenlink a cap and floor regime.** This is because the project does not seem to be in the interests of GB consumers based on the information available at this time. We are now seeking views on these minded-to positions.

9.2. The granting of a cap and floor regime in principle is subject to no material escalation in costs relative to the estimates submitted to us by project developers, or in line with those for comparable projects. This grant of a cap and floor regime in principle will also be subject to submission of the detailed cost information for our FPA within two years of our decision on the IPA.

Next steps

9.3. We are consulting on our minded-to position for eight weeks. This consultation will close on 2 May 2015. Details on how to respond to this consultation are included in Appendix 1.

9.4. Following this consultation we will assess responses. Subject to these responses, we aim to make a decision on the IPA for these four projects in summer 2015. Developers that pass the IPA stage will then need to submit detailed cost information at the FPA stage, nearer to an investment decision. The provisional cap and floor levels will be set at the FPA stage following our cost assessment.

Appendices

Index

Appendix 1 – Consultation response and questions

1.1. We would like to hear your views on anything in this document. We especially welcome responses to the specific questions at the beginning of each chapter and which are replicated below.

1.2. Please send responses by 2 May 2015 to:

- Stuart Borland
  Electricity Transmission
  9 Millbank, London. SW1P 3GE.
  0207 901 7134
  Cap.Floor@ofgem.gov.uk

1.3. Unless marked confidential, all responses will be published by placing them in our library and on our website www.ofgem.gov.uk. Respondents may request that their response is kept confidential. We shall respect this request, subject to any obligations to disclose information (for example under the Freedom of Information Act 2000 or the Environmental Information Regulations 2004).

1.4. Respondents who wish to have their responses remain confidential should clearly mark the document(s) to that effect and include the reasons for confidentiality. It would be helpful if responses could be submitted both electronically and in writing. Respondents are asked to put any confidential material in the appendices to their responses.

1.5. Having considered the responses to this consultation, we intend to make a final decision on the IPA for FAB Link, IFA2, Viking Link and Greenlink. Any questions on this document should, in the first instance, be directed to:

- Stuart Borland
  Electricity Transmission
  9 Millbank, London. SW1P 3GE.
  0207 901 7134
  Cap.Floor@ofgem.gov.uk

Chapter Three

Question 1: Do you agree with our minded-to positions on the four projects considered in this consultation?

Question 2: Is there any additional information that you think we should take into account when reaching our decision on the IPA of the projects?

Chapter Four

Question 3: What are your views on the approach Pöyry has taken to modelling the impact of cross-border interconnector flows?

Question 4: Do you have any additional evidence in this area that we should take into account?

Chapter Five

Question 5: Do you have any views on the information presented in this chapter?

Question 6: Are there any additional factors that you think we should have considered?

Chapter Six

Question 7: Have we appropriately assessed the hard-to-monetise impacts of the interconnectors?

Question 8: Are there any additional impacts of the interconnectors that we should consider qualitatively?

Chapter Seven

Question 9: Do you have any views on the information presented in this chapter?

Chapter Eight

Question 10: Do you have any comments on our assessment of the project plans?

Appendix 2 – Additional Impact Assessment considerations

Overview of appendix

1.1. Section 5A of the Utilities Act 2000 puts a duty on the Gas and Electricity Markets Authority (the Authority) to carry out an Impact Assessment (IA) for any proposal it believes to be important. Legislation defines 'important' by reference to a proposal which would involve a major change in our activities or significantly impact industry participants, the general public or the environment.

1.2. Our Impact Assessment (IA) of the four eligible interconnector projects being granted a cap and floor is embedded throughout the main body of this consultation.

1.3. This appendix includes consideration of additional items required in our Impact Assessment guidance but not covered in the main body of our consultation. The aim of this appendix is to ensure that we have fully considered the impacts of the projects being granted a cap and floor, against a baseline whereby the projects are not granted a cap and floor and do not go ahead.

1.4. The areas covered in this appendix, to supplement the main consultation document, are as follows: impact on competition; impact on health and safety; impact on vulnerable customers; and impact on existing and future interconnectors.

Impact on competition

1.5. Interconnectors can have a positive impact on competition in the generation of electricity, as we discussed in our IA for Nemo[68] and our NSN consultation document.[69]

1.6. Interconnection enables cross-border electricity flows and therefore results in larger electricity markets. This allows for increased numbers of market players to participate in both the generation and supply of electricity. Benefits of competition can be realised as new entrants participate across connected markets and incumbents face increased pressures to reduce costs.

1.7. For the Nemo link project, the accompanying study included quantified competition tests in the form of concentration ratios and Herfindahl-Hirschmann

[68] See Nemo IA: https://www.ofgem.gov.uk/publications-and-updates/cap-and-floor-regime-application-project-nemo-impact-assessment
[69] See NSN link consultation: https://www.ofgem.gov.uk/publications-and-updates/cap-and-floor-regime-initial-project-assessment-nsn-interconnector-norway-0

Indices.[70] The results outlined that Nemo link would have a small but positive impact on competition when testing the effect by market share.

1.8. We have not carried out quantified analysis of the impact of the four eligible interconnectors on competition in the GB wholesale market. This is because we consider that the analysis would give similar results as for Nemo when assessed individually. This similarity would be driven by factors such as the technology and asset type, and the timing of connection to the GB market. Overall, we expect the four interconnectors to marginally increase competition in GB, but that this increase would be small in relation to the total size of the GB wholesale market.

Impact on existing and future interconnectors

1.9. The impact on existing and future interconnectors is related to the consideration of competition, as the impact is brought about by the competition between interconnectors.

1.10. The quantitative modelling in the Pöyry report published alongside this consultation document has assessed the effects on existing and future interconnectors. This can be seen in the values attributed to interconnector welfare. This includes the erosion impact that FAB Link, IFA2, Viking Link and Greenlink would have upon the revenue of existing interconnectors.

1.11. We consider the presence of these four projects, together with NSN, from the first cap and floor window to reduce the amount of further interconnection required in GB in the future.

Impact on health and safety

1.12. We recognise that the Health and Safety Executive (HSE) is the principal regulator of safety and believe it is important to support the functions that it performs.

1.13. It is our view that there are no additional risks resulting from the development of interconnectors than from the development other types of network infrastructure.

1.14. We consider the potential negative impacts of the development of the cap and floor regime for the four interconnectors to be normal health and safety risks. These normal risks are associated with the installation, operation and maintenance of the interconnector and associated equipment. We consider that these can be controlled by safe working practices and compliance with relevant legislation by the project developers.

[70] The Herfindahl-Hirschmann Index is the sum of the square of the market share of firms in a market. The HHI scale ranges from a complete monopoly to a theoretical fully competitive market.

Impact on vulnerable customers

1.15. Our expectation is that FAB Link, IFA2 and Viking Link will provide net benefits for GB welfare. Part of this benefit is the import of lower priced electricity from France and Denmark, hence the lowering of energy bills for consumers.

1.16. Our social welfare modelling indicates that in the Base case, FAB Link, IFA2 and Viking Link combined provide to £8.2bn welfare for GB consumers. Greenlink is relatively marginal in comparison with a negative GB consumer benefit of -£259m over the 25 years.

1.17. We acknowledge that there is potential for bills to rise, in relative terms, as a consequence of payments when the interconnector revenues fall below the floor. We expect any payment from the floor, for any of the interconnectors, would be minimal. This expectation is in line with the Pöyry report accompanying this consultation document. Pöyry's modelling estimates that wholesale price reductions are likely to outweigh any floor payments for all four projects.

Appendix 3 – Discussion of Greenlink's market modelling

Scope of this appendix

1.1. In this appendix we provide a detailed discussion of differences between our and Element Power's economic market modelling relating to the Greenlink interconnector. We also assess what impact these differences have on our IPA conclusions for this project, after accounting for system operation and transmission network impacts (provided to us by NGET). Our assessment focusses on our (Pöyry's) Base case and Element Power's (Baringa's) Reference and Irish wind growth scenarios.

Differences in assumptions and modelling methodologies

1.2. Our and Element Power's modelling studies have some significant differences in modelling assumptions and methodology, which create some differences in the results. The key differences between the two studies we have identified are renewable capacity assumptions for the Republic of Ireland and Northern Ireland as well as marginal price formation modelling in the Single Electricity Market (SEM).

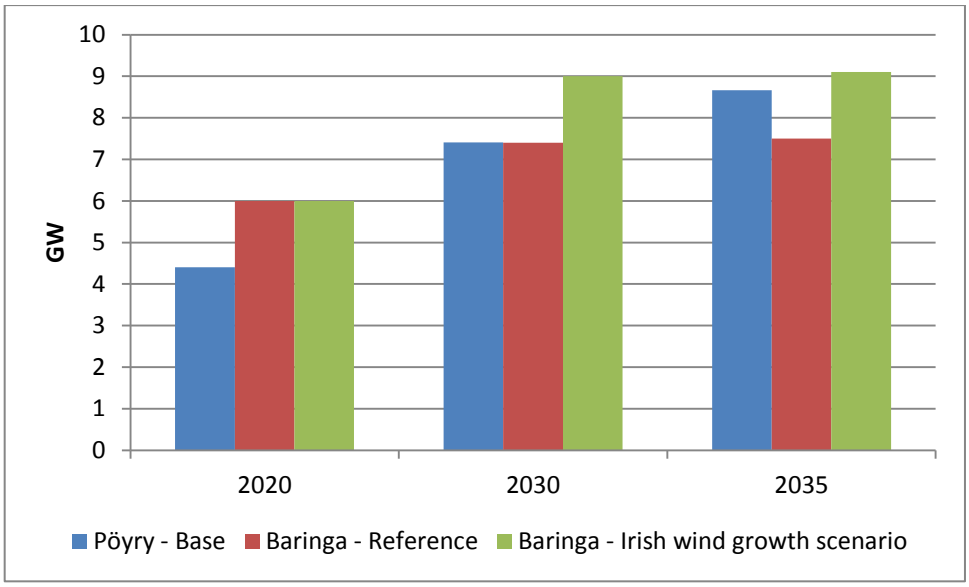
Differences in RES assumptions

1.3. Baringa conducted the modelling for Element Power's submission to Ofgem. As indicated by Chart 5, Baringa has assumed a much greater installed wind capacity in the SEM in 2020 compared to the study which Pöyry has conducted for us. The difference between the assumed capacity under the Pöyry Base case and Baringa's Reference and Irish Wind Growth scenarios only disappears in 2030 and 2035 respectively. Since SEM is a relatively small market, 2GW (or even less) of additional wind capacity could reduce the SEM wholesale price and therefore, create a greater arbitrage opportunity for an interconnector (such as Greenlink) between GB and Ireland.

1.4. Both Pöyry's and Baringa's assumptions are mainly based on Eirgrid's Generation Capacity Statement 2014 (GCS).[71] However, Pöyry has used more conservative figures for wind build to 2020 than Baringa from the ranges of new wind projections provided in the GCS.

[71] Eirgrid GCS (2014) - http://www.eirgrid.com/media/Generation%20Capacity%20Statement%202014.pdf

Chart 5. Comparison of SEM capacity assumptions (GW)



Differences in SEM price formation

1.5. Other substantial differences between our and developer's modelling studies are wind curtailment and resulting SEM price formation assumptions.

1.6. In particular, for the purposes of this study Pöyry has assumed a 75 per cent limit on the system non-synchronous penetration (SNSP) in SEM. This effectively means that non-synchronous generation could not contribute to more than 75 per cent of supply at any given time due to system operational security reasons (eg maintaining system inertia). As a result, even at times when wind output could in theory meet 100% of demand in SEM, wind generators would not be the marginal plant setting the price as the wind above the 75% limit would be curtailed and synchronous thermal generation would be required to provide the remaining 25 per cent of the supply. Compared to the developer's modelling, Pöyry's methodology results in a lesser arbitrage opportunity to Greenlink as low price periods in the SEM become less likely. We think this might be because the developer has not assumed wind curtailment in market price setting due to system security reasons in the same way we did.

1.7. In general, we have been advised by Pöyry that price formation in SEM post-2020 is currently uncertain as a new market design is required in line with the harmonisation of EU energy market rules. The regulatory authorities in the Republic of Ireland and Northern Ireland are still working on the detailed design of this new market and it is not yet clear how certain provisions will be implemented (such as those the system operators must take to ensure system stability and security of supply). In March 2013, the SEM Committee published a decision to not pay the energy price to any curtailed wind from January 2018

onwards.[72] The decision did not state whether curtailed wind would be removed from the market schedule for the purpose of setting the energy price.

1.8. Pöyry has informed us that both alternatives (i.e. including and excluding curtailed wind from energy price formation) remain plausible outcomes. In the face of this uncertainty Pöyry has assumed the removal of curtailed wind from the supply curve when calculating the power price, such that the modelled wholesale price reflects the true marginal cost of energy in all hours across the year. This behaviour should ensure the correct signals for thermal plant closure and investment. It is also noted that curtailed wind was removed from the supply curve when calculating the energy price in the July 2014 Eirgrid and SONI analysis[73] in support of the DS3 procurement design, so the approach that we have used is in line with the approach taken by the system operators in the Republic of Ireland and Northern Ireland at the time of our market modelling study.

Differences in market modelling results

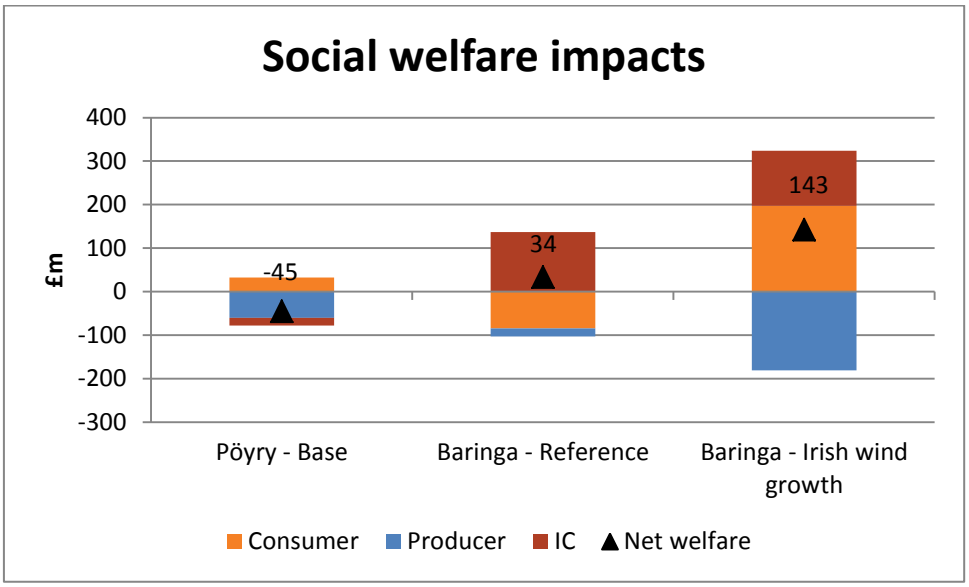
1.9. Given the differences in assumptions and modelling methodology, the findings of Pöyry's and Baringa's market modelling studies are different (see Chart 6).

1.10. In particular, Baringa's market modelling study presents positive social welfare impacts on GB in its Reference scenario compared to Pöyry's Base case (ie a benefit of £34m as opposed to a welfare loss of -£45m. In the High Irish wind scenario, Baringa's study suggests both positive GB consumer (~£200m) and total GB welfare (~£143m) impacts as a result of Greenlink.

[72] SEM-13-010, Treatment of Curtailment in Tie-break Situations, March 2013

[73] SEM-14-059c, System Services Valuation Further Analysis Report, Jul 2014

Chart 6: Comparison of Pöyry and Baringa market modelling results for GB (£m, 2013)



Note: We have adjusted Pöyry's Base case modelling results to reflect the fact that EWIC and Moyle interconnectors are either fully underwritten or wholy owned by the Irish and Northern Irish consumers respectively. So the Pöyry Base case number presented in this chart is different from what Pöyry has published in its report to us.

1.11. Whilst Baringa's Reference and High Irish Wind scenarios present better outcomes from the total GB welfare perspective (and in the case of Irish wind growth scenario, GB consumer perspective as well), it is worth noting that neither Baringa's study nor the independent Pöyry study take into account the GB network reinforcement costs or system operation (SO) impacts of the Greenlink project.

1.12. Table 17 below presents the summary of results using Baringa's modelling and NGET's network reinforcement costs and SO impacts across the main scenarios that Baringa has modelled. In line with the analysis presented in Chapters 3 and 4, we have also accounted for potential Irish CM revenues that Greenlink may receive.

Table 17: Summary analysis for Greenlink using Element Power's market modelling results [74] (£m, 2013)

Greenlink - using Baringa market modelling				
	Reference (Base)	High	Low	Irish wind growth
GB Wholesale price savings, including impacts of cap and floor payments (£m NPV)	-£84	-£248	£28	£278
Onshore reinforcements costs (£m - these are one off costs, not discounted over 25yrs)	0	0	0	0
System operation impacts (£m NPV)	-292	-146	-438	-292
Total GB consumers benefit (£m NPV)	**-377**	**-394**	**-411**	**-15**
Total GB welfare (sum of consumer, producer and interconnector welfare) NPV £m	**-259**	**-185**	**-481**	**-92**
Total GB consumers benefit (with CM)[75]	**-377**	**-394**	**-411**	**-15**
Total GB welfare (with CM)	**-206**	**-132**	**-428**	**-39**

1.13. As Table 17 indicates, if we use the market modelling results from the developer's submission (including the Irish Wind Growth sensitivity), when we account for the network reinforcement costs, SO impacts and potential revenues from the Irish CM we find that this would not affect our conclusions presented in Chapter 3.

[74] Based on an assumed cost and revenue sharing ratio of 50:50 between GB and Ireland. Social welfare impacts on East-West and Moyle interconnectors are fully attributed to SEM as these existing projects are either fully underwritten or wholy owned by Irish and Northern Irish consumers respectively.

[75] These figures do not account for potential cap payments (or reduced floor payments from consumers) as a result of CM payments increasing Greenlink's revenues. The maximum estimated impact of these additional revenues on GB consumer welfare is up to £53m. It would not be significant enough to change our conclusions.

Appendix 4 – Information on our assessment of hard-to-monetise impacts

1.1. Our chapter on qualitative impacts includes a summary of our assessment of hard-to-monetise impacts. Within the assessment there are a number of areas that together make up a strategic and sustainability assessment, in line with our Impact Assessment guidance.[76]

1.2. We provide further detail on the issues considered below:

- Optionality: The evaluation of specific, realistic options that may be enabled or prevented by a decision. Optionality is about recognising the value of maintaining flexibility and keeping options open to help accommodate future uncertainty.

- Diversity and resilience: Resilience is defined as the energy system's capacity to tolerate disturbance and continue to deliver energy services to consumers. A resilient energy system can recover from shocks quickly and still meet energy needs even if external circumstances have changed. In general, diversity is considered to increase resilience.

- Stress and security implications: This concerns the effect on security of supply; potential for extreme price and/or volatility in the market; and the UK's legally binding energy targets.

- Learning by doing and supply chain development: This is the consideration that there can be potential savings in cost by one company/individual going through a process and passing that learning onto others. This can result in a more efficient process via sharing of 'learned efficiencies'.

- Pathways and lock-in: Pathways is the idea that past decisions or events can affect the likelihood of future decisions, ie one decision precludes another. Lock-in is where pathways make certain desirable options unachievable.

- Natural assets and sustainability implications: This concerns the effect on consistency with UK 2050 targets; natural asset implications; and longer-term greenhouse gas (GHG) considerations.

[76] See our Impact Assessment guidance: https://www.ofgem.gov.uk/publications-and-updates/impact-assessment-guidance

Appendix 5 – Connection location, capacity, cable routes and technical design

1.1. Chapter 7 provides an overview of each developer's justification for choice of connection location, capacity, cable rote and technology. This appendix provides further detail on these choices. The information below was provided to us by each developer as part of its cap and floor application.

FAB Link	
Connection location	• The developer and NGET have both confirmed that areas along the south coast and south west of England were initially considered.[77] Sites were assessed on cable cost, grid reinforcement cost and grid constraint costs. Chickerell and Exeter were retained for further study. Other options were not taken forward due to the need for greater grid reinforcement and longer cable lengths. • Exeter was chosen as the most suitable connection location as capacity of 1400MW could be accommodated with little grid reinforcement and overall cable length was shorter than alternative options. Connection to Chickerell was not feasible as it required significant onshore grid reinforcement. NGET has said that Exeter was its preferred connection point for FAB Link.
Capacity	• A number of studies were performed to determine the proposed rating of the interconnector. Capacity above 1400MW was not viable because of limitations in the bidirectional interconnector flow the onshore grid in France could accommodate. A capacity of less than 1400MW would have resulted in lower economic benefits. 1400MW was the highest level of capacity which RTE could accommodate and is more desirable from a cost-benefit perspective.
GB landing point	• There is limited information available regarding the landfall site chosen for FAB Link. Cable routing remains subject to the outcome of technical analysis (including engineering surveys), land availability (particularly for the converter station), environmental consenting and stakeholder consultation processes. For the purposes of the IPA a distance of 20.7km from the Exeter 400kV substation to the landfall site is assumed.

[77] Five sites were identified: Fawley, Melksham, Bramley, Chickerell and Exeter.

Onshore cable route	• The onshore cable route is yet to be finalised. The developer has indicated that, where possible, they intend to route the onshore cables along public roads. This is to minimise the impact on stakeholders.
Offshore cable route	• Seabed surveys were performed for the cable route. For the GB end of the cable, the offshore route is constrained by steep slopes on the sides of the Hurd Deep.[78] The cable route remains subject to the outcome of environmental permitting and stakeholder consultation. Similarly, environmentally sensitive areas exist along the French coast. • The developer proposes to route the cable via Alderney (with 1.4km of onshore HVDC cable on Alderney), to allow for the development of renewable energy sources. We agree with our technical consultants that the proposal to route the offshore cable across Alderney is justified in order to allow for further development of local renewable energy sources. The offshore cable (via Alderney) is 167km long.
Technology choices	• For FAB Link the use of VSC technology is proposed, mainly due to NGET and the French System Operator, RTE requesting VSC technology. NGET requires the use VSC technology to ensure system stability in the South West of England. RTE requires the use of VSC to ensure stability of the nuclear generating units at Flamanville. Our technical consultants consider that reasons for using VSC technology are suitably justified. • The developer proposes to design the system with two 700MW cables in symmetrical monopole configuration. Consideration is also being given for all 1400MW of capacity to be provided via a single monopole circuit as this would be 5-10% cheaper. • Cable technology is yet to be decided as the developer is still to tender for this. According to the developer, tendering will allow comparison of costs of different cable technology, a greater number of companies to compete and reduce the likelihood of supply chain congestion. It is also thought that tendering should allow innovative solutions to be put forward.

IFA2	
Connection location	• Information from NGET and the developer confirms that a number of connection zones in the West Sussex, Hampshire and Dorset area of Southern England were initially identified. Three connection zones were considered further.[79] • Connection to Fawley substation was not taken forward due to need for a new cable tunnel to facilitate connection, which presented issues with consenting and risked delaying the project. This area also experiences flooding and subsidence so the converter station would need to be adapted to protect against these risks. Connection to the Ninfield substation was

[78] The Hurd Deep is a deep underwater valley in the English Channel and was used as a dumping ground for munitions following the First and Second World Wars.
[79] This included connection to Fawley, Chilling and Ninfield substations.

	also not taken forward because of the distance from shore, and need to route the onshore cable via urban areas which brought additional consenting risks. Additionally, a new 400kV overhead line from the southeast coast to London would be required to facilitate the connection which presented further considerable consenting, deliverability and cost risks to the project. • Connection to the Chilling substation presents the preferred location particularly when considering the risks (and associated deliverability and costs) associated with the other two connection sites. NGET agreed that Chilling was the most economic and efficient connection point taking into account all factors and risks.
GB landing point	• Five possible landfall sites were assessed. Two of these were discounted due to distance from the chosen connection location at the Chilling substation. Further optioneering is ongoing at three potential sites.
Capacity	• Capacity up to 2000MW was considered. A number of factors, including cost, security & quality of supply standards, land availability, cable and converter technology feasibility, and deliverability resulted in a proposed rating of 1000MW. The additional benefits of capacity above 1000MW did not significantly outweigh additional costs.
Onshore cable route	• Cables between the landfall site and the HVDC converter site and grid connection location will be buried underground. NGIH has chosen to do this (as opposed to using overhead cables) in order to minimise consenting risk, fault occurrences and maintenance requirements. Of the options available for installing the underground HVDC cable to the convertor station, NGIH suggest that installation across agricultural land may be the quickest, most cost effective approach and one that could minimise social and environmental impacts. However we note that consideration of all available options is ongoing.
Offshore cable route	• Initial considerations were to minimise the length of the offshore cable route in order to minimise cost, complexity, consenting risk and a number of other factors. The GB and French connection routes and offshore route were iteratively optioneered as part of, and following, the connection location identification. • The offshore cable route is approximately 208km (approximate 6% deviation from a straight line approach). A shorter route would have been to connect to the Haute-Normandie area in France however due to significant power generation including the Paluel (5,200 MW) and potential Penly (2,600 MW) nuclear power stations in that area, power flow from GB to France would have been highly restricted. NGIH has indicated that significant onshore reinforcement in France would have been required to allow for greater import capability.

Technology choices	• NGIH proposes to use VSC technology as it requires less land and is suitable for the land available at the proposed converter station. NGIH also proposes using VSC as it requires less network reinforcement. Discussions with RTE have identified that VSC technology is required in France due to network stability effects of the local nuclear generation. • Monopole, symmetrical monopole and bipole system configurations were considered. NGIH discounted the use of a monopole system due to technical and environmental limitations. The use of a bipole system was not considered further as it would be a more expensive solution. Therefore a symmetrical monopole design is proposed. • XLPE technology is not being used because of the risk that it will not meet the 2020 delivery date; this is because there was no established 1000MW XLPE cable for symmetrical monopole configuration.[80] As a result, testing would be required and NGIH has suggested that this could cause delays which would impact on project timescales. Although NGIH indicates they propose to use mass impregnated non-draining (MIND) cable technology, consideration will continue to be given to alternative cable options based on evolving technologies and commercial circumstances.

Viking Link	
Connection location	• Information from NGET and the developer suggests that north of the B8 boundary would trigger significant reinforcement and/or be reliant on an integrated offshore grid connection with significant costs and risks. • Connections south of the Thames Estuary were not considered due to additional offshore route length required to access this area. This area was also not considered further due to number of interconnectors connecting to this area (ie Nemo, Britned, ElecLink and IFA) and potential control system interactions. • Subsequently three connection points were identified, these included: West Burton Substation; Cottam Substation; and Bicker Fen Substation. • Bicker Fen was chosen as the preferred connection location as it was closest to the landfall site and has the lowest number of road crossings. Connecting to West Burton and Cottam would require additional onshore cabling which may have increased environmental impacts and led to additional consenting risks.
Capacity	• Capacity of 1000MW is proposed. Capacity is limited to 1000MW due to Danish equivalent of SQSS restrictions.[81] NGIH continues to evaluate the possibility of increasing capacity to 1400MW, achieved by two connection points at 700MW.

[80] The maximum is ~900MW
[81] Which requires maximum infeed loss of 1000MW

GB landing point	• Four potential landfall sites were identified which represented the closest feasible landfall sites to the connection location at Bicker Fen. Optioneering of the landfall sites is currently being undertaken prior to public planning consultation.
Onshore cable route	• Optioneering of the onshore route between Bicker Fen and four shortlisted landfall sites is currently being conducted. Due to salt laden air at the coastal location and consenting risks, undergrounding of the onshore cable was the preferred method of cable installation from the converter station to the connection location.
Offshore cable route	• The offshore route has largely been determined by feasible cable corridors. Viking Link aims to minimise cable length taking into account environmental constraints. However the option with the lowest amount of capex posed significant risk as it would require Viking Link to negotiate a new corridor through the German Exclusive Economic Zone.[82] The second lowest capex option was to route the cable through an identified corridor in the German Marine Spatial Plan. The length of the cable is expected to be around 650km.
Technology choices	• NGIH has not confirmed whether they propose to use CSC or VSC at this stage as there is no single factor that precludes the use of either technology; therefore NGIH is still considering both options. • Monopole, symmetrical monopole or bipole configurations are all viable for capacity of 1000MW. NGIH has not confirmed which configuration will be used as designs are still under consideration. • In order to minimise technology risk, NGIH has proposed to use MIND cable as it was found that no submarine XLPE cable was in operation or in contract at this voltage level at the time of contracting.[83] NGIH say that consideration may be given to alternative cable options based on evolving technology.

Greenlink	
Connection location	• Element Power indicates that the connection point will be at the existing 400kV Pembroke substation in Wales. We note that the Greenwire project currently holds an offer for 2000MW of transmission entry capacity at Pembroke for connection as early as October 2017.[84] Although the connection agreement is still to be modified to enable Greenlink to connect as an interconnector project, Element Power considers that the connection to Pembroke could be

[82] The German Exclusive Economic Zone is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources, including energy production from water and wind.
[83] NGIH notes that ABB has subsequently released a ±525Kv XLPE cable in August 2014.
[84] The Greenwire project currently has a generation connection agreement with National Grid to connect Irish Wind generation via HVDC transmission links to Pentir (1000MW) and Pembroke (2000MW).

	maintained.
Capacity	• Capacity is currently restricted to 500MW due to loss of infeed limitations in Ireland.[85] However capacity could increase to 700MW if the Irish loss of infeed limit is increased. Eirgrid, the Irish TSO, anticipates new forms of cheap reserves such as demand side management, storage and wind based reserves could enable potential increase of up to 700MW loss of infeed.
GB landing point	• Engineering studies and local consultation have been carried out and have identified a potential landing point south west of Pembroke.
Onshore cable route	• The approximate cable route crosses mainly farmland for approximately 8km to the landing point.
Offshore cable route	• Seabed surveys are still to be performed to determine the most suitable offshore cable route. Element Power has confirmed that the offshore route leading away from the landing point is complicated by the presence of a firing range owned by the Ministry of Defence. Element Power has reached agreement in principle with the Ministry of Defence for the cable to be laid on the perimeter of its range. Further risk mitigation is planned, including detailed ordnance surveys, and deeper burial depth or additional rock protection if required. • Further offshore, there are some restrictions on routing due to fishing grounds and mussel beds, but after around 10km, the seabed conditions are suitable for cable burial across the Irish Sea. Element Power has indicated that the length of the offshore cable is expected to be approximately 145km long.
Technology choices	• Element Power propose to use VSC technology as it requires less reinforcement to the AC grid at the connection points and will allow a very rapid change of flow direction and reactive power which could help to manage system stability. • The information provided by Element Power does not provide detail of cable technology or cable configuration.

[85] Currently 500MW.

Appendix 6 – Glossary

A

Ancillary services

Contracted services (such as frequency response and black start) available to the System Operator in order to maintain balance and to ensure the security and quality of electricity supply across the system.

B

BritNed

1000MW electricity interconnector between Great Britain and Netherlands, operational since April 2011.

C

Capital expenditure (capex)

Expenditure on investment in long-lived network assets, such as converter stations.

Connection date

The date from which a project developer has an agreement in place to allow for the transfer of electricity to and from the GB electricity transmission system.

Cost assessment

A process which enables us to determine the efficient levels of project expenditure.

Cost-benefit analysis

An evaluation of project costs against the upside benefits that such a project could provide.

Constraint costs

A constraint occurs when the capacity of transmission assets is exceeded so that not all of the required generation can be transmitted to other parts of the network, or an area of demand cannot be supplied with all of the required generation. The associated cost are the actions to re-dispatch generators to correct these system issues.

D

DC

Direct current.

DECC

Department of Energy and Climate Change.

Developer-led cap and floor regime

An approach whereby private developers identify the need for new capacity and build, own and operate the assets, but where returns are bounded by a cap (maximum return) and floor (minimum return).

E

East-West Interconnector (EWIC)

500MW HVDC electricity interconnector between GB and Ireland.

ElecLink

Planned 1000MW HVDC interconnector between GB and France.

ENTSO-E

European Network of Transmission System Operators for Electricity.

EU

European Union.

European Network Codes

A European process to develop detailed legislation that establish common technical and commercial rules governing access to energy networks, and remove barriers to trade between EU Member States.

F

FAB Link

France-Alderney-Britain. Proposed 1400MW HVDC electricity interconnector between GB and France (Via Alderney).

Final project assessment (FPA)

The stage at which we propose to examine detailed cost information for projects that apply for a cap and floor regulatory regime and have been recommended at the initial project assessment stage. At this stage we propose to make our final decision on granting a cap and floor regulatory regime to projects.

G

GB

Great Britain.

Greenlink

Proposed 500MW HVDC electricity interconnector between GB and Ireland.

GW

Giga Watt.

H

HVDC

High Voltage Direct Current.

I

IFA

Interconnexion France-Angleterre. 2000MW HVDC electricity interconnector between France and GB.

IFA 2

Interconnexion France-Angleterre 2. Proposed 1000MW HVDC electricity interconnector between France and GB.

Initial project assessment (IPA)

Our proposed initial project assessment will be our first assessment of the needs case of eligible interconnector projects. At this stage we will assess whether there is a case for the project based on projected costs and benefits.

Integrated Transmission Planning and Regulation Project (ITPR)

A project to review the GB electricity transmission arrangements for system planning and delivery that currently apply to onshore, offshore and interconnector assets.

Interconnector

Physical links which allow for the transfer of electricity across borders.

M

Moyle

450MW Interconnector between GB (Scotland) and Ireland.

Multiple Purpose Project (MPP)

A project that features some combination of onshore transmission, offshore transmission or interconnection. For example, a project that combines connection of offshore generation with interconnection to a different market.

MW

Mega Watt.

N

National Electricity Transmission System Operator (NETSO)

The entity responsible for operating the GB electricity transmission system and for entering into contracts with those who want to connect to and/or use the electricity transmission system, currently NGET.

National Grid Electricity Transmission (NGET)

NGET owns and maintains the onshore high-voltage electricity transmission system in England and Wales. It also acts as the National Electricity Transmission System Operator for GB.

Nemo

Planned 1000MW HVDC electricity interconnector between Belgium and Great Britain.

NSN

Proposed 1400MW HVDC electricity interconnector between GB and Norway.

NRA

National Regulatory Authority.

O

Ofgem

Office of Gas and Electricity Markets. Ofgem supports the Gas and Electricity Markets Authority (GEMA) in its day to day work.

S

System Operator (SO)

The entity charged with operating the GB high voltage electricity transmission system, currently NGET.

System Operator – System Operator (SO-SO) Trades

Actions taken between system operators following gate closure, either to elevate constraints or to manage system margins via interconnectors.

T

Transmission Owner (TO)

An owner of a high-voltage transmission network or asset.

Transmission System Operator (TSO)

Entity in charge of operating transmission assets, either for electricity or gas.

V

Viking Link

Proposed 1400MW HVDC electricity interconnector between GB and Denmark.

Appendix 7 – Feedback Questionnaire

1.1. We consider that consultation is at the heart of good policy development. We are keen to consider any comments or complaints about the manner in which this consultation has been conducted. We are keen to get your answers to the following questions:

1. Do you have any comments about the overall process adopted for this consultation?
2. Do you have any comments about the overall tone and content of the report?
3. Was the report easy to read and understand? Could it have been better written?
4. To what extent did the report's conclusions provide a balanced view?
5. To what extent did the report make reasoned recommendations for improvement?
6. Please add any further comments.

1.2. Please send your comments to:

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