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SCOTTISH HYDRO ELECTRIC TRANSMISSION (SHE TRANSMISSION): CAITHNESS – MORAY TRANSMISSION REINFORCEMENT

Strategic Wider Works Project Assessment Report - Final

Ofgem

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ABBREVIATIONS AND ACRONYMS

AIS	air-insulated switchgear
BM	benchmark (See benchmark descriptions at Section 3.1.4.2, page 20.)
CAPEX	capital expenditure
CDMC	Construction Design & Management Co-Ordinator
COW	Clerk of Works
DNV GL	The Energy Consultancy (formerly KEMA) who produced this review document
GIB	gas insulated busbars
GIS	gas insulated switchgear
GBP	GB pounds sterling
GSP	grid supply point
H&S	Health & Safety
kV	kilovolt – 1000 volts
LT21, LT41 etc.	The six sub-projects that, together, form the SHE Transmission Caithness – Moray Transmission Reinforcement proposal. They are all described in Section 2.2, page 9 of this report.
MVA	megavolt-ampere – 1 million volt-amperes
NETS SQSS	The National Electricity Transmission System Security and Quality of Supply Standard of the UK
OHL	overhead line
PEP	Project Execution Plan
QA	quality assurance
QS	quantity surveyor
RIIO-T1	The UK's regulatory transmission price control period T1
SHE Transmission	Scottish Hydro Electric Transmission plc, Transmission owner in North Scotland
SLD	single line diagram
SQ	supplementary question
SWW	Strategic Wider Works, as defined by Ofgem
TAAAC	thermal-resistant aluminium alloy conductor
TACSR	thermal-resistant aluminium alloy conductors steel reinforced
TO	transmission owner
WBS	work breakdown structure

EXECUTIVE SUMMARY

During the electricity transmission price control review to set the RIIO-T1 regulatory allowances there was uncertainty around both the need for, and the cost of, a number of major reinforcements being considered for the UK transmission system. These reinforcements were thus not included from the RIIO-T1 allowances at that time. However, to facilitate their subsequent necessary development during the RIIO-T1 price control period (1 April 2013 to 31 March 2021), Ofgem put in place an additional mechanism known as Strategic Wider Works (SWW), which enables such reinforcements to be considered as RIIO-T1 expenditure adjustments during the price control period.

Scottish Hydro Electric Transmission plc (SHE Transmission) has submitted an SWW application for a transmission reinforcement project between Caithness and Moray in the far north of Scotland, to accommodate the anticipated connection of large volumes of new renewable energy in that area.

In April 2014 DNV GL was appointed by Ofgem to provide an independent expert assessment of the technical aspects of this proposed project. This report describes the results of our assessment of the Caithness – Moray SWW project and provides conclusions to assist Ofgem's assessment of the appropriateness of SHE Transmission's proposed capital costs (CAPEX) and their treatment of project resourcing, risks and procurement.

The scope of works comprises six component projects, each being a major project itself. The six sub-projects are:

- LT41: Blackhillock Substation re-development;
- LT21: Spittal 275/132 kV Substation and Spittal – Blackhillock HVDC Link;
- LT23: Dounreay – Spittal 275 kV and Spittal – Mybster 132 kV overhead line reinforcements;
- LT24: Fyrish 275/132 kV Substation;
- LT25: Loch Buidhe 275/132 kV Substation; and
- LT42: Beauly – Loch Buidhe 275 kV overhead line reinforcement.

These six sub-projects are illustrated in Figure 3 (Page 11) and comprise onshore developments to the west, and separately to the north of the Moray Firth, along with an HVDC subsea cable connecting the network in Caithness to Blackhillock substation to the east of Inverness. We were asked to assess all of the sub-projects except part of LT21. LT21 comprises four major elements:

- Spittal AC substation – assessed;
- HVDC subsea cable – assessed; but
- HVDC convertors – not assessed; and
- HVDC underground cable – not assessed.

The overall cost submission for the Caithness-Moray Transmission reinforcement is £1.24bn. SHE Transmission's breakdown of this estimate by sub-project is presented in Table 1 on Page 13, and the elements of LT21 that were not assessed comprise some [•] of this total.

The first contracts have already been let by SHE Transmission and construction work is due to complete for all the sub-projects by December 2018.

The amount and quality of the information available for our assessment varied between sub-projects, so we used both detailed assessment (bottom-up) and benchmarking (top-down) techniques to assess the efficiency of SHE Transmission's capital costs (CAPEX) estimates. We used benchmark data from three independent sources, and found that it was reasonable to average these to establish a robust measure against which to assess SHE Transmission's CAPEX submission. Further details of our application of these techniques may be found in Section 3.1 on Page 16, whilst the reasoning behind our conclusions may be found, by sub-project, in Sections 3.2 to 3.7.

Resourcing and procurement submissions were assessed on the basis of our specialists' long and varied experience of transmission network construction in the UK, which was used to test the logic for the resourcing provisions and approach to procurement. Further information on resourcing and procurement, in particular the reasoning behind our conclusions, may be found in Sections 4 and 6 respectively.

SHE Transmission's approach to risk was likewise based upon our specialists' experience of designing and troubleshooting UK and other transmission networks, which was used to test the logic with which SHE Transmission justified their risk cost estimates. Further detail of the risks assessment, in particular the reasoning behind our conclusions, is provided in Section 5, Page 97.

The results of our assessment are summarized in the table below, which provides the total SHE Transmission submission including the elements of LT21 not assessed by us. This summary is also provided in the context that the routeing of the subsea HVDC cable in LT21 may not be efficient. An alternative route, within the context of this particular assessment, might show a saving of up to [•], however this particular part of the assessment needs to be checked further against SHE Transmission's wider strategic network plans. A summary of our assessment without taking account of any routeing inefficiency is provided in Table 47 on Page 117.

DNV GL assessment overall totals - including subsea cable				
Cost Category	**SHE T**	**DNV GL**	**Differences**	**% diff**
Project Management	**Data redacted**			38.5%
Regulatory & Consent				0.0%
Engineering				22.0%
Construction				10.1%
Commissioning				57.0%
Operations				0.0%
Risk				61.9%
Project Totals	**£1236.2 m**	**£1015.4 m**	**£220.9 m**	**17.9%**

This table indicates that:

- Project management resource is assessed as over-estimated by [•], or 38% of the total project management submission – we consider the manpower provision does not take adequate account of the responsibilities that should be assumed by the principal contractors;
- Regulatory and consent cost estimates are reasonable;
- Engineering resource is assessed as over-estimated by [•], or 22% of the total engineering resource submission – we consider the manpower provision does not take adequate account of the responsibilities that should be assumed by the principal contractor;
- Construction costs are assessed in some sub-projects to be reasonable, and in others to be overestimated. Overall we assess the overestimate to be [•], or 10% of the total construction submission, although this figure drops to [•] in the event that the subsea cable routeing is not found to be inefficient in the wider network plan;
- Commissioning resource is assessed as over-estimated by [•], or 57% of the total commissioning resource submission – we consider the manpower provision does not take adequate account of the responsibilities that should be assumed by the principal contractors;
- Operations cost estimates are reasonable; and
- Risk costs are assessed as over-estimated by [•], or 61.9% of the total risk submission – we consider the risk provision does not take adequate account of the offset of risk to the principal contractor, nor does it demonstrate that risk mitigation measures have been used to control the at-risk costs.

Overall the Caithness-Moray transmission reinforcement submission is assessed as over-estimated by £220.9m, or 17.9% of the overall project submission.

Breakdowns of the above assessment by sub-project may be found in Table 47 on Page 117, whilst further details for each sub-project are also provided within the report section relevant to the part of the assessment in question.

1 INTRODUCTION

1.1 Background

During the electricity transmission price control review to set the RIIO-T1 regulatory allowances there was uncertainty around both the need for, and the cost of, a number of major reinforcements being considered for the UK transmission system. These reinforcements were thus not included from the RIIO-T1 allowances at that time. However, to facilitate their subsequent necessary development during the RIIO-T1 price control period (1 April 2013 to 31 March 2021), Ofgem put in place an additional mechanism known as Strategic Wider Works (SWW), which enables such reinforcements to be considered as RIIO-T1 expenditure adjustments during the price control period.

The purpose of SWW network developments is to significantly extend and/or strengthen the transmission network in preparation for major changes to power flows. To put forward a project for consideration under the SWW mechanism, the relevant Transmission Owner (TO) must provide a "Needs Case" submission followed by a "Project Assessment" submission, in which the economic and technical cases respectively are described and fully justified.

Scottish Hydro Electric Transmission plc (SHE Transmission) has submitted an SWW application for a transmission reinforcement project between Caithness and Moray in the far north of Scotland, to accommodate the anticipated connection of large volumes of new renewable energy in that area. In April 2014 DNV GL was appointed by Ofgem to provide an independent expert assessment of the technical aspects of this proposed project.

This report describes the results of our assessment of the Caithness – Moray project and provides our conclusions, with a view of informing Ofgem's view on the appropriateness of the proposed costs, the treatment of risks, and the likelihood of the works proceeding as proposed by SHE Transmission.

1.2 Overview of SWW process under RIIO-T1

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

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

[*] RIIO-T1: Final Proposals for SP Transmission Ltd and Scottish Hydro Electric Transmission plc [April 2012] http://www.ofgem.gov.uk/Networks/Trans/PriceControls/RIIO-T1/ConRes/Documents1/SPTSHETLFPsupport.pdf

RIIO-T1: Final Proposals for National Grid Electricity Transmission and National Gas Grid [December 2012] http://www.ofgem.gov.uk/Pages/MoreInformation.aspx?docid=342&refer=Networks/Trans/PriceControls/RIIO-T1/ConRes

wider works outputs are assessed in terms of increases in the electricity transfer capability in accordance with the national security and planning standards for the transmission network, known as the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS).

The SWW arrangements are a part of the RIIO-T1 framework for all TOs. Details of the arrangements applicable to SHE Transmission, are set out in "Guidance on Strategic Wider Works Arrangements"† published by Ofgem in October 2013. They are designed to ensure value for money for consumers and timely funding of the construction costs and additional operating expenses associated with large projects that are needed to meet wider network capability requirements. Figure 1 below provides an overview of the stages in the overall SWW process:

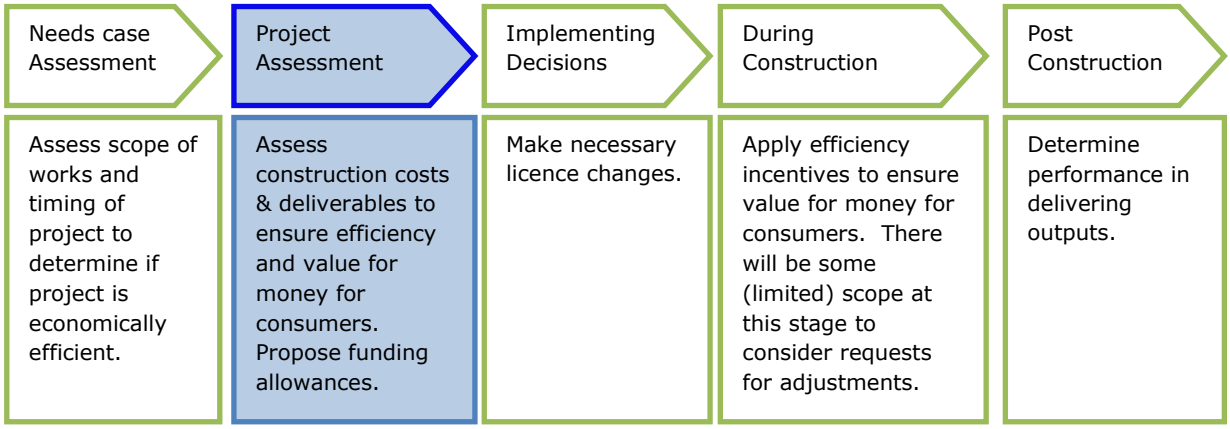

Figure 1: SWW Process – Context for this Project Assessment Review

The assessment leading to a decision on cost recovery involves two stages:

1) Needs Case assessment, following receipt of the TO's proposal submission; and

2) Project Assessment, following receipt of the technical case submission.

While each assessment area covers distinct issues, there is a degree of interaction between assessment of the Needs Case and the Project Assessment. The review of the technical project submission may be an input to the conclusion of the Needs Case assessment (e.g. by providing input assumptions based on updated cost estimates). In principle, however, completion of the full project assessment is subject to a positive conclusion from the Needs Case assessment.

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

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

† Available at: https://www.ofgem.gov.uk/ofgem-publications/83945/guidanceonthestategicwiderworksarrangementsinriiot1.pdf

Outputs Adjusting Event (COAE) and/or an Output Amendment (OA) mechanism will provide scope for ex-post adjustments in certain circumstances. The COAE mechanism will only apply to material changes attributable to a single prescribed event. Further details of the material changes and prescribed events relevant in SHE Transmission's case are set out in the guidance document referred to above.

Finally, post construction, Ofgem will determine performance in delivery of outputs. This will include establishing whether and when the agreed increase in boundary capability had been delivered and where applicable, understand the reasons for any failure to deliver in line with agreed outputs, and the extent to which the TO could be held responsible for this. Ofgem may address late delivery through the imposition of a financial penalty, which would be set taking into account the level of consumer detriment and any aggravating or mitigating actions taken by the TO.

1.3 Project assessment objectives

DNV GL was appointed in April 2014 to support Ofgem in its assessment of SHE Transmission's project submission and supporting evidence for its proposed Caithness – Moray transmission reinforcement project. Our assessment has been structured to provide the technical analysis and review of SHE Transmission's project submission and relevant additional documents supporting the submissions.

With Ofgem, DNV GL has engaged extensively with SHE Transmission, to seek further information on a number of issues and relevant considerations involved with this complex and large scale transmission project proposal. The assessment and analysis in our report cover the project assessment submission presented by SHE Transmission, additional clarification sought and provided by SHE Transmission at a number of bi-lateral meetings, and responses to a significant number of supplementary questions (SQs) raised by DNV GL and Ofgem.

The key objective of the project assessment is to review SWW Stage 2 (emphasised in Figure 1). In assessing the reinforcement proposal put forward by SHE Transmission we have considered the following aspects:

1) The consistency of SHE Transmission's proposal with fundamental guiding principles for SWW proposals;

2) Whether there is sufficient detail on the technical design to confirm that the costs are efficient and that any optional capabilities included in the proposal represent long-term value for money;

3) The appropriateness of the proposed costs, taking into account the conclusions on the above and any additional detailed cost assessment, including benchmarking of specific elements, such as:

    - Substation asset supply and installation;
    - HVAC cable supply and installation; and
    - Overhead line supply and installation.

- Note: Assessment of the HVDC and subsea cable costs was performed by Ofgem internally and it is outside of the scope of work for this report.

4) The robustness of the TO's process for selection and procurement and whether this process had been efficiently applied and could be expected to lead to an efficient outcome;

5) The efficiency of the proposed costs, taking into account the conclusions on the above and any additional detailed cost assessment including benchmarking of specific elements; and

6) The evaluation of risks, and the appropriateness of the proposed risk management strategy including the allocation of risks and the associated costs.

Under the principles of the RIIO framework, the depth of Ofgem's and DNV GL's supporting review of the above assessment areas is proportional to the quality of the project submission and the level of justification provided by SHE Transmission through reference to relevant supporting evidence.

1.4 Structure of this Report

The remainder of this report is structured as follows:

- Section 2 gives an overview of SHE Transmission's proposals;
- Section 3 provides our assessment of the capital works;
- Section 4 provides our assessment of the SHE Transmission resourcing levels;
- Section 5 provides our assessment of SHE Transmission approach to risk;
- Section 1 provides our assessment of SHE Transmission approach to procurement; and
- Section 7 summarises our findings.

2 OVERVIEW OF SHE TRANSMISSION'S PROPOSALS

Under the terms of its licence, SHE Transmission is required to provide an efficient, economic and co-ordinated transmission system in the north of Scotland. The transmission infrastructure needs to be capable of maintaining a minimum level of security of supply and of transporting electricity from and to customers. This chapter provides an overview of the current SHE Transmission network together with a description of the proposed works.

2.1 Existing SHE Transmission network

The existing SHE Transmission network in Caithness was predominantly developed in the 1950s and serves around 160 MW of local demand. The transmission system in the area to the north of Beauly is has limited capacity and requires significant reinforcement to accommodate the volume of renewable generation seeking connection in the area. Recently completed works (late 2013) to reinforce the transmission system north of Beauly, referred to as Beauly-Dounreay Phase 1, included the following works:

- Installation of a second circuit on the existing 275 kV overhead line between Beauly and Dounreay;
- Upgrade of the Dounreay substation; and
- Installation of Quadrature Boosters at Beauly on the 132 kV overhead lines between Beauly and Shin.

With these reinforcement works completed, the transmission system north of the North of Beauly Boundary B0 (see Figure 2 below) includes the following two steel tower routes:

1) A 275 kV double circuit overhead line (red route), the second circuit of which was commissioned under the Beauly-Dounreay Phase 1 works (previously only strung with one circuit); and
2) A 132 kV double circuit overhead line that connects all the east coast grid supply points (GSP) including Brora, Dunbeath, Mybster, Thurso and Dounreay.

As a result of this reinforcement, the transmission capacity of Boundary B0 has increased from 150 MW to 245 MW. SHE Transmission has indicated that this increased capacity is not adequate to accommodate the anticipated increase in renewable generation and that further reinforcement is required.

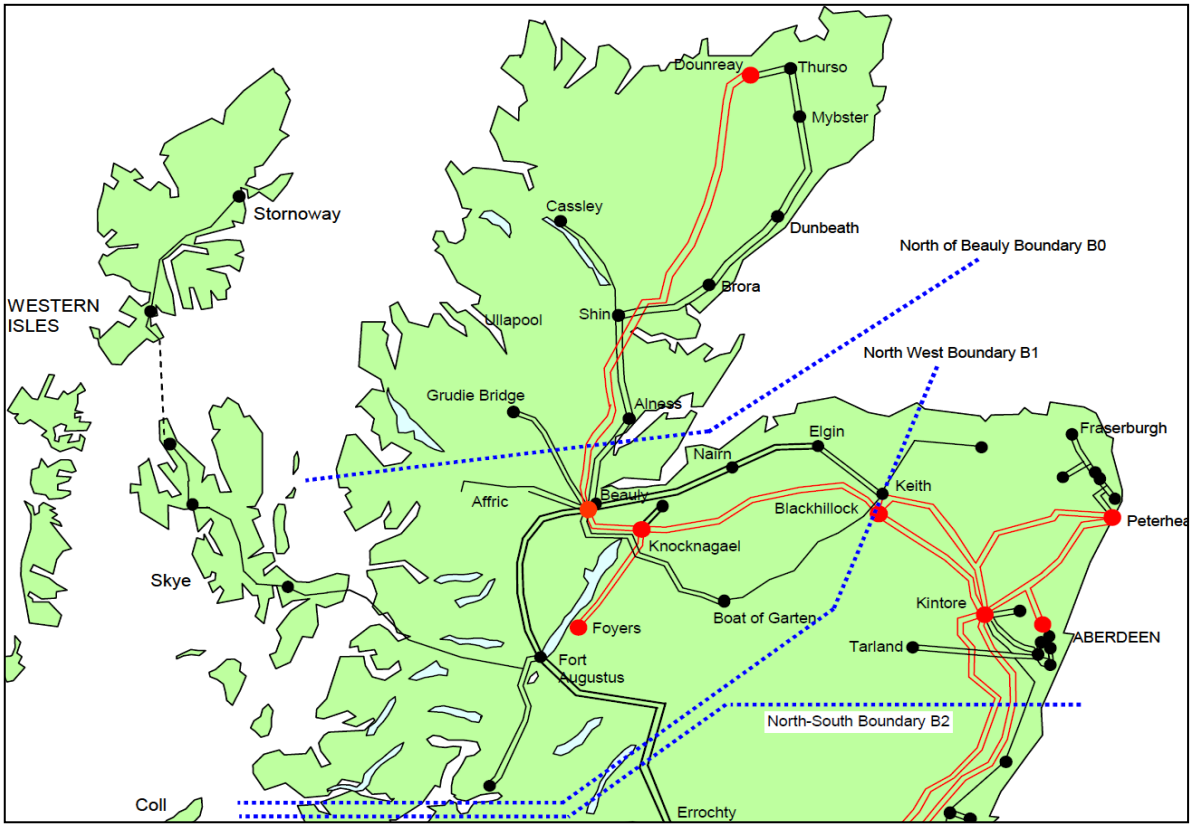

Figure 2: Existing SHE Transmission network with transmission boundaries[‡]

The transmission system between Boundary B0 and the North West Boundary B1 comprises a 275 kV double circuit overhead line between Beauly, Foyers and Blackhillock. In addition there are three 132 kV double circuit tower lines to the south and east of Beauly.

National Grid's Electricity Ten Year Statement has estimated that the current transmission capability across the North West Boundary B1 is around 500 MW. Two key reinforcements to Boundary B1 currently under construction are the Beauly–Blackhillock–Kintore project and the Beauly–Denny project, which are forecast for completion in 2014 and 2016 respectively. The completion of these reinforcements will increase the B1 boundary capability from 500 MW to around 2000 MW.

2.2 Description of the SHE Transmission proposals

The significant growth in renewable generation in the far north of Scotland is expected to require yet further capacity across the above-described transmission system boundaries B0 and B1 so, in 2013, SHE Transmission submitted to Ofgem their needs case for the proposed SWW Caithness – Moray transmission reinforcement (the subject of this report). The proposal included HVDC subsea cable and associated AC onshore works. In July 2014 Ofgem decided to accept the needs case subject to there being no material increase in project costs.

[‡] Source: SHE Transmission Needs Case Report, December 2013.

The overall cost submission for the Caithness-Moray Transmission reinforcement is in excess of £1bn and the scope of works comprises six component projects, each being a major project itself. The six sub-projects are:

- LT41: Blackhillock Substation re-development;
- LT21: Spittal 275/132 kV Substation and Spittal – Blackhillock HVDC Link;
- LT23: Dounreay – Spittal 275 kV and Spittal – Mybster 132 kV overhead line reinforcements;
- LT24: Fyrish 275/132 kV Substation;
- LT25: Loch Buidhe 275/132 kV Substation; and
- LT42: Beauly – Loch Buidhe 275 kV overhead line reinforcement.

These six sub-projects are illustrated in Figure 3 (on the next page) and are described further below.

2.2.1 LT41 - Blackhillock Substation Redevelopment

Blackhillock Substation is described as a key hub in the development of the integrated transmission system. The summary scope of this sub-project is to construct a new 400/275/132 kV AC substation adjacent to the site of the existing Blackhillock 275 kV AC Substation near Keith in Moray. This is a large transmission development consisting of:

- A new 400 kV gas insulated substation comprising 6 feeders, 2 bus couplers, bus section and reserve section switches;
- A new 275 kV air insulated substation comprising 10 feeders;
- A new 132 kV gas insulated substation comprising 4 feeders;
- Two 1200 MVA 400/275 kV supergrid transformers; and
- Two 360 MVA 275/132 kV supergrid transformers.

The Blackhillock sub-project also requires the following:

- Decommissioning and demolition of the existing 275 kV Blackhillock Substation assets made redundant by these new works;
- A new 275 kV 530 MVA cable from Blackhillock to Keith Substation (3.9 km);
- Overhead line (OHL) modifications at Blackhillock Substation; and
- Space for the high voltage direct current (HVDC) converter to be delivered under component project and space for a future HVDC converter.

The Caithness – Moray Transmission reinforcement SWW project will require a series of inter-related system outages and will be commissioned in stages. SHE Transmission indicate that Blackhillock's availability for use in September 2017 is critical for successful delivery of the overall project.

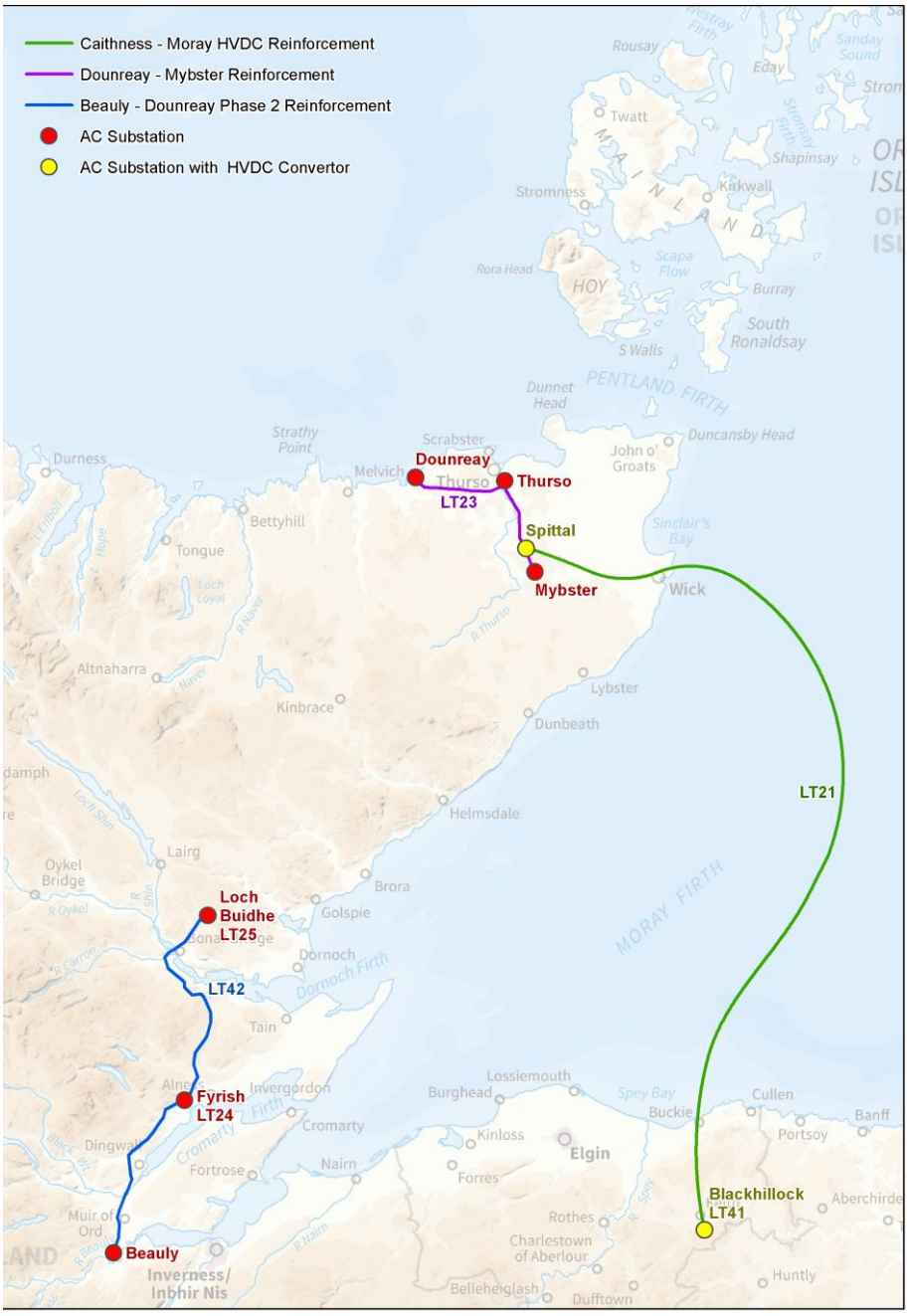

Figure 3: Geographic location of the six sub-projects

2.2.2 LT21: Spittal 275 kV / 132kV Substation and Spittal – Blackhillock HVDC Link

The summary scope of this component project is to construct a new 275/132 kV AC substation near Spittal in Caithness, a 1,200/800 MW HVDC link between Spittal Substation and the redeveloped Blackhillock Substation via an onshore/sub-sea HVDC cable circuit crossing the Moray Firth, and HVDC converters located at each substation.

The design of the Spittal – Blackhillock HVDC Link also contains an element of anticipatory investment. It incorporates an additional 400 MW of anticipatory transmission capacity from the

Caithness coast to Blackhillock; that is, beyond that required to accommodate expected onshore generation in Caithness. SHE Transmission identifies this as its preferred solution because it will allow forthcoming renewable generation in the Scottish islands to connect without requiring a second separate reinforcement.

2.2.3 LT23: Dounreay–Spittal 275 kV and Spittal–Mybster 132 kV Overhead Line

The summary scope of this sub-project is to construct a new substation near Thurso, an extension to the existing substation at Mybster, modifications to the existing substation at Dounreay, connection into the new substation at Spittal, a new double circuit 275 kV AC OHL between the substations at Dounreay, Thurso and Spittal, and a new double circuit 132 kV AC OHL between the substations at Spittal and Mybster. The scope also includes decommissioning and removal of existing assets made redundant by these new works.

2.2.4 LT24, LT25 and LT42: Substation and Overhead Line Developments

LT24, LT25 and LT42 may be considered as a group of sub-projects. The summary scope of these is:

- LT42: Re-conductor the west 275 kV OHL circuit between the existing substation at Beauly and the proposed substation at Loch Buidhe (the installation of the east circuit between Beauly and Dounreay has been delivered by a previously authorised project);
- LT24: Construct a new 275/132 kV substation at Fyrish; and
- LT25: Construct a new 275/132 kV substation at Loch Buidhe.

The scope also includes decommissioning and removal of existing assets made redundant by these new works.

2.3 Estimated Costs

The Caithness – Moray Transmission reinforcement SWW project is divided into two parts designated “A” and “B”, as follows:

Part A – LT41 (Blackhillock development sub-project); and

Part B – the other five sub-projects listed in Section 2.2 above.

SHE Transmission’s “Costs and Outputs Submission Part A” Rev 11.0, and dated 31 March 2014, states that the overall cost estimate of £1,236,225,624 for the combined Part A and Part B works has been generated using a combination of:

- Tendered prices procured from market competition;
- Estimates based on framework agreements and call-off rates;
- Estimates based on historical data generated from previously delivered projects;

- Estimates based on tendered prices for similar works, with appropriate adjustments for site specific requirements; and
- Estimates developed by the project team utilising recent and transferrable experience of live projects.

The cost estimate includes anticipated costs associated with the works and also includes a risk allowance. The same SHE Transmission Cost and Outputs Submission estimated the cost breakdown for each sub-project as shown in table 1 below:

Table redacted

Table 1: SHE Transmission Caithness Moray project cost breakdown

As mentioned above, these figures contained components of risk allowance, though the allocation of this allowance across the cost categories was not clear from the 31st March 2104 SHE Transmission document. For this reason we have based our assessment upon the additional information available from the SHE Transmission work breakdown structure (WBS) sheets associated with the sub-projects. This information is summarised in Table 2. Note that, for LT21, our scope for assessment did not include the HVDC converters. Note, also, that Table 2 reflects the outcome of Ofgem / SHE Transmission discussions held in early September 2104.

Table redacted

Table 2: Caithness Moray WBS project cost summary

We have based the analysis in this report upon the above numbers.

2.4 Delivery Strategy and Key Milestones

SHE Transmission has submitted a series of programmes for the Caithness – Moray project referenced "Ofgem Submission - December 2013". This programme identifies a number of key milestones for each of the component projects. The overall project has two common key milestones:

Key Milestone	Date
Costs and Outputs Submission to Ofgem	6 December 2013 (It is noted that this milestone was not achieved)
Anticipated Ofgem Determination	30th June 2014

Individual component sub-project Key Milestones are as follows:

LT41 – Blackhillock Substation	
Main Contract Award	*20th January 2014*
Transformer Contract Award	*21st April 2014*
Civil Works Commence	*17th February 2014*
Electrical Installation Commence – Blackhillock Substation	*26th May 2015*
Electrical Installation Complete – Blackhillock Substation	*9th March 2016*
Electrical Commissioning Complete - Blackhillock Substation	*26th May 2017*
LT23 Dounreay – Spittal - Mybster	
Transformer Contract Award	*1st August 2014*
Main Contract Award	*1st September 2014*
Civil Works Commence	*3rd November 2014*
Electrical Installation Commence – Thurso Substation	*12th January 2016*
Electrical Installation Complete – Thurso Substation	*12th January 2017*
Electrical Commissioning Complete - Thurso Substation	*5th May 2017*
Electrical Installation Commence – Mybster Substation	*8th February 2016*
Electrical Installation Complete – Mybster Substation	*7th July 2017*
Electrical Commissioning Complete - Mybster Substation	*8th September 2017*
Electrical Installation Commence – Dounreay Substation	*26th February 2016*
Electrical Installation Complete – Dounreay Substation	*31st October 2016*
Electrical Commissioning Complete - Dounreay Substation	*25th April 2017*
Commission and Handover	*18th January 2018*
LT24 Fyrish Substation	
Main Contract Award	*15th January 2015*
Civil Works Commence	*1st April 2015*
Electrical Installation Commence – Fyrish Substation	*4th May 2016*
Electrical Installation Complete – Fyrish Substation	*23rd December 2016*
Electrical Commissioning Complete - Fyrish Substation	*26th October 2017*
Commission and Handover	*26th October 2017*
LT25 Loch Buidhe Substation	
Main Contract Award	*15th January 2015*
Civil Works Commence	*1st April 2015*
Electrical Installation Commence – Loch Buidhe Substation	*1st June 2016*
Electrical Installation Complete – Loch Buidhe Substation	*9th February 2017*
Electrical Commissioning Complete - Loch Buidhe Substation	*26th October 2017*

Commission and Handover	*26th October 2017*
LT42 – Beauly – Loch Buidhe Re-conductor	
Main Contract Award	*15th January 2015*
Site Mobilisation	*4th April 2016*
Construction Complete	*26th May 2017*

2.5 DNV GL General Approach

Our assessment of the SHE Transmission proposal for the Caithness – Moray transmission reinforcement is detailed in the following chapters in this order:

- Assessment of Capital works;
- Assessment of Resource Levels;
- Assessment of Risk; and
- Assessment of Procurement.

3 ASSESSMENT OF CAPITAL WORKS

3.1 Approach

3.1.1 Overview

At the time of our assessment we had not been supplied with a full scope of works, or even component lists, for all of the substations. So, to progress our assessment of the efficiency of SHE Transmission's capital costs (CAPEX) estimates, we used a combination of two approaches – detailed (or "bottom-up") analysis and "top-down" bench-marking assessment – in the following steps:

Step 1: Detailed analysis of the proposed scope of construction work (including drawing up our own bill of quantities (components list) for the Blackhillock Substation (sub-project LT41);

Step 2: Detailed bottom-up analysis of the costs for Blackhillock substation using our own information from recent contracts and supplier sources. Comparison of the SHE Transmission costs submission with this analysis;

Step 3: Production of substation and overhead line cost benchmarks – some from Step 2. (It was possible to use Step 2 for some substation costs because our detailed analysis accorded well with the SHE Transmission costs for the Blackhillock Substation.) Top-down assessment of the costs of the same Blackhillock substation with the benchmarks, checking the results with those of Step 2 to calibrate the benchmarks;

Step 4: Top-down assessment of the costs of the remaining sub-projects of the Caithness – Moray transmission reinforcement, providing a consistent CAPEX assessment across all the substations; and

Step 5: Top-down assessment of the overhead lines (OHL) costs using benchmarks derived from DNV GL and Ofgem databases coupled with publicly available information (PB/IET Transmission Costing Study).

The reasoning behind these steps is as follows:

Step 1: We selected Blackhillock to start the assessment because it was more advanced in its development than the other parts of the project. Unlike them, this substation already had firm construction contracts in place and we thus anticipated that SHE Transmission's CAPEX submission for this substation would have the highest accuracy and greatest cost detail.

Only the LT41 Blackhillock sub-project was assessed using this detailed cost analysis approach because:

- The approach was complex, time consuming and requires high resource intensity – particularly in deriving a detailed scope of work;

- LT41 contains substation work at three different voltage levels (400 kV, 275 kV and 132 kV) and two different substation technologies (air-insulated and gas-insulated), which enabled appropriate benchmark unit costs to be derived for the other elements of the project; and
- We judged that LT41 offered a good base from which to assess the costs for the total Caithness – Moray transmission reinforcement project because, although the substation sizes vary:
    - We understand SHE Transmission to be utilising the same approach and contracting strategy for sub-projects of the transmission reinforcement; and
    - Substation location, equipment and resource supply and demand, material costs, exchange rates and inflation across the sub-projects are all tolerably comparable.

Step 2: Having produced a suitable bill of quantities (component list) for Blackhillock we were in a position to perform a detailed analysis of SHE Transmission's cost estimates for that substation using our knowledge of substation component costs.

Step 3: Since relatively little information was available on the remaining elements of the project, a detailed bottom-up analysis for these would have been less practical, and the time spent would have been less justified. For these elements, therefore, we opted for a top-down approach. This step, therefore, produced the costing benchmarks with which to perform this top-down assessment.

Step 4: Takes advantage of the previous 3 steps to complete the CAPEX efficiency assessment across the whole Caithness – Moray transmission reinforcement project. Even though data on the remaining elements was relatively sparse, a top-down approach to the assessment provides a good guide to the efficiency of the CAPEX submission.

Step 5: Since the Blackhillock sub-project did not contain OHL, and the sub-projects that do contain OHL are not as far advanced as Blackhillock, the top-down OHL cost assessments were made separately from the substation approach, and exploited information available within, and external to, DNV GL.

During this process, wherever appropriate and practical, we also sought clarifications for queries on apparent discrepancies in the submission data through the SQ process (described above in Section 1.3), through phone conferences and through the face-to-face meetings with SHE Transmission.

Further description of each of the above steps is presented in the sections below.

3.1.2 Step 1 – Scope and assumptions

SHE Transmission provided no detailed scope of works and very few diagrams for LT41, Blackhillock, at the start of our assessment, and in particular dimensioned drawings and component lists were missing. So in order to proceed we used our knowledge of UK and Scottish transmission best practice to formulate detailed assumptions about the scope of work to be costed – in particular, we drew up our own components list as the basis for our detailed costing analysis.

[Note: Later, we were able to confirm our electrical works assumptions against project detail issued by SHE Transmission. Only minor adjustments to our assumptions were found to be necessary.]

3.1.3 Step 2 – Detailed analysis of one substation

This part of our assessment identified key activities in the LT41 sub-project development and built up a total estimate of efficient costs from DNV GL's known efficient costs for each of these activities. The approach is based on comparisons of the SHE Transmission cost elements with DNV GL's own information from various sources, adjusted to take account of recent trends in costs and technology development.

DNV GL's bottom up assessment of the costs for Blackhillock substation was based on expert DNV GL engineering experience and judgment and upon knowledge of key project unit costs of individual plant items (i.e. transformers, switchgear, HVAC cables and overhead lines, civil costs etc.) including construction and installation. It used the information provided in Part A of the SHE Transmission Costs and Outputs submission to derive cost estimates for:

- Substation construction works (civils and shared costs);
- Unit Costs for 400 kV gas insulated switchgear (GIS) switch-bays;
- Unit Costs for 275 kV air insulated switchgear (AIS) switch-bays; and
- Unit Costs for 132 kV GIS switch-bays.

3.1.3.1 Estimating costs – electrical equipment in the GIS substations

As a first step to analysing Blackhillock's 400 kV and 132 kV GIS switchgear costs, DNV GL used the single line diagrams (SLD) provided to determine the number of switchbays in the 400 kV and 132 kV GIS substations. This is because:

- It is normal practice to assess substation costs on a bay-by-bay basis;
- Contractors normally tender high voltage switchgear on a bay-by-bay basis; and
- This is the basis of most equipment cost databases.

To fully assess the cost of the 400 kV GIS substation, DNV GL noted that there was a quantity of gas insulated busbar on some of the circuits and so requested details of busbar lengths to be able to fully estimate the cost of the substation. SHE Transmission supplied this information in a dimensioned drawing as part of the 15th April submission update.

3.1.3.2 Estimating costs – electrical equipment in the AIS substation

Air insulated switchgear is treated slightly differently as costing is on a component basis rather than by complete switchgear bay. Our method was as follows:

- The first task was to prepare our own component lists, because SHE Transmission had not provided substation component lists. We drew up lists (one for each AIS substation) using the supplied SLDs and layout drawings. We used these to identify the numbers of each of the major component types (such as circuit breakers, disconnectors, earth switches, current transformers, voltage transformers, surge arresters and steel structures) required for each substation, allowing us to proceed with the CAPEX assessment.

- We then applied our DNV GL knowledge of equipment costs to the component lists to derive a complete bottom up assessment of the likely cost of Blackhillock 275 kV AIS substation. This knowledge has been derived from recent contracts in the UK and in Europe and from our contacts with suppliers.

- From our cost assessment exercise for Blackhillock, we created major equipment unit cost benchmarks. These were key in our cost assessments for the other substation projects.

Note: We prepared the early component lists with our own knowledge of UK and Scottish transmission best practice but then, later, to ensure consistency with the SHE Transmission plans we compared these lists with a full component Bill of Quantities for the main switchgear equipment supplied in response to supplementary question CM_G_043 (20th June 2014). Only a very small discrepancy between the two sources was found, indicating that the basis of DNV GL cost estimate was technically sound. Following this check, however, we adjusted our estimated quantities – and subsequent calculations – to exactly match the SHE Transmission schedule.

3.1.3.3 Estimating civil works costs

Estimation of civil works through a desk-top exercise is a much less certain activity than for the electrical equipment due to the factors listed in the next paragraph. Since few details of project scope were provided at the start of our assessment, and in order to allow the assessment to progress, we separated out civil work estimates from those for the electrical equipment so that the civil works costs could be separately estimated. Below, we explain why.

Amongst the factors that can have a major impact upon the civil costs for any substation are:

- Scope of work, including the voltage and rating of equipment, the number of bays and the insulation technology employed;

- Geology, topology, and ground conditions;

- Site access – both local and regional conditions;

- Environmental constraints – for example, local flora, fauna, hydrology, archaeology and regional designations;

- Assumptions about future-proofing (extra space, foundations and service routes for future equipment); and

- Assumptions in allocating general project costs, including one-off civil costs, to individual benchmarked substation components.

As a result of these factors, the civil works costs may bear no proportional relation to the electrical costs. This becomes relevant where top-down assessments make assumptions about civil costs on the basis of what is known about the electrical equipment, since any of the above-listed factors could cause these assumptions to be seriously in error. We explain in Step 3, where we discuss our benchmarking, how we address this issue.

3.1.4 Step 3 – Top-down assessment - benchmarking

3.1.4.1 Benchmarking - general

Benchmarking is only normally undertaken for major equipment and construction activities and, in this case, included contractor engineering, contractor project management and installation costs. In assessing efficiency of the SHE Transmission estimates of substation construction costs we employed 3 suites of benchmarks. They are listed below:

- Substation costs (equipment and works) in £m
- Overhead line costs £m/km
- Cable cost £m/MW/km [§]

These costs are developed from, and compared with, data from the following sources:

- DNV GL internal database (Cost of Available Transmission Network Technology);
- RIIO-T1 asset cost data (provided by Ofgem);
- IET/PB Power Cost Study 2012(for OHL and cable circuit costs); and
- Unit costs from detailed bottom-up assessment of costs for Blackhillock.

We assess costs based on scope of work, design details, site specific information provided, efficiency and comparison with similar projects in the UK and internationally. We also recognise that project costs can vary due to a range of issues (location, supply chain, commodity prices, civil works etc.) which cannot be easily picked up during a top-down benchmarking assessment. Therefore, in assessing efficiency, our measure has been a +10% adjustment above the benchmark rather than the central benchmark value. Further detail about this approach is provided in Step 4 at 3.1.5 below.

Having produced our unit cost "benchmarks" for 400 kV GIS, 275 kV AIS and 132 kV GIS switchbays as described in the sections below, we satisfied ourselves that the benchmarks correlated well with the detailed analysis of costs developed in Step 2.

3.1.4.2 Substation benchmarking notes

We used three sources of benchmark data in this assessment:

- **Source 1** - DNV GL's recent knowledge of UK contracts, coupled with information from suppliers;
- **Source 2** - DNV GL's established database on UK and international equipment costs, indexed as appropriate; and
- **Source 3** - Ofgem's RRP data that is derived from UK licensee annual regulatory submissions.

[§] Assuming similar capacity and installation conditions

As mentioned in Section 3.1.3.3 above, the civil works costs for a substation are not necessarily in proportion to the electrical equipment costs. Therefore, to avoid 'losing sight of' the electrical equipment costs in the face of variable civils costs, we have used Source 1's substation cost benchmarking data in two ways and have developed two separate benchmarks from it. These two are described next:

- **"UK Elec + UK Civils"** – This benchmark aims at comparing the SHE Transmission submission with other whole substation project costs around the UK. Our approach was to compare the work on the three voltages at Blackhillock to that at other major substations comprising similar technologies. For example, the 400 kV GIS substation costs were compared to similar scale 400 kV GIS substation projects in the UK and Europe which were thought to have similar ground conditions. Similarly the 275 kV AIS and 132 kV GIS substation works were assessed against those of similar scale transmission projects of the same voltages. In each case, having identified appropriate projects, costs were normalised so far as possible to match the Blackhillock project scope. These estimates then became the basis for a set of bay-by-bay costs to form the "UK Elec + UK Civils" benchmark. As with the two benchmarks already described, it contains the same work elements (civil and electrical) as the SHE Transmission submission and is thus plotted directly into the bar-charts for comparison.

- **"UK Elec + SHE T Civils"** – By adopting SHE Transmission's own costs for civils work, this benchmark allows comparison of the electrical equipment costs from the SHE Transmission submission and the DNV GL Source 1 benchmark. Though electrical equipment costs are the focus of this benchmark, by including the SHE Transmission submission civils costs with the DNV GL Source 1 electrical equipment costs, this benchmark covers the complete scope of civil and electrical works, again allowing it to be directly compared with the other benchmarks on the bar-chart. Since this benchmark uses the same civils costs as the SHE Transmission submission any difference between it and the SHE Transmission submission is due to the electrical works element.

"DNV GL" and **"RRP Ofgem"** – Regarding Sources 2 & 3, in the top-down assessments that follow, the benchmarks derived from these two sources include their own estimates for both civil works and electrical equipment. They are thus comparable with the SHE Transmission submission values for the various sub-projects assessed in this report and are plotted directly into bar-charts next to the relevant SHE Transmission submission value. They are labelled "DNV GL" and "RRP Ofgem", respectively.

3.1.4.3 Overhead line benchmark notes

For the overhead line (OHL) works we have introduced the following benchmarks:

- The IET/PB Power Cost Study 2012; and

- Unit costs derived from OHL cost estimates provided by SHE Transmission as a part of the needs case submission for Caithness Moray, AC option.

So far as possible, our OHL CAPEX assessment has matched these data sources to the project specific circumstances and requirements. For example, for DNV GL unit costs we have broken down works into four CAPEX-related categories: towers, foundations, conductors and insulators. In deriving

unit costs we have defined for each of the categories volume and cost for the comparable route length.

3.1.4.4 Cable benchmark notes

Our benchmarking of AC underground cable cost has taken into consideration a number of fixed and variable cost drivers that contribute significantly to the total capital expenditures. Significant fixed costs included the cable terminal compound and cable testing, whilst variable elements included the cable system materials and installation. As with the overhead line benchmarking process, we introduced a number of benchmark data sources to guide our final recommendations. These included:

- The IET/PB Power Cost Study 2012;
- DNV GL internal database (Cost of Available Transmission Network Technology); and
- RIIOT1 asset cost data (provided by Ofgem).

3.1.5 Step 4 – Top-down assessment of remaining substations

We next used the cost benchmarks developed in Step 3 to inform the assessments of the other sub-projects of the Caithness – Moray transmission reinforcement.

To improve the robustness and applicability of our benchmarks to the SHE Transmission submission assessment we have taken three further steps:

- For each of the substations we have averaged the benchmark results from the three independent sources;
- We have separately allowed for the civil works associated with future bays and added this allowance to our benchmark averages; and
- With the above civils-corrected benchmarks, we have included an adjustment above the average values to accommodate the spread of the independent benchmark values.

These adjustments are explained next:

- **1 - Benchmark Averaging - "Three-BM Average"** – Cost benchmarks are not a high-accuracy method of assessing future costs. However, in the absence of firm costs, they do offer estimates based upon some previous experience. In order to increase the robustness of our three independent benchmarks (BM) we have averaged their results, thus notionally broadening the previous experience upon which they are based. We use this "Three-BM Average" as the basis for an efficient procurement comparison with the SHE Transmission submission – however, see the two further steps below.

  (Note that, although we show 4 sets of benchmarks for the sub-projects of this development, they are based upon only three independent sources of data. The "UK Elec + SHE T Civils" benchmarks are derived from a combination of the "UK Elec + UK Civils" benchmarks and the SHE Transmission civils costs submission, specifically to compare electrical costs, so they are not included in this Three-BM Average process.)

- **2 - Civils Correction – "Civils-corrected BM"** – In most cases SHE Transmission has included ground-space and civil works in the substation developments for spare and / or future bays. This is a perfectly appropriate way of planning transmission reinforcements where future connections are envisaged, since it is normally cost-effective over the life of the substation to execute the ground-works prior to installation and energisation of the first high voltage equipment on site.

  To help accommodate this approach in the benchmark comparison we have added a further allowance to each substation benchmark specifically to accommodate both the full bay costs of spare bays being built now and the civils costs of future bays whose electrical equipment has not yet been ordered. The former (spare bays) are already incorporated in our Three-BM Average costs, whilst the latter (future bays) are added to the three-BM Average to form a "Civils-corrected BM".

- **3 - The +10% adjustment** – There is a spread of independent benchmark values over the various substations, as might be expected. In general an individual benchmark does not deviate from the average of the benchmarks for a substation by more than +/- 5%, however in two cases (Loch Buidhe and Spittal) the deviation is closer to 9% but always less than 10%. For this reason we have applied a +10% adjustment on top of the Future-proofed BM, and we have judged any SHE Transmission submission lower than this value as likely to represent "efficient procurement".

  (Note: this +10% adjustment is added to the averaged benchmark values, not the maximum value. It is applied here in recognition of the uncertainty embodied by the benchmark approach to cost assessment.)

In Table 11 we present, for each substation, the "Three-BM average", the "Future bays civils costs" and the "Civils-corrected BM" figures for each sub-project, along with the percentage-adjusted Civils-corrected BM and, on this basis, the recommended capital allowances for each sub-project (and any recommended reductions to the submission).

Some of the sub-projects employ different voltages and technologies to Blackhillock so, to make a top down assessment of these project components, DNV GL used its database of project costs, in a similar manner to that described in Step 3 above, to derive unit costs for 132 kV AIS switchbays.

3.1.6 Step 5 – LT23 and LT42 overhead line cost assessment

We used the OHL cost benchmarks developed in Step 3 to inform the assessments of the overhead line costs within the Caithness – Moray transmission reinforcement. For the LT23 and LT42 sub-projects, some of the works was new OHL construction whilst the remainder was re-conducting.

Our approach to benchmarking costs for re-conductoring 275 kV OHL is based on the unit cost for new OHL adjusted by a scaling factor. (Unit costing for the construction of new line is outlined in Section 3.1.4.3.) It can be simply represented by the following formula:

$$\text{Re}-conductoring\_UCI = K * New\_OHL\_UCI$$

Where:

New_OHL_UCI is the unit cost for construction of new double circuit overhead line, in £m/km;

Re-conductoring_UCI is the unit cost for re-conductoring double overhead line circuit, in £m/km; and

K is the scaling cost factor between cost of new construction and restringing of a new 275 kV overhead line double circuit. This factor is set at [•] based on DNV GL experience.

3.2 LT41 - Blackhillock 400/275/132 kV Substation

This sub-project supplements existing substation facilities at Blackhillock. The new substation works include:

- 10 x 400 kV gas insulated switchgear (GIS) bays (6 feeders, 2 bus couplers, 1 bus section, 1 reserve section);
- 13 x 275 kV air insulated switchgear (AIS) bays (10 feeders, 2 bus couplers, 1 bus section);
- 8 x 132 kV GIS bays (4 feeders, 2 bus coupler, 1 bus section, 1 reserve bus section);
- Transformers and overhead line diversions at Blackhillock; and
- A 275 kV cable from Blackhillock to Keith, along with other minor works.

The construction cost breakdown as submitted is set out in Table 3 below:

Overview of construction costs	Cost Estimate
Forestry including felling and compensation	[•]
SHE Transmission Health & Safety Compliance	[•]
Public Road Improvements	[•]
Alteration works (incl. Diversions) - O/H Lines	[•]
Underground Cables	[•]
Substation Works	[•]
Transformers	[•]
Metering, Telecom, Protection, Control	[•]
Metering, Telecom, Protection, Control	[•]
Insurance (Construction)	[•]
LVAC Auxiliary System	[•]
Total (Substation Construction)	[•]

Table 3: LT41 Blackhillock substation works - cost estimate breakdown

Figure redacted

Figure 4: Distribution of LT41 construction costs

SHE Transmission work breakdown sheet for transformers does not detail the cost for associated civil works, so we have assessed these assuming they are included with the overall substation civil works.

Figure 5 compares the SHE Transmission's submitted costs with key benchmarks.

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Figure redacted

Figure 5: LT41: Blackhillock substation cost benchmark (incl. transformer costs)

The overall assessment indicates a close correlation between the SHE Transmission estimate and all the DNV GL benchmarks. In particular, the SHE Transmission submission costs are only [•] higher than the Three-BM Average and, with future bays' civils for Blackhillock included, this difference drops

to just [•]. On this basis we find the Blackhillock Substation capital works submission to be reasonable and consider it to represent procurement at current competitive market rates.

3.2.1 275 kV double circuit cable from Blackhillock to Keith

The most significant cost component of the Blackhillock substation works is the 275 kV cable from Blackhillock to Keith. The PEP indicates that this item comprises two 265 MVA 275 kV cable circuits, which we understand to be approximately 3.9 km long (each) and estimated by SHE Transmission at [•] together.

The SHE transmission submission gives no detailed information about the 275 kV cable between Blackhillock and Keith, but contains a non-titled/non-attributable cost estimate for the cable which indicates that the connection consists of two circuits of 1,000mm^2 copper XLPE insulated cable with an overall rating of 530MVA. The cost of cable supply and installation is sensitive to metal prices and to the terrain over which the cable will traverse so, in the absence of design details, we have compared the SHE Transmission submission with DNV GL's internal unit cost benchmarks and RRP unit costs provided by Ofgem. The results are presented in Table 4:

Table redacted

Table 4: Blackhillock-Keith 275 kV cable benchmark costs

The table indicates that the onshore installed cable costs appear [•] high when compared with Ofgem RRP, though reasonably close when compared with DNV GL cable unit cost. One reason for the Ofgem RRP benchmark estimating low is that the costs are quoted in £m/km and based on typical multiple kilometre cable lengths, where fixed build costs, such as cable terminations, termination compound and testing, and special works, such as for complex crossings, are included and apportioned over the whole circuit length. However, the onshore installation costs for this particular project relate to a short length of only 3.9km, for which the benchmark would tend to underestimate the fixed build costs.

However, unlike the Ofgem RRP unit cost, which apportions cable fixed build costs over a number of km route length, the DNV GL unit cost accounts specifically, and separately, for the fixed build costs and the cable and installation costs proportional to route length.

3.2.2 Total construction costs for Blackhillock

Figure 6 compares the SHE Transmission's submitted costs with key benchmarks.

Figure redacted

Figure 6: LT41: Benchmark comparison of total construction costs

Although SHE Transmission costs for LT41 exceed all of our benchmarks the excesses are only [•]. This [•] figure has already been largely explained as relating to the benchmarking of the 275 kV cable, and is thus not considered significant here.

On this basis we find the overall LT41 sub-project capital works submission to be reasonable and consider it to represent procurement at current competitive market rates.

3.3 LT21 – Caithness – Moray HVDC Reinforcement

LT21 Caithness-Moray component project can be split into the following components:

- **Spittal to Blackhillock HVDC Link**: HVDC equipment including construction of:
    - an 800 MW convertor located at Spittal (not analysed by DNV GL);
    - a 1200 MW convertor located at Blackhillock (not analysed by DNV GL); and
    - underground (onshore) cable connecting the convertors (not analysed by DNV GL); and
    - subsea cable connecting the convertors. The CAPEX for this component is part of the DNV GL scope of work and was analysed.
- **Spittal 275 kV / 132 kV Substation**: HVAC equipment including the construction of a new GIS 275 kV / 132 kV substation at Spittal in Caithness. The CAPEX for this component is part of the DNV GL scope of work and was analysed.

3.3.1 Review of LT21 Cable Routeing

SHE Transmission is planning to build a point-to-point HVDC subsea transmission link between Caithness (Spittal) and Moray (Blackhillock). The intention had previously been to take a mixed overland / subsea route from Spittal, running eastwards via Noss Head, to an offshore hub, where the link would connect into a north-south HVDC connector from Shetland to Blackhillock Substation via landfall at Portgordon (Figure 7). The total length of this extra link would be approximately 65 km [**], given the existence of the Shetland – Moray connector.

However, these plans have been superseded by the point-to-point HVDC link between Caithness-Moray because the Shetland – Moray connector will not be available at the time the transmission capacity is required to export power from new generation on the mainland. As Figure 7 shows, an extra 77 km or so of HVDC subsea cable is thus required to complete this Caithness – Moray project over and above the originally anticipated 65 km – a total of around 142 km.

** Note: All the distances quoted in this Section are approximate. They have been scaled from the Figures to the "Spittal to Hub Route Selection Report" provided by SHE Transmission to Ofgem in the course of Ofgem's review of the Caithness – Moray transmission reinforcement submission.

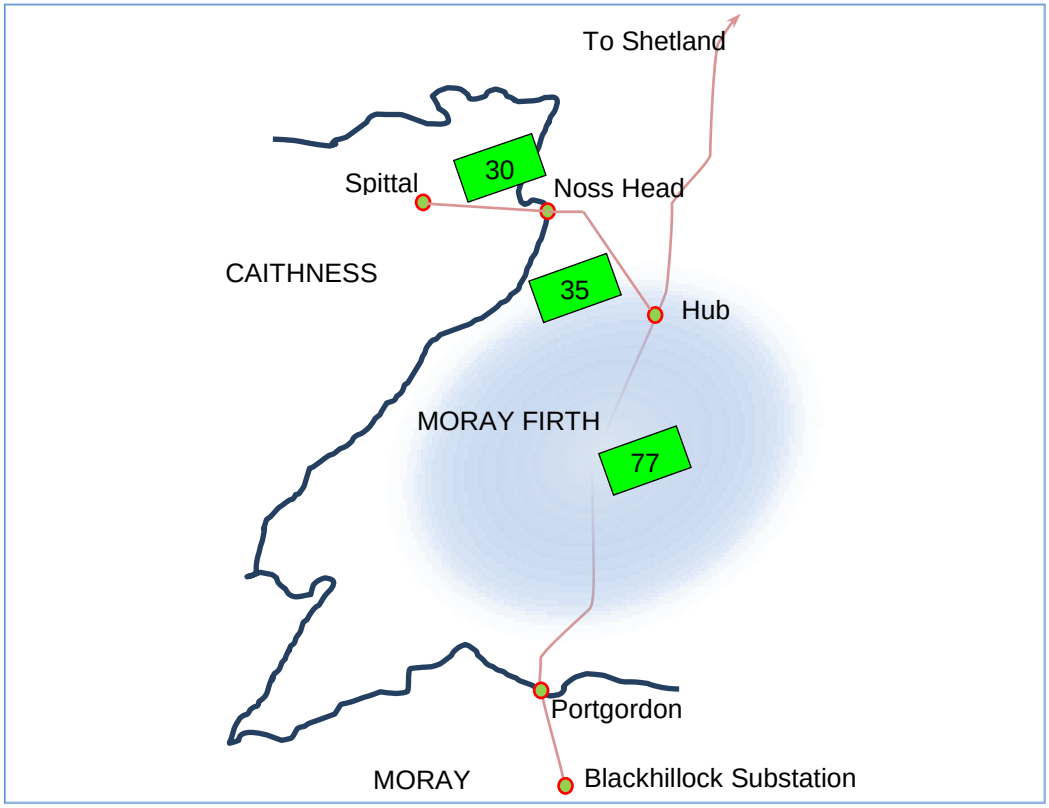

Figure 7: Existing proposed route showing extra 77 km of subsea circuit for LT21

3.3.1.1 Two Alternative Routes

This being the case, the HVDC hub is no longer a relevant consideration for the subsea cable route for the Caithness – Moray project itself. Therefore two alternative routes offer themselves for consideration by the project optioneering process, both significantly shorter than the overall 142 km presently proposed by SHE Transmission. They are designated here the Eastern Alternative, which still runs via Noss Head, and the Western Alternative, which would require a new landfall to be found further to the south-west. These two alternatives are shown in Figure 8.

The Eastern Alternative comprises the same overland cable route between Spittal and Noss Head as before plus a more direct subsea route from Noss Head to Portgordon. It would have a total route length of around 120 km to 125 km, but would pass through the proposed Beatrice offshore windfarm area.

The Western Alternative would try to take a direct line from Spittal to Portgordon. In this case the overland route might also be in the region of 30 km long, whilst the length of the submarine portion would lie between 70 km and 75 km. In this case the route would pass, with little or no deviation, to the south of the Beatrice wind farm. The alternative route lengths are compared in Table 5:

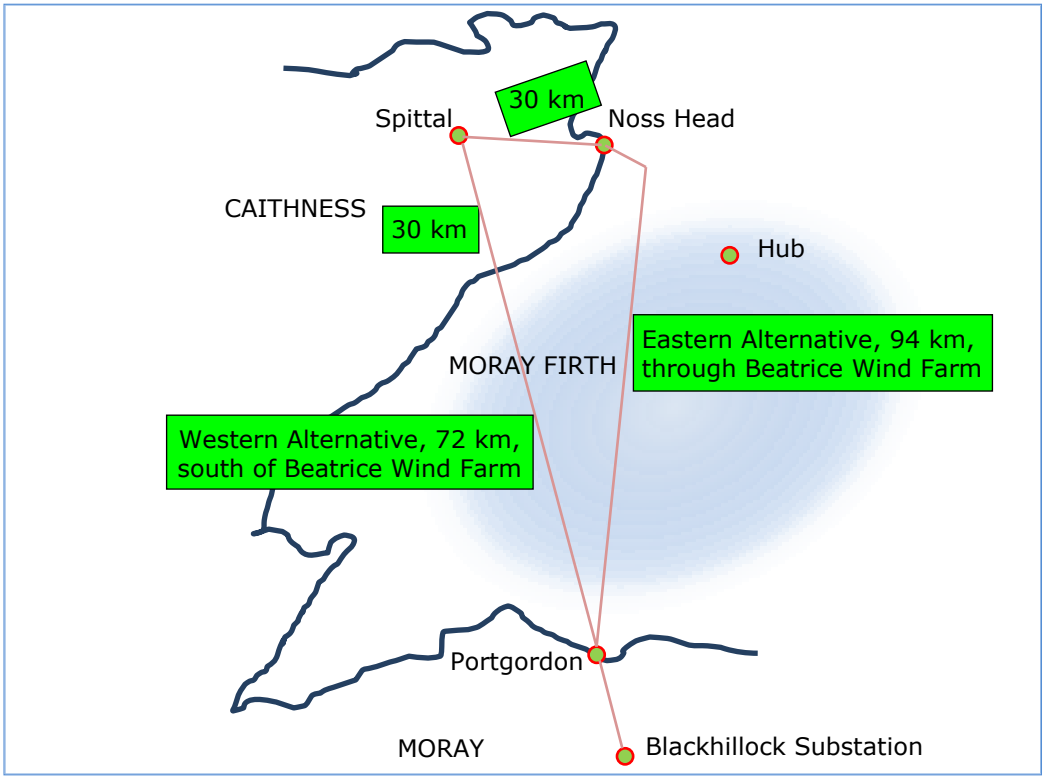

Figure 8: LT21 Eastern and Western Alternative Routes

Route lengths (km)	Existing	Eastern Alternative	Western Alternative
Onshore Section	30	30	30
Offshore Section	112	94	72
Total	142	124	102
Shorter by	-	18	40
Note: The Portgordon to Blackhillock circuit section is ignored since it is common to all solutions.			

Table 5: Route Lengths Compared

3.3.1.2 Constraints and Barriers

The viability of these two alternative routes would be subject to the constraints that lie along their paths. Some key constraints determined by SHE Transmission are shown in Figure 4.1 of their "Spittal to Hub Route Selection Report", shown next in Figure 9, which depicts part of the Moray Firth and surrounding terrain. It indicates:

- A cable route search corridor – hatched blue area;

- Obstacles to cable-laying – red blocks; and
- Proposed converter station and offshore hub search areas – green blocks.

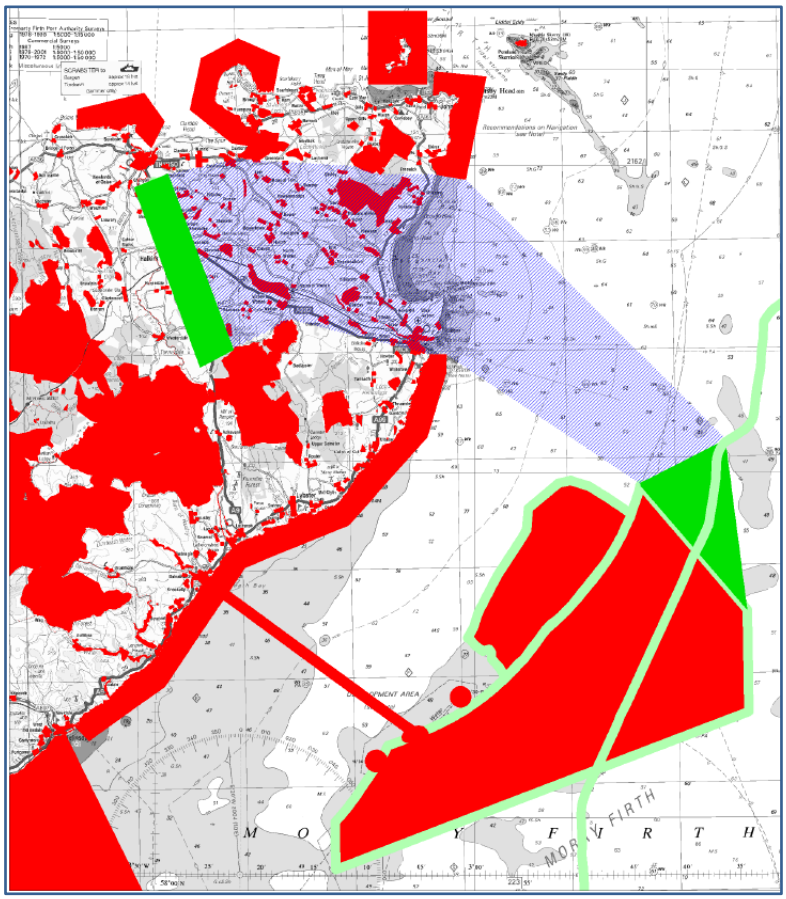

Figure 9: Figure 4.1 of the Spittal to Hub Route Selection Report

Figure 9 indicates that the obstacles to cable-laying include environmentally sensitive areas inland and along the coastline, existing oil wells, existing submarine power lines, and the area of the proposed Beatrice offshore wind farm. However, whilst we note the barriers to cable-laying indicated on this map, it is evident from the same diagram that these barriers do not, in themselves, comprise immoveable obstacles to cable routeing, since some of the largest barriers (the environmentally sensitive coastal region around Noss head and the Round 3 wind farm) are being crossed by the search corridors for the Spittal – Hub HVDC link and the Shetland – Portgordon connector respectively.

A recent SQ response (CM_LT21_047 to 052 Response.pdf) indicated that some other routes had been considered, however we have been unable to find a detailed description of these in the LT21 submission pack. Certainly the shorter "Western" overland route from Spittal along the A9 corridor to the A9/A99 road junction near the coast at Latheron does not appear to have been considered in depth. (This impression is confirmed by the SHE Transmission paper "Comments on HVDC cable routeing.pdf" and emailed to Ofgem on 16th Sep14, which states in its penultimate paragraph that this option has not been considered.) Some of the constraints and barriers on the Latheron route were mentioned in the SQ response; however there was no apparent consideration of the costs to

overcome the barriers (for example the power cable to, and the pipeline from, the expiring Beatrice oil field). Equally, there was no acknowledgement in the SQ response or the HVDC cable routeing paper that the environmental constraints might be overcome, yet the existing proposal already apparently breaches an environmentally sensitive area at Noss Head. Having said this, we recognise that much exploratory work and route surveying has already been carried out for the proposed routeing, so the assessment of any alternative route would need to offset the costs of both the extra surveys and any project delays against the anticipated cost savings due to a shorter route.

The Comments on the HVDC cable routeing paper does refer to possible future links to Pentland Firth and Shetland, however SHE Transmission has apparently made no firm decision yet about how these connections will be realised. This being the case, we consider that, if system requirements dictate a higher cost solution to accommodate future developments, then the excess cost should be clearly identified and justified as an anticipatory investment for the development concerned.

3.3.1.3 Potential CAPEX Efficiency

SHE Transmission's WBS for the LT21 HVDC subsea cable indicates a cost of some [•]. Of the five items listed there, the costs of the first two (01 – Subsea HVDC Cable, and 02 – DTS Fibre to HVDC Cables) would be proportional to distance. Notional cost reductions in proportion to the distance saved (72 km rather than 112 km) are shown in Table 6.

Table redacted

Table 6: LT21: Potential savings on HVDC cable routeing

Table 6 indicates that the Western Alternative could show a saving for the development of the C-M project of some [•]. Whilst this appears more efficient than the proposed route, it is necessary to check this result from the perspective of the development of the wider system. We are aware that SHE Transmission has provided analysis on the potential payback window of certain anticipatory investment made on the HVDC link for future connections from Shetland and the Pentland Firth.

3.3.1.4 Conclusion on LT21 HVDC circuit routeing

Optioneering for the LT21 Caithness – Moray HVDC Reinforcement following the decision to not employ an offshore HVDC hub does not appear to have considered all the routeing options in detail.

The Western Alternative as described in Section 3.3.1.1 may offer a cost saving of up to [•], particularly if the development plans for a transmission link to Shetland are significantly modified, or turn out to be not needed. We acknowledge, however, that pursuing a shorter route now could delay the completion of the C-M link and thus weaken its overall net benefits, particularly if increased constraint costs are a consequence.

Potentially there is an apparent CAPEX inefficiency associated with the cable routeing plans, and this sum has been included in our CAPEX allowance reduction recommendation. However, given the magnitude of this singe item, and the current planning uncertainty, it has been retained as a separate item in the summary tables and recommendation.

3.3.2 Spittal Substation (LT21)

Spittal Substation is a new GIS 275/132 kV substation, located in Caithness. The substation consists of the following items:

- Two 275/132 kV 240 MVA transformers connected to a single busbar 132 kV substation at Mybster;
- Two 275/132 kV, 240 MVA transformers connected to new double busbar 132 kV substation at Mybster;
- A 275 kV GIS double busbar substation comprising four transformer bays, six feeder bays and two bus section and two bus coupler bays. There is also space allowance for four spare (future) bays;
- A 132 kV GIS single busbar substation to accommodate 2 circuits to Mybster and the above mentioned two 275/132 kV 240 MVA transformers; and
- Prepared substation ground area to extend the 132 kV GIS substation to double busbar, sized to accommodate 4 SGT connections and 4 feeder bays.

Using the approach explained in Section 3.1 we have compared SHE Transmission cost estimates with our key cost benchmarks and the results are presented in Figure 10.

Figure redacted

Figure 10: LT21: Spittal Substation cost benchmarks (incl. Transformer cost)

The overall assessment shows that the SHE Transmission submission costs are higher than all of the benchmarks but are within [•] of the future bays' civils added to the Three-BM Average for Thurso. On this basis we find the Thurso Substation capital works submission to be reasonable and consider it to represent procurement at current competitive market rates.

3.4 LT23 – Dounreay–Mybster 275/132 kV

The LT23 Dounreay to Mybster 275/132 kV project involves:

- Extending the existing 275 kV substation at Dounreay;
- Constructing a new 275/132/33 kV substation at Thurso;
- Extending the existing 132 kV substation at Mybster; and
- Constructing new overhead lines.

Table redacted

Table 7

Table redacted

Table 7: LT23: Dounreay-Mybster 275/132 kV works cost estimate breakdown

Figure redacted

Figure 11: LT23: Distribution of construction costs

SHE Transmission work breakdown sheet for transformers does not include the cost for associated civil works so we have assessed the substations' works as including these elements. DNV GL has used the unit costs developed as part of the Blackhillock bottom-up assessment to develop costs for each of the substations making up this project. We next take each substation in turn.

3.4.1 LT23: Thurso South substation

Thurso South Substation is a new 275/132/33 kV AIS substation. Located approximately 2km south of the town of Thurso in an area of rough grazing, it is due to replace the existing Thurso GSP. The substation consists of the following items:

- Four 275/132 kV 240 MVA transformers and two 132/33 kV transformers. The 275/132 kV transformers are supplied from a 275 kV parallel busbar arrangement connected directly into, and forming part of, the overhead line circuits between Dounreay and Spittal substations.
- A 275 kV substation which, for the purposes of this assessment, has been treated as a 275 kV double busbar substation comprising four transformer bays, and two bus section bays. There are also four feeder bays but each of these four comprises simply a disconnector, some protection and a few busbars which, for costing purposes, are not equivalent to a double busbar feeder bay. These four have thus not been included in our assessment. This treatment of the four feeder bays is compensated by the fact that the other four bays are not full double busbar bays either. Overall it is expected that this treatment will underestimate the capital value by less than ¼ of one percent.
- A separate 132 kV double busbar substation comprising 6 transformer bays, two bus couplers, a bus section bay and a reserve bus section bay. Two of the 275/132 kV transformers are connected to the 132 kV substation by 132 kV cable, and the other two are connected by short busbars. We note that the 132kV switchboard includes two feeder bays to the proposed Gills Bay substation - we have assumed these to be anticipatory investment and included them in our assessment.
- The substation provides five 33 kV feeders from the distribution network to an indoor 33 kV distribution switch board.

Using the approach explained in Section 3.1 we have compared SHE Transmission cost estimates with key cost benchmarks and the results are presented in Figure 12.

Figure redacted

Figure 12: LT23:Thurso South substation cost benchmarks (incl. Transformer cost)

The overall assessment shows that the SHE Transmission submission costs are higher than all of the benchmarks but, when including future bay civils, are within [•] of the Three-BM Average for Thurso. On this basis we find the Thurso Substation capital works submission to be reasonable and consider it to represent procurement at current competitive market rates.

3.4.2 LT23: Mybster 132/33 kV Substation

Mybster substation extension will be constructed as two 132 kV single busbar sections laid out to allow conversion to a double busbar substation in the future. Each single busbar supports an overhead line feeder for the incoming lines and two transformer feeders. Due to substation layout constraints, one of the transformer feeders needs to be connected by a long 132 kV cable, whilst the others are busbar-connected. The project includes civil works to develop the whole site for a 14 bay AIS substation, so the civil works are significantly in excess of that required for the works being developed under this project.

SHE Transmission provided very little relevant information on this substation and, in particular, no dimensions for the 132 kV cable were provided, so DNV GL has estimated lengths from the available drawing. (The total cost of this cable, by DNV GL estimation, is less than [•] of the Mybster CAPEX submission).

Figure 13 compares the SHE Transmission submission with the DNV GL benchmarks.

Figure redacted

Figure 13: LT23: Mybster substation cost benchmarks

The overall assessment shows that the SHE Transmission cost estimate is significantly higher than all of the benchmarks, the submission being some [•] higher than the Three-BM Average even when it includes the future bays' civils. Carefully considering the total scope of work associated with constructing Mybster we have identified the following:

- Overall: Mybster 132 kV substation compound is set out as a 14 bay AIS substation but with only six feeder bays being populated (2 single busbars with three feeders on each busbar). Thus, the three benchmarks "DNV GL", "Ofgem RRP" and "UK Elec + UK Civils" would potentially underestimate the cost of civil works. However, our approach outlined in the paragraph entitled '2 - Civils Correction **– "Civils-corrected BM"**', Section 3.1.5 above, overcomes this issue so, even with the extra ground preparation civils work taken into account, it is still evident from the right-hand bar on the above chart that the SHE Transmission submission is some [•] higher than our benchmark average.
- Electrical works: We can find no obvious explanation for the cost differences between the electrical works costs of the submission and the benchmarks. These differences are highlighted by comparing the SHE Transmission submission bar in the above chart [•] with the "UK Elec + SHE T Civils" benchmark [•], the second bar of Figure 13. The benchmark is lower by around [•] of the CAPEX submission. (Section 3.1 provides an explanation of this benchmark.)

Taking into account the above analysis DNV GL believes that, since the SHE Transmission submission is substantially above the benchmarks, that [•] could reasonably be removed from the costs and outputs submission - see the DNV GL substation costs assessment summary, Table 11 below.

3.4.3 LT23: Dounreay 275 kV Substation

Dounreay is an existing 275 kV GIS substation which this project extends by:

- 2 x 275 kV feeder bays; and
- 1 x 275 kV bus coupler bay.

The new feeder bays will be connected to the overhead lines via an extensive 275 kV GIB / UGC system to a new sealing end compound outside the current substation boundary. No dimensions for the GIB and UGC have been submitted so DNV GL has estimated the length of these connections at 75m (total) of GIB and 170m (total) of UGC as part of this assessment.

The following bar-chart, Figure 14, compares the SHE Transmission submission with the DNV GL benchmarks.

Figure redacted

Figure 14: LT23: Dounreay Substation cost benchmarks (incl. Transformer cost)

The overall assessment shows that the SHE Transmission submission costs are well bracketed by the benchmarks (two higher, two lower) and sit marginally lower [•] than the Three-BM Average for Dounreay. On this basis we find the Dounreay Substation capital works submission to be reasonable and consider it to represent procurement at current competitive market rates.

3.4.4 LT23: Dounreay-Mybster New Overhead Lines

The sub-project consists of the following elements:

- A new 275 kV double circuit OHL from the 275 kV GIS busbar at Dounreay to the proposed Spittal Substation & HVDC Converter, via Thurso South Substation and including a cable sealing end compound at Dounreay; and
- A new 132 kV double circuit OHL between Spittal and Mybster substations in parallel with the existing 132 kV double circuit OHL. The existing OHL is to be retained.

Utilising the approach explained in Section 3.1 we have benchmarked the SHE Transmission submission cost against similar UK & international transmission projects. A comparison of the SHE Transmission costs and key benchmarks are shown in Figure 15.

Figure redacted

Figure 15: LT23: Dounreay-Mybster new OHL cost benchmarks

It is evident that the SHE Transmission cost estimates for the OHL exceed our benchmarks but by less than [•]. As a result we consider the Dounreay-Mybster 275 kV OHL capital works submission to represent procurement at current competitive market rates.

3.5 LT24 – Fyrish 275/132 kV Substation

LT24 Fyrish 275/132 kV sub-project involves constructing:

- a new 275/132/33 kV substation at Fyrish; and
- a 132 kV cable route between the new Fyrish Substation and the existing Alness GSP to replace the existing Alness 132 kV OHL T-off.

The construction cost breakdown, as submitted, is set out in Table 8 below:

Table redacted

Table 8: LT24: Fyrish 275/132 kV Substation Works Cost Estimate Breakdown

Figure redacted

Figure 16: LT24: Distribution of construction costs

The SHE Transmission WBS cost estimate for the transformers does not include the cost for associated civil works, so we have assumed them to be included with the substation works and assessed them on that basis.

The project consists of the following elements:

- A new 275 kV / 132 kV Air Insulated Switchgear (AIS) substation with about 10 hectares ground area, consisting of two 275/132 kV 240 MVA transformers supplied from a 275 kV parallel busbar connected directly into, and forming part of, the overhead line circuits between Beauly and Loch Buidhe substations;
    - Note: On the basis of the submitted Fyrish single line diagram 'Fyrish Substation SLD.pdf' dated 14May13 we have assessed this 275 kV substation as a 275 kV double busbar substation comprising two transformer bays, and one bus section bay (3 in total). There is also space for four feeder bays, but the equipment in each of these four comprises just a disconnector, earthing switch, a few busbars and some protection, so are not equivalent to double busbar feeder bays. These four have thus not been included in our assessment. This treatment of the four feeder bays is compensated by the fact that the other three bays are not full double busbar bays either. Overall, if anything, this treatment causes the benchmarks to over-estimate the electrical equipment value slightly.
- 275 kV OHL works which includes: removal of 2 towers with 402m of line and the construction of 4 new towers with 469m of 275 kV OHL;

- 132 kV OHL works which includes: removal of 858m of OHL and construction of 214m of new OHL in the vicinity of the substation, coupled with removal of 1342m of OHL between Alness Tee and Alness Substation.
- A new 132 kV double busbar comprising 3 Feeder bays, 2 transformer bays, two bus couplers, bus section bay and reserve bus section bay, with the two 275/132 kV transformers connected to the 132 kV substation by short busbars.

A comparison of the SHE Transmission costs and key benchmarks are shown in Figure 17.

Figure redacted

Figure 17: LT24: Fyrish substation cost benchmarks

The overall assessment shows that the SHE Transmission cost estimate is significantly higher than all of the benchmarks, the submission being some [•] higher than the Three-BM Average even when it includes the future bays' civils. Our analysis to investigate potential reasons for the discrepancy took account of the following details:

- The 132 kV busbar includes 5 spare bays which increases the substation length and, therefore, the prepared ground area, by about 40%;
- There are 4 x 275 kV feeders at the substation but they have minimal connection equipment at the substation (a disconnector and 2 earth switches only) – see the "Note" on the previous page.
- The "UK Elec + SHE T Civils" benchmark uses the cost of civil works as submitted by SHE Transmission, so any difference between the submission and this benchmark is due to electrical equipment costs. In this case the SHE Transmission electrical equipment costs are nearly [•] higher than the highest benchmark.

While we accept that some future proofing represents good practice, DNV GL consider that, especially for AIS substations, such practice should only affect the total cost of civil works, not the electrical works. However, our benchmarks are showing a significant and unexplained overestimate of electrical costs by the SHE Transmission submission.

Taking into account the above analysis DNV GL believes that the discrepancies between the SHE Transmission submission and the benchmarks remain substantial. We consider that the submission has been set too high and that [•] could reasonably be removed from the costs and outputs submission - see the DNV GL substation costs assessment summary, Table 11 below.

3.6 LT25 – Loch Buidhe 275/132 kV Substation

Loch Buidhe is a major new 275/132 kV substation development which includes:

- A 275 kV double busbar substation comprising 4 feeder bays, 2 transformer bays, 2 bus coupler bays, a bus section bay and a reserve section bay;

- 2 x 240 MVA 275/132 kV transformers feeding the 132 kV substation; and
- A 132 kV double busbar substation comprising 4 feeder bays, 2 transformer bays, 2 bus coupler bays, a bus section bay and a reserve section bay.

A comparison of the SHE Transmission costs and key benchmarks are presented in Figure 18.

Figure redacted

Figure 18: LT25: Loch Buidhe substation cost benchmarks

The overall assessment shows that the SHE Transmission cost estimate is significantly higher than all of the benchmarks, the submission being some [•] higher than the Three-BM Average even when it includes the future bays' civils. Our analysis to investigate potential reasons for the discrepancy took account of the following details:

- The 132 kV substation civils are sized for 4 future bays but there is no account of these in the underlying unit costs benchmarks;
- The 132 kV substation busbar is much shorter than the 275 kV busbar, but the site layout is built as a square, so there is considerable prepared land that is "spare" on the 132 kV portion of the site whose cost is not accounted for by the benchmark unit costs; and
- 275 kV busbar is set out with space for 6 future bays. This makes the busbar approximately 40% longer than necessary at present and increases the civil works costs beyond that anticipated by the benchmarks.

Acknowledging the fact that, due to the above points, three of our benchmarks are potentially underestimating the cost of civil works, we also need to note the following:

- The "UK Elec + SHE T Civils" benchmark already takes into the account total cost of civil works as submitted by SHE Transmission and still shows that SHE Transmission electrical costs are [•] higher than our benchmark.
- While we accept that some future proofing represents good practice it can only affect the total cost of civil works and not electrical works. Our benchmarks show a significant and unexplained difference in electrical costs.

Taking into account the above analysis DNV GL believes that the discrepancies between the SHE Transmission submission and the benchmarks remain substantial. We consider that the submission has been set too high and that [•] could reasonably be removed from the costs and outputs submission - see the DNV GL substation costs assessment summary, Table 11 below.

3.7 LT42 – Beauly-Loch Buidhe 275 kV re-conductoring

The LT42 Beauly-Loch Buidhe 275 kV re-conductoring project involves the following activities:

- Replace the existing single 520mm^2 TACSR [††] conductor with a single 625mm^2 TAAAC [‡‡] conductor and disposal of the old conductor, insulators and all associated fittings;
- Replace all phase conductor insulator attachment plates;
- Replace the bolts in the maintenance channels on all the tension towers;
- Replace all the suspension and tension insulator sets;
- Ground clearance rectification works as detailed below;
- West circuit tower x-arm strengthening works; and
- Minor deformed steelwork replacement works.

The construction cost breakdown submitted is set out in Table 9 below:

Table redacted

Table 9: LT42: Beauly-Loch Buidhe 275 kV re-conductoring cost estimate breakdown

Figure redacted

Figure 19: LT42: Distribution of construction costs

Our approach to benchmarking costs for re-conductoring 275 kV OHL is based on the unit cost for new OHL used in Section 3.1.6. A comparison of the SHE Transmission costs and key benchmarks are shown in Figure 20.

Figure redacted

Figure 20: LT42: Beauly-Loch Buidhe re-conductoring cost benchmarks

For the Beauly-Loch Buidhe 275 kV OHL re-conductoring, SHE Transmission capital cost estimates are below all of our benchmarks. We therefore consider that the costs for this OHL re-conductoring represent procurement at current competitive market rates.

3.8 Conclusions on Assessment of Capital Works

The individual sub-project considerations are summarised in this section. Since we have used different benchmarks for substation and OHL works we have presented our comparisons separately.

[††] TAAAC thermal-resistant aluminium alloy conductor
[‡‡] TACSR thermal-resistant aluminium alloy conductors steel reinforced

3.8.1 Substations and Cables

Table 10 compares the SHE Transmission submission for substation and cable capital works against the four benchmarks described in Section 3.1.4.2. It presents:

- SHE Transmission submitted cost (cells highlighted in orange);
- Benchmark values for each sub-project; and
- Percentage differences between the SHE Transmission submission and individual benchmarks, where we highlight in red all the instances where the SHE Transmission sub-project submission exceeds a benchmark by more than [•].

Table redacted

Table 10: DNV GL's substation capital works benchmarks summary

As explained in Section 3.1.5, having developed and compared the SHE Transmission submission with the benchmarks, we then applied three measures to the benchmarks in order to improve their applicability to the SHE Transmission submission. The results of the Section 3.1.5 measures are presented in Table 11, which sets out the following columns:

- SHE Transmission submitted cost (cells highlighted in orange) – repeated from the previous table for the convenience of the reader;
- The "Three-BM average", developed from the previous table;
- Our estimates of the extra civil engineering costs associated with future bays;
- The resulting "Civils-corrected" proofed BMs
- The result of a percentage adjustment to the BM to accommodate benchmarking uncertainty
- Any excess of the submission above this adjusted benchmark (which comprises the recommended reduction to the submission); and
- The resulting DNV GL recommended capital allowance for each substation sub-project.

Table redacted

Table 11: Summary of DNV GL benchmark assessment of substation costs

Based on our analysis and the information presented in Table 11, we summarise our findings on the substation capital works costs as follows:

- LT41: Blackhillock Substation – submission reasonable – represents efficient procurement;
- LT23: Thurso Substation – submission reasonable – represents efficient procurement;
- LT23: Mybster Substation – submission set too high – recommend reduction of [•];
- LT23: Dounreay Substation – submission reasonable – represents efficient procurement;

- LT24: Fyrish Substation – submission set too high – recommend reduction of [•];
- LT25: Loch Buidhe Substation – submission set too high – recommend reduction of [•]; and
- LT21: Spittal Substation – submission reasonable – represents efficient procurement.

In total, this represents a recommended reduction of [•] on the substation submission of [•].

3.8.2 Overhead Lines

The second summary table, Table 12, covers the OHL capital works. Based on our analysis and the information presented there, we have summarised our findings on the OHL capital works costs as follows:

- Dounreay-Mybster New OHL – SHE Transmission costs are higher than our benchmarks but [•] of all of them. We thus consider the Dounreay-Mybster New OHL capital works submission to represent procurement at current competitive market rates.
- Beauly-Loch Buidhe Re-conductoring – SHE Transmission cost estimates are well below all of our benchmarks therefore we considered that the capital costs for Beauly-Loch Buidhe 275 kV OHL re-conductoring represent procurement at current competitive market rates.

Table redacted

Table 12: Summary of DNV GL assessment of OHL capital works costs

Based on our analysis and the information presented in Table 12, we summarise our findings on the overhead line capital works costs as follows:

- LT23: Dounreay-Mybster overhead line – submission reasonable – represents efficient procurement;
- LT42: Beauly-Loch Buidhe overhead line – submission reasonable – represents efficient procurement;

In total, this represents a recommended reduction of zero on the overhead line submission of [•].

3.8.3 Overall CAPEX Picture

Table 13 presents the overall picture for substations, OHL and subsea cable together to show the assessment for all the capital work elements[§§] of the Caithness-Moray transmission reinforcement. It shows that DNV GL considers that some [•] of the SHE Transmission capital works submission [•] could reasonably be removed from the AC substation and OHL submission at this stage in the development. This sum rises to [•] if the savings on the HVDC cable routeing are included.

[§§] Excluding capital costs for converter stations

Table redacted

Table 13: Overall Caithness-Moray transmission reinforcement

Figure 21 and Figure 22 show this same information graphically:

Figure redacted

Figure 21: Caithness-Moray AC transmission reinforcement

Figure redacted

Figure 22: Overall Caithness-Moray transmission reinforcement

4 ASSESSMENT OF SHE TRANSMISSION RESOURCING LEVELS

4.1 Overview of DNV GL approach

To understand SHE Transmission's approach in estimating Project Management, Commissioning and Engineering resources we have reviewed the various documents provided for each project and, where necessary, sought clarification through Supplementary Questions (SQ). Documents that SHE Transmission provided for each project included:

- Project Organogram, showing the resources and management structure for the resources;
- Project programme, containing timelines for all the major project activities;
- Role descriptions in the Project Execution Plan (PEP), providing a brief outline of the role of each resource; and
- Resource estimates, containing a list of resources and a month-on-month resource usage profile for each resource.

Ofgem has requested DNV GL to assess whether SHE Transmission's estimated Project Management, Commissioning and Engineering elements of the project costs are credible and reasonable and to recommend (to Ofgem) whether to accept these costs in whole or in part.

For this desk-top assessment, for each type of activity, we have reviewed the SHE Transmission resource estimate against the programme, role descriptions and organogram and compared this with our experience with comparable transmission projects.

SHE Transmission has estimated a significant quantity of resources for this project. Having reviewed the documentation, DNV GL believes that the resource profiles generally align with the programmes although there are some resources that are allocated for excessive periods and these are discussed in our assessment below.

For Engineering, SHE Transmission has prepared their estimates using a mixture of quotations from specialist consultants, in house estimates and quotations from specialist service companies. DNV GL has compared the estimate profiles against the programmes and some of the resources appear to have been quoted for excessive periods. This is discussed further in our assessment below.

4.2 SHE Transmission Engineering Resource

4.2.1 LT41: Blackhillock 400/275/132 kV Substation WBS 04.03.03.01

SHE Transmission estimate for engineering costs for Blackhillock Substation reinforcement is [•] broken down as in Table 14 below.

General Investigations	Pre-entry surveys to roads	[•]
	Monitoring of Public Road Condition	[•]
	Construction Progress Photography	[•]
Substations	Electrical Consultants	[•]
	Civil Consultant	[•]
	Geotechnical Consultant	[•]
	Transformer Expediting Consultant	[•]
Overhead Lines	OHL Consultant	[•]
Underground Cables	Cable Consultant	[•]
	Total	[•]

Table 14: LT41: Blackhillock – SHE Transmission WBS Engineering Estimate

The General Investigations works are based on quotations for the works from specialist resources and the programmes for these investigations appear to align with the project programme. DNV GL assess that these costs are acceptable.

SHE Transmission resource estimate for engineering substation design staff totals 161.3 man-months or [•]. The submission explains that SHE Transmission intends to appoint consulting engineers to fulfil engineering roles but, for the purposes of the estimate, SHE Transmission internal rates have been used. The engineering estimate is for work in addition to the main design work which is carried out by the main contractor.

The engineering consultancy estimate is broken down as follows:

Substation Engineer	[•]
GIS Electrical Engineer	[•]
AIS Electrical Engineer	[•]
Civil Clerk of Works	[•]
Civil Engineer	[•]
Civil CAD	[•]
Geotechnical Engineer	[•]
Total	[•]

Table 15: LT41: Blackhillock – SHE Transmission engineering consultant cost estimate

DNV GL has reviewed the activity schedule and identified Main contractor electrical design engineer cost for primary and secondary design. The activity schedules costs total [•] which equates to about 200 man-months of design effort. This level of design effort compares to [•] of consultant effort. Comparing the consultants estimated effort to the contractors' effort, bearing in mind that the contractor is carrying out the actual full design ready for construction, this consultant resource seems disproportionate to the design resource for the main designers.

The resource profile identifies three engineers working part time prior to the installation phase and then full time throughout the installation and commissioning phase of the project. The PEP gives the roles as follows:

- **Substation Engineer -** Reporting to the Lead Design Engineer and provides technical input to checking the contractor's electrical design
- **AIS Site Electrical Engineer -** Site based, reporting to both the Design Manager and the
- **Construction Manager -** Duties include but are not limited to Safety, Quality and Environment on site including CDM interfaces ensuring that Quality, Health, Safety and Environmental procedures are followed. Site supervision of the AIS electrical contractor with regard to compliance with the required scope, programme and specification. Coordinate contractor and works with other site works.
- **GIS Site Electrical Engineer -** Site based, reporting to both the Design Manager and the Construction Manager. Duties include but are not limited to Safety, Quality and Environment on site including CDM interfaces ensuring that Quality, Health, Safety and Environmental procedures are followed. Site supervision of GIS electrical contractor with regard to compliance with the required scope and specification. Coordinate contractor and works with other site works.

The technology employed for this project is standard equipment in standard new build configurations and the majority, if not all, of the equipment proposed is Type Registered in the United Kingdom. The design will be carried out by the main contractor against SHE Transmission's specifications and, in DNV GL's experience, the client design engineer's role is one of design assurance, checking contractor designs against SHE Transmission's specifications. This role would take place predominantly prior to commencement of installation and is unlikely to be full time in any phase of the project. Following commencement of installation, the role would be expected to be small and it would certainly be hard to justify a full time client design engineer working on the project. Furthermore, as the contractor design engineers are likely to be office based with occasional visits to site it is difficult to justify a consultant engineer based on site as indicated by the profile.

So far as the GIS and AIS Electrical Engineers are concerned, this entails two part-time and then full-time engineers based on site responsible for Safety, Quality and Environment, along with supervision of the main contractor for compliance with scope, specification and programme. The main contractor has responsibility to manage the site and the works in accordance with all British and SHE Transmission standards and the SHE Transmission Project Management resource includes a full time site based Project Manager, SHE Transmission Manager, Construction Design & Management Co-Ordinator (CDMC), Safety Adviser, Environmental Clerk of Works, Environmental Manager, QA/QC Supervisor. It is difficult to justify further resources for these client activities.

DNV GL's view is therefore that the proposed substation engineering consultant estimate is significantly in excess of what is necessary bearing in mind that the main contractor is responsible for all original design, health, safety, environment, quality, scope, programme and adherence to specification.

More specifically, comparing the substation engineering consultant resource profile to the programme there are a number of areas of concern:

- All substation construction and stage 1 commissioning is complete by July 2016. The contractor's main design is fully complete well in advance of that. It is therefore difficult to conceive of the role of three consultant design engineers full time from July 2016 through to February 2017 with the substation consultant full time right through to April 2018 and 50% of his time right through to March 2019.

- Similarly, it is difficult to understand the need for a GIS consultant design engineer full time through to March 2018 and an AIS consultant full time to February 2017 and 50% of his time through to March 2019

DNV GL's assessment is that the client electrical design required is as set out in Table 16 below:

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Substation Engineer	Not required full time Jun 2016 to May 2017, Not required at after May 2017	[•]	
GIS Electrical Engineer	Not required full time Aug 2015 to May 2017, Not required at after May 2017	[•]	
AIS Electrical Engineer	Not required full time Aug 2015 to Feb 2017, Not required at after May 2017	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 16: LT41: Blackhillock – DNV GL Assessment of Electrical Engineering Resource

The SHE Transmission substation engineering estimate also includes four civil engineering resources amounting to [•]. This includes [•] for Civil engineer and CAD resource whereas the activity schedule for the main contract shows the main contractor having [•] to complete all civil design. As the Civil Engineer's role is to check the contractors design, the estimate for civil engineer seems disproportionate to the resource level to actually do the design.

The Civil Clerk of works is estimated at 27 man-months of resource or [•]. This resource is estimated as being required full time from June 2014 through to November 2015 and then 50% of his time to August 2016 and then decreasing but still utilised part time through to March 2019. The Level 2 programme submitted indicates that Civil works are complete by September 2015. Whereas that might be when the main substation civil works are complete, it is expected that there may be some finishing works following completion of the switchgear installation. Notwithstanding that, and acknowledging that there would be some work to complete following completion of the civil works by the main contractor, comparison with the programme would lead to questions about the justification for a Clerk of Works beyond the November 2015 which is two months following completion of the civil works.

As the Main Contractor is responsible for production of all designs, it is not clear what need there is for a client Civil CAD resource. Assuming that there was a need through the civil phase of the works, there can be no justification following completion of the civil works in September 2015. DNV GL assessment is that this resource is not required following completion of the civil works.

DNV GL assessment of the requirement for a Civil Consultants is set out in Table 17 below:

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Civil Clerk of Works	Not required after November 2015	[•]	
Civil Engineer	Not required after November 2015	[•]	
Civil CAD Resource	Not required, all drawings for project from main contractor	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 17: LT41: Blackhillock – DNV GL Assessment of Civil Engineering Resource

The LT41 design estimate is broken down into a number of discrete packages of work and the estimates are based on quotations from specialist consultants. However, DNV GL has identified some excessive allocation of resources resulting in an overestimate of electrical engineering resources of [•] and civil engineering resources of [•] indicating that the SHE Transmission Engineering estimate should be reduced by [•] to [•].

4.2.2 LT21: Caithness-Moray HVDC Reinforcement

SHE Transmission estimate for engineering costs for Caithness – Moray Reinforcement is [•] broken down in as in Table 18 below:

General Investigations	Project Mapping Services	[•]
	Bridge Inspection	[•]
	Pre-entry surveys to roads	[•]
	Monitoring of Public Road Condition	[•]
Sub Sea Cables	Offshore Employers Representative	[•]
Substations	Civil Design Consultant	[•]
	Expediting and Inspection	[•]
OHL	OHL Consultant	[•]

Underground Cables	Cable Consultant	[•]
	Civil Consultant	[•]
Onshore HVDC Convertor Station	HVDC Consultant	[•]
	Verification of HVDC System Studies	[•]
	Civil Consultant	[•]
	Quality Audit	[•]
	Expediting & Inspection	[•]
Total		[•]

Table 18: LT21: SHE Transmission Breakdown of Engineering Estimate

DNV GL has reviewed the breakdown of the Engineering work with the following results, which are summarised in Table 19 below:

- The Project Mapping is based on a quotation from IGIS to set up a GIS database and provide licences and service support. The mapping service covers the land and sea cables and the fixed substation sites. The quotation provides for 50 licences and 40 hours per month of service support from August 2014 to May 2018. Although SHE Transmission has proposed almost 100 staff working on the Caithness – Moray reinforcement project, the majority of these do not require access to mapping services. For example, the substation sites are single developments and it is unlikely that staff allocated to Spittal substation, Spittal HVDC and Blackhillock HVDC would need regular access to a mapping service. There is also no need for commercial staff to have any access to mapping services. Also, some staff may already have access licences via their involvement in other projects. Staff requiring access to mapping services would be expected to be Project Manager, wayleaves staff, environmental staff. In the early days of the project, some design engineers working on the cables may also need mapping services. DNV GL assessment is that no more than 20 licences could be required. Project services appear to include GIS data updates and photograph loading and management. The quotation is not clear on how data is obtained and updated but electronic data transfer is explained as being very quick so it is not clear how 40 hours per month can be expended in project services. Finally, all construction activities are completed by August 2017 so there is no need for continuing Mapping Services after that time.

- The Engineering estimate includes an HVDC Engineering Manager and the PEP identifies this resource as [•] who is employed by [•]. This resource is also included in the Project Management resource schedule so is duplicated here in the Engineering estimate and should therefore be removed for the engineering estimate

- Verification of HVDC System Studies: The engineering estimate includes for a consultant from August 2014 through to December 2018 which is 8 months after energisation of the equipment. Furthermore, system studies should be completed as part of the system design and certainly before commencement of electrical installation in August 2016.

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Project Mapping Services	Excessive allocation of licenses and system usage	[•]	
HVDC Consultant	Duplicate resource also included in Project Management resources	[•]	
Verification of HVDC System Studies	Resource allocated beyond reasonable time for requirement for system studies	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 19: LT21: DNV GL analysis of estimates of engineering cost

The design estimate is broken down into a number of discrete packages of work and the estimates are based on quotations from specialist consultants. However, DNV GL has identified some duplication of resources and excessive allocation of resources resulting in an overestimate of engineering resources of [•] and indicating that the SHE Transmission Engineering estimate should be reduced to [•].

4.2.3 LT23: Thurso, Mybster and Dounreay Substations

SHE Transmission estimate for Engineering costs for New Thurso, Mybster and Dounreay substations is [•] broken down as follows:

Project Mapping Services	[•]
Aerial Photography	[•]
Video Surveys	[•]
Substation Engineering	[•]
Overhead Line Engineering	[•]
Total	[•]

DNV GL has reviewed the breakdown of the Engineering work and the following considerations arise:

- The Project Mapping is based on a quotation from IGIS to set up a GIS database and provide licences and service support. This project involves three fixed substation sites and a new overhead line from Dounreay to Mybster. The quotation provides for 35 licences and 20 hours per month of service support from May 2014 to April 2018. Although the number of people identified to be working on this project is about 70, many of these do not need access to mapping services on a regular basis, if at all. DNV GL assessment is that no more than 20 licences should be required.

- The resource estimate for Substation Engineering is based on part time working for a number of weeks and is based on framework rates for the consultants employed. The length of engagement seems to correspond reasonably well with the programme and the estimates are considered acceptable.

- The resource estimate for the Overhead Line consultant is based on a quotation from a suitable consultant. The length of engagement of the consultant seems to correspond reasonably well with the programme and the estimates are considered acceptable.

These results are summarised in Table 20 below:

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Project Mapping Services	Excessive allocation of licenses and system usage	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 20: LT21: DNV GL assessment of changes to Engineering Resources

The Engineering resource estimate is broken down into a number of small discrete packages of work and the estimates are based on quotations from specialist consultants. Other than a minor change, the estimates are considered acceptable

4.2.4 LT24: Fyrish 275/132 kV Substation

SHE Transmission estimate for Engineering costs for Fyrish substation is [•] broken down as follows:

Project Mapping	[•]
Aerial Surveys	[•]
Video surveys to roads	[•]
Topographical Surveys and Site Investigation	[•]
Substation work	[•]
Overhead Line work	[•]
Total	[•]

DNV GL has reviewed the breakdown of the Engineering work with the following results which are summarised in Table 21below:

The Project Mapping is based on a quotation from IGIS to set up a GIS database and provide licences and service support. The full quotation has not been provided but it is understood to provide for 3 licences for the project plus updating services. This is a small cost and is considered to be acceptable

The aerial photography quotation includes for aerial photography of the Fyrish substation site on a quarterly basis during 2014/15, 2015/16, 2016/17 and 2017/18. As this is a fixed substation site, in DNV GL's experience this quarterly aerial photography serves no purpose and is not required.

The substation and overhead line engineering is made up of a number of smaller packages for civil and electrical design review and transformer manufacturing expediting. DNV GL has reviewed the estimates against the work values identified for the main contractors work and the programme and the consultants fees are considered relatively small and acceptable.

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Aerial Surveys	Quarterly surveys not required	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 21: LT24: Fyrish - DNV GL assessment of changes to Engineering Resources

The design estimate is broken down into a number of small discrete packages of work and the estimates are based on quotations form specialist consultants. In overall terms the individual package costs are relatively minor and are considered acceptable except for the quarterly aerial photography which is considered unnecessary.

4.2.5 LT25: Loch Buidhe 275/132 kV Substation

The SHE Transmission estimate for engineering costs for Loch Buidhe substation is [•], broken down as follows:

Project Mapping Services	[•]
Aerial Photography	[•]
Video surveys to roads	[•]
Topographical Survey & Site Investigation	[•]
Substation Work	[•]
Overhead Line Work	[•]
Total	[•]

DNV GL has reviewed the breakdown of the engineering work with the following results:

- The project mapping is based on a quotation from IGIS to set up a GIS database and provide licences and service support. The full quotation has not been provided but it is understood to provide for 3 licences for the project plus updating services. This is a small cost and is considered to be acceptable
- The aerial photography quotation includes for aerial photography of the Loch Buidhe substation site on a quarterly basis during 2014/15, 2015/16, 2016/17 and 2017/18. As this is a fixed substation site, in DNV GL's experience this quarterly aerial photography serves no purpose and is not required.
- The substation engineering is made up of a number of smaller packages for civil and electrical design review and transformer manufacturing expediting. DNV GL has reviewed the estimates against the work values identified for the main contractors work and the programme and the consultants fees are considered relatively small and acceptable.

These results are summarised in Table 22 below:

Resource	Cause	Change
SHE Transmission resource submission		[•]

Aerial Surveys	Quarterly surveys not required	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 22: LT25: Loch Buidhe - DNV GL assessment of changes to Engineering Resources

The design estimate is broken down into a number of small discrete packages of work and the estimates are based on quotations form specialist consultants. In overall terms the individual package costs are relatively minor and are considered acceptable except for the quarterly aerial photography which is considered unnecessary.

4.2.6 LT42: Beauly-Loch Buidhe Overhead Line

SHE Transmission estimate for engineering costs for Beauly to Loch Buidhe overhead line is [•] broken down as follows:

Project mapping services	**[•]**
Aerial Photography	[•]
Video surveys to roads	[•]
Topographical Survey & Site Investigation	[•]
Overhead Line Work	[•]
Total	[•]

DNV GL has reviewed the breakdown of the Engineering work with the following results:

The Project Mapping is based on a quotation from IGIS to set up a GIS database and provide licences and service support. The full quotation has not been provided but it is understood to provide for 3 licences for the project plus updating services. This is a small cost and is considered to be acceptable

The aerial photography quotation includes for aerial photography of the Beauly - Loch Buidhe overhead line route before and after construction. This is considered a reasonable approach and is acceptable.

The overhead line engineering is made up of a number of smaller packages for civil and overhead line design review and transformer manufacturing expediting. DNV GL has reviewed the estimates against the programme and the consultants fees are considered relatively small and acceptable.

The engineering estimate is broken down into a number of small discrete packages of work and the estimates are based on quotations from specialist consultants. In overall terms the individual package costs are relatively minor and are considered acceptable

4.2.7 Conclusion on Engineering Resource Estimates

The above considerations are summarised in Figure 23.

Figure redacted

Figure 23: Engineering costs: SHE-Transmission submission and DNV GL assessment

Figure 23 indicates that, for the Engineering costs for the Caithness-Moray transmission reinforcement, some [•] could reasonably be removed from the SHE Transmission submission.

4.3 SHE Transmission Project Management Resource

4.3.1 LT41: Blackhillock 400/275/132 kV Substation

SHE Transmission submission includes Project Management resources for the period February 2014 to March 2019, a time period of 62 months. The resource estimate amounts to 788 man-months of internal resources with a total cost of [•] with an additional cost of [•] allowance from unallocated staff. The total cost estimate is therefore confirmed as [•].

DNV GL has compared the resource estimate to the Level 2 programme submitted as part of the Cost and Outputs submission. Key dates for the programme are identified in Table 23 below:

LT41: Blackhillock Substation	
Main Substation Contract Award	21st April 2014
Cable Contract Award	21st April 2014
Transformer Contract Award	11th June 2014
Civil Works Commence	12th May 2014
Electrical Installation 275 kV Substation Commence	8th May 2015
Electrical Installation 275 kV Substation Complete	20th April 2016
Electrical Installation 400 kV Substation Commence	4th September 2015
Electrical Installation 400 kV Substation Complete	20th April 2016

Electrical Installation 132 kV Substation Commence	27th August 2015
Electrical Installation 132 kV Substation Complete	25th January 2016
Stage 2 Commissioning Commence	1st August 2016
Stage 2 Commissioning Complete	26th May 2017
Decommission old 275 kV substation - Commence	7th August 2018
Demolish old 275 kV substation - Complete	4th January 2019
Clear site	1st March 2019

Table 23: LT41: Blackhillock Substation Key Dates

The key dates in the programme demonstrate that the new Blackhillock substation is fully constructed by 20th April 2016 and Stage 2 commissioned by 26th May 2017. The programme shows no further works on the site until the commencement of decommissioning of the old 275 kV substation in August 2018 whereas SHE Transmission resource estimate shows a significant resource requirement in this period. The resource cost estimate in this period equates to 161 man-months of effort or [•].

DNV GL recognises that some small amount of project management resource may be needed after commissioning to ensure that the contractors records and as built drawings are completed satisfactorily but this does not require a full project team including two full time project managers for 14 months and it is recommended that the majority of this cost is disallowed.

DNV GL has reviewed the resource estimate against the role descriptions in the Project Execution Plan (PEP).

- Lead Project Manager/Project Manager: The role of project manager is as Client Project Manager as the actual management of the construction works is being carried out by the main contractor. The PEP describes the Lead Project Manager as having responsibility for a cluster of projects in the Keith area, yet he is allocated full time (62 months) to the Blackhillock project. Additionally, there is a project manager who has overall responsibility for safe delivery of the Blackhillock project who is also allocated full time (62 months) to the project.

  There is also a Site Construction Manager who is also site based, reports to the project manager and whose principal role is described as coordination the construction and commissioning elements of the work and is allocated for 59 months.

  Overall, bearing in mind that the contractor is actually managing the works, there does not seem to be a role for two full time client project managers and a site manager all based on site. DNV GL assessment is that a portion of the Lead Project Managers time should not be allocated to the project (to reflect the portfolio nature of his role) and that he shouldn't be site based.

- Contract Manager (Site based): Resource estimate for this role is full time until June 2018 and then reducing time. The role is described as commercial forecast, monitoring and reporting, procurement of framework consents including consultants and contractors. It is difficult to justify a full time role, on site for this resource following contract award. The main substation The major works contracts including civil works for the substation are expected to have been awarded by 11th June 2014 and normal monitoring and reporting on the contracts are routinely carried out and reports supplied by the contractor's Quantity Surveyor. It is understood that SHE Transmission senior management may require detailed updates, normally monthly but this is hardly a full time job for a Contracts manager and there doesn't seem to be any need for him to be site based. DNV GL's analysis indicates that there should be a much reduced resource requirement for the Contract Manager following main contract award.

- Site Interface / Civil Manager: Described as required to supervise the safe civil engineering construction with regard to their compliance with the scope of works and specification. This resource is allocated full time from March 2014 until February 2018 but the programme shows that site civil works are completed by 18th September 2015. It is therefore difficult to justify the civil site interface manager being required beyond this date.

- The role of site based administration receptionist is estimated at [•] and is shown as "head office staff moved to site". This role on site would normally be provided by the contractor and it is anticipated that the role could be more efficiently sourced from local contracted labour at a significantly lower cost. The hourly rate used in the estimate is about £48/hour and DNV GL estimate that this role could be sourced locally at [•]. It is recommended that the allowance for this role is reduced by [•].

- The resource profile shows a senior Project Planner whose role is to monitor, review and report on contractors' programmes allocated full time throughout the project. This allocation is inconsistent with all the other component projects in the submission and since the contractors prepare the programmes it is difficult to justify a full time site-based resource on this project.

DNV GL's analysis of the Project Management resource costs indicates that there is a large over estimate of resource costs in the Costs and Outputs submission. The analysis is summarised in Table 24 below:

Resource	Cause	Change
SHE Transmission resource submission		[•]
All Resources	No work on site May 2017 – July 2018	[•]
Lead Project Manager, Project Manager, Site Construction Manager	Excessive client side project management	[•]

Contracts Manager	Insufficient justification for resource following award of main contracts	[•]	
Site Interface/Civil Manager	Insufficient justification for resource following completion of civil works	[•]	
Admin / Receptionist		[•]	
Senior Project Planner	Resource level inconsistent with other component projects and difficult to justify this level of resource	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 24: LT41: Blackhillock Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•], reducing the Project Management allowable cost to [•].

4.3.2 LT21: Caithness – Moray HVDC Reinforcement

SHE Transmission submission includes Project Management resources for the period May 2014 to June 2019, a time period of 62 months. The resource estimate includes not only that associated with Spittal AC substation, but also that associated with LT21's OHL, UGC, HVDC converters and subsea HVDC cable. It amounts to 2706 man-months of internal resources with a total cost of [•] with an additional cost of [•] allowance for unallocated staff. Including [•] for international travel and [•] uplift to expenses for accommodation in Aberdeen, and remote locations, the total cost estimate submission is [•] [***].

DNV GL has compared the resource estimate to the Level 2 programme submitted as part of the Cost and Outputs submission. Key dates for the programme are identified in Table 25 below:

[***] These details provided in SHE Transmission spreadsheet CM_G_021 Attachment 1_LT21 Project Management.xlsx

Table 25: LT21: Caithness HVDC Reinforcement Key Dates	
Main Contract Award –	1st August 2014
LT21: Spittal Substation	
Main Substation Contract Award	*1st August 2014*
Detailed Design Complete	*31st December 2014*
Civil Works Commence	*3rd November 2014*
Main Substation Civil Works Complete	*7th October 2015*
Electrical Installation Commence	*15th October 2015*
Electrical Installation Complete	*22nd June 2016*
Stage 1 Commissioning Commence	*18th April 2016*
Stage 1 Commissioning Complete	*Date Not provided*
Stage 2 Commissioning Commence	*Date Not Provided*
Stage 2 Commissioning Complete	*11th May 2017*
Spittal HVDC Converter	
Civil Works Commence	*Presumed part of Substation works*
Main Substation Civil Works Complete	
Electrical Installation Commence	*21st November 2016*
Electrical Installation Complete	*27th October 2017*
Stage 1 Commissioning Commence	*20th November 2017*
Stage 1 Commissioning Complete	*Date Not provided*
Stage 2 Commissioning Commence	*Date Not Provided*
Stage 2 Commissioning Complete	*13th April 2018*
LT21: Blackhillock HVDC Converter	
Civil Works Commence	*Presumed part of Substation works*
Main Substation Civil Works Complete	
Electrical Installation Commence	*11th August 2016*
Electrical Installation Complete	*17th November 2017*

Stage 1 Commissioning Commence	*20th November 2017*
Stage 1 Commissioning Complete	*Date Not provided*
Stage 2 Commissioning Commence	*Date Not Provided*
Stage 2 Commissioning Complete	*13th April 2018*
LT21: HVDC Cabling	
Land Cables Electrical Installation Commence	*10th August 2015*
Land Cables Electrical Installation Complete	*11th August 2017*
Sea Cables Electrical Installation Commence	*5th January 2016*
Sea Cables Electrical Installation Complete	*18th August 2017*
Commissioning Commence	*20th November 2017*
Commissioning Complete	*13th April 2018*

Table 25: LT21: Caithness HVDC Reinforcement Key Dates

The key dates in the programme demonstrate that the Caithness HVDC project is fully constructed by 17th November 2017 and Stage 2 commissioned by 13th April 2018. The project resource schedule shows resources allocated through to the end of December 2018.

DNV GL has reviewed the resource estimate against the programme and role descriptions in the Project Execution Plan (PEP), and notes the following:

- The resource profile shows a site based Administration Support working full time at Spittal from May 2014 and half time at Blackhillock. As site is not established until November 2014, these resources are not required until then. Furthermore there is a site based Receptionist also allocated from the point of site establishment. As described, this appears to be excessive allocation of resource to administration and reception which, if necessary at all, would not demand a full time role. DNV GL assessment is that the Reception and Administration support together is one role.

- The resource estimate includes two full time Heavy Electrical Inspectors working throughout the construction of the HVDC substations. These are site based and the role is described as Reporting to the Construction Managers and responsible for inspection of Electrical apparatus and plant. SHE Transmission has not seen these roles to be necessary on any of the other component projects. Since the contractor is fully responsible for the supply, installation, inspection and testing of the electrical apparatus and plant, there is no anticipated role for the client in inspecting the apparatus. Similarly, the resource estimate includes two C&P inspectors who also have not been seen as necessary on the other component projects. Hence this role is not seen as necessary on this project. We can see no justification for their inclusion on the resource estimate.

- The programme shows that main Civil Works for all three component projects are completed by the end of October 2015 yet the resource profile has a civil project engineer allocated through to December 2017 and another allocated to March 2018. As no works are programmed it is hard to justify the need for two civil project engineers after the completion of civil works.

- Similarly, it is difficult to justify a Civil Design Manager continuing to work on the project after the completion of civil works.

- The resource profile indicates a need for the CDMC from May 2014 to December 2018 but all construction works are complete by November 2017. There is a role for the CDMC post construction but this is an advisory role and is expected to be less than that shown in the proposed profile. Also, the proposed profile shows the CDMC to Mar 2018 and we judge this to be an excessive retention of this role post the completion of works.

- The resource profile shows a site based Cost Engineer allocated full time from May 2014 through to December 2018. The role is described as providing cost control and reports directly to the Senior Commercial Manager. As it is not planned to place contracts until 1st August 2014, there can be no work required of this resource before this time - and certainly not full time. Furthermore, it is not clear how compiling cost reports could be a full time role. For the other component projects making up the Caithness to Moray reinforcement submission, the time allocated for this resource varies from 10 days per month on Blackhillock, which looks excessive down to 3 days per month on Dounreay – Mybster and less than one day per month on Fyrish and Loch Buidhe. There also cannot be any work required following completion of the construction works.

- The resource profile identifies an Office based Environmental Manager from May 2014 to December 2018 along with a site based Environmental Manager and site based Environmental supervisor but all construction works are complete by November 2017 and there can be no requirement for these resources following completion of construction works.

- The resource profile identifies an Health & Safety Manager from May 2014 to December 2018 and two site based Health and Safety Advisors to May 2018 but all construction works are complete by November 2017 and there can be no requirement for an these resources following completion of construction works

- The resource profile identifies an AC/HVDC Commissioning Lead but this resource is also included in the Commissioning resource profile and should be removed from the Project management profile.

- The resource profile identifies a Senior Commercial/Procurement Manager working full time on the project from May 2014 to December 2018 whose role is commercial management, control, administration and report of all elements of the Caithness Moray project. With modern communications, it is not clear why this would be a site based role as there are site based engineers and Quantity Surveyors monitoring the project. It is also not clear why this would be a full time role as most of the routine reporting and dealing with claims would be handled by

the Project Manager and site Quantity surveyor. DNV GL assessment is that this role is part time and office based.

- The resource profile shows a Subsea Project Manager allocated full time from June 2016 to December 2018 whereas the subsea cable installation is completed by August 2017. There can be no requirement for this resource following completion of the project records
- The resource profile shows two Community Liaison Officers working through to May 2018. This is recognised as an essential resource where there are major construction works over an extended period but these resources are unlikely to be required once main construction has finished.
- The Organogram and resource profiles show the following Project Management professionals allocated to Spittal:
    - Lead Project Manager – site based, full time
    - Sub-project managers for Spittal AC substation, Spittal HVDC convertor station, Spittal Land Cable – site based, full time
    - Construction Managers for Spittal AC substation, Spittal HVDC convertor station, Spittal Land Cable – site based, full time
    - Heavy Electrical Inspector – site based, full time
    - P&C Inspector – site based, full time
    - Convertor supervisor – site based, full time
- Similarly, for the Southern side at Blackhillock, there is the following staff:
    - Lead Project Manager – site based, full time
    - Sub-project managers for Blackhillock HVDC convertor station, Spittal Land Cable – site based, full time
    - Construction Managers for Blackhillock HVDC convertor station, Spittal Land Cable – site based, full time
    - Heavy Electrical Inspector – site based, full time
    - P&C Inspector – site based, full time
    - Convertor supervisor – site based, full time
- DNV acknowledge that it is important to for SHE Transmission to have a presence on site to monitor and inspect the works but DNV analysis is that this level of monitoring and inspection is excessive particularly if you look at Spittal AC substation and the land cables. Both of these projects are standard Transmission Projects being built in a “greenfield environment” with tried and tested technology. DNV analysis is that a structure with a lead project manager and a project manager/engineer plus a site engineer is adequate for the client tasks to be carried

out. It appears that the Construction manager proposed is being charged at the same rate as the project manager and this seems excessive for a subordinate role but overall, DNV assessment is that the project managers and construction manager combined should be sufficient to carry out the client roles required and that the additional inspectors are not required.

- The Resource profile shows five Contracts Managers (Site based) working full time for various times between May 2014 and May 2018. The role is described as commercial forecast, monitoring and reporting, procurement of framework consents including consultants and contractors. It is difficult to justify a full time role, on site for this resource following contract award. The major works contracts are expected to have been awarded by 1st August 2014 and normal monitoring and reporting on the contracts are routinely carried out and reports supplied by the contractor's Quantity Surveyor. It is understood that SHE Transmission senior management may require detailed updates, normally monthly but this is hardly a full time job for a Contracts manager and there doesn't seem to be any need for him to be site based. DNV GL's analysis indicates that there should be a much reduced resource requirement for the Contract Manager following main contract award.

- The resource profile identifies two Convertor Supervisors responsible for inspection of Convertor apparatus and plant. The main contractor has full responsibility for the supply, installation and testing of apparatus and plant so there is no need for SHE Transmission to inspect this equipment. This role should be removed.

- The resource profile shows two site based Document Controllers working from May 2014 one shared between Spittal substation and the Spittal HVDC works and the other on the Blackhillock HVDC site. As site establishment is not established until November 2014 there is no requirement for the resource prior to that date. Furthermore the profile shows the shared resource at Spittal finishing on the substation in December 2017 but then transferring to work full time on the HVDC project. This is odd as it begs the question of why there is more document work to do on the HVDC project after the construction works are all complete. The two document controllers are allocated through to May 2018. It's also not clear why a full time resource is required for the Blackhillock works but a shared resource is adequate for Spittal.

- The resource profile identifies a site based HVDC Engineering Manager, site based HVDC Lead Engineer from May 2014 to May 2018 responsible for SHE Transmission HVDC design. As all design by SDHE Transmission and the contractors will be complete and design assured prior to manufacture and installation, there can be no role for these resources following commencement of site installation.

- The resource profile identifies a Procurement Officer whose role is to provide procurement services directly to the senior commercial manager. It's not clear what this actually means but it's hard to see what requires a full time procurement officer on a project whose major parts are procured through major contracts and this resource should be removed

- The resource profile identifies a number of site based project engineers responsible for substation design, Cable systems, Control and Protection, Convertors, NMC, System design. As all design by SHE Transmission and the contractors will be complete and design assured

prior to manufacture and installation, there can be no role for these resources following commencement of site installation. The resource profile includes a Project Engineer Systems Studies working full time from May 2014 through to May 2018. All system studies should have been carried out prior to the HVDC design and contract placing. It is difficult to see a full time role carrying out system studies and this role should be removed

- The resource profile identifies a Project Engineer OHL working through to December 2017 whereas the Spittal substation is commissioned by May 2017 and no further work is required after that date.

- The resource profile identifies two site based Project Planners allocated from May 2014 through to May 2018 whose role is to monitor, review and report on contractors programmes. Although the site isn't established until November, it would be expected that a planner might carry out these roles from the date of placing the main contracts. Having said that, the main contractors planners will monitor and update the programmes in a format specified by SHE Transmission, There would also normally be a monthly reporting cycle but it is difficult to see how this could equate to 29 man-days per month. Furthermore, once the main construction is complete there can be little or no role in planning.

- The resource profile identifies a site based Project Co-ordinator for the Spittal AC substation from May 2014 through to December 2017. As site establishment is not planned until November 2014 there is no site based work in this period. The electrical installation works at Spittal substation are also complete by June 2016and only commissioning tasks are carried on after this point, there does not seem to be a role for a project co-ordinator after this time

- The resource profile identifies two site based Quality engineers allocated from May 2014 to May 2018. There is no site based role until site establishment in November 2014 and no role following completion of construction works

- The resource profile shows a Quantity surveyor (Diversions/Facilitation) allocated full time from May 2014 to May 2014. These works are not shown in the submitted programme but the diversions are a very minor part of this project in terms of scope and value. It is inconceivable that there is a full time quantity Surveyor required to report on these works. The Spittal substation works are complete by June 2016 and it is anticipated that the overhead line diversions would also be complete by this time and the Quantity Surveyor would not then be required. It also isn't clear how this could be a full time role from May 2014 to November 2016. The overhead line diversions are likely to take place in the summer months and look to be relatively minor taking place over a short period of time.

- The resource profile identifies a Quantity Surveyor Land Cable allocated from October 2014 although the installation does not commence until August 2015 so there can be no work for a Quantity Surveyor in this period. There is also a Quantity surveyor (Sea Cables) allocated from the commencement of installation to May 2018 although the installation is complete by August 2017.

- The resource profile and organogram identifies a Technical Project Manager along with a Technical Engineer Underground Cable and a Technical Engineer HVDC. The roles are

described as reporting to the Project Delivery Director and responsible for the technical delivery of the Caithness Moray cluster of projects. However there are numerous project managers on the project along with a number of design managers and engineers. It is difficult to conceive of the need for these roles when the design and delivery is the responsibility of the project manager and technical departments and these roles are assessed to be unnecessary.

Note: Following discussions with SHE Transmission, it appears that the role was not adequately described in the submitted PEP and the role is now described as managing interfaces with other SHE Transmission projects and with Network Management Centre and ensuring that outages are adequately identified and controlled. DNV accept that access to the system is important but believe that the resource identified is significantly in excess of that required. All the projects in this component are green-field developments with limited need for system access until final energisation. It is recognised that it is essential to manage this process carefully but in our view this does not require a manager working full time from May 2014 until May 2018 and two engineers working part-time from May 2014 and then fulltime from May 2015 to May 2018. DNV assessment is that one part time engineer can manage these tasks.

DNV GL's analysis of the Project Management resource costs thus indicates that there is a large over estimate of resource costs in the Costs and Outputs submission.

In addition, we note that SHE Transmission has not treated LT21 PM resources in the same way as the other sub-projects. For them, SHE Transmission uplifted the rates of all site-based staff by [•] prior to calculating their overall costs, and uplifted office-based staff costs (referred to by SHE Transmission as 'unallocated staff') by [•] after calculating their project costs. The reason for this variation in approach is not clear, neither is the reason for the [•] uplift in the first place. However, for LT21, SHE Transmission has uplifted the rates of all site-based staff by [•] prior to calculating their overall costs (as for the other sub-projects), but then uplifted ALL staff costs by [•] after calculating their project costs. This second uplift amounts to around [•] and appears without any apparent justification. A [•] uplift to unallocated staff would amount to around [•] so we recommend disallowing the [•] and substituting it with an allowance of [•].

DNV GL analysis is summarised in Table 26 below, which lists recommended reductions to the submission:

Table 26 - Resource	Cause	Change
SHE Transmission resource submission		[•]
Admin Support/Reception	Duplicate resources	[•]
Heavy Electrical and C & P Inspectors	Resource not necessary	[•]
Caithness Lead Project Manager	Project completes earlier than shown in profile	[•]

Table 26 - Resource	Cause	Change
Civil Engineering Manager	Not required following completion of civil works	[•]
AC Lead Engineering Manager		[•]
CDMC		[•]
Cost Engineer	Full time role not necessary	[•]
Environmental Manager, Environmental Supervisor	Not required following completion of construction works	[•]
Health and Safety Manager, Health and Safety Advisers		[•]
HVDC Lead Engineering Manager, Programme Manager, Projects Controls Manager, Project Director, Quality Manager, Risk Manager	No work following reasonable completion of project	[•]
Senior Commercial Manager		[•]
Subsea Lead Project Manager	Not required following completion of construction works	[•]
Community Liaison Officers	Not required following completion of construction works	[•]
Construction Managers	Not required prior to mobilisation to site	[•]
Contract Managers	Not full time roles	[•]
Convertor Supervisors	Role not required	[•]
Document Controllers	Not required before site establishment and usage not consistent	[•]
HVDC Engineering Manager, Lead Design Engineer	Not required following completion of contractors design	[•]

Table 26 - Resource	Cause	Change	
Procurement Officer	Not required	[•]	
Project Engineers	Not required following completion of contractor's design	[•]	
Project Planning Engineers	Excessive resource allocation	[•]	
Project Co-coordinator	Not required before site establishment nor after completion of construction	[•]	
Quality Engineers	Not required before site establishment nor after completion of construction	[•]	
Quantity Surveyors	Not required before site establishment nor after completion of construction	[•]	
Technical Engineer HVDC, Technical Engineer UG Cable, Technical Lead Project Manager	Roles not required	[•]	
Graduate Engineer	(Overhead)	[•]	
[•] uplift (unallocated staff)	No justification	[•]	
Substituted [•] uplift	Same treatment as the other sub-projects	[•]	
Balancing figure	As per SHE Transmission spreadsheet [†††]	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 26: LT21: Caithness Moray Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•] which reduces the Project Management allowable cost to [•].

[†††] CM_G_021 Attachment 1_LT21 Project Management.xlsx

4.3.3 LT23: Dounreay-Mybster 275/132 kV Overhead Line and Substations

SHE Transmission submission includes Project Management resources for the period June 2014 to March 2019, a time period of 59 months. The resource estimate amounts to 1518 man-months of internal resources with a total cost of [•] plus [•] for Unallocated staff making a total Project Management Resource of [•]. This sum represents [•] of the main construction works cost of [•] which seems to be a high proportion for internal client resources for monitoring and managing competent contractors who are actually carrying out the work.

Key dates for the programme for the LT21 project are identified in Table 27 below:

Table 27: LT23: Dounreay-Mybster 275 kV Overhead Line and Substations	
Main Contract Award –	1st September 2014
New Thurso Substation	
Main Substation Contract Award	1st September 2014
Detailed Design Complete	4th April 2016
Civil Works Commence	6th March 2015
Main Substation Civil Works Complete	6th June 2016
Electrical Installation Commence	11th February 2016
Electrical Installation Complete	16th November 2016
Stage 1 Commissioning Commence	8th September 2016
Stage 1 Commissioning Complete	Date Not provided
Stage 2 Commissioning Commence	Date Not Provided
Stage 2 Commissioning Complete	26th June 2017
Old Substation Dismantle Commence	27th November 2017
Old Substation Dismantle Complete	22nd December 2017
Mybster Substation	
Civil Works Commence	6th March 2015
Main Substation Civil Works Complete	6th June 2016

Table 27: LT23: Dounreay-Mybster 275 kV Overhead Line and Substations	
Electrical Installation Commence	11th February 2016
Electrical Installation Complete	30th September 2016
Stage 1 Commissioning Commence	3rd October 2016
Stage 1 Commissioning Complete	Date Not provided
Stage 2 Commissioning Commence	Date Not Provided
Stage 2 Commissioning Complete	28th February 2018
Dounreay Substation	
Civil Works Commence	24th July 2015
Main Substation Civil Works Complete	2nd November 2015
Electrical Installation Commence	2nd November 2015
Electrical Installation Complete	12th April 2016
Stage 1 Commissioning Commence	12th April 2016
Stage 1 Commissioning Complete	Date Not provided
Stage 2 Commissioning Commence	Date Not Provided
Stage 2 Commissioning Complete	4th April 2017

Table 27: LT23: Dounreay-Mybster Key Dates

The key dates in the programme for LT23 show completion and full energisation of the overhead line and substations by 28th February 2018. Following energisation there are some Overhead line dismantling works (February 2019 – December 2019) but no other works are continuing after the energisation date.

DNV GL has reviewed the resource estimate against the role descriptions in the Project Execution Plan (PEP) and against the programme with the following results.

- Project energisation is programmed for 28th February 2018 and yet there are considerable resources identified from February 2018 to March 2019. The resources in this period amount to 173 man-months of effort at a cost of [•]. It would be normal for some resources to continue with completing the project paperwork for a period of about 4 months after completion of the project but not all resources are necessary in this period.

- The resource profile shows an AIS Electrical Supervisor at Mybster for the period November 2015 to March 2018 and an AIS Supervisor at New Thurso from December 2015 to December 2017. The project has full time site based project manager and construction manager at these sites and this resource is considered to be adequate for SHE Transmission client role.

- The resource profile indicates the need for a CAD engineer throughout the project to provide updated drawings and as built however all drawings are the responsibility of the contractor who has been paid to provide the necessary drawings. DNV GL assessment is that there is no requirement for SHE Transmission to have a CAD resource.

- The resource profile indicates a need for the CDMC from August 2014 to March 2019 but all works, including commissioning, are complete by February 2018 so there can be no requirement for a CDMC from March 2018.

- The resource profile shows a Site based Construction Manager. DNV assess that SHE Transmission site presence is required but that the times allocated may be slightly excessive.

- The Resource profile shows a Contracts Manager (Site based) full time from August 2014 until November 2018 and then reducing time to March 2019. The role is described as commercial forecast, monitoring and reporting, procurement of framework consents including consultants and contractors. It is difficult to justify a full time role, on site for this resource following contract award. The main substation The major works contracts including civil works for the substation are expected to have been awarded by 1st September 2014 and normal monitoring and reporting on the contracts are routinely carried out and reports supplied by the contractor's Quantity Surveyor. It is understood that SHE Transmission senior management may require detailed updates, normally monthly but this is hardly a full time job for a Contracts manager and there doesn't seem to be any need for him to be site based. DNV GL's analysis indicates that there should be a much reduced resource requirement for the Contract Manager following main contract award.

- The resource profile shows an Engineer (Civils) at Dounreay for the period March 2015 to June 2017 but the Civil works at Dounreay are completed by November 2015. Similarly there is an Engineer Civils allocated to Thurso and Mybster for the period December 2014 to February 2018 although the work at Mybster & New Thurso is completed by June 2016. There is a further Engineer Civils on the Overhead Line from October 2014 until December 2018, whereas the Overhead lines are complete by October 2017. DNV GL assessment is that these roles are not additional to other supervisory/inspection roles on site and are not required.

- The resource profile shows a site based Engineer (Electrical), whose role is overseeing site electrical design and testing and ensuring contractor compliance with requirements, at Dounreay for the period August 2014 to September 2017 but the programme shows that the Electrical works at Dounreay are completed by April 2016. DNV assessment is that any requirement for this work can be undertaken by the site project manage and/or site construction manager and further site based resource is not required.

- There is also a site based Electrical Engineer allocated to Thurso and Mybster substations from August 2015 to March 2018 and a Site Electrical Engineer allocated to the Overhead

Line works from January 2015 to March 2019 although the overhead line work is complete by October 2017. DNV assessment is that any requirement for this work can be undertaken by the site project manage and/or site construction manager and further site based resource is not required.

- The resource profile identifies an Environmental Officer/Manager and an Environmental Adviser from August 2014 to March 2019 however all construction works are complete by November 2017and these resources would not be required after completion of construction.

- The resource profile identifies a Field Engineer from October 2014 to March 2019. The role is described in the PEP as Site based, reporting to Transmission Operations Manager, responsible for liaison from Operations and checking ongoing installation on behalf of Operations. DNV GL assessment is that this role provides no function relating to the project as there are already other staff checking the installation, and that the role should be removed

- The resource profile identifies a Forestry and Tree Cutting Manager from August 2014 to February 2019. However tree removal is one of the project preparation works and is shown on the programme as complete by January 2015 in which case there is no role for this resource after January 2015.

- The resource profile shows a GIS supervisor at Dounreay for the period August 2014 to July 2017. This role is not described in the PEP although there is a GIS Site Electrical Engineer which may be this resource. DNV assessment is that this role is included in the role of other site staff and is not required.

- The resource profile shows a Graduate Engineer Civils at Dounreay and Thurso & Mybster for the period June 2015 to June 2016. In a similar way to the Engineer Civil, DNV GL assessment is that this role is not required after completion of the site civil works.

- The resource profile shows a Graduate Engineer Electrical at Dounreay, Thurso & Mybster and on the Overhead line. In a similar way to the Engineer Electrical, DNV GL assessment is that this role is not required after completion of the site civil works.

- The resource profile shows a site based Project Engineer – Cables for the project from August 2014 to November 2018. The drawings show that there are only two short lengths of cable at Dounreay and these works are complete by April 2016. New Thurso and Mybster do not have any cable works. DNV GL assessment is that the Project Engineer is only required during cable installation at Dounreay

- The resource profile identifies a Project Engineer (Civil) for the period August 2014 to February 2019 but all civil works are complete by February 2017 so there is no requirement for a civil project engineer for a further 2 year period

- The resource profile identifies a Project Engineer (Design) for the period August 2014 to January 2019 but all construction works are complete by February 2017 so there is no requirement for a project engineer (design) for a further 2 year period

- The resource profile identifies a Project Engineer (Telecoms) for the period August 2014 to December 2018 but all substation construction works are complete by November 2016 so there is no requirement for a project engineer (design) for a further 3 year period

- The resource profile identifies a site-based QS for Dounreay from September 2014 to October 2017 however the electrical installation at Dounreay is completed by April 2016, so there should be no need for a QS after that time. Similarly, at Thurso & Mybster there is a QS programmed from July 2014 to March 2018 yet the electrical installation is due to be completed by November 2016. Again, a QS is programmed for the overhead line from August 2014 to February 2019 whereas the installation work is due to be completed by February 2017.

- The resource profile shows a Site Environmental Clerk of Works at Dounreay for the period May 2015 to July 2017. As the Civil works at Dounreay are completed by November 2015 and it is likely that most of this work is required during the civil phase of works, DNV GL assessment is that this role is not required after November 2015. Similarly, a Site Environmental Clerk of Works is identified for Thurso & Mybster from November 2014 to December 2017 where the civil works is complete by June 2016

- The resource profile identifies 4 Site Project Managers on this project, one at each substation and one for the overhead line. These are all supported by project engineers and a site construction manager. After reviewing the scope of works and mindful that the role is client project manager and that the contractors have appointed a project manager to manage the actual design and construction works, it is DNV GL assessment that this is not a full time role for any of the sites and furthermore, the role is not required following reasonable completion of the works.

- The resource profile identifies a need for a Wayleaves Officer from August 2014 to March 2019 and a Wayleaves Assistant for the period from November 2014 to February 2018. The construction work on the overhead lines is completed by October 2017 and there should be no requirement for Wayleaves support on the project after the completion of construction.

DNV GL's analysis of the Project Management resource costs indicates that there is an overestimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 28 below:

Table 28: Resource	Cause	Change
SHE Transmission resource submission		[●]
All Resources	All site commissioned and energised by February 2018. No further work required following completion of final records	[●]

Table 28: Resource	Cause	Change
AIS Supervisor	AIS Installation complete at New Thurso by November 2016 and at Mybster by September 2016. Not required after this time	[•]
CAD Engineer	Not required as contractor provides drawings and as built	[•]
CDMC	Not required when site works complete	[•]
Construction Manager (Site)	Role appears to be similar to Project Manager, not required	[•]
Contracts Manager (Site)	Not full time role	[•]
Engineer (Civils)	Civil works complete at Dounreay by November 2015, at New Thurso & Mybster by June 2016 and on the overhead Line by March 2017. Civil Engineer not required to check contractor designs following completion of works	[•]
Engineer (Electrical)	Electrical works complete at Dounreay by April 2016, at New Thurso and Mybster by June 2016 and on the overhead line by February 2017. Electrical Engineer not required to check contractor designs when installation works complete.	[•]
Environmental Officer/Manager & Environmental Adviser	Not required following completion of construction in Nov 2017	[•]
Field Engineer	Not required	[•]
Forestry and Tree Cutting Manager	Not required following completion of tree clearance in January 2015	[•]

Table 28: Resource	Cause	Change
GIS Supervisor	Dounreay electrical installation complete by April 2016. GISC supervisor not required after that time	[•]
Graduate Civil Engineers/Technicians	Civil works complete at Dounreay by November 2015, at New Thurso & Mybster by June 2016 and on the overhead Line by March 2017. Civil Engineer not required to check contractor designs following completion of works	[•]
Graduate Electrical Engineers/Technicians	Electrical works complete at Dounreay by April 2016, at New Thurso and Mybster by June 2016 and on the overhead line by February 2017. Electrical Engineer not required to check contractor designs when installation work complete.	[•]
Project Engineer (Cable)	Cable works complete by April 2016	[•]
Project Engineer (Civil)	Civil works complete by Feb 2017	[•]
Project Engineer (Design)	Electrical installation complete by February 2017	[•]
Project Engineer (Telecoms)	Substation construction complete by November 2016	[•]
QS Dounreay	Substation construction complete by November 2016	[•]
QS Thurso & Mybster	Substation construction complete by November 2016	[•]
QS Overhead Line	Overhead Line Construction complete by October 2017	[•]

Table 28: Resource	Cause	Change	
Site Environmental Clerk of Works	Not required following completion of civil works	[•]	
Site Project Manager	Not required full time and not required following reasonable completion of project	[•]	
Wayleaves Officer/Assistant		[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 28: LT23: Dounreay-Mybster Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•] which reduces the Project Management allowable cost to [•].

4.3.4 LT24: Fyrish 275/132 kV Substation

SHE Transmission submission includes Project Management resources for the period February 2015 to November 2018, a time period of 46 months. The resource estimate amounts to 495 man-months of internal resources with a total cost of [•] plus [•] for unallocated staff making a total Project Management Resource of [•].

LT24, LT25 & LT42 is a coordinated project with Key dates for the programme for the three projects identified in Table 29 below:

Table 29: LT24: Fyrish, LT25: Loch Buidhe Substations, & LT42: Beauly-Loch Buidhe Re-conducting Key Dates	
Contract Award – Underground Cable Design	14th Aug 2013
Contract Award – Transformer Design	23rd August 2013
Contract Award – Substation Design	4th December 2013
LT24: Fyrish Substation	
Main Substation Contract Award	15th January 2015
Civil Works Commence	1st April 2015

Main Substation Civil Works Complete	3rd May 2016
Electrical Installation Commence	4th May 2016
Electrical Installation Complete	23rd December 2016
Stage 1 Commissioning Commence	4th January 2017
Stage 1 Commissioning Complete	1st June 2017
Stage 2 Commissioning Commence	2nd June 2017
Stage 2 Commissioning Complete	26th October 2017
Landscaping and Reinstatement Commence	2nd June 2017
Landscaping and Reinstatement Complete	10th Nov 2017
LT25: Loch Buidhe Substation	
Civil Works Commence	1st April 2015
Main Substation Civil Works Complete	31st May 2016
Electrical Installation Commence	1st June 2016
Electrical Installation Complete	9th February 2017
Stage 1 Commissioning Commence	10th February 2107
Stage 1 Commissioning Complete	26th October 2017
Stage 2 Commissioning Commence	27th October 2017
Stage 2 Commissioning Complete	27th April 2018
Landscaping and Reinstatement Commence	14th July 2017
Landscaping and Reinstatement Complete	22nd Dec 2017
LT42: Beauly to Loch Buidhe Re-conductoring	
Commence Phase 1	4th April 2016
Complete Phase 1	14th October 2016

Commence Phase 2	3rd April 2016
Complete Phase 2	26th May 2017
Landscaping and Reinstatement Commence	18th April 2016
Landscaping and Reinstatement Complete	1st Aug 2017

Table 29: Fyrish & Loch Buidhe Substations & Beauly-Loch Buidhe OHL - Key Dates

The key dates in the programme for LT24 Fyrish Substation demonstrate that the new substation at Fyrish is fully constructed and stage 2 commissioned by 26th October 2017.There is some landscaping works to complete after this date but this is shown as complete by 10th November 2017 after which there are no further works at Fyrish.

DNV GL has compared the resource estimate to the Level 2 programme submitted as part of the Cost and Outputs submission. The resource submission shows a significant project management resource requirement through to November 2018. The resource cost estimate in this period equates to 161 man-months of effort or [•]. It is recognised that projects are not complete on the day of commissioning and that there is a period of completing records following energisation but this period should not be 12 months, a four month period should be sufficient. DNV GL assessment is that the Project Management resource is excessive in the period December 2017 – November 2017 by [•].

DNV GL has reviewed the resource estimate against the role descriptions in the Project Execution Plan (PEP) with the following results:

- The programme shows that main Civil Works are completed by the end of May 2016. There is some landscaping works to be completed in the period June – November 2017 but, following completion of site records, it is difficult to justify two civil engineers continuing to work on the project particularly in the period from September 2016 – August 2017. Similarly, there appears to be no justification for either a Site Civil engineer or Site Civil Technician once the civil works are completed. DNV GL assessment is that these resources are not required and the resource estimate should be reduced by [•].

- The resource profile identifies four engineering roles responsible for checking the contractors electrical designs. Electrical construction is complete by December 2016 so it is difficult to see what designs are being checked after this time and arguably, the contractors designs are completed well before this date to allow completion of the installation. DNV GL assessment is that these resources should have a reduction of [•].

- The resource estimate identifies a Site GIS Technician for Fyrish substation but Fyrish is an AIS substation with 275 kV AIS busbars and a 132 kV AIS double busbar substation. The drawings and technical scope of work do not identify any GIS equipment on the site so DNV GL assessment is that this resource should be removed from the estimate which should therefore be reduced by [•].

- The resource estimate identifies a Resident Engineer Electrical and a Site Electrical Technician from February 2015 through to December 2017. As there are no electrical works until May 2016 there seems to be little role for a these resources until, say, April 2016 Furthermore, these roles can be covered by the site construction manager and the engineering graduate so DNV GL assessment is that this resource is not required, leading to a reduction of [•].

- The resource estimate includes a FAT Engineer – Electrical from February 2015 to December 2017. As all the electrical installation is complete by December 2016, there can be no need for a FAT Engineer Electrical form December 2016 onwards, it is arguable that all FAT testing will be complete well before December 2016 but DNV GL assessment is that the resource estimate should be reduced by [•].

- The resource profile for Project Support manager has an average of about one day per month throughout the project but September 2017 has 68 days in the month. It is assumed that this is an error in the profile and should be reduced by 67 hours or [•].

- The resource profile includes a Project Construction Manager who is site based, apparently full time shared between LT24, LT25 & LT42. There does not appear to be a role description for this position but there is already a Full time site based Project Manager and a site Construction Manager on each of the projects along with support staff. This role does not appear necessary and should be removed.

- The Site Environmental Clerk of Works is responsible for supervision and management of the environmental compliance of the construction site. This work would be most necessary during the civil phase of works but it is difficult to understand a role during the Electrical Installation and commissioning of the site. DNV GL assessment is that the resource should not be necessary during Electrical installation and commissioning.

- The resource profile includes a Contract Administrator part time and then full time throughout the project. DNV GL assessment is that this is not a full time role and an adjustment should be made to the allocation.

As stated in the introduction to this section, LT24, LT25 and LT42 are three co-ordinated and connected projects. DNV GL has examined the three Project Management resource schedules as a group and there are some examples of identical resource profiles within the group and resource types that do not seem appropriate in all three projects. DNV GL assessment of these anomalies is set out here:

- Wayleave Officer and Assistant Wayleave Officer: Each of the three projects LT24, LT25 & LT42 has an almost identical resource profile for these resources. Wayleave Officers are normally associated with construction of Overhead line works and strangely the Wayleave Officer profile for LT42 (overhead Line project) has slightly less resource than either of the two substation projects. All the Overhead line works, including the tower changes at the substations will be carried out by the Overhead line contractor and are included in the cost of LT42. DNV GL assessment is that the Wayleave and Assistant Wayleave resources included in the substation projects should be disallowed.

- Environmental Adviser OHL: Following the same argument as for the Wayleave Officers, there is no need for an Environmental Advised OHL on a substation project, this resource is already captured in project LT42
- OHL Design Engineer: Similarly there is no requirement for an Overhead Line Design Engineer on the Substation project as this resource resides within LT42 profile.
- SAP (OHL): Again, this resource is duplicated in LT42, there is already and SAP in the Substation project and the SAP in LT42 and this is where the resource should be allocated.

DNV GL's analysis of the Project Management resource costs indicates that there is an overestimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 30 below:

Resource	Cause	Change	SHE T Estimate
All Resources			[•]
All Resources	Substation commissioned by Oct 2017	[•]	
Civil Engineering	Civil Works complete May 2016	[•]	
Electrical Engineering	Electrical works complete by December 2016	[•]	
CAD Engineer	Not required as contractor provides drawings and as built	[•]	
Site GIS Technician	No GIS on site	[•]	
Site Electrical Engineering	Site electrical resource not required until Electrical build commences	[•]	
FAT Engineer - Electrical	No FAT tests following completion of electrical installation	[•]	
Project Support Manager	Error in profile for September 2017	[•]	
Wayleave Officer	Not required for Substation project	[•]	
Assistant Wayleave Officer	Not required for Substation project	[•]	

Resource	Cause	Change	SHE T Estimate
Environmental Adviser OHL	Not required for Substation project	[•]	
Overhead Line Engineer	Not required for Substation project	[•]	
SAP (OHL)	Not required for Substation project	[•]	
Project Construction Manager	Duplicated resource, not required	[•]	
Site Environment COW	Not required during Electrical Installation and commissioning	[•]	
Contract Administrator	Not full time role	[•]	
Total Reduction / Revised Estimate		[•]	[•]

Table 30: LT24: Fyrish Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•], which reduces the Project Management allowable cost to [•].

4.3.5 LT25: Loch Buidhe 275/132 kV Substation

The key dates in the programme for LT25 Loch Buidhe Substation demonstrate that the new substation at Loch Buidhe is fully constructed and Stage 2 commissioned by 27th April 2018 after which there are no further works at Buidhe.

DNV GL has examined the resource profile and noted that it is absolutely identical in every way to the profile for Fyrish substation. DNV GL consider this curious as, although much of the construction work is similar, the programmes of construction are different. The programmes both commence site works in April 2015 but Fyrish is Stage 2 commissioned by October 2017 whereas Loch Buidhe is not Stage 2 commissioned until April 2018. DNV GL would have expected differences in the project management due to these programme differences and anticipate that these differences have been identified and appropriate adjustments made in their assessments which identifies different savings form the submitted profiles.

DNV GL has compared the resource estimate to the Level 2 programme submitted as part of the Cost and Outputs submission.

- The programme shows that main Civil Works are completed by the end of May 2016. There is some landscaping works to be completed in the period July – December 2017 but, following completion of site records, it is difficult to justify two civil engineers continuing to work on the

project particularly in the period from September 2016 – April 2017. Similarly, there appears to be no justification for either a Site Civil engineer or Site Civil Technician once the civil works are completed. DNV GL assessment is that these resources are not required and the resource estimate should be reduced by [•].

- The resource profile identifies four engineering roles responsible for checking the contractors electrical designs. Electrical construction is complete by February 2017 so it is difficult to see what designs are being checked after this time and arguably, the contractors designs are completed well before this date to allow completion of the installation. DNV GL assessment is that these resources should have a reduction of [•].

- The Resource profile identifies a CAD engineer whose role is described as providing updated drawings through the contract period and as-built. As the contractor is required to provide all drawings and as-built, there does not seem to be a role for this resource which should be removed from the profile requirement.

- The resource estimate identifies a Site GIS Technician for Loch Buidhe substation but Loch Buidhe is an AIS substation with 275 kV AIS busbars and a 132 kV AIS double busbar substation. The drawings and technical scope of work do not identify any GIS equipment on the site so DNV GL assessment is that this resource should be removed from the estimate which should therefore be reduced by [•].

- The resource estimate identifies a Resident Engineer Electrical and a Site Electrical Technician from February 2015 through to December 2017. As there are no electrical works until May 2016 there seems to be little role for a these resources until, say, April 2016. Furthermore, these roles can be covered by the site construction manager and engineering graduate so DNV GL assessment is that this resource is not required, leading to a reduction of [•].

- The resource estimate includes a FAT Engineer – Electrical from February 2015 to December 2017. As all the electrical installation is complete by February 2017, there can be no need for a FAT Engineer Electrical from February 2017 onwards, it is arguable that all FAT testing will be complete well before December 2016 but DNV GL assessment is that the resource estimate should be reduced by [•].

- The resource profile for Project Support Manager has an average of about one day per month throughout the project but September 2017 has 68 days in the month. It is assumed that this is an error in the profile and should be reduced by 67 hours or [•].

- The resource profile includes a Project Construction Manager who is site based, apparently full time shared between LT24, LT25 & LT42. There does not appear to be a role description for this position but there is already a full time site based Project Manager and a Site Construction Manager on each of the projects along with support staff. This role does not appear to be necessary and should be removed.

- The resource profile identifies a Project Office Manager responsible for project office management and a Site QA & Admin Manager responsible for overall administration /

coordination and support to the site team. This is a considerable amount of office management and DNV GL assessment is that one person only is required.

- The Site Environmental Clerk of Works is responsible for supervision and management of the environmental compliance of the construction site. This work would be most necessary during the Civil Phase of works but it is difficult to understand a role during the Electrical Installation and commissioning of the site. DNV GL assessment is that the resource should not be necessary during Electrical installation and commissioning. This also applies to the QS who is unlikely to be necessary during the Electrical works.

- The resource profile includes a Project Administrator part time and then full time throughout the project. DNV GL assessment is that this is not a full time role and an adjustment should be made to the allocation.

As stated in the introduction to this section, LT24, LT25 and LT42 are three co-ordinated and connected projects. DNV GL has examined the three Project Management resource schedules as a group and there are some examples of identical resource profiles within the group and resource types that do not seem appropriate in all three projects. DNV GL assessment of these anomalies is set out here:

- Wayleave Officer and Assistant Wayleave Officer: Each of the three projects LT24, LT25 & LT42 has an almost identical resource profile for these resources. Wayleave Officers are normally associated with construction of Overhead line works and strangely the Wayleave Officer profile for LT42 (overhead Line project) has slightly less resource than either of the two substation projects. All the Overhead line works, including the tower changes at the substations will be carried out by the Overhead line contractor and are included in the cost of LT42. DNV GL assessment is that the Wayleave and Assistant Wayleave resources included in the substation projects should be disallowed.

- Environmental Adviser OHL: Following the same argument as for the Wayleave Officers, there is no need for an Environmental Advised OHL on a substation project, this resource is already captured in project LT42

- OHL Design Engineer: Similarly there is no requirement for an Overhead Line Design Engineer on the Substation project as this resource resides within LT42 profile.

- SAP (OHL): Again, this resource is duplicated in LT42, there is already and SAP in the Substation project and the SAP in LT42 and this is where the resource should be allocated.

DNV GL's analysis of the Project Management resource costs indicates that there is an overestimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 31 below:

Table 31 - Resource	Cause	Change
SHE Transmission resource submission		[●]

Table 31 - Resource	Cause	Change
All Resources	Substation commissioned by Oct 2017	[•]
Civil Engineering	Civil Works complete May 2016	[•]
Electrical Engineering	Electrical works complete by February 2017	[•]
CAD Engineer	Not required as contractor provides drawings and as built	[•]
Site GIS Technician	No GIS on site	[•]
Site Electrical Engineering	Site electrical resource not required until Electrical build commences	[•]
FAT Engineer - Electrical	No FAT tests following completion of electrical installation	[•]
Project Support Manager	Error in profile for September 2017	[•]
Wayleave Officer	Not required for Substation project	[•]
Assistant Wayleave Officer	Not required for Substation project	[•]
Environmental Adviser OHL	Not required for Substation project	[•]
OHL Engineer	Not required for Substation project	[•]
SAP (OHL)	Not Required for Substation Project	[•]
Project Office Manager	Role overlaps with Site QA & Administration Manager. Role not therefore required	[•]
Project Construction Manager	Duplicated resource, not required	[•]

Table 31 - Resource	Cause	Change	
Site Environment COW	Not required during Electrical Installation and commissioning	[•]	
Contract Administrator	Not full time role	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 31: LT25: Loch Buidhe Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of of [•] which reduces the Project Management allowable cost to [•].

4.3.6 LT42: Beauly-Loch Buidhe Reconductoring

SHE Transmission submission includes Project Management resources for the period February 2015 to June 2018, a time period of 41 months. The resource estimate amounts to 443 man-months of internal resources with a total cost of [•] plus [•] for unallocated staff making a total Project Management Resource of [•]. This sum represents [•] of the main construction works cost of [•] which seems to be a high proportion for internal client resources for monitoring and managing competent contractors who are actually carrying out the work.

The key dates for this project show that mobilisation for Phase 1 works is in April 2016 with completion of Phase 1 by October 2016. Mobilisation for Phase 2 works in April 2017 with completion of all works by May 2017. Landscaping and reinstatement will take placed from April 2016 until August 2017. The Key dates for the programme for the LT42 project are identified in Table 29 above:

DNV GL has reviewed the resource estimate against the role descriptions in the Project Execution Plan (PEP) and against the programme with the following results.

- Project completion is programmed for 26th May 2017 and yet there are considerable resources identified from May 2017 to June 2018. DNV GL recognises that there is time required for project completion and assess that this should be finished by the end of September 2017. The resources estimated from October 2017 to June 2018 amount to 36 man-months of effort at a cost of [•].

- The resource profile indicates the need for a CAD engineer throughout the project to provide updated drawings and as built however all drawings are the responsibility of the contractor who has been paid to provide the necessary drawings. DNV GL assessment is that there is no requirement for SHE Transmission to have a CAD resource.

- The resource profile identifies a Civil Design Manager, Civil Engineer, Resident Engineer Civil, Site Civil Technician for varying periods during the project. This is a fittings and conductor replacement project and is the second circuit to be replaced on these towers. DNV GL

assessment is that there are no civil construction works required and any tower strengthening or refurbishment necessary should already have been carried out.

- The resource profile identifies a site based Contract Administrator and a QS full time on the Overhead line project. The role is not defined in the PEP but looking at other projects the role appears to be reporting to the Senior Commercial Surveyor with the Commercial Management, Control, administration and reporting of specific elements of the OHL works. These two resources appear to be carrying out the same role yet this project is a straightforward fittings and conductor replacement project. As such it is not anticipated that there would be enough work for one person never mind two.

- The Project Management Resource schedule includes a Commissioning Engineer and an SAP Overhead Lines. For consistency with the other projects, this resource has been moved to the Commissioning section and has been considered that section of the report

- The resource profile shows an Electrical Design Manager and an Engineering Manager but the Engineering manager doesn't appear on the organogram or in the PEP role description. It looks as if the Engineering Manager is a duplicated role and should be removed.

- The resource profile identifies a Field Unit Manager. From other projects it appears that the field unit role is reporting to Transmission Operations Manager, responsible for liaison from Operations and checking ongoing installation on behalf of Operations. DNV GL assessment is that this role provides no function relating to the project and that the role should be removed

- The resource profile identifies a Project Controls Planner, a Project Controls Engineer and site based Transmission Planning. This appears to be excessive planning resource for a relatively straightforward conductor and fittings replacement project – the resources should be adjusted downwards accordingly.

- The resource profile identifies a site based Project Office Manager. This is a highly expensive resource and DNV GL assessment is that the role is not value for money on site and is not required

- The resource profile identifies a Site based Electrical Technician and a site based Engineering Graduate both full time. Their role is described as assisting the Resident Engineering staff with supervision and recording of the construction works. This project is a straightforward fittings and conductor replacement project and is unlikely to require 2 full time staff to record the works. There is also no work to record prior to mobilisation for Phase 1 or between completion of Phase 1 and site mobilisation for Phase 2.

- The resource profile shows a Site Environmental Manager, a Site Environmental Clerk of Works, a Site H&S Manager, and a Site QA allocated throughout the project but there can be no requirement for this resource between completion of Phase 1 and site mobilisation for Phase 2.

- The resource profile shows a site based Project Manager, site based Project Construction Manager and a Site Construction Manager allocated to this project. The PEP describes the Project Construction Manager role as reporting to the Project Manager with the principal role

of coordinating the construction and commissioning elements of the works. The organogram shows that the Construction Manager sits between the Project Manager and the Project Engineers. The Site Construction Manager does not appear to be on the organogram but is understood to be a site based engineer. The project manager is also supported by project engineers and technicians. DNV GL assessment is that the role of Project Construction Manager is not required.

DNV GL's analysis of the Project Management resource costs indicates that there is an overestimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 32 below:

Table 32 - Resource	Cause	Change	SHE Transmission Estimate
All Resources			[•]
All Resources	All complete by May 2017. No further work required following completion of final records by September 2017	[•]	
CAD Engineer	Not required as contractor provides drawings and as built	[•]	
Civil Design Manager, Civil Engineer, Resident Engineer Civil, Site Civil Technician	No civil works, not required	[•]	
Commissioning Engineer / SAP Overhead Line	For consistency with other projects, moved to commissioning resource	[•]	
Contract Administrator & QS	Insufficient work for 2 site based people. Remove Contract Administrator. Also no work for QS in period between completion of Phase 1 and mobilisation for Phase 2	[•]	
Engineering Manager	Duplicated role	[•]	
Field Unit Manager	No role in project	[•]	

Table 32 - Resource	Cause	Change	SHE Transmission Estimate
Project Controls Engineer / Transmission Planning	Duplicated roles to be removed	[•]	
Project Manager, Site based Project Construction Manager and a Site Construction Manager	Three Project Managers: one not required	[•]	
Project Office Manager	Not required	[•]	
Resident Engineer Electrical	Not required prior to mobilisation to site nor in period between completion of Phase 1 and mobilisation for Stage 2	[•]	
Site Electrical Technician and Site Graduate Engineer	Not enough work for two engineers and no work prior to mobilisation and between work phases	[•]	
Site Environmental Manager & Clerk of Works, Site H&S Manager and Site QA Manager	Not required between phases 1 and 2	[•]	
Total Reduction / Revised Allowance		[•]	[•]

Table 32: LT42: Beauly-Loch Buidhe OHL Project Management Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•] which reduces the Project Management allowable cost to [•].

4.3.7 Conclusion Project Management Resource Estimates

The above considerations for all the sub-projects are summarised in Figure 24.

Figure redacted

Figure 24: Project Management - summary of costs assessment

Figure 24 indicates that, for the Project Management costs for the Caithness-Moray transmission reinforcement, some [•] could reasonably be removed from the SHE Transmission submission.

4.4 SHE Transmission Commissioning Resource

4.4.1 LT41: Blackhillock 400/2756/132 kV Substation WBS

DNV GL has analysed the SHE Transmission submission commissioning resource estimates with the construction programmes and has found a number of areas of concern.

- According to the programme the three components of the Blackhillock development are fully stage 2 commissioned by May 2017. It is recognised that final records work needs to be completed following final commissioning but this should take no longer than 3 months interaction with the contractors and is not a full time job over that period. In fact, the resource schedule shows the Commissioning engineer AIS leaving the project 2 months after the completion of commissioning of the 275 kV substation.

- Three Commissioning engineers have been allocated to the project with one dedicated commissioning engineer allocated for each of the 132 kV GIS, 275 kV AIS and 400 kV GIS substations. Following the logic of the allocation for Commissioning Engineer (AIS), DNV GL's assessment is that the 132 kV GIS commissioning engineer should finish by July 2017 and the 400 kV GIS commissioning engineer should finish by May 2017.

- It is noted that the Commission Lead is allocated from November 2014, 11 months in advance of the commencement of stage 1 commissioning of the 275 kV substation. This is considered a sensible approach to ensure that preparations for stage 2 commissioning are adequately prepared for in advance. However it is not expected that the Commissioning Lead would need to be allocated full time through the Stage 1 commissioning as this is commissioning to demonstrate the correct operation of equipment and is the absolute responsibility of the contractor. SHE Transmission role would be witnessing of tests where they wished to do so and it is not expected that this could be a full time role. There is no explanation for the reduction in the allocation of this resource in January 2017 and whereas, 2.5 days per week still look excessive during Stage 1 commissioning, DNV GL assessment is that it would be acceptable for the Commission Lead to be allocated for 50% of his time to this project through the Stage 1 commissioning period.

- As indicated above, in addition to the Commissioning Lead, there are 3 Commissioning Engineers allocated full time throughout the Stage 1 commissioning of the substation. The substation is not energised and remains the responsibility of the main contractor until it comes under SHE Transmission Safety Rules. The commissioning role during stage 1 commissioning is to witness tests for correct operation of the new equipment. As the substations will not be energised and the responsibility for correct operation lies with the contractor, it is difficult to envisage a full time role for three commissioning engineers as the main contractor is required to provide commissioning engineers themselves to plan and carry out the stage 1 tests. Again,

DNV GL assessment is that 50% of the time allocated to the project during Stage 1 commissioning remains excessive but is acceptable for the current assessment.

- There is a Field Engineer allocated to the project. The role is described as reporting to the Transmission Operations Manager and responsible for ongoing liaison from Operations and checking ongoing installation on behalf of operations. This resource is allocated mainly at 50% of his time through most of the project and full time during the demolition phase of the old 275 kV substation. DNV GL assessment is that the role of liaison with Operations Department and checking ongoing installation should be via the Project Manager and his regular reports to senior management. This resource represents a cost of [•] but DNV GL assessment is that there is no need for this resource and it should be removed.

- The Commission SAP is described as responsible for formal authorisation of commissioning and energisation of assets for both Stage 1 and Stage 2 of the AIS elements of the works. DNV GL would expect and SAP to be available for the AIS and GIS parts of the works however the requirement for an SAP is not expected to be necessary until the substation comes under SHE Transmission Safety Rules. Whereas DNV GL assessment is that the requirement for ands SAP is less than that allocated during Stage 1 commissioning, having reviewed the allocation any reduction in SAP resource is considered to be immaterial.

- The programme describes a two month period to de-energise the old 275 kV substation followed a 3 month Demolition phase of old to 4th January 2019. Following decommissioning of the old 275 kV substation there can be no role for Commission Lead and Commissioning engineer, it is also unclear what role and SAP could have during the demolition phase of the work. DNV GL assessment is that these roles should not be allocated during the demolition phase of the old 275 kV substation.

DNV GL's analysis of the Commissioning resource costs indicates that there is a large over estimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 33 below:

Resource	Cause	Change
SHE Transmission resource submission		[•]
ALL Resources	No work on site May 2017 – July 2018	[•]
Commission Lead	Reduced Allocation during Stage 1 Commissioning	[•]
Commissioning Engineer (AIS), 1 & 2	Reduced Allocation during Stage 1 Commissioning	[•]
Field Engineer	Resource not required	[•]

All resources	Reduced allocation during demolition of old 275 kV substation	[•]
Total reduction / Recommended allowance		[•] [•]

Table 33: LT41: Blackhillock Commissioning Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•] reducing the Commissioning allowable cost to [•].

4.4.2 LT21: Caithness – Moray HVDC Reinforcement

SHE Transmission resource estimate for Commissioning totals 237.7 man-months at a cost of [•]. It is noted that the value for commissioning in the Cost Summary WBS breakdown is [•] but there is no other document explaining the difference between these values. DNV GL has used the Resource profile and programme in this assessment.

- The resource profile identifies a Commissioning Lead HVDC commissioning allocated from May 2014 but the main contracts will not be placed until November 2014. No work on commissioning is therefore required in this period
- The resource profile identifies a Project Engineer HVDC Commissioning working 50% of his time throughout the construction and commissioning phase. The role is described as responsible for the commissioning engineering for the project. The responsibility for commissioning lies with the contractor and their proposals should be reviewed via client commissioning panels by the Commissioning Lead and the Project Manager. There is no requirement for this role on other component projects and therefore there does not seem to be any role in this project either
- The resource profile identifies two commissioning engineers for Spittal substation allocated full time from June 2016 to August 2017. As commissioning proposal will be engineered by the contractor who will be providing commissioning engineers to carry out the work, there is insufficient client work to justify two SHE Transmission engineers. The resource profile also identifies
- The resource profile identifies two field engineers whose role is described as responsible for asset operation and takeover. The Field Engineer for the North is allocated full time on the HVDC project from August 2015 and then split between Spittal substation and Spittal HVDC from November 2015 until February 2017 and then full time again on Spittal HVDC until May 2018. This profile means that the field engineer is allocated prior to completion of civil works but there is no reason for him to be involved at this stage. The site is a construction site under the contractors control and there is nothing to takeover and operate. It is not anticipated that there is any work for this resource until the Electrical Installation works are completed. The resource allocation also switches to full time on the HVDC project when the work at Spittal is

complete, this doesn't make any sense at all. Similarly, the Field Engineer on Blackhillock HVDC is full time throughout whereas the one at Spittal is 50%. This also doesn't make sense as the work at both convertor stations is similar.

DNV GL's analysis of the Commissioning resource costs indicates that there is a large over estimate of resource costs in the Costs and Outputs submission. DNV GL analysis is summarised in Table 34 below:

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Commissioning Lead HVDC	No required prior to placement of contracts	[•]	
Project Engineer HVDC Commissioning	Resource not required	[•]	
Commissioning Engineers	Excessive resource allocated	[•]	
Field Engineers	Excessive resource allocated	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 34: LT21: Commissioning Resource Estimates

DNV GL analysis indicates a cost estimate excess of [•] reducing the Commissioning allowable cost to [•].

4.4.3 LT23: Dounreay-Mybster 275/132 kV Overhead Line and Substations

SHE Transmission resource estimate for Commissioning totals 61 man-months at a cost of [•]. Although there are three substations involved and an overhead line, this doesn't compare favourably with SHE Transmissions estimate for Fyrish. New Thurso substation has a similar scope of work to Fyrish but Mybster has much less scope and yet the total submitted for New Thurso and Mybster is more than twice the estimate for Fyrish. These estimates do not therefore seem to be consistent.

DNV GL has carried out a review of the commissioning resource against the programme, unfortunately the programmes provided did not identify the completion of Stage 1 commissioning and the start of Stage 2 commissioning. DNV GL has therefore made some assumptions based on the scope of work and likely duration of the commissioning work.

DNV GL assessment is set out below:

- The SHE Transmission resource profile has commissioning resource as late as December 2018 yet, for all sites, Stage 2 commissioning is complete and all works energised by 28th

February 2018, there is therefore no requirement for commissioning resource beyond February 2018.

- The SHE Transmission profile includes a Commissioning Lead from December 2014 until December 2018 commencing with four days per month and increasing to 6 days per month from January 2016. That is a considerable resource in the period from December 2014 to April 2016 when the first substation commences Stage 1 commissioning. From January 2016 there is also two further commissioning engineers allocated up to the commencement of Stage 1 commissioning. DNV GL assessment is that the Lead Commissioning engineer resource is more than adequate to attend early commissioning meetings and that there is no requirement for further commissioning engineers prior to the commencement of Stage 1 testing.
- For commissioning of the Overhead Line, the profile starts at 2.5 days per week and then, part way through the commissioning, increases to 5 days per week. There appears to be no logical reason for this and DNV GL assessment is that this should remain at 2.5 days per week.
- For New Thurso and Mybster, the profile indicates 2.5 days per week for each site so that the requirement drops to 2.5 days per week when New Thurso is complete only it doesn't reduce immediately.
- For Dounreay, the SHE Transmission profile shows a commissioning resource requirement for 5 months after the completion of commission.

DNV GL assessment of necessary commissioning resources is set out in Table 35 below:

Resource	Cause	Change	
SHE Transmission resource submission			[•]
Overall Lead Commissioning Engineer	No work after February 2018	[•]	
OHL Commissioning Engineer	See text above	[•]	
New Thurso & Mybster Commissioning Engineer	See Text above	[•]	
Dounreay	See Text Above	[•]	
Total reduction / Recommended allowance		[•]	[•]

Table 35: LT23: Commissioning Resource Estimates for Dounreay-Mybster OHL and Substations

DNV GL analysis indicates a cost estimate excess of [•] reducing the Commissioning allowable cost to [•].

4.4.4 LT24: Fyrish 275/132 kV Substation WBS

SHE Transmission resource estimate for Commissioning totals 12 man-months at a cost of [•]. The resource estimate looks quite odd in the build up to the commencement of Stage 1 commissioning with 10 days every other month for the Commissioning Engineer. DNV GL took the view that this was a strange profile but equated to approximately 1 day per week throughout this period and, whilst this might be more than required in the early days of the project, it was considered acceptable. DNV GL also compared the resource estimate for commissioning resource with the programme and noted a good correlation of the estimate with the programme and therefore assessed the resource estimate to be reasonable.

4.4.5 LT25: Loch Buidhe 275/132 kV Substation WBS

SHE Transmission Commissioning profile for Loch Buidhe is identical to the profile for Fyrish with the addition of a Lead Commissioning engineer. However the commissioning dates for the two projects are different and the profile, although it is titled LT25 Loch Buidhe, identifies LT24 in the actual schedule. DNV GL assessment is that there is a mismatch between the programme and the resource estimate and DNV GL has prepared an alternative commissioning schedule based on the Fyrish submission. DNV GL assessment of necessary commissioning resources is set out in Table 36 below:

Resource	Cause	Change	SHE T Estimate
All Resources			[•]
SAP	Increase in SAP resource to match programme	[•]	
Commissioning Engineer	Increase in Commissioning Engineer resource to match programme	[•]	
Lead Commissioning Engineer	Not Required	[•]	
	Total reduction	[•]	[•]

Table 36: LT25: Commissioning Resource Estimates for Loch Buidhe Substation

DNV GL analysis indicates a cost estimate excess of [•] reducing the Commissioning allowable cost to [•].

4.4.6 LT42: Beauly-Loch Buidhe Re-conductoring

SHE Transmission included the Commissioning resource within the Project Management resource profile. For consistency in analysis, DNV GL has removed the SAP and Commissioning Engineer resource and considered it in this section.

The commissioning schedule shows that an SAP is required for 40% of his time from Dec'15 to Jun'17. However, the contractor is not mobilised to site until Apr'16 and there can be no significant

requirement for an SAP prior to site mobilisation. Furthermore, there is insignificant need for an SAP following issue of work permits until construction of each phase is complete and cancellation of permits is required. Hence, DNV GL's analysis is that there should be a reduction of [•] in the commissioning resource.

Resource	Cause	Change	SHE T Estimate
All Resources			[•]
SAP	SAP resources not required prior to mobilisation or in the period between Phase 1 and Phase 2	[•]	
	Total reduction and revised allowance	[•]	[•]

Table 37: LT42: Commissioning Resource for Beauly-Loch Buidhe OHL

DNV GL analysis indicates a resource cost estimate excess of [•], reducing the commissioning allowable resource cost to [•].

4.4.7 Conclusion Commissioning

The DNV GL considerations for estimates on commissioning costs are summarised and presented in Figure 25.

Figure 25 indicates that, for the Commissioning costs for the Caithness-Moray transmission reinforcement, some [•] could reasonably be removed from the SHE Transmission submission at this stage in the development.

Figure redacted

Figure 25: Commissioning costs - summary of DNV GL assessment

4.5 Conclusion on Engineering, Project Management and Commissioning

We note the following observations/conclusion from our assessment of Engineering, project management and commissioning costs:

- The overall observation is that SHE Transmission has set up a massive project management and engineering team around this project. There is a very large site presence with a large office complex, administration/office management, reception, multiple project/site managers, supervisors, inspectors etc.
- The main contractors have been contracted to design, manufacture, supply, install and commission a number of projects. They have full responsibility for this work. Other than the

HVDC, the substation equipment, cables and overhead line equipment are all standard equipment in wide use throughout the UK.

- Many of the allocated SHE Transmission staff are described as supervising the works, whilst many others are support staff to the site team. However, the main contractors will supervise the works with their own site teams and are contracted to be responsible to do so. The overriding impression is that SHE Transmission does not trust contractors to supervise the works adequately and has put in a large management team to supervise the supervisors.

- This doesn't seem to be an efficient or cost effective way of managing these projects and DNV GL assessment has been made on the basis that the contractors are paid to do the work, whilst SHE Transmission's role, as client, is one of managing appropriate interfaces between contractors and monitoring progress through regular reports and review. This approach should lead to a significant reduction in the need for SHE Transmission staff and, particularly, the site presence.

The combined Engineering, Project Management and Commissioning costs are summarised below in Figure 26. DNV GL assesses that some [•] of the CAPEX submission [•] could reasonably be removed from the SHE Transmission submission.

Figure redacted

Figure 26: Overall resourcing submission – comparison with DNV GL assessment

5 ASSESSMENT OF SHE TRANSMISSION APPROACH TO RISK

5.1 Introduction

For each construction project within the Caithness-Moray transmission reinforcement , SHE Transmission has identified and evaluated the risks most likely to impact the outturn of the project capital costs (CAPEX). Ofgem has thus asked DNV GL to review these cost risk estimates and make recommendations on them.

SHE Transmission estimated the risks to each project's costs in a three-step process:

- Step 1 – Identify the risks: For each project (substation or transmission circuit build), SHE Transmission established a risk register, recorded a description of each identified risk and, generally, noted control actions to be taken;
- Step 2 – Identify the impacts: For each risk on a project, SHE Transmission estimated the probability that the project's capital budget, resourcing level or time allowance would be inadequate, and also estimated the minimum and maximum (and in some cases the "most likely" (ML)) cost impact of that eventuality.
- Step 3 – Identify the expected project cost: For each project they then modelled these risks with the Monte Carlo (MC) tool @Risk to identify the median, or "P50" [‡‡‡] overall expected cost impact of all these risks on the project outturn cost. [§§§]

The P50 value (in GBP) is presented by SHE Transmission as a risk element of each project's cost, expected to be incurred alongside, and in addition to, the main capital cost of the project.

In this section of the report, therefore, DNV GL reviews SHE Transmission's estimates of the extra costs they expect to be incurred during construction.

5.2 Assessment Methodology

Our aim has been to assess whether SHE Transmission's estimated risk elements of each project's costs are credible and reasonable and to recommend whether to accept these costs in whole or in part.

For this desk-top assessment we have taken the following approach:

- Reviewed SHE Transmission's overall approach to project risk;

‡‡‡ The "P50" value refers to the value of the 50th percentile, or median, of the MC simulated scenario outputs. It is the level of risk cost that was not exceeded by 50% of the modelled scenarios. Note that, if the output histogram is skewed, the median may not equal the mean.

§§§ For the MC modelling in Step 3, probability density functions are assigned to each risk. Where SHE Transmission has been able to identify a "most likely" (ML) cost of the risk event, the company has modelled the probability as a triangular density function with Min, ML and Max at the three points on the triangle. Where there was inadequate information to estimate anything other than Min and Max values a uniform distribution was used.

- Scrutinised in detail the risks with the greatest impacts; and
- Extrapolated our findings, as appropriate, to the remaining risks.

Each of these three steps is described further next.

5.2.1 Review of SHE Transmission's Approach to Risk

To understand SHE Transmission's approach to risk we reviewed the various risk-associated documents provided for each project. Where necessary, and where time allowed, we sought clarification through Supplementary Questions (SQ) [****] and, occasionally [††††], telephone conference discussion. Documents that SHE Transmission provided for each project included:

- Quantitative Risk Analysis Report (QRAR), containing a description of the project scope and it's quantified cost risk analysis (QCRA);
- Risk Register (Excel), containing a list of project risks along with their mitigation actions, assessed probabilities and cost impacts; and
- Risk model outputs (Excel or .pdf), as charts and tables.

We also took account of Ofgem's observations during their attendance at SHE Transmission risk workshops early in July 2014.

5.2.2 Scrutinising Project Risks

To obtain a first impression of credibility and reasonableness of the risk cost submission we focussed upon the project risks with the highest probabilities and, separately, those with the largest expected (ML) impacts. We also looked for anomalies associated with the risk descriptions, probabilities of occurrence and the cost impacts should a contingency materialise. The method we followed for each project was as follows:

- Examine the project risk register (Excel files) as provided by SHE Transmission and filter out all those risks that have not been included in the MC quantitative risk analysis (QRA) and those that were marked as closed. Our assumption here is that only open QRA risks are being submitted to Ofgem for review;
- Note for exclusion from the allowance any risks that, according to the "Close-out Date" column, were time expired;
- Identify risks whose estimated probability of occurrence is 70% or higher. (We understand that Ofgem is considering treating risks with such high probability as "issues" with the CAPEX and resourcing estimates, rather than as project risks. We assessed only one of those probabilities as remaining at 70% or higher after mitigation (LT21-CN-787) and this was noted for inclusion in the CAPEX assessment.);

**** An SQ is a formal Supplementary Question raised by Ofgem in a written format to SHE Transmission, anticipating a corresponding written response in reply. The progress of SQs is managed through the regular updating of an SQ log.

†††† One hour telephone conferences took place on 24th June and 6th August 2014.

- Develop, from the SHE Transmission estimates of cost (impact) and probability of occurrence, an expected cost impact [‡‡‡‡] for each risk;
- Sort the risks by the size of this expected cost impact;
- Review, for the top-ranking items, and for all the high probability items, the description of the risk, the risk control actions", the modelling notes (for additional clarification) and probability of occurrence along with the minimum, ML and maximum costs should the risk be realised;
- Discuss, or raise as SQs, questions of clarification;
- Review the answers provided by SHE Transmission and take a view on the credibility and reasonableness of the risks considered; and
- Apply an adjustment factor to each scrutinised risk considered to be significantly too high, and apply that factor to the risk's contribution to the expected cost impact calculated for each risk;
- Sum the adjusted expected cost impacts and establish the percentage adjustment (it was always found to be a reduction). Scale the adjusted expected cost impacts to match the MC output P50 risk sum submitted by SHE Transmission; and
- Extrapolate these findings to the remaining risks – as described next.

5.2.3 Extrapolating Findings

It has not been practicable to review every risk identified for every project in the time available for this review. Our approach to covering this limitation has been, for each project, to extrapolate our findings on the scrutinised risks to the remainder in that project on a value percentage basis, as follows:

(i) Establish the percentage of the risk submission value that has been scrutinised (see Section 5.2.2 above);

(ii) Establish the overall percentage reduction proposed on those risks (again, see Section 5.2.2 above); and then

(iii) Apply that same percentage reduction to the remaining risk evaluations.

(Expired risks have been excluded from this extrapolation process.)

5.3 Findings

5.3.1 Review of SHE Transmission's Overall Approach

We understand that risk workshops have been held periodically though the development of the project. Ofgem officers were invited to workshops on 1st and 2nd July 2014 (covering on-shore and

‡‡‡‡ The expected cost impact was calculated by multiplying the SHE Transmission ML Impact (if it was stated) or the average of the Min and Max Impacts (if it was not) by the SHE Transmission probability of occurrence.

offshore cable risks respectively) and the notes from these meetings have provided a “snapshot” of the degree to which these workshops sought to manage and mitigate the risks identified. Other than this, our main sources of evidence have been the SHE Transmission risk documents issued to Ofgem (key items listed in Section 5.2.1) and the two telephone conferences between Ofgem, SHE Transmission and DNV GL.

These sources suggest that SHE Transmission’s approach to project risk assessment is methodical and detailed. So far as we can tell, SHE Transmission considers the risks on a project-by-project and risk-by-risk basis, and develops their project risk registers and risk models using contributions made in the workshops. The use of Monte Carlo (MC) analysis is appropriate for a project of this magnitude.

The following concerns, however, were noted regarding the QRA and its associated data:

- The project risk registers were not of uniform format. Some included both “Risk Control Actions” and “Status/actions” columns (for example LT42), whilst others (for example LT21) were short of the latter column, leaving the reviewers wondering whether, and how, mitigating actions were being followed up.
- Expanding from the point above, in the same way that consideration of the mitigating actions (at least, as recorded in the risk registers) has not always been followed through, neither has the mitigating effect of these actions on the cost impact been apparent. It often seems that the impacts and probabilities evaluated in the MC analysis are the pre-mitigation rather than the post-mitigation values. For example, LT21-CN-067 refers to work across various areas where protected species are present, and cites 6 mitigating measures (including surveys) to control this risk. Yet there remains an estimated 75% probability of an impact of between [•] (estimates not explained). We would have expected the risk registers to contain a clear statement of each estimated risk both prior to, and then post, any proposed mitigating actions.
- SHE Transmission modelling has not included any consideration of positive or negative correlation between the risks being modelled. This degrades the case for the cost and effort of using MC in the first place, since the accuracy of the results is likely to be impaired. Whilst the additional complexity of such modelling might not be worthwhile for the smaller risks, we would have expected the largest risks to have been assessed in this way, if only manually, to understand and manage the full impact of the largest credible risks.
- SHE Transmission appears to have modelled some (large) costs in a way that allows them to be triggered more than once by risks that could overlap, or could occur simultaneously, whilst in practice we would expect to see only a single occurrence of these costs. One example of this apparent double counting of risk cost can be seen in risks LT21-CN-630 (Delay in offshore installation) and LT21-CN-654 (Marine Licence requires amendment). Here, either risk could trigger the cost of the offshore vessel spread (at [•] per day). Both these risks could be realised together, and they are modelled to be able to do so, however it is inappropriate to model the cost of the offshore vessel spread ([•], for example) at a high probability of being counted twice.
- The same two examples of risks (LT21-CN-630 and LT21-CN-654) illustrate a more general risk assessment concern. The description of the former is, “Delay in offshore installation may move campaigns to less favourable period or the following year's window and increase

weather downtime from that anticipated.", and is thus quite vague in terms of its triggering event. That of the latter is, "Marine Licence requires amendment due to quantities of rock protection anticipated. Burial protection plan needs to be submitted to marine Scotland for consultation with stakeholders - risk that marine licence delayed. There is a major joint planned which may be out with the consented boundary", a definition that could easily be picked up by the former risk and thus, effectively counted twice. In addition to the possible double counting due to overlap, both are accorded a 50% probability without reasoned justification or recognition of the interaction in the risk register.

- The MC models for some of the projects look as if inadequate runs have been made to reliably fix the P50 value. For example, whilst the left hand histogram in Figure 27 below (relating to LT21, HVDC) shows a reasonable convergence towards mean and median values, the right hand histogram in the same Figure (relating to LT41, Blackhillock S/S) is much less conclusive. The LT21 and LT41 histograms were the outputs of a 10,000 iteration run and a 1,000 iteration run, respectively. The latter histogram's median could easily be higher than is justified by the risks being modelled, thus over-estimating the expected impact by, perhaps, 5 – 10%.

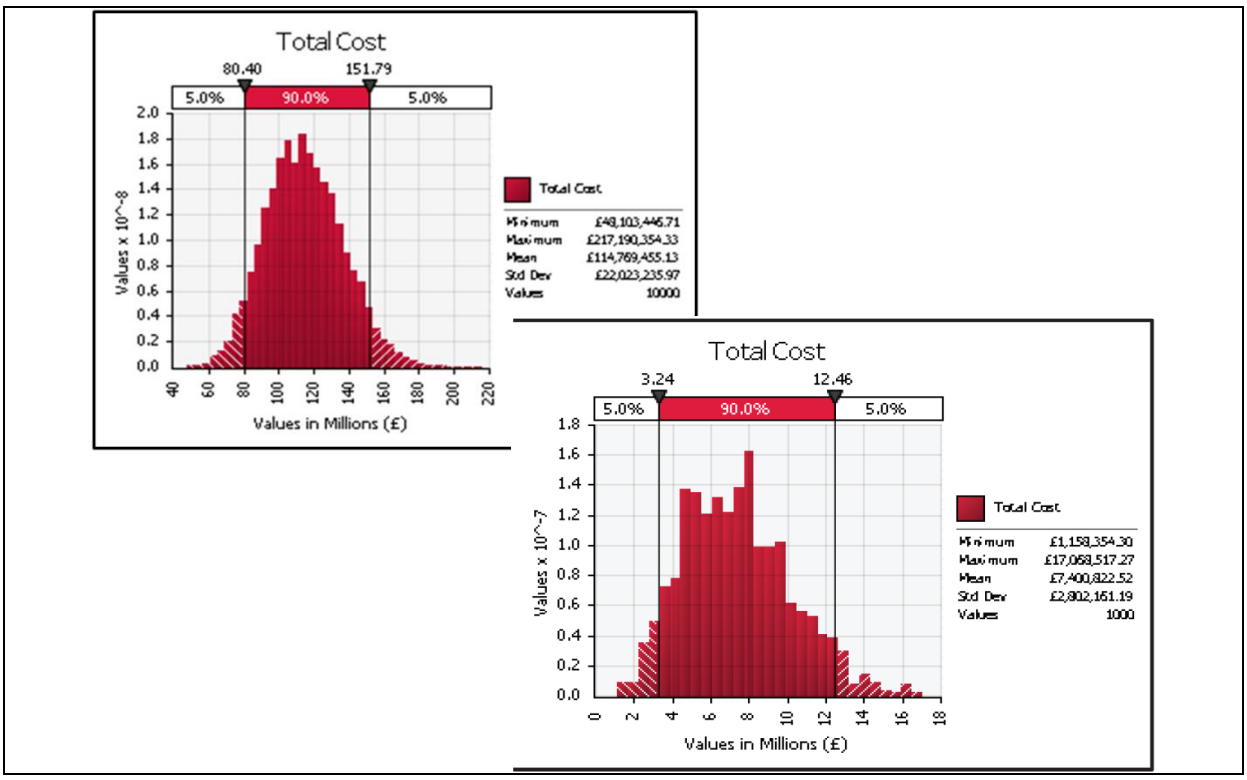

Figure 27: Enough Monte Carlo iterations?

Some of these concerns picked up by the desk-top analysis, have been reinforced by notes from Ofgem's attendance at the risk workshops, where the general impressions received were that:

- On assessing probabilities - Much weight was given to "past experience", though no hard statistical evidence for the assertions of a particular contingency's frequency, likelihood or cost was presented;

- On assessing probabilities and impacts - Very few of the attendees claimed to bring the "past experience" to the table, so there was little, if any, challenging of the assertions made, or references to past lessons learned;
- On incentives to minimise project risk - The only technical challenging that was observed tended to increase, rather than decrease the expected impact of a risk and, apart from the removal from the risk register of a few low-value items, no reduction in the general expected cost of project risk was observed; and
- On quality of risk assessment - The time devoted, even to the largest expected impact risks, was very brief (3 - 6 minutes), with no evidence that the effects of diligent management of risk reduction were being fed into the risk modelling.

This is disappointing, since we would have expected to see evidence of serious managerial effort prioritising the reduction of the larger value risks and, concurrently, the effects of this being fed into the risk model.

5.3.1.1 Scrutinising Project Risks - General

Our review of the project risk registers followed the methodology outlined in Section 5.2.2. The following notes refer to a selection of the open risks included in the QRA, and indicate reasons why we believe the risk submission should be adjusted. Each project is taken in turn – first the AC, then the HVDC.

5.3.2 LT23 – Dounreay-Mybster 275/132 kV

The file LT23 Dounreay Mybster Risk Register March 14.xlsx contains 69 open QRA risks with a total expected impact of around [•] on a [•] capital project ([•]). We noted that:

- Risk 5 shows a 65% probability of a [•] delay to planned outages. SQs were raised to further understand this risk (for several of the projects) and significant planning effort for the far- to near-term was described (see SHE Transmission's "CM_LT23_001 Response.pdf"). Given the sophisticated planning process to avoid overlapping outages for known requirements this explanation effectively places the trigger for this risk on unplanned outage delays due to genuinely unexpected events. The stated impact of this risk therefore seems improbably high, and we estimate 25% of this.
- Risk 134 shows a 50% probability of a [•] delay to start of works, including site surveys and seasonally affected activities. An SQ confirmed that this related to a delayed regulatory determination. The logic for the impact of this risk appears to be flawed both because a quality submission leading to a timely regulatory determination is entirely within the control of SHE Transmission, and because the awaited determination concerns the level of the regulatory allowance (which shouldn't give rise to a works delay), not acceptance of the basic needs case.
- Risk 99 shows a 35% probability of a [•] delay to works due to programme conflicts. SHE Transmission has its own competent project management resources and we thus estimate that the probability of such a clash should not need to be set higher than 10%.

- Risks 146 to 149 show a 70% probability of changes to the HSE's CDM Regulations 2007 imposing additional duties and responsibilities on the Thurso, Mybster, Dounreay and OHL construction sites. The costs considered to be at risk due to this cause vary depending upon size of site and are assessed at [•] in total. No mitigation is proposed, other than ensuring the new regulations are implemented – which does not relate to this risk. The HSE website http://www.hse.gov.uk/consult/condocs/cd261.htm indicates that the objectives of the current review are:

  " … improved co-ordination, better value for money, improved efficiency and use of technological changes in Construction 2025, the Government's industrial strategy for construction.

  "The main proposed changes are to: make the Regulations easier to understand; replace the CDM co-ordinator role with the principal designer; replace the ACOP with targeted guidance; replace the detailed and prescriptive requirements for individual and corporate competence with a more generic requirement; align notification requirements with the Directive and apply the Regulations to domestic clients but in a proportionate way."

  The HSE web-page http://press.hse.gov.uk/2014/consultation-on-replacement-of-the-construction-design-and-management-regulations-2007/ outlines the proposed changes as follows:

  These objectives do not, on the evidence presented, appear to comprise a 70% risk of greater health and safety regulation compliance costs; we thus estimate that the mitigated expected impacts should not be greater than 50% of that submitted.

- Risk 10 shows a 40% probability of unavailability of internal project management resources, cost range of [•]. It expires in Jul'14 and has thus been discounted in this review.

The effect of applying these modifications is summarised in Table 38.

Note that the figures of the first line (labelled "≥ 70% Probable") are provided separately here, for information, but are all included in the third line (labelled "Scrutinised") since they were each scrutinised. The 'Totals' line thus just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table.

Table redacted

Table 38: LT23: Risk Summary – Dounreay-Mybster 275/132 kV

5.3.3 LT24 – Fyrish 275/132 kV Substation

The file LT24-PM-109 Fyrish Risk Register 18.3.14.xlsx contains 34 open QRA risks with a total expected impact of around [•] on a [•] capital project ([•]). We noted that:

- Risk 49 shows a 70% probability of occurrence of [•] additional costs for the substation earthing system. This appears to be the unmitigated risk estimate, since the supplemental earthing report has apparently now been delivered and should allow a much narrower (and probably lower) range of cost impact to be estimated. From the wordings of the Risk

Description, Risk Control Actions and Status/actions columns of the risk register, our assessment is that the impact should not be set higher than 50% of that submitted.

- Risk 84 shows a 70% probability of changes to the HSE's CDM Regulations 2007 imposing additional duties and responsibilities on the Fyrish construction site amounting to [•]. No serious mitigation is proposed in the submission, though we estimate that the mitigated expected impact should be in the order of 50% of that submitted (see further explanation at LT23 Risks 146-149, p103).
- Risk 39 shows a 50% probability of a [•] delay to commissioning works due to lack of SAP resource. Given the 2-3 year look-ahead with recruiting currently underway, and the assurances already received that SHE Transmission will have the necessary resource (Risk Register status/actions column), we estimate that this risk should be set no higher than 20% probability;
- Risk 4 shows a 50% probability of a [•] delay to works due to programme conflicts with other projects. SHE Transmission has its own competent project management resources and we thus estimate that the probability of such a clash should not need to be set higher than 10%; and
- Risk 67, with a 30% probability of cost in the range [•], expired in Jun'14.

The effect of applying these modifications is summarised in Table 39. Note: As explained in the note above Table 38, the 'Totals' line just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table:

Table redacted

Table 39: LT24 Risk Summary – Fyrish 275/132 kV Substation

5.3.4 LT25 – Loch Buidhe 275/132 kV Substation

The file LT25-PM-109 Loch Buidhe Risk Register 18.3.14.xlsx contains 32 open QRA risks with a total expected impact of [•] on a [•] capital project ([•]). We noted that:

- Risk 47 shows a 50% probability of a [•] delay to commissioning works due to lack of SAP resource. Given the 2-3 year look-ahead with recruiting currently underway, and the assurances already received that SHE Transmission will have the necessary resource (RR status/actions column), we estimate that this risk should be set no higher than 20%.
- Risk 4 shows a 50% probability of a [•] delay to works due to programme conflicts with other projects. SHE Transmission has its own competent project management resources and we thus estimate that the probability of such a clash should not need to be set higher than 10%.
- Risk 64 shows a 20% probability of a [•] delay to works due to programme "interface between parties" associated with the OHL tie-ins. As with Risk 4, SHE Transmission has its own competent project management resources and we thus estimate that the probability of such an interface-induced delay should not need to be set higher than 10%.

- Risk 8 shows a 50% probability of a [•] delay to commissioning works due to lack of engineering design and project support. Given that the necessary resources have been identified and budgeted within the project and that the Regulator has already accepted the needs case for this work, necessary recruiting should be able to proceed in good time. In any event, a lack of resource in this situation would tend to be an SHE Transmission-wide phenomenon rather than project-specific, so for both of these reasons we recommend that this risk, such as it is, should not be allowed against this project.
- Risk 80 shows a 70% probability of changes to the HSE's CDM Regulations 2007 imposing additional duties and responsibilities on the Loch Buidhe construction site amounting to [•]. No serious mitigation is proposed in the submission, though we estimate that the mitigated expected impact should be in the order of 50% of that submitted (see further explanation at LT23 Risks 146-149, p103).

The effect of applying these modifications is summarised in Table 40. Note: As explained in the note above Table 38, the 'Totals' line just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table:

Table redacted

Table 40: LT25: Risk Summary – Loch Buidhe 275/132 kV Substation

5.3.5 LT41 – Blackhillock Substation Redevelopment

The file LT41 RR 07.04.14 Attachment 03.xlsx contains 32 open QRA risks with a total expected impact of around [•] on a [•] capital project ([•]). We noted that:

- Risks 090, 108 and 104 were estimated by SHE Transmission as having a 70% or higher probability of occurrence. Ofgem considers that probabilities of 70% and above should be treated as "issues" in the CAPEX sum and be removed from the risk allowance. These appear to be risk assessments with pre-mitigation impacts, since it would be unusual to treat events with such high probabilities as anything less than "more-or-less certain" and include them in the CAPEX budget. We have assessed the likely post-mitigation impacts for each of these risks and the outcomes are fed into the table below, firstly on a line of their own (for transparency) and secondly included in the set of scrutinised risks. None were assessed as 70% probability or above post mitigation.
- Risks 047, 084, 089, 097 and 107, with a total value of [•], have all expired.
- Risk 072 shows a 50% probability that enough space has not been allowed for the new protection panels, implying a cost range of [•]. Mitigation comprises a site survey to check space requirements by Dec'16. No reason has been given for this uncertainty or the reason why it needs to remain open another 18 months. It is also unclear why wiring needs to be installed and then rewired, or why it is uncertain whether an extension is required, so late in the programme. We estimate that the impact would be reduced by at least 50% if the proposed survey and designs were completed before the works are started.

The effect of applying these modifications is summarised in Table 41. Note: As explained in the note above Table 38, the 'Totals' line just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table:

Table redacted

Table 41: LT41: Risk Summary – Blackhillock Substation Redevelopment

5.3.6 LT42 – Beauly-Loch Buidhe 275 kV Re-conductoring

The file LT42-PM-109 OHL BT1 Risk Register 18.3.14.xlsx contains 18 open QRA risks with a total expected impact of [•] on a [•] capital project ([•]). We noted that:

- Risk 52 shows a 70% probability of changes to the HSE's CDM Regulations 2007 imposing additional duties and responsibilities on the project. The HSE indicate that, even though their review is yet to be completed, the CDM coordinator role is being replaced not augmented and, from their description of the objectives of their review we estimate that the impact from this risk will not exceed half that submitted by SHE Transmission (see further explanation at LT23 Risks 146-149, p103).
- Risk 4 shows a 50% probability of a [•] delay to works due to programme conflicts with other projects. SHE Transmission has its own competent project management resources and we thus estimate that the probability of such a clash should not need to be set higher than 10%.
- Risk 39 shows a 50% probability of a [•] delay to commissioning works due to lack of SAP resource. Given the 2-3 year look-ahead with recruiting currently underway, and the assurances already received that SHE Transmission will have the necessary resource (RR status/actions column), we estimate that this risk should be set no higher than 20%.
- Risk 52 shows a 70% probability of changes to the HSE's CDM Regulations 2007 imposing additional duties and responsibilities on the OHL construction site amounting to [•]. No serious mitigation is proposed in the submission, though we estimate that the mitigated expected impact should be in the order of 50% of that submitted (see further explanation at LT23 Risks 146-149, p103).
- Risk 43 shows a 50% probability of a [•] outage delay due to generation constraint or heavy rain. The minimum delay is put at 10 days, and the maximum at 30 weeks (probably 30 days was intended). Given the risk control actions listed in the Risk Register we anticipate that the mitigated impact would be closer to half to two-thirds (say 60%) of this probability.

The effect of applying these modifications is summarised in Table 42. Note: As explained in the note above Table 38, the 'Totals' line just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table:

Table redacted

Table 42: LT42: Risk Summary – Beauly-Loch Buidhe 275 kV Re-conductoring

5.3.7 LT21 – Caithness-Moray HVDC Reinforcement

The file LT21 Caithness HVDC Reinforcement Risk Register v8 25.3.14.xlsx contains 130 open QRA risks with a total expected impact of [•] on a [•] capital project ([•]). We noted that:

- Twelve risks (Risk 030, 067, 071, 083, 755, 762, 765, 787, 847, 850, 857 and 861) show a 70% or greater probability of cost risk to the project. Most of these appear to be risk assessments with pre-mitigation impacts, since it would be unusual to treat events with such high probabilities as anything less than "more-or-less certain" and thus include them in the CAPEX budget. We have assessed the likely post-mitigation impacts for each of these risks and the outcomes are fed into the table below, firstly on a line of their own (for transparency) and secondly included in the set of scrutinised risks.
- The 70% probability, post-mitigation, of risk LT21-CN-787 appears justified by the risk Register content and, since Ofgem considers such high probability risks should be treated as "virtually certain issues", we recommend that the risk be closed and that full allowance be made for it in the CAPEX sum.
- Seventeen risks (the first being Risk 166, the last being Risk 872) had expired by the date of this review, and we consider they should be removed from the risk allowance.
- Risk 421 indicates a 50% probability that the "preferred bidder excludes additional works associated with free spans". Further details regarding the justification, control actions, probability and impact of this risk have been requested via an SQ but, for the purposes of the deadline for this present review, and in line with the note in the Risk Register regarding closure of this risk, we recommend that it is not allowed.
- Risk 447 indicates a 50% probability of a currency exchange rate threat of between [•]. This takes no account of the possibility of the reverse effect, or of hedging (mitigating) opportunities to control this risk. We consider that maximum impact should be estimated no higher than the hedging cost, say 10% of that stated.
- Risk 746 indicates a horizontal directional drilling and landfall unviability risk with a 50% probability of a [•] cost range. It seems unreasonable that this uncertainty should be arranged to persist up to the point where laying vessel dates are fixed. The need-case for this project is approved by the Regulator so, in our view, early surveys and drilling could mitigate such large degrees of cost uncertainty by at least 50%.
- Risk 029 indicates a 50% probability of a [•] weather delay in excess of that allowed for by the contractor. There is no evidence that the contractor would not reasonably have estimated this risk himself prior to his bid, so we estimate that the residual contingency impact resting with SHE Transmission should be reduced by at least one half.
- Risk 781 indicates a 60% residual risk that the contractor finds more rock-removal needed on the overland cable route than anticipated. It seems unreasonable to agree a contract that is more likely than not to fail to meet requirements without additional resource, especially when ground surveys should be able to reduce this risk considerably. In addition, it is unclear why the up-to 12 weeks delay incurs SHE Transmission staff costs of [•] per week. We estimate that this overall risk value should be reduced by at least 50%.

The effect of applying these modifications is summarised in Table 43. Note: As explained in the note above Table 38, the 'Totals' line just adds up the 'Expired', 'Scrutinised' and 'Extrapolated' lines of the table:

Table redacted

Table 43: LT21: Risk Summary – Caithness-Moray HVDC Reinforcement

5.3.8 Extrapolating Findings

Extrapolated assessment of the submission risks was carried out as described in Section 5.2.3 and the results included as a separate line in each of the six tables above (Table 38 to Table 43 inclusive). A summary of the results of the extrapolation may be found in Table 44.

Table redacted

Table 44: Risk summary by assessment category for all sub-projects

As a rule of thumb, we would anticipate risk (or contingency) allowances of between 5-10% for substation and overhead line projects, looking towards the lower end of this range for standard extensions, refurbishments, and overhead line re-conducting, and with these values lowered to the extent that risk has been passed to the main contractor of an EPC agreement. For a subsea project we might expect a higher allowance, depending upon the proportions of the substation, underground cable and subsea elements. Table **redacted**

Table 45 indicates that all except the LT25 and, possibly, the LT41 submissions were high, although even these two sub-projects' risk submissions contained significant sums that were not adequately justified by the evidence in the risk register.

Table redacted

Table 45: Risk summary by sub-project for all sub-projects

More generally, two further points emerge:

- Regarding the way the risk allowance is to be used, we understand that Ofgem (the consumer) and SHE Transmission are each to contribute half the P50 (or other allowance) value, with an equal redistribution if the outturn of all risk expenditure on a given project is less than this. Normal practice is to place the impact of a risk with the entity best able to control it which, in this case would be SHE Transmission rather than Ofgem. We would thus recommend a review of this risk-sharing arrangement in order to retain incentive on SHE Transmission to manage project risk to an economic minimum rather than to maximize regulatory asset value (RAV).
- Having reviewed these risk submissions we are left with the concern that the "ex ante" approach to fixing risk allowances introduces perverse incentives and additional (business) risk for both the consumer and the electricity company by forcing an unnecessarily early agreement on risk expenditure.

5.4 Conclusions on Risk

Our assessment concludes that, for the AC and HVDC elements of the Caithness-Moray transmission reinforcement together, some [•] of the risk provision ([•]) could reasonably be removed from the risk submission at this stage in the development. This is shown graphically in Figure 28:

Figure redacted

Figure 28: Risk submission – Comparison with DNV GL assessment

Our further conclusions on risk are that:

- The risk submissions were generally a factor of [•] above our expectations for these projects, however the adjusted risk values presented in this report would bring the allowance within the expected range;
- The proposed risk-sharing arrangement only partially places the risk impact upon the party best able to control it, thus exposing the consumer to the risk that there is inadequate incentive to minimise contingent expenditure; and
- The “ex ante” approach to fixing risk allowances allows less than optimum management of project risk.

6 ASSESSMENT OF SHE TRANSMISSION APPROACH TO PROCUREMENT

We have undertaken a review of SHE Transmission's approach to procurement and selection to determine whether the process of acquiring equipment and services (to be) for the Caithness Moray reinforcement is efficient and can be expected to deliver value for money for consumers.

To this end, we have assessed how SHE Transmission has engaged with the market (of potential suppliers) as well as the evaluation criteria SHE Transmission has applied in short-listing and selecting technology, services, and suppliers thereof. In our assessment we:

- Provide an overview of different categories works and services covered by the procurement process;
- Review how SHE Transmission has contracted for such works and services; and
- Assess whether the overall process meets public procurement requirements.

Note that our assessment does not include a detailed assessment of the cost (price) of equipment and services, which is discussed in section 4 above, but focuses on the procurement process.

6.1 Works and services covered by the procurement process

Figure 29 below provides a breakdown of the overall project costs for the Caithness Moray reinforcement into different categories.

Figure redacted

Figure 29: Total project costs per category[§§§§]

Figure 29 shows that Construction is the main area of procurement activity, covering [•] of total project costs. The remaining project costs are a combination of fees, project management and operational costs, and outright purchases (e.g. land), which SHE Transmission has either acquired through existing framework agreement, or are not subject to public procurement principles do not apply, and are therefore not covered in this review.

Construction costs can be further broken down into five categories as illustrated in Figure 30 below.

Figure redacted

Figure 30: Breakdown of construction procurement costs by category

[§§§§] This chart does not include costs associated with LT21 as this was outside of our scope

6.2 Contracting Approach

For construction-related projects, SHE Transmission's preferred form of contract is the New Engineering Contract 3 (NEC3) which has been adopted for the majority of contracts on this project. This ensures consistency of approach across the various elements of the project. The main NEC3 contract options that have been utilised on this project - and the primary construction activities which fall therein are:

- Option A (Priced Contract with Activity Schedule) – Substations, Overhead Line, HVDC, Public Road Improvements
- Option B (Priced Contract with Bill of Quantities) – Overhead Line diversion works
- NEC3 Supply Contract – Super Grid Transformers

However, the supply and installation of Grid Transformers will be delivered under an existing framework, which utilises EB/BEAMA 1979 (A) - Conditions of Contract for Plant including Erection.

Due to the complexity and diverse range of construction techniques across the various work packages within the project, it was determined that turnkey design and build contracts is the most suitable and efficient strategy for the majority of the work packages. This approach enables the various contractors to take ownership of (within pre-defined criteria), and coordinate the design, procurement, engineering, construction, testing and commissioning of the works. It is in line with the other contracts that we have procured in the past, in projects of a similar type and complexity.

6.2.1 Framework Agreements

The key features of this Contracting and Procurement strategy are for all appointments both consultancy and construction for these works to be carried out using frameworks contracts currently in place, procured by the procurement and commercial department.

In procuring construction work, SHE Transmission has entered into multiple framework agreements, through which it has contracted a pre-selected group of suppliers to deliver construction services broadly within the categories given in Figure 30. The following provides a brief account of SHE Transmission considerations in opting for a system of framework agreements, which we consider valid and reasonable.

- Overhead Lines and AC Substation works

SHE Transmission considers the timely delivery of OHL and AC Substation works a critical factor in the successful completion of the CM reinforcement project. Taking into account this criticality, and considering that the remote location of the projects in comparison to the resource base for the industry, SHE Transmission decided that procurement on a transactional basis would be unlikely to provide the long term certainty necessary to secure the required resources. SHE Transmission therefore considered that a committed framework agreement would be the most appropriate, and awarded this framework in 2013.

The Sub Station Supply Chain Framework Contract includes the following elements:

- Civil Engineering Works
- Electrical Design & Construction Works
- Equipment Supply & Installation*****
- Commissioning and testing
- Reinstatement Works

The substations to be delivered on the Caithness – Moray transmission reinforcement SWW project have been allocated within the framework agreements to specific AC substations as follows:

- Spittal: [•]
- Blackhillock: [•]
- Loch Buidhe: [•]
- Fyrish: [•]
- Mybster extension: [•]
- Thurso South: [•]
- Dounreay extension: [•]

The OHL Supply Chain Framework Contract will include the following elements:

- Design
- Access and Infrastructure
- Material Supply
- Installation of conductors and fittings
- Commissioning and testing
- Reinstatement Works

The OHL works on the Caithness – Moray transmission reinforcement SWW project have been allocated within the framework agreement to specific contractors as follows:

- Dounreay – Thurso – Spittal – Mybster: [•]
- Beauly – Loch Buidhe: [•]
- Blackhillock 275 kV deviations: [•]

***** Includes localised 275kV & 132kV underground cable diversion

- Spittal Substation 132 kV deviations: [•]

- Cables†††††

The strategy is to deliver cable contracts by utilising an NEC3 Option A Priced Contract with Activity Schedule. This contract is being procured via a competitive one off tender event and will be a single stage design and construct contract.

SHE Transmission has used a fixed price design and build procurement strategy for the HVAC subsea cable supply and installation.

- Transformers

Electrical Transformers will be procured via a call-off contract from SHE Transmission existing Transformer Framework contract. The call-off contract will be the NEC3 Supply Contract and will require the transformer contractor to supply and install the transformers. It is anticipated that nomination of transformer contracts to the main electrical design and build contract will be preferred to remove interface risk and ensure that detailed design and installation are coordinated fully by the Substation Framework contractor.

- Other works

The approach for the AC onshore cabling, of the Caithness – Moray HVDC transmission reinforcement SWW project is similar to that adopted on the OHL and substation works, namely framework contracts have been awarded on a design and build basis.

The approach for the electricity distribution works and telecommunications portions of the Caithness – Moray HVDC transmission reinforcement SWW project is to utilise SHE Transmission's own companies, Scottish Hydro Electric Power Distribution and SHE Transmission Telecoms, to deliver these works.

PRIs may be delivered either through the civil portion of the OHL and substation frameworks or may be delivered via a separate PRI framework agreement, depending on the location, scale and timing of the improvements required.

6.2.2 Contracts in place

The following lists the key contracts in place for the Caithness Moray reinforcement:

- Substation Framework Contract Call-Off for delivery of all GIS, AIS and Civils Work for the new Blackhillock Substation. *(NEC3 Option A Contract.)*

- Standalone Design and Build Contract for the new cable circuits (e.g. Blackhillock to Keith Cable Works). *(NEC3 Option A Contract.)*

†††††Cable procurement excludes localised 132kV underground cable diversions

- Overhead Line Framework Contract Call-Off for delivery of all the 132 kV and 275 kV overhead line works.
- The grid transformers will be procured through the Transformer framework and supplied to the Substation Contractor
- Design consultants will be retained using the existing framework agreements to continue to give professional input on the project: challenging design proposals, working with contractors to value engineer, and assist with the assessment of the final contractor's proposals ahead of negotiating the contract prices.
- Specialist RTU and telecoms equipment will be procured and supplied by SHE Transmission telecoms.

Table 46 below provides an overview of the specific works contract under the different framework agreements, the contracts conditions that apply, and the approximate value associated with each contract.

Project	Works	Approx value	Contract Conditions	Special Conditions to be implmented
LT24, LT25 and LT41	Loch Buidhe substation	Data redacted	NEC3 Option A	Substation Framework Terms & Conditions
	Fyrish substation		NEC3 Option A	Substation Framework Terms & Conditions
	Overhead line		NEC3 Option A	Overhead Line Framework Terms & Conditions
	Underground cable		NEC3 Option A	132kV Framework Terms & Conditions
	Blackhillock substation		NEC3 Option A	Substation Framework Terms & Conditions
	Fyrish substation advance PRI works (construction)		NEC3 Option A	Substation Framework Terms & Conditions
	Transformer procurement		TBC	Transformer Framework Terms & Conditions
LT23 and LT42	Thurso South substation		NEC3 Option A	Substation Framework Terms & Conditions
	Mybster substation		NEC3 Option A	Substation Framework Terms & Conditions
	Doureay substation		NEC3 Option A	Substation Framework Terms & Conditions
	Overhead line Transformer procurement		NEC3 Option A BEAMA	Overhead Line Framework Terms & Conditions Transformer Framework Terms & Conditions
	DNO diversion for OHL works and transfer of 33kV circuits from Thurso to Thurso South		Internal P.O.	SSE PD4 Terms & Conditions
	Public road improvement works		NEC3 Option A	Framework Terms & Conditions
	Forestry		NEC3 Option A	Framework Terms & Conditions
	33kV switchgear		NEC3 Option A	Framework Terms & Conditions

Table 46: Overview of Works Contracted under Different framework Agreements

6.3 The Procurement Process

From our review of SHE Transmission's documentation on the procurement of different works as described above, we have established that the procurement process follows the following steps:

1. Advertising of the contract opportunity on public platforms (such as in the OJEU) including a description of the scope and timing of works involved;
2. Prequalification process to select tenderers based on technical and economic criteria;
3. Tender process for selected tenderers;
4. Contract Award to the most economically advantageous tender response, based on a relative scoring for the following criteria:

a. Health & safety / environment;

b. Technical;

c. Quality; and

d. Programme.

5. Contract award notifications followed by a debrief and standstill period.

The procurement process followed by SHE Transmission is a common approach to projects of this nature, and we have not found any information to indicate that the process has not been transparent or non-discriminatory, or otherwise preventing an open and competitive bidding process. We therefore consider the process followed by SHE Transmission to be appropriate for the works procured.

6.4 Conclusion

We have reviewed SHE transmissions approach to contracting for specific pieces of work in the CM reinforcement project, as well as the overall procurement process applied, and consider both to be appropriate for this project and conducive to an efficient outcome for consumers.

7 SUMMARY OF ASSESSMENT

7.1 Recommendations on CAPEX

Our assessment of the five key aspects of the Technical Case is summarised as follows:

- **Construction costs – AC components** - Taking into the consideration scope of work, location and timeline of project delivery the SHE Transmission estimate for the AC capital work elements of the Caithness-Moray transmission reinforcement is some [•] higher than DNV GL view on efficient expenditure.

- **Construction costs – HVDC Subsea cable** - Optioneering for the LT21 Caithness – Moray HVDC Reinforcement has not included all apparent route options. In particular it does not appear to have considered the shortest route, which could, at a high-level estimate, save up to [•] on the current proposal. (Note: Whilst this sum is included in our overall CAPEX reduction assessment, the view is developed on the basis of CAPEX efficiency for the C-M SWW reinforcement, and needs to be checked against the longer term requirements of wider network developments. Given the magnitude of this singe item, and the current planning uncertainty, it has been retained as a separate item in the recommendation.)

- **Engineering, Project Management and Commissioning** - The overall observation is that SHE Transmission has set up a massive project management and engineering team around this project. There is a very large site presence with a large office complex, administration/office management, reception, multiple project/site managers, supervisors, inspectors etc. Based on the information provided DNV GL concluded that some [•] could reasonably be removed from the SHE Transmission submission.

- **Risk** - All except the LT25 (Loch Buidhe) and, possibly the LT41 (Blackhillock) submissions were too high. For the AC and HVDC elements of the Caithness-Moray transmission reinforcement together, our assessment concluded that some [•] of the risk provision [•] could reasonably be removed from the risk submission.

- **Procurement** - We have reviewed SHE transmissions approach to contracting for specific pieces of work in the CM reinforcement project, as well as the overall procurement process applied, and consider both to be appropriate for this project and conducive to an efficient outcome for consumers.

The above considerations are summarised in Table 47 (onshore) below which indicates that some [•] ([•] of the submission could reasonably be removed from the SHE Transmission submission for the C-M transmission reinforcement. If the subsea cable re-routeing is to be included in the consideration then this reduction could rise towards [•], as shown in Table 48 (which includes subsea). However, as already noted, this conclusion is made in the specific context of the C-M project, and the deductions associated with the subsea cable, in particular, require checking in the broader context of wider network development plans.

Table redacted

Table 47: Summary comparison of submission with DNV GL assessment – onshore only

Table redacted

Table 48: Summary comparison of submission with DNV GL assessment – with subsea

The conclusions summarized in the above tables are shown graphically in Figure 31 and **Figure redacted**

Figure 32 for ‘onshore only’, and ‘including subsea’, respectively.

Figure redacted

Figure 31: Summary assessment – onshore only

Figure redacted

Figure 32: Summary assessment - with subsea