Orkney Project - Final Needs Case Assessment

A report for Ofgem

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Customer Details

Customer Name:	Office of Gas and Electricity Markets (Ofgem)
Customer Address:	10 South Colonnade, Canary Wharf, London, E14 4PU
Customer Reference:	Orkney Project - Final Needs Case Assessment
Contact Person:	Rafiek Versmissen (rafiek.versmissen@dnvgl.com)

DNV GL Company Details

DNV GL Legal Entity:	DNV GL Limited
DNV GL Organisation Unit:	Energy Markets & Technology
DNV GL Address:	30 Stamford Street, London, SE1 9LQ
DNV GL Telephone:	+44 20 3816 5879
DNV GL org. No.:	E-NG-N
Contact Person:	Rafiek Versmissen (rafiek.versmissen@dnvgl.com)

About this document

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Prepared by:

Rafiek Versmissen
Director - Energy Markets & Technology

Approved by:

Michael Dodd
Market Area Manager UK & Ireland

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EXECUTIVE SUMMARY

Background

Ofgem's Strategic Wider Works (SWW) mechanism enables significant electricity transmission system reinforcements to be considered as expenditure adjustments within the RIIO-T1 price control period (1 April 2013 to 31 March 2021) in order to facilitate large network developments that deliver benefits to consumers.

SHE Transmission has submitted a Final Needs Case proposal for the construction of a transmission link from mainland Scotland to Orkney under the SWW mechanism. Ofgem has appointed DNV GL to provide an independent expert review of SHE Transmission's submission, focusing on the justification of anticipated load growth on and around Orkney, as well as the functionality and delivery of the proposed solution.

This report provides DNV GL's expert review of the Final Needs Case submission as well as recommendations to Ofgem in its evaluation of SHE Transmission's proposal.

Summary of the Final Needs Case submission

SHE Transmission proposes to install a 220kV, 220MW HVAC subsea cable from Orkney (Finstown) to the Scottish mainland (Dounreay) by October 2022. SHE Transmission has outlined that the need for this subsea link is contingent on at least 70MW of new generation on Orkney connecting by 2023, for which the existing distribution network on Orkney, currently connected to the mainland by two subsea cables, would not have sufficient capacity.

The proposed subsea cable would be part of a 2-staged approach, with further growth in generation capacity on and around Orkney potentially necessitating a second, similar, subsea cable at a later date. The current submission covers only the (first) proposed subsea cable in 2022.

In justifying the need for the proposed reinforcement, SHE Transmission's consultant, GHD, has assessed a range of generation scenarios for potential future load growth on Orkney, principally in the form of onshore wind and tidal capacity, to be commissioned from Q1 2023 onwards.

The submission compares five potential options to deliver the required reinforcement, testing whether they meet the minimum technical, operational and safety requirements across the generation scenarios, and subsequently to determine which option is the most economic, as well as to identify the delivery date that maximises the economic outcome and minimises regret (opportunity costs). From this assessment, the 220kV single AC was identified as the optimum reinforcement option.

DNV GL's assessment

Onshore Wind Generation Scenarios

DNV GL has reviewed GHD's assumptions regarding generation project development timings, and productivity and load factors for onshore wind generators, and concludes they are reasonable.

We consider that GHD has adopted a reasonable approach in performing a risk-weighted assessment of future generation to account for the additional uncertainty in the development and financial viability of each individual project and to develop a range of reasonable generation scenarios. It should be noted the 5-year period to 2023 is suitable to enable each project to achieve planning, FID and construction, but at this early stage there is no certainty in any of the 24 individual wind projects identified in the Generation Database.

As part of our assessment, DNV GL has considered GHD's assumptions regarding the potential financeability of onshore wind projects on Orkney, both with and without CfD (Contracts for Difference) Funding. We support GHD's findings that onshore wind projects are financeable with CfD funding and onshore distribution-connected wind farms may not necessarily need to rely on CfD funding to be economically viable in the future.

DNV GL considers the CfD and LCoE (Levelised Cost of Energy) analysis presented by GHD to provides a robust analysis for the economic viability of onshore wind. GHD's 5 generation scenarios assume between 45% and 70% of the onshore wind projects currently in development on Orkney could be successful in a future RIW (Remote Island Wind) CfD auction, which DNV GL considers reasonable for the 5-year period to 2023. This reflects an average 50% success rate for onshore wind, which is broadly at the level assumed in GHD's scenarios S2 or S3, for onshore wind, over the period 2023-2025.

Therefore, based on the following points DNV GL considers GHD's wind generation scenarios S1 to S5, represent a reasonable range of scenarios for onshore wind over the period 2023-2025:

- The 5-year timescale to 2023 is suitable to enable projects currently in "scoping" to achieve the development and construction milestones;
- Orkney's high wind resource and capacity factors have resulted in significant interest in onshore wind, with 24 projects, totalling 250MW identified by GHD;
- The low levelised cost of energy of distribution connected onshore wind projects on Orkney is anticipated to enable projects to be financed and constructed without additional support; and
- Remote Island Wind CfD support enables both transmission and distribution projects to be financed and constructed on Orkney.

Tidal Generation Scenarios

DNV GL does not consider the assumed scale and timing of tidal generation capacity to be reasonable, particularly in relation to large tidal arrays in the mid-to-late 2020s. The principal reason for this is that tidal is still an infant technology, and the construction of large arrays requires substantial specialist equipment and processes that are currently being tested and will take years to be refined further and de-risked.

DNV GL does not disagree with SHE Transmission's assumptions on tidal load factors, however, like SHE Transmission, we agree that tidal load factors are highly uncertain.

As regards the financeability of tidal generation projects, DNV GL concurs with GHDs finding that tidal would not currently be competitive in CfD auctions unless it participates in a separate funding pot. Although we generally expect advancement in tidal generation technology that may make it more competitive in the future, we consider the road and timing to commercial viability remains uncertain, principally due to cost and productivity uncertainties.

We therefore do not consider the development of tidal generation as depicted in GHD's high scenarios, particularly beyond 2025, is likely in terms of scale and timing. However, we also consider that it is not unreasonable to assume that a small amount of tidal capacity, broadly at the level assumed in GHD's scenario S1 or S2 over 2023-2025, could come forward with EMEC for testing purposes.

Assessment of options considered

Splitting the option assessment into two separate stages, namely assessing the appropriate route for the submarine cable and assessing the appropriate electrical connection is the right approach because it provides focus on each of these two areas.

DNV GL believes that SHE Transmission has identified credible landfall options on Caithness and Orkney and considered all possible Strategic Route Options for the subsea cable in relation to these options. The applied assessment method (a five-stage approach), if properly applied, offers a sufficient condition for finding the best Strategic Route Option.

DNV GL considers that the optioneering applied should be extended with two additional options for the Orkney link with the Scottish mainland. One option is related to the use of a 275kV subsea cable, the other to a 66kV submarine cable. DNV GL recommends that the CBA is updated to include these additional options to verify the robustness of the preferred solution.

A review of the wider network infrastructure on and around Orkney is not part of the scope of this assignment. However, we consider that a solution developed in holistic consideration of both local transmission and distribution infrastructure can potentially deliver added benefits for consumers. We recommend that an integral distribution and transmission network analysis is undertaken to further inform the assessment of the Orkney Transmission link.

Cost Assessment

DNV GL considers that the cable costs of the options provided by SHE Transmission are relatively high. This is possibly due to location-specific installation costs of the cable which SHE Transmission has considered. SHE Transmissions cost estimates for HVAC substations are reasonable across all options, including the preferred solution.

We recommend that Ofgem should seek greater transparency and request more detailed information on the installation costs of the cables and substations in a possible Project Assessment under the SWW process.

Assessment of the proposed delivery plan

DNV GL has reviewed the delivery plan for the Orkney Transmission Link and, based on the information provided by SHE Transmission, we consider that the project approach is appropriate. The project lead time is based on relevant studies and consultations with stakeholders, as well as reflecting lessons learned from previous experience. Overall, the project plan provides confidence that the link can be delivered in a timely and effective manner.

As regards risk management, we conclude that, although the project approach is appropriate in principle it is not clear to us whether SHE Transmission has included sufficient contingency in the lead times of the key activities to cope with (unexpected) changes. We therefore recommend that contingencies in lead times are henceforth formally discussed in the risk workshops to obtain more robust strategies and project plans.

Aside from planning contingency, we believe that SHE Transmission has a structured project risk management process in place with which the risks of Orkney Transmission project can be efficiently managed. SHE Transmission has identified the key risks for the Orkney Transmission Link project, although we do consider that going forward, SHE Transmission can be more specific in its description of project risks to facilitate their assessment.

We have also assessed all construction-related assumptions provided by SHE Transmission, taking as a given[1] that the proposed construction schedule aims to deliver the Orkney link by October 2022. To achieve this date, DNV GL believes that the start of construction should not be later than the beginning Q4 of 2019, as proposed by SHE Transmission. However, this estimate of the latest start date of the construction work is based on limited information and we recommend it be revised as more information becomes available.

Key recommendations

Based on our assessment, DNV GL recommends that Ofgem undertakes the following:

1) Regarding generation capacity coming forward on Orkney, DNV GL finds scenarios S1-S5 for wind generation to be reasonable for the period 2023-2025, but considers only scenarios S1-S2 to be reasonable for tidal generation over the same period. We therefore recommend that, in assessing the current Final Needs Case, Ofgem places its focus on scenarios S1-S2.
2) DNV GL recommends that the CBA undertaken by National Grid (as System Operator) is extended to include two additional options, a 275kV subsea cable and a 66kV submarine cable, to verify the robustness of the preferred solution.
3) DNV GL considers that cable costs provided by SHE Transmission are relatively high across all options, which is possibly due to location-specific installation costs of the cable which SHE Transmission has considered. We recommend that Ofgem seek

[1] Since we have not undertaken a detailed review of the CBA from which SHE Transmission has identified this date.

greater transparency and request further detail on the installation costs of the cables in a possible Project Assessment.

4) Our review of SHE Transmission's approach to risk management has uncovered some potential limitations. We recommend that should the project progress, contingencies in lead times are henceforth formally discussed in the risk workshops to obtain more robust strategies and project plans. Furthermore, to increase clarity to facilitate a review of the risks, we recommend that going forward, SHE Transmission be more specific in its description of project risks.

5) DNV GL considers that a solution developed in joint consideration of the local transmission and distribution network infrastructure can potentially deliver added benefits for consumers, and we recommend that an integral distribution and transmission network analysis is undertaken to further inform the assessment of the Orkney Transmission link.

1 INTRODUCTION

1.1 Background

The SWW mechanism enables transmission owners (TOs) to propose large investment projects that have not yet been awarded funding under the RIIO-T1 price control, and allows Ofgem to investigate the need and required funding for such projects, to inform its decision on whether the TO should be allowed to recover its investment costs. At a high level, the SWW process investigates whether:

- there is a need for investment from a technical perspective;
- the TO, through a process of optioneering, has arrived at a proposed investment that
  - constitutes an appropriate technical solution; and
  - is efficient in terms of its costs and delivery (timing);
- the proposed investment is in the best interest of consumers.

SHE Transmission has recently submitted a Final Needs Case proposal for the construction of a transmission link from mainland Scotland to Orkney under the SWW mechanism. Since the proposed project is still in development, Ofgem’s focus at this point in the process is to determine whether the need for the Orkney link is justified, and whether SHE Transmission is proposing an appropriate technical solution. Specifically, Ofgem is seeking to confirm whether SHE Transmission has sufficiently demonstrated that

- consumer benefit from additional generation connecting on Orkney will more than offset the cost of delivering the link;
- the link should be commissioned by 2022; and
- that the design put forward is the most economically efficient solution when compared against viable alternatives and credible increases and decreases in generation connecting on Orkney.

To assist with assessing the Final Needs Case, Ofgem has appointed DNV GL to provide an independent expert review of certain aspects of SHE Transmission’s proposed Orkney transmission reinforcement project. This report provides DNV GL’s review of the Final Needs Case submission as well as recommendations to Ofgem to support its evaluation of SHE Transmission’s proposal.

1.2 SWW Assessment process

1.2.1 General Process

The Strategic Wider Works process for RIIO-T1 has been introduced to enable the onshore TOs to put forward major (in terms of cost and/or scale) wider transmission system reinforcements that were not included in the TOs’ baseline packages of the RIIO-T1 Final Proposals.

In the context of RIIO-T1, network developments to strengthen or extend the electricity transmission system are known as "wider works outputs". In general, these wider works outputs are triggered by new generation connections (including those that might be expected in the future), load growth, wider network system security requirements, or a combination of these. In the RIIO output framework, the wider works outputs are assessed in terms of increases in the electricity transfer capability in accordance with the SQSS.[2]

The SWW arrangements are a part of the RIIO-T1 framework for all TOs. Details of the arrangements applicable to the three GB TOs are set out in Ofgem's guidance.[3] They are designed to ensure value for money for consumers and timely funding of the construction costs and additional operating expenses associated with large projects that are needed to meet wider network capability requirements.

Ofgem's assessment leading to a decision on a TO's cost recovery involves three stages:

1. Initial Needs Case assessment - not less than 9-12 months before the TO's final planning consultation;[4]
2. Final Needs Case assessment – when need for the project is more certain (e.g. after the generator(s) driving the need for reinforcement has taken a final investment decision or equivalent financial commitment); and
3. Project Assessment – following the Final Needs Case submission, and typically when the majority of the contracts to complete the work are significantly developed.

While each assessment area covers distinct issues, there is a degree of interaction between the assessment of the Final Needs Case and the Project Assessment. In principle, however, completion of the full Project Assessment is subject to a positive conclusion from the Final Needs Case assessment.

Where, following the above assessments, the Authority reaches a decision to allow cost recovery, Ofgem will take forward the necessary licence changes to reflect that decision. This will include specification of ex-ante total expenditure funding allowances (with annual profile), secondary deliverables and a completion date for the delivery of the outputs.

During construction, Ofgem will monitor progress towards outputs, and expenditure against profiled allowances. The risk of differences between allowances and expenditure will be allocated between the TO and consumers through the price control efficiency incentive mechanism.

Finally, post construction, Ofgem will determine performance in delivery of outputs. This will include establishing whether and when the agreed increase in boundary capability had been delivered and, where applicable, understanding the reasons for any

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2 The National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS), currently at Version 2.3, 4 December 2104

3 Ofgem, *Guidance on the Strategic Wider Works arrangements in the electricity transmission price control, RIIO-T1*, 24 November 2017. Available at: https://www.ofgem.gov.uk/ofgem-publications/125277

4 Ofgem did not undertake an Initial Needs Case assessment of the Orkney project.

failure to deliver in line with agreed outputs, and the extent to which the TO could be held responsible for this.

1.2.2 Context for this assessment report

DNV GL has been appointed by Ofgem to answer a number of specific questions about SHE Transmission's Final Needs Case submission. At the highest level, these questions can be split into the following areas of assessment:

1) Part A: Whether SHE Transmission has entered appropriate inputs into its cost-benefit analysis (CBA), where
    - Questions A1 to A4 pertain to the **assessment of the generation scenarios** informing the CBA**;** and
    - Questions A5 and A6 pertain to the **feasibility and costing** of SHE Transmission's proposed solution; and
2) Part B: Whether SHE Transmission has developed a **suitable delivery plan**.

Table 1 below provides a full overview of Ofgem's questions.

1.3 Structure of this Report

The remainder of this proposal is structured as follows:

- Section 2 provides a high-level summary of relevant areas of SHE Transmission's submission;
- Section 3 sets our Part A of our assessment;
- Section 4 describes part B of our assessment; and
- Section 5 summarises our findings and provides recommendations to Ofgem.

Table 1: Grouping of Ofgem's Specific Questions

A1	Are SHE Transmission's assumptions regarding the level of generation that will/won't require a CfD to be economically viable, reasonable and well justified? This should include consideration of the following areas: 1) the productivity and load factors that SHE Transmission have assumed to be relevant to the identified projects; 2) the likely financeability and hurdle rates of the identified projects, including consideration of the relevant transmission charging arrangements; and 3) the likely construction timings for the identified projects
A2	Are SHE Transmission's technology specific assumptions around increased uptake on Orkney during the 2020s reasonable and well justified?
A3	At what point in a generation project's development could Ofgem be confident that the project will commission?
A4	Do the scenarios used by SHE Transmission represent a reasonable distribution of potential outcomes for future generation on Orkney?
A5	Has SHE Transmission considered all feasible options or operational measures to address the capacity requirements on Orkney?
A6	Are any costs relating to technical functionality beyond the minimum required to deliver the project's requirement across each of the options within the CBA clearly identified, quantified and justified?
B1	Does SHE Transmission's delivery plan/schedule provide sufficient detail and justification on assumptions relating to project lead times and key milestones, and interactions with the CfD auction process?
B2	Has SHE Transmission sufficiently justified that construction cannot be started later?
B3	In the view of the Service Provider, what is the latest date that construction could start without compromising/risking timely delivery of the link?
B4	Does SHE Transmission's delivery plan appropriately consider the specific risks associated with delivery of this project? (e.g. shifts in generation levels, potential planning sensitivities).
B5	Has SHE Transmission justified that it has a plan to efficiently manage these risks?
B6	Has SHE Transmission provided a robust strategy for the ongoing review of the work programme and implementation of changes on the project as it develops?

2 OVERVIEW OF SHE TRANSMISSION'S SUBMISSION

This section sets out the information reviewed by DNV GL to inform its assessment and provides a high-level summary of SHE Transmission's Final Needs Case submission, reflecting specifically on areas relevant to this assessment.

2.1 Documents and information reviewed for this assessment

To inform this assessment, DNV GL has assessed the following documents and information:

- SHE Transmission's Final Needs Case Submission of 05 March 2018 ("the needs case submission"), including, as relevant, its Appendices 1-9;
- GHD's cost-benefit analysis provided as a separate appendix to the submission ("the GHD report");
- Information obtained from SHE Transmission and/or GHD through Supplementary Questions (SQ) under the SWW process;
    - We make specific reference to an excel database of generation projects ("the generation database") and accompanying memorandum ("the memo") provided by GHD; and
- Further discussion and documents provided at workshops with Ofgem, SHE Transmission, GHD and DNV GL.

Any other documents reviewed by DNV GL are referred to explicitly in this report.

2.2 Summary of the Final Needs Case

2.2.1 The proposed solution

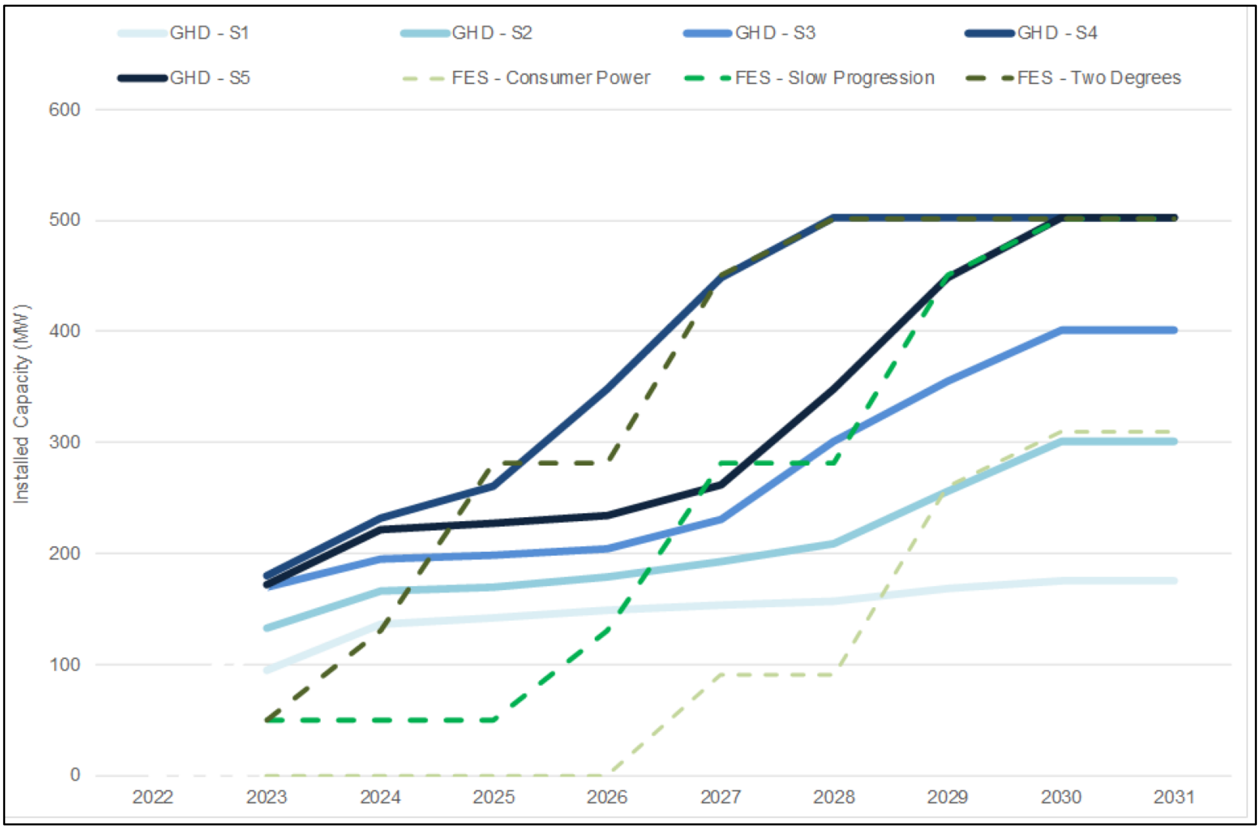
SHE Transmission is proposing to install a 220kV, 220MW HVAC subsea cable from Orkney (Finstown) to the Scottish mainland (Dounreay) by October 2022. SHE Transmission has outlined that the need for this subsea link is contingent on at least 70MW of new generation on Orkney connecting by 2023, for which the existing distribution network on Orkney, currently connected to the mainland by two subsea cables, would not have sufficient capacity.

The proposed subsea cable would be part of a 2-staged approach, with further growth in generation capacity on and around Orkney potentially necessitating a second, similar, subsea cable at a later date. The current submission covers only the first proposed subsea cable in 2022, although its discussion of generation developments covers the period out to 2031.

2.2.2 Generation Scenarios

In justifying the need for the proposed reinforcement, SHE Transmission has assessed a range of generation scenarios (Figure 1 below). The generation scenarios include 5 scenarios (S1-S5) developed by GHD as well as three National Grid Future Energy Scenarios (FES), excluding the FES Steady State scenario as it assumes no generation growth on Orkney. The key difference between the GHD scenarios and the FES is that the latter are developed on a top-down basis interpreting wider industry, policy, technological and economic developments, whereas the former are developed bottom-up, based on (interpretation of) information available regarding local generation projects and other developments specific to Orkney.

Figure 1: Generation Scenarios Considered



2.2.3 Cost-benefit analysis

The submission compares five potential cable options (Table 2) to deliver the required reinforcement. The test for these options is to first to confirm whether they meet the minimum technical, operational and safety requirements across the generation scenarios, and subsequently to determine which option is the most economic, as well as to identify the delivery date that maximises the economic outcome of the project.

Table 2: Cable options considered

Option	Technology	No. of Circuits	Voltage (kV)	Rating (MW)	EISD*
1	HVAC	1	132	130	2022
2	HVAC	1	220	220	2022
3a	HVAC	2	220	440 (2 x 220)	2022
3b	HVAC	2	220	440 (2 x 220)	2022 (1st); 2024 (2nd)
4	HVDC	1	+/- 300	300	2022
5	HVDC	1	+/- 300	600	2022

** Earliest in-service date*

The cost-benefit analysis presented in the GHD report tests the economics of each option under each scenario S1-S5 based on their ability to avoid or reduce transmission constraints, assuming constraint cost scenarios of £55/MWh and £70/MWh (£2018), respectively, confirming the 220kV single AC reinforcement option (Option 2) in 2022 as one of the options generating a positive net present value (NPV) across all generation scenarios (although not the highest across all scenarios).

GHD has also undertaken a "least worst regret (LWR)" analysis to identify the option with the smallest opportunity cost across all generation scenarios and potential delivery years. From this assessment, GHD concludes Option 2 is the LWR option at £55/MWh constraint costs, its optimum delivery year is 2022, but Option 3b (a phased double 220kV AC link) is the LWR at £70/MWh as well as at higher generation scenarios, indicating the potential merit of "the phased approach," i.e. to follow up the first 220kV AC link with another link at a later date. Although the second cable is not formally subject of the current Final Needs Case submission, its inclusion may demonstrate the potential longer term economic benefit that can only be realised by delivering Option 2 first.

From this assessment, GHD concludes that Option 2, the 220kV single AC is the optimum reinforcement option. DNV GL has noted that the cost-benefit analysis undertaken by National Grid, in its role as System Operator, broadly supports GHD's analysis.

3 ASSESSMENT PART A: INPUTS TO THE CBA

3.1 Generation Assessment (Questions A1-A4)

Background to generation scenarios presented

SHE Transmission's submission includes five different generation scenarios, which each consider future growth in onshore wind, tidal generation and solar. These scenarios have been part-informed by GHD's bottom-up analysis of information available regarding local generation projects and other developments specific to Orkney. We consider these scenarios more relevant to this Needs Case than the FES scenarios, which have been developed top-down and do not consider the same level of detail pertaining to Orkney. Of principal relevance to this Needs Case is what the GHD scenarios assume regarding growth in onshore wind generation on Orkney, which the Needs Case presents as the key driver for the preferred solution, a single 220kV single AC subsea cable.

The GHD scenarios also assess potential growth in tidal generation installations around Orkney, assuming the vast majority of potential tidal capacity may emerge by the late 2020s. As presented by GHD, tidal generation capacity is therefore more relevant to a potential 2nd subsea cable to be considered at a later date as part of what the Needs Case refers to as a "phased approach," but this cable is not formally subject to the current Needs Case. It is however worth noting that when National Grid undertook a sensitivity on its cost-benefit analysis to remove all tidal generation from the scenarios, a 132kV transmission link was all that was ever required to connect Orkney.

Supplementary information on onshore wind projects

A detailed generation database (the "Generation Database") has been provided to DNV GL by GHD, along with an accompanying memo (the "Memo"), through Supplementary Questions (SQ) under the SWW process. Within the detailed generation database, projects have been categorised according to the following criteria:

- Stage of development (scoping, planning application submitted, planning application consented, under construction, operational);
- Grid connection application (either "contracted" by SHET or a "consortia" approach);
- Transmission or distribution network connected asset;
- Assumed funding support mechanism (Contract for Difference or Feed-in-Tariff).

DNV GL understands that specific projects were identified from GHD's research and used as a "first cut" for the generation scenario development. This "first cut" comprised 24 wind farm projects varying in total installed capacity from 0.9 MW to 66 MW. The largest capacity wind farm considered in the first cut is a single [redacted] project [redacted] for which an application for 66 MW of export capacity has been made. Approximately half of the 24 wind farm projects (the 24 projects total 250 MW) are assumed to apply for a Contract for Difference, consisting mostly of distribution connected projects with 2 assumed to be transmission contracted. The remaining wind farms are distribution contracted and total 24 MW. The Memo also provides commentary on the assumptions made regarding which projects will require a Contract for Difference and their likely success rate, which feeds in to the different generation scenarios considered. It should be noted the 5-year period to 2023 is suitable to enable each project to achieve planning, FID and construction, but at this early stage there is no certainty in each of the 24 individual wind projects identified in the Generation Database.

Of the total of approximately 250 MW, approximately 110 MW of onshore wind is assumed to be realised in Scenario 1. This can be translated into a "success rate," i.e. the proportion of wind farm projects on Orkney progressing to full operation. For Scenario 1 this success rate would be approximately 45% (110/250). For Scenario 5, the total capacity of successful CfD projects is assumed to increase to approximately 177 MW, resulting in a ~70% success rate).

GHD provides its rationale for the assumptions regarding the potential success of wind projects in the 2019 CfD auction, or the potential to be financeable without CfDs:

- 71MW of distribution-connected projects that would connect in 2023 in all scenarios, which:
    - may not require CfDs to be financeable as they do not pay transmission charges and therefore have a relatively low levelised cost of energy (LCoE);
    - could also potentially secure a BELLA/BEGA [5] and become eligible for constraint payments, providing a further financial benefit that would support their financeability; and
    - would be able to secure power purchase agreements (PPAs) even without CfD support.
- A [redacted] MW distribution-connected and council-owned project (with a further [redacted] MW being considered), for which GHD assumes varying levels of commissioning from 2023 onwards, but that would likely be developed since it is distribution-connected (with the benefits above) and because of strong backing from the Orkney Islands council, which:
    - has previously invested in 2 wind farms on Orkney;
    - may accept a longer payback period or lower return on investment as the project will create socio-economic benefits for Orkney (and which would lead to a lower LCoE);
    - may have access to lower cost capital (which again would lead to a lower LCoE); and
    - should be well placed to secure a PPA with a supplier for the output of the wind farm.
- [redacted] Transmission-connected projects, which GHD assume do not progress in S1 due to an inability to secure a CfD contract, but which do progress at increasing rates under scenarios S2-S5, assuming partial or full CfD success.

5 Bilateral Embedded Licence exemptable Large power station Agreements (BELLAs) and Bilateral Embedded Generation Agreements (BEGAs) allow embedded generators (indirect) access to the transmission network but exempt them from some of the technical requirements of plants directly connected to the transmission network including, under certain criteria, liability for Transmission Network Use of System (TNUoS) charges or Balancing Services Use of System (BSUoS) charges. See: https://www.nationalgrid.com/sites/default/files/documents/14270-Contractual%20Obligations%20to%20participate%20in%20the%20Balancing%20Mechanism.pdf.

- 24MW of small-scale distribution connected wind generators with varying rates of progress across scenarios. In S1 GHD assume the FiT scheme is, and remains, closed for new participants in 2019, and therefore only a few community-owned projects might progress, as they could secure a PPA on the back of low LCoE. Higher-end scenarios assume higher rates of progress based on a potential replacement for the FiT scheme and/or falling technology costs. Regardless of the means by which these projects are financed, GHD identifies these wind farm projects as 'FiT' and therefore DNV GL has adopted the same label in referring to these projects.

GHD also reports that it is aware of potential additional distribution-connected onshore wind projects, but it has not included these in its scenarios.

3.1.1 Question A1: Are SHE Transmission's assumptions regarding the level of generation that will/won't require a CfD to be economically viable, reasonable and well justified?

In answering this question, we consider the likely construction timings for the generation projects identified in GHD's scenarios, the productivity and load factors for these projects, and their potential reliance on, and access to, CfD subsidies to be economically viable.

3.1.1.1 Construction timings

Wind projects

GHD's scenarios S1-S5 regarding the potential development of wind farm projects focus on [redacted] distribution connected projects (totalling 71MW) of the 250 MW of projects which have been identified in the Generation Database. These [redacted] distribution connected projects are assumed to connect at full capacity under all scenarios, and a single council-owned wind farm project (also distribution connected and up to [redacted]MW in capacity) which is assumed to progress at various rates across the GHD scenarios. Although the scenarios presented by GHD focus on [redacted] of the 24 projects identified in the Generation Database there is no certainty in each of these individual projects being built. There are several milestones which need to be achieved in order for a wind farm project to successfully progress through early development to construction and operation. The key requirements are:

- Planning consent granted;
- Grid connection agreed; and
- That it is financially viable (if necessary with an appropriate funding support mechanism such as a Contract for Difference (CfD), Feed in Tariff (FiT) or Power Purchase Agreement (PPA)).

As each of these requirements are achieved, the certainty of a project progressing to construction and operation increases. The typical timescales for a UK wind farm project to progress through the planning process to construction varies and is dependent upon many project-specific factors relating to planning and the steps required to reach financial close (i.e. have all contracts regarding turbine supply as well as grid connection agreements in place).

DNV GL notes that in the generation scenarios, GHD assumes that a percentage of wind projects come on line at the earliest from 2023; i.e. 5 years from now. In general, DNV GL considers a timescale of approximately 5 years to enable each of the 24 wind farm projects to progress through planning to construction is representative. Therefore, given the combination of the 5-year timescale and 24 projects identified in the Generation Database, a number of wind farm projects are likely to achieve the identified milestones and finance, resulting in the construction of a number of projects from 2023. However, it should be noted that there is no absolute certainty in any individual project at this early stage.

DNV GL further notes that of the wind farm projects considered in the Generation Database to build the generation scenarios, only [redacted] projects have applied for planning consent. These [redacted] projects are assumed to progress in some form in GHD's scenarios S2-S5; they are not included in scenario S1. The remaining wind farm projects considered in GHD's scenarios are at a much earlier stage of development and are in "scoping". By their very nature, projects in their early development phase such as scoping are subject to higher risks and uncertainty in progressing through to construction. The Memo states that *"The database categorises known wind generation projects and assigns each a likelihood of construction across all generation scenarios."* Therefore, DNV GL considers the higher risks and uncertainty associated with early development projects has been considered and accounted for in the GHD analysis. This has been accounted for in the generation scenarios by assuming not all project will progress, using different levels of success rates from the 24 wind farm projects which have been identified, as discussed in Section 3.1. DNV GL notes that all wind farm projects assumed to come forward by 2023 in scenario S1 are currently in "scoping" and total 83 MW. They are expected to achieve the development and construction milestones given the 5-year timescale to 2023. Given the 24 wind farm projects totalling 250MW of potential developments that GHD has identified coming through from scoping from its bottom-up analysis described in Section 3.1, DNV GL consider the onshore wind generation scenarios S1-S5 to be reasonable in accounting for the risks and uncertainty associated with early development projects achieving the milestones identified above which each project needs to achieve to progress through to construction.

Tidal projects

The focus of GHD's scenarios S1-S5 regarding the potential development of tidal generation is a single [redacted]MW development assumed to be commissioned by 2023, and the serial development of capacity under the major arrays (of [redacted] and [redacted] MW, respectively) from 2023 onwards. The [redacted]MW project is assumed to commission in full by 2023 under all scenarios, whereas the rate of capacity realised for the arrays increases as scenarios become more bullish. The higher end scenarios also assume some further projects to be commissioned by the late 2020s, in addition to the [redacted]MW and [redacted]MW arrays.

The general uncertainties of tidal power as a technology affect the feasibility of constructing all of this potential tidal capacity. Major tidal arrays, like the ones being considered by GHD, require deployment of subsea hubs through which to connect to the onshore system, development of ways to protect and stabilise cables, as well as specialist equipment to facilitate serial turbine development in a cost effective and safe way. Much of this specialist equipment, as well as supporting processes, are currently being developed through tidal prototype installations and testing facilities and will take years to be refined further. For this reason, we consider that the development of the large arrays is highly uncertain, and their potential construction is not likely to proceed at the rate and timing assumed in GHD's higher end scenarios. However, smaller projects do not require the same degree of supporting infrastructure, such as hubs, and should be able to connect directly to the Orkney onshore network. Hence, it is not unreasonable to assume that the construction of the [redacted]MW tidal installation project could be completed by 2023.

3.1.1.2 Productivity and load factors

Onshore wind projects

For a wind generating asset, the level of generation, and hence revenue, will be dependent upon the wind resource, the project configuration and turbine technology proposed for the site. For the levelised cost of energy assessment, this is captured by the annual capacity factor assumed for the project:[6]

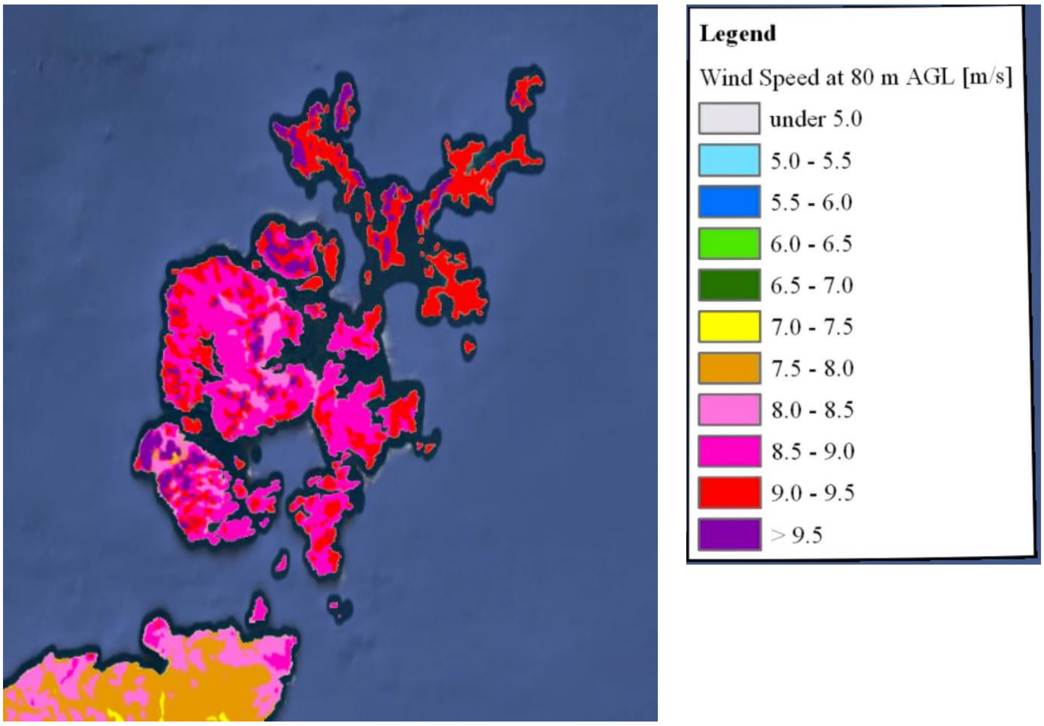
"Our analysis indicates a 'low' wind year results in an annual capacity factor of 40.8% and a 'high' wind year a capacity factor of 47.9%. The 'medium' or average wind year shows an annual capacity factor of 44.4%. We have adopted the medium wind output profile as our central case as the broad range of historic time series data in terms of number of years and sites results in an average capacity factor that is highly representative of the average attainable by a wind project in Orkney over its life."

DNV GL agrees with the approach to use historical data from operational wind farm projects to inform representative assumptions regarding wind farm performance going forward. The capacity factors presented in the GHD Report are broadly in line with DNV GL's experience in the area.

To further review and comment upon this assumption of 44.4% for an annual capacity factor, DNV GL has undertaken a high level indicative energy yield assessment based on DNV GL's Wind Map of the UK derived from mesoscale modelling. The long-term mean wind speed estimated at an assumed typical turbine hub height of 80 m is between 8.5 m/s and 9.5 m/s, demonstrating good wind resource availability at Orkney.

6 GHD report, p31.

Figure 2: DNV GL Wind Map of Orkney



We consider turbine technology in the range 2MW to 4MW to be representative of wind farm deployments on Orkney, and have assumed a typical power curve for that turbine envelope. Finally, DNV GL has used the indicative estimate of the long-term mean wind speed at Orkney together with an assumption for the shape of the wind speed distribution and the turbine power curve, with indicative assumptions for typical energy loss factors to derive an indicative estimate of the net energy yield and hence capacity factor that can be expected from wind farm projects on Orkney. The results from this analysis broadly supports the 44.4% average capacity factor assumed by GHD.

Tidal projects

GHD provides the following discussion of the potential productivity of tidal generation around Orkney:[7]

"Whilst significant historical data exists for wind generation on Orkney, given the relative infancy of marine generation, obtaining historical output data is more challenging. Historic output data for one existing tidal turbine on Orkney was obtained for a typical month. The overall annual capacity factor, if this typical month was used as representative for a full year, is 41.5%. The long-term average capacity factor for a given tidal site will be dependent on the type of marine turbine installed, with SHE-T data suggesting a typical capacity factor between 35% - 45%. Therefore, the empirical historic data is broadly in the middle of this range."

We agree with this discussion in that it underlines that gauging the potential productivity of tidal generation is a difficult task given that tidal technology is in an early stage of development and availability of historical data is very limited. GHD's assumption of a 41.5% annual factor within a range of 35-45% is not unreasonable,

[7] GHD report, p31-32.

but is highly uncertain given that it is based on a typical month for a single turbine - although we do note that GHD has provided supplementary information on another project reporting capacity factors within this range.

The 35-45% capacity factor range itself is indicative of the uncertainties of tidal capacity factors, which strongly vary with the location of the tidal installation (exposure to waves) and the specific technology deployed. Different technologies vary in their sensitivity to wave influence, but also may have different underlying systems (such as pitch control and the yaw system) that affect the power performance as well as when the turbine can or cannot be operational. It is also important to highlight that tidal site characteristics may change dramatically between very short distances and that an array of turbines will also behave differently from an isolated turbine.

3.1.1.3 Economic viability

Due to their high levelised cost of energy, onshore wind projects, like most renewable generation projects, require financial support mechanisms, such as the Contracts for Difference (CfD) scheme, to be economically viable. GHD has explored the potential financeability of onshore wind projects on Orkney with and without CfD funding support.

Onshore wind financeability with CfD support

GHD has provided a supplementary assessment of potential outcomes of CfD auctions in 2019. The analysis accounts for the assumed CfD funding in 2019, competition between Remote Island Wind (RIW) and assumed CfD clearing price. The analysis is based on the following assumptions:

- Total available CfD funding of £295m in 2019;
- Auction clearing price for island onshore wind, Advanced Conversion Technologies (ACT) and offshore wind of £[redacted] to £[redacted]/MWh in 2012 prices;
- Assumed wholesale price £52/MWh in 2018 prices;
- [redacted]-[redacted]MW of distribution connected onshore wind on Orkney bidding for CfD support with an estimated required strike price of £[redacted]/MWh in 2018 prices;
- [redacted]MW of transmission connected onshore wind on Orkney bidding for CfD support with an estimated required strike price of £[redacted]-[redacted]/MWh in 2018 prices;
- [redacted]MW of transmission connected onshore wind on Shetland and Western Isles with an average bidding for CfD support with an estimated required strike price of £[redacted]/MWh in 2018 prices; and
- [redacted]MW of distribution connected onshore wind on Shetland and Western Isles with an average bidding for CfD support with an estimated required strike price of £[redacted]/MWh in 2018 prices.

DNV GL finds GHD assumptions for CfD funding, clearing price and estimated required strike price to be reasonable. The assumed required strike price is aligned with the high-level cost of energy modelling detailed below, and accounts for the additional TNUoS charges for transmission connected projects.

GHD's CfD analysis results in 100MW to 140MW of onshore wind achieving CfD support. The analysis results in three example outcomes and these are summarised below:

- Example 1 (Orkney 132 kV cable) [redacted] MW of distribution connected onshore wind in Orkney;
- Example 2 (Orkney 220 kV cable) [redacted] MW of distribution connected onshore wind in Orkney and [redacted] MW of transmission connected onshore wind; and
- Example 3 (Orkney 220 kV cable with lower strike price) [redacted] MW of distribution connected onshore wind in Orkney and [redacted] MW of transmission connected onshore wind.

DNV GL considers GHD's CfD assumptions and three examples to be reasonable, resulting in 100MW to 140MW of onshore wind on Orkney. This is broadly at the level assumed in GHD's scenarios S2 or S3, for onshore wind, over the period 2023-2025.

Onshore wind financeability without CfD support

GHD notes that wind generation could potentially be economically viable without a (CfD) support mechanism. Key to GHD's reasoning is that distribution-connected projects have a comparatively low LCoE because they do not pay transmission charges and may (through a BELLA/BEGA) be eligible for constraint payments, increasing their ability to secure PPAs. DNV GL agrees with this reasoning in principle.[8]

Moreover, in May 2018 "the UK's first subsid-free" onshore wind project, Withernwick II, reached financial close.[9] DNV GL understands that Withernwick II is distribution-connected and financed principally through a corporate Power Purchase Agreement (PPA), lending further credence to the potential viability of onshore wind project without CfD support. It should be noted that Withernwick II is a 4 turbine extension to the existing Withernwick Wind Farm, the extension wind project may have increased economically viable due to minor synergies in balance of plant and grid connection with the existing project.

GHD has also undertaken high level cost of energy modelling for both distribution and transmission connected onshore wind projects based on the following assumptions:

- Capex £1300/kW;
- Opex 5% of capex (including approximation of tax);
- 20-year life;
- Discount rate 6%;
- 45% capacity factor; and
- TNUoS in the range of £100/MW to £130/MW

DNV GL considers the above assumptions as reasonable for the period 2023-2025. The capacity factor is aligned with the analysis of operational project detail in the productivity and load factor section, above. Based on the above assumptions GHD has

8 DNV GL notes that Ofgem is currently considering the outcome of its July 2018 consultation on reform of charging arrangements for distributed generation technologies, which may be considered as part of a Significant Code Review (SCR). Should a potential future SCR result in distributed generation technologies having to pay TNUoS charges, this may affect the financeability of such projects. See: https://www.ofgem.gov.uk/system/files/docs/2018/07/network_access_consultation_july_2018_-_final.pdf

9 https://www.windpowermonthly.com/article/1465279/uks-first-subsidy-free-project-reaches-financial-close

estimated an LCoE of £49.9/MWh for distribution connected onshore wind and £71/MWh for transmission connected projects.

GHD has further identified that projects with local council support which may require a lower IRR, and GHD has assumed a reduced discount rate of 4%. GHD has estimated a potentially lower LCoE of £45/MWh for project with local support.

Based on the cost analysis GHD notes that BEIS' wholesale (baseload) electricity price forecast averages £52.70/MWh from 2023 until the end of the forecasting period at 2035. Even a 10% reduction on this central price would still enable the projects on Orkney with the lowest costs of energy to be economically viable if a PPA can be established at this price. DNV GL considers these results to support the proposition that distribution connected wind generation on Orkney could potentially be economically viable without a (CfD) support mechanism.

Onshore wind financeability without FiT support

GHD has considered a number of small scale distribution connected wind generators (comprising single sub-MW turbines). As noted in Section 3.1, GHD identifies these as 'FiT' projects.

The GHD memo states low rates of progress for these projects in scenario S1, reflecting a scenario where "the FiT scheme, currently due to close to new applicants in April 2019, is not resurrected in any form". However, the GHD memo further notes that Scenario 1 does assume "some single turbine community projects progress because of a low levelised cost of energy and their potential to secure a PPA".

DNV GL considers the above assumptions to be reasonable for the FiT projects due to the low levelised cost of energy and the increased likelihood of these projects securing a PPA. For example, and noted previously that the MW scale Withernwick II project located in the UK has secured a PPA. FiT projects are discussed further in Section 3.1.4.

Conclusion on the economic viability of onshore wind projects

DNV GL supports GHD's findings that there are several ways in which onshore distribution-connected wind farms could be financed and constructed, including RIW CfD and potentially without a support mechanism. Recent market evidence provides some support for this proposition.

Whilst it is not possible for DNV GL to comment on the specific economic viability of individual projects, DNV GL considers that GHD has adopted a reasonable approach in performing a risk-weighted assessment of future generation to account for the additional uncertainty in the financial viability of projects and to develop a range of reasonable generation scenarios.

DNV GL considers the CfD and LCoE analysis presented by GHD to provide a robust analysis for the economic viability of onshore wind. The resulting 5 generation scenarios assumed success rates (i.e. the proportion of wind projects applying for and securing a CfD) of ~45% to ~70% for onshore wind projects, which DNV GL considers as reasonable based on the 5-year period to 2023. DNV GL considers it reasonable to assume a success rate of ~50% for onshore wind based on the CfD and LCoE analysis, which is broadly at the level assumed in GHD's scenarios S2 or S3, for onshore wind, over the period 2023-2025.

Tidal projects

The GHD report provides a broad commentary on the prospect for marine generation in general and around Orkney. It provides comments on the declining financing appetite since the 2008 credit crisis and a focus on lower cost renewables, followed by recent advances in the development of tidal technology as well as evidence of renewed public sector (EU, Scottish government) support.

Supplementary analysis undertaken by GHD as part of the SWW review process provides an assessment of the ability of (wind and) tidal projects in securing CfD funding. GHD's illustrative analysis assumes a £[redacted]/MWh strike price (in today's prices) as a broad proxy for the LCOE of tidal installations. Based on an assumed wholesale price of £52.5/MWh, tidal installation would require a CfD subsidy of £[redacted]/MWh, over 5 times as much as offshore or island-based onshore wind. GHD concludes that[10]

"Tidal flow generation will not be able to compete head to head with offshore wind or islands onshore wind and will require a separate funding pot."

Our first observation on this assessment is to note that estimating a single reliable LCOE for tidal generation is challenging due to the early stage of tidal technology, the variety of technologies (and costs) being tested, and the dependency of both project costs and energy yields (discussed above) on its specific location. Where GHD assumes a strike price of £220/MWh, National Grid refers to a "future cost of tidal redispatch" of £150/MWh,[11] indicating how wide the potential range is, but also indicating that the LCOE for tidal is considerably above the LCOE[12] for wind generators.

DNV GL concurs with GHD's finding that tidal would not currently be competitive in CfD auctions unless it participates in a separate funding pot. By way of recent evidence to support this view, we note the Meygen tidal project in Pentland Firth participated in CfD auction round 2 in September 2017, but lost out to (principally) offshore wind and waste-to-energy projects, and is subsequently exploring alternative funding options with the UK government.[13]

Although we generally expect advancement in tidal generation technology that may make it more competitive in the future, we consider the road and timing to commercial viability remains uncertain. Earlier in this section we have commented on uncertainties in constructing tidal installations, particularly the serial development of large arrays, as well as uncertainties in their productivity. It will take considerable investments at a comparatively high risk to overcome these uncertainties, before tidal farm development at scale will become feasible. We therefore do not consider the development of tidal generation as depicted in GHD's high end scenarios, particularly beyond 2025, is likely in terms of scale and timing.

However, we do consider that for testing purposes, it is reasonable to assume that a small amount of tidal capacity may come forward, connected with the European Marine Energy Centre (EMEC). Such projects would be developed to test prototypes and need not be commercially viable, and therefore would not require CfD support. We consider

10 Supplementary information ([redacted]) provided 12/06/2018.

11 National Grid, Orkney Islands Strategic Wider Works – Needs Case: Cost Benefit Analysis, [redacted].

12 Department for Business, Energy & Industrial Strategy (BEIS), *Electricity Generation Costs*, November 2016, Table 6 estimates

13 https://www.scotsman.com/news/atlantis-to-seek-backing-to-extend-tidal-energy-project-1-4565866

that it is not unreasonable to assume that such capacity might be broadly at the level assumed in GHD's scenario S1 or S2 over 2023-2025.

3.1.2 Question A2: Are SHE Transmission's technology specific assumptions around increased uptake on Orkney during the 2020s reasonable and well justified?

Onshore wind projects

GHD has developed a detailed database of all anticipated generation projects; this has been compiled from a review of public sources, information provided by SHE Transmission and SHEPD, and stakeholder engagement on Orkney. GHD's Generation Database has been used to define the projected capacity levels considered in the five generation scenarios.

DNV GL has undertaken a high-level review of the GHD Generation Database against a publicly available source of wind farm projects either in planning or operational[14]. The publicly available information broadly supports the information in the GHD Generation Database for projects that have submitted planning applications, particularly for the larger sized projects which will have a more significant impact on the generation scenario considerations.

We note that the total amount of onshore wind project capacity assumed in GHD's Generation Database from which the generation scenarios are derived is approximately 250 MW. As noted in Section 3.1.1.1, the majority of the wind projects considered in GHD's Generation Database are in the scoping phase. We note that the publicly available database referred to for comparison[13] does not include projects in the scoping phase, and therefore DNV GL is unable to comment explicitly on whether the capacity of wind projects considered in the database is reasonable.

However, DNV GL recognise that GHD will have obtained a comprehensive understanding of projects that are in the earlier phase of development through stakeholder engagement and information received from SHE Transmission and SHEPD regarding grid connection applications.

3.1.3 Question A3: At what point in a generation project's development could Ofgem be confident that the project will commission?

The standard assumption in industry is that only once financial close has been achieved and construction has commenced on a generation project can one be confident the project will be commissioned. The further away from the construction phase a project is, the more uncertain it is that it will be commissioned.

DNV GL considers a risk-weighted assessment of future generation, where possible informed by specific information pertaining to individual projects (particularly major projects), to be necessary in order to develop a range of reasonable generation scenarios. DNV GL has reviewed SHET's assumptions regarding the degree(s) of certainty of specific projects, taking account of our assessments under questions A1

14 https://www.gov.uk/, accessed May 2018.

and A2 above, make the following comments regarding the project development assumptions made for wind and marine projects within the generation scenarios considered.

Scenarios 1-5 assume a success rate of ~45% to ~70% (i.e. the proportion of projects applying for and securing a CfD) for onshore wind, as discussed in Section 3.1. DNV GL considers this range of success rate for onshore wind to constitute a reasonable weighted approach.

As set out in Section 3.1.1, any expectation regarding tidal capacity being commissioned is inherently uncertain, principally due to the early stage of tidal generation technology and the many risks and uncertainties in the construction and subsequent operation of these installations, but also because tidal generators will not normally be competitive in CfD auctions. Hence, we consider that one cannot be confident of any tidal generation being commissioned to operate commercially. However, for testing purposes, we consider a small amount of tidal capacity connected with EMEC may come forward.

3.1.4 Question A4: Do the scenarios used by SHE Transmission represent a reasonable distribution of potential outcomes for future generation on Orkney?

We note that the lower end of GHD's generation scenarios, specifically Scenarios 1 and 2, are driven primarily by the assumptions made regarding onshore wind projects being built. The higher end, however, is driven by the assumptions made for tidal projects coming through to completion. Given that, as assumed by GHD and SHE Transmission, the vast majority of tidal generation will be commissioned between 2025 and 2031, this (potential) capacity is mostly relevant for the second subsea cable proposed under the phased approach, which we understand is to be subject of a further Needs Case application in the future.

Wind projects

The focus of GHD's scenarios S1-S5 regarding the potential development of wind farm projects is [redacted] distribution connected projects which are assumed to progress at various rates across the GHD scenarios.

For the wind projects, DNV GL has focussed its review on Scenario 1. DNV GL notes that the [redacted] potential CfD projects with total installed capacity of approximately 136 MW and [redacted] potential FiT projects with a total installed capacity of approximately 12 MW are included in Scenario 1 of the GHD Report. A proportion of these projects is assumed to be operational in 2023, with the rest coming online in subsequent years.

GHD's assumptions and DNV GL commentary regarding the CfD projects in Scenario 1 are discussed further in Section 3.1.1.

For subsequent scenarios, the [redacted] transmission-connected wind farm projects are assumed to have varying levels of success in securing a CfD and capacity is commissioned at different times. GHD assumes progressively more success for these projects in securing CfDs for its higher-end scenarios, and DNV GL considers this a reasonable range of outcomes to be tested.

In addition to these larger wind farm projects in the generation scenarios, there are a number of small scale distribution-connected wind farms, labelled as 'FiT' in the GHD analysis and amounting in total to 24 MW, which are assumed to have differing rates of progression across all the generation scenarios considered. In the higher-end scenarios, GHD's assumed rates of progress increase, assuming that a FiT replacement scheme emerges as well as a higher number of projects securing PPAs due to low levelised cost of energy. Although these outcomes are increasingly bullish, we consider they are reasonable outcomes to be explored.

Overall, DNV GL broadly agrees that GHD scenarios 1-5 assess a reasonable range of potential outcomes for future onshore wind generation on Orkney because of the following key reasons:

- The 5-year timescale to 2023 is suitable to enable projects currently in "scoping" to achieve the development and construction milestones;
- Orkney's high wind resource and capacity factors have resulted in significant interest in onshore wind, with 24 projects, totalling 250MW identified by GHD;
- The low LCoE of distribution connected onshore wind projects on Orkney is anticipated to enable projects to be financed and constructed without additional support; and

  Remote Island Wind CfD support enables both transmission and distribution projects to be financed and constructed on Orkney.

Tidal projects

As set out in section 3.1.1, we do not consider GHD's higher-end scenarios for tidal generation uptake to be realistic, particularly not for the period from 2025 onwards. However, a small amount of non-commercial tidal capacity is not unlikely to come forward as testing/prototype installations connected with EMEC. We consider that it is not unreasonable to assume that such capacity might be broadly at the level assumed in GHD's scenario S1 or S2 over 2023-2025.

3.2 Option Feasibility and Costing (Questions A5-A6)

This section assesses SHE Transmission's approach to **optioneering and costing** the proposed reinforcement (Questions A5 and A6).

3.2.1 Question A5: Has SHE Transmission considered all feasible options or operational measures to address the capacity requirements on Orkney?

In this section, we assess whether SHE Transmission has considered reasonable alternative investment options and/or operational measures to accommodate the capacity requirement, including:

- the methodology and rationale applied to the optioneering assessment;
- whether other feasible options should have been considered; and
- whether appropriate options were used in the CBA analysis.

3.2.1.1 Optioneering

Two-stage option assessment

SHE Transmission has adopted a two-stage option assessment. First the most appropriate subsea route for cable installation was identified, and then the most appropriate electrical connection for the chosen route was examined. The first option filter was carried out as a strategic route options assessment (SROA) and the second filter was an assessment of the cable configuration and specification from a technical and cost benefit viewpoint.

DNV GL Assessment of the two-stage option approach

SHE Transmission has taken a reasonable approach to split the option assessment into two separate stages: assessment of the appropriate route for the subsea cable; and assessment of the appropriate electrical connection. This split approach creates appropriate focus for 2 key aspects of this project. In particular, the assessment of submarine cable routing deserves specific attention, because (in general) offshore activities remain relatively new to transmission companies. Such assessments require the ability to manage and coordinate a relatively complex and multidisciplinary programme. The identification and assessment of a submarine route requires the consideration of environmental impacts, meteorological and oceanographic conditions, seabed sediments and existing marine use. Through the two-staged approach, DNV GL believes that SHE Transmission has enabled itself to focus appropriately on the key elements requiring assessment at each stage.

Strategic Route Options Assessment

SHE Transmission has based its preferred cable route on a methodology that uses a RAG (Red Amber Green) system to assess geographical project options. The assessment of the options aims to identify the best route, considering relevant environmental and technical and economic factors based on results from desktop studies as well as site investigation data. As guideline for this assessment SHE Transmission has applied the Holford Rules[15] as well as its internal subsea cable route selection guidance.

The following five-stage approach has been applied:

1. Baseline information and connection components
2. Rationale on technically feasible components using key assumptions and constraints
    - New Substation Location in Orkney (including Grid Supply Point)
    - Onshore Transmission infrastructure on Orkney
    - Landfall Options on Orkney
    - Subsea Cable Corridor between landfall options

[15] Holford Rules: https://www.nationalgrid.com/sites/default/files/documents/13795-The%20Holford%20Rules.pdf

- Landfall Options in Caithness
- Onshore Transmission infrastructure on Caithness
- Upgraded or new substation location on Caithness

3. Identification of strategic options:
4. Assessment of strategic option with a RAG assessment
5. Identification of the preferred route.

In this context, it useful to know that landfall options are most decisive for the strategic option locations. SHE Transmission identified six viable options that were further assessed. Figure 3 and

Table 3 below summarise the options and provide a geographical overview, as provided by the Needs Case submission.

Figure 3: Map of Strategic Route Options

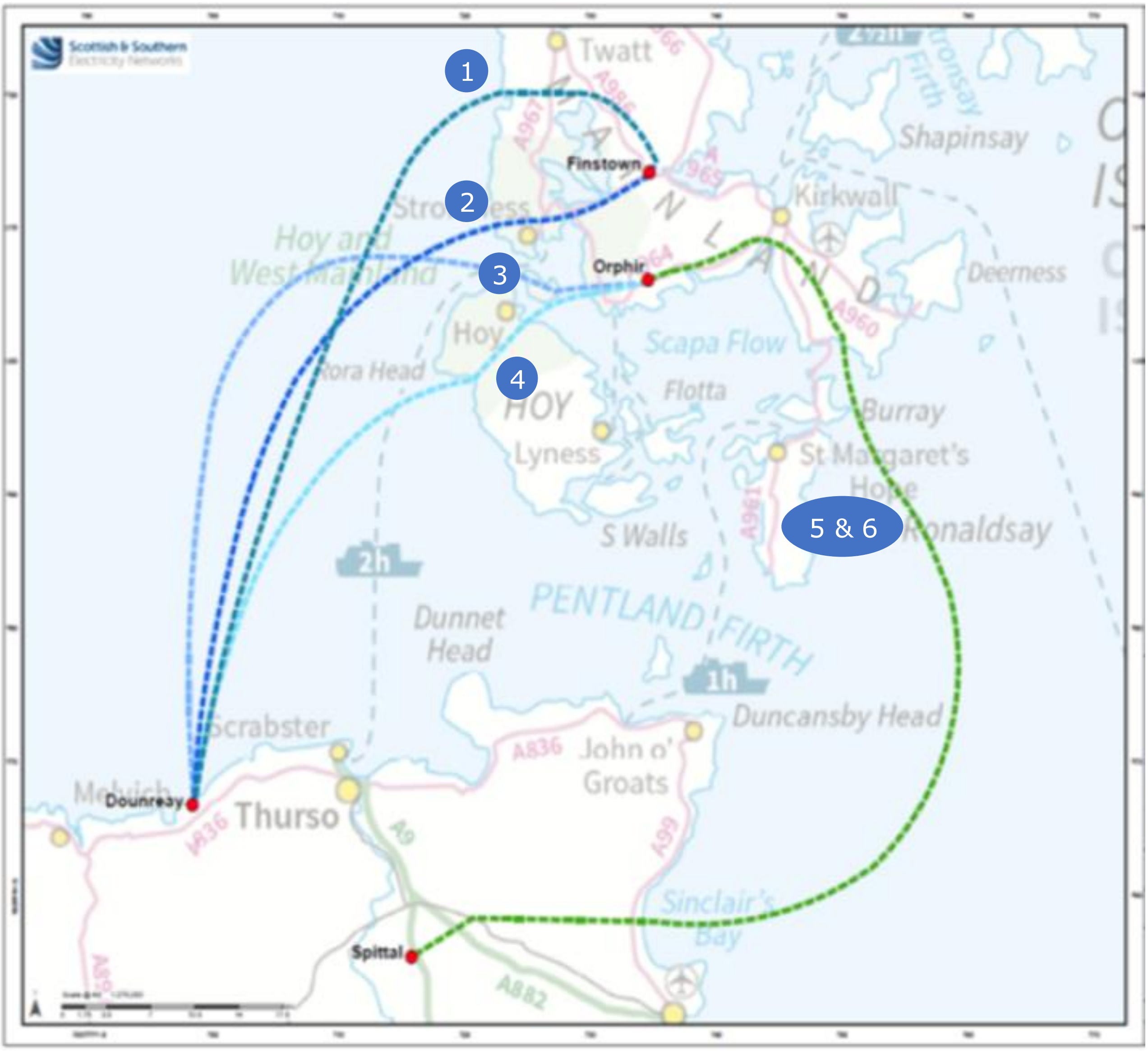


Table 3: Strategic Route Options

Option	East or West Route	Overall Length (km)	Route Description
SROA-1	West	82	Dounreay to Finstown via Bay of Skaill (land/sea cable)
SROA-2	West	68	Dounreay to Finstown via Billa Croo (land/sea cable)
SROA-3	West	66	Dounreay to Orphir via Graemsey (land/sea cable)
SROA-4	West	60	Dounreay to Orphir via Hoy (land/sea cable)
SROA-5	East	99	Spittal to Orphir (land/sea cable from mainland coast to Orkney, Caithness OHL)
SROA-6	East	105	Spittal to Orphir (land/sea cable from mainland coast to Orkney, Caithness cable)

Through the RAG assessment, SHE Transmission assesses a number of key criteria from the following disciplines: constructability, technology, system planning, environment, planning consents and cost estimate. The assessment highlights key issues and risks associated with each option, and informs SHE Transmission's ranking of options (Table 4).

Table 4: Orkney RAG Assessment

Option	Constructability	Technology	System Planning	Environment	Planning Consents	Cost Estimate	Rank
SROA-1	Amber	Green	Amber	Green	Green	Amber	4
SROA-2	Amber	Green	Green	Green	Green	Green	1
SROA-3	Red	Green	Green	Green	Green	Green	3
SROA-4	Amber	Green	Green	Green	Amber	Green	2
SROA-5	Amber	Green	Amber	Green	Amber	Red	6
SROA-6	Amber	Green	Amber	Green	Green	Red	5

The result of the RAG assessment shows that the SROA-2 (Finstown substation via onshore cable to south west Orkney and mainland landfall and subsea connection to Dounreay) achieved the highest ranking when compared against the other 5 route options.

DNV GL Assessment of the Strategic Route Options

SHE Transmission has applied a common approach consisting of five phases for the Strategic Route Options Assessment: establish initial situation, assumptions and boundary conditions, plan and execute actions for finding options (option identification), transparent assessment of results (RAG method) and identification of the best option.

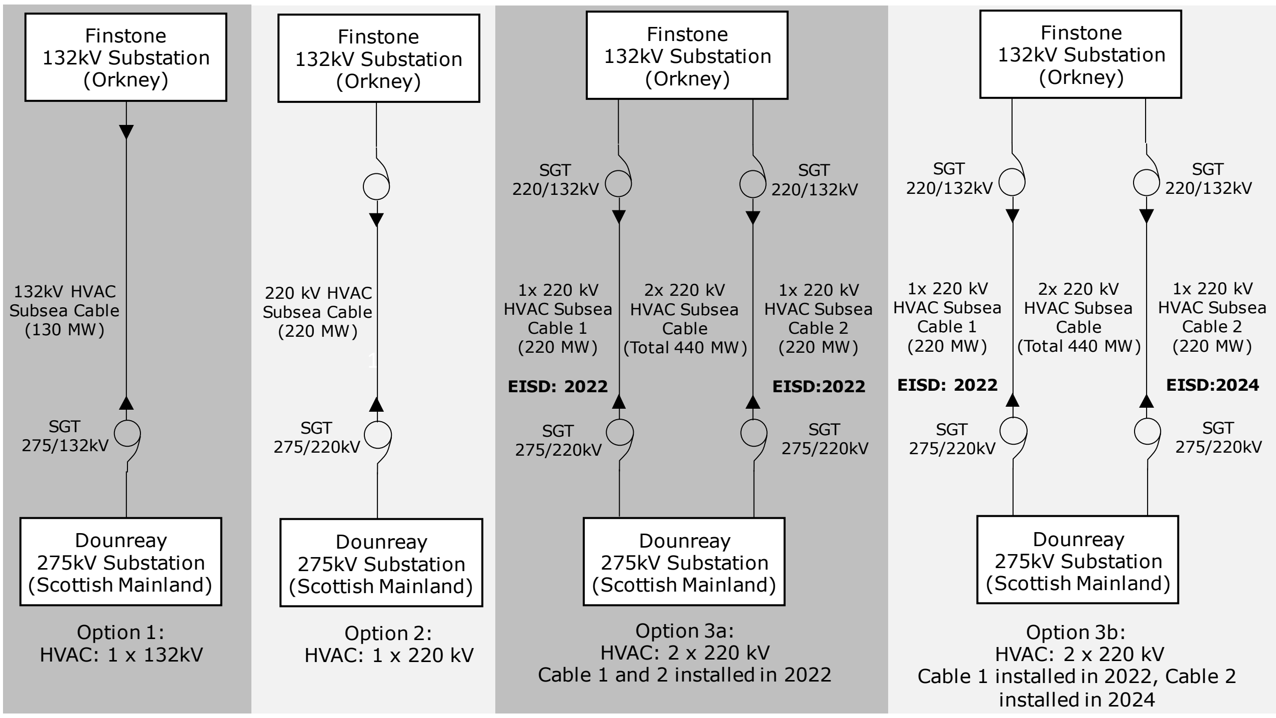
We consider that SHE Transmission has applied a well-structured and effectively managed process to determine the best cable route.

This part of the optioneering requires experience and expertise across a range of disciplines e.g. environmental designation, meteorological and oceanographic assessment, and seabed sediments and existing marine use, as well as assessing the value of World Heritage Sites on the Orkney Islands. SHE Transmission's Final Need Case report demonstrates that this expertise is present and has been used in this part of the optioneering. DNV GL believes that SHE Transmission has considered all possible Strategic Route Options for the subsea cable. Specifically, SHE Transmission has considered all routes related to the identified credible landfall options on Caithness and Orkney.

Subsea Cable Options Considered

In its Final Needs Case submission, SHE Transmission identifies five possible reinforcement options for the transmission link from Orkney to the Scottish mainland and a 132kV transmission network on Orkney Islands. Three options are based on HVAC technology (Figure 4) and two on HVDC technology. The schematics were submitted in the Needs case submission:

Figure 4: Schematic representation of three HVAC options



Option 1 – Single 132 kV subsea cable – involves a 132kV HVAC cable with a cable capacity of 130 MW. SHE Transmission through previous project experience from the SHEPD Isle of Wright cables indicates that the capacity of 130 MW can be met with a 132kV cable.

Option 2 – Single 220kV subsea cable – involves a 220 kV HVAC cable with a cable capacity of 220MW. SHE Transmission indicates that previous experience with the recent Kintyre-Hunterston project has shown that a 220kV cable with a capacity of 220 MW should be possible. However, SHE Transmission did not consider higher voltages due to project challenges with cable weight, installation, vessel availability, increasing charging currents and landfall installation which can reduce the cable ratings.

Option 3a – Double 220kV subsea cables installed together – involves two 220kV HVAC cables with a SQSS compliant capacity of 220 MW (N-1 criterion) and a non-compliant SQSS capacity of 440MW. SHE Transmission provided this option to explore the possible outcomes around compliance with SQSS and the benefit of providing 440MW capacity up front. SHE Transmission did not consider higher voltages due to project challenges with cable weight, installation, vessel availability, increasing charging currents and landfall installation which can reduce the cable ratings.

Option 3b – Double 220kV subsea cables installed in different phases – involves the same approach as for option 3a with the difference that the cables are installed in different phases to increase efficiency and flexibility by SHE Transmission. This option was introduced to explore the phasing between the first cable installation with an EISD of October 2022 followed by a second cable with an EISD of October 2024. The CBA studies explore the optimal timing of the phased cable installation to provide the most economic project.

Option 4 – HVDC link with a cable capacity of 300 MW – involves an HVDC connection between Orkney and the Scottish mainland with a balanced monopole HVDC configuration and a link capacity of 300 MW. SHE Transmission has prior experience with HVDC projects as in the Caithness Moray Project and the studies for other links to the Scottish islands.

Option 5 – HVDC link with a cable capacity of 600 MW – involves an HVDC connection between Orkney and the Scottish mainland with a balanced monopole HVDC configuration and a link capacity of 600 MW. SHE Transmission has prior experience with HVDC projects as in the Caithness Moray Project and the studies for other links to the Scottish islands.

In addition to Options 1-5 set out above, SHEP-D has indicated that it plans to replace one of the existing 33kV subsea cables which currently connects Orkney to the Scottish mainland due to faults on the existing cable. Replacement with a 66kV cable may a credible option. SHE Transmission did not consider this option in detail in its initial optioneering as it was felt that the cost of this option would be high relative to the constraints it could relieve.

DNV GL Assessment on the Subsea Cable Options Considered

SHE Transmission has considered five options for the subsea cable, three based on HVAC technology and two on HVDC technology. Regarding the technology choice, we consider that HVAC technology is normally used for relatively short distances (less than 70-80 km) for cost reasons and because it is a familiar technology with which network companies have a lot of experience (more than 60 years). For this reason alone, DNV GL understands the general preference for HVAC technology, except for the cable route Orphir to Spittal (see Table 3), the length of the identified cable routes falls within the limit of 80 km.

Whether all (credible) cable options have been considered depends on the voltage level (275kV) of transmission network on the Scottish mainland, the voltage level of the planned transmission network on Orkney, commercial experience with HVAC subsea cable and the extent to which the options comply with SQSS. SHE Transmission noted that subsea cable options with a voltage level higher than 220kV have not been considered due to project challenges such as cable weight, installation, vessel availability, increasing charging currents and landfall installations. DNV GL recognizes these project obstacles but would like to challenge this "no-need-to-be-considered" pre-assumption and states that it is useful to examine the option of a submarine 275kV cable, even if this was just for completeness. An ENTSO report[16] shows positive developments in the area of subsea cables, for example the possibility to apply 257kV and 400kV subsea cables and the construction of new vessels.

It is also worth mentioning that the plans of SHEPD in accommodating renewable generation developments on Orkney and cable connection with the Scottish mainland can be decisive for the considered options. If SHEPD, for instance, had advanced plans to upgrade one of the existing 33kV cable connections with the Scottish mainland to a 66kV cable, this might have impacted the choice of the best option. The installation of a 66 kV (rating:70 - 90 MVA) cable would increase the import/export capacity from around 40 MW to around 70 – 110MW, assuming an adequate reactive compensation.

Apart from the comparatively low cost of a 66kV cable, the main advantage of implementation of this plan is the time saved laying the cable, since the existing cable route, Scorraday (Orkney) – Thurso (Scottish mainland) could be used. Moreover, cost savings in cable-laying and maintenance can be obtained through the experience gained with the two existing subsea cables. On the other hand, compared with cable of higher voltage (e.g. 132 kV or 220 kV), the electrical losses of a 66kV cable are higher. It cannot be ruled out that an optioneering and cost-benefit analysis that also takes into account the increased export/import capacity resulting from the installation of the 66kV cable connection (Scorraday - Thurso) might yield a preferred option that differs from that of SHE-T, e.g. in transmission capacity and phasing. However, since the option has not been explored, this has not been demonstrated.

DNV GL has not been asked to undertake a detailed assessment of the cost-benefit analysis informing the identification of the preferred solution. We do provide an assessment of key inputs to the CBA, including our views on the generation scenarios (questions A1-A4 in section 3.1) and our assessment of efficient reinforcement costs (question A6 in section 3.2.2). However, based on our assessment of SHE Transmission's approach to optioneering, we consider that the CBA should be expanded to include two further options identified above:

- Application of a subsea cable connection with the voltage level (275kV) of the transmission network of the Scottish mainland; and
- Application of a 66kV subsea cable connection as a replacement for the 33kV subsea cable that is approaching the end of its useful life (noting that this option strictly speaking is not within the mandate of a transmission business, and that in any case coordination with SHEPD would be required).

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[16] ENTSO-E (2012): Offshore Transmission Technology (http://www.benelux.int/files/6814/0923/4514/offshore_grid_technology.pdf)

Assessment of these options would enhance the robustness of the CBA and confirm whether the preferred solution does represent best value for money for consumers.

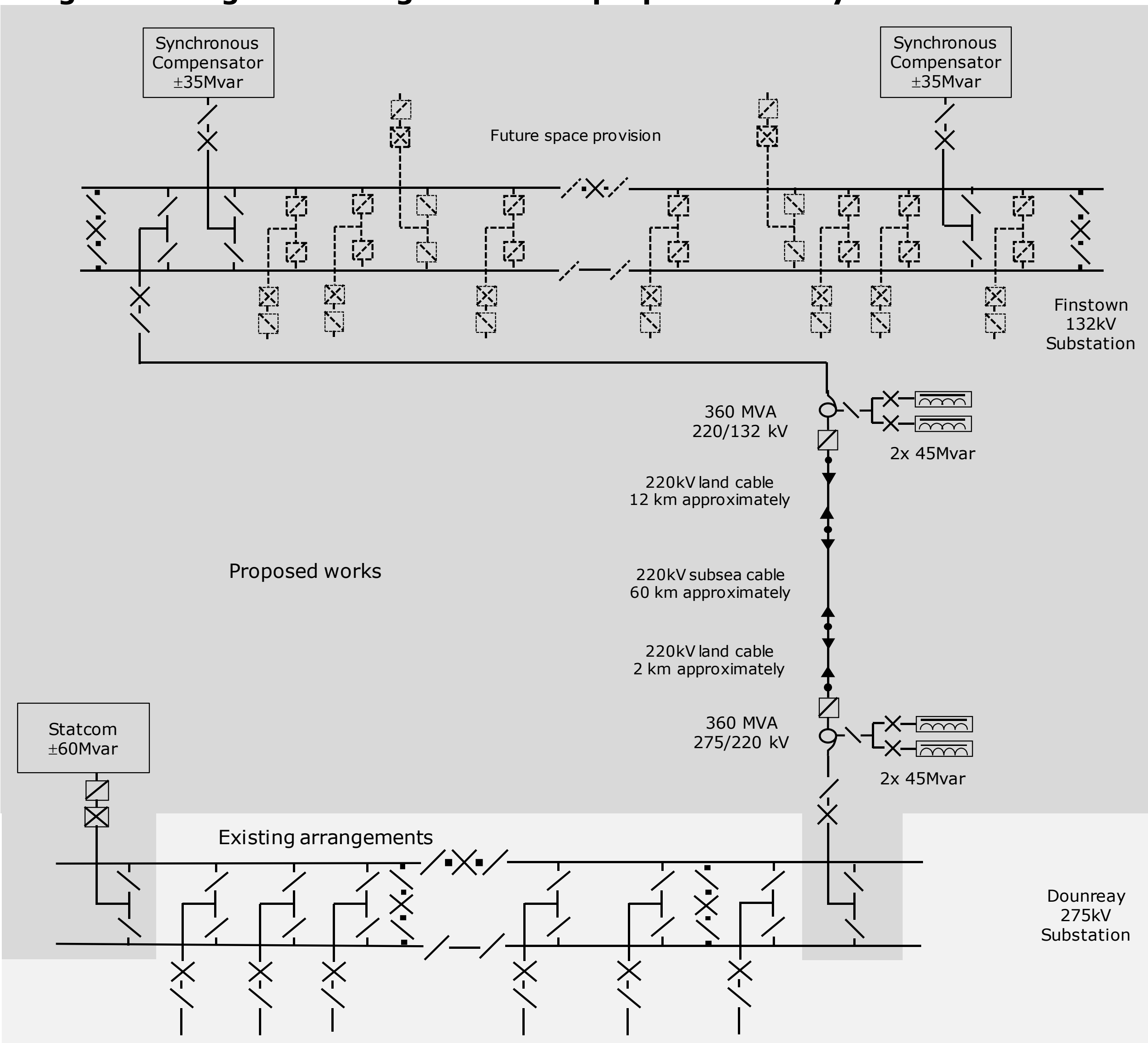
We conclude that although the optioneering approach is not unreasonable, we believe that the above two options are potentially feasible and would merit consideration alongside the other options considered so far.

Preferred Reinforcement Option

Figure 5 shows SHE Transmission's preferred route: the 220kV subsea cable will be connected between Dounreay on the Scottish mainland and a new 132kV substation at Finstown on Orkney. Figure 6 provides the single line diagram.

Figure 5: Preferred Route for the Orkney Link

Figure 6: Single Line Diagram for the proposed Orkney Transmission Link



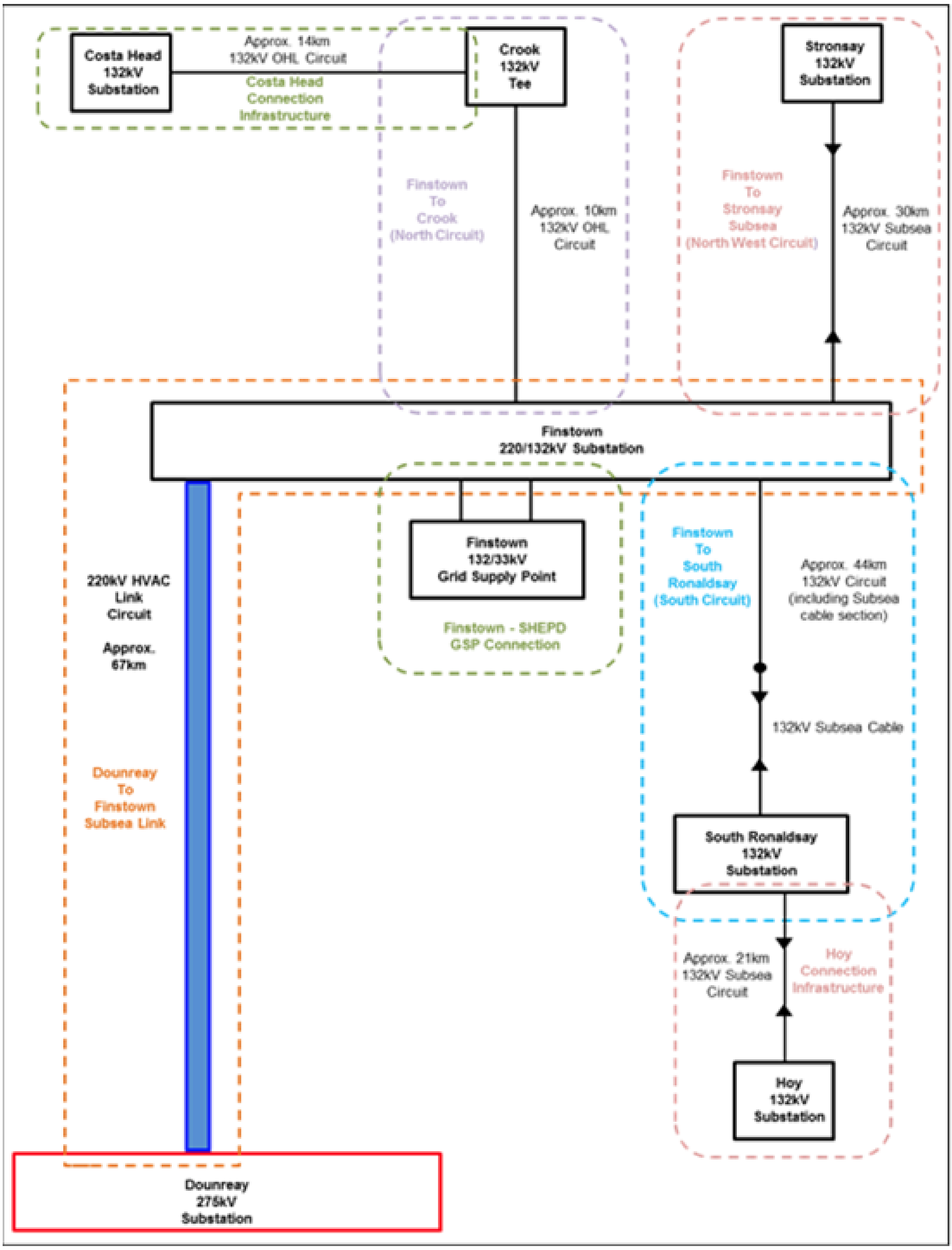
As described in section 2.2, SHE Transmission's preferred reinforcement option is a single AC 220 kV, 220 MW subsea cable to be commissioned in 2022 (Option 2). Under a 2-staged approach, Option 2 might turn into Option 3b, involving a second cable in 2024, but that is contingent on future generation developments and not subject to the current Needs Case submission. SHE Transmission has based its preferred solution on a cost-benefit analysis of the 5 options considered, including a Least Worst Regret Analysis.

Local transmission infrastructure

Alongside its specific considerations for the Orkney link, SHE Transmission provides an assessment of what it refers to as "Local Transmission Infrastructure" on Orkney, by way of context to the proposed reinforcement. Due to the geographical spread of the generators on Orkney a 132kV local transmission network will be required on the island. This infrastructure will be based on single-circuit overhead lines which are strung on wood pole structures as opposed to steel towers. An inter-island subsea cable may also be necessary to connect generation across the islands.

As currently envisaged by SHE Transmission, the local 132kV infrastructure is made up by a radial network. A single-line block diagram of the Orkney link and the proposed 132kV infrastructure is shown in Figure 7 below.

Figure 7: Single Line Diagram of the Orkney Island 132 kV Local Infrastructure



The Final Needs case submission identifies the following additional infrastructure in local transmission network:

- 32km 132kV transmission line from Finstown substation to the south-eastern end of the Orkney mainland (in the region of Holm) where it would transition to a 10 km 132kV subsea cable connecting to a new South Ronaldsay 132kV substation,
- 10km 132kV transmission line from the Finstown substation to a new substation at Crook,
- 21km 132kV subsea transmission cable from South Ronaldsay substation to a new Hoy 132kV substation,
- 12km 132kV transmission line from Finstown substation transitioning to an 8km subsea cable connecting to a new 132kV substation one Hoy,
- 14km 132kV transmission line from Crook substation to a new 132kV substation in the vicinity of the proposed Costa Head tidal project,
- 3km 132kV transmission line from Finstown substation transitioning to a 30km subsea cable connecting to a new 132kV substation on Stronsay.

The development of the 132kV infrastructure is subject to public consultation and planning. The final design and routing still have to be finalised based on precise need for transmission capacity.

DNV GL Assessment of the local transmission infrastructure

Review of SHE Transmissions considerations of the local network infrastructure is not formally part of the scope of this assignment. However, we believe its consideration bears relevance to SHE Transmission's proposed solution and provide a high-level opinion here.

SHE Transmission has provided only one solution for the local transmission infrastructure, which we consider insufficient for a comprehensive assessment of the proposed reinforcement in the context of the wider network area, which we consider should include the distribution network. Although SHE Transmission has indicated that it cooperates with SHEPD, it is insufficiently clear from the Needs Case submission whether this cooperation has resulted in a transmission network design based on studies in which power transmission and distribution are considered together, i.e. based on integrated network analyses. Particularly, for this case where a green field approach for transmission is concerned - there is no transmission network at Orkney - an integrated approach provides benefits. An integrated network analysis ensures that the interaction between the transmission network and the distribution network is also taken into account, so that a transmission network design can be chosen that maximizes power transmission and distribution, while meeting security of supply requirements. We believe that a comprehensive integrated network study might discover other technically feasible and economical solutions (such as, for instance, the aforementioned 66kV cable upgrade) that are missed when the transmission network and distribution network are separately studied.

Hence, we consider that a solution developed in holistic consideration of the local transmission and distribution infrastructure can potentially deliver added benefits for consumers, and we recommend that an integral network analysis is undertaken to further inform the assessment of the Orkney Transmission link.

3.2.2 Question A6: Are any costs relating to technical functionality beyond the minimum required to deliver the project's requirement across each of the options within the CBA clearly identified, quantified and justified?

3.2.2.1 Transmission Link Option Costs

SHE Transmission has noted that its cost estimates have been derived from historical project costs and informed and updated by the most recent tender information and framework arrangement as and when available.

Table 5: Cost Summary for the Options

Option	Technology	Item	Cost(£m)
1	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]
		Link (Subsea/Land cable)	[redacted]
2	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]
		Link (Subsea/Land cable)	[redacted]
3a	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]
		Link (Subsea/Land cable)	[redacted]
3b	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]
		Link (Subsea/Land cable)	[redacted]
4	HVDC	Dounreay/Finstown Substation	[redacted]
		Link (Subsea/Land cable + Converter Stations)	[redacted]
5	HVDC	Dounreay/Finstown Substation	[redacted]
		Link (Subsea/Land cable + Converter Stations)	[redacted]

DNV GL Assessment on Transmission Link Cost Options

In order to assess SHE transmission's cost estimates, DNV GL has prepared its own estimates of the costs of the options considered. Our cost estimates are based on DNV GL's internal cost database and on cost figures obtained from National Grid's Ten-Year Electricity Statement 2015, Appendix E. For a more detailed assessment, we have split the total costs into the following cost items: cable costs, substation costs, HVDC cost and local transmission network costs. Our review is discussed by reference to these building blocks.

Table 6: Estimated cost DNV GL

Option	Tech-nology	Item	SHE Transmission Cost Estimate (£m)	DNV GL Cost Estimate (£m)	Difference
1	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable)	[redacted]	[redacted]	[redacted]
2	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable)	[redacted]	[redacted]	[redacted]
3a	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable)	[redacted]	[redacted]	[redacted]
3b	HVAC	Dounreay/Finstown Substation (incl voltage regulation)	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable)	[redacted]	[redacted]	[redacted]
4	HVDC	Dounreay/Finstown Substation	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable + Converter Stations)	[redacted]	[redacted]	[redacted]
5	HVDC	Dounreay/Finstown Substation	[redacted]	[redacted]	[redacted]
		Link (Subsea/Land cable + Converter Stations)	[redacted]	[redacted]	[redacted]

Cable costs

A comparison of the cost estimated by DNV GL (Table 6) with the cost estimated by SHE Transmission shows that DNV GL's cost estimation is consistently lower. A possible explanation for this difference lies in the fact that our estimate only covers typical installation costs for subsea cables, but we cannot estimate possible location-specific costs for laying the cable options proposed. Estimating location-specific installation costs remains a challenge, due to the many factors at play, including, among others, seabed morphology, laying methodology, the burial depth and vessel costs. Moreover, due to the relative small number of subsea cable projects, available reference data is very limited and costing methodologies and categorisation are inconsistent.

We also note that SHE Transmission has provided a high level overall cost estimate, which is not unreasonable for Final Needs Case stage, but we would consider further detail and transparency will need to be provided in a potential future Project Assessment.

Substation costs

As part of the proposed works, the Dounreay substation needs to be extended, whereas a new substation needs to be built at Finstown. As a result, the scope of works associated with each of the substations varies, which is reflected in the associated costs. The existing substation in Dounreay will be extended with transformers, shunt reactors, STATCOM and the additional switchgear bays. The proposed new substation in Finstown will include components such as transformers, shunt reactors, synchronous condensers and the respective switchgear bays which will increase the total cost of the substation.

We have based our cost estimate for the substations on information provided by SHE Transmission, which reflects the configuration of the substations in each option, as well as cost figures from the National Grid Ten Year Electricity Statement. The HVAC substation costs estimated by SHE Transmission are lower than those estimated by DNV GL. The main reason for this difference is that DNV GL has based the cost estimation on much higher unit cost for the SGT transformers and included two additional 132/33kV transformers in estimation of the cost of substation Finstown. The 132/33 kV transformers are required for evacuation of electric power from 33kV grid Orkney. This difference in cost estimates, although on the high side, reflect the stage of the project and its uncertainties, and we consider differences in the 15% - 30% range not to be unreasonable.

HVDC costs

SHE Transmission has provided single figures of £531 million and £590 million for the HVDC links of 300MW and 600MW respectively. These cover the subsea/land cable and converter station costs. The results are included in Table 6, which shows that our estimates of the substations and those provided by SHE Transmission are in the same order of magnitude: the difference is less than 15%, which we consider acceptable in this stage of the SWW process. Table 6 also shows that the cost estimates of DNV GL of the cable are lower than those of SHE Transmission. As noted above, a plausible explanation is that we have not taken into account the typical location-specific costs for subsea cables.

Conclusion

DNV GL considers that the substation cost of the options provided by SHE Transmission reasonable. However, the cable costs provided by SHE Transmission are relatively high, compared with those of DNV GL. This is possibly due to location-specific installation costs of the cable which SHE Transmission has taken into account. In the Project Assessment stage of the SWW process, specific information about the impact of location-specific circumstances on cable laying should be more informative.

3.2.2.2 Cost related to the Preferred Solution

Figure 8 shows the single line diagram of the preferred solution: the Dounreay substation is extended with two additional bays, a STATCOM and a GTS with reactive compensation. The Finstown substation consists of 14 switchgear bays, a transformer for the connection between Orkney and the Scottish mainland, two transformers for connections to the local transmission network at Orkney and two bays for the connection of two synchronous condensers. The corresponding cost breakdown of the preferred solution provided by SHE transmission is provided in Table 7.

Figure 8: Single line diagram of the preferred solution (Option 2)

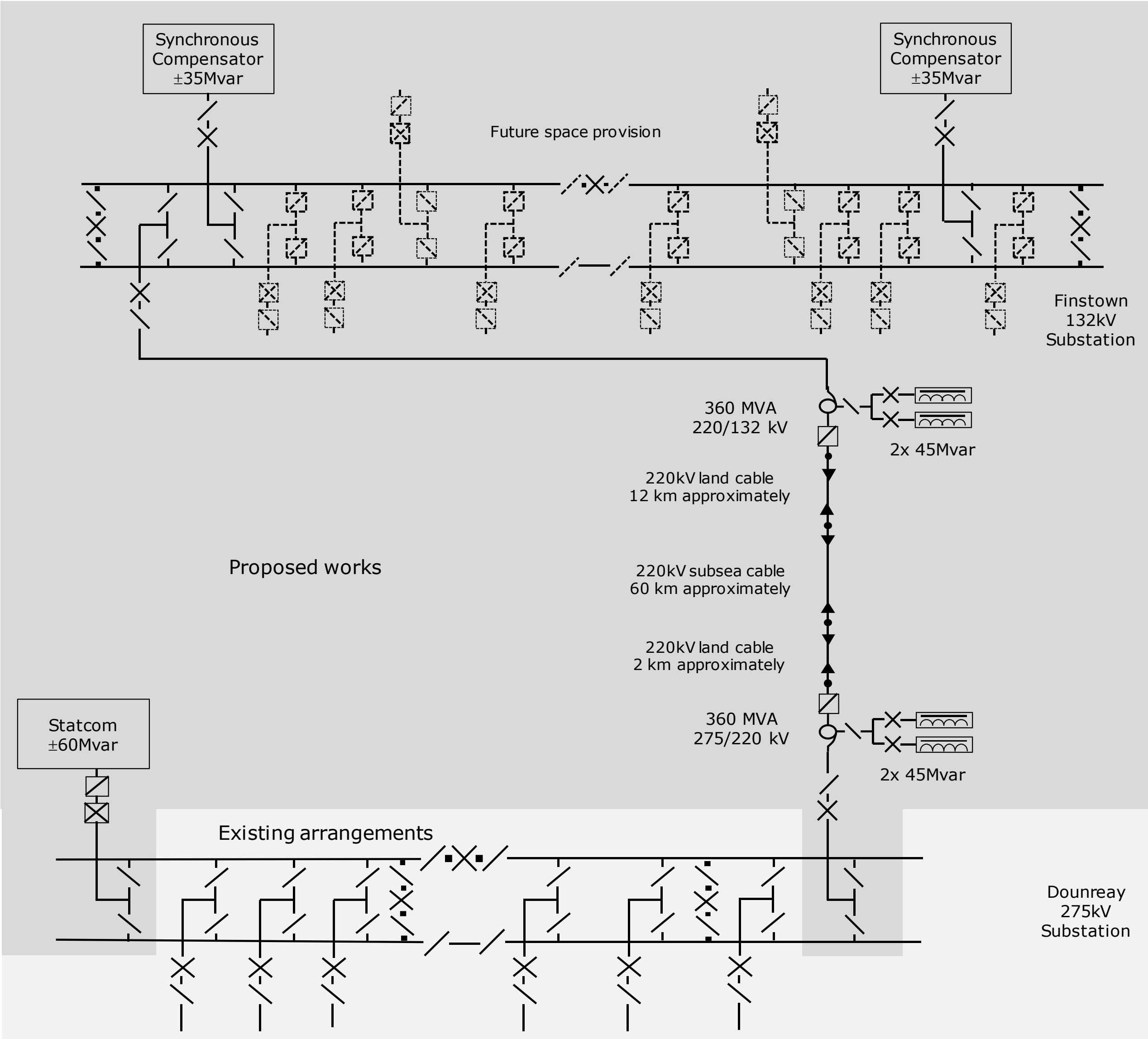


Table 7: Cost breakdown of the preferred solution

Cost Breakdown	Cost (£ million)
Dounreay/Finstown Substation (incl voltage regulation)	[redacted]
Link (Subsea/Land Cable)	[redacted]
TOTAL	**264**

3.3 Summary of Findings

3.3.1 Questions A1-A4

Onshore wind projects

DNV GL has reviewed GHD's assumptions regarding the production timings and productivity and load factors for onshore wind generators and concludes they are reasonable.

DNV GL has also assessed GHD's assumptions regarding the potential financeability of onshore wind projects on Orkney, both with and without CFD funding. We support GHD's findings that onshore distribution-connected wind farms need not necessarily rely on CfD funding to be economically viable and considers recent market evidence provides some support for this proposition.

We also consider that GHD has adopted a reasonable approach in performing a risk-weighted assessment of future generation to account for the additional uncertainty in the financial viability of projects and to develop a range of reasonable generation scenarios.

DNV GL considers the CfD and LCoE analysis presented by GHD to provide a robust analysis for the economic viability of onshore wind. GHD's 5 generation scenarios assume between 45% and 70% of onshore wind projects on Orkney could be successful in a future RIW CfD auction, which DNV GL considers reasonable for the 5-year period to 2023. This reflects an average 50% success rate for onshore wind, which is broadly at the level assumed in GHD's scenarios S2 or S3, for onshore wind, over the period 2023-2025.

Tidal projects

DNV GL does not consider the assumed scale and timing of tidal generation capacity to be reasonable, particularly in relation to large tidal arrays in the mid-to-late 2020s. The principal reason for this is that tidal is still an infant technology, and the construction of large arrays requires substantial specialist equipment and processes that are currently being tested and will take years to be refined further and de-risked.

DNV GL does not disagree with SHE Transmission's assumptions on tidal load factors, however, like SHE Transmission, we agree that tidal load factors are highly uncertain.

As regards the financeability of tidal generation projects, DNV GL concurs with GHDs finding that tidal would not currently be competitive in CfD auctions unless it participates in a separate funding pot. Although we generally expect advancement in tidal generation technology that may make it more competitive in the future, we consider the road and timing to commercial viability remains uncertain, principally due to cost and productivity uncertainties.

We therefore do not consider the development of tidal generation as depicted in GHD's high end scenarios, particularly beyond 2025, is likely in terms of scale and timing. However, we also consider that it is not unreasonable to assume that a small amount of tidal capacity, broadly at the level assumed in GHD's scenario S1 or S2 over 2023-2025, could come forward with EMEC for testing purposes.

3.3.2 Question A5

Splitting the option assessment into two separate stages, namely assessing the appropriate route for the submarine cable and assessing the appropriate electrical connection is the right approach because it provides focus on each of these two areas.

DNV GL believes that SHE Transmission has considered all possible Strategic Route Options for the subsea cable, i.e. SHE Transmission has considered all routes related to the identified credible landfall options on Caithness and Orkney.

DNV GL believes that the optioneering applied should be extended with two additional options for the Orkney link with the Scottish mainland. One option is related to the use of a 275kV subsea cable, the other to a 66 kV submarine cable. DNV GL recommends that SHE-Transmission re-run the CBA, extended with these additional options to verify the robustness of the preferred solution

A review of the Local Transmission Infrastructure is not part of the scope of this assignment. However, we consider that a solution developed in consideration of the local transmission infrastructure can potentially deliver added benefits for consumers, and we recommend that an integral distribution and transmission network analysis is undertaken to further inform the assessment of the Orkney Transmission link.

3.3.3 Question A6

DNV GL considers that the cable costs of the options provided by SHE Transmission are relatively high. This is possibly due to location-specific installation costs of the cable which SHE Transmission has considered. In the Project Assessment stage of the SWW process, specific information about the impact of location-specific circumstances on cable laying should be more decisive.

DNV GL considers that the cost estimates of the HVAC substations of the options and preferred solution provided by SHE Transmission reasonable.

4 ASSESSMENT PART B: SUITABILITY OF THE DELIVERY PLAN

This section focuses on the **suitability of the delivery plan** (Questions B1-B6) for SHE Transmission's proposed reinforcement option, as well as other reinforcement options identified in the optioneering analysis.

4.1 Suitability of the Delivery Plan

4.1.1 Question B1: Does SHE Transmission's delivery plan/schedule provide sufficient detail and justification on assumptions relating to project lead times and key milestones, and interactions with the CfD auction process?

SHE Transmission's Delivery Plan

The Orkney Transmission link has been nominated as a Large Capital Project (LCP), meaning that the project will progress through the following SSE LCP guidance outlined in Figure 9 and explained below:

Figure 9: SSE LCP guidance framework[17]

1. **Opportunity assessment**. The opportunity assessment stage relates to the assessment of the business opportunities which are the best strategic and regulatory fit. The purpose of this stage is to provide a technically, environmentally and economically feasible option to be developed further. Key milestones/deliverables include:
    - Evaluation of the SROA resulting and the preferred option between the Orkney islands and the Scottish mainland;
    - Specification of Works Information for the tender process; and
    - A statutory and public consultation (November 2017) with: communities, Orkney Council (OIC), Scottish Natural Heritage, Scottish Environment Protection Agency and Historic Environment Scotland option between the Orkney islands and the Scottish mainland.
2. **Development**. The development stage is the phase where the selected options are being assessed further with desk and site investigation studies in order to further define the best alternative solution. Engagement with statutory and other stakeholders is necessary to employ a consent strategy. The final goal of the stage is to select the best option. Key milestones/deliverables include:

17 Needs case submission, figure 15, p47.

- Final Needs Case and CBA;
- 220 kV Cable and 220/132 kV Substation Tender and Assessment;
- Consultation Project and Alternative Approach: Stakeholder events in February 2018 in Orkney and Glasgow, and consultation in June 2018;
- Needs Case Report; 'minded to' decision published in late 2018.

3. **Refinement**. The refinement stage confirms the technology choice and concludes the environmental studies. Engagement with contractors and developers is requested in order to better refine the programme, cost and execution risk. At the end of this stage the full capital investment funding is requested from the SHEPD Board to take the project through execution. Key milestones/deliverables include:
    - Project Assessment submission and discussion with Ofgem; decision for the overall programme end of Q1 2019;
    - Consent Submission Marine/Terrestrial: Marine Scotland Licence Application (end of Q3 2018) and Town and Country Planning Consent for the 220kV cable and the 220/132 kV substation (beginning of Q4 2018);
4. **Execution**. The execution stage is followed after the capital funding has been secured and is the stage where the detailed design of the components is being procured, constructed and commissioned. Key milestones/deliverables include:
    - Site preparation and construction, manufacture and installation of equipment
    - Commissioning (begin in Q2 2022 and complete in Q4 2022)
    - Energisation of the Orkney Transmission link and substation at Finstown (October 2022)
5. **Operate and evaluate.** In the final stage of the SSE LCP guidance the project asset is handed over the project owner to operate and evaluate. Key deliverable:
    - Hand-over documents

SHE Transmission has actively engaged relevant stakeholders in all stages included in the SSE LCP guidance. Table 8 shows the identified key stakeholders. A stakeholder engagement plan has been developed to structure engagement of the stakeholders.

Table 8: Stakeholder Group and Organisation

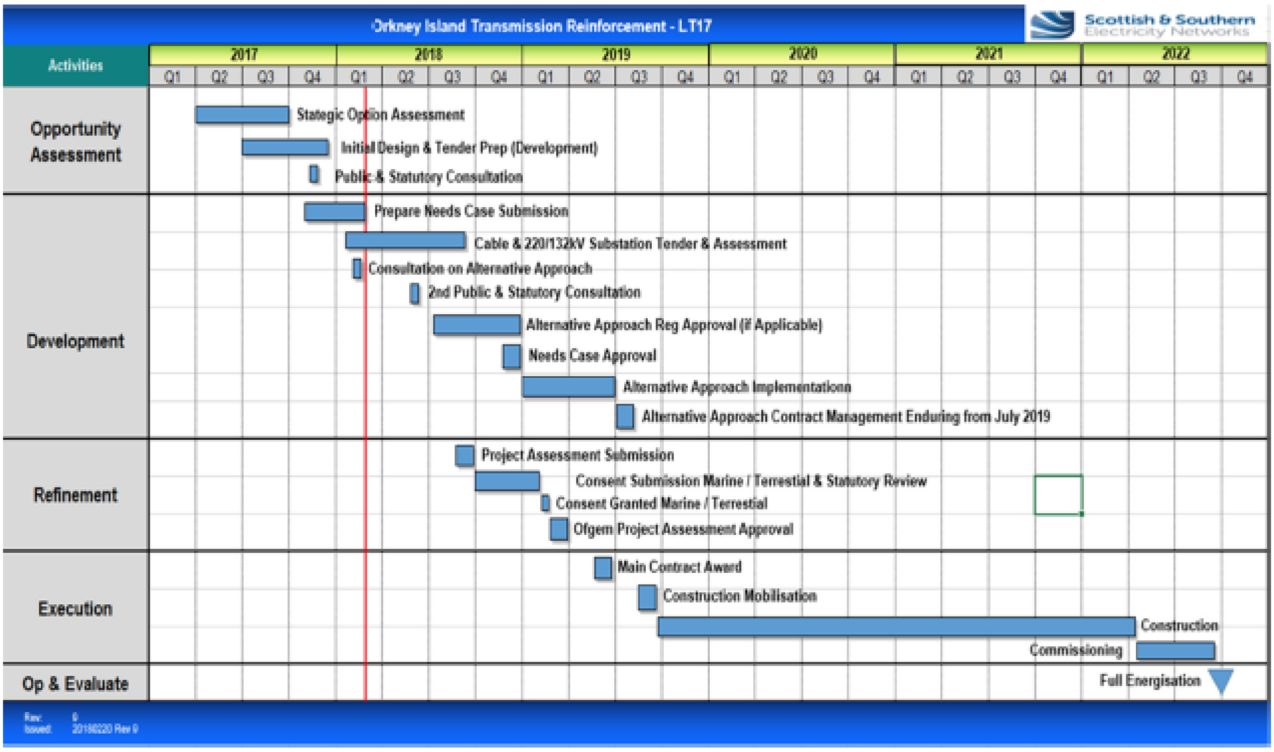
Stakeholder Group	Organisation
Industry	Regulator: Ofgem; System Operator: National Grid; Other Industry Parties e.g. other Network Operators, Developers.
Developers	Transmission connected customers; providing support to SHEPD in their consortium engagement.
Political representatives and government bodies	The UK Government's Department of Business, Energy and Industrial Strategy (BEIS); The Scottish Government's Energy Directorate; Orkney Islands Council (both officials and elected members); and local elected members (MPs and MSPs).
Media	Various, mainly local.
Community/local residents	Community and local residents
Statutory consultees	Scotland National Heritage; Scotland Environmental Protection Agency; Marine Scotland.

On request, SHE Transmission has also provided the required set of deliverables accompanied with gate 2 of the SSE LCP guidance framework. The following deliverables are included:

- Health and Safety Plan: a management plan that considers asset integrity and responses to the design, construction and operational risks for the project.
- Environmental requirements: the plan identifies requirements and responsibilities for handover to preconstruction and construction surveys and identify documentation required to satisfy planning conditions
- Cost estimate classification: an estimation of project cost elements based upon definitive layouts and preferred engineering design together with an associated program.
- Business case: in which the project and its strategic fit is further defined.
- Project development: in which the project scope is further developed, and the strategic objectives and assumptions are confirmed.
- Contract and Procurement strategy: where options for contract and procurement strategies shall have been developed and preferred options identified.
- Planning permission and land options: in which planning application and land options shall have been submitted and secured.
- Grid connection: in which a grid connection offer has been received and the route is known.
- Refinement resource review: in which resources required for project refinement are identified.
- Industry contractual and communication framework: in which industry codes, rules and governance requirements are identified and document areas which do not conform with rules are identified.
- Detailed site feasibility: in which required site investigations (if necessary) are further conducted.
- Basis of design complete: in which technology assessment are complete and technology is selected.
- Risk management plan: in which the risk plan is further defined.
- Quality management: in which the quality strategy throughout the project lifecycle is defined.
- Lessons learned: in which workshop is help to identify and record lessons learned from the development phase.

The corresponding schedule of key programme activities as provided in the Needs case submission is depicted in Figure 10.

Figure 10: Key Programme Activities



DNV GL Assessment on SHE Transmission's Delivery Plan

SHE Transmission has designated the Orkney Transmission Link project as a Large Capital Project, which means that project governance and management are based on a specific framework for large projects, the SSE LCP Governance Framework. The project has a five-stage approach with defined milestones/deliverables and documents for each gate. Both the description of the gate 2 deliverables, the milestones in the Final Needs Case report, as well as and the Needs Case workshop provide sufficient confidence that SHE Transmission has investigated the most important subjects that determine the project lead times. These include:

- responses to the design, construction and operational risks for the project;
- permits and land options to submit and secure the planning applications;
- requirements and responsibilities for handover to preconstruction, construction surveys and identify documentation required to satisfy planning conditions; and
- issues regarding the supply chain and potential risk of postponement.

Most of the deliverables were generated after consultation with the (identified) stakeholders. Stakeholder consultation is carried out according to a stakeholder engagement plan, which is partly based on lessons learned from previous projects.

Based on the information provided by SHE transmission, we consider the project approach for the Orkney Transmission Link is appropriate, demonstrating that the project lead times are based on relevant studies and consultations with stakeholders, as well as reflecting lessons learned from previous experience. Overall, the project plan provides confidence that the link can be delivered in a timely and effective manner.

4.1.2 Questions B2 and B3: Has SHE Transmission sufficiently justified that construction cannot be started later? What is the latest date that construction could start without compromising/risking timely delivery of the link?

4.1.2.1 Construction-related assumptions

A key assumption informing the proposed timing for the Orkney link is that a number of onshore wind projects driving the need for the reinforcement are expected to participate in the Spring 2019 CfD auction, through which they would possibly secure subsidies requiring them to be operational from Spring 2023 onwards.

To meet the capacity need required for these projects and taking into account weather-related constraints on the construction programme (which effectively preclude construction during winter months), SHE Transmission has set the Orkney link's target energisation date at October 2022. This would ensure the Orkney link is operational prior to the commissioning of the onshore wind generators that drive the need for reinforcement. This means SHE Transmission would deliver on its connection agreements.

Figure 11 shows a high-level overview of the key project milestones. To achieve the completion/energisation date (October 2022), taking into account equipment manufacture and delivery timescales for this project, the construction need to start in 2019 or at the latest early in 2020.

Figure 11: High-level overview of key project milestones

SHE Transmission makes the following assumptions regarding delivery of specific works:

1. Substation works

SHE Transmission has tendered the substation works via mini-competition to the four incumbent contractors on the existing Substation Framework. The contract has been tendered as two Lots:

- Lot1: A new 275kV substation at Dounreay West 275/220kV, including an extension to the existing Dounreay 275kV Substation; and
- Lot2: A new 220/132kV Substation at Finstown.

2. Transformers

SHE Transmission will procure the transformers via a mini competitive tender on an existing Transformer Framework. The manufacturing of the transformer from order date is approximately 18 months to complete. Delivery of the transformers will be required on site early Q1 2022 to meet current commissioning dates.

3. Subsea Cable

SHE Transmission noted that following contract award of the subsea and land cable contract (expected Q2 2019), a manufacturing slot will be placed by the winning tenderer for the subsea cable. This process takes approximately 18 months with the construction works due to commence Q4 2021 with an on-site construction programme of approximately 2 to 3 months to lay the cable.

DNV GL Assessment on Construction-related assumptions

Please note that DNV GL has not assessed the CBA analysis undertaken by SHE Transmission, save for some of the inputs to the CBA, such as generation scenarios and the costing of the options. We therefore cannot judge whether the timing proposed by SHE Transmission, i.e. delivery of Option 2 by October 2022, truly constitutes the most economic project outcome. Our assessment of the construction timing advocated by SHE Transmission therefore takes the October 2022 delivery date as a given and discusses the required construction timing to deliver the proposed solution by this date.

SHE Transmission has presented the duration of the construction as a single activity (refer to Figure 10). After mobilisation, a total period of approximately 30 months (2½ years) has been given for the construction. The cable construction work, i.e. cable manufacturing and cable laying, are decisive for the total construction time. The construction of the two substations is not decisive, because it concerns two conventional substations that can be built in less than two years, provided that there are no consenting delays and the two transformers can be delivered on time. The cable construction work introduces the largest uncertainty in the project. Other than the permits, the following issues generally contribute to this uncertainty:

- Availability of specialist vessel and weather conditions;
- The type of cable and its burial depth and hence whether ploughing, jetting or trenching will be the preferred option;
- The ground conditions, chosen depth and cable type will govern the installation method and will impact the cable installation. Burial depths can significantly impact the speed of laying as can the sea bed conditions;
- The rating of the cable and it size, and hence the number of installation campaigns, also being influenced by the size of cable laying vessel available;
- Vessels tend to have weight limit on their turntables and hence cables with higher rating will have shorter lengths, with more campaigns, and more joints; and
- Landing point at different locations (e.g. drilling under seas defences) and the number of crossings that occur, where various forms of cable protection need to be deployed (rock dumping, mattresses).

The many uncertainty factors and the fact that offshore cables in the energy sector are relatively new, make it almost impossible to give a statistically sound estimate of the duration of cable construction work. Based on currently available information, DNV GL believes that 2½ years for the construction work for the Orkney transmission link is a realistic timeframe to address the identified uncertainties.

Taking into account a duration of 6 months for commissioning, this means that the last date on which the construction can start without jeopardizing the timely delivery of the Orkney Transmission link, a start of construction (after mobilisation) beginning Q4 of 2019 is required, which SHE Transmission also indicated in the overall planning (refer to Figure 10).

DNV GL believes that the start of the construction should not be later than Q4 2019, as proposed by SHE Transmission. This estimate of the latest start date of the construction work is based on limited information and should be revised as more information becomes available.

4.1.3 Question B4: Does SHE Transmission's delivery plan appropriately consider the specific risks associated with delivery of this project? (e.g. shifts in generation levels, potential planning sensitivities)

Key risks and mitigation actions considered

Table 9 below provides the key risks and associated mitigation actions SHE Transmission has foreseen. The applied Risk Management methodology is described in the next section 4.1.4.

Table 9: Key project risks and associated mitigation actions

#	Risk Class	Risk Reference	Risk Description	Mitigation action
1	Programme and cost	Weather during development and construction stages	Weather conditions are considered a risk to all packages. This is currently managed as one risk; however, it will be split into each package as the project progresses. The weather risk is particularly sensitive for subsea cabling as the marine vessels can only operate in certain conditions	
2	Environmental Impact	Orkney Substation	The Substation is near a World Heritage Site (WHS). Whilst the site is out with the WHS boundary, it will remain visible from the site. There is a risk that key stakeholders may object to the substation development in its current location, leading to consenting delays that may result in redesign.	Mitigation measures being explored include provision of bunding to minimise the impact on WHS site and the local community.
3	Site Security	Dounreay Substation	The Ministry of Defence (MoD). Vulcan site near Dounreay presents a significant interface risk. The MoD have highlighted concerns over the project compromising its site security and are concerned that substation cameras are potentially recording its site.	We have begun discussions with Vulcan Site Security to establish a collaborative approach to managing interface risks and, as part of these discussions, changes to the site layout or substation design may be required
4	Environmental Impact	Ground Contamination	Due to the proximity to the Vulcan site there may be an increased risk of ground contamination. The project team have survey data and have used the Ground Hog System, which can detect radio-active material, to identify areas of concern.	The Project Team will continue to monitor the contamination/radioactive material risk.

#	Risk Class	Risk Reference	Risk Description	Mitigation action
5	Environmental Impact	Land Cables	Unforeseen archaeology encountered during the construction phase of the land cable at Warebeth and Finstown, has the potential to delay or stop works.	Mitigating actions include archaeology desk studies, site walkovers and written scheme of investigations in advance of works commencing. While work is being undertaken, a report will be provided prior to any intrusive works and a watching brief to be provided by the contractor for the duration of the works on site.
6	Technical risk	Subsea Cables HDD and Marine conditions	The potential for horizontal directional drilling (HDD) at or near the landfall locations presents a technical challenge to the contractor as the angle, depth and length can impact on achievable cable rating. Another impact to cable installation is unexpected seabed conditions, identified during the marine surveys, such as unexploded ordnance; Orkney was a key naval base in both World Wars. There is a requirement to bury cables under seabed sediment and the inability to procure enough sediment will result in a requirement to use alternative cable protection methods or to deviate the cable route, impacting project costs and schedule.	Civil investigation at the landfalls are being undertaken as well as applying previous project knowledge gained in the use of HDD, e.g. Caithness Moray. Surveys are being done in advance to provide advanced notice of the possible need to deviate the route.

#	Risk Class	Risk Reference	Risk Description	Mitigation action
7	Programme and Cost	Availability of experienced resource and accommodation	A lack of experienced construction resources in Orkney will pose a programme and cost risk to the project. The project must rely on contractors travelling to and staying on the island for the duration of the civil works during development and construction works. This will lead to constraints on the island accommodation as Orkney is a popular tourist destination.	Potential mitigation measures would include implementation of a phased contracting strategy to minimise impacts on the island and sourcing local labour and plant where available during works on the island.
8	Alternative Approach	Timing	The proposed timeline and implementation of the alternative approach is subject to both stakeholder consultation and Ofgem approval. SHE Transmission is currently seeking feedback on our timeline in our alternative approach consultation which is due to close on 12 March 2018. Initial feedback from the stakeholder events has indicated that developers have viewed the timeline as needing acceleration. This will be reviewed following the closure of the consultation period.	Mitigation measures to ensure the implementation timeline is realistic and achievable have included continuous engagement with stakeholders and Ofgem, ensuring there is enough time for consultation and feedback as well as factoring in enough time for any Ofgem review and/or approval of the alternative approach.

DNV GL Assessment on Key risks and mitigation actions considered

SHE Transmission has provided an overview of the key risks that have been identified and that are being continuously monitored and discussed to define or adjust mitigation actions during the project phases. The overview shows that SHE Transmission has defined eight risk classes, which are (partly) based on experience (lesson learned) from previous projects. We consider the eight risk classes to be sufficient to span a "risk search space", i.e. to identify all potential risks related to this project. More specifically, DNV GL agrees that SHE Transmission has created a well-defined space for searching risks attached to this project, making it easier and more effective to identify risks (search): with the introduction of the eight risk classes SHE Transmission has increased the chance to identify the most important risks of the Orkney Transmission Link project.

As a minor remark, we consider that SHE Transmission may, to increase clarity, tighten the definition of certain risks. For example, it is not immediately clear that risks under "Environmental impact" involve the risks of not obtaining licenses or obtaining them too late.

We conclude that SHE Transmission has identified the key risks for the Orkney Transmission project. To increase clarity and to facilitate a review of the risks, we recommend that SHE Transmission be more specific in the description of some risks.

4.1.4 Question B5: Has SHE Transmission justified that it has a plan to efficiently manage these risks?

Risk management approach

The Orkney Transmission project has applied a similar Risk Management approach to other SSE Large Capital Projects. KERIS (Knowledge Exchange Risk Information System), a software tool, is used to support the management of project risk. Key characteristics of KERIS include a repository for project risks, functions to create and assess risks, and to track risk mitigation actions. Risks and mitigation actions are assigned owners who are then accountable for updating the project risk register. To ensure that risk data is reliable and can be used to support project decision making, risk owners are continuously updating the KERIS system.

The Orkney link project Risk Register is a live document that will evolve through continuous updates and contributions from the Orkney Project Team. The Orkney link project Risk Register will also be informed by risk data from other projects held on KERIS. As a form of lessons learned, access can be obtained to risk records from other projects and the associated successful mitigation measures. The risks are the input in a probabilistic risk model ('@Risk' excel tool) that generates a monetary value that will be included in the Project Assessment.

The SSE Corporate Risk Team will be responsible for managing the performance and monitoring the implementation of risk management on the project. To this end, this team will be responsible for:

- independently facilitate monthly risk workshops to collectively review and challenge the project risk register organised by the Orkney link project Team;

- undertaking the probabilistic risk analysis required for the Project Assessment phase of the SWW submission; and
- provide the Orkney link risk owners with weekly reports detailing the status of Risks and Actions to highlight risks/actions requiring attention.

SHE Transmission has indicated that lessons learned from previous project are considered in the risk management process. For instance:

- SHE Transmission will use a small team to constantly communicate with the marine survey to minimize the survey time;
- engagement with the local authorities regarding the fishing activities will be pursued; and
- compliance to Health and Safety requirements for construction in the UK must be clear to the contractor.

DNV GL Assessment on Risk management approach

SHE Transmission has a structured, mainly practical project risk management process. The project risk management process contains some key elements of IEC standard: risk identification, risk assessment, risk treatment, risk review and risk monitoring. SHE Transmission uses proprietary software tools to support the project risk management process. The Final Needs Case report and the discussion during the workshop did not give DNV GL any reason to doubt that SHE Transmission manages the risks related to the Orkney Transmission link project efficiently: a reasonable risk management plan (process) is in place and its implementation to date looks adequate, given that risk workshops are held on a monthly basis and risk owners receive weekly reports.

DNV GL concludes that SHE Transmission has a structured project risk management process in place through which the risks of Orkney Transmission project can be efficiently managed.

4.1.5 Question B6: Has SHE Transmission provided a robust strategy for the ongoing review of the work programme and implementation of changes on the project as it develops?

As previously noted in Section 4.1.1, the Orkney link is a Large Capital Project (LCP) as defined by the SSE LCP Governance Framework. This means that the project will progress through five stages to completion as shown Figure 9. The identified project risks (listed in Table 9) show that these stages ultimately translate into changes in project lead time and/or project costs.

DNV GL assessment

SHE Transmission has presented a fixed schedule (Table 9) of activities and does not discuss how changes in e.g. lead time of activities will impact the schedule. Only if the lead times of activities contain sufficient in-built contingency, the delivery plan and schedule presented in the Final Needs Case report will not change. It is not clear to DNV GL whether this is the case. For this reason, we recommend that the topic of contingencies in the lead times is formally raised in the risk workshops to obtain more robust strategies and / or project plans.

4.2 Summary of Findings

DNV GL has reviewed the delivery plan for the Orkney Transmission Link and, based on the information provided by SHE Transmission, we consider that the project approach is appropriate, demonstrating that the project lead time is based on relevant studies and consultations with stakeholders, as well as reflecting lessons learnt from previous experience. Overall, the project plan provides confidence that the link can be delivered in a timely and effective manner.

As regards risk management, we conclude that, although the project approach is appropriate in principle it is not clear to us whether SHE Transmission has included sufficient contingency in the lead times of the key activities to cope with (unexpected) changes. We therefore recommend that contingencies in lead times are henceforth formally discussed in the risk workshops to obtain more robust strategies and project plans.

Aside from planning contingency, we believe that SHE Transmission has a structured project risk management process in place with which the risks of Orkney Transmission project can be efficiently managed. SHE Transmission has identified the key risks for the Orkney Transmission Link project. To increase clarity to facilitate a review of the risks, we recommend that SHE Transmission be more specific in its description of project risks.

We have also assessed all construction-related assumptions provided by SHE Transmission, taking as a given[18] that the proposed construction schedule aims to deliver the Orkney link by October 2022. To achieve this date, DNV GL believes that start of the construction should not be later than beginning Q4 of 2019, as proposed by SHE Transmission. However, this estimate of the latest start date of the construction work is based on limited information and should be revised as more information becomes available.

[18] Since we have not undertaken a detailed review of the CBA from which SHE Transmission has identified this date.

5 OVERALL CONCLUSION AND RECOMMENDATIONS

Ofgem has asked DNV GL to assess SHE Transmission's Final Need's Case submission for the Orkney transmission project and answer a set of questions to determine whether SHE Transmission has entered appropriate inputs into its CBA, including assessment of proposed generation scenarios, as well as the feasibility and costing of options considered. In addition, DNV GL has answered a set of questions informing whether SHE Transmission has developed a suitable delivery plan for its proposed solution. The following summarises our conclusions and provides our recommendations to Ofgem.

5.1 Assessment of Generation Scenarios (Questions A1-A4)

5.1.1 Onshore Wind

DNV GL has reviewed GHD's assumptions regarding the production timings and productivity and load factors for onshore wind generators and concludes they are reasonable.

DNV GL has also assessed GHD's assumptions regarding the potential financeability of onshore wind projects on Orkney, both with and without CFD Funding. We support GHD's findings that onshore distribution-connected wind farms need not necessarily rely on CfD funding to be economically viable and considers recent market evidence provides some support for this proposition.

We also consider that GHD has adopted a reasonable approach in performing a risk-weighted assessment of future generation to account for the additional uncertainty in the financial viability of projects and to develop a range of reasonable generation scenarios. Although we note that the specific wind projects identified by GHD are all in an early stage of development, and there is no certainty at this stage that they will go ahead, it is clear that there is high interest for onshore wind generation development on Orkney because of high wind yields, local support, and low LCoE – all of which increase the financeability of such projects.

DNV GL considers the CfD and LCoE analysis presented by GHD to provide a robust analysis for the economic viability of onshore wind. GHD's 5 generation scenarios assume between 45% and 70% of onshore wind projects on Orkney could be successful in a future RIW CfD auction, which DNV GL considers as reasonable based on the 5-year period to 2023. This reflects an average 50% success rate for onshore wind, which is broadly at the level assumed in GHD's scenarios S2 or S3, for onshore wind, over the period 2023-2025.

5.1.2 Tidal projects

DNV GL does not consider the assumed scale and timing of tidal generation capacity to be reasonable, particularly in relation to large tidal arrays in the mid-to-late 2020s. The principal reason for this is that tidal is still an infant technology, and the construction of large arrays requires substantial specialist equipment and processes that are currently being tested and will take years to be refined further and de-risked.

DNV GL does not disagree with SHE Transmission's assumptions on tidal load factors, however, like SHE Transmission, we agree that tidal load factors are highly uncertain.

As regards the financeability of tidal generation projects, DNV GL concurs with GHDs finding that tidal would not currently be competitive in CfD auctions unless it participates in a separate funding pot. Although we generally expect advancement in tidal generation technology that may make it more competitive in the future, we consider the road and timing to commercial viability remains uncertain, principally due to cost and productivity uncertainties.

We therefore do not consider the development of tidal generation as depicted in GHD's high end scenarios, particularly beyond 2025, is likely in terms of scale and timing. However, we also consider that it is not unreasonable to assume that a small amount of tidal capacity, broadly at the level assumed in GHD's scenario S1 or S2 over 2023-2025, could come forward with EMEC for testing purposes.

5.2 Assessment of Options considered (Question A5)

Splitting the option assessment into two separate stages, namely assessing the appropriate route for the submarine cable and assessing the appropriate electrical connection is the right approach because it provides focus on each of these two areas.

DNV GL believes that SHE Transmission has considered all possible Strategic Route Options for the subsea cable, i.e. SHE Transmission has considered all routes related to the identified credible landfall options on Caithness and Orkney. DNV GL considers that the optioneering applied should be extended with two additional options for the Orkney link with the Scottish mainland. One option is related to the use of a 275kV subsea cable, the other to a 66kV submarine cable. DNV GL recommends to re-execute the CBA, extended with these additional options to verify the robustness of the preferred solution.

A review of the Local Transmission Infrastructure is not part of the scope of this assignment. However, we consider that a solution developed in joint consideration of the local transmission and distribution infrastructure can potentially deliver added benefits for consumers, and we recommend that an integral distribution and transmission network analysis is undertaken to further inform the assessment of the Orkney Transmission link.

5.3 Cost Assessment (Question A6)

DNV GL considers that the cable costs of the options provided by SHE Transmission are relatively high This is possibly due to location-specific installation costs of the cable which SHE Transmission has considered. We recommend that Ofgem should seek greater transparency and request detailed information on the installation costs of the cables in a possible Project Assessment under the SWW process.

DNV GL considers that the cost estimates of the HVAC substations of the options and preferred solution provided by SHE Transmission are reasonable.

5.4 Assessment of the proposed delivery plan (Questions B1-B5)

DNV GL has reviewed the delivery plan for the Orkney Transmission Link and, based on the information provided by SHE Transmission, we consider that the project approach is appropriate, demonstrating that the project lead time is based on relevant studies and consultations with stakeholders, as well as reflecting lessons learned from previous experience. Overall, the project plan provides confidence that the link can be delivered in a timely and effective manner.

As regards risk management, we conclude that, although the project approach is sound in principle it is not clear to us whether SHE Transmission has included sufficient contingency in the lead times of the key activities to cope with (unexpected) changes. We therefore recommend that contingencies in lead times are henceforth formally discussed in the risk workshops to obtain more robust strategies and project plans.

Aside from planning contingency, we believe that SHE Transmission has a structured project risk management process in place with which the risks of Orkney Transmission project can be efficiently managed. SHE Transmission has identified the key risks for the Orkney Transmission Link project. To increase clarity to facilitate a review of the risks, we recommend that SHE Transmission be more specific in its description of project risks.

We have also assessed all construction-related assumptions provided by SHE Transmission to deliver the Orkney link by October 2022. To achieve this date, DNV GL believes that the start of construction should not be later than the beginning of Q4 2019, as proposed by SHE Transmission. However, this estimate of the latest start date of the construction work is based on limited information at this stage of the project and we recommend it be revised as more information becomes available.

ABOUT DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.