Offshore Coordination project

Stakeholder feedback August 2020 engagement

September 2020

nationalgridESO

Contents

Introduction

The offshore coordination project was set up to assess the most beneficial approach for consumers and coastal communities to meet the levels of offshore wind that will be required to meet the Government's commitment to net zero greenhouse gas emissions from all sectors in the United Kingdom by 2050. As a first step, we will set out the costs and benefits of different integrated offshore conceptual network designs by the end of December 2020 and determine the next steps to unblock barriers to achieving the recommended approaches. At the start of August 2020, we facilitated two webinars with all interested stakeholders to talk through our findings at our second set of engagement in the project. The areas below highlight the different workstreams within the project.

1) Technology readiness and cost for offshore integration

2) Offshore conceptual network design, impact on the onshore network and cost benefit analysis

3) A review of the offshore connections process to encourage more coordination

4) Gap analysis and review of existing work to inform a potential phase 2 of work

Following the webinars on 4 August 2020, we also hosted stakeholder workshops to get feedback on the work completed to date and invited stakeholders to provide feedback in writing should they prefer to do so. Stakeholders included representatives from onshore and offshore transmission owners (TOs), interconnectors, offshore developers and technology providers.

This document provides the following:

- **A summary** of the responses we received to the questions we sought feedback on and what we are doing with that feedback
- All **question and answers** from the two webinars
- **Next steps** - what will we be working on next and when will we be seeking your feedback again

The presentation material and recordings of the webinars can be found at the following link.

Questions on the feedback form

Question	Summary of stakeholder group feedback	What we are doing with the feedback
Offshore coordinated conceptual designs applied to GB network and impact of technology availability and barriers on network designs		
Q1. What are your views on the way in which the conceptual network designs have been applied to the GB network in the examples given?	Some Offshore Transmission Owners (OFTOs) and Offshore Developers fed back that they expected to see an offshore alternating current (AC) design and that they additionally thought that the following would be a good way to present the transition that would have to occur from today to the 2050 view: • The point to point approach (the current radial approach) • An integrated solution using technology that is available today • An integrated multi terminal solution Transmission Owners fed back that some further, more detailed work should be completed with the ESO to underpin the work being undertaken on the onshore impact. They highlighted that if this was not to happen due to time constraints that the appropriate caveats be added. It was noted by an interconnector that some of the conceptual designs had restrictions in their potential to expand (Topology 4 and Topology 5). Some respondents also fed back that the content of the presentation provided was ambitious and heading in the right direction.	The illustrative proposals of a future non-integrated and integrated approach to offshore capture this feedback, with both AC and high voltage direct current (HVDC) designs represented in both approaches. We agree that these three points should be explored. The illustrative approaches for 2030 and 2050 network design use technology that is available internationally today. Our report also identifies various opportunities to evolve such designs by realising objectives in innovation and development strategies that provide the potential for further options in future years. Our report indicates initial analysis of these impacts. We are happy to work with TOs to further explore these areas and the effect of these designs further. The work completed to date sets the vision of where we need to get to and we agree that this needs to be underpinned by a detailed plan as part of the Offshore Transmission Network Review. The expansion of designs T4 and T5 may be achieved via AC interconnections between such designs, which is an approach already used within Europe. Our report also notes areas of the Security and Quality of Supply Standard (SQSS) that have

		the potential to further expand the individual capacity or the building blocks of these solutions.
Q2. Do you think that results show clear benefits of integrated vs. radial solutions in 2030 and 2050 based on the examples shared in the webinar and in advance of the cost-benefit analysis?	It was noted by most respondents that there was likely to be benefits of an integrated approach in some areas of Great Britain and that what had been presented was useful. An independent researcher commented that achieving the 2030 goal with coordinated solutions will require urgent action to influence projects currently being planned or even 'in flight' and priority needs to be given to this now.	We expect the relative benefits of solutions will vary across GB- the cost benefit analysis (CBA) being conducted will report on this variation further. With the pace of development shown in the *FES,* the greatest benefits will be seen from taking forward an integrated approach from as early as possible. Our analysis assumes that there is a level of integration between 2025 and 2030, and this is what would be an ideal scenario to deliver maximum integration. However, from a practical point of view some of the assumed integration in the earlier stages of the designs may not be possible in reality, where projects are already at an advanced stage of development. Therefore, full integration before 2030, as envisaged in this analysis, may be not be achievable and changes may need to happen in a phased way for projects connecting in that period. This will impact on the extent to which the number of onshore landing points can be reduced by 2030 and potential savings by 2050. Our expectation is that projects with connection agreements already in place will proceed as planned. We are committed to working with the relevant TOs and developers to continue to progress on the basis of those agreements. We appreciate though that there may be appetite from some developers for a voluntary opt in approach and would welcome discussions on this in relation to ESO processes. BEIS and Ofgem would also welcome conversations on this, as invited in their recent open letter[1].

[1] https://www.gov.uk/government/publications/increasing-the-level-of-coordination-in-offshore-electricity-infrastructure-beis-and-ofgem-open-letter

Q3. What is your view on a modular approach of building the network over time?	All respondents agreed that this was a good approach but that the presentation needed to outline the modular steps proposed for each area of Great Britain and that thinking would be required to assess what was required in each case. • Some OFTOs fed back that they agreed with the approach but that this was not shown in the slides. They stated that the material presented did not detail the modular stages required to meet the end state. • An OFTO put forward that a no-regrets approach could be a way to progress with agreement with BEIS and Ofgem. • An interconnector developer fed back that the initial stages required would be to start at small(er) commercially viable scale, for example a multi-purpose interconnector. In addition, it was highlighted that there needs to be a mechanism for anticipatory investment to allow this approach to occur. • An offshore developer stated that consideration is needed around how radial links could be integrated enabled to allow this approach if appropriate at a later date. • A Transmission Owner noted early establishment of key system parameters and design standards that may mean adapting to future technology change would be a challenge.	We recognise that given the expansive nature of the discussion our webinar was not able to get into the information in the underlying detail. Our full draft CBA describes the approach further and we are happy to discuss the detail further as part of the consultation workshops coming up in October. Multi-purpose interconnector solutions are included in the integrated analysis. Our draft CBA notes that framework and technical analysis areas (code review) would need to be addressed to achieve this. The CBA report also notes how solutions may be sequenced to begin as radial and evolve into more integrated solutions over time. In addition, it notes that in an integrated design, where offshore assets are shared, performance onshore is now a function of those collective assets, wind farm connections and their overall control. This is unlike today, where performance of a project onshore can define the design of the radial elements offshore. Further clarity on offshore standards and parameters of performance is beneficial within the context of industry technical code review. In proposing these illustrative GB designs, our approach has been to ensure the impact on the onshore system is to maintain onshore system levels of performance and security of supply.
Q4. Do you see the offshore integrated option as a way for future offshore wind deployment?	Stakeholders agreed that they saw a place for an offshore integrated option but that there were a lot of barriers that would need to be overcome to facilitate this option and that these need to start to be addressed urgently to realise the 2030 and 2050 government targets.	The draft CBA considers the technical barriers and opportunities and, at a high level, how they are respectively overcome and realised. We recognise that broader considerations will need to be explored in order to maximise the changes of realising the benefits of an integrated network by 2030.

Q5. Do you have any views on the methodology for applying conceptual designs to Great Britain? For example, how might it become part of business as usual; do you think it should be repeated regularly based on new Future Energy Scenarios information? If so, what criteria would you use to do this and how often do you suggest this work should be completed?	• A TO suggested that a year would be too frequent to review the conceptual designs, and instead proposed that a significant change to the Future Energy Scenarios (FES) triggered this work. The resource implication was also highlighted. • An interconnector developer suggested that the development and enhancement of the Network Options Assessment (NOA) process, to be able to provide both strategic and near-term grid development guidance, could be a methodology. They also suggested that, for each new project concept, it may be beneficial to review existing designs to determine whether any new innovations could be integrated. • An OFTO suggested a step change in design of the network may be required in some individual cases, although for normal network development it is not necessary. It was highlighted that a masterplan for the 2050 net-zero vision would greatly benefit this work and that it should be assessed when technology and/or demand changes sufficiently	The draft CBA discusses our method and key inputs, which may be monitored as changes occur to trigger such repeat assessments. The precise methods and processes surrounding this would require further discussion as would the way in which activities such as the provision of offshore integrated re-design are achieved going forward. This would align with our Initial method in constructing those Illustrative Integrated designs for GB as discussed in the webinar. Many thanks to stakeholders for feeding in ideas around how this process could work.
Q6. Do you agree that technology development and innovation development strategies should accompany the delivery of Offshore Wind towards 2030 and 2050 targets? What are the key features that you believe should be within these strategies and who do you think would be best placed to develop these?	• An OFTO stated that they didn't believe that programmes should be put at risk by waiting for developments that might never happen. • An independent researcher feedback that it would be lower risk to be an 'early adopter' of innovation, and this suggests that monitoring and engaging in advanced work elsewhere may be a better strategy than committing to risky adoption of untried technologies. • They also stated that immediate adoption of locally coordinated approaches e.g. all wind farms in an area forming part of a particular Crown Estate Round could be connected to common offshore infrastructure and delivered to shore at a brownfield site using HVDC, as one suggestion. • An interconnector agreed that technology development to support the practicable deployment of offshore wind in the timescales considered is necessary to accompany delivery. They stated that	The modular design approach can be aligned to development pace of an offshore region or collection of regions. However, the risk of that offshore capacity not occurring at that pace or scale would remain a risk surrounding be present any stage in integrated design commitments. We note that the risks of "early adoption" of integrated approaches in our draft CBA, but also note that the technology to support it is available. Monitoring activities elsewhere and committing more slowly to such approaches conversely comes with a risk of not realising the opportunities and benefits from an integrated strategy, which our CBA work explores further. One of our recommendations as part of the consultation is that there is a role for such

	the overall direction and development of these should be aligned with BEIS's role in offshore wind development. In addition, they suggested that on a technical level the technology development strategy establishments, such as the existing National HVDC Centre, should have links to the relevant industrial and academic stakeholders and would be a potential candidate for the strategy development activity. • An Interconnector highlighted that technology development and application is vital, especially in relation to offshore multi-terminal DC. • They suggested that the ESO looks at the trial projects other European transmission system operators (TSOs) are conducting, with a view to adopting these and adapting them to GB requirements. They expanded that the commercial risk to progress with higher voltage cable/converter stations is very high and, in their view, careful consideration must be taken against using certain Paper and Extruded cable technologies which have a less than favourable track record or are yet to be implemented in projects at the desired voltage and conditions.	innovation and development strategy activity, and that were integrated solutions taken forward, arrangements to support that should be found. We agree that these parallel activities are key to realising the benefits from the integrated approach with the most efficient solutions. Assessing trial projects that European TSOs are conducting is beyond the scope of our phase 1 work but could be explored further in future work to utilise relevant good practice. In our report we note the importance of in-service history and for these reasons we have adopted a cautious approach to the deployment of higher rated cables and operating voltages of HVDC solutions to beyond 2030.
Q7. Are there other benefits or considerations arising from integrated designs that should be captured from the power system analysis work that should be taken into account in the next steps of cost benefit analysis work?	• An interconnector developer asked whether the ESO is considering carbon footprint modelling. They highlighted the value in having clarity on and specificity of the onshore transmission benefits, through avoided costs and impacts that can be achieved through integrated offshore designs. • Influencing the Crown Estate to release wind farm areas in chunks that match economic coordination and on-shore delivery was put forward. • A TO stated that local onshore reinforcement requirements and costs are excluded from the assessment and these should be considered. • An OFTO stated the integrated approach should offer some degree of redundancy compared to the existing radial circuits.	The carbon impact of solutions is considered in our draft CBA. We note in our draft CBA that the locations and timing of offshore projects are key factors in influencing the detailed design of integrated solutions. We have a section with our Connection Report which proposes the packaging of connections and sea bed leases in coordination between the ESO and Crown Estates. We also note that, with respect to counterfactual solutions, too many variables existed to precisely define future local network extension and its impacts. Further work could be undertaken in this

		area. Integrated solutions by comparison require more limited local system integration and as such are fully discussed in our work. With reference to integrated solutions, we note in our report that pooling project capacity behind an arrangement with multiple onshore connections to different onshore areas of GB can offer greater resilience against both offshore and onshore system outages and faults. The nature of these benefits is further quantified in our CBA assessments.
Q8. Do you have any other comments?	Does the slide in relation to SQSS imply that offshore coordination would be treated as an exception and each development having to go through raising an exception?	Our current integrated designs do not assume SQSS changes, and as such no exceptions would be needed in taking these forward. We note SQSS changes may offer opportunities for more efficient integrated design solutions, however such a change would be the subject of collective industry review of a proposed modification of the SQSS in this area.
Offshore connection review		
Q1. What are your five highest priority opportunities in the connection work stream?	Stakeholders fedback that the following opportunities should be prioritised: • Policy and code change • Regulations e.g. offshore tender regulations • The Connections and Infrastructure Note (CION) • Coordination of leasing rounds • Anticipatory investment	Many thanks to stakeholders for putting forward your priorities. We have now created our draft Offshore connections review paper which pulls together all of the feedback we have received in this area. We note that anticipatory investment change would need to be led by Ofgem.
Q2. Are there any opportunities missing from the presentation that you would like to feed into the process?	No additional ones highlighted.	N/A

Q3. Do you have any other comments?	Other areas highlighted: • Some stakeholders stated that offshore developers should not be formally designated a role as a 'shadow' offshore TO during the design and construction stage, this should be completed by the ESO. Others stated that a shadow TO role could be an option to explore. • The generator-led OFTO model may not encourage coordination when multiple developers are present. Significant change should be considered to address this. • CBAs for the connection of multiple, coordinated, projects may show different results to CBAs done on a project by project basis, including the potential economy of connecting at existing brownfield sites. Revised processes need to cater for this. The current Least Worst Regrets process may not be fit for purpose in this regard as it is so risk averse. • A better assessment of onshore adverse impacts is needed prior to agreeing grid connections, to take full account of all infrastructure and cable trenches etc. required by both the TO and the windfarm/interconnector developers, not just the TO component. This may need more time allocation but if coordinated projects are progressed together there should be an overall net time and cost saving.	We are conscious of the mixed feedback we received on formally designating developers as shadow offshore TOs. However, we feel that there is benefit in further exploring who builds connection assets offshore. If greater transparency and visibility can be driven via a wider role for the developer, we believe it is worth consideration and investigation. We acknowledge there maybe downsides or unintended consequences, and this should be investigated by the appropriate organisation in the BEIS-led Offshore Transmission Network Review. Changes to the generator-led OFTO model go beyond the remit of the ESO. We will pass this feedback onto the relevant organisations involved in the Offshore Transmission Network Review. Options for grouped CBAs in the CION process are being considered as part of this review, along with onshore Impacts. The regional CION or grouped study is proposed to consider all infrastructure and accommodate a number of connections together, in a more coordinated way. All these options will be explored further with more engagement of key stakeholders as part of our potential Phase 2 work.
Potential phase 2		
Q1. Do you agree with our proposed areas of focus for phase 2?	TOs highlighted the need for more granular work on the onshore impacts now rather than it being part of phase 2. A stakeholder asked when the strategy and roadmap would be in place to deliver the vision that we are outlining as the ESO.	As part of phase 1 of the project we will be setting the vision of what an integrated offshore system could look like in 2030 and 2050. We recognise the feedback provided here and will be working with the TOs as the project progresses.

		This work sits within the OTNR project that BEIS is leading. Should we proceed with phase 2 of our project this will detail the roadmap on how we would implement some of the deliverables within our remit such as code changes. BEIS will own the overall strategy and roadmap for all of the deliverables that need to happen to enact the vision.
Q2. Are there any areas you feel are missing that the ESO should be focusing on?	N/A	N/A
Q3. Do you have any other comments?	There is a need for simpler, more transparent, processes rather than more special cases within current processes.	We agree with this comment provided and will endeavour to support this approach.
Cost-benefit analysis		
Q1. Do you have any feedback on the approach being taken on the cost benefit analysis?	The following feedback was received around the CBA: • Why is the CO_2 variation quantified rather than monetarised using the price of carbon? • Can grid losses not be monetarised?	Monetisation of the CO_2 variation will lead to double-counting. Total generation costs monetised within system costs already include the CO_2 price as each generator bids at the marginal cost of production which is "fuel price + CO_2 emission costs". If we monetised them again in the CO_2 variation KPI (now called Carbon Intensity Variation KPI), this would mean they are counted twice. Please see our CBA framework for more detail.
	• Can security of supply not be monetarised using failure statistics and the resultant loss of generation?	Security of supply can also be monetised. However, again this would lead to double counting. Total generation covers demand and losses, hence total generation costs account for the extra generated energy that is required to compensate for losses (please see our CBA framework).
	• Need to develop an industry-leading way of valuing (and preferably monetising) the adverse impacts of the onshore implementations of these	It is not loss of generation but loss of demand that is usually quantified when analysing security. This

		projects, to be set against the capital costs of Offshore Coordination. This would both support better decision making and help reduce community barriers by demonstrating a more objective approach to the location of onshore infrastructure. This activity could be set up as an important workstream in its own right	requires simulations under different scenarios and is not within the scope of this phase of work. Moreover, monetising is difficult because it is hard to know exactly what is the value of lost load (VoLL) - there are some known values but none of them is widely accepted. Please see the CBA framework for a fuller explanation. We will consider whether this should be addressed in the potential next phase of our work.

Questions and answers from commercial webinar 4 August 2020

We received lots of great questions as part of our two webinar sessions on the 4 August 2020. This section provides you with a written response to each of the questions asked.

Commercial webinar - Cost-benefit analysis and the offshore connection review

Q1. From a developer perspective risk of connection delay is very important; is this going to be factored into the CBA framework?

This won't be included in the CBA as the risk of connection delay is project specific. The delay can't be objectively modelled or anticipated as a direct implication of certain grid designs. However, we will reflect on these risks in our qualitative discussion of potential merits of integrated and radial grids.

Q2. Socioeconomic impact is a well-established subject. It can start monetising impacts. E.g. How much is 100 lost jobs worth as an NPV?

- We have deliberately decided not to monetise impacts related to employment growth. The CBA is concerned with the assessment of how the integrated grid design compares to the counterfactual. It is our assumption that the scale of offshore wind development does not change depending on the grid topology that is deemed to be more optimal as a result of our assessment – therefore potential impacts on employment rates will not change depending on which conceptual grid design is implemented. We are not aware of any objective evidence on whether either integrated designs or radial would lead to higher employment levels.
- We agree that certain studies have proposed monetary values that can be assigned to employment growth / reduction effects. However, we believe that these values are often arguable and there is no value that would be widely accepted as an industry standard.
- We acknowledge that in the ideal case it is worth to explore these impacts. In order to respect the time limitations of this project we have taken a practical approach to the CBA framework, which in order to focus the analysis on objectively evaluated key performance indicators (KPIs) does not include quantification of these effects.

Q3. This should not delay projects in flight?

Our aim is that the project does not delay developments that are already progressing.

Q4. Will you look at alternative interconnector operations to address wind availability and boundary congestion?

Operation of interconnectors is subject to relevant regulation both of EU and GB. In our market modelling we consider that interconnectors are operated in the most optimal way from the market perspective and are solely used for trading purposes based on the price difference between connected bidding zones.

Q5. The timescales may be aligned with BEIS, but they are not aligned to the timescales discussed in this morning's webinar. Nor is it reasonable to expect no code changes before 2025.

For clarity we have aligned our terminology across the commercial and technical streams of the project for "Immediate", "Short", "Medium" and "Long" term.

Timeframe	Meaning
Long term	Early/mid 2030s and beyond
Medium term	Mid-late 2020s-early 2030s
Short term	Mid to late-2020s
Immediate	Early 2020s

We would envisage a number of the potential code changes would be implemented before 2025.

Q6. The connections workstream, this is a hugely important aspect and it is great to hear it is being worked on. Has the team looked at the work done by the sector deal working group on regulatory barriers? This looked at the process from application all the way through to OFTO asset transfer.

We have considered the outcomes from the sector deal and points, such as optimal use of co-location of technologies and its efficiencies. Transmission system planning, design and coordination with review of the Connection and Infrastructure Options Note (CION) process, has also been considered, to encourage coordination. We are happy to discuss this and any further opportunities you feel are not covered in our review.

Q7. I thought from the previous webinar that 'short term' was considered 'post 2030'. has there been a change in the timescales over which the ESO is now considering this project?

For clarity we have aligned our terminology across the commercial and technical streams of the project for “Immediate”, “Short”, “Medium” and “Long” term.

Timeframe	**Meaning**
Long term	Early/mid 2030s and beyond
Medium term	Mid-late 2020s-early 2030s
Short term	Mid to late-2020s
Immediate	Early 2020s

Q8. Where does a coordinated approach leave the Generator Build option for its connection assets?

In this phase of this work we are only considering the technical aspects and costs and benefits of different approaches. The regulatory and commercial framework will be considered the relevant organisation as part of the wider BEIS-led Offshore Transmission Network Review[2], of which we form part.

Q9. In the STC (SO-TO Code) there is no such thing as a "pre-CION" and "post-CION" grid connection offers. Those terms are undefined, and it concerns me that ESO are becoming used to offering connections in this way - which is not suitable for certainty and confidence building for Developers. We should be moving away from this informal approach as soon as possible.

The Connections workstream is considering a move to codify and potentially formalise the CION process as part of our review into how we can make coordination the default in the connection processes. As you will see this Is one of our recommendations.

[2] https://www.gov.uk/government/publications/offshore-transmission-network-review

Q10. Why does the offshore network need a separate SO? Would it not be more efficient to have one SO overseeing the whole GB system both onshore and offshore and hence this role should be done by NGESO with competition for the offshore TO roles.

We have no plans to propose a separate offshore SO. Roles and responsibilities in any changed approach is something that may be considered later in the wider BEIS-led Offshore Transmission Network Review (OTNR).

Q11. Is it time to end Generator-Build OFTO Model to force coordination?

As set out in response to question 8, in this phase of this work we are only considering the technical aspects and costs and benefits of different approaches. The regulatory and commercial framework will be considered the relevant organisation as part of the wider BEIS-led Offshore Transmission Network Review, of which we form part.

Q12.What do you mean by a separate connection process for interconnectors and could you explain a little more about the benefits of this?

The suggestion is in the sense of considering ways how the process can be made more adaptable to address novel connection requests or different types of connections such as interconnectors. The suggestion Is to investigate ways to make connecting as easy and flexible as possible.

Q13.Could you share more on the offshore developers "shadow TO" role?

This idea was suggested by an offshore wind developer and would work in such a way that the developers would be more involved in the design and construction of transmission assets as a “Shadow” Transmission Owner, using their Generation licenses as a mechanism to accede System Owner Transmission Owner Code (STC).

The Connection and Infrastructure Options Note (CION) is presently a Transmission Owner (TO) /Electricity System Operator (ESO) discussion and developers are not involved in such discussions. Transparency and open discussions could reduce cost, encourage coordination and benefit the end-consumers.

Q14.What is being done to identify suitable 'pathfinder projects'?

The terms of reference in the Offshore Transmission Network Review set out that one of the workstreams will seek to “explore early opportunities for coordination through pathfinder projects, considering regulatory flexibility to allow developers to test innovative approaches”. BEIS and Ofgem invited expressions of interest in these projects through their recent open letter[3].

Q15.A single SO overseeing both onshore and offshore GB system management is best placed to manage overall coordination. Competitive tender for TO roles on applicable sections of transmission network will promote and encourage good practice standardisation and efficient management. NGESO is best placed to do this.

Thank you for your feedback, we will feed this into the appropriate part of the BEIS Offshore Transmission Network Review.

[3] https://www.gov.uk/government/publications/increasing-the-level-of-coordination-in-offshore-electricity-infrastructure-beis-and-ofgem-open-letter

Q16. Is it time within the next leasing rounds to promote OFTO led build of Offshore connected transmission systems?

Our project will provide a view of the technical aspects and costs and benefits of a more integrated approach. This will feed through to the development of a plan to deliver it if a more coordinated approach is the recommended option.

Q17. Will this pick-up bootstraps too? As they haven't been built yet there is a potential quick win?

The proposed Eastern Links are included in our technical assessment.

Q18. When is it envisaged that offshore grid connection offers be considered in the application process? Is this currently being considered by connection applications being submitted this year that fall with the timeframe (e.g. 2028 to 2033 for instance?)

The ESO could begin to consider the current applications for Round 4 wind farms for offshore connections subject to an understanding of the mechanisms of how the process could work and regulations around it. As soon as we begin to get more detail around this we will keep you informed.

Q19. On connections, please can you look at how connection process can be developed for integrated transmission and interconnection projects. I'm not seeing much on that in the material so far.

Integrated transmission and interconnection projects are being considered as part of Co-location of technologies and works for interconnectors (MPI – Multipurpose interconnectors) referenced in the webinar presentation. Currently there are opportunities for further clarity around legislation and how co-location would work between different companies. In our connections report we have indicated we would like to discuss this further with stakeholders.

Q20. This morning's presentation considered projects being built on a site by site basis and then being drawn into the interconnected network at a later date. Has this transitional process/ costs etc been considered?

We are conscious of the challenges around how we transition smoothly and will include these issues in relation to the connections process in our review. The wider transitional process, where it goes beyond the ESO's, remit is the sort of thing likely to be considered in the BEIS-led OTNR.

Q21. Can we collectively work with OFGEM on their evolution to 'regulate for netzero' as opposed to how they regulate now?

We are working closely with Ofgem and would encourage a collaborative approach across the industry as we seek greater increased offshore coordination

Q22. Currently this is all missing from the ESO's RIIO2 business plan - how/when will it be added?

We are engaged with colleagues internally and with Ofgem on how we manage the work we are doing going forward and how it gets included in our RIIO-2 business plans. We will provide an update on this once there is a clearer view.

Technical webinar

Q1. Can you please confirm the NPV calculation will consider all costs CAPEX and OPEX?

The NPV calculation in the cost-benefit analysis will consider CAPEX and OPEX of the primary grid components such as:

- Offshore platforms
- HVAC transformers

- Reactive compensation
- HVAC cables
- HVDC cables
- HVDC converters
- DC circuit breakers
- Overhead lines where relevant for onshore reinforcement

More detail on this can be found in our Cost-benefit analysis report.

Q2. What are the technical risks to delivering multi terminal HVDC networks and how can this be managed?

- Multi-terminal arrangements are not without precedent internationally. Within Europe, a VSC-HVDC based multiterminal arrangement is underway, Caithness-Moray-Shetland, and the project is due for completion by 2024. In China, there are existing multi-terminal arrangements that incorporate onshore DC substations and include DC circuit breakers.
- At this stage, the conceptual design options we have developed for Great Britain do not include types of substations for which there is no operational precedent nor clearly identified benefits. Noting current development work that is progressing across both Europe and Asia, our offshore design proposals are sufficiently flexible to incorporate with pan-European meshed offshore grids should this approach emerge during the timeframe of our analysis.
- Our Holistic Approach to Offshore Planning report discusses risks and opportunities associated with multi-terminal designs and their delivery. Our slides highlight the principle risks and the consultants propose options to manage those risks. We will consider this further and set out our views in our consultation and report at the end of Phase 1 of the project.

Q3. The possibility of a pilot project to test "next-gen" DC transmission (>320kV/1000MW) was mentioned. The EU is also contemplating such "life-size test". Considering Brexit are you thinking of a specific, separate "GB" effort, or would the UK be part of a larger initiative?

Our 'identifying and overcoming technology risks and barriers' work identifies that as part of a development strategy, trials may be beneficial to support future new technology deployment. The specifics surrounding how such a trial could be taken forward in the future have not been addressed in phase 1 work and need to be considered within the context of the BEIS Offshore Transmission Network Review[1], within which this ESO project sits.

Q4. You talk about counterfactual connections being made using standard building blocks that can then be brought into an integrated solution in the future as it is developed but when will those standard building blocks be developed as offshore wind farms are being designed and built now?

For the counterfactual, the potential to use standard building blocks would be a project specific decision. The differences between the integrated and counterfactual approach as documented as part of this project. We outline the areas where de-risking innovation strategy and development strategy may support potential future integrated designs.

Q5. How are the costs of direct current circuit breakers (DCCB) and direct current (DC) protection which are still in development being calculated in the CBA?

As part of our previous webinar, we explained that DCCBs and associated protections are part of our unit cost considerations for this project. Unit costs are based on both PROMOTION[2] project data and current international experience of deployment. As relatively new components with limited installations, a bottom-up

approach was used to estimate the cost of DCCBs based on our understanding of the most promising solutions (hybrid DCCB, mechanical DCCB etc).

Q6. Does an incremental buildout suggest a preferred sequence of deploying offshore wind at each location or terminal to minimise costs? Just thinking that auction results currently dictate buildout sequence right now for offshore wind projects

One benefit of designs using offshore collection hubs, is that hub location is optimised across the range of projects that the hub could support, rather than on an individual project basis. As such the precise sequencing of projects offshore does not influence the physical design of the integrated offshore network. Whilst the precise sequencing of offshore projects does not influence the overall integrated offshore design, it may influence how the HVDC solution's control system is designed. The control strategy for HVDC solutions needs to function across the range of construction stages for the offshore network, as well as supporting the full range of operating conditions for that network.

As part of our de-risking strategy, we note the importance of progressing composite testing and design activities in this area alongside implementation in order to provide appropriate insight for codes and standards development work.

Q7. Has (or will) the technical workstream considered impact on ownership boundaries, design processes and compliance processes?

As part of our consideration of technical risk and options for overcoming such barriers, we note that compliance and performance requirements are frequently defined by reference to an onshore interface point. Future integrated designs will be satisfying multiple project connections (given the sharing of assets offshore), evolving over time (as the offshore capacity is grown) and supporting onshore system integration considerations (such as boundary capacity and other areas of support). As such for the delivery of integrated offshore network solutions, we believe that a review of Codes and Standards is required to provide clarity in terms of performance requirements within offshore networks as well as defining roles and responsibilities for each party. Where within the ESO's remit, these are considerations we are proposing progressing as part of a potential second phase of work.

Q8. What framework options will be considered for encouraging coordination of offshore network development across the renewables industry? Incentive mechanisms?

It is not part of the scope of Phase 1 of this project to consider such areas of incentivisation. This likely goes beyond the remit of the ESO. If relevant It would be considered as part of the wider Offshore Transmission Network Review.

Q9. Thank you for such ambitious content - How quickly can such integration be delivered? BEIS, Ofgem and others will all need to be involved in this. When will discussions about deliverability and timescales commence with these parties?

We agree that a change to a more integrated approach would be a matter for industry consultation and consensus on next steps. It is being progressed through BEIS's Offshore Transmission Network Review. The findings from Phase 1 of this project aim to provide information on the costs, opportunities and benefits that may be achieved by an integrated approach compared to the current radial approach and will feed into that review.

Q10. Is there a risk of stranded offshore/onshore assets if wind farms with a point to point connection are then brought into an integrated connection? Who will be responsible for these costs?

Our technical workstream has identified an integrated approach that seeks to take account of existing developments. As part of phase 1 of this project, there is no intention to disrupt projects that are under

construction. Considerations of stranded assets are not expected to arise for projects under construction, except where a developer seeks to vary the design of a specific project to achieve a more integrated solution.

Q11. Very progressive - on overcoming barriers, you refer to developing TRL maturity and identifying pilots etc. the timeframes 2030 / 2035 are clearly ones that can be targeted with new tech that is not mature today. Is there a process to address the risk of locking in the suboptimal tech versus not getting it done? Suggest a suitable process with a portfolio of potential techs developed and monitored rather than betting the house on one tech for an integrated approach. What are your thoughts?

Across the range of technologies which may benefit the implementation of integrated offshore solutions for GB, we fully agree that TRL is not static and as such must be actively monitored. We recommend complementary approaches as part of an innovation and development strategy to actively monitor technology developments and assess suitability for use as part of the transmission system within Great Britain.

Improved coordination of innovation and development activities should better facilitate delivery of new technology options that beyond those that have already been identified as realisable between now and 2030.

Q12. What is the expected evolution of HVDC breakers in this timeframe? How relevant is that for the deliverability of this plan?

Please also refer to our response to question 2.

We have identified a need for onshore DC substations including HVDC breakers within the North Scotland area (Caithness-Moray-Shetland multi terminal arrangement) of our integrated design solutions. There is established precedent for the deployment of multi -terminal arrangements and based on the range of data HVDC circuit breaker capability is expected to be available within the timeframe required for this project.

The deployment of multi-terminal arrangements allows a dual benefit of an offshore connection and, consequential onshore system support that can be realised flexibly. This type of integrated design solution can remove the need for several point to point connections being marshalled within onshore AC substations and deliver benefits including a reduction in the volumes of onshore AC infrastructure and onshore HVDC convertor terminals that are needed. We consider that inclusion of HV DC circuit breakers within our integrated design proposals is warranted due the benefits that are expected to be provided.

Q13. I think the thing that struck me most what that, even though you mention under “why are we looking at this” that the government wants 40GW by 2030, and even though no one seems to believe that this can be achieved with radial connections, there didn’t seem to be much evidence that **accelerating** offshore grid connection was an aim?

- Thank you for highlighting how the presentation came across. Developing an approach to connecting the significant levels of offshore wind in the required timescales in a way that minimises the impact on consumers and coastal communities is the overarching objective for the project and we will ensure that we are clearer on this context in future.
- Our application of conceptual designs and outline proposals for integrated offshore are based upon data from the FES 2020 Leading the Way scenario [4]This scenario illustrates an accelerated delivery, meeting or exceeding current Government targets for 2030 and 2050, including the 40 GW of offshore wind by 2030, with widespread use of net zero supporting technologies.
- There are limited radial connections within our integrated offshore proposals. In line with our design approach for this project, radial connections are shared across projects in order to maximise their capability and effectiveness as part of the integrated (HVAC or HVDC) design options for the connection of these large volumes of Offshore wind across GB. Our methodology for delivering integrated designs may be repeated as backgrounds change and/or technology options evolve. We

[4] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

consider that our methodology can respond to the changing pace and scale of connections that will be required to meet the Government targets.

Q14. There seems to be a desire in the technical workstream to use the number of cable landfalls / onshore cables as a proxy for environmental impact. This strikes me as rather simplistic for a few reasons.

a. ***The number of power cables is less important than the number of times that new trenches have to be excavated in the same area. Installing extra ducts for future projects, like TenneT on Norderney or SPR in East Anglia is an easily accessible benefit of co-ordination that hasn't really been mentioned.***

Given the scope of the design and analysis work for this project and the limited webinar time, it was not possible to provide a comprehensive, detailed summary. Our main focus of presentation in the webinar was to provide information about the offshore network design options that we have identified and analysed.

In respect of the design work that has been carried out, we considered "how" the designs are delivered as well as defining "what" the designs are. Our modular approach allows us to analyse possible future expansion opportunities and assess cost and environmental impact reductions that could be delivered with a phased development approach.

We have used a number of high-level illustrative measures for environmental impact within our presentations to date and note that the measures identified will continue to evolve as the work progresses. We agree that a measure based on number of cables is not illustrative of all relevant environmental considerations, but we consider that it does provides a useful measure for landing, onshore routing and onshore convertor and/or other substation infrastructure that can be used as part of a comparative assessment of design options.

As noted during the webinar, the full scope of offshore and onshore asset requirements (including in respect of cost and environmental impact considerations) for each of our outline GB integrated designs has been captured and informs the cost-benefit analysis (CBA).

b. ***Although some windfarms' onshore power cables have been a bit controversial (though nothing like the amount of opposition that a typical overhead line gets), many others – the vast majority, I think - have been permitted with no problems at all. A blanket "all onshore cables are bad" measure is inappropriate.***

We can confirm this is not a measure we are using for our detailed assessment work. As discussed above, the number of cables and indeed asset counts more generally, provide a high-level illustration of areas where integrated offshore design may provide benefits. Our CBA assessment considers the impacts associated with our proposed design options.

c. ***Although they may be out of sight, it is not necessarily the case that offshore cables are going to be easier to build and permit. Often onshore cables are easier, sometimes much easier.***

We agree that there are a wide range of areas to consider for delivery of offshore networks in terms of costs and practical implementation factors. For these reasons, our designs seek to implement solutions which efficiently consolidate offshore asset requirements. Whilst this was not a specific area of focus at the webinar, these detailed considerations fed into both our detailed design work and our CBA.

Q15. Good to see that you're looking at whether the 1320MW limit should be increased. I would encourage ESO to undertake a CBA of this in the current scope of work (if it is not being done already). This could be an easy win.

We consider that a review of the Security and Quality of Supply Standard (SQSS) limit would be of benefit and recognise the broad range of design limitations that relate to the existing requirements. Whilst consideration of a change to the SQSS is not within the scope of Phase 1 of this project, we are proposing an assessment in relation to this takes place in our potential second phase of work.

Q16. The Irish Sea "Integrated" design example (slide 18) had two HVDC cables connecting wind farms to shore, with AC cable(s) connecting the two windfarms together. Is the idea that the interconnecting AC cables are normally in-service or just for emergencies? If normally in-service, are the two offshore HVDC converters synchronised with each other?

For the Irish Sea integrated design option, the operation of AC cables between the projects would be largely dictated by the operating level of the wind generation that it is supporting at a given time. The maximum size of the offshore AC island forming an AC network must not exceed the normal infeed loss offshore (as per the existing SQSS). As part of this project, we have identified possible opportunities to evolve offshore technology but also to review the existing SQSS requirement. For phase 1 of this project, our proposed network design options must meet existing requirements and work within the capability available within the current development horizon, whilst having a methodology which is sufficiently flexible for changes in the future.

For SQSS compliance purposes at high wind output, the AC interlinks would need to be open offshore, allocating appropriate power to the most suitable HVDC circuit connections to the onshore system. At times of high wind output, the AC interlinks would fulfil an emergency role. This operation characteristic is equivalent to that currently operated in Germany across a number of offshore projects.

At levels of wind operation where the AC interlinks do not need to remain open for SQSS compliance purposes, we propose that the AC interlinks should be closed and operated with a control philosophy which both collectively supports the offshore network and may also complement the wider network operation. Such approaches would make use of insights obtained from HVDC bootstrap reinforcements of the onshore system both in Great Britain and elsewhere in Europe. Ensuring that HVDC control systems are comprehensively designed, tested and robustly deployed are critical features of our integrated approach.

Q17. Slide 16 of the Cost Benefit Analysis has "renewable energy" listed as one of the benefits that couldn't be monetised. This surprised me – connecting more offshore wind means less gas burnt and less CO_2 emitted, and there are well established approaches to putting a monetary value on CO_2 emissions. In any event, given that parliament has declared a climate emergency, surely connecting 40GW of offshore wind is simply something we MUST do – not a vague benefit to be weighed against various other costs and issues?

Due to time limitations, we were unable to provide a more detailed summary of our CBA methodology. We can confirm that our CBA framework for this project fully captures both benefits identified in this question. As part of our assessment, we do not monetise these factors, and only report quantitatively as these factors are implicitly accounted for in the socio-economic welfare KPI used, (which is founded on generation costs):

- Renewable energy sources have lower marginal prices, thus reduce total generation costs; and
- CO_2 emissions negatively affect the marginal price of conventional power plants and through that affect total generation costs.

Monetising these factors separately in addition to monetising generation costs, would lead to double-counting.

Next steps

We have published this feedback document alongside our consultation which launched on 30 September 2020. We are running interactive feedback sessions throughout the consultation period, which closes on **28 October 2020**, and you can find details of these sessions on our website here.

Following the closure of our consultation we will be working to finalise our three documents below for publication on **by the end of 2020** following your feedback:

- Holistic approach to offshore transmission planning
- Cost-benefit analysis report
- Offshore connections review

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