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Executive Summary

Ofgem has commissioned TNEI Services Ltd ("TNEI") and Pöyry Management Consulting (UK) Ltd (Pöyry) to provide technical support with their assessment of the Initial Needs Case (INC) for the North West Coast Connections (NWCC) transmission project. The NWCC project is required in order to connect the proposed Moorside nuclear power station adjacent to Sellafield. National Grid Electricity Transmission (NGET) submitted an INC for the NWCC project on the 6th May 2016 as the first part of the Strategic Wider Works (SWW) process.

Our analysis has evaluated three key elements of the INC:

1. Inputs into NGET's Cost Benefit Analysis (CBA), including whether the process used and options progressed are appropriate, and whether cost inputs and other assumptions are justified.
2. NGET's delivery plan to determine whether it is efficient and whether risks have been appropriately considered.
3. Whether the project would be suitable for competitive tendering, using the criteria set out by Ofgem.

This assessment has been based on justification and evidence provided by NGET in the INC as well as additional information requested through a supplementary questions process and several workshops. We have applied quantitative and qualitative analysis where appropriate, using a Red Amber Green (RAG) rating approach to summarise our views and highlight areas of concern that require further evidencing or consideration.

Preferred Connection Option

NGET's preferred option for connection of Moorside to the main interconnected transmission system is via a double overhead line circuit north to Harker substation and a double circuit south to Middleton substation comprising of overhead line, underground cable and cable tunnel sections. The cable tunnel crosses Morecambe Bay and is 22km in length. The total P50[1] cost of this option is estimated by NGET to be £2.5bn at this stage.

Cost Benefits Analysis Inputs

NGET evaluated a range of potential connection points, circuit options (in terms of numbers of circuits), strategic options (overhead lines, HVDC, North/South circuits) and detailed routing options. Options were discounted at each stage based on criteria such as security of supply, technical feasibility, cost-benefit and environmental/consenting risk to narrow down the options taken through to the CBA.

Optioneering

[1] P50 and P80 cost values take into account probabilities to provide a measure of confidence e.g. the probability of the final cost being less than the P50 figure is 50% and, similarly, the probability of it being less than the P80 figure is 80%.

Our assessment of the optioneering process carried out by NGET included review of the appropriateness of the technical requirements, design and consideration of alternative options. Our independent view is that the stated technical requirements for the various options considered are reasonable and the technical design of the preferred option delivers the required capacity and is technically robust. NGET has provided sufficient evidence and justification to enable us to reach this view.

There are no additional reinforcement options or operational measures that have not been considered by NGET that would be technically and economically feasible to connect Moorside.

Discounting of Options

NGET has generally provided sufficient and valid reasoning for the exclusion of specific options throughout the optioneering process evidenced through reference to technical specifications, cost data, expert analysis and stakeholder consultations. Specifically, appropriate consideration has been given to the environmental sensitivities presented by routing an overhead line through the South Lakes section of the Lake District National Park and we are in agreement with discounting of this option.

We have engaged with specialist cable consultants at Petrofac to explore assumptions about installation costs for the "back check" routes around Morecambe Bay in more detail. Based on this discussion, we believe a subsea HVAC cable could be routed around Morecambe bay at a comparable or possibly lower cost than NGET's preferred option. In addition, we do not believe the environmental impacts of routing a subsea cable around Morecambe Bay have been explored in enough detail yet to justify ruling them out on a consenting basis. We also have concerns in relation to the discounting of routing options for the southern route due to the potential for use of a high capacity three-core subsea cable. This could significantly reduce the cable corridor and has not been sufficiently explored by NGET in our view.

We accept that there are considerable environmental sensitivities in relation to routing of a cable corridor (in the order of 1km in width) across Morecambe Bay and NGET has provided evidence to substantiate this and the risk posed to consentability.

Whilst we do not agree with the discounting of HVDC solutions on the basis of technical grounds alone, there is strong justification for discounting on the basis of cost. It is also understood from NGET that NuGen are concerned about using HVDC for connection of a nuclear power plant which would be a novel, first-of-a-kind application.

Costs

We have carried out a high level cost benchmarking comparison for key assets (overhead lines, underground cables, subsea HVDC cables and converters and cable tunnel) including ENWL distribution network enabling works for progressed strategic options and are satisfied that the unit costs are appropriate in magnitude and the cost build-up and level of detail is valid for optioneering. NGET has provided supporting details of the cost methodology including calculation of unit costs. Specifically, the scope of the cable tunnel and associated costs seem reasonable.

For the risk methodology, we are satisfied that the approach taken by NGET is consistent and robust with the risks identified for each key asset element and the rating and probability assigned to these being generally appropriate. We are in agreement with the risks that emerge as being significant and no risk categories appear to have been unreasonably included or excluded. There appear to be some minor errors and risk double counting in places.

Cost Benefit Analysis Inputs

The CBA conducted by NGET is thorough and we are happy that the CBA approach is reasonable, appropriate and well justified. A least-worst cost analysis approach is used and clearly demonstrates the economic benefits of the preferred option.

The use of 2015 Future Energy Scenarios (FES) is reasonable. Whilst the technical boundary transfer capability analysis is based on Gone Green only (although the boundary transfer capabilities are not very sensitive to the other FES), the CBA assesses the effect of all four 2015 FES. We have explored this in detail with NGET and are happy that the approach is reasonable and captures the key differences between the various FES and across the connection options.

The outputs of the model are found to be reasonable in magnitude and vary in the expected directions (e.g. higher wind capacity leads to higher constrained energy, greater wider reinforcement requirements leads to increased costs) and in reasonable amounts.

Finally, we believe the sensitivity analysis is generally appropriate to characterise the impact of various uncertainties such as influence of wider works timing and generation connection and verify the selection of the preferred option. We have provided some modelling recommendations in this report which require clarification ahead of the Final Needs Case assessment.

Summary

Overall, we are generally satisfied that NGET's approach to reaching a preferred strategic option for the project is appropriate. However, we think it may be appropriate to explore in more depth the options for a three core cable around Morecambe Bay, following the "back check" routes identified in the INC.

Optioneering	Discounting	Cost	Cost Benefit Analysis
			

Suitability of Delivery Plan

NGET has provided high level details of the original As-Is and Customer Choice programmes. This is of reasonable detail at this stage of project development. The Customer Choice programme has been developed following identification in late 2015 by NGET that the

400/132kV Stainburn substation was no longer required to maintain security of supply to the distribution network, following stakeholder consultations on landscape and visual impact mitigation for the 400kV overhead line double circuit. This would allow NGET to potentially provide site supplies by rephasing the northern transmission works earlier in the programme. In the As-Is programme, these were to be provided by ENWL however once the northern transmission works are completed by NGET, these 132kV circuits would become redundant. NuGen have requested the Customer Choice programme through the latest Modification Application submitted Nov 2016 that is currently being reviewed by National Grid.

The preferred delivery plan outlines a number of activities and associated durations for key assets including overhead lines, cable tunnel and substations. We have reviewed the detail and in particular for the cable tunnel which is on the critical path. The activities which include tendering, award and first site access, construction and commissioning are broadly reasonable for a project of this scale and for the technology and techniques to be used in tunnel boring and fitting out. The timing of various activities also appears to be relatively efficient with no notable delays. NGET has carried out some preliminary market engagement with suppliers for the cable tunnel to inform design, costs and programme.

Programme Risks

NGET has identified a set of specific risks associated with delivering the programme. These risks are related to process of tendering, commissioning and managing the ongoing work. These include scope, delay to DCO decision, ENW interfaces and supply interruptions, procurement, commissioning and extreme weather.

There is still significant uncertainty regarding these risks and this uncertainty will be reduced as the project moves forward and more information on the site specific characteristics and risks of each project element are revealed. As the design for the preferred connection option is further developed, the risk will reduce, and so it is essential that the registered risks are updated on a regular basis ahead of the Final Needs Case and the Project Assessment. An additional factor that will impact on the quantification of the programme risk is the extent to which the NWCC is tendered under the CATO regime.

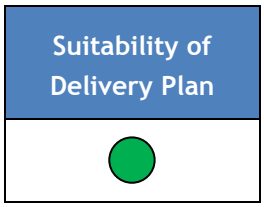
Based on our assessment of the NWCC programme and the associated risks, we have identified a number of issues that may impact on delivery of the project. [redacted] If the Customer Choice programme is implemented then the northern overhead line and substation works are also on the critical path along with the cable tunnel. NGET has indicated that this will not result in any increased programme risk however our view is that including another contracted milestone, increasing overall project management towards the start of the

project, and rephasing of ENW enabling works will likely increase programme risk although perhaps not materially in cost terms. This should be reconsidered in the risk register.

NGET has also responded that NuGen has made clear public indications that their CfD is still on track for 2018. We recommend that NGET update Ofgem if there are any changes from the current anticipated position.

Summary

Generally the delivery plan for tender, design and construction of various elements of NWCC are appropriate in our view. We would expect that these will be developed in greater detail as the design is further progressed, additional survey and analysis work is completed, and milestones are achieved and reflected in the updated risk register.



Suitability for Competition

Tendering Packages and Eligibility for Competition

Beyond assessment of the INC, we have reviewed the suitability of the NWCC project for competition based on the criteria that Ofgem has set out. These criteria are that the assets must be: new, separable, and high value. We have proposed a number of illustrative tendering approaches to evaluate the risks, opportunities and efficiency of each one.

Our analysis indicates that there is a balance to be met in the level of disaggregation of tendering packages, to provide sufficient market opportunity and opportunity for innovation whilst not introducing further interfacing complexity. For example, it is not yet clear under the ECIT regime who will take overall responsibility for managing the timely delivery of a project involving multiple CATOs, or who will bear the financial risk associated with managing the increased number of technical and commercial interfaces. Further development of ECIT regime policy could lead to introduction of measures or incentives to mitigate these risks.

On a review of our qualitative assessment, it appears that tendering the North, South and Cable Tunnel elements separately may provide the best balance. However, there would still be some requirement for management of interfaces between the CATOS. This option may also be the best fit for the current Customer Choice NWCC delivery programme e.g. the North route and cable tunnel elements of the package could be delivered by the incumbent TO if timescales for these elements make tendering too challenging.

For the current NWCC design, we don't believe there are additional benefits to be gained by additional electrical separability.

Risks Associated with Tendering

Risks affected by tendering and risks and opportunities introduced by tendering the NWCC project have been evaluated. The timescales for cable tunnel build and the completion of the northern overhead line circuit (which are not unreasonable based on our review of information provided by NGET), will likely make it too challenging to tender these sections of the project through the ECIT regime in terms of programme risk i.e. not meeting contracted dates. It should however be possible to tender the southern route and substation works.

A delay in the contract date may however reduce the programme constraint for the cable tunnel and northern works enabling more project elements to be tendered through the ECIT regime. NuGen anticipates that the first reactor will be connected in 2025.

Key risks introduced by tendering include management of [redacted] commercial arrangements with ENWL, interfaces and impact on potential for financial innovation. For example, there may be a number of CATOs who will need to contract and coordinate with ENWL and this may negatively impact costs and programme risks, in particular. There will also be a need for increased multi-lateral stakeholder engagement between Ofgem, NuGen, NGET, ENWL and the CATOs to enable efficient project delivery.

There is however an opportunity for CATO to bring a range of efficiencies and innovations to the project. For example, National Grid's current plan is to progress a tunnel with a 5m diameter, as this is a reasonable worst case. A CATO may be able to use innovative methods which allow for a smaller tunnel diameter.

Assessment of Preliminary Works

Preliminary works that have been completed by NGET are appropriate in scope and methodology. A reasonable balance appears to have been struck between targeting areas of high risk for more detailed assessment and minimising survey costs and timescales. Further preliminary works are required before tendering, such as detailed ground surveys for the cable tunnel, substations and overhead line routes, to reduce risk.

Glossary

AONB	Areas of Natural Beauty
BEIS	Department for Business, Energy and Industrial Strategy
CATO	Competitively Appointed Transmission Owner
CBA	Cost Benefit Analysis
CFD	Contract for Difference
DCO	Development Consent Order
ECIT	Extending Competition in Transmission
FES	Future Energy Scenarios
FID	Financial Investment Decision
FSA	First Site Access
INC	Initial Needs Case
LDNP	Lake District National Park
LVIA	Landscape and Visual Impact Assessment
NGET	National Grid Electricity Transmission
NWCC	North West Coast Connections
RAG	Red Amber Green
RIIO-T1	Revenue = Incentives + Innovation + Outputs Transmission 1
SO	System Operator
SWW	Strategic Wider Works
SRMC	Short-Run Marginal Cost
TO	Transmission Owner

1 Introduction

In order to connect the proposed Moorside nuclear power station at Sellafield, National Grid Electricity Transmission Limited (NGET) is developing the North West Coast Connections (NWCC) transmission project. This will involve the construction of new transmission assets in Cumbria.

On 6th May 2016, NGET submitted an Initial Needs Case (INC) for the NWCC project, as the first part of the Strategic Wider Works (SWW) process. Ofgem will use this assessment to (i) ensure that it is comfortable with the options which NGET have selected, ahead of a DCO submission and (ii) determine whether the NWCC project is suitable for onshore competitive tendering, which could result in the appointment of a Competitively Appointed Transmission Owner (CATO).

Ofgem has commissioned TNEI Services Ltd ("TNEI") and Pöyry Management Consulting (UK) Ltd (Pöyry) to provide technical support with their assessment of the INC. TNEI and Pöyry have:

- **Assessed the inputs into NGET's Cost Benefit Analysis (CBA), including whether the process used and options progressed are appropriate, and whether cost inputs and other assumptions are justified. This is Part A of TNEI and Pöyry's scope;**
- **Assessed NGET's delivery plan to determine whether it is efficient and whether risks have been appropriately considered. This is Part B of TNEI and Pöyry's scope; and**
- **Determined whether the project would be suitable for competitive tendering, using the criteria set out by Ofgem. This is Part C of TNEI and Pöyry's scope.**

This report provides TNEI and Pöyry's assessment of Part A, B and C of the scope.

1.1 Structure

The rest of this report is structured as follows:

1. The remainder of **Section 1** introduces the scope of the INC assessment which Ofgem will complete, describes the NWCC project at a high level, and sets out the approach taken by TNEI and Pöyry to complete the work;
2. **Section 2** sets out our assessment of Part A of the scope, including an assessment of NGET's optioneering process, an assessment of the options that were explored and discounted, analysis on the cost inputs in the CBA model, and examination of other macroeconomic and technical assumptions in the CBA; and
3. **Section 3** sets our assessment of Part B of the scope, including an assessment of the efficiency of the proposed delivery plan and the consideration of risks within the plan.

4. **Section 4** sets our assessment of Part C of the scope, including an assessment of the suitability of the project for competition in transmission, how it could be tendered and key risks and opportunities.

1.2 North West Coast Connections Project

NuGeneration Ltd (NuGen) is proposing to construct Moorside nuclear power station, with 3.4 GW capacity, in the North West of England near Sellafield. Moorside will be built with three reactors, and has connections with NGET for 1,129 MW of TEC in 2025, 1,129 MW of TEC in 2026, and 1,129 MW of TEC in 2027 (total TEC of 3,387 MW).

There is currently no transmission infrastructure near Sellafield and the capacity of the proposed power station is too large to be accommodated on Electricity North West's (ENW) existing 132 kV network. Therefore, NGET is proposing to build new high voltage infrastructure assets to connect Moorside to the existing National Electricity Transmission System (NETS).

Figure 1-1: The existing NETS near Moorside (Source: NGET[2])

NGET publically announced its preferred route corridor in June 2015, following a long process of optioneering and consultation. The route corridor consists of two parts; a route

[2] http://www.northwestcoastconnections.com/bgo/overviewwhyourworkneeded.asp

heading north from Moorside to connect to the existing network at Harker substation near Carlisle and a route heading south across the Furness Peninsula and then via a tunnel under Morecambe Bay to connect to the existing network at Middleton substation, near Heysham.

Transmission-level construction work is anticipated to begin on the project in 2019, although some distribution works will commence ahead of this. NGET now plan further work on the Emerging Preferred Route Corridors, are currently holding a statutory (Section 42 / Section 47) Consultation, and plan to apply for development consent in 2017. On May 6 2016, NGET submitted the project's initial needs case for consideration under the Strategic Wider Works arrangements within RIIO-T1.

1.3 The Initials Needs Case Assessment

The INC Assessment, a new stage in the Strategic Wider Works (SWW) process, gives Ofgem an opportunity to assess the process the relevant TO has taken to determine its favoured option which will be taken forward to a Development Consent Order (DCO) application.

SWW allows Transmission Owners (TOs) to propose large investment projects on a case-by-case basis. This can be beneficial to both the TOs and the consumers for large projects which did not have certainty of need during the setting of the price control.

In England & Wales, a project is classified as SWW if it meets any one of the following criteria:

- Forecast costs of more than £500m;
- Forecast costs of between £100m and £500m, supported by only one customer and not required under the majority of scenarios; and
- Forecast costs of less than £100m, supported by only one customer, not required under the majority of scenarios, requires consent.

The SWW process is set out in Figure 1-2: SWW Process (Source: Adapted from NGET), showing the actions required by Ofgem and the actions required by the relevant TO (in this case, NGET).

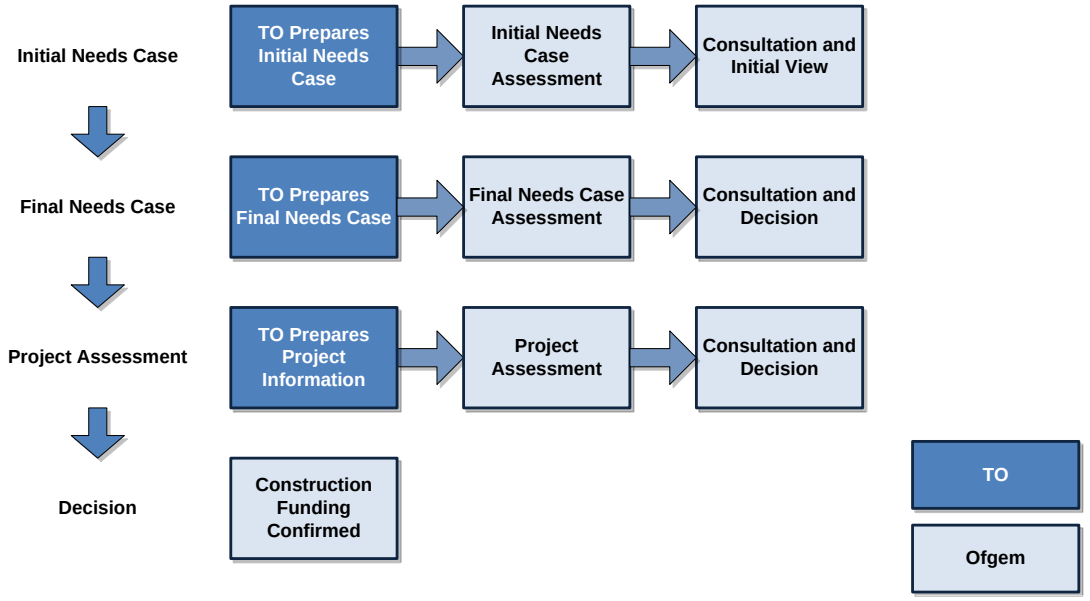


Figure 1-2: SWW Process (Source: Adapted from NGET[3])

The initial needs case is a new stage of assessment which takes place while the project is still in development. It is focused on the justification for the project (economic and technical) and considers the decision making processes undertaken to eliminate options and take forward a preferred option. The timing of the initial assessment is such that the review is intended to fall ahead of the TO's own planning consent consultation (Section 42 / Section 47 consultation).

The final needs case will be undertaken closer to the point where the TO will begin construction. Then, costs will be assessed in detail throughout the project assessment stage. If Ofgem decides to allow the TO to recover the costs of the project, the necessary licence changes will be made (e.g. specifying funding allowances for capital and operating expenditure). Progress is monitored during and after construction.

In parallel to the SWW process, an assessment of whether the project would be appropriate for competitive tendering is made during the initials needs case assessment. The initial needs case is a new stage in the assessment of SWW projects not currently reflected in the existing SWW guidance document, but the process still falls under the governance of special condition 6I of NGET's transmission licence.

1.3.1 Competitive Tendering

Ofgem has been developing the Extending Competition in Transmission (ECIT) project since the conclusions of the Integrated Transmission Planning and Regulation (ITPR) project were published in March 2015. Within these conclusions, Ofgem set out its aims to introduce

[3] Electricity Ten Year Statement (2014)

competitive tendering to the construction of onshore electricity transmission assets that are new, separable, and high value.

During RIIO-T1, Ofgem has stated that SWW projects could be eligible for tendering (if they meet the criteria of new, separable and high value.) The NWCC project could therefore be eligible for competitive tendering.

1.4 Approach

This report is based on our comprehensive review of NGET's North West Coast Connections Project Initial Need Case (NWCC INC), delivered to Ofgem in May 2016. This includes the Main Report, as well as all the appendices.

Where we have identified gaps in the provided information, or where we have required further clarification, we have posed Supplementary Questions (SQs) to NGET, via Ofgem. The answers to these SQs have also been considered in our assessment. We have also engaged directly with NGET through a series of six workshops.

- **Workshop 1, 9th June 2016:** NGET provided an overview of the project and the process they had followed to reach their preferred option.
- **Workshop 2, 30th June 2016:** NGET provided more detail on a number of areas including boundary capabilities, estimation of costs and risks and technical designs;
- **Workshop 3, 20th July 2016:** This workshop was used to discuss subsea cable options and programme delivery in greater detail.
- **Workshop 4, 3rd August 2016:** This workshop was used to discuss the cost assumptions for onshore assets and the cost build-up methodology detail.
- **Workshop 5, 11th August 2016:** This workshop was used to discuss the boundary transfer capability modelling in detail.
- **Workshop 6, 5th September 2016:** This workshop was used to discuss the subsea cable options in greater detail.

Our assessment is separated into three parts:

- In Part A, we examine whether NGET have selected the most appropriate option for NWCC;
- In Part B, we investigate whether NGET have developed a robust and efficient programme for delivering the project; and
- In Part C, we explore whether the NWCC project could be suitable for competitive tendering.

In each part of our assessment, we have used Red-Amber-Green (RAG) ratings to qualitatively rate different aspects of NGET's INC.

A Green rating means that we are broadly supportive of the relevant process, analysis, inputs or results and it is well evidenced and justified.

An Amber rating means that we believe NGET has not provided sufficient justification or evidence for us to fully support what it has stated within the INC.

A Red rating means that we disagree with the application of the relevant process or inputs or do not support the relevant analysis or results.

2 Part A: Cost Benefit Analysis Inputs

2.1 Optioneering Approach

Box 2-1: Specific Review Questions
Whether NGET's approach to reaching a preferred strategic option for the project is appropriate: • Are stated technical requirements within options considered well justified? • The technical design of the preferred option is technically robust and delivers the required capacity • Are there any additional feasible reinforcement options or operational measures that could connect the power station but haven't been considered by NGET? **Whether NGET has justified the exclusion of specific options from the CBA analysis** • Has NGET accurately identified the environmental sensitivities presented by routing an overhead or underground line through the South Lakes section of the Lake District National Park? In particular, has it provided sufficient evidence to appropriately reflect the impact this would be likely to have on the planning process? • Has NGET accurately identified the environmental sensitivities presented by routing a seabed cable array across Morecambe Bay? In particular, has it provided sufficient evidence to appropriately reflect the impact this would be likely to have on the planning process? • Has the discounting of HVDC solutions on technical grounds been based on sound reasoning?

NGET's generic optioneering process is described in 'Our Approach to the Design and Routeing of New Electricity Transmission Lines' and 'Our Approach to Options Appraisal', both published in 2012. The former describes a six stage process – the INC provides detail on the first two of these stages:

- Strategic Options; and
- Outline Routeing and Siting.

The process used by NGET to identify and assess options for NWCC is set out in approximate chronological order in the INC. The process is illustrated in Figure 2-1 below, which distinguishes between strategic optioneering, and optioneering for routeing and siting. The process described in the INC is broadly the same as that which is set out in the aforementioned documents, although there is more detail in the INC, for example, interactions with wider works, consideration of interactions with the DNO etc.

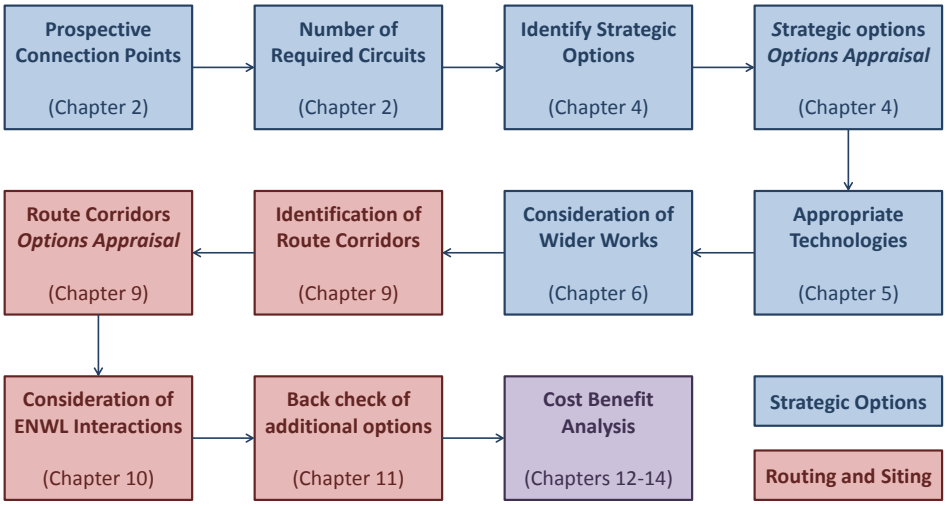


Figure 2-1: NGET Optioneering Approach

2.1.1 Appropriateness of the Optioneering Process

NGET's defined process allows it to consider a wide range of potential options (Strategic Options), ruling out those that do not perform well and only taking forward the most promising options for detailed development. This is a sensible way to approach optioneering for transmission network assets.

NGET has closely adhered to their defined process although they have considered many other important factors such as the impact on the wider system, and the interactions with ENWL's distribution network.

NGET has carried out a back-check of their preferred route against three route options which were identified later in the process. Furthermore, options which were discounted earlier in the process (four circuits north, and the south offshore HVDC option) have been revisited in a cost benefit analysis to check that the selected option gives the best value for money.

2.1.2 Technical Requirements

The key technical requirements which have shaped the INC are:

1. The network planning and operation requirements within the NETS SQSS; and
2. Required circuit ratings determined through power system simulations in DigSilent PowerFactory software.

2.1.2.1 NETS SQSS Requirements

NGET identifies three key criteria with the NETS SQSS that need to be considered within the NWCC optioneering process:

- Chapter 2 Section 2.6 – Infrequent infeed loss risk
- Chapter 4 Section 4.6 – Overloading of primary transmission equipment

- Chapter 4 Section 4.6 – System stability

We agree that these are the key criteria to consider when designing a generation connection.

2.1.2.2 Circuit Ratings

The required ratings of circuits have been robustly calculated in the INC based on power system modelling. Circuit impedances for the NWCC infrastructure are based on 2x 700mm^2 conductor and three scenarios are assessed, each of which considers a different volume of pre-fault power transfer across the B6 boundary (from 2.4 GW up to the maximum[4] of 4.4 GW).

This assessment does not appear to account for the reduction in boundary capability caused by the NWCC project. NGET identify wider works required to address this reduction in boundary capability, but these do not appear to have been included in the model. Such a reduction in boundary capability may mean that Scenario 3 (with a 4.4 GW transfer across B6) is not credible without also including some form of reinforcement to reinstate the boundary capability. However, we would consider study limitations/simplifications like this to be acceptable as the assessment was completed at an early stage of project development.

2.1.3 Environmental Constraints

NGET's 'Our Approach to the Design and Routing of New Electricity Transmission Lines' and 'Our Approach to Options Appraisal', both 2012, set out environmental and social topics to be considered during the optioneering process. The process for the NWCC has focused on those topics most likely to result in significant effects that will represent substantial consenting risk (i.e. landscape and visual effects, effect on heritage and effects on ecology). This focus and approach is appropriate.

Assessment has focused on the avoidance of high value environmental designations with some topics (i.e. socio-economic, transport, ground conditions and flood risk) given a lighter touch appraisal. The approach has been appropriate with identification of routing options having been based on avoidance of the key constraints in line with an approach of avoiding environmental effects as the most preferential form of mitigation. At this INC stage, less detailed consideration of those topics where effects are more localised and more readily mitigable (e.g. micro-siting or foundation design to reduce flood risk) represents a reasonable approach.

The Holford Rules appear to have been appropriately applied at this stage in scheme design. The Holford Rules provide broad design guidance that can only be applied in the context of the broad route. Constraints mapping of the key amenity areas (LDNP, AONBs, international

[4] This is the maximum boundary capability of the existing AC circuits, as stated in ETYS 2015, and does not account for the additional capability added by the Western and Eastern HVDC links (which are included in the model).

and national ecological designations) has allowed corridors to be identified and further survey and assessment is ongoing that will allow guidance within the Holford Rules to be considered to inform decisions on final routeing, technological choices and mitigation measures. Proposals to remove existing 132kV distribution lines and minimise incidences of 'wirescape' are in line with the Rules. From discussions with consultants engaged by NGET, it is clear that route corridor alignment is taking into account other Rules including consideration of skyline backgrounds within key views and the crossing of ridges.

Within the INC, NGET's overview of the Strategic Options Process appropriately sets the potential conflict with national and international designations in the context of National Planning Policy within EN-1.

This approach appears appropriate and to have been applied consistently. More detailed consideration of key constraints has been undertaken as options progressed through the process.

2.1.4 Alternative Feasible Options

It appears that NGET have considered all credible Connection Options, all credible Strategic Options, and all credible Routeing Options with the INC. Additional Strategic Options which could have been considered would probably involve more distant connection points, the benefits of which would probably be outweighed by the additional costs or environmental/socioeconomic impacts.

Other Strategic Options which may be possible include:

- Integrating an offshore HVDC circuit with a wider integrated offshore transmission network (e.g. with some of the planned offshore wind farms or the Western HVDC); or
- Connecting directly into SPT's system in the South West of Scotland, by crossing the Solway Firth, in order to provide a third high capacity AC route across the B6 boundary.

Although these options may be theoretically possible, we would not expect them to be credible in practice due to various technical, economic and environmental challenges and the uncertainty of planned future offshore and onshore generation and offshore transmission links. For example, challenges associated with offshore integration (particularly multi-terminal HVDC) are well documented[5] and would therefore make an integrated offshore option very challenging. A connection into SPT's system would require a crossing of the Solway Firth, which would likely have many technical and environmental challenges. Furthermore, there is uncertainty about the future of the transmission network in this

[5] There is lots of discussion of the commercial challenges associated with offshore coordination on Ofgem's website https://www.ofgem.gov.uk/publications-and-updates/consultation-proposed-framework-enable-coordination-offshore-transmission

ABB give a brief overview of the technical challenges associated with multiterminal HVDC http://www.abb.co.uk/cawp/seitp202/605900453ca679eec12578f70047d137.aspx

region, but based on recent announcements from SPT[6] it seems unlikely that a high capacity/high voltage connection would be possible.

We have therefore not considered these highly speculative options in any great detail, and would not expect NGET to have done so either.

2.2 Options Considered

We have carried out an assessment of the discounting of options by NGET at various stages of optioneering and the corresponding justification. This is based on consideration of the following factors; technical design and technology, installation, cost, environmental impacts and consenting and potential wider network impacts.

The four stages of optioneering we have considered are:

- Consideration of potential connection points;
- Assessment of different circuit options (in terms of numbers of circuits);
- The Strategic Options assessment;
- The detailed investigation of each routing option.

At each of these optioneering stages, NGET discounted some options. This chapter of our assessment summarises the reasons NGET provide for discounting options, and gives our view on whether or not this was appropriate. We have presented this in four tables, using the RAG ratings set out in Section 1.4 to summarise our view.

The links between the different optioneering stages and the four assessment tables in this report is summarised in Figure 2-2: Optioneering Process used for NWCC.

[6] http://www.spenergynetworks.co.uk/userfiles/file/DG_Developer_Forum_2016_07_29.pdf accessed 16th August 2016.

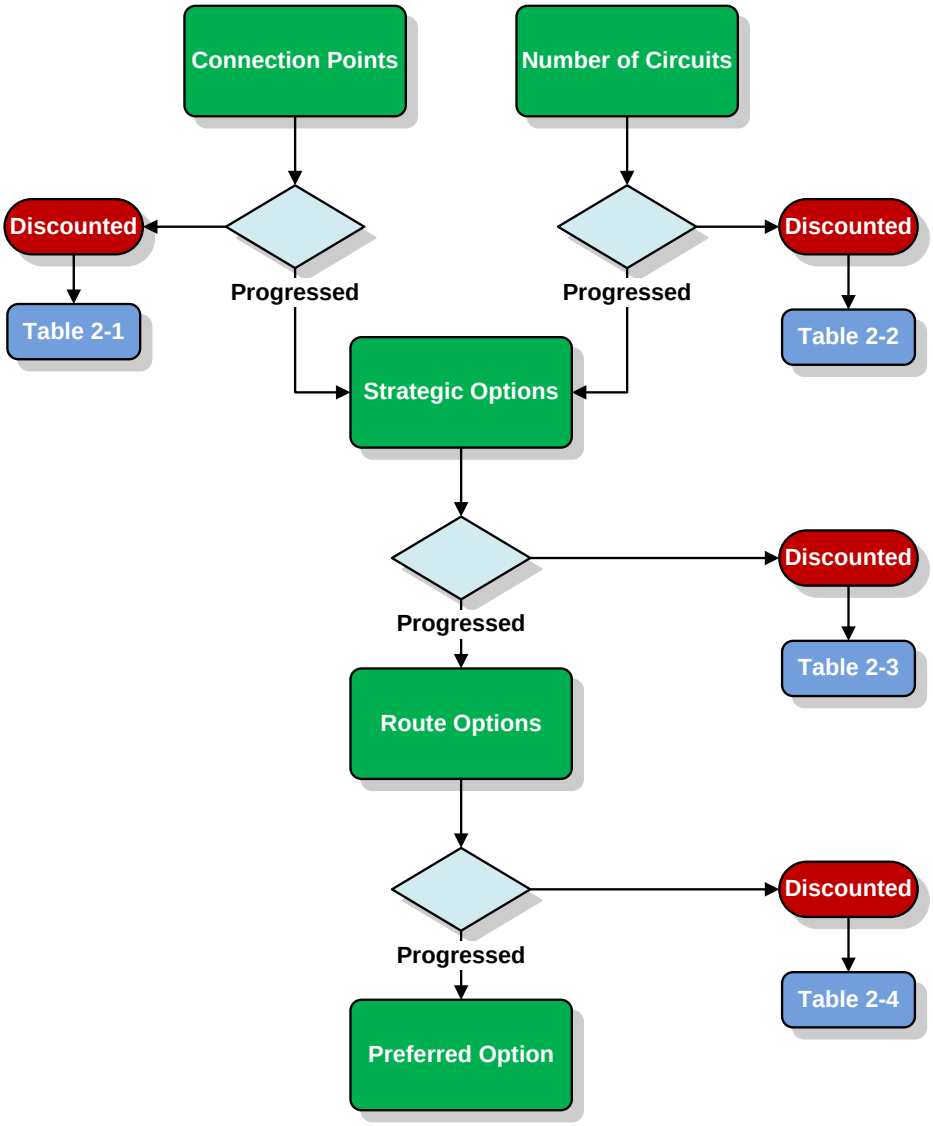


Figure 2-2: Optioneering Process used for NWCC

2.2.1 Connection Points

Table 2-1 summarises the connection points considered in the INC – "The Requirement for a New Connection in the North West" and our view on whether or not it was appropriate to discount each option. All of the options except those denoted 5 and 10 are discounted at this stage. Please note that this is our numbering of options, these options are not numbered in the NWCC INC.

Table 2-1 Assessment of Connection Options Discounting

#	Option	Reason for Discounting		Comment	
1	Connections north of Harker	Technical Cost	All power would ultimately flow through Harker substation North to South so connections further north offer no additional system benefit and route length would be longer. New circuits would use broadly the same routes, so there would be no routing/consenting benefits.		Agree – no additional system benefits, likely to be more costly.
2	Connection to Wishaw	Cost	The first point north of Harker that offers benefits through improved connectivity with the system. However, 180km away from Moorside so route length is not feasible.		Agree - interconnectivity benefits but high cost.
3	Connections between Harker and Hutton	Environmental Socio-economic	No system benefits, as all power flows on the same circuit. No benefits from a shorter/more direct route, as the new circuit would have to go straight through the LDNP which is not credible.		Agree – Environmental/consenting barrier.
4	Connection to new Substation at Harker	Cost	Harker substation can be extended, so aside from any saving in circuit length, there is no benefit associated with a new substation.		Agree – Cost.
5	Connection to Harker	Progressed			Agree – this appears to be the most suitable connection point in the North.
6	Connection to Hutton	Technical Environmental Socio-economic	Connecting a large infeed at Hutton causes issues during faults (overloads, non-compliance with the requirements of the NETS SQSS). Any new circuit would encroach on LDNP.		Agree – Environmental/consenting barrier and significant technical issues.
7	Connection to Penwortham	Cost	Connections to Penwortham would be more costly than connections elsewhere in the Heysham ring (Middleton, Heysham, or Stanah), as it is located further south, with no additional system benefits. Any resultant reinforcement requirements would be common to all connection points.		Agree – Cost.

#	Option	Reason for Discounting		Comment	
8	Connection to Stanah	Cost	Heysham and Middleton offer shorter circuit routes than Stanah, which provides no additional system benefits.		Agree – cost, however Stanah connection could be preferable/shorter for offshore routes. NGET does consider it when looking at Strategic Options, hence a green rating.
9	Connection to Heysham	Cost	Heysham substation is physically constrained and cannot be easily extended. It offers no additional system benefits over Middleton.		Agree – whilst we are not able to verify the physical space constraints at Heysham, there is no additional benefit from connecting to Heysham compared to Middleton.
10	Connection to Middleton	Progressed			Agree – this appears to be the most suitable connection point to the South.

2.2.2 Circuits

Table 2-2 summarises the number of circuits for the connection considered in the INC – "Assessment of System Requirements to Provide a NETS SQSS Compliant Connection for Moorside Power Station" and our view on whether or not it was appropriate to discount each option.

It is clear that a two circuit option would not be technically compliant with the NETS SQSS and has been ruled out. A three circuit option would also not be technically compliant with NETS SQSS which ensures that for the loss of any two transmission circuits (and other secured events) there shall be no resulting overloading of any other equipment.

NGET indicate that the highest post fault continuous thermal rating available from a 400kV single circuit overhead line (triple Araucaria) is 3,820 MVA (winter) and 3,320 MVA (summer) based on currently available and type registered equipment on the NGET transmission system. This is consistent with 2015 ETYS. The total maximum output from Moorside power station is given as 3,985 MVA at 0.85 power factor lagging at the 400 kV terminals, confirming the gap in capacity.

Thus, during a planned maintenance outage on any of the three circuits, the output of the generation at Moorside would either need to be constrained, or the system operator holds addition reserve to secure against the potential loss of >1800MW of generation infeed. Also, post fault dynamic instability was observed in a number of power system studies carried out by NGET for a two circuits fault.

A three circuit solution is attractive as it has the potential to reduce cost and environmental impacts. NGET identified a number of potential mitigations that may make a three circuit solution possible:

- A commercial inter-trip scheme that is permanently armed during the summer period to secure against the two circuit loss scenario. NGET provided further information which demonstrated that costs associated with this mitigation are very high, based on previous experience of intertrip arrangements. [redacted] This does not include costs associated with lost generation due to the slow start-up time for the nuclear generation units; and
- Stability issues could be addressed by the installation of, for example, series compensation, which has a supplied cost on the order of £1m per 100 MVA.

In summary, the cost of a commercial intertrip permanently armed during summer rules out a three circuit option. [redacted]

Table 2-2 Assessment of Circuit Design Options Discounting

#	Option	Reason for Discounting		Comment	
A	Two circuit options	Technical	With a double circuit option, an N-D fault would disconnect the entire 3.4GW power station. This violates the infrequent infeed loss risk criterion.		Agree – NETS SQSS violation.
B	Three circuit options	Technical Cost	With three circuits, an N-D outage would lead to short term overloading of primary transmission equipment, and there would be system stability issues. It would be necessary to reduce the output of the power station. This could be managed through a commercial intertrip permanently armed during summer however, it would be very costly.		Agree – NETS SQSS violation or high cost.
C	Four circuit options	Progressed			Agree – four circuits is the smallest number that satisfies all the key criteria within the SQSS.

2.2.3 Strategic Options

The majority of strategic options were ruled out for two simple reasons:

1. NGET believed that the northern search area could accommodate a double circuit route without 'significant additional mitigation' (although it could require rationalisation of the existing ENWL circuits). Therefore, there was deemed to be no additional benefit from routing northern circuits offshore, and all options which involved northern circuits offshore were ruled out: Options 2, 6, 8 and 9.
2. NGET identified that it would not be feasible to route two onshore double circuits in the southern search area based on initial environmental assessment and stakeholder consultation. This therefore ruled out the option with two onshore double circuits south, two offshore double circuits south (on the basis that a double circuit could more easily be routed onshore), and one double circuit south onshore with one double circuit south offshore (on the basis that the offshore double circuit could more readily be routed north onshore). Essentially, all options which involved two double circuits going south were removed: Options 3, 4 and 10.

We are broadly supportive of this reasoning. [redacted]

It may have been useful for NGET to consider the (presumably reduced) wider impact on system capability of an option which routed four circuits south – presumably, this would have had a reduced impact on boundary capability which may have resulted in lower constraint costs in the CBA.

At this stage, only three options remained:

- Option 1 – 2 Double Circuits North Onshore (renamed to Option 1);
- Option 5 - 1 Double Circuit North Onshore & 1 Double Circuit South Onshore (renamed to Option 2); and
- Option 7 - 1 Double Circuit North Onshore & 1 Double Circuit South Offshore (renamed to Option 3).

Subsequently, Option 1 was ruled out due to the impact it had on wider system performance and boundary capabilities. However, the option was "back-checked" within the CBA in order to quantify this reduction in boundary capability. This is discussed in more detail in Section 2.4.

Table 2-3 Assessment of Discounting of Strategic Options

#	Option	Reason for Discounting			Comment
1	2 Double Circuits North Onshore	Cost	Increased power flows north exacerbate north-south power flows across B6 boundary and could trigger costly wider works. Landscape and visual impacts including cumulative impacts of twin double circuits. Risk of additional mitigation being required to mitigate cumulative effects resulting from 2 OHL runs.		Agree – Increased wider works will result in higher costs and appropriate justification and evidence is provided for this.[7] During preferred options consultation Natural England expressed preferences for offshore routing in the northern section noting the significant landscape and visual risk posed by 2 onshore double circuits.
2	2 Double Circuits North Offshore	Cost	The distance and corresponding cost of offshore subsea cables for this route make it infeasible. High level of ecological designations which could not be completely avoided. Existing offshore wind farms, shellfish beds and the Kirkcudbright MOD firing range are socio-economic constraints.		Agree – Compared to an onshore option, this option is significantly more costly. Also agree that there are environmental constraints that would represent high consenting risks. While we do not consider that these alone warrant discounting of this option, they add weight to a decision primarily based on costs.

[7] Note that this is on the basis of the Wider Works options presented by NGET in the INC.

#	Option	Reason for Discounting		Comment	
3	2 Double Circuits South Onshore	Environmental Socio-economic	This route would cross some areas of the LDNP. Environmental sensitivities mean that 2 double circuits would present an extremely high consenting risk. Feedback from stakeholders received in 2012 supports this. Highest magnitude of impacts on the highly sensitive receptors of the onshore south route.		Agree - Natural England's consultation response to Preferred Strategic Options Consultation seeks to rule this out and LDNP has raised objections which would likely be carried through to the DCO process. Furthermore, mitigations would likely result in significant cost due to undergrounding.
4	2 Double Circuits South Offshore	Cost	The routing of this option would need to avoid the Eskmeals firing range, significantly increasing circuit distance and corresponding costs whether HVAC or HVDC.		Agree - the high cost of the route mean that both HVAC and HVDC costs would be prohibitive.
5	1 Double Circuit North Onshore & 1 Double Circuit South Onshore	Progressed			Agree – this option is likely to present a low cost solution relative to many of the others described, and has reduced wider impact relative to Option 1.
6	1 Double Circuit North Offshore & 1 Double Circuit South Offshore	Cost	Discounted as lower cost alternatives are available i.e. onshore north and onshore south.		Agree - the additional cost of the fully offshore option is not justifiable when there are lower cost options available onshore.
7	1 Double Circuit North Onshore & 1 Double Circuit South Offshore	Progressed to next stage of option discounting – this provides a credible alternative to Option 1 and Option 5.			Agree – this option has benefit over Option 5 as it entirely avoids the LDNP. It is likely to be the lowest cost option which does so while not affecting overall system capability (as Option 1).
8	1 Double Circuit North Offshore & 1 Double Circuit South Onshore	Cost	Discounted as lower cost alternatives are available i.e. onshore north.		Agree - the additional cost and difficulty of the offshore North option is not justifiable when compared to, for example, the onshore North option.

#	Option	Reason for Discounting		Comment	
9	1 Double Circuit North Onshore & 1 Double Circuit North Offshore	Cost Technical	Discounted as lower cost alternatives are available i.e. onshore north, onshore south.		Agree – cost of the northern offshore circuit is high. Also while offshore designations represent environmental constraints, it is not clear that these would outweigh impacts (particularly landscape, visual and ecological impacts) resulting from onshore routing. It is worth noting that LDNP, in responding to strategic options in 2012 stated that it did not have significant concerns regarding the northern onshore component for a single double circuit. However impacts on other designations including the Hadrian's Wall WHS require detailed consideration of mitigation options.
10	1 Double Circuit South Onshore & 1 Double Circuit South Offshore	Cost	Northern onshore double circuit could be delivered more cheaply than a 2nd southern circuit offshore. Also, LDNP do not have significant concerns for one northern onshore double circuit.		Agree - A northern onshore route has been shown some support from consultees. A southern offshore circuit provides environmental benefits, primarily relating to decreased landscape and visual effects but at significantly higher cost.

2.2.4 Routing Options

This assessment considers the appropriateness of the discounting of a number of routing options for the onshore southern route. This is described in the INC with routing, environmental constraints and consentability discussed at a high level.

Table 2-4 Assessment of Discounting of Onshore South Routing Options

#	Option	Reason for Discounting			Comment
2	One double circuit South onshore to Middleton substation with a **tunnel across Morecambe Bay**	Progressed			We agree that this option should be progressed to allow detailed consideration of the option to utilise a tunnel beneath Morecambe Bay due to the ability to minimise environmental effects and reduce consenting risks.
2e	**Enhanced option 2** - Triple Araucaria and L13 towers	Cost	This option is assessed in the Cost Benefit Analysis and does not perform as well as Option 2, although it is never explicitly stated that this option has been ruled out.		We agree that it is appropriate to discount this option based on the output of the cost benefit analysis.
3	One double circuit **south Offshore HVDC** to Stanah substation	Cost Technical	This option has the highest capital cost when compared to other options. In addition, concerns were expressed about the use of HVDC technology to connect a Nuclear Power station.		We support the discounting of this option on cost grounds. We recognise the technical challenges associated with the use of HVDC systems, although we do not believe that this option presents significantly greater risk than any other VSC HVDC project – many of the technical issues described are common to VSC HVDC technology in general.
4	One double circuit South to Stanah substation via **Walney Island Offshore AC cable**	Cost	This backcheck option was ruled out as (i) its estimated capital cost would be higher than that of the preferred option, and (ii) the route would cross high-level ecological designations which might introduce consenting risk and costly timing constraints for installation and maintenance.		We believe that NGET has not sufficiently justified the discounting of this option. Specifically, on the aspects of: i. The detailed cost of cable supply and installation. Our view of NGET's assumptions is that the costs are too high. i. The environmental impacts that such a cable would have and whether this would be consentable in comparison with the tunnel.

#	Option	Reason for Discounting		Comment	
5	One double circuit South to Stanah substation via **Kirkstanton Offshore AC cable**	Cost	This backcheck option was ruled out as (i) its estimated capital cost would be higher than that of the preferred option, and (ii) the route would cross high-level ecological designations which might introduce consenting risk and costly timing constraints for installation and maintenance.		We believe that NGET has not sufficiently justified the discounting of this option. Specifically, on the aspects of: ii. The detailed cost of cable supply and installation. Our view of NGET's assumptions is that the costs are overly pessimistic. iii. The environmental impacts that such a cable would have and whether this would be consentable in comparison with the tunnel.
6	One double circuit onshore South to Quernmore substation **(South Lakeland)**	Environmental	NGET sought legal advice which suggested that there would be a substantial risk to consent for this option as an alternative option exists (the Morecambe Bay tunnel) which reduces impacts on the National Park and the ecological designations in the area. NGET has considered various forms of mitigation although these are costly and, in some cases, may not be achievable or acceptable (e.g. due to ground conditions, ecological impacts or impacts on cultural heritage).		We agree with NGET's decision not to progress this option. Getting consent for this option would likely require lots of mitigation (e.g. undergrounding) which would be very costly [redacted] and may not be possible due to geological conditions underlying the route corridor and the difficulties in utilising underground cabling. Undergrounding sections of circuit requires the installation of Sealing End Compounds which need to be carefully sited and which also result in environmental effects. Where frequent switches between undergrounding and overhead lines are required to accommodate ground conditions this may reduce the effectiveness of this options as mitigation. The consenting risk associated with this option would therefore be very high, particularly when there is an alternative option available which does not require a route through the South Lakeland section of the LDNP.

#	Option	Reason for Discounting		Comment	
7	One double circuit onshore South to Middleton substation via **Roosecote and Morecambe Bay buried AC cable**	Environmental	This option was discounted due to the impact that a cable array would be expected to have on the sensitive and highly protected habitats within Morecambe Bay. NGET concluded that rock armour would have to be installed to protect the cables, and that this rock armour could have a negative impact on the SAC designation of the bay, creating a build-up of sediment.		We believe that NGET should have considered within the original INC whether the use of three core cables would be possible, and whether it would reduce the cost of the option and the environmental impacts. In addition, alternative cable installation methods should have been considered. However, based on subsequent information received in the supplementary Q&A process and in workshops, we are satisfied that even a three core cable option would have a wide swathe and would not significantly reduce the environmental impact on the bay. Therefore, this option would likely still carry a significant consenting risk.
8	One double circuit onshore South to Stanah substation via **Roosecote Offshore AC cable**	Cost	This backcheck option was ruled out as (i) its estimated capital cost would be higher than that of the preferred option, and (ii) the route would cross high-level ecological designations which would increase consenting risk and costly timing constraints for installation and maintenance.		We believe that NGET has not sufficiently justified the discounting of this option. Specifically, on the aspects of: iv. The detailed cost of cable supply and installation. Our view of NGET's assumptions is that the costs are overly pessimistic. i. The environmental impacts that such a cable would have and whether this would be consentable in comparison with the tunnel.
9	One double circuit onshore South to Middleton substation via **Overhead Line across Morecambe Bay**	Environmental	This option would have a high risk of not being consentable due to impact on wildlife (birds), the impact on natural movement of sediments within the bay, and the high landscape and visual impacts affecting the LDNP and other sensitive landscapes.		We support NGET's decisions not to progress this option further.

2.2.5 Discussion of Optioneering

2.2.5.1 Environmental Sensitivities

Ofgem specifically wishes to understand whether NGET has correctly identified environmental sensitivities in relation to:

- Passage through the South Lakeland sections; and
- The seabed cable array across Morecambe Bay.

In particular, Ofgem wanted appraisal of whether sufficient detail had been covered to appropriately reflect the impact on consenting.

South Lakeland

The INC has identified the key sensitivities, focussing on ecological, landscape and heritage designations.

Landscape designations considered are the LDNP, Arnside and Silverdale AONB and Forest of Bowland AONB. The INC clearly sets out the baseline with regard to these designations. Based on the assessment provided to this point and understanding the sensitivity of this section of the route, it is clear that developing a further OHL through South Lakeland presents substantial consenting risk. Areas of rock outcrop or shallow superficial sediments limit the potential to mitigate landscape and visual impacts through undergrounding.

Similarly ecological designations have been identified during the optioneering process and the baseline is set out within the INC noting where there is the likelihood of their being significant effects on sensitive receptors. [redacted] These assumptions appear to have been carried forward into the cost estimates provided.

The INC acknowledges socio-economic effects without including detailed assessments. Consenting risk associated with socio-economics is inherently linked with those effects that are discussed in detail in relation to designations. As a result, at this stage, the treatment of socio-economic impacts to date does not restrict consideration of the impact on consenting.

Overall, environmental sensitivities have been accurately identified and evidence has been provided to highlight the potential consenting risks. The level of risk will be dependent on final routeing and the incorporation of effective mitigation measures to reduce environmental effects to a level considered acceptable when balanced against the benefits of the scheme. The use of back checking of options once environmental impacts and the need for mitigation have been accurately assessed, will allow NGET to validate the preferred option decision with a fuller understanding of consenting risk.

Morecambe Bay Seabed Array

The sea bed array option is excluded due to the impacts on the sensitive and highly protected habitats within the bay relating to disturbance during construction and the likelihood of the cable array, when rock armour protection is deployed, arresting the natural

movement of sediments. Detailed assessment is included within the INC with the Executive Summary stating that the cable array, running perpendicular to flows could lead to *'the establishment of areas of permanent vegetation and/or sections of permanent channel leading to a change in the extent of intertidal mudflats and sandflats and of habitats such as sandmarsh'*.

Natural England, in its response dated July 2012, provided comments on impacts on marine habitats that are relevant to consideration of an array across Morecambe Bay. It noted that stony/hard substrate habitats are likely to have slow recoverability from the effects of cable trenching but that corridors through areas of soft sediment would have the capability to re-stabilise and re-colonise more quickly. Natural England's response illustrates the complexity of the habitats within the Bay and the consenting risk attached to development which may result in harm.

The weight given to the importance of the movement of sediments within the bay and sensitivity of high value and high sensitivity habitats is appropriate. The INC references assessments relating to the Walney Extension and Ormonde Offshore Wind Farms and concludes that there would be a need for rock armour protection where shallow sediments prevent cabling being buried or there is the likelihood of lengths of cable becoming exposed due to the natural movement of sediments.

The final extent of the deployment of rock armour protection is not clear. Nevertheless it is agreed that the likely effects upon the sensitive habitats within the intertidal areas as a result of the array forming barriers to natural sediment movement could be significant and present a substantial consenting risk. The laying of wind farm export cables within Morecambe Bay has previously been found to be acceptable. However, the impacts of those cables, routed within a deeper water channel more generally in alignment with natural sediment movements and utilising corridors characterised by soft sediments that are more capable of recovery following cable laying, would be expected to be of lesser magnitude than an array of cables crossing the bay perpendicular to the main sediment flows and across less resilient habitats.

As well as the differences in the likely impacts between the wind farm export cables and an NWCC array, additional cumulative effects must also be considered. Those cumulative effects would need complex assessment and be subject to a high degree of uncertainty. It is anticipated that there would be a requirement for extensive monitoring post consent to understand the complex interactions between the array, inter-tidal habitats and the species that rely upon them.

Selection of potential landing points for an array is detailed within the INC. There are numerous constraints that substantially limit the options. HDD would likely be required to avoid impacts on areas of salt marsh that form part of the suite of ecological designation within Morecambe Bay.

Summary

Environmental sensitivities have been accurately identified within the INC. A cable array will certainly involve consenting risk in relation to the effects on highly protected sensitive

habitats. From an environmental and consenting perspective it seems unlikely that a cable array would be a viable option given the number of cables required and the width of the cable corridor (for single core or three core). The amount of sensitive habitat likely to be affected and the level of environmental effects will also depend on the routing and the use of rock armour which is likely to effectively create groynes perpendicular to flows. Uncertainty over the morphological change within the bay and the effects that a cable array would have over time are also considered to mean that there would always be a very high consenting risk attached to that option.

Consideration of the Impacts on Consenting within the CBA

It is considered that the INC provides a sufficiently detailed consideration of the environmental sensitivities around the cable array and tunnel options. However, consenting risk has not factored in these assessments. NGET confirm that specific planning and consenting challenges have not been identified separately, and therefore taken into account, at this stage. A generic DCO risk uplift that would be considered suitable for all similar projects, has been applied in the CBA. Therefore, while the process to date has allowed a good understanding of environmental sensitivities, these have not been fed into the CBA to allow option specific analysis taking into account potentially determinative consenting challenges. This appears appropriate at this stage in the project but option specific analysis should be included in future backchecks following completion of the EIA.

2.2.5.2 *Assumed HVAC Subsea Cable Designs and Installation for Option 7*

NGET selected a single core subsea cable design for HVAC offshore routing options. NGET commissioned a report on the HVAC subsea cable design which states:

"The high power transfer required for these cables means that the cable cores have a large diameter and are relatively heavy. This coupled with the use of very large diameter, rigid joints leads manufacturers to offer single core cables rather than three core XLPE cable for this application."

ABB have recently (2013) installed a 1100 MW 420 kV AC three-core cable system for the Little Belt project in Denmark[8]. The design included two cables per phase (for a total of two cables) over a distance of 7.5 km. NGET's Technology Appendix E within the Electricity Ten Year Statement also includes some discussion of future developments in subsea three core cables, which is summarised in the figure below. This shows that three core cables up to 700 MW per cable are expected to be available within the next 5 years.

[8] ABB, "World's most powerful three-core submarine cable Little Belt Visual Enhancement Scheme, Denmark", Accessed 14th July 2016,

https://library.e.abb.com/public/689213765eef0d49c1257c0e00243c4f/Little%20belt%20brochure%202GM8001-gb%20korr3.pdf

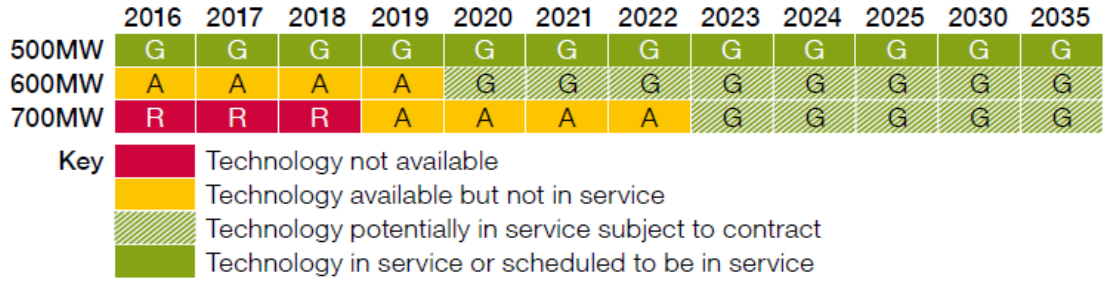


Figure 2-3: Three Core AC Submarine Cable Technology Availability (Source: NGET)

We would expect that the supply and installation costs for each cable would be greater, for example the cable would be heavier, reducing the availability of appropriate cable lay vessels and increasing jointing operations. However, the number of cables that need to be supplied and installed would be reduced significantly, from 18 to 8 or 10, depending on cable capacity. We would therefore not expect the overall cost of this routing option to increase and furthermore, it may decrease with respect to the single core cable option. As Option 7 was ruled out on an environmental basis[9] it would require further consideration of the environmental impacts of these three core cables. Our view is that even with a reduced number of cables, the potential environmental impact of this option would make it challenging to obtain consent for, particularly when considered against the cable tunnel option, and that therefore National Grid is correct to not progress Option 7 further.

2.2.5.3 Assumed HVAC Subsea Cable Designs and Installation for Back-Check Options

The "back-check" routing options around Morecambe Bay were largely ruled out based on cost, with consideration also given to environmental impacts.

Three core cables would allow for 8 to 10 cables to be used instead of 18, depending on cable capacity. This should reduce the cost of cable supply, although would increase installation costs per cable. This would also significantly reduce the environmental impact of this option and other routing options around Morecambe Bay due to reduced cable corridor, particularly if alternative installation options could be utilised. The potential for use of three core cables was discussed in more detail at a workshop with NGET, who subsequently provided cable costings for a three core cable option.

We engaged with specialist cable consultants at Petrofac to explore this in more detail. They identified a number of issues with both the single-core and the three-core cost estimates. Based on our own independent assessment and through an examination of NGET's cost estimates, we consider that it may be possible for the overall costs of each of the back check cable options to be reduced significantly. These options could ultimately end up with comparable or even lower costs than NGET's preferred option. Further opportunities for cost reduction exist, these are not explored further here as they are beyond the current scope.

[9] The single core cable option was not ruled out on a cost basis – it is cheaper than NGET's preferred option. Therefore, a reduction in cost alone would be unlikely to change the preferred option.

We also recognise however, that there may also be cost reduction opportunities for the cable tunnel.

We suggest that these options are examined in more detail to understand costs and cost sensitivities. In particular, the following should be examined in more detail:

- Weather analysis on vessels to establish a realistic downtime estimate;
- Optimisation of scheduling of offshore installation and vessel requirements;
- Gathering of vendor quotes for rock dump and vessel hire;
- Revised crossing design;

As noted above, these options were largely ruled out based on cost.

2.2.6 Technical Designs

2.2.6.1 Overhead Line

The proposed technical design includes two double circuits. For the overhead line sections, each circuit consists of three bundles of 2x700 mm^2 'Twin Araucaria' conductor. NGET quotes the ratings in Table 2-6 for Twin Araucaria conductor.

Table 2-5 400kV Overhead Line Ratings

	Winter	Spring/ Autumn	Summer
75°C	2,550 MVA	2,420 MVA	2,210 MVA
85°C	2,720 MVA	2,610 MVA	2,410 MVA
90°C	2,810 MVA	2,700 MVA	2,510 MVA

30.5nΩ.m AAAC, 2x700mm^2 'Twin Araucaria'

These ratings are quoted in Tables B3, B4 and B5 in the National Grid standard TGN(E) 26 -" Technical Guidance Note" on "Current Ratings for Overhead Lines".

By operating at temperatures greater than 75°C, Twin Araucaria conductor can meet the 2,557 MVA rating requirement for Winter, Spring and Autumn ambient temperatures. The summer rating of the circuit is not adequate to meet this requirement. However, NGET believes that it is not credible that the scenario of high B6 boundary transfers (which coincides with low demand) would coincide with both Moorside operating at its full output, and an outage of one Moorside to Middleton circuit. Therefore, NGET expects the Twin Araucaria will also meet likely summer requirements. It is our view that this is a reasonable assumption as the Moorside power plant would provide base load during low summer demand, with reduced B6 transfer.

2.2.6.2 *Underground Cable*

Where required, underground cable sections will consist of 2x2500mm^2 single core cables per phase.

We understand from drawings provided by NGET that their preliminary design is for cables to be buried at a depth of approximately 1m, with 0.5m separation between each phase (in agricultural land) and at a reduced depth of around 0.85m within a duct within public highways (still with the same separation).

To deliver the required rating of 2,557 MVA, each cable system needs to be capable of carrying 1.846 kA. An ABB datasheet on Land Cable Systems quotes the ratings in Table 2-6 for 2500 mm^2 cables in the ground. These are adjusted to allow for phase spacing of >400mm^2[10].

Table 2-6 400kV Underground Cable Ratings

	Cross bonded	Both ends
	90°C	90°C
Rating (A)	1,875	1000
Adjusted Rating (A)	2,081	1110

These ratings assumed a burial depth of 1m, ground temperature of 20°C, soil resistivity of 1Km/W.

As can be seen from Table 2-6, the 2500mm^2 would be expected to deliver the required current rating as long as it is cross-bonded.

2.2.6.3 *Tunnel Design*

NGET is proposing to install 2x2500mm^2 single core cables per phase within the tunnel. To deliver the required rating of 2,557 MVA, each cable system needs to be capable of carrying 1.846 kA. An ABB datasheet on Land Cable Systems quotes the ratings in Table 2-7 for 2500 mm^2 cables in the air.

Table 2-7 400kV Underground Cable Ratings in Tunnel

	Cross bonded		Both ends	
	65°C	90°C	65°C	90°C

[10] Assuming a cable diameter of 135mm^2, based on the provided drawings.

Rating (A)	2,095	2,845	1,065	1,515

These ratings assumed the ambient temperature of the tunnel is 35 °C. Based on the cable tunnel report, we understand that the ambient temperature will be closer to 50 °C which may affect the rating

Cross bonded cables will give the required current rating. Based on the data provided by ABB, smaller cables (e.g. 2000mm^2) could feasibly also give the required rating however these would need to be operated at slightly higher temperatures which might affect the ambient temperature within the tunnel.

The report commissioned by NGET on Proposed Tunnel Diameter Options Appraisal seems to justify the selected tunnel diameter of 5m sufficiently. The report provides evidence that a tunnel diameter less than 5m wouldn't offer sufficient space to comply with Health and Safety requirements and fit in all plant and equipment. A diameter larger than 5m would be suitable from a construction perspective but the spoil removal for larger diameters scores poorly on sustainability criteria. Furthermore, cable installation in larger diameter tunnels starts to create installation issues due to a requirement for working platforms to access higher parts of the tunnel for example. So a 5m internal diameter appears to be the optimal size when considering all the various, and relevant aspects. Larger diameter tunnels would require smaller headhouses (less ventilation plant), but the difference in size is negligible when considered in context to the tunnel project as a whole.

NGET has also indicated that 5m diameter is felt to be appropriate for the purposes of obtaining consent whilst not restricting the final contractor design excessively given project specifics.

We are satisfied that the cable tunnel design and selected diameter is appropriate and well justified.

NGET used analysis from a reputable cable tunnel construction contractor, to provide an indicative cable tunnel costing proposal. This indicates that increasing tunnel diameter does not have significant impact on costs with an increase from 4m to 5m increasing cost by only 6% although the IET Electricity Transmission Costing Study[11] suggests that an increase in tunnel diameter from 4m to 5m would add about 15-20% to cost. It is not clear why the difference is not so substantial.

2.2.6.4 Mitigation Assumptions

[redacted]

[11] Parsons Brinckerhoff and Associates, IET Transmission Costing Study, January 2012. http://www.theiet.org/factfiles/transmission-report.cfm

[redacted]

Removal of existing 132kV lines along the northern route would be a key mitigation to minimise cumulative landscape and visual and cultural heritage impacts. Within the cost estimates in the initial needs case, costs associated with this are included within 'Final Network Configuration' costs [redacted]

For a single double circuit onshore to the north it is assumed that one existing 132kV line would be dismantled and none of the new 400kV double circuit would be undergrounded. [redacted]

Partial mitigation has been assumed south of Moorside and north of Roosecote. [redacted]

The extent and likely effectiveness of mitigation involving undergrounding within the LDNP will be key in obtaining planning consent in light of the consultee responses to date, location within the LDNP and the relationship between the small scale landscape of the coastal plain and the inland fells. [redacted]

Other mitigation measures, such as post consent ecological survey and monitoring or archaeological mitigation, appear to have been considered generically for all options. Specific assumptions should be possible following completion of the EIA.

2.2.7 Assessment Summary

Optioneering

Our assessment of the optioneering process carried out by NGET included review of the appropriateness of the technical requirements, design and consideration of alternative options. Our independent view is that the stated technical requirements for the various options considered are reasonable and the technical design of the preferred option delivers the required capacity and is technically robust.

There are no additional reinforcement options or operational measures that have not been considered by NGET that would be technically and economically feasible to connect Moorside.

Optioneering Approach	Technical Requirements	Technical Design	Alternative Options
			

Discounting of Options

NGET has generally provided sufficient and valid reasoning for the exclusion of specific options throughout the optioneering process evidenced through reference to technical specifications, cost data, expert analysis and stakeholder consultations. Specifically, appropriate consideration has been given to the environmental sensitivities presented by routing an overhead line through the South Lakes section of the Lake District National Park and we are in agreement with discounting of this option.

However, we have concerns in relation to the discounting of routing options for the southern route due to the potential for use of a subsea cable, and a lack of consideration of a high capacity three-core subsea cable. This could significantly reduce the cable corridor footprint and has not been sufficiently explored by NGET in our view. We accept that there are considerable environmental sensitivities in relation to routing of a cable corridor (in the order of 1km across) across Morecambe Bay and NGET has provided evidence to substantiate this and the risk posed to consentability. However, a reduced cable corridor footprint should reduce the environmental impact.

Also, whilst we do not agree with the discounting of HVDC solutions on the basis of technical grounds alone, there is strong justification for discounting on the basis of cost. It is also understood from NGET that NuGen is concerned about using HVDC for connection of a nuclear power plant which would be a novel, first-of-a-kind application at this voltage level.

Discounting - Connection Options	Discounting - Circuit Options	Discounting - Strategic Options	Discounting - Routing
			

2.3 Costs of Options

Box 2-2: Specific Review Questions

Whether the methodology for estimating the costs of options is sufficiently accurate and allows a fair comparison between the different options:

- Based on high-level industry benchmarks, do the estimated capex costs of the options included in the CBA appear reasonable?
- 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?
- Based on technical best practice and industry cost benchmarks, does the technical scope of the proposed tunnel and associated cost appear reasonable?
- Do the costs proposed for the hypothetical alternative route through the South Lakes section of the Lake District National Park appear reasonable?
- Following a thorough review of the methodology used across all options, has a consistent risk methodology been followed for all options?
- Based on a review of the risks included for each option, have any risk categories been unreasonably included or excluded?

2.3.1 Reasonableness of Costs

2.3.1.1 NGET Approach to Costs

NGET's approach to developing cost estimates is described the INC. The process used is approximately as follows:

1. Assumptions about component requirements for each option have been made based on technical requirements and information about environmental constraints (which, for example, inform assumptions about required mitigations);
2. Unit costs from NGET's estimating data base have been used. These are built up from historical information, recent tender, completed projects, and other relevant information such as the Electricity Transmission Costing Study (IET Report) and a Parsons Brinkerhoff report about Morecambe bay crossings;
3. NGET has clarified that where it was clear that a cost taken from another project contain risk costs, these have been stripped out of the base cost. Where it was not possible to identify the existence of risk costs (such as with HVDC) there was assumed to be no risk within these costs as it would be impossible to identify. There is, therefore, some potential for double counting of risk costs. However, we consider that this an appropriate method based on the information available and the current status of the project. Additionally, this 'double counting' could be addressed within

the risk assessment process which accounts for uncertainty in cost estimates and in the scope or design of assets;

4. Each option is broken into various components such as overhead lines, substations, cables, project management, DCO costs, land management costs. The cost for each of these components is estimated from the estimating data base, using established work breakdown structures for overhead line and cable elements, and the NGET cost book for substations;
5. P50 and P80 risk costs are estimated, as per the risk methodology described below.

2.3.1.2 Circuit Cost Benchmarking

We have compared a selection of *'headline'* base cost figures for NWCC circuit elements (including overhead lines, underground cables, subsea HVDC cables and tunnel cables) of each option in Table 2-4 to the figures contained within the IET Electricity Transmission Costing Study[11], a common industry benchmark.

Note that NGET includes costs for 'Land acquisition, surveys etc'. We understand that the IET's benchmark costs exclude land acquisition, and also exclude most survey costs. Therefore, for this benchmarking exercise, we have excluded these costs from the NWCC figures.

All contingency and project management costs have been removed from the IET cost figures, and we have excluded PM and P50/P80 costs from the NWCC estimates. The medium capacity circuit costs have been used for overhead lines and underground AC cables. We have provided a range of costs for the subsea HVDC option, based on both the Low (3GW) and Medium (6GW) circuit capacities, as the required size of the NWCC link (4 GW) sits between these two benchmarks.

Table 2-8 Circuit Cost Benchmarking (400kV Double Circuits, Installed Costs)

Circuit Element	Distance	Cost (£ M)	
		NWCC	IET
Underground Cable (Option 2)	[redacted]	[redacted]	[redacted]
North OHL (Option 2)	[redacted]	[redacted]	[redacted]
South OHL (Option 2)	[redacted]	[redacted]	[redacted]
Tunnel (Option 2)	[redacted]	[redacted]	[redacted]

Circuit Element	Distance	Cost (£ M)	
		NWCC	IET
Subsea Cable HVDC (Option 3)	[redacted]	[redacted]	[redacted]
Underground Cable¥ (Option 6)	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

*We have added an 18.2% uplift to account for the diameter (5m) of the NWCC tunnel – the central estimate is based on a 4m diameter.

¥ based on the total distance of undergrounding for the preferred South route

[redacted]

Figure 2-4: [redacted]

This benchmarking suggests that the overhead line and underground cable costs are robust and of the right order of magnitude. NWCC's HVDC costs sit between the estimates for a 3 GW and a 6 GW system. [redacted]

The only significant discrepancies between the NWCC and IET costs is for the 22km tunnel under Morecambe Bay. However, this comparison suggests that the cost estimate from NGET may actually be slightly too high. If the cost of the tunnel was more similar to the benchmark from the IET, then the cost of Option 2 would reduce, making this option potentially more attractive.

The IET report does not provide costs for subsea AC cables. Instead, these costs have been benchmarked against unit cost data provided by NGET in the Technology Appendix of ETYS.

For all four options which contain an AC subsea cable element (Option 4, Option 5, Option 7 and Option 8), the supply and installation cost of the subsea cable and the length have been taken to determine the per km cost for a three cable per phase double circuit. This in turn has been used to derive the cost for a single cable per phase double circuit (simply by dividing the per km cost by a factor of six). A benchmarking cost range has been derived from the ETYS based on single core cables with capacities of 900 – 1000 MW, with each cable installed in an individual trench. We estimate that the susbsea cables used in the NWCC optioneering process is approximately 800-900 MW (3c per phase to deliver 2500MW). The results of this benchmarking are shown in Figure 2-5, along with the distance of the subsea cable for that option.

Figure 2-5

2.3.1.3 Substation Cost Benchmarking

The costs of the Roosecote and Moorside substations have been benchmarked against information within NGET's Use of System Charging Statement[12] and the costs contained with the technology appendix of the ETYS 2015. These asset costs have been used in an in-house TNEI cost estimation tool, which includes generic % uplifts for works costs (including transportation, civils, erection/commissioning) as well as overhead costs including design, project management and consents. The results of this benchmarking are shown in Table 2-9. There is close agreement between the TNEI cost estimate and the NWCC cost, particularly for installed costs.

Table 2-9 Substation Cost Benchmarking

	NWCC		TNEI	
	Installed	Overhead	Installed	Overhead
Moorside Substation				
Roosecote Substation				

2.3.1.4 Distribution Cost Benchmarking

We have carried out a high level benchmarking assessment of the distribution final network configuration costs. We have done this based on the volumes provided in the supplementary question process using a TNEI in-house asset cost database.

Based purely on the costs provided, we have calculated a headline cost of £99m. This is comparable to the cost quoted in the INC . However, we recommend that benchmarking of distribution costs is revisited in greater detail at a later stage of the SWW process (e.g. the FNC or the Project Assessment).

[12] This statement provides illustrative connection charges which includes an estimate of the Gross Asset Value of substation bays, transformers, and sealing cables.

For diversions and infringements, NGET states that there will be 25 132kV diversions/infringements, [redacted]. The provided drawings for an example scheme show that the route requires dismantlement of approximately 1.7km of two 132kV steel tower overhead line sections. NGET's cost [redacted] for doing this does not appear unreasonable, assuming that the existing route is steel tower rather than wood pole.

If all 132 kV diversions/infringements have similar costs then this would account for the majority of the [redacted] cost on EHV diversions/infringements – this might suggest that the majority of these are for steel tower sections. [redacted] We are generally in agreement but would suggest all these figures are revisited in much greater detail at a later stage of the SWW process.

2.3.1.5 Project Management Costs

Project management costs are set at a pro-rata value [redacted]. This is common across all assets and options. Our view is that this is an acceptable approach for estimating project management costs at this stage of project development and the value is an appropriate magnitude for the project type although unusually precise. We would expect 10 to 15% at this stage.

2.3.1.6 Planning and Consenting Costs

Table 2-10 summarises the planning and consenting costs set out in the INC.

Table 2-10 Summary of Planning and Consents Costs

#	Option	Northern Section	Southern Section
1	Two double circuits north onshore.	[redacted]	[redacted]
2	One double circuit South onshore to Middleton substation with a **tunnel across Morecambe Bay**	[redacted]	[redacted]
2e	**Enhanced option 2** - Triple Araucaria and L13 towers	[redacted]	[redacted]
3	One double circuit **south Offshore HVDC** to Stanah substation from Moorside	[redacted]	[redacted]
4	One double circuit onshore North to Harker substation and one double circuit South to Stanah substation via **Walney Island Offshore AC cable**	[redacted]	[redacted]

#	Option	Northern Section	Southern Section
5	One double circuit onshore North to Harker substation and one double circuit South to Stanah substation via **Kirkstanton Offshore AC cable**	[redacted]	[redacted]
6	One double circuit onshore North to Harker substation and one double circuit onshore South to Quernmore substation **(South Lakeland)**	[redacted]	[redacted]
7	One double circuit onshore north to Harker substation and one double circuit onshore South to Middleton substation via **Roosecote and Morecambe Bay buried AC cable**	[redacted]	[redacted]
8	One double circuit onshore north to Harker substation and one double circuit onshore South to Stanah substation via **Roosecote Offshore AC cable**	[redacted]	[redacted]

Per kilometre costs vary and appear to have been calculated back from the assumed overall costs. NGET have provided an explanation of the calculation of costs in the supplementary Q&A process. The forecasts for all options are based on the base cost estimate for the preferred option. NGET's methodology then allows costs for some elements (e.g. legal, land and environmental costs) to be modified specific to the characteristics of each option. A review of the breakdown provided by NGET illustrates that little difference has been identified between the various options. The same environmental costs have been applied for Options 2, 4, 6, 7 and 8 but it is clear that costs would vary considerably. For example a cable array across the bay would require extensive data collection, modelling and assessment to understand the characteristics of the bay.

The degree of variation between many of the options is low. While in reality costs between the options would be expected to vary to a greater degree, differences would be unlikely to be material to overall decision making and the approach appears reasonable at this point in the process.

NGET explained that it was in the process of re-working the above costs so that they were more option specific however this has not been received and Ofgem should monitor this as the project progresses. For the final needs case submission, DCO costs should be considered and presented in more detail.

2.3.1.7 *Strategic Options Cost Estimates*

Detailed benchmarking of the costs used at the Strategic Options stage is not considered to be necessary, as these are high level costs only used to compare strategic options. Based on a high level review of the costs, they appear to be appropriate and we are comfortable that no options have been inappropriately excluded on the basis of the Strategic Options costs.

2.3.2 Consideration of Risks

NGET provided both its Risk Methodology Approach as part of the INC and a comprehensive list of the Risk Registers submitted as part of this project. While both appear to be robust there is still significant uncertainty regarding the risks due to a combination of the lead time for the project and the fact that the precise design of the 'preferred option' has yet to be finalised.

2.3.2.1 *Approach to Risk*

A key principle of the regulatory price control framework such as RIIO-T1 and associated Strategic Wider Works infrastructure is that risk should be allocated to the party best able to control or influence it. Therefore, the key aspect of our assessment of NGETs risk methodology was understanding how NGET proposes to influence the level and timing of the risk. Risk costs can sometimes be reduced through contracting arrangements or consideration of alternative solutions in response to consenting difficulties.

Table 2-11 presents the 'Quantified Cost Impact of the Risks' associated with the key schemes that make up the NWCC programme. The risks were quantified using a generic quantification model used widely within NGET for large-scale infrastructure projects at an early stage of development. These costs also included provision for estimating and scope uncertainty given the early stage of development of the NWCC programme.

As a result of the size and scope of the project and the uncertainty associated with the long lead time for construction, the total cost impact of the risks is significant (20% uplift for P50 and 31% uplift for P80 against the 'Base estimate'). In particular the works associated with the HVDC cable and tunnelling lead to a cost impact that will need to be carefully managed. The P50 and P80 percentage uplifts to base costs are also presented in **Error! Reference source not found.**.

Table 2-11 Quantified Cost Impact of Risks

Scheme	Pmean (£m)	P50 (£m)	P80 (£m)
OHL New	[redacted]	[redacted]	[redacted]
OHL New & Cables	[redacted]	[redacted]	[redacted]
OHL Refurbishment / Removal	[redacted]	[redacted]	[redacted]
Cable	[redacted]	[redacted]	[redacted]

New Substation	[redacted]	[redacted]	[redacted]
Substation Modification	[redacted]	[redacted]	[redacted]
Morecambe Bay Tunnel	[redacted]	[redacted]	[redacted]
HVDC Cable	[redacted]	[redacted]	[redacted]
ENWL Works	[redacted]	[redacted]	[redacted]
Development Consent Order	[redacted]	[redacted]	[redacted]
Programme	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]

[redacted]

Figure 2-6 [redacted]

As NGET set out in the INC report, there is still significant uncertainty regarding these risks. This uncertainty will be reduced as the project moves forward and more information on the site specific characteristics and risks of each sub scheme are revealed. As the design for the preferred connection option is further developed, the risk will reduce, and so it is essential that the registered risks are updated on a regular basis ahead of the Final Needs Case and the Project Assessment.

An additional factor that will impact on the quantification of the risk is the extent to which these 'schemes' are tendered under the CATO regime. If this approach is taken forward there will need to be a more detailed assessment of the degree of interdependencies between the development and construction of each of the schemes. For example this assessment would need to identify whether from a 'risk cost' point of view it is economically efficient that some of the schemes are clustered together to minimise the risks. This is assessed further in Part C.

2.3.2.2 [redacted]

[redacted]

2.3.2.3 Risk Registers

Each of the individual risk registers in the INC follow a uniform template. This template is robust in that it provides information on complexity, criticality, impact on the project and programme contingency at a time stating when the risk was created.

While we understand the risk registers have been developed to enable the calculation of generic uplift for scheme types (and not specifically for NWCC), we believe that the structure of the current risk registers should be consistent with the future risk register. As a result our comments on the risk register, provided below, should be used as guidance for the full risk register:

- **Timestamp:** we would expect that the risk register would have a time-stamp option to identify when the risk had been reviewed or when aspects of the risks had changed and the register updated. The lack of this information makes it difficult to know whether the 'Risk Register' is being reviewed on a periodic basis, which we would expect, or whether Risks are being identified and listed for the purpose of 'being seen to take account for the risks'.
- **Responsibility:** the 'Risk register' does not identify or nominate a responsible person whose job it is to ensure the risk is mitigated. We understand from the risk methodology that the risks are assigned to a manager who has notional responsibility, but the name of this manager is not highlighted on the 'risk register' submission. As a consequence it is difficult to identify who is responsible, and how much responsibility for the risks is being placed on any one individual.
- **Evolution of risks:** The risk register does not appear to include the option to detail the evolution of risks over time, or to provide details on the dates of signed contracts.
    - Whether there have been changes in the magnitude of the risks over time?
    - The value of the risks compared to the value of the project over time?

Generally, risks should reduce as construction works progress and there is greater certainty on remaining works requirements. Therefore is it important that the risk register is updated so that it is able to reflect any change in risk that occurs as the project moves towards completion.

2.3.2.4 Review of Risks and Risk Costs

For all risk registers, scope / design uncertainty and estimating uncertainty are captured separately and as the most material risks. These are typically double the total risk of the other risk items. This is generally appropriate at this stage of the design process.

Overhead Line Risk

In general, overhead line risk registers seem to have captured the most significant risks that we would expect could affect an overhead line project. Based on previous engagement with CATO stakeholders, high risks items include land access, outage availability, interfaces, and ground conditions.

[redacted]

Cable Tunnel Risk

We consider all the main project risks to the tunnel build to be covered in risk registers. The three greatest risks to the tunnel project are described in Chapter 13 of the INC as:

- Limited geotechnical information;
- Tunnel design (see below); and
- Installing 12 x 400kV cables. [redacted]

The risk register is slightly at variance with the above list when considering risk in terms of cost. The register would suggest that the three greatest risks are:

- Limited geotechnical Information;
- Tunnel/islet design; and
- Water inflow.

However, it appears that sufficient consideration is being given to all risks and no major risks have been omitted.

[redacted]

It is understood that the tunnel design is being discussed with the HSE and it is assumed that an acceptably safe design will arise from this consultation process. [redacted]

Considering overall programme costs and uncertainties, the tunnel project has the greatest P80 uplift and second greatest P50 uplift. Therefore, it can be considered that the tunnel has the potential to be the 'riskiest' element of the entire programme and needs greatest focus / attention. We would fully agree that the cable tunnel is the riskiest element of the programme and our view is that the magnitude of the programme risk is reasonable and appropriate.

In general, it is our view that the cable tunnel risks seem to have been adequately considered and assessed and that the magnitude of risk costs are appropriate.

Underground Cables

The most significant project risks are construction resources, DCO Conditions, ground conditions and environmental constraints. We are in agreement with the rating and magnitude of risks.

HVDC Subsea Cable Risk

The risk register appears to be comprehensive with the most significant project risks identified as nuclear power station interface, environmental constraints and HVDC converters. The nuclear power station interface risk has been scored as very high probability and very high impact, due to the impact it could have on nuclear regulatory approval. The risks described for an HVDC connection are not unique to the Moorside project and we would expect that these could be mitigated through design (e.g. of the control system). Given the voltage and capacity of the required HVDC subsea cable, this risk is appropriate.

We agree that it is appropriate to include a further 'consent delays' risk due to additional licences and associated interfaces required for marine installations.

HVAC Subsea Cable Risk

This risk register was not included in the INC but provided in response to a request for further information. It is broadly similar to the risk register for HVDC subsea cables but without HVDC associated risks.

In general, the project risk scores associated with cable installation seem appropriate. However, we would caution on application of the generic risks on this register. For example, a risk is included relating to failure of cable joints. [redacted] A further risk is included relating to unexploded ordnance due to the cables crossing the end of the Eskmeals firing range which is route specific.

Additionally, a risk is included relating to uncertainty in the design of the cable route. In our opinion, this risk is double counted – a generic risk is already included for Scope/Design uncertainty.

Consenting (DCO) Risk

The DCO Risk Register has captured the key risks. The majority of DCO risk is calculated within the DCO Risk Register while risks associated with DCO Conditions are considered separately in other Risk Registers. Quantified costs for relating to DCO Conditions for the use of HVDC and for the Morecambe Bay tunnel appear more conservative, without having seen the estimations behind these.

A generic uplift for DCO risk has been utilised for all assessed options without any weighting applied either to baseline costs or probability relating to option specific consenting risks. Nevertheless, we recognise that an onshore South Lakeland route would represent a higher consenting risk than a Morecambe Bay crossing and therefore factoring in consenting risk would not promote this over the preferred option. We also recognise that consenting risk relating to a cable array crossing of Morecambe Bay is likely to be higher than the risk attached to the preferred tunnel option. However, the magnitude will be dependent on the technological solution (i.e. width of the cable route corridor and design of cable trenching and protection), route selection for the cable array and therefore the magnitude of environmental impacts.

Programme delay is factored into the DCO Register both under consents and consultation process as well as being a separate line in the Programme Register. It appears to have been double counted unless quantified costs have been calculated taking into account these separate items.

DCO estimating uncertainty and scope/design uncertainty look to have been considered reasonably at this point in the process.

Distribution Works Risk

ENWL works associated with the NWCC i.e. infringements, diversions and final ENWL network configuration, are outlined in the INC with DCO conditions, construction resources and network resilience identified as the most significant project risks in the risk register. Scope / Design uncertainty and estimating uncertainty are also included as material risks. All risks are generally appropriate in magnitude in our view.

The INC states that ENWL has developed a Technical Approach guidance document in line with ENWL's existing policies and licence conditions to ensure a consistent approach to developing potential solutions to reinstate the network. This policy is being discussed between National Grid, ENWL and Ofgem. ENWL has also developed an Outage Risk approach that considers how work should be planned and undertaken on the distribution network to ensure there is no impact on the security of supply to existing customers.

There appears to have been close engagement between National Grid and ENWL from an early stage in developing the scope and costs for distribution network enabling works. A distribution system options appraisal has been carried and includes assessment of risks such as technical, consenting and environmental constraints to select the preferred option. This should support an effective risk strategy.

In terms of the delivery plan, the Customer Choice programme would require ENWL enabling works to commence earlier than originally planned. NGET has indicated that the Customer

Choice programme will not result in any increased programme risk however our view is that the rephasing of ENWL enabling works for example, will likely increase programme risk for ENWL interfaces. This is explored further in Section 3.

Substation Modification Risk

Ground conditions, DCO conditions and site access are identified as the most significant project risks for new substations. For modifications to existing substations, unknown buried services or obstructions, site access and environmental constraints are identified as the most significant project risks. We would broadly agree with the ranking and magnitude of the identified risks.

The estimating uncertainty risk cost (scope / design uncertainty and estimating uncertainty risks) is a factor of 3 of the project risks which is higher than the other risk elements. However, as a proportion of the base cost, this is not unreasonable. For new substations, ground conditions are a key uncertainty and this could be higher however, ground condition uncertainty is captured to an extent within estimating uncertainty risk.

Programme Risk

Scope definition and delay to DCO decision are identified as the greatest risks for programme. Programme risks are considered in greater detail in Section 3 - Part B.

2.3.3 Assessment Summary

We have carried out a high level cost benchmarking comparison for key assets (overhead lines, underground cables, subsea HVDC cables and converters and cable tunnel) including ENWL distribution network enabling works for progressed strategic options and are satisfied that the unit costs are appropriate in magnitude and the cost build-up and level of detail is valid for optioneering. Specifically, the scope of the cable tunnel and associated costs seem reasonable.

[redacted]

For the risk methodology, we are satisfied that the approach taken by NGET is consistent and robust with the risks identified for each key asset element and the rating and probability assigned to these being generally appropriate. We are in agreement with the risks that emerge as being significant and no risk categories appear to have been unreasonably included or excluded. There does appear to be some minor errors and risk double counting in places.

Cost Benchmarking	Tunnel Scope and Cost	Risk Methodology	Risk Uplifts
			

Risk uplifts for various elements are generally appropriate in magnitude and in terms of significant risks identified and ranked. However, there appear to be some minor errors and risk double counting in places.

2.4 Cost Benefit Analyses

Box 2-3: Specific Review Questions
Whether other assumptions and inputs used in the quantitative cost benefit analysis are valid, including but not limited to a consideration of: • Demand and generation scenarios, with a comparison of the latter to the contractual background and historical rates of consent approval, slippage in connection dates or TEC reduction requests; • Are the sensitivities included in the CBA by NGET reasonable, have any alternatives not been considered? • Load factors for new generation; • Modelled power flows;

2.4.1 Overview of Modelling Approach

The general approach to the Cost Benefit Analysis (CBA) is set out in detail by NGET in its Initial Needs Case (INC).

Prior to conducting the detailed constraint analysis and the CBA, NGET assessed ten options for providing connection at Moorside. On the basis of an initial environmental and socio-economic assessment of potential routes, NGET has assessed the impact of works in the Northern Corridor and Southern Corridor. This assessment has enabled NGET to reduce an original set of ten options, to the three options put forward in the CBA.

2.4.1.1 Use of Least Worst Regrets

NGET has used the 'Least Worst Regrets' methodology to assess the relative benefits of the preferred three options. This approach has been widely used by NGET before and also across many sectors where investment choices must be made under conditions of uncertainty.

We agree that this approach is the most appropriate as it allows robust and clear decision making where the information is uncertain, and provides a solution that can minimise the regret of a decision across a large number of scenarios.

2.4.1.2 Use of Back-checking

As part of the CBA process NGET has also used 'back-checking' to ensure that the preferred option remained the best option. This process allowed NGET exclude options from the CBA ahead of the assessment. For example it identified that three of the offshore cable array

options would be more expensive than the preferred option. As a result these option where not taken forwarded into the CBA.

- One double circuit onshore south with an offshore cable array connection between Kirksanton and Stanah substation;
- One double circuit onshore south with an offshore cable array connection between Walney Island and Stanah substation; and
- One double circuit onshore south with an offshore cable array connection between Rampside and Stanah substation.

As the project develops and more information becomes available in regard to the precise nature of the works required, it will be important that NGET continue to back-check its previous decision.

2.4.1.3 Appropriateness of the ELSI Model

NGET has undertaken detailed analysis of the energy flows which feed into the constraint modelling and thus, CBA. This analysis has been undertaken using its in-house ELSI model. NGET provides an overview of the ELSI model in the INC submission, and the model is available to download online. The model is Excel-based and uses Visual Basic linear programming. It applies the following modelling process:

- First step: the model looks at the short-run marginal cost of each zonal fuel type and dispatches available generation – from the cheapest through to the most expensive – until total GB demand is met. This is referred to as the 'unconstrained dispatch'. At this point, the network (boundaries) is assumed to have infinite capacity.
- Second step: the model takes the unconstrained dispatch of generation and looks at the resulting power transfers across defined network boundaries. The ELSI model compares the power transfers with the actual boundary capacity and re-dispatches generation where necessary to relieve any instances where power transfer exceeds network capacity (i.e. a constraint has occurred). This re-dispatch is referred to as the 'constrained dispatch' of generation.

The ELSI model has been developed in two stages. The first ELSI model was designed to model the flows across the GB network, where flows with other countries are optimised assuming a profile of fixed prices. The ELSI model was subsequently expanded to model neighbouring European countries to enable more accurate modelling of interconnector flows.

The GB-focussed ELSI model was designed and developed specifically to allow NGET to replicate the flows of electricity across the GB network. The model is tried and tested over a number of Strategic Wider Works assessments and regulatory submissions, and we are not aware of any fundamental issues with the model.

However based on our assessment of the ELSI model, we believe it has limitations in relation to certain elements of the modelling methodology, specifically:

- **Start-up and No-load optimisation**[13]**:** the ELSI model does not include start-up and no-load optimisation. This can affect the distribution of generation around the country and therefore constraint costs.
- **Wind:** the ELSI model does random sampling of wind data, rather than using a set of fixed wind years. It is our view that it is therefore unlikely to properly capture extremes. This could impact on the North – South Flows due to the capacity of wind located in Scotland.
- **CHP:** the ELSI model treats CHP as a normal plant i.e. dispatched according to a single Short-Run Marginal Cost (SRMC). In our view this does not accurately capture the various possible operating modes of CHP plant, or its must-run characteristics. This could impact on the flows around the network.
- **Reservoir hydro:** GB reservoir hydro is not included within the ELSI model's main optimisation process, it is instead included via a pre-defined dispatch optimisation. This may impact on the distribution of generation, particularly in Scotland and Wales, and could therefore impact constraint flows.
- **Coal:** The model includes no constraints on the annual load factor of coal plant – as a result it has the potential to over-dispatch coal, which again could impact on the distribution of flows across the system.

As we touched on in the bullets, these issues have the potential to impact the distribution and volume of flows across GB, and as a result it could impact on the decisions made regarding the management of constraints. However, in our view these limitations will probably not impact the decision to go ahead with Option 2, since it is likely to impact across all of the options equally. However without repeating the analysis with the new model, we cannot be certain that this is the case.

2.4.1.4 Future of ELSI

NGET recently purchased a pan-European electricity market model, BID3, from Pöyry Management Consulting (UK) Limited (Pöyry). In the future, NGET intends to undertake its analysis using BID3 and its associated data sets, replacing current ELSI models.

As part of this purchase Pöyry conducted a benchmarking study between the ELSI model and BID3 to understand the differences between the two models. This benchmarking identified a number of key differences, which could impact on the system flows. However without repeating the analysis with the new model it is not possible to state when these differences will be material.

[13] The start-up cost is the additional cost associated with starting up a Generator Unit from a cold, warm or hot state to a position where it is generating. The no-load costs are those incurred by the generator when running with zero output. Both the start-up and no-load cost will vary from plant to plant based on a number of factors including energy costs (fuels and carbon) and technical constraints. These additional costs should be included in the short-run marginal cost calculation for each generator.

Therefore, given the importance of this project and the expenditure involved it is our view that NGET should consider reviewing the analysis using the new model once it is fully functional. This will provide a valuable benchmark and ensure consistency with NGET's future modelling assessment.

2.4.2 Input Data

2.4.2.1 Future Energy Scenarios

NGET uses the following 2015 Future Energy Scenarios as inputs into the CBA modelling:

- Slow Progression;
- Gone Green;
- No Progression; and
- Consumer Power.

The Future Energy Scenarios are designed to show a range of credible pathways for the future of energy, from today out to 2050. The scenarios are internally developed but draw on extensive stakeholder consultation and detailed network analysis. In assessing the appropriateness of the FES input data we make the following comments:

- **Peak demand:** NGET uses a single demand profile and therefore it will not capture any extreme demand conditions
- **Wind profiles:** ELSI randomly samples several years of weather data to form a single profile for the year, rather than using a full set of historical years. It is therefore unlikely to properly capture extremes.
- **Nuclear build:** There is no new nuclear build prior to 2026 across all four FES, which is inconsistent with the proposed plan to connect Moorside in three tranches starting 2025. In the modelling for this project, National Grid has added Moorside progressively from 2024/5 in line with TEC data. In order to balance the scenario, corresponding amounts of nuclear capacity has been removed at other nuclear sites remote from Moorside. While this approach will preserve the price curves associated with the FES, it does not reflect the 'credible pathway' developed through stakeholder consultation.

Notwithstanding the comments above, we do not have any major concerns about the appropriateness of the FES input scenarios. While we may argue with some of the FES assumptions it is our view that the scenarios are both internally consistent and cover a reasonable range of outcomes of the future.

2.4.2.2 Financial Assumptions

The financial assumptions and approach used within the CBA modelling appear to be consistent with best practise. One example would be NGET using the Spackman approach to calculate the present value of the options (the "Spackman approach" is recommended by the British Joint Regulators Group deals with discount rates for projects with private investment and public benefits).

As a result we do not have any significant comments in relation to the financial assumptions.

2.4.3 Output - Energy Flows and Constraints

NGET has modelled constraints in two stages, in the first stage it defines the boundary transfer capabilities of the zones (with and without Moorside) and then in the second stage its uses the ELSI model to determine the constraint volumes and costs which feed into the Cost Benefit Analysis.

Boundary transfer capabilities are determined in the power systems analysis package Power Factory based on a network model representing the system in 2026 (the connection date of the last Moorside unit) and consistent with NETS SQSS. Only one Future Energy Scenario (Gone Green 2015) has been considered in the analysis to determine boundary transfer capability. Demand background is only modelled for one year, 2015 Year 7 (2021) however this is acceptable with demand uncertainty increase. Modifications to the model were made around the regions covered by the three boundaries (B06, B07 and B07a) to reflect available generation in 2026. This analysis is documented within Appendix 6A of the INC.

NGET's view is that there is a deterministic need for increased boundary transfer across B6 (and B7, B7a) as shown in Figure 2-7 in all FES, and therefore it is appropriate to use the worst-case generation scenario (Gone Green) to determine the boundary transfer capability. This is illustrated in Figure 2-7 which shows the B6 boundary capability against future requirements. These boundary capabilities were then used in the ELSI/CBA to determine constraint costs and assessed again all four Future Energy Scenarios.

We have sought clarification from NGET as to whether or not the boundary transfer capabilities would be different for different scenarios (for example, if the boundary studies were completed using 'No Progression', would the results be different to those in Section 6 in the INC). It is our view that the Gone Green Scenarios will lead to the highest level of north-south flows and hence the greatest requirement for additional reinforcements, however it is widely perceived that the Gone Green scenario is now a low probability. There are also large amounts of wind generation present in the south west of Scotland in the Gone Green scenario (as compared to other scenarios). This was confirmed by NGET through provision of regional geographic breakdowns of generation.

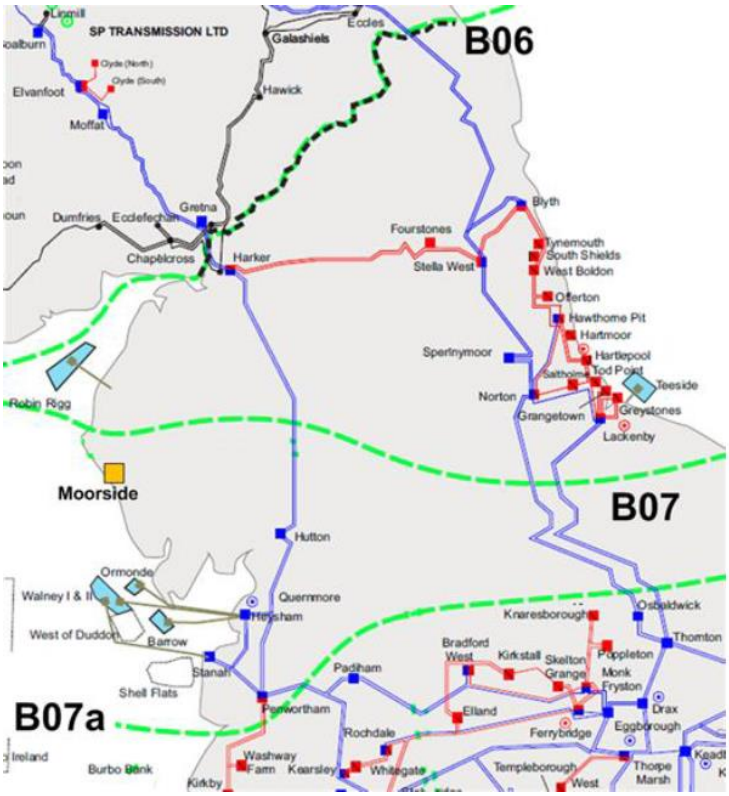


Figure 2-7 Transmission Boundaries in the Vicinity of Moorside (Source: NGET)

NGET states:

There are two main factors that influence the power flows in the north west area of the transmission system: transfers across the B6 boundary (i.e. Scotland to England), and for the purposes of this project, the connection of Moorside power station.

The maximum volume of power that can be securely carried on the AC circuits (i.e. in order to ensure no post fault thermal overloading of the AC system) is 4.4 GW. All four FES show that the boundary transfer requirement for the B6 boundary will continue to grow in the future.

As a result it is immaterial, in terms of representing a credible worst case network condition, which of the FES are selected to make up the wider generation mix as long as the B6 transfer is set to 4.4 GW as the resulting power flows around the north west area will be identical.

It could be possible for different generation scenarios to influence the thermal capability of a local boundary if generation was to be place in different locations (e.g. a generator placed very close to a particular circuit could result in an overload that would not be present under a different scenario. However, this is not the case with the B6 boundary as the cumulative generation in Scotland shares broadly equally down the two AC double circuits and hence specific location of generation does not affect the thermal boundary limit.

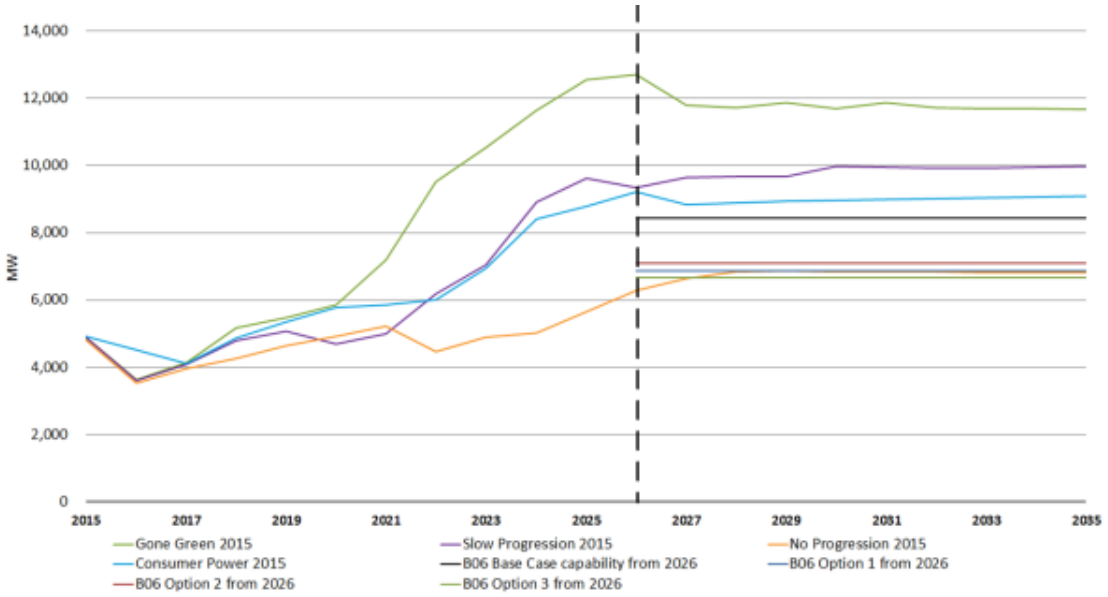


Figure 2-8 B6 Boundary Transfer Capabilities under a Range of FES and Moorside Connection Options (Source: NGET)

Based on our desktop assessment of the network topology and power flows in the region under NETS SQSS and the various FES, we agree with NGET that the FES will not materially influence the boundary transfer capabilities of B6, B7 and B7a under the modelled network conditions. However, we have some general concern that under different circumstances (e.g. for different projects), the choice of scenario could affect the calculated boundary capability. For example, if examining a boundary which has more than two AC circuit routes crossing it or if there is a large amount of generation adjacent to the boundary in one scenario but not another.

The Cost Benefit Analysis was then used to assess year round constraint savings of combinations of the connection Options and wider works against all four FES. Based on the assessment by NGET, all four of the FES will result in the maximum "credible worst-case" boundary transfer of 4.4GW across B6 (and correspondingly, worst-case power flows across B7 and B7a), however these will occur at different levels of regularity (for example, Gone Green system would show high Scotland – England transfers occurring more often and for longer durations). NGET has indicated that based on their analysis, this difference in regularity and duration does not alter the magnitude of the worst case condition itself. All of this analysis is consistent with the evidence provided by NGET, we have not undertaken independent modelling of flows and constraints.

2.4.4 Scenarios and Sensitivities

The CBA assessment covered a broad range of scenarios. NGET selected three preferred connection options (from an initial list of 10) to be assessed in the CBA. Each of the three options was then assessed – this assessment included various wider works that would be required to enable the options to be taken forward (i.e. the wider works required under each option was not necessarily the same, and a number of alternative wider works solutions

were proposed for each of the selected connection options). We believe the range of the scenario assessment is appropriate.

In addition, NGET presented a number of sensitivities on the constraint assessment, including:

- Optimal timing analysis of the wider works; and
- Changes in reactor size associated with the proposed power station.

These sensitivities were used by NGET to test the robustness of the recommendations of the CBA assessment. It presented a clear picture of how the NPV of options and the selection of the 'Least Worst' option was affected by both technical and non-technical factors.

Despite the wide range of scenarios and sensitivities presented, we believe that there are other key sensitivities that have not been tested. These include:

- **Delays to the commissioning of Moorside:** The constraint cost analysis was based on a 2026 deployment of all three reactors at Moorside and there was no assessment of the impact of a delay in this deployment. Following a request for information, NGET stated that:

  'there is a low likelihood that there would be a change to the outcome of the CBA for a 12 month project delay and the selection of the preferred connection option as the Least Worst Regret option. This is because a 1 year time change within a 40 year horizon is not likely to have sufficient influence over the outputs to change the outcome. Delays of longer duration could introduce a greater chance of a change to the LWR and would result in the need to revisit the whole assessment.'

  This statement whilst true, does not provide us with significant comfort on the potential costs of a delay or the likelihood of a delay occurring or whether a longer delay would impact on the selection of Option 2.

- **Changes to commodity prices:** Given recent events in regard to the result of the 'EU in out' referendum, there has been a significant impact on the financial markets. The volatility in the value of currency and the cost of borrowing have the potential to impact on costs of delivering these works. Following a request for information NGET stated that:

  'This CBA used the most recent FES data sets but if material delay to Moorside commissioning exists then it follows that the analysis could be repeated with the latest FES data and any cost or design amendments.'

  We believe that it is unlikely that the current range of scenarios used by NGET account for the impact of a one off shock, such as GBs decision to leave the EU. Therefore we believe it is important that NGET reviews its current assumptions or undertake a sensitivity analysis in order to provide an assessment of the likely impact of the change ahead of the Final Needs Case.

- **Changes in the FES:** During the course of the study, NGET updated its Future Energy Scenarios. Therefore we believe it is important for NGET to highlight the key

differences in relation to this work and explain the potential impact on the CBA. Upon request, NGET stated *'that the wider trends represented in the four FES option would not materially impact on the Moorside preferred option and Moorside is assumed to connect in line with its contracted position across all scenarios'*.

However this statement appears to be in contradiction with the Nuclear build scenarios presented in the FES 2016. As in the 2015 FES, there is no new nuclear build prior to 2026 across all four FES, which is inconsistent with the proposed plan to connect Moorside in three tranches starting 2024. For the purposes of this study, National Grid added Moorside progressively from 2024/5 (in line with TEC data) into the modelling at the expense of other nuclear generation. However it appears this change has not been reflected in the FES 2016.

2.4.5 Wider Works Options

NGET presented several combinations of Wider Works to compliment and facilitate the enabling works of each of the Options. Through power modelling NGET presented an economic appraisal of the costs. The idea of this assessment was to understand what combinations of wider works would deliver the greatest benefit.

Table 2-12 Capital Cost of Wider Works Options £m

Wider Work	Description	P50 Cost
1	Penwortham reconductoring	[redacted]
2	New double circuit Harker-Stella West	[redacted]
3	New double circuit Harker-Penwortham	[redacted]
4 / 5 / 6	Respectively, one, two and four MSCx	[redacted]

[redacted]

2.4.6 CBA Outputs Summary

The CBA assessment is clear in presenting results of the three strategic options considered Option 1, Option 2 & 2e and Option 3, against the counterfactual of not reinforcing the networks and no Moorside development.

NGET's analysis compares the projected lifetime costs (does not include operational costs at this stage) and benefits the three strategic options. The analysis by NGET shows that for three out of the four FES scenarios, Option 2 with wider works 1 and 2, is the Least Worst Regret option. NGET will specifically consider the need for wider works 1 and 2 as part of wider network updates.

All potential options deliver a negative Net Present Value (NPV). This reflects the fact that Moorside's location exacerbates known constraint issues across an already congested

Scotland to England boundary, relative to the counterfactual condition of no Moorside development, coupled with the large investment cost.

Option 3 has the highest capital costs and as a result it performs the worst when combined with the wider works options, while Option 2 is shown to be the best under both P50 and P80 analysis.

The CBA assessment identified that Option 2 is the option of least worst regrets across all four of NGET FES. As a result, this is the option NGET believes will deliver the most benefits for consumers.

Table 2-13 Least Worst Regrets Analysis (NPV of constraint savings) £m

Option	Worst Regret			
	P50	Scenario	P80	Scenario
Opt1	[redacted]	[redacted]	[redacted]	[redacted]
Opt2	[redacted]	[redacted]	[redacted]	[redacted]
Opt2e	[redacted]	[redacted]	[redacted]	[redacted]
Opt3	[redacted]	[redacted]	[redacted]	[redacted]
Opt2 w15	[redacted]	[redacted]	[redacted]	[redacted]
Opt2e w15	[redacted]	[redacted]	[redacted]	[redacted]
Opt3 w14	[redacted]	[redacted]	[redacted]	[redacted]
Opt1 w153	[redacted]	[redacted]	[redacted]	[redacted]
Opt1 w162	[redacted]	[redacted]	[redacted]	[redacted]
Opt2 w12	[redacted]	[redacted]	[redacted]	[redacted]
Opt2e w12	[redacted]	[redacted]	[redacted]	[redacted]
Least Worst Regret	[redacted]		[redacted]	

2.4.6.1 Sensitivity Analysis

Sensitivity analysis was also undertaken by NGET to consider the timing impact of the wider works, and the impact of reducing the generation connection to two units from three.

- **Generation connection:** the CBA results associated with a move to two reactors were consistent with the three reactor assessment and demonstrated that the best connection option was Option 2. Although it is important to highlight that under a 'No progression' scenario Option 1 was the preferred solution.
- **Optimal timing of wider works:** The wider works component of the analysis can be flexed because they are not required to satisfy the connection obligations. As a result NGET committed to testing the impact of delaying a selection of wider works:
    - EWs 2 (fixed for 2024/5);
    - WWs 1 (flexed from 2024 to 2031); and
    - WWs 2 (flexed from WW1 delivery to +7 years).

  As a result of this least worst regret assessment, NGET indicated that there is a case for delivering both WWs 1 and WWs 2 in time for October 2024. However the case for WWs 1 is stronger than for WWs 2, and the decision on both should be kept under review in the event of significant changes.
- **Cost change impacts on the CBA decision:** Specifically NGET considered the impact of a cost change associated with moving away from the current Least Worst Regrets 'Option 2 – wider works 1 / 2'. As part of this assessment NGET revisited the CBA assessment and flexed the CAPEX costs associated with Wider Works 2 and 3 (please see table 3-7 above) until there was a change in the Least Worst Regrets decision.

  This assessment found that there would need to be a reduction of 21% of the original P50 costs to change the 'No Progression' scenario from 'Option 2 – Wider Works 1 / 5' to 'Option 1 – Wider works 1 / 5 / 3'. All three other scenarios remained at zero regret for the preferred option (Option 2 – wider works 1 / 2). NGET also tested reductions up to 80% for Wider Works 2 and 3 and found no change in the results of the CBA. For the P80 Capex Costs, a reduction of 28% was needed to get the same outcome as in the P50 analysis.

  In addition NGET also tested how much the preferred option would need to increase before the CBA outcome would change. The analysis found that the P50 (P80) costs of Option 2 / 2e enabling works would need to increase by 18% (8%) to change the preferred option wider works and the an increase of 40% (33%) would be needed to move away from Option 2.

  It was concluded that Option 2 – wider works 1 / 2 was still the preferred option of Least Worst Regrets, and that the change to 'No Progression Option 1 – Wider works 1 / 5 / 3' is a result of the lower level of constraint savings in this scenario.

2.4.7 Assessment Summary

Based on our assessment of the analysis provided by NGET, we are happy that the CBA approach is reasonable, appropriate and well justified. Notwithstanding the comments raised in section 2.4.2, the FES input scenarios appear to be appropriate. The outputs of the model are consistent with the inputs of the four FES i.e. modelled least worst regret costs provided by NGET for the different connection and reinforcement options are found to be

reasonable in magnitude and vary in the expected directions (e.g. higher wind capacity leads to higher constrained energy, greater wider reinforcement requirements leads to increased costs) and in reasonable amounts.

Finally, we believe the sensitivity analysis is generally appropriate to characterise the impact of various uncertainties and verify the selection of the preferred option.

Appropriateness of CBA Inputs	Appropriateness of CBA Outputs constraints	Range of CBA Scenarios and sensitivities
		

2.4.8 Recommendations

Although the CBA conducted by NGET is thorough and clear in most aspects, we have raised concerns in this report which require clarification ahead of the Final Needs Case assessment.

2.4.8.1 Modelling

The methodology used in the ELSI model has the potential to impact the distribution and volume of flows across GB, and as a result it could impact on the decisions made regarding the management of constraints.

We would recommend that NGET repeats its analysis ahead of the Final Needs Case Assessment, provided its new model is operational. This would remove any of the uncertainty regarding the impact of the methodology on the materiality of the results.

2.4.8.2 Data Inputs

We recommend further analysis of the input data in relation to:

- Changes to commodity prices: Given recent events in regard to the 'EU in out' referendum there has been a significant impact on the financial markets.
- Changes in the FES: During the course of the study NGET has updated its Future Energy Scenarios.

We would recommend that NGET updates its analysis ahead of delivering its Final Needs Case Analysis with the updated Future Energy Scenarios.

3 Part B: Suitability of the Delivery Plan

Box 3-1: Specific Review Questions

- Does NGET's delivery plan/schedule provide sufficient detail and justification on assumptions relating to project lead times and key milestones?
- Does the proposed timing of Grid's construction phase for the project reflect the most efficient means of meeting NuGen's connection timetable, or could construction start earlier/ later?
- Has NGET explained why specific elements of the work programme are planned to be brought forward and justified the additional costs associated with an accelerated programme?
- Does NGET's delivery plan appropriately consider the specific risks associated with delivery of this project? (e.g. potential planning sensitivities, supply chain issues, cost uncertainties, weather-related risks and risks to consumers, such as technology risks or delays in delivery)
- Has NGET justified that it has a plan to efficiently manage these risks?
- Has NGET provided a robust strategy for the ongoing review of the work programme and implementation of changes on the project as it develops?

3.1 Justification and Efficiency of the Delivery Plan

3.1.1 Introduction

NGET initially developed the NWCC project programme based on [redacted] This was to allow NuGen to start the main construction phase (as opposed to the site clearance phase) of the power station build in 2021, based on the original contracted connection of the first unit in October 2024. This is denoted as the 'As-Is' programme with northern transmission works being phased between 2022 and 2024.

[redacted]

[redacted] NGET states that this should result in savings to consumers by avoiding the need for investment in the ENWL network which would ultimately need to be removed once NWCC transmission infrastructure was in place.

3.1.2 Customer Choice Programme

3.1.2.1 Site Supplies Scope and Cost

NGET has provided further supporting information on the indicative scope of site supplies based on informal discussions with ENWL. This involves;

- Reinforcement of two 132kV double circuits between Harker and Sellafield, one of which would likely then need to be removed as mitigation for the proposed 400kV double circuit northern route;
- Additional 400/132kV supergrid transformer (SGT) at Harker which would not provide any benefit in the long term as the capacity of the connection between Harker and Sellafield would be limited by the remaining overhead line capacity and not by the SGT capacity at Harker.

The budget cost for these works is estimated by ENWL [redacted]. ENWL stated that these costs were based on a range of options, timescales and different connection arrangements costs. Our cost benchmarking analysis is generally in agreement with these costs for upgrading two 132kV double circuits over the 81km of circuit length between Moorside and Harker substations and a new 400/132kV supergrid transformer.

3.1.2.2 Value to Consumers

[redacted] This is somewhat less than the budget estimate for site supplies provided by ENWL and thus suggests that the Customer Choice programme is efficient based on the evidence provided by NGET and ENWL.

NGET has also indicated that with the Customer Choice programme, there is an overlap between the ENWL and NGET works to relocate a portion of ENWL assets to allow the installation of overlapping / inter-crossing NGET assets. This results in some inefficient working and therefore it is anticipated that the construction period of the northern works will be longer than in the As Is programme. Note that this is accounted for already within the programme..

3.1.2.3 Stakeholder Engagement on Customer Choice Programme

NGET has discussed the Customer Choice programme with NuGen which has signalled a desire for Moorside's site supplies to be provided by 2022 through a Modification Application submitted by NuGen in November 2016.

NGET has also confirmed that they engaged with ENWL in late 2015 on the Customer Choice programme in order to *"ensure that a realistic integrated programme of both transmission*

and distribution works was produced to be confident that the site supplies could feasibly be brought forward before discussion with NuGen".

In our view, NGET is engaging in an appropriate and timely manner with the key stakeholders.

3.1.2.4 Impact on Competition

The Customer Choice programme may significantly impact on the possibility for competition in onshore transmission. Specifically, it may be challenging to tender the northern works without impacting on the contracted customer connection date. NuGen does not intend to connect the first reactor until 2025. However, this may not remove the programme constraint for competition if the site supplies need to be provided by 2022.

3.1.3 Key Milestones

Key milestones for NuGen are presented below in Table 3-1.

Table 3-1 Key Milestones for NuGen

Contracted Dates	Non-Contracted Dates
Moorside DCO submission date: Q2 2017	Interim Investment Decision: April 2017
Moorside DCO consent decision: Q3 2018	Site investigation/ minor works: Q2 2017
Nuclear Site Licence Granted: Q3 2018	Contract for Difference: 2018
Backfeed: 30 April 2024	Final Investment Decision: Q4 2018
Reactor 1 commission: 31 October 2024[14]	Construction work starts on the site of the Power Station:2018

A large amount of tendering, completion of NuGen milestones, initial design work, and enabling construction works (including ENWL works) are required in advance of the DCO decision, in order to meet the overall programme. Generally, in both programmes, site works or detailed design is scheduled until after DCO decision. However, some enabling

[14] While the contract is for 2024 it is expected (based on publically available information) that commissioning will occur in 2025.

works for the distribution network and site supplies works is scheduled to take place before. This is appropriate for the project in our view.

3.1.4 Assessment of Programme Elements

Individual programme elements have been assessed to evaluate the appropriateness of timing and duration with relation to lead time, construction complexity, interdependencies, and contingencies. Please note that this is based on the Customer Choice programme although there are many similarities with the As-Is programme.

3.1.4.1 Cable Tunnel

This is a significant element of the project, starting early and finishing late in the programme and is on the critical path. The key elements are as follows;

- Tunnel and cable detailed design ([redacted]): Based on the complexity of the project, this is generally appropriate in our view. It is noted that tunnel and islet build commences halfway through the tunnel and cable design activity according to the NWCC programme so NGET appear to be scheduling activities efficiently in order to not delay tunnel build.
- Tunnel and islet build ([redacted]): The tunnel will be bored simultaneously from the north and the south using two tunnel boring machines, the tunnels will then be cleaned and fitted out. [redacted][15] There may be opportunities to improve the tunnel programme but, comparing with similar projects and considering potential ground conditions, the programme is not considered excessive.
- Cable manufacture ([redacted]) – This occurs in parallel with the tunnel and islet build. Based on our experience of cables of this rating, manufacturing time is largely driven by demand with the actual manufacturing process being quite rapid. The manufacturer will typically produce the cable in single continuous run and cut as required (for mounting on a carousel or cable drums) depending on installation methodology/transport (ship or road). NGET estimates for cable manufacture timescales at this voltage and capacity are reasonable in our experience.
- Cable install and commission ([redacted]) – this will take place following tunnel and islet build, it is not possible to commence until the tunnel has been cleaned and

[15] [redacted]

fitted out. [redacted].

The full tunnel programme is reproduced in Table 3-2: Cable Tunnel Programme, based on the document submitted in response to SQ46, with these critical path elements indicated in red.

NGET has provided details of their early engagement with the market (which is ongoing) to obtain guidance on levels of relevant experience and capabilities, contract strategies and contractual relationship preferences, perception of key risks, good practices with customer relationships and experience in with working with cable manufacturers. NGET indicated that some further research into defining the extent of the global market place has been commissioned.

From its market engagement, NGET found that the Morecambe Bay tunnel is seen as an attractive proposition and the market place has the capacity to deliver. However, the islet and ventilation shaft would be undertaken by a specialist marine contractor of which fewer, with the prerequisite skills and experience, exist in the market place. This would reduce the number of possible Joint Ventures.

NGET has indicated that there is a lead time of approximately 12 months from placement of order to a new tunnel boring machine (TBM) being delivered to site and no issues have been raised regarding this lead time by the identified contractors (who have good working relationships with TBM manufacturers). In our view, this is a reasonable lead time for such equipment and NGET appear to have engaged with the market at an appropriate level at this stage to inform development of the project programme.

Due to the programme timescales, NGET has indicated that the cable tunnel needs to be tendered and contracted by Q2 2018, in advance of NuGen's FID. This would be very challenging to tender through the ECIT regime. In general, we believe that this is a valid timetable.

Table 3-2: Cable Tunnel Programme

[redacted]

3.1.5 Substations

[redacted]. Contractor tendering takes approximately 12 months. Tender award and First Site Access (FSA) is of [redacted] months duration leading to commencement of construction. In our experience, these are reasonable and appropriate timescales for these types of works.

3.1.6 Overhead Lines

Overhead line build durations are from about [redacted] months/ km for part of the northern route and southern route (Harker-Stainburn, Moorside to Roosecote) to [redacted] month/km in duration for Moorside to Stainburn in the Customer Choice programme. From our experience, this is broadly appropriate. For example, for Beauly Denny, SP Transmission energised a 20km section of 400kV overhead line in November 2015[16], from first site access in early 2012 and construction commencing in 2014. This equates to an overhead line build duration of up to approximately 1.3 months/km if build commenced January 2014. NGET state that with the Customer Choice programme there is an overlap between the ENWL and National Grid undertakings resulting in inefficient working and therefore the construction period for Moorside to Stainburn is anticipated to take longer.

Contractor tendering takes approximately [redacted] before construction commences. In our experience, these are reasonable and appropriate timescales for these types of works.

3.1.7 Environmental Sensitivities and Consenting

The high level delivery programme allows for an 18 month DCO determination period. This is in line with current typical timescales. Programme risk should be interrogated considering an extended determination process including the possibility of Judicial Review. Assumptions relating to timescales of the DCO process appear appropriate.

A high level EIA programme for survey effort throughout 2016 was provided. Whilst there are errors in terms of the timings of some survey effort (e.g. great crested newt surveys programmed during the summer months) the overall programme, as discussed during the August site visit, appears robust and able to deliver the EIA in line with the overall programme.

The plan for efficient management of consenting risk is not detailed within the INC although the process to date has managed risk through stakeholder consultation and adoption of an iterative optioneering and design process.

As well as the programme risk that should be embodied within DCO risk, there are additional risks which can be identified in the INC but which have not been explicitly considered. The

[16] SP Energy Networks, Beauly Denny Overhead Line Upgrade, Accessed July 2016.
http://www.spenergynetworks.co.uk/pages/beauly_denny_overhead_line_upgrade.asp

programme sets out receipt of the DCO decision in late 2018 followed by discharge of requirements and then enabling works and site establishment that would both begin in early 2019. Where those works would take place within or adjacent to the SPAs or other areas where wintering birds are a key sensitivity, it may be that work would be delayed until the end of the over wintering period in April and therefore the programme appears optimistic in that it does not include any seasonal ornithological delays.

Where a balance needs to be struck, in deciding on the preferred option, between cost, technological risk and consenting risk, it is not clear how NGET has traded off increased cost against technical and consenting risks.

3.2 Consideration of Programme Risks

[redacted] As part of this split NGET has identified a set of specific risks associated with delivering the programme. These risks are related to process of tendering, commissioning and managing the ongoing work. A full list of the programme risks are set out in Table 3-3 below:

Table 3-3 Programme Risks

Scheme	Pmean (£m)
Scope Definition	[redacted]
Delay to DCO Decision	[redacted]
ENW Interfaces	[redacted]
NG Commissioning Resources	[redacted]
Procurement Process	[redacted]
Scope of Work	[redacted]
Objections / Protests	[redacted]
ENW Supply Interruption	[redacted]
Extreme Weather	[redacted]
Scope / Design Uncertainty	[redacted]
Estimating Uncertainty	[redacted]
Total	[redacted]

Table 3-3 above shows that the expected value of the risks associated with the programme are small compared to the expected value of the risks for other individual schemes (see

Table 2-11 Quantified Cost Impact of Risks). In addition NGET's analysis of the expected value of the risks associated with Scope / Design and Estimating Uncertainty for the programme is set at zero. The expected value of the risks associated with Scope / Design and Estimating Uncertainty are associated with the potential for extended timescales for this project - to cover the possibility that during the development of the design, additional project scope or equipment will be identified that was not included in the initial, high level design. However because the 'Programme Risk Register' is concerned primarily with project management and delivery, the issues around 'Scope / Design Uncertainty' are not relevant, and as a result we believe that it is not unreasonable to set this value at zero.

3.3 Impact of Programme Risks on Project Delivery

The expected value of the programme risks are small relative to the other schemes which make up the NWCC, however delays to the programme can have knock on impact on the construction phase of the work. Delays in construction have significant costs associated with them and could ultimately lead to a delay in the commissioning dates.

Based on our assessment of the NWCC programme and the associated risks, we have identified a number of issues that may impact on delivery of the project. These issues are set out below and focus on the requirements for construction ahead of the FNC decision, and specifically in relation to [redacted] negotiations for the Contract for Difference. Our specific concerns are presented below:

- [redacted]
  - [redacted]
  - [redacted]

[redacted]

- **CFD discussions:** Based on the INC report, the CFD is expected to be in place by 2018 ahead of the Final Needs Case. However since the delivery of the INC report there have been significant changes in the UK, for example the referendum decision to leave the EU and the folding of DECC into a new department called Department of Business, Energy and Industrial Strategy. Given these events we sought additional clarity from NGET on the current position regarding the CFD discussions.

  NGET has responded that NuGen has made clear public indications that their CfD is still on track for 2018. This is because in order for NuGen to start construction they need to have obtained their FID. While we cannot question the validity of these public statements, we believe that NGET should seek to immediately clarify with NuGen and the new BEIS department that the discussions for the CFD are still on track for 2018.

- **Customer Choice Programme:** If the Customer Choice programme is implemented then the northern overhead line and substation works are also on the critical path along with the cable tunnel. NGET has indicated that this will not result in any increased programme risk however our view is that including another contracted milestone, increasing overall project management towards the start of the project, and rephasing of ENW enabling works will likely increase programme risk although perhaps not materially in cost terms. This should be reconsidered in the risk register however.

3.4 Summary

Based on the evidence provided, our view is that the Customer Choice programme seems to be a more appropriate delivery plan that avoids the build of costly assets that will be removed at a later date, for a relatively small additional commercial charge that is more than offset by the cost of site supplies as provided by ENWL. [redacted]

[redacted]

The activities in the delivery plan which include tendering, award and first site access, construction and commissioning are broadly reasonable for a project of this scale and for the technology and techniques to be used in tunnel boring and fitting out. The timing of various activities also appears to be relatively efficient with no notable delays. NGET has carried out some preliminary market engagement with suppliers for the cable tunnel to inform design, costs and programme. We would expect that these will be developed in greater detail as the design is further progressed, additional survey and analysis work is completed, and milestones are achieved and reflected in the updated risk register.

There is still significant uncertainty regarding programme risks and this uncertainty will be reduced as the project moves forward and more information on the site specific characteristics and risks of each project element are revealed. As the design for the preferred connection option is further developed, the risk will reduce, and so it is essential that the registered risks are updated on a regular basis ahead of the Final Needs Case and the Project Assessment. An additional factor that will impact on the quantification of the programme risk is the extent to which the NWCC is tendered under the CATO regime.

Based on our assessment of the NWCC programme and the associated risks, we have identified a number of issues that may impact on delivery of the project. These include indemnity, CFD discussions and the move to Customer Choice programme. If the Customer Choice programme is implemented then the northern overhead line and substation works are also on the critical path along with the cable tunnel. NGET has indicated that this will not result in any increased programme risk however our view is that including another contracted milestone, increasing overall project management towards the start of the project, and ENW enabling works will likely increase programme risk although perhaps not materially in cost terms. This should be reconsidered in the risk register.

NGET has also responded that NuGen has made clear public indications that their CfD is still on track for 2018.

In addition, we recommend that:

- NGET should clarify whether the next phase of community engagement is likely to impact on the proposed DCO submission date in Spring 2017 and, therefore, the wider programme;
- NGET should engage with NuGen and the new department, BEIS, as quickly as possible to understand if there are any additional risks to the project delivery due to investment uncertainty following the recent referendum and abolishment of DECC;
- NGET should update Ofgem if there are any changes from the current anticipated connection arrangements due to NuGen submitting a Modification Application; and
- NGET should seek to immediately clarify with NuGen and BEIS that the discussions for the CFD are still on track for 2018.

Justification and Efficiency of Delivery Plan	Programme Risk Identification & Management
	

4 Part C: Suitability for Competition

Box 4-1: Specific Review Questions

• Assessment of the project against the criteria that Ofgem has set out for onshore competition;
• Consideration of the key risks and opportunities to a Competitively Appointed Transmission Owner (CATO) in constructing and operating the project. This should include any key limitations or opportunities for efficiency and innovation provided by:
  ○ the project design and preliminary works (as undertaken to date, and as planned up to the point of overall planning approval); and
  ○ the number and nature of interfaces with other parties.
• Consideration of the technical impact of splitting the project into two or more packages for tendering.

This section sets out the suitability of the NWCC project for competitive tendering under the CATO regime. This includes discussion of:

- Potential ways in which the project could be 'packaged' for tendering;
- The eligibility of these different packages for tendering (with respect to the eligibility criteria);
- Discussion of the risks and opportunities associated with tendering; and
- Assessment of the preliminary works undertaken to date.

As a whole, the project satisfies the three criteria:

- The vast majority of the assets are new (with the exception of some of the works at the existing Harker and Middleton substations);
- The project is high value – irrespective of which option is progressed, it will exceed the £100m threshold; and
- The project is separable – clear ownership boundaries can be defined at key interface points.

Note, however, that this is dependent on how the project is packaged, as discussed in Sections 4.1 and 4.2.

The other factor that is most likely to affect the appropriateness of the project to competition is the project delivery programme. The cable tunnel construction is on the critical path and NGET has indicated that the tunnel needs to be tendered and contracted by Q2 2018. Also, in the Customer Choice programme, with site supplies provided by National Grid, the northern transmission assets will need to be rephased to be completed by 2022. Thus, it is likely that the timescales will not allow for the tunnel or the Northern OHL section

to be tendered competitively through the ECIT regime. This is discussed in more detail in Section 4.3.

4.1 Tendering Packages

4.1.1 Proposed Tendering Package

Five separate hypothetical packages for tendering the NWCC project have been considered. This is not exhaustive, however it explores a large enough range of possibilities so that all key issues can be considered. The five packages range from a single large tender package, to a series of smaller tender packages. These are:

1. **Whole Project:** The entirety of the NWCC project's transmission assets are tendered together[17];
2. **North and South:** The North and South (inc overhead line, underground cabling and cable tunnel) routes are tendered separately;
3. **North, South OHL and Tunnel:** The North OHL, South OHL, and cable tunnel are tendered separately;
4. **Individual Elements:** The NWCC project elements are separated at substation/circuit interfaces e.g. overhead line sections between substations and the cable tunnel are tendered separately, and substations are tendered separately; and
5. **Bundled Substations:** As per package four, but with the all substations works packaged together.

[17] Note that, based on input and advice from Ofgem, we have assumed that the substation extensions at Harker and Middleton could be categorised as "new" assets. Therefore, these elements of the works could potentially be eligible for tendering. However, we would recommend that eligibility of substation extensions is considered on a case by case basis and in discussion with NGET, as eligibility will depend on, for example, the extent of the work which needs to take place within the existing TO compound, the nature of the resulting interfaces etc. In Figure 4-1, the existing substations are shown as "Not Tendered" with extensions/modifications etc represented as part of one of the CATO projects.

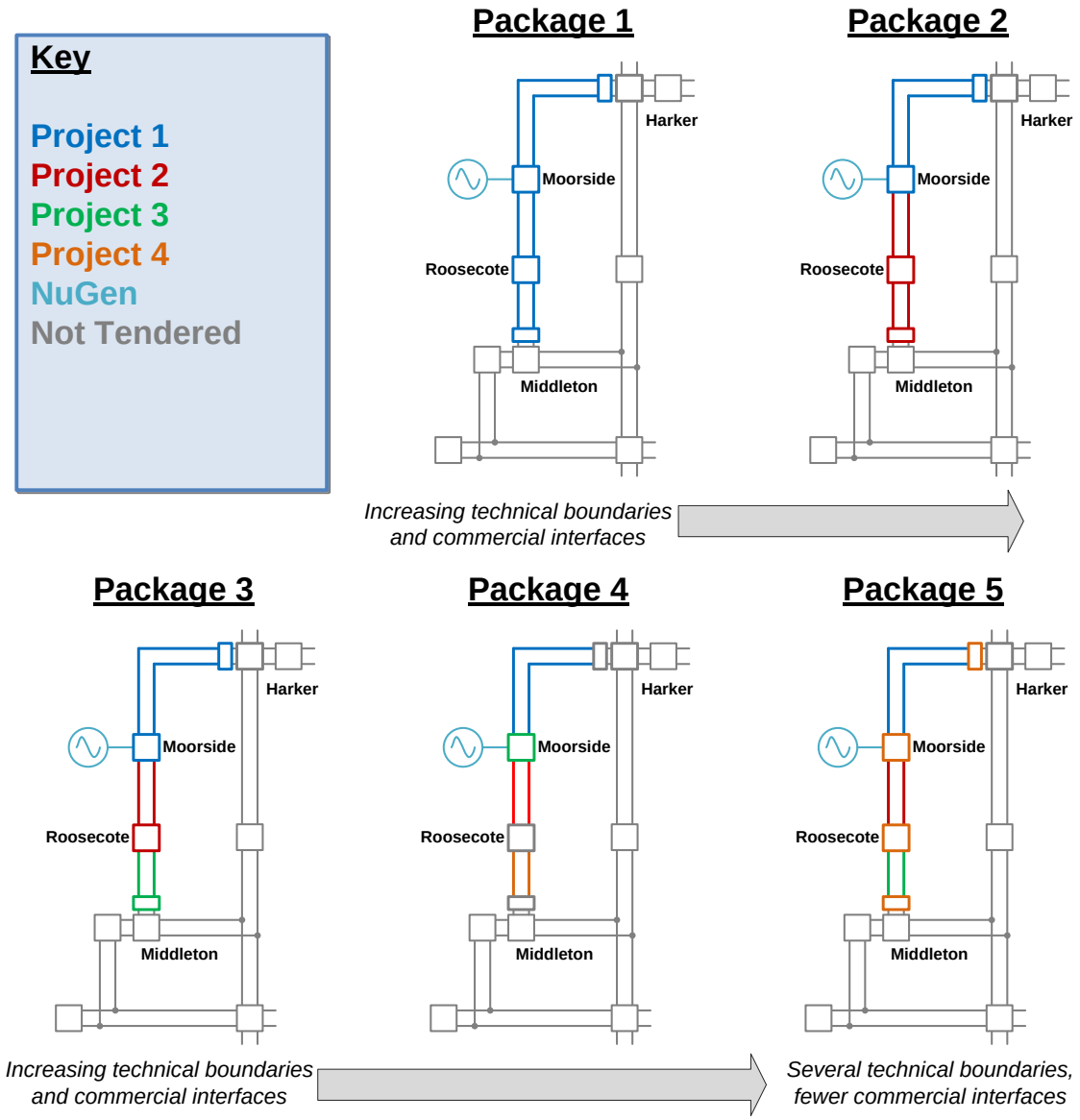


Figure 4-1: NWCC Tendering Packages

These five packages are described in more detail below in the following subsections.

4.1.1.1 Tendering Package 1 - Whole Project

This would involve tendering the entirety of the NWCC project as a single project including all the new circuits (overhead lines and tunnel), new substations, and substation modifications.

4.1.1.2 Tendering Package 2 - North and South (inc Tunnel)

This would involve tendering the north and south circuit routes separately, including the new substations at Roosecote and Moorside and substation extensions.

4.1.1.3 Tendering Package 3 – North, South and Tunnel

This would involve tendering the north and south overhead line routes, including the new substations and extensions, as separate projects, with the new Roosecote substation tendered separately from the cable tunnel.

4.1.1.4 Tendering Package 4 – Individual Elements

This would involve tendering each of the circuits between substations (Moorside to Harker, Moorside to Roosecote, Roosecote to Middleton) as separate CATO projects. The new Moorside substation would be tendered as a standalone project. The new substation at Roosecote and the modifications at Harker and Middleton would be delivered by the incumbent TO (as these would not qualify as high value).

4.1.1.5 Tendering Package 5 – Packaged Substations

This would involve tendering each of the circuits between substations (Moorside to Stainburn, Stainburn to Harker, Moorside to Roosecote, Roosecote to Middleton) as separate CATO projects. The new Moorside substation would be bundled together with the new substations at Stainburn and Roosecote as a single tendered project.

4.1.2 Assessment of Tendering Packages

To qualitatively assess the hypothetical tendering packages, the following high-level assessment headings are used.

- **Eligibility:** When considering tendering packages for projects, the eligibility criteria should be kept in mind – the total tendering package should be £100m or greater in value, and that the separability of the project should be considered[18]. Eligibility of the hypothetical tendering packages is discussed in detail in Section 4.2;
- **Interfaces:** Related to the point above, we have assumed that interfaces would be located at circuit assets that enable electrical separation i.e. circuit breakers. The total number of technical (electrical) and commercial interfaces with other stakeholders e.g. NGET, ENWL, NuGen other CATOs etc. should be considered. We have assumed that, in general, a large number of interfaces is not desirable as this introduces risks relating to, for example, delays to the programme, management of interfaces etc. There may also need to be a party responsible for any costs or liabilities associated with interfaces;
- **Size:** Our view is that, when considering separation of larger projects into multiple smaller projects, there is a balance to be struck between:

[18] We have assumed that further separation of projects into sections which are not electrically separate may create interfacing issues which would need to be justified and managed. Therefore, we have only explored tendering packages which are already electrically separable, noting that it would be possible although not necessarily efficient to further subdivide some of these packages.

i. The economies of scale associated with higher value projects and the ability to engage the market more readily;

ii. The greater risk associated with larger projects and potential for lower engagement from prospective CATOs if there are fewer opportunities;

iii. The risk associated with increasing number of technical and commercial interfaces between various parties and co-ordination of these.

Therefore, when looking at tendering packages, it is our view that projects should be large enough to benefit from economies of scale and keep interfaces to a minimum, but not so large that they carry undue risk or reduce the market for prospective CATOs.

In general, we expect that any projects which qualify as high value will be large enough that they benefit from economies of scale but that tendering smaller projects may be more costly for bidders and the wider market due to the relatively fixed costs of tender preparation.

- **Technology Efficiency:** It might be appropriate to tender separately elements of a larger project which utilise different technologies, as there may be some companies which are more experienced at delivering some technologies (e.g. HVDC, cable tunnels) than others. Where a tendering package involves separating out different technologies into different tendering packages (e.g. overhead lines, tunnels, substations), this will be assessed favourably. Where a package requires a single CATO to deliver multiple technologies, we have assumed that they would have to subcontract to another contractor, and that there would be a premium and increased risk associated with this; and
- **Distinct:** It may be beneficial to tender separately elements of a project which are distinct e.g. due to their geographic location or the phasing of their construction.

Table 4-1 summarises our assessment of the tendering packages described above against these criteria. A green rating indicates that we do not foresee there being any significant risks and rate this approach positively in terms of opportunities, an amber rating indicates that whilst there are some tendering opportunities, we expect there may be some risks that need to be managed or mitigated, and a red rating indicates that we think that there would be significant risks associated with tendering in this way.

This qualitative analysis suggests that tendering by individual elements (Package 4), or with packaged substations (Package 5), may result in techno-economic efficiencies, but that this would introduce significant interface issues. For example, it is not clear who would take overall responsibility for managing the timely delivery of the project, or who would bear the financial risk associated with managing the increased technical and commercial interfaces. This may need an oversight party, or alternatively, CATOs may need to be incentivised to pool together to share risk and manage responsibilities. It is possible that further development of ECIT regime policy could lead to introduction of measures or incentives to mitigate this risk, in which case, these ratings may be scored differently.

Therefore, it is likely that packages which are less disaggregated will be more appropriate. On a review of our qualitative assessment, it appears that tendering the North, South and Cable Tunnel package separately (Package 3) may provide the best balance between these criteria. However, there would still be some requirement for management of interfaces between the CATOs.

This option may also be the best fit for the current NWCC delivery programme e.g. the North route and cable tunnel elements of the package could be delivered by the incumbent TO if timescales for these elements make tendering challenging[19]. In Section 4.3 we set out our view on the challenges associated with those sections, given the programme requirements discussed in Section 0.

Please note that this is indicative only and actual tendering packages may be more efficiently delivered by a combination of the above.

Table 4-1 Summary of Assessment of Hypothetical Tendering Packages

Package	Eligibility	Interfaces	Size	Technology	Distinct
1. Whole Project					
2. North and South (inc tunnel)					
3. North, South and Tunnel					
4. Individual Elements					
5. Packaged Substations					

Our assessment is based on the following observations. Note that throughout we have assumed that a CATO doing some of the extension/modification works at Harker and Middleton can be classified as new and will not affect project eligibility.

1. Tendering the **Whole Project** as one package:
    - **Eligibility:** Eligible. It may be necessary for some of the interfacing work to be completed by NGET (as the incumbent TO);

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- **Interfaces:** Reduces the number of technical and commercial interfaces. Interfaces would exist between the CATO and NGET, NuGen and ENWL. Risk and responsibility for managing this could sit with the CATO;
- **Size:** Would result in the entire project being delivered by a single large CATO which would provide only a single opportunity for potential CATOs;
- **Technology:** Requires a single CATO to deliver both overhead lines, tunnels and substations which may require sub-contracting of specialist expertise if it does not exist within the capability of the core CATO parties; and
- **Distinct:** Requires a single CATO to deliver a project which spans a large geographic area with multiple construction phases.

2. Tendering the **North and South** routes as two separate packages,:
   - **Eligibility:** Eligible. It may be necessary for some of the interfacing work to be completed by NGET (as the incumbent TO);
   - **Interfaces:** Introduces further interfaces which would need to be managed between CATOs and NuGen, NGET, ENWL. Responsibility and risk for managing interfaces would have to be assigned either to one CATO, shared between CATOs or retained by NGET as SO (or possibly as TO, although this risk would potentially be disproportionately large to their scope of work);
   - **Size:** Would result in the entire project being delivered by two smaller CATOs providing opportunities for the market;
   - **Technology:** Requires a single CATO to deliver both overhead lines, tunnels and substations for the Southern route, which may require sub-contracting of specialist expertise if it does not exist within the capability of the core CATO parties; and
   - **Distinct:** Requires the CATO for the Southern section to deliver a project with multi-phase construction (tunnel, overhead line, substations).
3. Tendering the North and South routes as two separate packages, with a third package for the **Morecambe Bay cable tunnel**:
   - **Eligibility:** Eligible. It may be necessary for some of the interfacing work to be completed by NGET (as the incumbent TO);
   - **Interfaces:** Introduces further interfaces which would need to be managed between CATOs and NuGen, NGET, ENWL. Responsibility and risk for managing interfaces would have to be assigned either to one CATO, shared between CATOs or retained by NGET as SO (or possibly as TO, although this risk would potentially be disproportionately large to their scope of work);
   - **Size:** Would result in the project being delivered by three smaller CATOs providing several opportunities for the market;
   - **Technology:** Allows separate delivery of tunnels and overhead lines, although substations still to be delivered by circuit CATOs; and

- **Distinct:** Distinct phasing so that each CATO (e.g. Northern overhead lines, Southern overhead lines and tunnel) can construct their assets separately.

4. Tendering all the **Individual Elements** of the project separately:
    - **Eligibility:** Makes some elements of the project ineligible for competition, as they do not meet the high value criteria, including the substation works at Middleton, Harker and the new substation at Roosecote.
    - **Interfaces:** This would introduce a large number of technical and commercial interfaces between multiple CATOs, NGET, ENWL and NuGen. Responsibility and risk for managing interfaces may have to be shared between NGET and all the CATOs, or retained by NGET as SO (or possibly as TO, although this risk would potentially be disproportionately large to their scope of work);
    - **Size:** This would result in the entire project being delivered by lots of small CATOs which may benefit establishment of the market;
    - **Technology:** Results in separate (specialist) contractors delivering overhead lines, the tunnel and substations; and
    - **Distinct:** Distinct phasing so that each CATO (e.g. Northern overhead lines, Southern overhead lines and tunnel) can construct their assets separately (although there would need to be close coordination between delivery of circuits and substations).
5. Tendering all the Individual Elements of the project separately except for new **substations** which are **packaged** together:
    - **Eligibility:** Eligible. It may be necessary for some of the interfacing work to be completed by NGET (as the incumbent TO). Packaging the substations together means that they are all eligible to be tendered;
    - **Interfaces:** This would introduce a large number of technical and commercial interfaces between multiple CATOs, NGET, ENWL and NuGen. Responsibility and risk for managing interfaces would probably have to be shared somehow between NGET and all the CATOs, or retained by NGET as SO (or possibly as TO, although this risk would potentially be disproportionately large to their scope of work);
    - **Size:** This would result in the entire project being delivered by lots of small CATOs;
    - **Technology:** Results in separate contractors delivering overhead lines, the tunnel and substations; and
    - **Distinct:** Distinct phasing so that each CATO (e.g. Northern overhead lines, Southern overhead lines and tunnel) can construct their assets separately (although there would need to be close coordination between delivery of circuits and substations). The delivery of the substations would not

necessarily be distinct (e.g. if the Northern overhead line was required earlier than the Southern, then Stainburn and Moorside substations may be required many years ahead of Roosecote), and the substations are geographically quite remote from each other.

4.1.3 Additional Electrical Separability

We were asked to consider whether additional electrical separability would be appropriate for this project. For the current NWCC design, we don't believe there are additional benefits to be gained by additional electrical separability. Individual elements described above are already electrically separated by circuit breakers.

[redacted]This could then be delivered by CATOs specialising in underground cables. However, due to the potential for interface issues as described above, we do not believe that the benefit of this would outweigh the potential risks and additional costs involved in tendering separately. In addition, it is unlikely that the switchgear required to achieve this (including circuit breakers, isolators etc) could be accommodated within a standard cable sealing end platform or compound, which means that it might require modifications to the DCO.

In addition, we don't believe that further separation of tendering packages into sections which are not electrically separate e.g. splitting overhead line circuits but not requiring circuit breakers, would introduce benefits, as discussed previously.

4.2 Eligibility for Competition

4.2.1 Overview of Criteria

4.2.1.1 New

The majority of assets which comprise the NWCC project are new by definition, as there is no existing transmission infrastructure in the region. The exceptions are the existing substations at Harker and Middleton which will need to be modified/extended as part of this project. However, depending on the final scope of the extension/modification works, this could be categorised as new. For the purposes of this assessment, we have assumed that these substation works will still be categorised as new and therefore considered to sit within the proposed packages of works.

4.2.1.2 Separable

We expect that most of the assets will be separable (although consideration may need to be given to the modification of existing substations as discussed above).

We have also considered the potential for electrical separability which, although not necessary, may be beneficial. As long as assets are separated into tendering packages based on circuit breakers, then they will be electrically separable. The Connection and Use of System Code (CUSC) contains rules which define boundaries for AC assets, for both Gas

Insulated and Air Insulated switchgear. By adhering to these principles, it will be possible to define tendering packages which are electrically separable.

4.2.1.3 High-Value

Eligibility against the high value criteria has been assessed by looking at the base costs for the relevant elements of the project cost. Where tendering packages involve breaking out the project into smaller sub-projects, this has been done based on the costs contained within Appendix 12, with Planning & Consent and Project Management costs pro-rated across all parts of the project based on cost. We have presented both the base costs, P50, and P80 costs as presented in the Initials Needs Case.

Table 4-2 Eligibility of Tendering Packages for Competition

Option	Project Element	New	Separable	High-Value	Eligible	Base (£m)	P50 (£m)	P80 (£m)
1. Whole project	Whole project	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
2. North and South (including Tunnel)	North (including Moorside)	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	South (including tunnel)	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
3. North, South and Tunnel	North OHL + Moorside + Harker	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	South + Roosecote	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Tunnel + Middleton	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
4. Individual Elements	North OHL	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Harker	✓	✓	✗	**No**	[redacted]	[redacted]	[redacted]
	Moorside	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	South OHL	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Tunnel	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Middleton	✓	✓	✗	**No**	[redacted]	[redacted]	[redacted]
	Roosecote	✓	✓	✗	**No**	[redacted]	[redacted]	[redacted]

Option	Project Element	New	Separable	High-Value	Eligible	Base (£m)	P50 (£m)	P80 (£m)
5. Packaged Substations	North OHL	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	South OHL	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Tunnel	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]
	Packaged Substations	✓	✓	✓	**Yes**	[redacted]	[redacted]	[redacted]

4.2.2 Assessment Summary

Our analysis indicates that there is a balance to be met in the level of disaggregation of tendering packages, to provide sufficient market opportunity and opportunity for innovation whilst not introducing further interfacing complexity. For example, it is not yet clear under the ECIT regime how ownership of technical risks and allocation of financial risk will be managed. This could be particularly complicated when there are multiple CATOs with more technical and commercial interfaces. Further development of ECIT regime policy could lead to introduction of measures or incentives to mitigate these risks.

On a review of our qualitative assessment, it appears that tendering the North, South and Cable Tunnel package separately (Package 3) may provide the best balance. However, there would still be some requirement for management of interfaces between the CATOS. This option may also be the best fit for the current Customer Choice NWCC delivery programme e.g. the North route and cable tunnel elements of the package could be delivered by the incumbent TO if timescales for these elements make tendering challenging. The next section expounds on our views regarding these timescales and other risks associated with tendering.

For the current NWCC design, we don't believe there are additional benefits to be gained by additional electrical separability.

4.3 Risks Associated with Tendering

4.3.1 Risks or Opportunities which Affect Tendering

There are a number of risks that may affect the eligibility of elements of the project for tendering. These are described in more detail below.

4.3.1.1 Programme

Due to the timescales in the Customer Choice programme, NGET has indicated that the cable tunnel needs to be tendered and contracted by Q2 2018 prior to NuGen FID in Q3 2018. We are satisfied that the timescale provided by NGET for the cable tunnel in the delivery plan are generally reasonable and efficient and based on guidance from sufficient engagement with the market. Thus, in our view this could make it challenging to tender the cable tunnel through the ECIT regime. The northern overhead line works could also be challenging to tender as part of the ECIT regime if required for completion in 2022, in accordance with the Customer Choice delivery programme.

It should however be possible in principle to tender the southern overhead line and substation works with no risk anticipated for the programme.

4.3.1.2 Delay in FID

A delay in NuGen's FID could represent a risk in terms of preliminary or construction works carried out by the CATO "at risk" if the CATO is contracted before FID. However, it may be possible to mitigate this with transfer of indemnity to a third party. Given the expected position of the CATO arrangements, it is unlikely that the tendering process for NWCC would be completed before FID in which case this risk, if it materialised, would not impact on

CATO works. This risk should be revisited for future SWW projects where it may be feasible to finalise tendering prior to FID, in the case of a commercial generation connection.

4.3.1.3 Delay in Contract Date

A delay in the contract date may reduce the programme constraint for the cable tunnel and northern works depending on the underlying cause, enabling more project elements to be tendered through the ECIT regime. NuGen anticipates that the first reactor will be connected in 2025 as clarified in the Modification Application submitted in November 2016 which details the updated timing for site supplies which is driving the accelerated delivery of the northern works.

4.3.1.4 Delay in DCO/Non-award of DCO

Award of DCO for NWCC is timed to coincide with the NuGen FID. As it is unlikely that a CATO will be appointed prior to FID, delay or non-award of DCO would not impact on CATO works. This risk should be revisited for future SWW projects where it may be feasible to finalise CATO appointment prior to DCO award.

4.3.1.5 Design Uncertainty

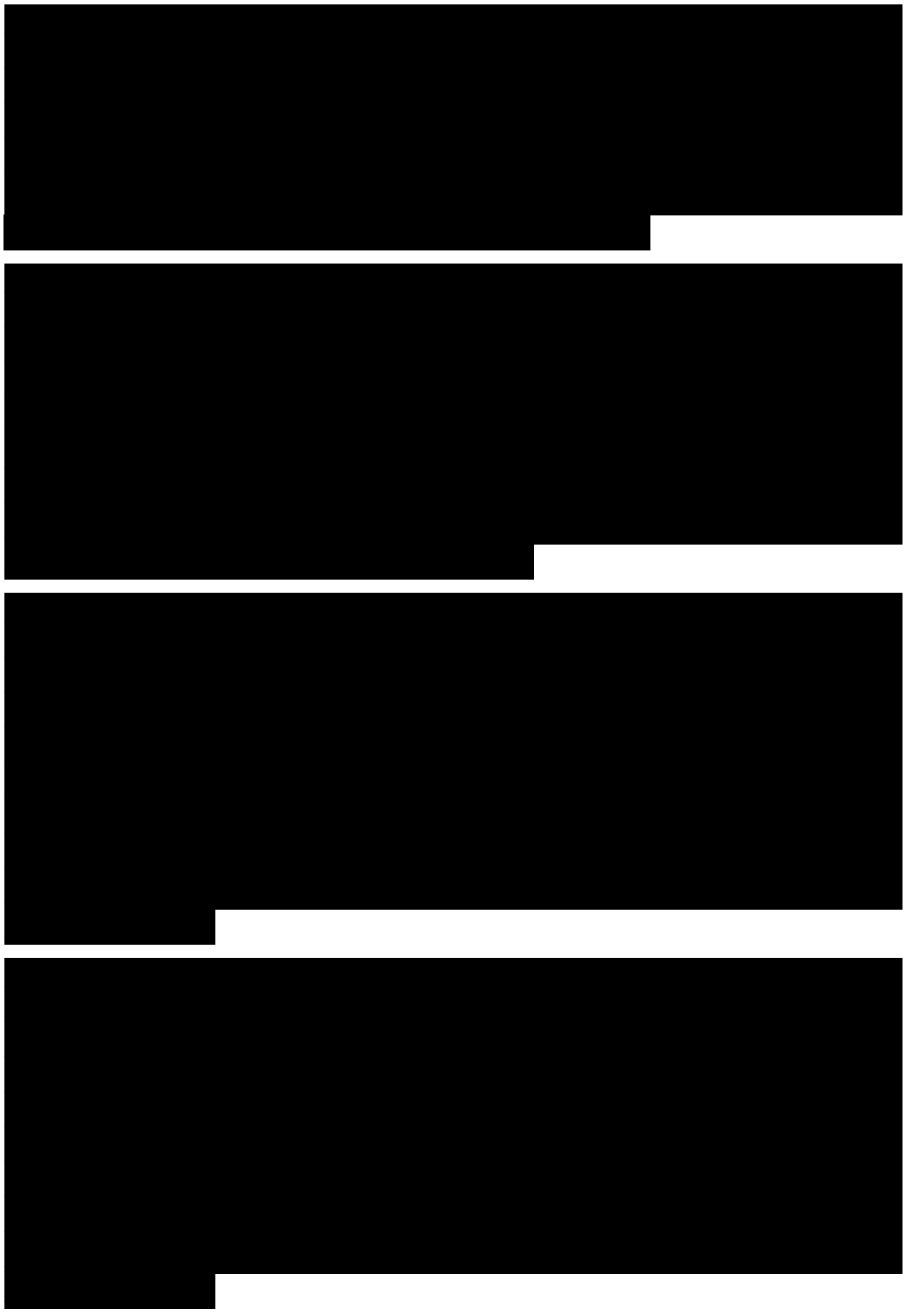
There are a number of factors that may contribute to design and cost uncertainty that may not be available to potential CATOs at the tendering stage. These include geotechnical data, flood risk, unexploded ordnance data etc. NGET has indicated that borehole surveys are currently being carried out for the cable tunnel in Morecambe Bay which will help to reduce construction risk for potential CATOs. NGET has confirmed that detailed ground surveys have not been done yet for overhead line foundations and are based on generic assumptions. This is another key risk area, specifically for foundation design.

4.3.2 Risks or Opportunities Introduced by Tendering

4.3.2.1 [redacted]

[redacted]

- [redacted]



4.3.2.2 *Commercial Arrangements with ENWL*

There will be considerable interaction between National Grid and ENWL during the construction of the project - the ENWL onsite works will need to precede the start of some of the National Grid works, and would need to begin in March 2018 in order to meet the proposed programme for the customer connection date. According to the INC report this interaction will focus on the mitigation works to remove existing 132kV overhead lines north

and south of Moorside and works to temporarily or permanently relocate existing infrastructure to facilitate the safe construction of the 400kV connection. National Grid and ENWL have worked together to reduce the risks associated with this work, the main risk being the disruption of electricity supply to customers on the ENWL network.

National Grid and ENWL are in the process of developing commercial arrangements to ensure that the work ENWL needs to complete prior to the FNC decision, can be completed. A purchase order has been developed to cover the time and expenses spent on the project so far (supporting the distribution system options and INC submission and meetings). [redacted] The INC states that together with Ofgem, National Grid and ENWL have been in discussions to work out the arrangement for the delivery of future work – the current proposal is to set up a framework agreement.

As a result, the future contractual arrangements between National Grid and ENWL will be crucial to the successful delivery of the project, and will need to resolve a set of complicated interactions[20]. ENWL mobilisation in 2017 and the first site access in 2018 are crucial to meeting the customer connection date. For example, any delays or constraints to the construction works could impact other elements of the project. In addition ENWL will be required to undertake outages on their network to support construction and so will need to carefully manage its own network maintenance during this period. To enable this site access by 2018, ENWL will need to start its own work tendering process during 2017.

National Grid has indicated that the future contract with ENWL is actively being developed and its scope will include site supplies for cable tunnel construction and enabling works for the northern and southern routes required from 2018. The scope of the work being undertaken by ENWL implies that the current contract it has with National Grid could need to be transferred and split across a number of CATO participants.

20 [redacted][21]

https://www.ofgem.gov.uk/system/files/docs/2016/08/extending_competition_in_electricity_transmission_-_tender_models_and_market_offering_0.pdf

The complexity of these arrangements means that the introduction of competitive tendering must be carefully planned to ensure that the working relationships with ENWL are clear and well-defined and do not negatively impact on the delivery of its works. The key considerations for ENWL in the event of competitive tendering are likely to include:

- **Contracting**: As stated above, there is a possibility that ENWL will need to coordinate with multiple CATOs in the event of competitive tendering. If this leads to a requirement for separate contractual negotiations, it will be important to ensure that this process does not lead to an inefficient use of time, resource and costs. For example there may be benefit in developing a 'model' contract that will be used between the CATOs and ENWL.
- **ENWL internal management**: It will be important that ENWL is given adequate time to plan its resourcing in the event of competitive tendering. The internal management structure required to ensure that the work is completed on time is likely to be different in the event it has to coordinate with several CATOs as opposed to National Grid alone (i.e. there would need to be coordination by ENWL).
- **Coordination of construction**: Effective coordination of the construction projects will be important given the potential for involvement from multiple CATOs. For example there may be a part of the construction project that will require coordination between the multiple CATOs and ENWL – this increases the possibility that a delay in the work by one CATO has a knock-on impact that could ultimately lead to a delay in the connection date.
- **Timing of works**: The ongoing progress and eventual completion of the ENWL works is critical to meeting the DCO timelines and ultimate connection date. It will be important that any additional negotiations required as a result of the CATO arrangements do not stall the construction process and lead to delays.

In order to mitigate these risks further, work will be undertaken by ENWL and National Grid to develop a detailed integrated construction programme – this is likely to be improved as the scope of the ENWL works becomes more certain.

Given the potential impact of the tendering arrangements on the work being completed by ENWL, it is our recommendation that the potential challenges involved in this are explored further outside the scope of this study.

4.3.2.3 Interfaces

Tendering the project into a number of contracts will require some co-ordination between all key stakeholders including NGET, various CATOS, Ofgem and ENWL during the design, construction and commissioning periods. It is not clear yet whether NGET as System Operator would provide oversight of individual CATOs or there would be another co-ordination mechanism. This could possibly be more efficiently provided by the Transmission Owner function of NGET however, as a potential CATO this is likely to create a conflict of interest. There should be some commercial recognition of the impact of programme delays for one element of the transmission project affecting the programme of another, separately tendered element. This generic risk should be considered during the development of the competition in onshore transmission regime.

4.3.2.4 Innovations from CATOs

Tendering of the project should enable CATOs to introduce innovations in design, construction techniques, financing etc. Technical innovations might include innovative substation designs and/or novel construction techniques (within the bounds of the DCO for the late CATO model), delivering further value for consumers. For example, National Grid has proposed a tunnel with a 5m diameter as a reasonable worst case scenario. It is possible that a CATO could propose innovative tunnelling designs or construction methods which allow for the diameter to be reduced, potentially leading to reduced cost and minimised environmental impact. One possible route to realise this benefit could be to allow some room for innovation from bidders when preparing a bid.

4.3.2.5 Financial Considerations

Ofgem has stated that the revenue period for CATOs will be 25 years. Under the Customer Choice option, the northern overhead line route will need to be in place from 2022 – presumably, the revenue period will have to start at the same time. On the other hand, the tunnel and southern overhead line route do not need to be in place until 2025. If these assets are all tendered as a single package then revenues may need to be tied to the completion of stages, as outlined in the Ofgem's August consultation[21].

Ofgem has noted (based on CEPA's report[22]) that a need to obtain finance for a period of over 30 years may limit the financing options which a CATO has. Ofgem also noted that the length of the construction period also has to be considered since CATOs need to raise debt during construction[23]. Ofgem states that "Where the construction period is longer than 3-5 years, CATOs may have to start paying significant debt interest before revenue starts, leading these payments to be capitalised"[21]. This could mean that a CATO for the cable tunnel, which has an estimated construction period of over 6 years, would have to capitalise debt payments, which may not be efficient.

Both the issues described above would also affect the "packaged substations" option described in Section 4.1 – each substation is required at a different time, which might require staged revenue periods. The total construction period for all of the substations is eight years, which might lead to inefficient financing if debt payments have to be capitalised. This could be considered when making a decision on tendering.

21 https://www.ofgem.gov.uk/system/files/docs/2016/08/extending_competition_in_electricity_transmission_-_tender_models_and_market_offering_0.pdf

22 https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/cepa_cato_final_report_oct_15_0.pdf

23 https://www.ofgem.gov.uk/sites/default/files/docs/2015/10/ecit_consultation_v6_final_for_publication_0.pdf

4.3.3 Summary

The timescales for cable tunnel build and the completion of the northern overhead line circuit (which are not unreasonable based on our review of information provided by NGET), may make it challenging to tender through the ECIT regime in terms of programme risk i.e. not meeting current contracted dates. It should however be possible in principle to tender the southern overhead line and substation works with no risk to project delivery.

A delay in the contract date may however reduce the programme constraint for the cable tunnel and northern works enabling more project elements to be tendered through the ECIT regime. NuGen anticipates that the first reactor will be connected in 2025.

Key risks introduced by tendering include management of indemnity arrangements, commercial arrangements with ENWL, interfaces and impact on potential for financial innovation. For example, there may be a number of CATOs who will need to contract and coordinate with ENWL and this may negatively impact costs and programme risks in particular. There will also be a need for increased multi-lateral stakeholder engagement between Ofgem, NuGen, NGET, ENWL and the CATOs to enable efficient project delivery.

There is however an opportunity for CATO to bring design innovation within the bounds of the DCO.

The risks and opportunities associated with tendering are summarised in Table 4-3: Risks and Opportunities which may Affect Tendering and Table 4-5:

- Minor risks are marked in Green;
- Moderate risks are marked in Amber;
- Significant risks are marked in Red; and
- Opportunities are marked in **Yellow**.

Table 4-3: Risks and Opportunities which may Affect Tendering

Risk	Description	Score	Status
Programme	**Risk** that programme makes it challenging to accommodate tenders for tunnel and north route due to lead times between FID and energisation of the first reactor.		The delivery programme as set out may make tendering the tunnel and north route challenging.If indemnity is transferable, it could allow for tendering to be completed pre-FID.
Delay in FID	**Risk** that FID delay could affect preliminary works.		Transfer of indemnity could mitigate this. Unlikely that tendering would be completed before FID so would not impact CATO works.
Delay in Contract Date	Delay in contract date may bring **opportunities** for tendering if it reduces the constraints on programme.		NuGen has requested to delay energisation until 2025 through a Modification Application.
Delay/non-award of DCO	**Risk** that delay in DCO for NWCC or non-award, which is coupled to NuGen FID, could impact on CATO.		Unlikely that tendering would be completed before FID so would not impact CATO works.
Design Uncertainty	**Risks** associated with many factors which could add design and cost uncertainty that CATOs may not have access to at design stage e.g. geotechnical date, flood risk, UXO.		NGET is carrying out surveys at the moment (e.g. borehole surveys for tunnel). Detailed surveys for OHL foundations have not been done. Design/estimating uncertainty has been considered in the risk cost calculation.

Table 4-4: Risks and opportunities which may affect tendering

Risk	Description	Score	Status
Indemnity arrangements	**Risks** and or **opportunities** associated with NuGen's indemnity with National Grid's SO function.		Not clear how this may impact the process of handover to contractors/third parties. NGET and Ofgem should discuss potential impacts. It may be more appropriate for these sorts of arrangements to be entered into with the SO function as it may better facilitate competition to other TOs/CATOs. This may then present an opportunity for tendering.
	Risks associated with handover of indemnities to contractors/third parties.		Unlikely that a CATO would start work until after a FID. Therefore, transfer of indemnity unlikely to be a significant issue. A delay *is* still possible, however. National Grid should keep Ofgem informed of progress of discussions of the indemnity.
Commercial arrangements with ENWL	***Risk** that any need for ENWL to contract with multiple CATOs could lead to inefficiencies.*		*May be useful to develop a 'model' contract for use between ENWL and CATOs.*
	Risk that interfacing with multiple CATOs could require a different internal management approach within ENWL		ENWL must be given adequate time to plan its resourcing if NWCC is competitively tendered.
	Risks associated with coordination of construction and management of interfaces between ENWL and CATO(s). Could affect programme.		May further support idea that projects with multiple parties require an oversight party.

Risk	Description	Score	Status
	Risks associated with the timing of the ENWL works.		These works are on the critical path for the DCO and the final connection. Additional negotiations required due to CATO arrangements must not stall construction process.
	Summary of **risks** associated with ENWL works.		Potential challenges associated with the ENWL agreements should be explored in further detail.
Interfaces	Risks related to co-ordination required between many stakeholders including NGET, CATO(s), Ofgem, ENWL throughout entire programme. If this is managed by TO function of NGET, could lead to conflicts of interest.		This risk will be particularly prevalent if there are multiple CATOs involved in the scheme. Not yet clear whether NGET as System Operator would provide oversight, or if other coordination mechanisms could be used. Options for oversight should be explored in more detail.
Innovations from CATOs	**Opportunities** for CATOs to bring innovations to the project which deliver further value for consumers. Could be financial, design, construction. For example, CATO may be able to propose innovative tunnelling methods which allow for a smaller diameter tunnel to be constructed.		Ofgem could allow some room for innovation from bidders when preparing bids.

Risk	Description	Score	Status
Financial considerations	Multi-stage projects may mean that some parts of the assets are energised while others are still in construction.		Revenues may need to be tied to the completion of stages, as outlined in Ofgem's August consultation[24].
	Projects with longer construction periods may need to capitalise debt payments, which may not be efficient. Likely to affect the cable tunnel which has a six year construction period. Could affect the entire project if all tendered together.		Ofgem should continue to explore this.

[24] https://www.ofgem.gov.uk/system/files/docs/2016/08/extending_competition_in_electricity_transmission_-_tender_models_and_market_offering_0.pdf

4.4 Assessment of Preliminary Works

Preliminary works that have been completed by NGET at this stage are presented in Table 4-5 along with our view on appropriateness for a tender process. This includes potential impact on bidders during the tender process and during CATO delivery, and recommendations for any further works (if required).

Preliminary works carried out to date have been appropriate in scope and methodology. A reasonable balance appears to have been struck between targeting areas of high risk for more detailed assessment and minimising survey costs and timescales.

Table 4-5 Assessment of Preliminary Works

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Access to Land	[redacted]	Continuing negotiations with remaining landowners.	Ideally voluntary agreements will be in place but the DCO can include provisions for involuntary access for a third party. Restrictive physical access could require additional land deals or require additional consents if outwith the development boundary.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Onshore Ground Conditions	Desk based assessment.	Geo-technical surveys in areas of identified high risk including limited contamination testing.	Assumed mitigation measures may be subject to actual ground conditions. Conditions may limit mitigation options resulting in consenting risk. Foundation design and cost is highly dependent on ground conditions. Would recommend that detailed ground surveys are carried out prior to tendering.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Cultural Heritage and Archaeology	Heritage assessment underway including targeted geo-physical surveys. Stakeholder consultation.	Targeted intrusive investigation. Input into the design process.	Both geophysical and geotechnical surveys can be relatively expensive and both would have programme implications. There may be implications for the ability to employ mitigation (i.e. UGC) resulting in consenting risk.
Flood Risk and Hydrology	Mapping of flood risk and baseline assessment including collation of data from the Environment Agency and local authorities. Targeted preliminary walkover of the route in June 2015.	Further walkover at Preliminary Environmental Information stage. Flood Risk Assessment. Input into the design process.	May impact on construction techniques. Mitigation may be through amendments to design, inclusion of Sustainable Drainage Systems (SuDS) or application of construction best practice.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Non-avian Ecology	Preliminary Ecological Assessment and baseline protected species and habitat surveys. Review of existing baseline data. Stakeholder consultation.	Completing surveys. Input into the design process. Detailed design of mitigation measures.	Surveys will identify the need for, and provide data to inform applications for, protected species licenses. These will be required ahead of commencement of construction works. Potential bidders will want to establish and cost post consent survey and monitoring requirements.
Ornithology	2 years of baseline surveys. Review of existing baseline data. Stakeholder consultation.	Completing surveys. Input into the design process. Detailed design of mitigation measures.	Ornithology represents a substantial consenting risk due to the likely effects on international designations. Survey and assessment methodology must be robust. Potential bidders will want to establish and cost post consent survey and monitoring requirements.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Socio-economic Impacts	Survey work is underway looking at perception and route usage. Baseline analysis and collation of data including community engagement.	Stakeholder and community engagement later in 2016.	The INC leans on opinion poll data gathered on other developments. More detailed scheme specific assessment of the impacts on tourism and recreation will be required to inform final mitigation designs.
Morecambe Bay Tunnel - Construction Noise and Vibration	Preliminary assessments underway.	Finalisation of construction methodology to confirm need for and degree of dredging and piling. Detailed assessment to be included within the Environmental Statement.	Preliminary assessments suggest no unacceptable effects. Effects would be temporary and reversible but may be subject to seasonal restrictions to avoid disturbance of overwintering birds.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Morecambe Bay Tunnel - Spoil Disposal	Preliminary calculation of volumes and design of processes to remove and treat spoil.	Detailed assessment of options to re-use material and of likely sources of disposal including the options to use rail infrastructure. Traffic assessment.	Substantial volumes of spoil will be created with treatment required at the tunnel heads. Traffic impacts may be significant and require mitigation. It is not clear what costs of spoil disposal will amount to. This should be monitored as the project progresses.
Morecambe Bay - Bathymetry	Borehole testing. Review of available data and impact assessments undertaken for the offshore wind farm export cabling.	Detailed analysis of the impacts of the preferred tunnel option.	Monitoring data from the offshore wind farm export cables should be analysed.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Unexploded Ordnance (UXO)	Desk based study.	UXO risk assessments feeding into the EIA.	Small/localised UXO's may be able to be dealt with quickly/easily/low cost. Risk of additional survey effort and then clearance of UXO or route realignment.
Topography	Consideration of topography in route corridor assessments.	Appraisal during detailed design process. Detailed topographical studies of high risk areas.	Complex topography can lead to difficult/costly infrastructure design. Collection of onsite topographical data can be time consuming and it would be inefficient to have multiple bidders collect the same data. If sufficient data is not made available in the tender process bidders are likely to cost this into bids or require re-openers.

Aspect	Preliminary Works to Date	Future Works up to Receipt of the DCO	Comments
Need for Post Consent Ecological Surveys	Full suite of ecological and ornithological surveys.	Would be embodied within the DCO requirements. Should be identified during the EIA.	Potentially expensive with potential to cause programme delays. However, implications for works would typically be limited and manageable. There may be programme implications (e.g. avoiding breeding bird season) but these can be identified within the tender specification.