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Consultation

Interconnector policy review: Working Paper 2 – Socio-economic modelling

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We are consulting on the analysis, proposed conclusions, and early proposals from workstream 2 of the interconnector policy review, which looks at interconnector socio-economic modelling. We would welcome views from a range of stakeholders.

This document outlines the scope, purpose and questions of the consultation and how you can get involved. Once the consultation is closed, we will consider all responses. We want to be transparent in our consultations. We will publish the non-confidential responses we receive alongside a decision on next steps on our website at **Ofgem.gov.uk/consultations**. If you want your response – in whole or in part – to be considered confidential, please tell us in your response and explain why. Please clearly mark the parts of your response that you consider to be confidential, and if possible, put the confidential material in separate appendices to your response.

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Executive summary

In August 2020, Ofgem launched a review of its regulatory policy and approach to new electricity interconnectors. The objectives of the review are two-fold: firstly, to establish whether there is a need for further GB interconnection capacity beyond those projects currently with regulatory approval; and secondly, to consider Ofgem's approach to the regulation of future GB interconnection. The review has been broken down into four workstreams considering specific aspects of regulatory policy and decision making.

This working paper summarises our analysis, findings, and provisional recommendations from workstream 2 – socio-economic modelling. In this workstream we procured AFRY Management Consultants ("AFRY") to undertake electricity market modelling to help us determine whether there is likely a need for further interconnection from a socio-economic standpoint. We have considered the outputs of this modelling alongside other relevant public modelling studies, including the National Grid Electricity System Operator (NGESO) Network Options Assessment (NOA) and the ENTSO-E Ten Year Network Development Plan (TYNDP).

Based on the results of our independent modelling study, stakeholder feedback, and consideration of external analysis we are proposing the following conclusions and initial proposals:

- There is likely a positive needs case for further GB interconnection, from a socio-economic perspective, beyond those projects currently operational, under construction, and those that are under development with existing regulatory approval.

- The net welfare impact of future GB interconnection is likely to be positive. However, when comparing our latest electricity market modelling to modelling undertaken in support of our cap and floor Window 1 and Window 2 initial project assessments, we expect a shift in the allocation of socio-economic welfare benefits between consumers and producers, and between GB and the connecting countries. This is primarily because, over the modelling horizon, GB energy prices are due to fall and be more regularly set by intermittent renewables. This leads to a different import-export balance compared to those seen in previous studies.

- Scenario modelling holds significant uncertainty due to the rapidly changing energy policy environment and drive towards decarbonisation in both GB and connecting countries. It is

therefore increasingly important that we consider a range of plausible scenarios and modelling studies when taking decisions on socio-economic impacts.

- There are a number of limitations in the scope of the modelling methodology that we have used that influence the outcomes, and we need to consider these carefully when reaching our provisional conclusions and initial proposals. One notable example is that our modelling is based exclusively on day-ahead market pricing and trade. In future, as intermittency becomes an increasing determinant of price and flows between connecting markets, we might expect to see some value shift from day-ahead to intraday market timeframes.

- The approach to socio-economic modelling for interconnectors historically used by Ofgem also does not capture the full range of impacts of interconnection on the GB energy system and the consumer. When assessing the needs case for future interconnectors we therefore need to continue to consider the wider impacts that are being explored through workstream 3 of the interconnector policy review.

We are now seeking stakeholder feedback on our analysis, conclusions and initial proposals through this public consultation. We will then consolidate the findings across each workstream in a single decision paper, which will provide our final recommendations for the future regulation of interconnectors in GB.

1. Introduction

Context

1.1. Electricity interconnectors are the physical links that allow the transfer of electricity across borders. The cap and floor regime is the regulated route for electricity interconnector developers in Great Britain. We decided to roll out the cap and floor regulatory regime to new near-term electricity interconnectors in August 2014 to incentivise the delivery of further cross-border infrastructure.

1.2. Before the cap and floor regime was introduced, a limited number of electricity interconnectors had been either built or proposed: IFA (2GW) to France, Moyle (0.5GW) to Northern Ireland, BritNed (1GW) to the Netherlands, and the East West interconnector (0.5GW) to the Republic of Ireland. These interconnectors were mostly developed as standalone projects on a merchant basis.

1.3. We recognised that there was benefit in further interconnection and therefore a need to develop a regulated regime for electricity interconnectors to incentivise further development. We proposed a cap and floor regime initially for the Nemo Link interconnector (1GW) to Belgium in 2013[1], and more broadly as an enduring regime in 2014[2].

1.4. We have subsequently held two cap and floor application windows in 2014 and 2016, and have awarded a cap and floor regime in principle to nine interconnectors totalling 10.9GW in cross-border capacity. If all of these projects go ahead, alongside existing interconnectors and approved projects under development on a merchant basis, GB interconnection capacity could increase to 15.9GW.

1.5. We have committed to reviewing our regulatory policy and approach ahead of any further cap and floor application windows. This is to ensure that both further interconnection, and the regulatory framework for delivery, remain in consumers' best interests. We consider

[1] Cap and Floor Regime for Regulated Electricity Interconnector Investment for application to project NEMO (2013): https://www.ofgem.gov.uk/publications-and-updates/cap-and-floor-regime-regulated-electricityinterconnector-investment-application-project-nemo

[2] Decision to roll out a cap and floor regime to near-term electricity interconnectors (2014): https://www.ofgem.gov.uk/publications-and-updates/decision-roll-out-cap-and-floor-regime-near-term-electricityinterconnectors

that now is the right time for this review for a number of reasons as set out in our August 2020 open letter to interested stakeholders [3].

1.6. We are also undertaking our review in the context of Government's net-zero target for carbon emissions by 2050. In December 2020 the Department for Business, Energy, & Industrial Strategy (BEIS) published its Energy White Paper[4] setting out how the UK will clean up its energy system to reach net-zero. In the Energy White Paper BEIS committed to working with Ofgem, developers and European partners to realise at least 18GW of interconnector capacity by 2030.

Scope of the review

1.7. The primary objective of the interconnector policy review is to establish whether there is a need for further GB interconnection capacity beyond those projects currently with regulatory approval. If so, the secondary objective of this review is to consider Ofgem's approach to the regulation of future GB interconnection.

1.8. We decided to deliver this review through four workstreams (WS):

- WS1 – Review of the cap and floor regime to date
- WS2 – Socio-economic modelling
- WS3 – Review of the wider impacts of interconnection
- WS4 – Multiple Purpose Interconnectors (MPIs)

1.9. We decided to use a targeted engagement approach in order to maximise value from stakeholder input and invited interested stakeholders to notify us of their interest in the interconnector policy review in our August 2020 open letter. We have subsequently engaged with stakeholders through workstream groups and stakeholder forums.

[3] Open letter: Notification to interested stakeholders of our interconnector policy review (2020): https://www.ofgem.gov.uk/system/files/docs/2020/08/open_letter_-_interconnector_policy_review.pdf
[4] Energy white paper: Powering our net zero future: https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

Scope of workstream 2

1.10. The objective of workstream 2 is to understand whether further GB interconnection beyond the current baseline is likely in the interests of GB and GB consumers from a socio-economic perspective. We procured AFRY to undertake socio-economic electricity market modelling to help meet the objective. In this workstream we consider the outputs of that modelling exercise in conjunction with other relevant public modelling exercises and the wider strategic energy policy landscape.

1.11. We recognise that interconnectors have wider impacts that are not captured in traditional socio-economic electricity market modelling, including transmission system impacts; these wider impacts are explored through workstream 3 of the interconnector policy review. When reaching our final decisions and recommendations for the review we will consider both workstream 2 and workstream 3 in parallel.

1.12. The objective of workstream 2 is not to provide Ofgem's view of an optimal level interconnection nor to indicate the suitability of any real or notional project for a possible future regulatory regime. Subject to the final conclusions of this review, we would need to separately assess the likely impact of any potential future projects in due course.

1.13. This workstream considers point-to-point interconnectors only – it does not consider the potential socio-economic impact of multiple-purpose interconnectors (MPIs). However, our analysis will be a proxy for further interconnector capacity between markets, which may also be applicable to MPIs. MPIs are considered in workstream 4 of the interconnector policy review.

1.14. Throughout this document we present a number of proposed recommendations; these are summarised in Section 3. Following consultation, we will build on these recommendations and proposals to determine our approach to the regulation of future interconnection. Any proposals, recommendations or potential changes discussed in our working paper consultations will not be confirmed until our final decision on the interconnector policy review. In addition, any proposals or recommendations for change that are discussed in our working paper consultations will not be retrospectively applied, and will not affect or change aspects of the existing cap and floor regime that applies to projects that we have already approved.

1.15. This consultation paper should be read alongside those published for the other workstreams of this review and not in isolation, as the information and proposed recommendations presented in each paper are interlinked.

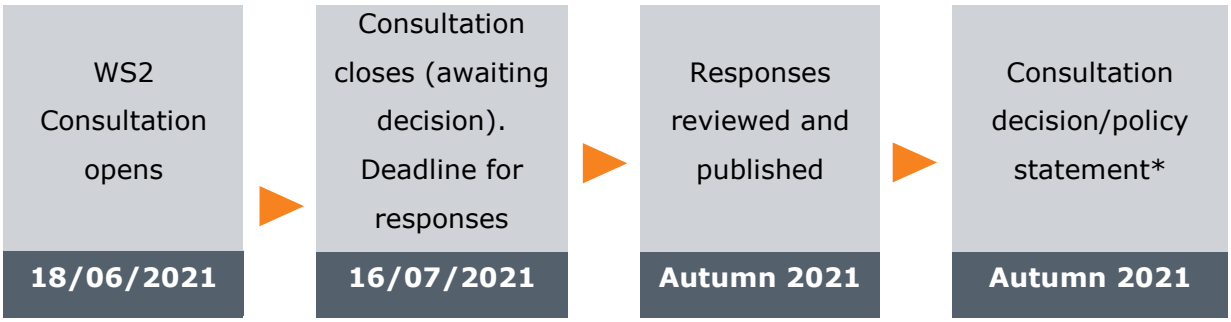
What are we consulting on?

1.16. The purpose of this consultation is to get views from stakeholders on our analysis, proposed conclusions, and initial proposals from workstream 2 of the interconnector policy review.

1.17. Consultation questions are summarised in Section 4 – Consultation.

Consultation stages

1.18. This consultation is one of four working papers covering each of the work streams. Based on the responses received and drawing upon each working papers, we will publish our decision paper presenting our final proposals in relation to the future of the cap and floor regime in Autumn 2021. We will endeavour to action those final recommendations following that decision.



How to respond

1.19. We want to hear from anyone interested in this consultation. Please send your response to email address detailed on this document's front page.

1.20. We've asked for your feedback in each of the questions throughout. Please respond to each one as fully as you can.

1.21. We will publish non-confidential responses on our website at www.ofgem.gov.uk/consultations.

Your response, data and confidentiality

1.22. You can ask us to keep your response, or parts of your response, confidential. We'll respect this, subject to obligations to disclose information, for example, under the Freedom of Information Act 2000, the Environmental Information Regulations 2004, statutory directions, court orders, government regulations or where you give us explicit permission to disclose. If you do want us to keep your response confidential, please clearly mark this on your response and explain why.

1.23. If you wish us to keep part of your response confidential, please clearly mark those parts of your response that you do wish to be kept confidential and those that you do not wish to be kept confidential. Please put the confidential material in a separate appendix to your response. If necessary, we'll get in touch with you to discuss which parts of the information in your response should be kept confidential, and which can be published. We might ask for reasons why.

1.24. If the information you give in your response contains personal data under the General Data Protection Regulation (GDPR) and domestic legislation on data protection, the Gas and Electricity Markets Authority will be the data controller for the purposes of GDPR. Ofgem uses the information in responses in performing its statutory functions and in accordance with section 105 of the Utilities Act 2000. Please refer to our Privacy Notice on consultations, see Appendix 1.

1.25. If you wish to respond confidentially, we'll keep your response itself confidential, but we will publish the number (but not the names) of confidential responses we receive. We won't link responses to respondents if we publish a summary of responses, and we will evaluate each response on its own merits without undermining your right to confidentiality.

General feedback

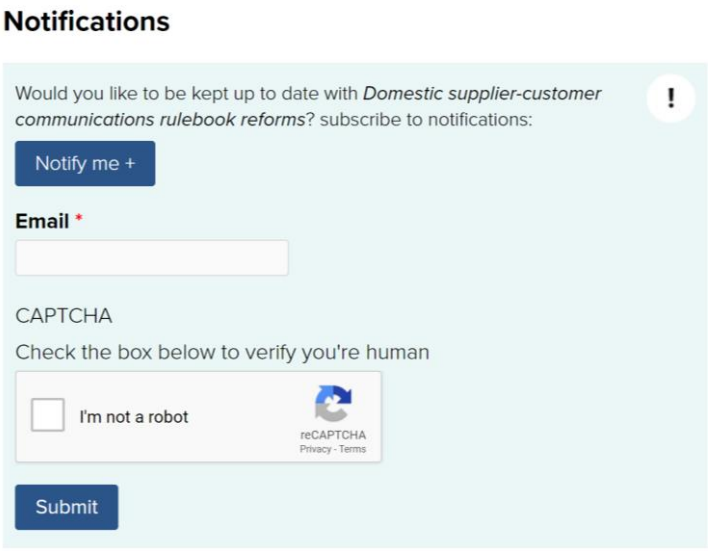
1.26. We believe that consultation is at the heart of good policy development. We welcome any comments about how we've run this consultation. We'd also like to get your answers to these questions:

1. Do you have any comments about the overall process of this consultation?
2. Do you have any comments about its tone and content?
3. Was it easy to read and understand? Or could it have been better written?
4. Were its conclusions balanced?
5. Did it make reasoned recommendations for improvement?
6. Any further comments?

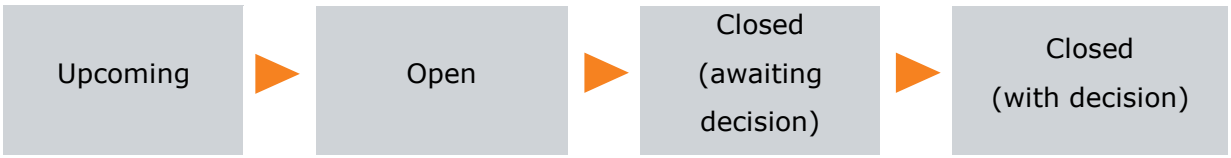
1.27. Please send any general feedback comments to stakeholders@ofgem.gov.uk

How to track the progress of the consultation

1.28. You can track the progress of a consultation from upcoming to decision status using the 'notify me' function on a consultation page when published on our website. Ofgem.gov.uk/consultations.



1.29. Once subscribed to the notifications for a particular consultation, you will receive an email to notify you when it has changed status. Our consultation stages are:



2. Workstream 2 analysis

Section summary

In this section we summarise the processes we undertook throughout workstream 2 and the key outcomes that informed our conclusion and early recommendations.

Questions

Question 1: Do you agree with the approach we have taken to workstream 2?

Question 2: What are your views on the scenarios, assumptions and methodology that AFRY has used to model notional future interconnectors and the impact of cross-border interconnector flows?

Question 3: Do you agree with our view on the results of AFRY's modelling? Do you agree that this modelling supports the needs case for further interconnection?

Question 4: Is there any further information or additional studies that you think should be factored into our analysis?

Approach to workstream 2 analysis

2.1. The objective of workstream 2 of the interconnector policy review is to help us determine whether there is likely a need for further GB interconnection, beyond the pipeline of projects that we have approved through our cap and floor Window 1 and Window 2, from a socio-economic perspective. Under this workstream we have:

- Commissioned an independent socio-economic electricity market modelling study;
- Sought interested stakeholder feedback on the modelling scenarios, methodology, and results;
- Reviewed the outcomes of external studies.

Independent socio-economic market modelling study

2.2. Socio-economic electricity market modelling is a useful tool when assessing the likely future impacts of interconnectors. We used socio-economic cost benefit analysis (CBA) to help inform our assessments of cap and floor Window 1 and Window 2 interconnectors at the initial project assessment stage of the regime. It also forms a core part of network planning across Europe, from the NGESO Network Options Assessment (NOA) for Interconnectors in GB to the ENTSO-E Ten Year Network Development Plan (TYNDP) for Europe.

2.3. As part of workstream 2 we commissioned AFRY to undertake an independent socio-economic electricity market modelling exercise. The aim of this exercise was to inform us on whether further interconnection between GB and its neighbours is economically and commercially justified, whether further interconnection capacity benefits GB consumers and the wider energy system, and whether a cap and floor regime helps deliver beneficial projects. We sought interested stakeholder feedback on AFRY's modelling in March 2020 and which we have considered throughout this working paper.

2.4. This modelling exercise does not consider the wider impacts of interconnectors, which are being explored in workstream 3 of this review. It also does not explicitly consider the impact of MPIs which are being considered in workstream 4 of this review, however our analysis is a proxy for further interconnector capacity between markets, which may also be applicable to MPIs.

2.5. Alongside this consultation we have published an independent modelling report delivered by AFRY and an Excel data file of modelling inputs.

2.6. It is important to note that this modelling exercise is designed to test the general need for further interconnection beyond projects that we have already approved through the cap and floor regime. It is stylised modelling and includes assumptions and simplifications in order to meet its objectives. The outputs of this exercise should not be considered an Ofgem assessment of where we need additional interconnector projects, nor should it be considered an indication of the applicability of any individual project for a future regulatory regime. Any potential future projects would be assessed on their own merits through the processes and frameworks that are being considered through the wider interconnector policy review.

Scenarios

2.7. This analysis uses a range of plausible scenarios in order to test the impact of notional future interconnectors under a range of market conditions. Consistent with our approach to interconnector modelling at our initial project assessment stage for cap and floor Window 1 and Window 2, we decided to use scenarios that reflect high, base and low cases of interconnector value.

2.8. Similarly, we decided it was appropriate to base these scenarios as far as possible on publicly available data sets, most notably the NGESO Future Energy Scenarios (FES)[5] for GB and the ENTSO-E TYNDP[6] scenarios for the connecting countries. Given that different public data sets have been combined some adjustments were made to those public datasets to ensure internal scenario consistency (e.g. reasonable security of supply margins) and to reflect variation in interconnector value drivers. It is important to maintain internal consistency of scenarios to ensure that the resulting future energy system, that the scenarios represent, is realistic in terms of supply, demand, and narrative. The scenarios developed by AFRY for the purposes of this modelling can therefore be considered bespoke.

2.9. In October 2020, we sought interested stakeholder input on a proposed set of three scenarios. Stakeholders were broadly supportive of the approach, but noted that it was important for scenarios to meet decarbonisation objectives and to better reflect the latest policy in connecting countries. We subsequently requested that AFRY develop a new "Net Zero" scenario. This scenario was developed to take a uniform approach, as far as possible, to the decarbonisation commitment of the analysed countries, and to remove any large bias in the interconnector evaluation which depends on diverging decarbonisation policies. For the Net-Zero scenario AFRY therefore used additional data sources to the TYNDP scenarios for the connecting countries. In addition, we also decided to include a sensitivity on the Net Zero scenario to test the impact of the recommendation of the NGESO-led Balancing Services Use of System (BSUoS) taskforce[7], that BSUoS charges are no longer applied to generators in GB.

[5] NGESO Future Energy Scenarios (FES) 2020: https://www.nationalgrideso.com/future-energy/future-energy-scenarios
[6] ENTSO-E TYNDP 2020 scenarios: https://2020.entsos-tyndp-scenarios.eu/
[7] Balancing Services Charges Task Force: http://www.chargingfutures.com/charging-reforms/task-forces/previous-task-forces/balancing-services-charges-task-force/what-is-the-balancing-services-charges-task-force/

2.10. Full details of scenario development are included in AFRY's independent report published alongside this consultation.

Modelling approach

2.11. The methodology agreed with AFRY starts by establishing an initial baseline which includes all interconnectors that are currently operational, under construction or under development with regulatory approval. During scenario development additional notional interconnectors were added to that initial baseline in subsequent modelling years where required to maintain internal consistency of scenarios.

2.12. The modelling then begins with an iterative cycle whereby marginal interconnector capacities are added to the interconnector capacity baseline on each connected border, and the expected internal rate of return (IRR) of each is calculated under the Net Zero scenario. A new notional interconnector of standard size is then added to the baseline on the border with the highest IRR, if it meets an IRR threshold of 7%. This process was repeated until further notional capacity no longer meets the IRR threshold, which would suggest limited developer appetite in further projects at that border. The notional interconnectors identified through this process are then assessed with a full cost-benefit analysis (CBA) to understand their impact on cross-border trade and socio-economic welfare. Full details of this process can be found in AFRY's report published alongside this consultation.

2.13. This iterative process is designed to select notional capacities on which to perform a socio-economic CBA. Given that we operate a developer-led approach to interconnector development in GB, we considered it appropriate to use a high-level proxy of commercial attractiveness for this purpose. This assessment is not designed to test whether an investor should invest in a particular project; we recognise that would require additional detail and analysis. For that reason the identification of notional future interconnectors through this methodology should not be considered an Ofgem view of the economic or investment case for future interconnectors.

2.14. The approach taken to the socio-economic cost benefit analysis is consistent with that applied by AFRY in the modelling they performed for us during our cap and floor Window 1 and Window 2 initial project assessments. The underlying electricity market modelling for this study has been conducted using AFRY's in-house BID3 model, which is a power market model, used to simulate the dispatch of all supply and demand in electricity markets.

2.15. The cost-benefit analysis considers the change in the various components of socio-economic welfare in a world with and without each assessed notional interconnector. The changes combine to give us a view of the quantifiable welfare impacts. A detailed explanation of the socio-economic cost benefit analysis methodology can be found in AFRY's (then Poyry Management Consulting) 2017 independent report for the cap and floor Window 2 initial project assessment[8]. The CBA is performed under the full range of scenarios described in this document.

Modelling assumptions

2.16. We have used a number of assumptions to inform the modelling approach and to set an appropriate scope for AFRY's modelling exercise. Some of the key assumptions are explained below.

Interconnector baseline

2.17. We consider it important to set our baseline for the purposes of interconnector modelling on an objective basis. For this modelling the starting baseline is all interconnectors that are currently operational, under construction or have been granted regulatory approval through our cap and floor regime. These are assumed to be operational by 2025 across all scenarios.

2.18. Additional notional interconnector capacities were added to the initial baseline during scenario development in subsequent modelled years, where economically justified, to maintain the internal consistency of the scenarios so to align the scenarios with the FES. This is an important step to ensure that each scenario represents a realistic energy system where supply, demand, and flexibility are balanced. That additional notional baseline capacity is not based upon any assumptions about actual projects under-development, but instead was selected based on overall system cost minimisation during scenario development.

2.19. Comparison was made to the total interconnection capacity in the relevant FES on which each scenario was based for the GB portion; comparison to the specific real and notional interconnectors included in the FES was not made. This is important to ensure the bespoke

8 Near term interconnector cost benefit analysis: independent report (cap & floor window 2): https://www.ofgem.gov.uk/system/files/docs/2018/01/near-term_interconnector_cost_and_benefit_analysis_-_independent_report_.pdf

scenarios created for this modelling do not deviate too significantly from the data sets upon which the scenarios are based. Where the baseline does deviate from the FES, this is primarily due to our decision to include all existing and approved cap and floor projects from 2025. In the long-term, deviations from the FES can also occur where these contribute to overall system cost minimisation, and due to the fact that our scenarios are based upon both FES and ENTSO-E data.

Internal Rate of Return (IRR)

The modelling methodology uses an IRR test to select notional near-term future interconnectors that are added to the baseline and taken forward for a socio-economic CBA. We considered that IRR was an appropriate test as it provides a high-level indication of commerciality, so therefore provides a useful indication of where future projects may come forward in a developer led regime. We acknowledge that this is a simplification of commerciality, however we consider it appropriate and proportionate as a proxy to identify notional projects for socio-economic assessment in order to meet modelling objectives. The selection of notional projects via the IRR test in this modelling should not therefore be considered Ofgem's view of the investment attractiveness of any notional or named project.

2.20. In using the IRR, it was appropriate to select a threshold at which no more notional projects are added to the baseline to ensure a manageable level of notional interconnection is taken to socio-economic assessment. We chose to use an IRR threshold of 7%. This was based on general observations of the market, project experience, and consideration of how the cap is set. This is a simplified assumption for the purposes of this study, and is not an Ofgem view on what an appropriate return for an equivalent interconnector either should be or would likely be.

Interconnector costs and revenues

2.21. AFRY's study makes a number of assumptions on the sources of interconnector costs and revenues for the purposes of the cost benefit analysis.

- For interconnector costs, the modelling relied on AFRY's standard assumptions for subsea interconnector costs, which take into account type, length and capacity of the cable. Cap and floor level estimates have been derived from these cost inputs. We have also conducted a sensitivity on the Net Zero scenario to reflect cost changes as a result of potential future changes in Balancing Services Use of System (BSUoS) charges.

- Interconnector revenues calculated in AFRY's model are based on the modelling of congestion rents generated from the allocation of capacity in the day-ahead market timeframe. This is based on assumed optimised market trading (including implicit allocation of capacity and electricity [9]), and does not include projected revenues from either (a) long-term capacity auctions or (b) shorter-term trading and capacity allocation in the intraday or balancing timeframes.

- We recognise that some potential additional revenue sources have not been included in this analysis. At the time of model development there was uncertainty around the implementation of EU requirements on the participation of foreign capacities in the GB capacity market. Implementation of such requirements would potentially alter the interconnector revenue stream, so we decided not to include capacity market revenues. We recognise that this situation has now changed and we will reconsider the inclusion of CM revenues in future modelling. However, inherent challenges remain regardless of the participation model, such as the need to project annual derating factors on a long-term basis.

- We have also not considered revenue from potential balancing or ancillary services. At present, a number of ancillary services providers are contracted bilaterally, with service provision and revenues earned varying based on factors such as technical design and location on the transmission system. This would likely require additional project-specific analysis and is difficult to predict on a notional or a long-term basis.

Cap and floor regime

2.22. The modelling assumes that notional future interconnectors operate under a cap and floor regime equivalent to that implemented for Window 2 interconnectors. This assumption enables us to test the potential impact of a cap and floor regime on future interconnectors. Under this assumption, the modelling considers the revenues generated by each notional future interconnector against cap and floor levels, and the resulting payments to or from the consumer are factored into welfare figures. However, this is a simplified assumption, and does

[9] Following the UK's exit from the EU, we acknowledge that the landscape of the trading arrangements has changed, but in line with the requirements of the Trade and Cooperation Agreement it is expected there will be implicit trading arrangement again in the near future.

not consider potential other regulatory models and/or changes to the design of the cap and floor regime in future.

Modelling results

2.23. The step-wise approach to identify potential additional capacity, as outlined in paragraph 2.13 and 2.14, in the Net Zero scenario yielded four notional new interconnectors; two to each of North West Europe (NWE2025 and NWE2030) and the Irish Single Energy Market (SEM2025 and SEM2030) in both 2025 and 2030.

2.24. The CBA applied to these notional interconnectors shows that there is a net positive welfare impact (when considering GB and the connecting country) under most scenarios. However, the results suggest that these notional new interconnectors do not generally deliver welfare benefits to GB consumers. The distribution of benefits to GB overall (considering consumers, producers and interconnectors in aggregate) is more marginal and nuanced.

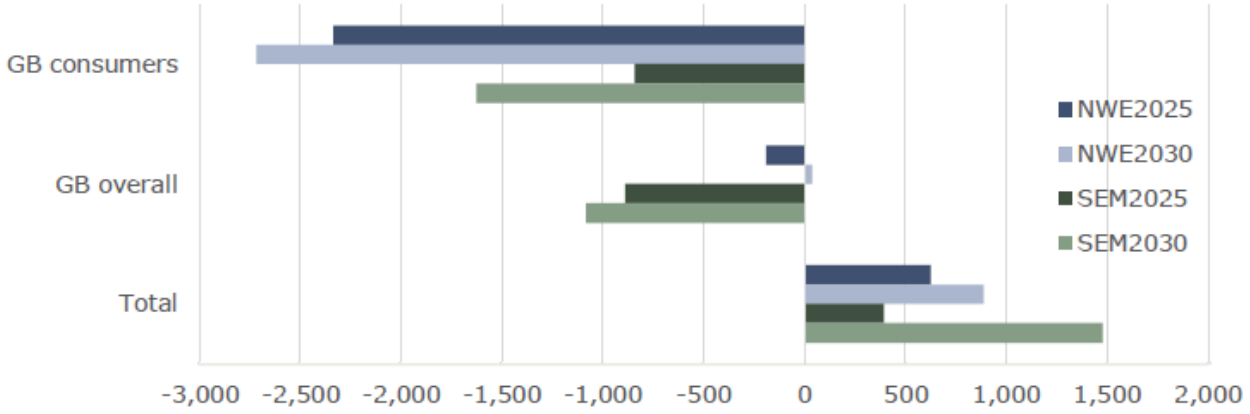


Figure 1: Socio-economic impact of potential interconnector projects (€mn, NPV at 3.5% over a 25-year project life, real 2019) in the Net Zero scenario.

2.25. Driving these results is the way in which GB and its neighbours are assumed to meet their net zero ambitions in the modelling scenarios; although the Net Zero scenario was designed in part to remove bias resulting from these effects. While GB has significant growth in offshore wind resources, other countries are expected to rely more on onshore wind, solar PV, nuclear, and other forms of low carbon generation. GB is also expected to utilise CCS biomass and CCS gas, often more so than its neighbours. The volume of renewable deployment in the GB scenarios out to 2030 and 2040 is significant across most scenarios, meaning that GB prices are increasingly driven by their low marginal cost. Price is also influenced by carbon pricing; this was varied scenarios as a value driver but across all

scenarios the Carbon Price Support (CPS) remained in place until the early 2030s. These combined effects lead to GB electricity wholesale prices generally falling relative to its neighbours. The price differentials driving this narrative generally diverge from around 2030 depending on the scenario. Our analysis also takes into account effects on consumers from low carbon support payments, such as Contracts for Difference (CfDs). This means that when interconnectors lead to higher GB wholesale prices due to exports, consumers do not necessarily face the full effect when generation is operating with a CfD.

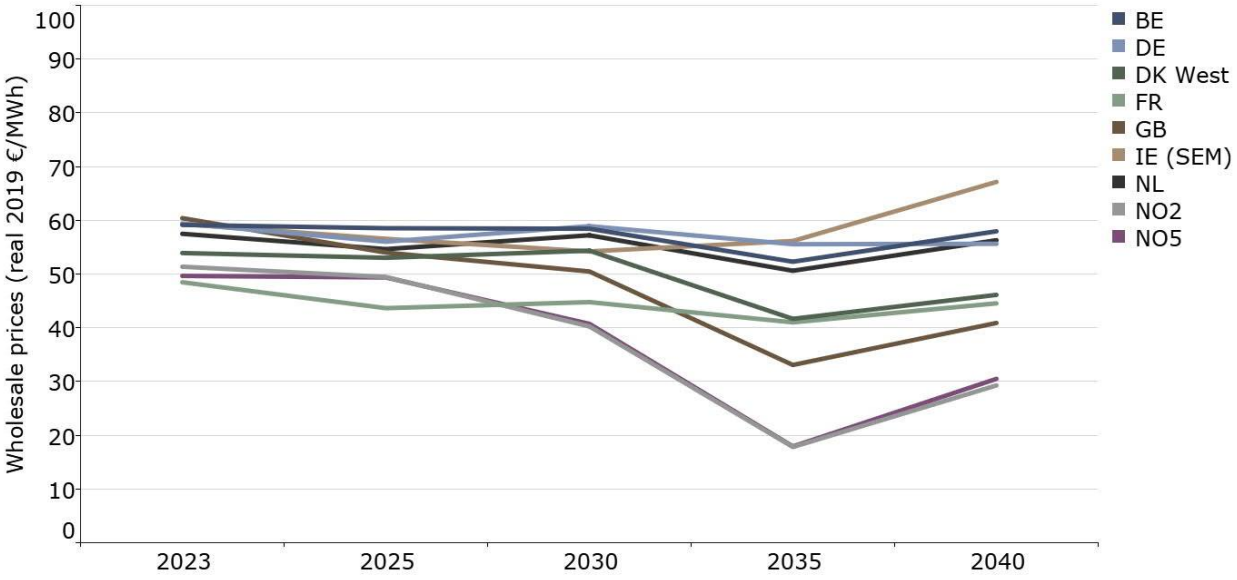


Figure 2: Wholesale power prices by country in the Net Zero scenario

2.26. Interconnector flows respond to price differentials. The effect of falling GB electricity wholesale prices in these scenarios is therefore that interconnectors generally become net exporters of electricity from GB. Interconnectors marginalise wholesale price differentials between the connected countries, so by exporting cheaper electricity from GB the effect of interconnectors in these scenarios is to raise GB electricity wholesale prices. Increased wholesale prices lead to negative consumer impacts but positive producer impacts. The marginalisation of price differentials also cannibalises revenues from existing interconnectors, leading to negative interconnector welfare impacts.

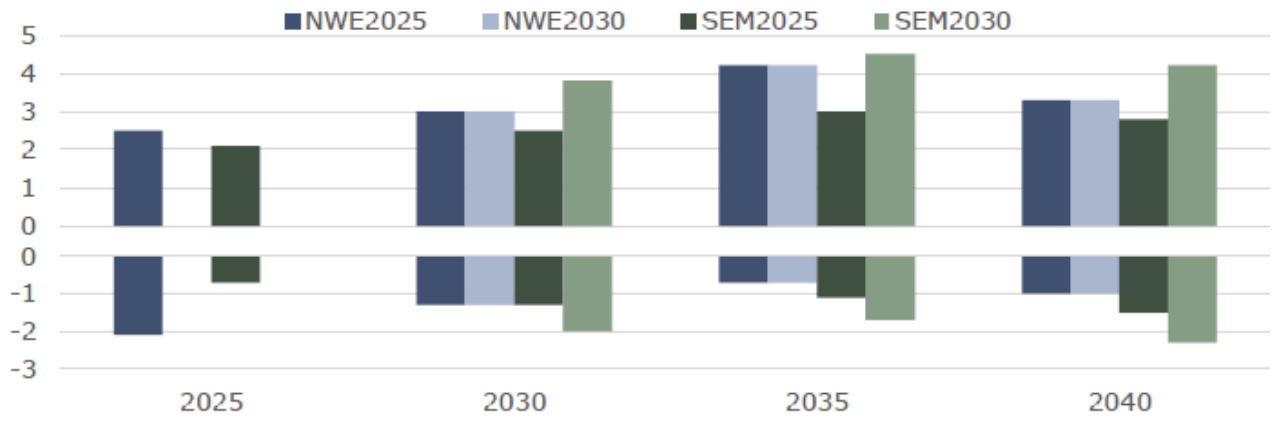


Figure 3: GB imports (+ve) and GB exports (-ve) on potential interconnector projects (TWh) in the Net Zero scenario.

2.27. Our modelling suggests that in general those notional new interconnectors that connect in 2030 are more likely to have a positive overall welfare impact than those connecting in 2025. This is because market spreads are higher in later years, providing a clearer price signal for market flows. Furthermore, the modelling suggests that if those projects were to be developed under a cap and floor regime in its current form they would likely require floor payments in the early years of operation. However, from 2035 onwards most of the revenues from the new notional interconnectors would be expected to fall within the band of the cap and floor, or to exceed the cap.

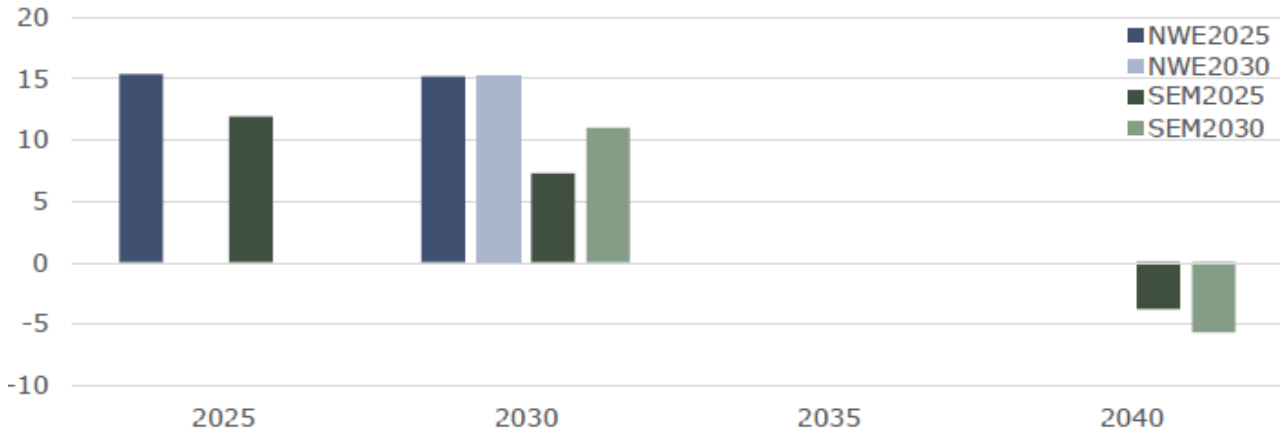


Figure 4: Cap (-ve) and floor (+ve) payments to identified notional connections (€mn, real 2019) in the Net Zero scenario.

2.28. The limitations to the scope of our modelling are also important when considering the modelled interconnector flows, and therefore the distribution of welfare. Whilst the general

pattern is that GB wholesale prices are lower than connected markets and therefore that GB becomes a net exporter, we also expect to see a greater degree of volatility in flows as prices react to intermittency and changes in weather patterns. Some of that volatility is captured in day-ahead prices and therefore our modelling. However, we might also expect more volatility to be reflected in other market timeframes, such as intraday. Whilst this is not captured in our modelling methodology or the results discussed in this section, this might suggest that a larger portion of total value of future projects will be captured outside the scope of these results.

2.29. The effect of removing BSUoS charges from generation in our Net Zero sensitivity is small and leads to leads to slightly lower prices in GB (€0.9/MWh on average over the modelled period). The impact of this removal on interconnector welfare effects is similarly small, with a slight positive impact on GB consumers; the effect is more nuanced for GB and net-welfare as NWE projects are positively impacted, but SEM projects are negatively affected.

Our view of the results

2.30. On balance, we think this modelling supports the needs case for further interconnection when considering socio-economic impact on a net welfare basis. However, the modelling implies a likely shift in the allocation of socio-economic welfare benefits for notional future projects relative to the electricity market modelling used to inform our cap and floor Window 1 and Window 2 initial project assessments. It implies a shift in the allocation of benefits between consumers and producers, and between the connected countries.

2.31. We recognise that any modelling exercise is subject to uncertainty. This exercise uses a stylised modelling approach and includes assumptions and simplifications in order to meet its objectives. On balance we consider that these assumptions are likely to underplay the socio-economic needs case of future interconnection, specifically:

- Our starting baseline assumption is that all projects with regulatory approval under the cap and floor regime are operational by 2025. We recognise that this assumption may lead to an underestimate of the socio-economic impact of notional future interconnectors due to the revenues cannibalisation effect as each new interconnector reduces wholesale electricity price differentials between connected markets.

- In addition, the modelling baseline includes additional notional baseline capacity (1.4-8.8GW by 2040 across scenarios) beyond projects with existing approval to

ensure scenarios are internally consistent. The presence of this additional notational capacity means our baseline is higher than the default pipeline, and this will have a negative bearing on the modelling results.

- The modelling results show that notional future interconnectors are likely to be less beneficial overall in 2025, but increasingly beneficial from 2030 onwards. This suggests that notional projects commissioned later (nearer 2030) are more likely to be positive than our current modelling suggests. In practice, we would not expect potential future interconnectors to be online much before 2030. This changes the import-export balance and would be likely to change the overall benefit and the distribution of costs and benefits.

- Our modelling approach captures the value of interconnectors in day-ahead markets only. Whilst this is a standard assumption for long-term electricity market modelling exercises, this means potential value (consumer, producer and interconnector) that would accrue through shorter market timeframes (i.e. intraday and balancing) is not reflected in the results. In practice, as energy mixes become more intermittent and dispatch profiles are increasingly weather-dependent, we might expect to see a higher proportion of overall value captured closer to real time (i.e. the share of overall value captured in the day-ahead market may reduce).

- Interconnectors are likely to receive additional revenue sources to those considered in this modelling. Specifically, further interconnectors may receive additional revenue from participation in capacity markets and in providing ancillary services. These potential additional revenue sources are not reflected in the modelling results and, all things being equal, would reduce the likelihood and impact of floor payments and would increase the likelihood and impact of cap payments.

2.32. The results also suggest that notional future interconnectors could be subject to both cap and floor payments depending on location, timing, and scenario. We note however that this is based on average expectations of project costs and the application of a cap and floor regime in its current form. This implies that a cap and floor regime could play an important role for potential future interconnectors in providing downside protection to incentivise investment at the floor, and in returning value to consumers at the cap.

2.33. The outcomes of this socio-economic modelling can be very sensitive to small changes in certain input parameters, especially related to the difference in deployment of low-carbon generation capacity in GB and its neighbours. We therefore consider it increasingly important

to assess projects for any future regulatory regime under a range of plausible scenarios. We may also need to consider the outputs from different modelling studies when making any potential future needs case decisions, each of which might approach scenario development and cost-benefit analysis in different ways.

Review of external studies

2.34. We have reviewed a number of external socio-economic welfare studies that are available in the public domain and that were shared with us through our stakeholder engagement. Generally, external studies align with our socio-economic modelling in supporting the need for further interconnection beyond the projects with existing regulatory approval. This section highlights some key external sources of analysis.

Network Options Assessment (NOA)

2.35. The Network Options Assessment for Interconnectors (NOA IC) is an annual assessment performed by National Grid Electricity System Operator (ESO). It provides a market and network assessment of the optimal level of interconnection capacity to GB. It evaluates social economic welfare, as well as constraint costs and capital expenditure costs of both the interconnection capacity and network reinforcements. The NOA IC is not a recommendation or an assessment of the viability of actual current or future projects, nor does it provide any project specific information.

2.36. The latest NOA IC[10] shows that interconnection capacity in the range of 16.9GW to 27.7GW between GB and European markets by 2040 would provide the maximum benefit to GB and European consumers. The bottom end of this range falls above the current baseline of 15.9GW if all interconnectors that are under construction or under development in cap and floor Windows 1 and 2 reach commercial operation. This can broadly be interpreted as consistent with AFRY's modelling in supporting the needs case for further interconnection.

[10] The 2021 NOA for Interconnectors is available at: https://www.nationalgrideso.com/research-publications/network-options-assessment-noa

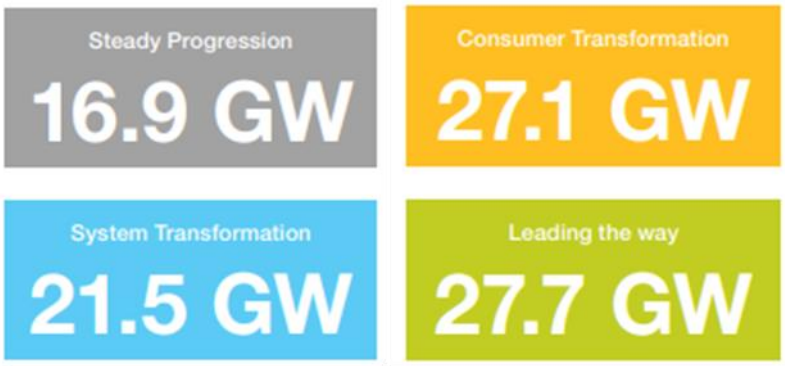


Figure 5: Optimal interconnection for each FES including the base case level. Source NGESO NOA 2021 (*https://www.nationalgrideso.com/document/185881/download*)

2.37. The NOA IC shows a similar pattern in the impact of modelled scenarios on wholesale prices and the resulting direction of flow along interconnectors to the policy review modelling. Specifically, the NOA IC shows that interconnectors will primarily export from GB from circa 2030 across most scenarios, except Steady Progression.

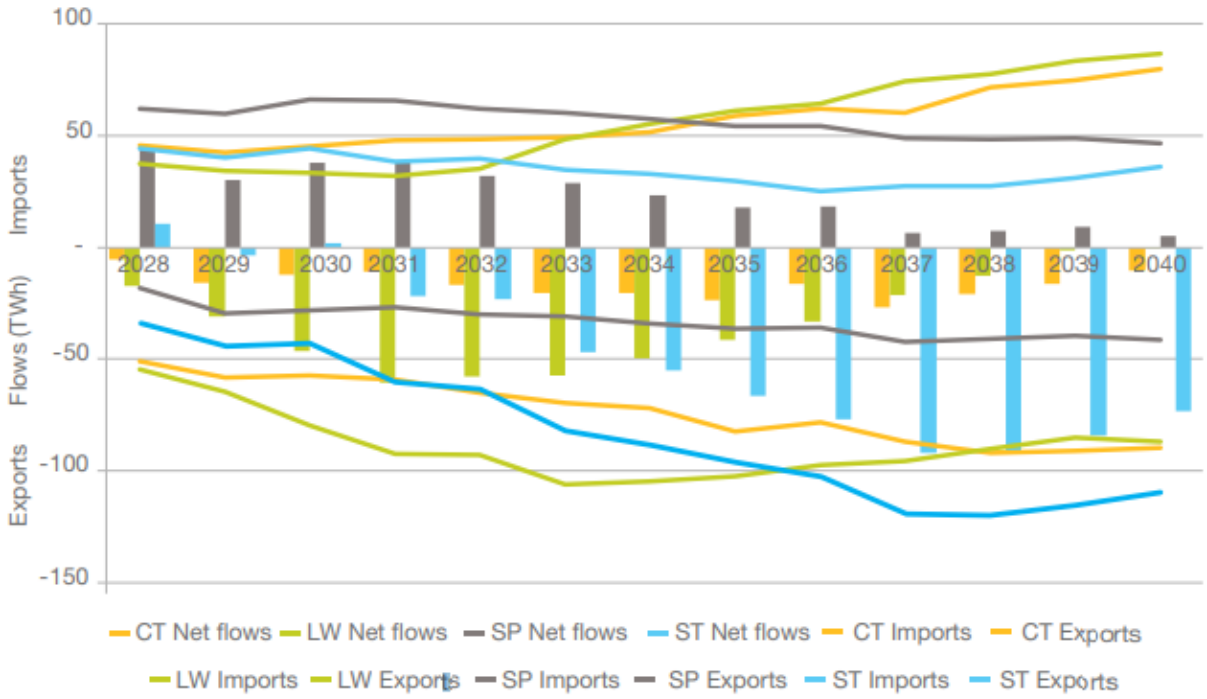


Figure 6: Annual import and export flows in each of the FES. Source NGESO NOA 2021 (*https://www.nationalgrideso.com/document/185881/download*)

2.38. Some similarities between the NOA IC and AFRY's policy review modelling are expected as both are based broadly on the same scenario data for GB. This means that GB wholesale prices are modelled to fall across most scenarios in both sets of modelling, due to significant

growth in GB renewable penetration. Differences arise, however, because the policy review modelling makes different assumptions for connecting countries, and makes adjustments to the FES to ensure internal consistency of scenarios used. The makeup of the baseline level of interconnection also differs. Both of these differences will affect market price differentials, the volume and direction of interconnector flows, and therefore the distribution of welfare.

2.39. There are also differences in objectives and modelling approach. The NOA IC optimises for net benefit which includes socio-economic welfare, capital costs, and constraint costs. As a result, an optimal pathway is presented for each of the FES. The policy review modelling optimises for IRR on a single scenario, and applies a socio-economic CBA across several scenarios to only those projects identified from that optimisation. Furthermore, AFRY's modelling does not consider constraint costs when socio-economic welfare is calculated.

Ten Year Network Development Plan (TYNDP)

2.40. The ENTSO-E[11] Ten Year Network Development Plan (TYNDP) is the European electricity infrastructure development plan. It looks at the future power system and considers the role that specific electricity infrastructure projects have on meeting system needs and European energy goals under a range of scenarios. The TYNDP scenarios for 2020 were developed jointly for gas and electricity project assessments.

2.41. The 2020 ENTSO-E system needs study[12] notes a system need for additional GB interconnection capacity beyond their reference grid in 2030 and 2040, based on a net socio-economic welfare (SEW) analysis. ENTSO-E identify this system need by determining the optimal combination of potential capacity increases that minimises total system costs. They do note however that this is only one solution for meeting the identified system needs which is based on cross-border transmission capacity increases. The identified needs could be addressed in multiple ways by considering other technologies. Similarly, ENTSO-E note that this is a solution based on SEW system needs; different solutions may arise if other systems needs are considered, such as system resilience, system security, or other societal benefits. For example, the TYNDP main report notes a need for further GB interconnection when considering security of supply and RES integration criteria.

[11] ENTSO-E is the European Network of Transmission System Operators for Electricity
[12] Completing the map - Power system needs in 2030 and 2040 https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2020/Foropinion/IoSN2020MainReport.pdf

2.42. Specifically, in 2030 ENTSO-E identifies an additional 1GW of capacity between GB and the SEM and an additional 1.4GW capacity between GB and France. In 2040 it identifies a further 1.4GW capacity between GB and France, and 2GW between GB and the Netherlands. The reference grid for this system needs assessment includes a lower baseline of GB interconnection capacity by 2025 than the AFRY modelling.

2.43. As part of the TYNDP process, project promoters are invited to submit their projects for cost benefit analysis. In the 2020 TYNDP 17GB of interconnector projects[13] were assessed, which includes multiple purpose interconnectors. The outcome of the TYNDP cost benefit analysis is positive for most of those projects. The TYNDP 2020 report14 compares the identified SEW based system needs, alongside other system needs, to the capacities submitted by project promoters. In general, for GB the capacity of projects submitted by project promoters exceed the SEW system needs identified on most borders.

2.44. The cost-benefit analysis methodology used in the TYNDP assessments considers net European socio-economic welfare, although the exact methodology used to calculate this figure differs slightly from the AFRY cost benefit analysis methodology, and so we would expect some differences in results. In addition to SEW, the TYNDP CBA also quantifies a number of other benefit categories relating to greenhouse gas emissions, the integration of renewables, impact on grid losses, and security of supply. These benefit categories are not assessed in AFRY's modelling. We will separately be considering some of these factors in workstream 3 of this policy review.

2.45. We consider that the ENTSO-E TYNDP package of publications suggests that there is a need for further GB interconnection, both when considering socio-economic welfare and other system needs. The TYNDP demonstrates a strong pipeline of potential projects to satisfy those system needs, most of which are assessed as delivering a positive socio-economic impact.

[13] TYNDP Online project sheets https://tyndp2020-project-platform.azurewebsites.net/projectsheets
[14] TYNDP 2020 report https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2020/Foropinion/TYNDP2020_Main_Report.pdf

Other studies

2.46. We have reviewed a number of other modelling studies identified through our literature review and submitted by stakeholders.

2.47. The majority of studies considered are independent assessments submitted in confidence by project developers through regulatory processes. Whilst these studies focus primarily on the project in question, they do show a high degree of fluctuation in outputs. A commonality across these studies is that they demonstrate high welfare from interconnection. Generally, the scenarios used in these studies suggest that interconnectors are more likely to import in the future, reflecting the same change in generation mix shown in AFRY's analysis.

2.48. Other studies are generally performed by academia, consultancies and research groups, aimed at the commercial market or for academic purposes. Many studies are not necessarily focussed on socio-economic welfare assessment although comparison can be drawn in scenarios used and the effect of potential changes in the import-export balance over time.

2.49. Through the Interconnection in a Changing Energy System (ICE) research programme, the University of Strathclyde and Imperial College London performed modelling focussed on the impact of interconnectors on the GB electricity sector and European carbon emissions[15]. Based on TYNDP scenario input data their modelling suggests that in the near term new interconnection increases imports and reduces GB electricity prices, whilst in the medium term GB can expect increased exports and reduced or reversed price impacts. The result of this is reduced utilisation and revenue potential of interconnectors over time.

2.50. Our review of other studies shows that, whilst most studies conclude that further interconnection in future is likely to benefit society and enable the transition to decarbonised energy systems, the results of socio-economic modelling for interconnectors are extremely sensitive to small changes in input parameters. It is therefore difficult to draw meaningful and resilient conclusions from a single piece of analysis, and assessments should use a range of plausible future scenarios or pathways to test a range of inputs and outcomes.

[15] The impact of interconnectors on the GB electricity sector and European carbon emissions. Callum MacIver, Waqquas Bukhsh, Keith R.W.Bell - Institute for Energy and Environment at the University of Strathclyde. https://www.sciencedirect.com/science/article/abs/pii/S0301421521000392?dgcid=author

3. Conclusions and initial proposals

Section summary

In this section we summarise the conclusions and initial proposals that have been set out and discussed throughout this document.

Questions

Question 5: Do you agree with our conclusions? If not please explain why and provide supporting information if available.

Conclusions

3.1. Our workstream 2 analysis suggests that:

- Socio-economic electricity market modelling remains a valuable tool for assessing the needs case for future interconnectors. However, we acknowledge that any modelling exercise has uncertainty and limitations that should be taken into full consideration when making regulatory decision.

- The scenarios under which modelling has been performed have evolved materially over time, and we expect them to continue to evolve as energy policy emerges in response to decarbonisation ambitions in GB and connecting countries.

- The result of the evolution in scenarios used by Ofgem for the purposes of interconnector modelling suggests there has been a shift in the allocation of welfare benefits from consumers to producers, and between the connected countries. This is as a result of GB power prices falling in response to changes in the energy system required to meet net-zero, and often doing so more quickly than in connected markets, which means that interconnectors switch from operating as net importers to net exporters.

- Based on the modelling exercise performed by AFRY for this workstream and a review of other relevant studies, we consider that there is likely a socio-economic need for further interconnection beyond those projects currently operational, under construction, or in development with regulatory approval under the cap and floor regime.

- We recognise that the allocation of benefits from the modelling suggests a negative impact on GB consumers from a socio-economic standpoint, however we consider that the modelling methodology and assumptions underplay interconnectors' socio-economic value. It is also important to consider that in our modelled scenarios GB prices are materially lower than present day, so consumers are already better off; the role that interconnectors play in these scenarios is therefore different. The wider benefits that we expect interconnectors to deliver in the future, as discussed in workstream 3 of the review, are not captured in this socio-economic assessment.

- The modelling suggests that if future interconnectors operate under a cap and floor regime (in its current form) their revenues will likely fall below the floor in the early years of, and above the cap in later years, of operation. This implies that in order to incentivise further interconnection a mechanism such as the cap and floor may be required, but also provides assurance it would also give back to consumers in the long-term.

Initial proposals

3.2. In response to the conclusions drawn from workstream 2 we propose the following:

- There is likely a need for further GB interconnection, and a need for a regulatory regime to incentivise further investment in a way which continues to be beneficial for consumers.

- Socio-economic modelling should continue to form an important part of needs case assessments of interconnections in any future regulatory regime resulting from this policy review. However, the proportion of overall interconnector value captured in our modelling may be reducing over time. In any future regulatory assessments, we will need to consider additional modelling exercises and/or methodologies to ensure it remains as up to date and fit for purpose as possible.

- Any future modelling should continue to consider a realistic range of plausible scenarios, and the outputs of any Ofgem-led modelling exercise should be considered alongside a range of other independent modelling exercises when taking future regulatory decisions.

- We will explore options to integrate the quantification of wider impacts into future socio-economic assessments. This recommendation ties in with the recommendation of

workstream 3 that wider impacts should form a key part of future regulatory assessments for interconnectors.

- Options to assess the specific socio-economic impacts of multiple purpose interconnectors should be explored. This recommendation ties in with the recommendations of workstream 4.

4. Consultation questions

Section summary

In this section we set out the specific questions on which we would like feedback

Questions

Where possible, we would welcome feedback on the individual questions per section. However, we recognise this may be detailed and time-consuming, so would also appreciate feedback on the broad themes or overarching questions if preferred.

In responding please be as specific and concise as possible – for example, if providing feedback on specific conclusions or recommendations, please clearly explain.

Section 2

Question 1: Do you agree with the approach we have taken to workstream 2?

Question 2: What are your views on the scenarios, assumptions and methodology that AFRY has used to model notional future interconnectors and the impact of cross-border interconnector flows?

Question 3: Do you agree with our view on the results of AFRY's modelling? Do you agree that this modelling supports the needs case for further interconnection?

Question 4: Is there any further information or additional studies that you think should be factored into our analysis?

Section 3

Question 5: Do you agree with our conclusions? If not please explain why and provide supporting information if available.

Other

Question 6: Do you have any further feedback on the work presented in this consultation document?

Appendix 1 – Privacy notice on consultations

Personal data

The following explains your rights and gives you the information you are entitled to under the General Data Protection Regulation (GDPR).

Note that this section only refers to your personal data (your name address and anything that could be used to identify you personally) not the content of your response to the consultation.

1. The identity of the controller and contact details of our Data Protection Officer

The Gas and Electricity Markets Authority is the controller, (for ease of reference, "Ofgem"). The Data Protection Officer can be contacted at dpo@ofgem.gov.uk

2. Why we are collecting your personal data

Your personal data is being collected as an essential part of the consultation process, so that we can contact you regarding your response and for statistical purposes. We may also use it to contact you about related matters.

3. Our legal basis for processing your personal data

As a public authority, the GDPR makes provision for Ofgem to process personal data as necessary for the effective performance of a task carried out in the public interest. i.e. a consultation.

3. With whom we will be sharing your personal data

Your personal data will not be shared outside of Ofgem.

4. For how long we will keep your personal data, or criteria used to determine the retention period.

Your personal data will be held in line with our processes.

5. Your rights

The data we are collecting is your personal data, and you have considerable say over what happens to it. You have the right to:

- know how we use your personal data
- access your personal data
- have personal data corrected if it is inaccurate or incomplete
- ask us to delete personal data when we no longer need it
- ask us to restrict how we process your data

- get your data from us and re-use it across other services
- object to certain ways we use your data
- be safeguarded against risks where decisions based on your data are taken entirely automatically
- tell us if we can share your information with 3rd parties
- tell us your preferred frequency, content and format of our communications with you
- to lodge a complaint with the independent Information Commissioner (ICO) if you think we are not handling your data fairly or in accordance with the law. You can contact the ICO at https://ico.org.uk/, or telephone 0303 123 1113.

6. Your personal data will not be sent overseas (Note that this cannot be claimed if using Survey Monkey for the consultation as their servers are in the US. In that case use "the Data you provide directly will be stored by Survey Monkey on their servers in the United States. We have taken all necessary precautions to ensure that your rights in term of data protection will not be compromised by this".

7. Your personal data will not be used for any automated decision making.

8. Your personal data will be stored in a secure government IT system. (If using a third party system such as Survey Monkey to gather the data, you will need to state clearly at which point the data will be moved from there to our internal systems.)

9. More information For more information on how Ofgem processes your data, click on the link to our "Ofgem privacy promise".